EXPERT INSIGHT

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Sustainable IT Playbook for Technology Leaders

A hands-on guide to designing and scaling sustainable IT strategies for the digital age

Second Edition

Forewords by:

David Entwistle
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Proofreader: Rounak Kulkarni
Production Designer: Ajay Patule
Growth Lead: Nivedita Singh

First published: October 2022
Second edition: January 2026

Production reference: 1121225

Published by Packt Publishing Ltd.
Grosvenor House
11 St Paul's Square
Birmingham
B3 1RB, UK.

ISBN 978-1-80610-529-8

www.packtpub.com

To my mother, Agneta, my father, Jerry, and my sister, Malin — thank you for being my inspiration, catalyst, and North Star.

To my wife, Michela — your love and partnership give meaning to every step of this journey.

To my children, Wilgot and Harald — you are the reason I remain committed to this mission.

To Rick Pastore — thank you for your partnership, insight, and shared dedication to advancing Sustainable IT.

And finally, to all the remarkable people who have contributed to this book and who dedicate their lives and careers to sustainability — your passion, purpose, and commitment continue to inspire me and make this work possible.

- Niklas Sundberg

This is dedicated to my mother, Virginia, who raised me to be a young reader, to the great teachers who guided me, and to my professional colleagues who supported my career as a reporter, writer, editor, and researcher, Mary Brandel, Lew McCreary, Abbie Lundberg, Pam Stenson, and Kath Marston. Thank you, Niklas Sundberg, for the generous opportunity to update and add to your amazing work in this book. Lastly, I thank my spouse, Carolyn Balinskas, for seeing me through all the anxious bits of work and life in general.

- Rick Pastore

Business Foreword



Over my career, I've served in hospitals and health systems in Texas, Wisconsin, Utah, and now California. Each stop has shaped my perspective on what it means to lead in health care. But my time in California has underscored, more than anywhere else, the need for leadership in addressing the growing impact of the environment on our health. I'll never forget the year 2020. As health systems around the world contended with a global pandemic, wildfires here in California sent great clouds of smoke billowing over the Bay Area, choking our skies and turning them a surreal shade of orange. For days, the sun failed to break through the haze.

The air was so hazardous that simply breathing it carried health risks. That reality played out in our emergency department, where patients suddenly arrived struggling to catch their breath.

Moments like this shape how I see my responsibility as President and CEO of Stanford Health Care. Like all academic health systems, we are committed not only to caring for patients when they are ill, but also to preventing disease and strengthening the conditions that allow people to live healthier lives. If our mission is to heal, it must extend beyond the walls of our hospitals to the environmental factors that directly affect human health.

Climate change is the number one public health threat of our time. Rising temperatures, worsening air quality, more frequent wildfires, and increasingly volatile storms contribute to respiratory illness, cardiovascular stress, infectious disease spread, and even heat-related deaths. These effects are not distributed equally. Vulnerable and underserved communities—the same populations already facing the steepest barriers to care—are often those most severely impacted.

The health care industry has a unique responsibility to address this threat. Globally, health systems account for nearly five percent of greenhouse gas emissions. If the industry were a country, it would rank among the top five emitters in the world. In the United States, hospitals and health systems have an outsized footprint due to energy-intensive operations, complex supply chains, and significant waste generation. This creates a paradox: in the act of delivering care, we are also contributing to the conditions that negatively impact health.

That is why decarbonizing health care must be seen as a fundamental extension of our mission. "First, do no harm" applies not only at the patient's bedside but also in how we build, power, and sustain our operations. Every choice we make—from sourcing supplies to managing energy and designing facilities—has ripple effects on people's long-term health.

At Stanford Health Care, we are turning this commitment into action. To guide our progress, we established a dedicated Sustainability Program Office. This team coordinates cross-functional workgroups, expands our greenhouse gas emissions inventories, sets measurable targets for energy, waste, transportation, and supply chain improvements, and works collaboratively with industry consortia.

Through this lens of sustainability, we've empowered clinicians and staff to take action in their respective domains to reduce our environmental footprint without compromising care quality. As just one example, one of our sustainability medical directors, in collaboration with infection prevention, facilities engineering, and clinicians, reduced greenhouse gas emissions by more than 1,000 tons by phasing down the use of nitrous oxide, a widely used anesthetic with a very high global warming potential. This work has greatly contributed to reducing our remaining direct emissions by 50%.

In many cases, investments in natural resource efficiency have also strengthened our financial sustainability, proving that the right thing to do can also be the fiscally smart thing to do. These efforts are backed by a strong business case, allowing us to reinvest in programs that drive further impact.

Today, we are challenging ourselves to bring the same rigor to **information technology (IT)** that we apply to our clinical and operational sustainability goals. Our Technology & Digital Solutions has accelerated the adoption of energy-efficient equipment and more sustainable procurement practices, ensuring that the systems behind patient care are designed with environmental stewardship in mind. Stanford Health Care is featured in *Chapter 3*, *The Fundamental Building Blocks of a Sustainable IT Practice*, for its efforts to embed IT sustainability into our organizational framework.

Beyond environmental stewardship, we also view IT sustainability through another vital lens: how we govern powerful new technologies with the potential to reshape society. Chief among them is **artificial intelligence (AI)**. While AI holds enormous potential to improve medicine, it also raises profound ethical and social questions. At Stanford Health Care, we have made trustworthiness, fairness, and safety the cornerstones of our AI strategy. Our governance framework, which is detailed in *Chapter 4*, *Responsible and Sustainable AI Governance*, is designed to ensure that AI supports—rather than supplants—the judgment of clinicians, strengthens patient trust, and advances equitable care.

This second edition of the *Sustainable IT Playbook for Technology Leaders* could not be more timely. The new chapters on **responsible AI**, **social sustainability**, and **sustainability data** expand the conversation in ways that reflect the realities that leaders face today. Each of these themes underscores a simple truth: sustainability and social responsibility are no longer siloed projects. They touch every decision we make, from how we govern new technologies, to how we engage with our communities, to how we measure progress and hold ourselves accountable.

Although this book is written with IT leaders in mind, its lessons are for all of us. For CEOs, sustainability officers, and every member of the C-suite, it underscores just how essential IT is to the enterprise. We rely on IT to provide us with the data to inform sound decisions, to shrink our digital carbon footprint and reduce e-waste, and to ensure that AI is governed responsibly. Without that leadership, our progress would fall short of our goals.

The journey ahead will not be easy. Promoting sustainability requires persistence, collaboration, and a willingness to rethink long-standing practices. And as AI continues to rapidly evolve, we will need agile governance models that can keep pace. But the stakes could not be higher. As leaders, we are entrusted with an enormous responsibility to the people we serve and the planet on which their health depends. I'm confident that we will do the right thing.

My optimism rests on the same conviction that has guided my career: that when dedicated people come together, they can accomplish amazing things. We have seen it in how our clinicians and staff have embraced sustainability at Stanford Health Care—in every sense of the word. We have seen it in how health systems across the country are joining coalitions to reduce emissions and share best practices. And we see it here, in the work of this essential playbook. By picking it up, you are already part of the solution, proving that the leadership we need is already in the room and ready to act.

David Entwistle, President and CEO, Stanford Health Care

Technology Foreword



It's almost surreal and exhausting to think that I started working in the IT sector in 1996. It has been nearly three decades of unrelenting change, innovation, and a drive for productivity, during which the pace of change has continued to accelerate as time has progressed. A career in IT has come with its share of stress, as it involves the emotional and physical costs associated with every change, whether it's a critical system upgrade, a massive compliance effort, or the continuous rollouts of emerging technology such as cloud, mobile, and AI. In IT, we have felt the constant need to master new skills, prepare for all contingencies, and troubleshoot at a moment's notice, which has created an ever-present sense of pressure.

It's an industry full of passionate problem-solvers who frequently wrestle with exhaustion, persistent anxiety, and the emotional stakes of maintaining modern society's infrastructure, all while facing the constant pressure to do more with less.

When I think of crisis and IT, I *fondly* remember the Y2K crisis. It was also known as the *Millennium Bug*, stemming from the fear that computers using two-digit year representations (e.g., "99" for 1999) would misinterpret "00" as 1900 instead of 2000 when the date rolled over at the new millennium. This was expected to cause critical systems across banking, utilities, telecommunications, transportation, and government to malfunction, leading to potential failures in infrastructure, causing financial miscalculations, and widespread societal disruptions.

The massive pre-emptive investments to address the Y2K bug were unprecedented, with global costs estimated by Gartner of between $300 billion and $600 billion. Those of us in IT spent countless hours preparing for the looming disaster by conducting code audits to review and update millions of lines of data-sensitive code, and replacing or upgrading outdated hardware and software.

Special technology teams were formed to ensure compliance, sometimes requiring organizations to certify the Y2K-readiness of their entire supply chain, with remedial updates and certifications pushed down to all suppliers and subcontractors. Contingency planning and public awareness campaigns were also funded to mitigate the risk in case remediation efforts failed. Legislative support included the Year 2000 Information and Readiness Disclosure Act in the US, which encouraged information sharing and limited liability for Y2K readiness disclosures. This collective global effort involved the remediation of embedded systems, coordination through government councils and international conferences, and a substantial mobilization of IT professionals working around the world, around the clock, all aimed at avoiding disruptions in banking, utilities, communications, and public infrastructure. And what happened when January 1, 2000, arrived? Minor issues, no major disruption, crisis averted.

Well, here we are, 25 years later, facing a different crisis. The climate crisis. It's another global shared looming disaster with surface temperatures projected to average between 1.2°C and 1.9°C higher than the pre-industrial baseline. With greenhouse gas emissions at record levels, global efforts to limit temperatures to 1.5°C are falling drastically short. In 2024, the planet experienced its hottest year on record, marked by intense heatwaves, devastating wildfires, and unprecedented floods that displaced communities and claimed thousands of lives. Yet this time, the pace of action is far too slow, with at least three-quarters of tracked progress indicators well off target, committing the world to even greater risks from sea level rise, food insecurity, ecosystem collapse, and humanitarian crises. While technology isn't the primary root cause of this problem, it is a contributing factor, and one that will grow as our reliance on technology expands and evolves.

The Y2K crisis and the current climate crisis present sharply contrasting challenges in scope, solutions, and societal response. Y2K was a specific, well-defined technical risk with a fixed deadline of midnight January 1, 2000, and a clear pathway for mitigation. Organizations had to mobilize quickly, invest in remediating systems, and coordinate on a global scale. Its risks were immediately tangible to businesses and governments, prompting rapid action and resolution within a matter of months. In contrast, the climate crisis is broad, ongoing, and diffuse, with impacts accumulating over decades across ecosystems and economies. Even though scientists warn that the window to avert the worst consequences is rapidly closing, the immediacy and liability that drove effective Y2K action are absent from climate action, making unified, urgent measures far more elusive even as the consequences of inaction threaten the foundations of modern society.

Despite these differences, we can do what IT does best and apply the lessons learned with the same clear-eyed urgency, coordination, investment, and adaptability from Y2K to how we address the current crisis. Right?

Y2K galvanized global action because experts communicated worst-case scenarios, established a clear deadline, and made the technical risks personal and urgent for decision makers. Wait, hasn't that been happening? The Y2K threat felt close to home, with the potential to disrupt banking, healthcare, and utilities, which made individuals, companies, and governments personally invested. Okay, hold my beer, I'm pretty sure that's been happening because the impacts are real. People's health, lives, and livelihoods have already been directly impacted by climate change. Y2K was solved by upgrading, reengineering, and deploying fixes. Okay, IT, this sounds like something right up our alley. Design, build, and implement innovative technology solutions. Here's the catch. We need to do that without exacerbating the current crisis.

Y2K was resolved through unprecedented cooperation among governments, industries, and technical communities, achieved by sharing information, setting standards, and monitoring progress. Climate action similarly demands international collaboration and transparent commitments across all sectors. Although there are commitments to science-based targets and net-zero pledges, the pace needs to accelerate, which is where IT can help through innovation and automation. That is why I am so excited about this book. The second edition of the *Sustainable IT Playbook for Technology Leaders* builds on the progressive vision of technology executive Niklas Sundberg's 2022 first edition. Reading the first book was, shall I dare say, life-changing for me. It was pivotal in shaping my mission to harness the power of people and technology for sustainable innovation, to enable business, people, and the planet to thrive. It led me to join SustainableIT.org, where I continue to collaborate with like-minded IT executives and professionals from around the world on similar missions. My journey has also led me to an organization that has sustainability at its heart: NTT DATA, a global leader in AI, digital business, and technology services with a mission of "*accelerating client success and positively impacting society through responsible innovation*." In my role as NTT DATA's Head of Global IT Sustainability Center of Expertise, I focus on sustainability in IT, sustainable sourcing for IT, and sustainability by IT in support of NTT DATA NET-ZERO Vision 2040. I am thrilled that this second edition introduces new and expanded chapters related to responsible AI, social sustainability, and sustainable architecture and data, and highlights best practices and lessons learned from nearly 20 new case studies. It doesn't just describe the macro levers that can be pulled for sustainable IT; it also provides blueprints for practical solutions, and it is all very relevant to today's challenges.

So, here we are. Thirty years later. I, we, have another problem to solve, and it's a much bigger one. We need to apply the Y2K sense of urgency to solutions that require fundamental, long-term changes to energy systems, technologies, behaviors, and economic models. This book is a way to unite those fantastic problem solvers, galvanize global action through collaboration, share information, and set standards, not only to continue to hold society's infrastructure together, but to ensure our infrastructure can be sustained for businesses, people, and the planet for many years to come.

IT, assemble.

Dr. Katia Chaban, NTT DATA's Head of Global IT Sustainability Center of Expertise

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Previously, Niklas served as Senior Vice President and CIO at ASSA ABLOY Global Solutions, Head of Global Enterprise Architecture at ASSA ABLOY Group, Managing Partner at Gartner, and Executive Vice President of Connecta, a publicly traded professional services firm.

Niklas is a recognized advocate for Sustainable IT and Responsible Technology leadership. The absence of comprehensive literature in the field motivated him to write the Sustainable IT Playbook for Technology Leaders, establishing one of the first structured frameworks for practitioners. He is a member of the Board of Directors at SustainableIT.org, an executive-led nonprofit advancing global sustainability through digital leadership.



Richard (Rick) Pastore is the research principal of SustainableIT.org, where he develops and delivers research-based insights, tools, and seminars for executives driving technology-led **environmental, social, and governance** (**ESG**) sustainability. These include the ESG Sustainability Standards for IT and the IT Toolkit for Responsible and Sustainable AI, a project involving input from 50 tech leaders from a dozen industries. In this role, he continues to be inspired by the IT profession's culture of collaboration and shared purpose in solving seemingly impossible challenges.

Rick has had a long career in IT media, including more than a decade as writer and editor of *CIO* magazine and contributing editor to `cio.com`. He helped grow the CIO Executive Council, a global peer advisory and leadership development program, which he served as VP. Prior to joining SustainableIT.org in 2022, Rick was the senior director and IT research advisor for benchmarking and consulting firm The Hackett Group.

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The authors are indebted to the following technology and sustainability professionals for contributing original material to the book:

- **Sue Allchurch**, Chief of Outreach and Engagement, United Nations Global Compact
- **Dr. Ahmad Antar**, Instructor, Harvard Sustainability Graduate Program, Founder and Board Member, Digital Emissions
- **Helena Babelon**, Global Head of IT Sustainability, Siemens
- **Ben Blanquera**, Vice President of AI and Sustainability, Rackspace Technology
- **Mark Butcher**, Director of Posetiv Cloud Ltd.
- **Cristina Castiglioni**, Senior Consultant for Transformation, Heartprint GmbH
- **Camilla Cederquist**, Head of Sustainability Programs and Circular Business Development at Atea Sustainability Focus
- **Michael Colarossi**, Head of Enterprise Sustainability, Avery Dennison
- **David Costa**, Chief Sustainability Business Officer, NTT Data
- **Francesco Del Bello**, Leader of WashPass, Haier
- **Jody Elliott**, Head of IT Risk and Sustainability at National Grid
- **David Entwistle**, President and CEO, Stanford Health Care
- **Woody Evans**, VP, Global Sales Engineering, Perforce
- **Stephen Fuller**, Supply Chain Management Expert and Senior Developer of Supply Chain and Chemical Management Criteria for TCO Certified
- **Bernard Gavgani**, Senior Advisor and former Global CIO, BNP Paribas
- **Sophie Graham**, Chief Sustainability Officer, IFS
- **Ron Guerrier**, Chief Technology Officer, Save the Children
- **James Hall**, Head of GreenOps, Greenpixie

- **Asim Hussain**, Executive Director, Green Software Foundation
- **Rainer Karcher**, Founder and CEO, Heartprint GmbH, CSO of SustainableIT.org
- **Brian Kirkland**, CIO, Choice Hotels International
- **Abhaykumar Kukreja**, Corporate IT Responsible AI Leader/Associate VP, Cognizant
- **Fiona Leibundgut**, Digital Sustainability Advisor, SparkIT Consulting
- **Ralph Loura**, Board Chairman, SustainableIT.org
- **Michael Mansard**, Principal Director of Subscription Strategy and EMEA Chair of the Subscribed Institute at Zuora
- **Kai Martin**, Chief Sustainability Officer, The Pasha Group
- **Michael Mlynarski**, Co-founder and Managing Director of QualityMinds GmbH
- **Ann Molin**, Founder and Secretary General, Hack for Earth Foundation
- **Frieder Olfe**, Head of Sustainability Technology, TUI Group
- **Mauri Paz**, Head of ESG and Third-Party Risk Products, ServiceNow
- **Dr. Berndt Pilgram**, Product Data & Information Security Governance Lead at Fresenius Medical Care
- **Sanjay Podder**, Managing Director, Global Lead for Technology Sustainability Innovation, Accenture
- **Lisa Pratico**, Chair, Sustainable Architectures and Responsible AI, IASAGlobal.org
- **Philipp Sattlecker**, IT Sustainability Strategy Manager, Siemens
- **Fabian Schnippering**, Manager, Sustainable IT & Business Technology, Capgemini Invent
- **Brandon Smith**, Vice President of IT ESG at Human-I-T.org
- **Richard Torres**, IT Development Project Manager
- **Wiebren van der Zee**, Sustainability Domain Expert, Sustainable IT, Office of the CIO, ABN AMRO Bank
- **David Welling**, IT Sustainability Governance Lead at National Grid
- **Matt Yeh**, VP of Product Marketing, Perforce

We also acknowledge the following individuals who contributed in a variety of ways, including research, updating and providing permission to use existing SustainableIT.org materials, and providing custom lifecycle assessment data for IT products:

- **Tim Bailey**, Director of Communications, Harvard University Information Technology
- **Fahmida Bangert**, Executive Director, Sustainability Program Office, Stanford Health Care

- **David Best**, Vice President, SustainableIT.org
- **Karoline Bierlich**, Marketing and Communications, osapiens
- **Marina Colom**, Schneider Digital Global Communications Manager, Schneider Electric
- **Kara DiCamillo**, Marketing Manager – Green IT, Schneider Electric
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- **Steven Earhart**, Senior Principal Site Reliability Engineering, AIOps, Mastercard
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- **Sebastian Gier**, Co-founder and Managing Director, Footprint Intelligence
- **Dan Gottschalk,** Marketing Program Manager, SustainableIT.org
- **Josh Harbert**, President, SustainableIT.org
- **JP Iversen**, Group CIO, Electrolux
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Preface

It's hard to believe that only a few years have passed since I wrote the first edition of this book. In that time, the world has changed in ways both inspiring and unsettling. The impacts of climate change are unmistakable: *the years 2023 and 2024 were the hottest ever recorded*, with unprecedented wildfires across Canada, Europe, and the Mediterranean; severe droughts in the Horn of Africa; and historic floods displacing millions in Brazil and Southeast Asia. Despite record solar and wind deployment, CO_2e levels reached a record 57.7 gigatonnes in 2024, still climbing when they must fall by half this decade to preserve a livable planet. Global e-waste is the fastest-growing waste stream, surpassing 60 million metric tonnes annually, even as new policies such as the EU Digital Product Passport and Right-to-Repair Directive aim to reverse the tide.

Yet, amid the anxiety, we've also witnessed remarkable courage, ingenuity, and purpose. In the span of three years, the global renewable electricity capacity has increased by 49%, and solar energy production has more than doubled. Over 77% of global GDP now falls under a national net-zero commitment. Sustainability has moved from the edge of corporate strategy to its core—driven not only by regulators and investors, but by employees, customers, and communities demanding integrity and action.

Yet for IT, progress remains uneven. Hundreds of companies have established sustainable IT programs, GreenOps practices, and responsible AI principles. But many organizations still lack accurate baselines for IT emissions, and most AI deployments overlook lifecycle energy and water impacts or fail to consider whether large language model AI is even necessary at all for the application.

Indeed, the explosion of AI is rapidly transforming how organizations operate, make decisions, and create value. As a lifelong technologist, I have been inspired by AI's potential to accelerate progress on some of the world's hardest problems—from decarbonizing supply chains and optimizing grids to designing sustainable materials and medicines. But I've also seen how quickly innovation can outpace our ability to govern it responsibly.

The corporate AI boom has fueled unprecedented investment in digital infrastructure, but also unprecedented energy demand. The International Energy Agency now projects that global data center electricity consumption could exceed 1,000 TWh annually by 2026, roughly equivalent to Japan's total power use. The same algorithms that help us discover cleaner fuels or monitor deforestation are also driving a surge in emissions from massive AI training clusters and water-cooled data centers. The lesson is clear: technology itself must become sustainable, or its promise will be undermined by its own footprint.

In my previous role as chief information officer at ASSA ABLOY, a manufacturer of physical and digital access products, I established a sustainable IT emissions baseline and our sustainable IT strategy. That's when the idea for this book was born, with the goal of guiding other technology leaders on similar journeys. I hoped to provide a practical framework explaining not just "*why*," but "*what*" and "*how*," with IT sustainability "plays" that readers may choose and adapt to their context.

Since publication of the first edition, I have taken a new role as chief technology officer at Kuehne+Nagel, the world's largest air and sea freight forwarder and one of the largest global third-party logistics companies. My motivation was the greater opportunity for sustainability transformation impact that such a large logistics company represented. There, I am privileged to lead a passionate group of IT professionals committed to sustainable digital transformation.

Over this same period, I have interacted with sustainability leaders across the world and seen the rise of a growing ecosystem of professionals who view IT not only as a driver of digital progress but as a catalyst for planetary stewardship. What strikes me most about these collaborations is the spirit of shared purpose. Chief technology officers, enterprise architects, and engineers who once competed on features or costs are now comparing carbon intensities, renewable power contracts, AI life cycle governance models, and e-waste recovery rates. These are conversations that would have been rare—or even uncomfortable—a few years ago. Now, they are becoming the language of modern IT leadership.

Part of this ecosystem development has been led by SustainableIT.org, a global nonprofit founded in 2022 by sustainability-focused IT executives. SustainableIT has been a tireless engine of awareness and education, peer advisory research, and real-world best practices. That is the reason I asked their research principal, Richard (Rick) Pastore, to co-author the second edition of the book. Rick brings decades of research, communications, and guidance on IT strategy and leadership, and has eagerly embraced our tech sustainability challenges. I'm grateful for all the work he has put into revising the book and leveraging his organization's latest assets to bring it up to date. This edition integrates new insights on AI governance and energy intensity; digital product lifecycle planning; sustainable enterprise architecture; and the ethical, social, and economic dimensions of sustainable IT.

It draws on the collective intelligence of a growing movement—leaders and practitioners across industries and continents who are proving that IT can be high-performing, cost-responsible, and planet-positive.

My own motivation has deepened as well over this period. I no longer think about sustainability only in terms of professional responsibility, but as an intergenerational one. My children, now in school and growing up in a world of climate anxiety and digital wonder, remind me daily that technology is both our inheritance and our legacy. The systems we build today will either burden or empower their generation. That realization keeps me grounded in both urgency and optimism.

As we move into the second half of this decade and close in on our urgent 2030 targets, the IT community is forming a shared understanding: sustainability is no longer a constraint—it is the next frontier of innovation. Today's CIOs, CTOs, and CDOs are not just enablers of business efficiency—they are architects of sustainable transformation. Technology is how humanity solves problems at scale—and sustainability is the defining problem of our time. Our challenge is to bring these forces together, with humility, discipline, and imagination.

Let this book's second edition serve as both a guide and a call to action—for every IT leader who chooses to lead with purpose, accountability, and hope.

Niklas Sundberg

Who this book is for

This book is for executive IT leaders such as CIOs, CDOs, and CTOs dedicated to influencing, inspiring, and engaging businesses, organizations, and individuals to reduce their carbon footprint through Sustainable IT practices. It is also a practical guide for IT leaders of any level with responsibility for IT sustainability transformation.

What this book covers

The second edition of *Sustainable IT Playbook for Technology Leaders* distills insights from more than 60 contributing IT practitioners and sustainability experts, explores 20 new case studies, and presents the perspectives of CTOs/CIOs, chief architects, chief sustainability officers, and CEOs from industries including finance, manufacturing, healthcare, high tech, transportation, utilities, and hospitality. Each chapter includes resources such as benchmarks, frameworks, and principles; vendor score sheets and a master services agreement; a business case template; award-winning use cases, and standardized metrics relevant to every IT impact area. An IT Sustainability Reference Model helps to frame topics chapter by chapter.

Part 1: Why Is Sustainable IT Important?

Chapter 1, *Our Most Significant Challenge Ahead*, addresses the basics of climate change and the breadth and depth that digitalization and hyperconnectivity have on our planet and society.

Chapter 2, Rise of Sustainable IT, defines sustainable IT and summarizes the main drivers for a sustainable IT agenda. It probes the three aspects of *sustainability in IT*, *sustainability by IT*, and *IT for society*. Finally, it lays out IT's **environmental, social, and governance** (**ESG**) considerations.

Part 2: What Are Sustainable IT Practices?

Chapter 3, *The Fundamental Building Blocks of a Sustainable IT Practice*, is an introduction to the topics explored in depth in *Part 2* of the book, which focuses on the main ingredients of a sustainable IT agenda. These include energy, emissions, AI, social impact, talent, metrics, and tech procurement.

Chapter 4, *Responsible and Sustainable AI Governance*, explores AI's ESG impacts, positive and negative, and provides AI lifecycle governance principles and frameworks for responsible and sustainable scaling.

Chapter 5, *Social Sustainability: Accessibility, AI, and the Digital Divide*, considers IT system inclusivity and accessibility, how to mitigate the social risks of AI systems, and ways that IT can directly shrink the digital divide.

Chapter 6, *Data Centers and the Cloud*, tackles the sustainability challenges of IT's data center and cloud environments. Strategies and tools for measuring and mitigating emissions, including GreenOps, will be explored in detail.

Chapter 7, *Applications and Architecture*, recommends methods to optimize IT's application portfolio to run more sustainably, and describes how to enable architects to embed sustainability into enterprise architecture.

Chapter 8, *Data*, addresses the challenge of rampant data proliferation that our applications and AI systems contribute to, and the environmental impact we can have through better controls. It also advises on how to establish centralized, automated ESG data management to inform enterprise-level sustainability decisions and reporting.

Chapter 9, *IT Hardware Management*, explains the impact of IT equipment on emissions, how to make more sustainability-aware hardware choices, and how to manage hardware lifecycles for greater sustainability and lower costs. The chapter also looks closely at circular IT hardware planning and what is required to transition from a linear to a circular economy.

Chapter 10, *Energy Resource Management*, describes how different IT assets consume energy, and provides information on carbon-aware methods to reduce both cost and consumption.

Chapter 11, *Leveraging Your Buying Power*, introduces the different facets of sustainable IT vendor management and procurement and how these disciplines can be leveraged to make the supply chain more sustainable, transparent, and resilient.

Chapter 12, *Sustainability by IT*, explores how information technology can be applied to reduce environmental burdens in society by innovating sustainable business models, including a shift from ownership to "usership."

Part 3: How Do You Accelerate Sustainable IT?

Chapter 13, *Get Started Today*, opens *Part 3* of the book by walking through goal setting, a starter strategy, and recommended first steps in the sustainable IT journey. It presents the Sustainable IT maturity model©, a framework for understanding and benchmarking critical capabilities. It provides the chief sustainability officer's perspective on how to team up effectively. Finally, it gives step-by-step instructions for calculating IT's carbon emissions baseline.

Chapter 14, *Putting a Sustainable IT Strategy in Place*, walks readers through the process of creating a three-year sustainable IT strategic plan and roadmap. The chapter presents several case studies and examples from companies that have established Sustainable IT programs, as well as a template for making the business case for sustainable IT investment.

Chapter 15, *From Strategy to Action – Lead with Purpose and Deliver Progress Quickly*, wraps up the book with a call to lead sustainability with purpose and caution, and how to scale your impact beyond company walls. Lastly, it brings everything together through a recap of the main recommendations made throughout the previous chapters.

To get the most out of this book

The chapters can be read in any order, but it is important to be well grounded in the impact IT has on sustainability and the motivations to embark on this journey. Those who have already made progress can compare their approaches and actions to the book's recommendations and checklists, and assess their current state of capability maturity. Organizations just starting out can map out their first steps and learn from the lessons of the early movers presented in the case studies.

Every reader should pay particular attention to *Chapter 4*, *Responsible and Sustainable AI Governance*. With the rush to adopt AI and the proliferation of use cases, this is IT's most urgent challenge.

No software is required to get the most out of this book. However, there is a website accompanying the book, where readers can download additional book resources in PDF, PowerPoint, and Excel formats. The site, hosted by SustainableIT, is `https://www.sustainableit.org/sustainable-it-playbook`.

SustainableIT membership: Readers wanting information on joining SustainableIT.org as a member or supporter should visit `sustainableIT.org` or send an email to `mailto:info@sustainableIT.org`.

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We also provide a PDF file with color images of the screenshots and diagrams used in this book. You can download it here: `https://packt.link/gbp/9781806105298`.

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Part 1

Why Is Sustainable IT Important?

Part 1 tells the story of *why* Sustainable IT matters—why humanity stands at a defining crossroads and why digital progress can no longer be separated from planetary survival. We are introduced to the definition of sustainable IT, what distinguishes **sustainability in IT**, **sustainability by IT**, and **IT for society**. It quantifies IT's environmental, social, and governance impacts and explores the business case for sustainable technology.

This part of the book includes the following chapters:

- *Chapter 1, Our Most Significant Challenge Ahead*
- *Chapter 2, Rise of Sustainable IT*

1

Our Most Significant Challenge Ahead

> *Earth's life support systems are the sum of the planet's ice sheets, oceans, forests, rivers, lakes, a rich diversity of life, and gigantic recirculations of carbon, water, nitrogen, and phosphorus. The system is now most definitely unstable and could push it over the edge, taking us – 7.8 billion people – with it.*
>
> *Johan Rockström*

As we begin our journey with the foundational chapters of this book, many of you will likewise be navigating the early stages of your journey toward technology-enabled sustainability. While 90% of IT leaders report that their organization currently runs some kind of **Environmental, Social, and Governance (ESG)** initiative, only 40% say they are prepared to meet ESG regulations, and only 55% are pursuing sustainable IT initiatives (SAP LeanIX 2024). As of September 2024, the IT executive members of the professional association SustainableIT.org average two to three years of formal focus on IT sustainability. Their capability maturity averages 2.3 on a scale of 1–5, with 1 being "beginning" and 5 being "optimized." More on maturity later, but the point here is that no one is very far behind or far ahead—the IT profession is learning together.

To that end, this book will ensure that your teams have a firm grounding and thorough understanding of how IT impacts ESG and where their actions can make a difference. Chapters that dive deeper into topics such as sustainable architecture, **Artificial Intelligence (AI)** governance, and tech procurement will help you build on your momentum and broaden scope and scale.

The main objective of this chapter is to introduce you to climate change. It will teach you basic concepts such as the **Greenhouse Gas (GHG)** protocol, carbon accounting, Scopes 1, 2, 3, and 4 definitions, the **Science-Based Targets initiative (SBTi)**, net-zero standards, biodiversity reporting frameworks, and **circular economy principles**. These key concepts will be beneficial in later chapters when we dig into sustainable IT practices for you to understand how everything is linked together and what actionable insights you can formulate.

In this chapter, we will cover the following topics:

- The challenge of climate change
- The history of sustainability
- The Paris Agreement, EU taxonomy, and reporting directives
- The GHG protocol corporate standard
- Science-based targets
- Sustainability trends
- Circular economy practices
- IT's climate impact
- Sustainability's politicization and the need for courageous leadership

By the end of this chapter, you will have learned the fundamentals of climate change and understand the implications of IT on the environment, what we all need to do to start living more sustainably within the constraints of planet Earth, and how you can make IT decisions to ensure greener practices.

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Climate change — our most significant challenge ahead

The 2024 Global Risks Report published by the **World Economic Forum** highlighted extreme weather events—amplified by climate change—as the number one risk over the next decade (World Economic Forum 2024). In 2025, it was ranked second to state-based armed conflict. The effects are felt all over the planet in extreme heat, cold, massive precipitation, drought, or wildfire. Climate change affects us all. It is a global problem that we jointly need to work on to solve. GHG emissions are more than 60% higher than in 1990. On March 20, 2023, the **Intergovernmental Panel on Climate Change** (**IPCC**) reviewed the AR6 Synthesis Report, which paints a grim picture that we continue to spiral downward, but some solutions are starting to emerge to curb the climate crisis. We need to urgently transition into a sustainable way of living where we stay well within the constraints of Earth. Humanity is currently taking significantly more than we put back in. We use the equivalent of 1.75% of Earth's resources to provide the resources we use and absorb our waste (Ginér, et al. 2022).

Due to rising temperatures, we are approaching a tipping point, or what scientists have labeled as the danger zone. We are not taking the necessary and drastic steps to avoid a global crisis at an unprecedented scale with unimaginable consequences. To stop climate change quickly enough, we need to think differently to develop solutions that can break the carbon emission curve. Climate policy has had a new focus in recent years: net-zero emissions. Net zero refers to a state in which the **total GHG** emissions produced by human activities are balanced by the amount of GHGs removed from the atmosphere. This balance is typically achieved by reducing emissions as much as possible through efficiency, renewable energy, and clean technologies, and then offsetting any remaining emissions through carbon removal solutions such as reforestation, carbon capture and storage, or direct air capture. It is different from "carbon neutral," in which emissions are offset by purchasing carbon credits, without necessarily reducing actual emissions, and "zero emissions," where no emissions are produced at all.

The **Paris Agreement** reaffirmed the commitment to limit the global temperature rise to well below 2°C preferably around 1.5°C. Reaching net-zero emissions is often expressed in target dates, such as halving GHG emissions by 2030 and achieving net zero by 2040 or 2050.

According to the **United Nations Environment Program** (**UNEP**), Emissions Gap Report 2025, global GHG emissions reached a record 57.7 Gt CO_2e in 2024, a 2.3% increase from 2023. This growth rate was higher than the 1.6% increase recorded the previous year and over four times the average annual growth rate during the 2010s (UNEP 2025). The European Commission's Emissions Database for Global Atmospheric Research reports that global GHG emissions in 2023 reached 53.0 Gt CO_2eq (excluding land use) (European Commission 2024). For this book, we have chosen to use the measurement of 59.1 Gt CO_2e (range: ± 5.9), which includes emissions from **Land Use Change** (**LUC**). We prefer to focus on the bigger picture of how we can, as a start, halve our global CO_2 emissions in the next decade and stay within the 1.5 OC range.

Prominent scientists such as **Johan Rockström** and **Michael E. Mann** are at the forefront of climate change and global sustainability. Climate advocates such as **Christiana Figueres**, **David Attenborough**, **Al Gore**, and **Greta Thunberg** are working to raise awareness and drive change. Assessment reports (*ipcc.ch* 2022) from UN IPCC tell us that the threat is imminent. We have a severe climate crisis on our hands.

The primary drivers of climate change are human emissions of CO_2 and other GHGs, overpopulation, increased loss of biodiversity, soaring use of finite rare earth metals, and an increased waste management problem, especially within **electronic waste** (**e-waste**). However, the fundamental focus should be on the solutions we need to put in place to ensure the growing trend declines in the coming years. The climate crisis is one of the world's most pressing challenges (IPCC 2013). Throughout Earth's history, there has been a link between global temperature and GHG concentrations, especially CO_2 (Lacis, et al. 2010).

What are GHG emissions?

Before we go any further, let us dissect what carbon footprint is. You have probably heard the term carbon footprint before, but it can be hard to grasp. In our context, carbon footprint is the amount of GHG emissions generated by business activities during a given period—such as producing a laptop, smartphone, or tablet; commuting to work; or shipping a new product. It includes CO_2—the gas most commonly emitted by humans—and other climate-relevant gases, such as methane, nitrous oxide, and fluorinated gases. Throughout the book, these GHGs will be expressed as a volume by weight, e.g., **tonnes of CO_2 equivalent** (in short, **tCO_2e**) to ensure consistency.

The 2024 emissions totals illustrated in *Figure 1.1*, rounded up to 58 gigatonnes to come from several broad sources: energy, industry, agriculture, transportation, and land use such as forestry as well as waste water treatment (UNEP 2025). These emissions result in increased heat trapping in the atmosphere. The consequence of trapped heat is an increase in Earth's temperature, which is on track to exceed the safe limit of 1.5°C. The increase in temperature also results in several dangerous knock-on effects, such as melting ice caps, which lead to not only rising sea levels and flooding but also to more severe storms, droughts, and wildfires:

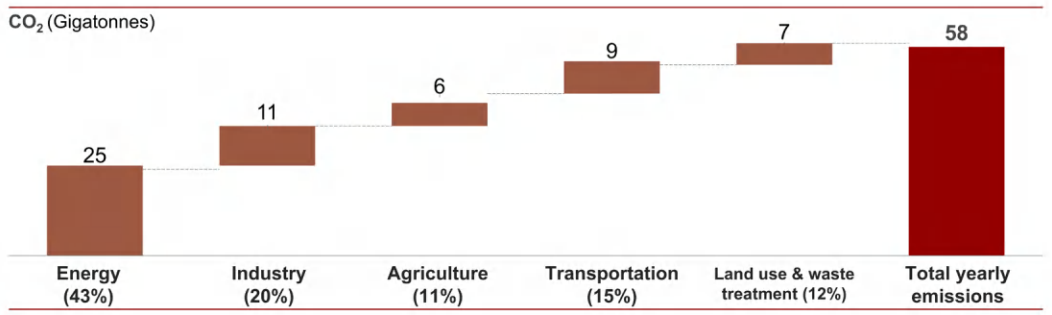


Figure 1.1 – How GHG emissions add up

The energy sector is responsible for 43% of total emissions per year. This is primarily because the majority of energy sources draw from fossil fuels such as coal and oil instead of renewable energy sources such as wind, solar, water turbines, or geothermal. The industry sector emits 20%, primarily due to GHG emissions from cement and steel manufacturing, which are both CO_2-intensive. GHG emissions from agriculture make up 11% of the global total. This is primarily due to the extensive use of fertilizers to grow crops and the release of methane gas from cattle, but the sector also requires an enormous amount of water, contributing to water distress.

To make the idea of carbon footprint more tangible, let us look at a few examples. A single flight from London to Los Angeles produces around 1.4 tonnes of CO_2e, which is roughly 8.1 months of the CO_2 budget for one person, based on the Paris Agreement's objective of maintaining global temperature warming "well below" 2°C. Commuting to work just under one hour a day, roughly 51.5 km (32 miles), amounts to 3.2 tonnes of CO_2 over a full year for the average American. One person in the US emits approximately 14.4 tonnes of CO_2 per year, compared to a person in India, who only emits 2.1 tonnes of CO_2 a year.

Mining of all the world's Bitcoin renders a carbon footprint of 98.1 $MtCO_2$, which is comparable to the carbon footprint of Qatar (Global Carbon Project 2024). Mining of just a single Bitcoin generates about 574 kg of CO_2, equivalent to the carbon footprint of 1,272,181 Visa transactions or 95,667 hours of watching YouTube videos (Digiconomist 2025). *Figure 1.2* illustrates a few of the examples described earlier:

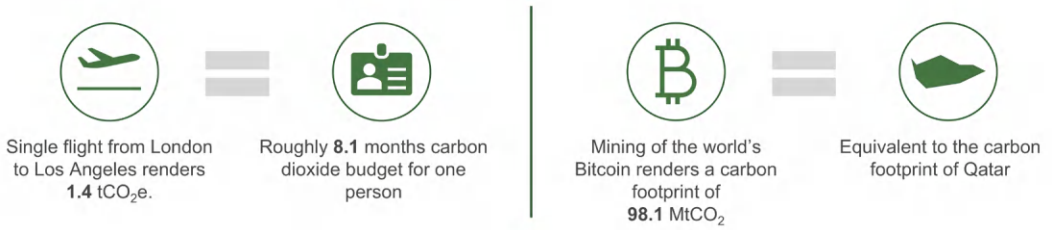


Figure 1.2 – Carbon emission comparison between common use cases

The preceding figure illustrates emissions data in the form of equivalencies to help readers more easily understand the volumes and their scale. In this case, the equivalencies are an individual and a country. It is a useful practice to state energy and water consumption levels, as well as emissions and e-waste volumes, as equivalencies that are tangible and relatable to your audience. Even water volume can be challenging to comprehend—unless you know that **2.5 million liters or 660,000 gallons of water** is the equivalent of an Olympic-size swimming pool.

How did we get here?

In the 1950s, we saw tremendous economic prosperity post **World War II** (**WWII**) (O. G. Rockström 2021). Still, it was also the take-off point for global warming, loss of nature, and deterioration of biodiversity. Human ingenuity gave rise to an unprecedented level of global prosperity in the form of rising GDP and income per capita, which was also regrettably ended more than 12,000 years of relative climate change stability. By introducing emission-intensive forms of production and consumption, we have reached a point where these unprecedented levels are no longer sustainable (*ipcc.ch* 2021). In the past, there has been financial prosperity at the expense of environmental prosperity. Going forward, we need to find other metrics to measure our prosperity that are more in line with important social and environmental factors.

Let us look at how the planet has warmed from the 1850s to the present day to set the scene. Following a stable period of temperature deviation over the past 10,000 years, the Earth's average temperature began to rise. In the chart in *Figure 1.3*, we see the increased rate of global temperature rise since the 1970s.

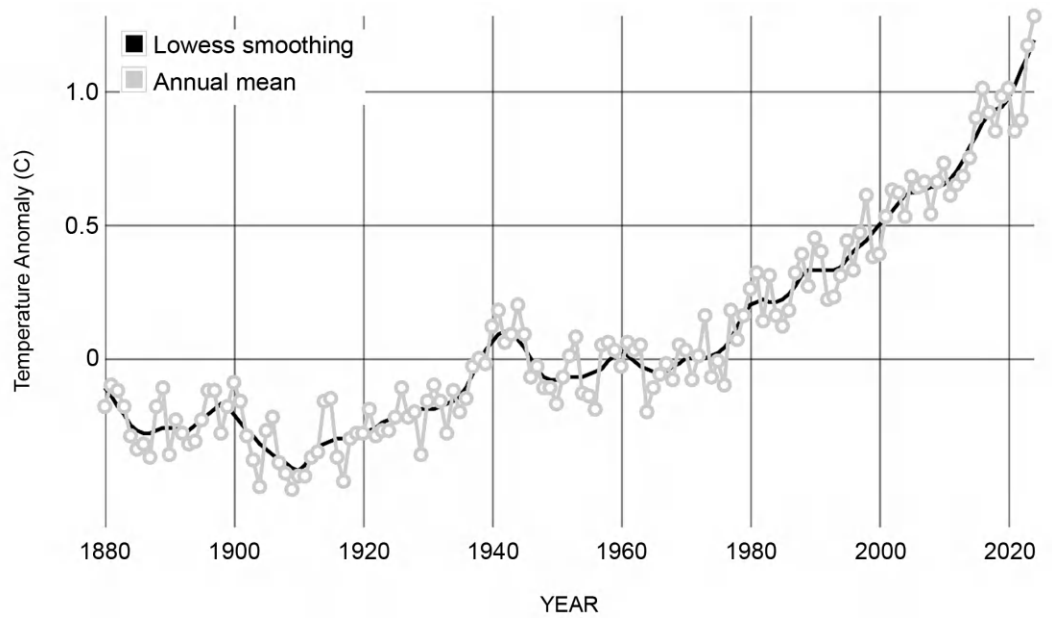


Figure 1.3 – Rise in global temperatures at an increased rate (Source: Climate.nasa.gov)

Most research agrees that there has been an average temperature rise of 1.1°C since the mid-19th century, with a sharp rise since the 1980s. Certain regions, including parts of Europe and Northern Canada, have experienced warming at significantly higher rates than the global average. Some have already seen a 3°C increase since pre-industrial times, nearly three times the global average increase. The year 2024 had the warmest average global temperature on record (NASA 2024).

Scientists have a large consensus that we need to limit global warming to just 1.5°C to stay in the safe zone. This is to avoid the catastrophic impacts of climate change. This was also explicitly called out in the 2015 Paris Agreement: "*We cannot rule out that if Earth's CO_2 emission doubles, the Earth's temperature might double to a catastrophic 5OC*" (O. G. Rockström 2021). Unfortunately, according to carbon emissions calculations by the UNEP, we are on track to increase temperatures by 2.3-2.5°C, surpassing the 1.5°C target within the next decade (UNEP 2025). Our original target of cutting 2020-level emissions in half by 2030 is still broadly valid as an indicator of country-level ambition. However, the UNEP 2025 Emissions Gap Report states that to remain on a pathway to limit warming to 1.5 °C, global emissions must decline 42% from current levels by 2030 and 57% by 2035. To meet the less optimal average temperature increase limit of 2°C, emissions must be reduced by 28% by 2030 and 37% by 2035. These more ambitious and challenging reductions will mitigate climate-related damage and maintain the possibility of reversing our average temperature increase to 1.5°C by 2100.

Bending the curve

We need to stabilize concentrations of CO_2 and other GHGs in Earth's atmosphere to slow down rising temperatures and halt increasing global temperatures completely (IPCC 2013). The atmospheric concentration of CO_2 measures **parts per million** (**ppm**). Since the 1960s, the atmospheric concentration of CO_2 has continued to rise. The primary reason for this change was the Industrial Revolution and the rise of human emissions of CO_2 from burning fossil fuels. There is a strong belief that the safety limit for CO_2 in the atmosphere is around 350 ppm, according to work by NASA scientist James Hansen. Unfortunately, as we see in the chart in the following figure, we surpassed that milestone back in 1988 (NASA n.d.), and in 2025, we have been surpassing levels above 430 ppm (NOAA 2025). Time is running out, and the tide is against us. As global citizens, we need to decarbonize our atmosphere and rapidly bend the curve:

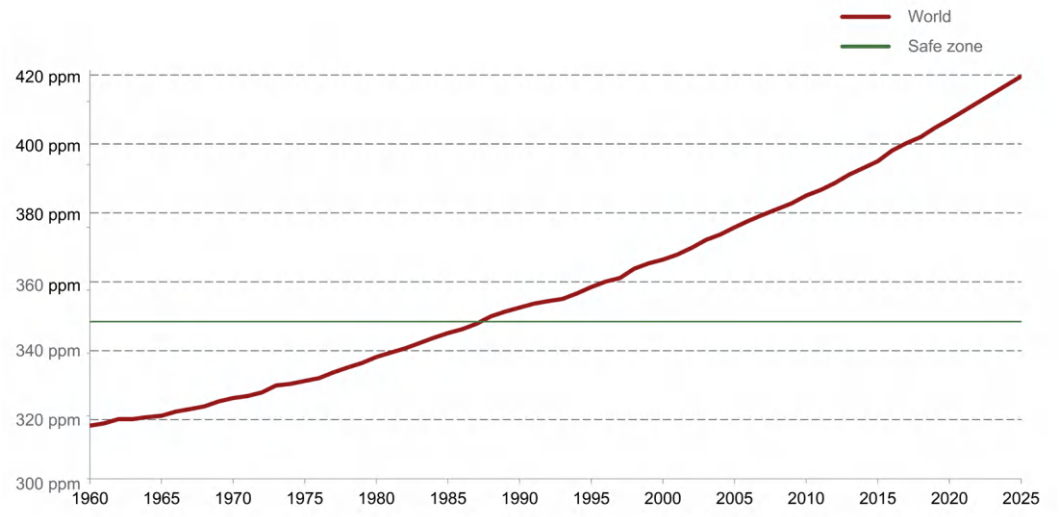


Figure 1.4 – Atmospheric concentrations of CO_2 continue to rise

We already operate outside many of Earth's safe planetary boundaries (Rockström et al. 2021), which means we must urgently deploy exponential solutions that deeply shrink emissions by 2030. Originally inspired by Moore's law (which states that the number of transistors in a dense **Integrated Circuit** (**IC**) doubles roughly every two years), the **carbon law** proposed halving global CO_2 emissions every decade—from 57 Gt in 2019 to 30 Gt by 2030, then continuing in 2040 and 2050 (Rockström et al. 2017). The carbon law remains a useful baseline ambition, but reality demands steeper and faster declines, the deployment of large-scale carbon removals, and differentiated trajectories across sectors (power, industry, transport, and agriculture).

In this light, rather than a rigid law, the carbon law should be a minimum moral and strategic benchmark—one that must be exceeded if we hope to maintain planetary stability while transitioning to net zero.

This is a considerable undertaking. Yet, we firmly believe that the solutions to curb the climate crisis also lie within using existing technology in the right way and exploring new technological discoveries and advancements. Most of the key concepts we will explore in this book are already here. But further improvements are still needed, such as managing ICT equipment with full circularity and renewable energy sources to meet the world's needs.

The history of climate action

Before we jump into the definition of sustainable IT, first, let us zoom out and look at what sustainability means and where it originates. In 1983, the UN appointed former Norwegian prime minister **Gro Harlem Brundtland** to run the new World Commission on Environment and Development (*Our Common Future, Chapter 2, Towards Sustainable Development* n.d.). This commission is more famously known as the *Brundtland Commission*. The *Our Common Future* report was released after four years and outlined sustainable development as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (Brundtland Commission 1987).

Furthermore, the commission unified environmentalism by defining three pillars of sustainability in the world's development agenda. The three pillars of sustainability consider ecological, social, and economic dimensions (see *Figure 1.5*), recognizing that all three elements are heavily dependent on each other to build lasting prosperity:

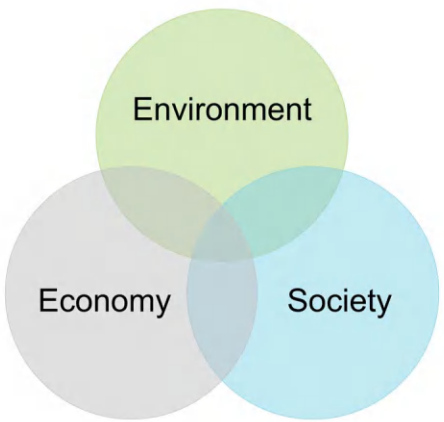


Figure 1.5 – Three pillars of sustainability: environment, society, and economy

Environmental sustainability

Environmental sustainability makes sure that Earth's ecological integrity is maintained. The planetary boundaries are balanced, while natural resources can replenish themselves faster than they are consumed.

Social sustainability

Social sustainability provides fulfillment of basic human necessities for all people worldwide. People have to have access to enough resources to guarantee that their families and communities are healthy and secure.

Economic sustainability

Economic sustainability outlines that all people worldwide can maintain their interdependence and access the resources they require to meet their financial and other needs. The economic system is available and intact for everyone to ensure secure sources of livelihood.

Despite the anti-ESG political climate today in the US and varying degrees of resistance or hesitancy to more aggressively address climate change in countries such as Poland, Hungary, the Czech Republic, and Mexico, sustainability remains good for business. **Great Place To Work** underscores that ESG efforts are "a necessity," not just buzzwords: they're "a potent tool for boosting employee engagement, attracting top talent, and winning over consumers" (Great Place To Work 2025).

Kelly Services finds that "mission-driven" companies enjoy 40% higher retention and outperform peers in innovation—reflecting clear business benefits of ESG alignment (Kelly Services 2025)

ScienceDirect notes a significant relationship between ESG performance and stock returns, especially for private-sector companies (ScienceDirect 2023).

Where governments refuse to accept stronger measures or actively oppose climate action, companies must act without government support, in their own best interests as well as that of the planet we share.

Triple bottom line – people, planet, and profit

Although *Our Common Future* defined the three pillars of sustainability, the **triple bottom line**, also known as the **3Ps**, is the most common framework referenced within business language today. It is still gaining popularity. The 3Ps were created by **John Elkington** back in 1995, three decades ago, and he defines the key imperative for sustainability as simultaneously maximizing benefits for people, the planet, and profit (Kraaijenbrink 2019):

- **People**: The citizens of our planet. What positive and negative impacts does a corporation have on our people?
- **Planet**: Our planet and the environment in which we reside. What positive and negative impacts does an organization have on our planet and our environment?
- **Profit**: The financial and long-term value creation of a corporation. What positive and negative impacts does an organization have on the local, national, and international economy?

As *Figure 1.6* illustrates, when these three factors intersect, you can maximize the benefits and create a sustainable future:

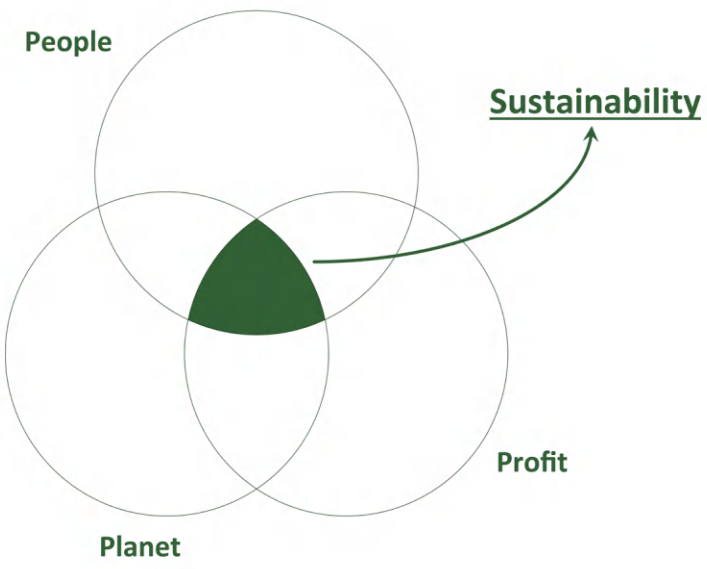


Figure 1.6 – 3Ps of the triple bottom line

Several accounting and reporting frameworks have emerged out of the 3Ps, for example, **ESG** (a framework focusing on **environmental, social, and governance** factors), **Social Return on Investment (SROI)**, **Return on Sustainability Investment (ROSI)**, and the **Trucost approach**.

We will be referencing the 3Ps framework frequently throughout the book.



UN Sustainable Development Goals

In 2015, the UN formed a blueprint for achieving a better and more sustainable future. It is a call to action to end poverty, protect the planet, and promote peace and prosperity. It is expressed in 17 goals that should be fulfilled no later than 2030. These are more commonly known as the UN's 17 Sustainable Development Goals (`https://sdgs.un.org/goals`).

The Paris Agreement

At the **Conference of the Parties (COP)** 21 in Paris in 2015, the Paris Agreement, often referred to as the Paris Climate Accords, was adopted. Signed by 196 parties, the Paris Agreement is a legally binding international treaty on climate change. The Paris Agreement was the first unified global commitment. World governments have committed to curbing global temperatures and pursuing efforts to limit warming to 1.5°C. Under the agreement, each party must draft a plan and report regularly on progress.

A major flaw of the Paris Agreement is that it lacks a common reporting framework, robust guidelines, and governance. Instead, it leaves it up to its parties to define their emission pathways to net zero. Since there is no common framework based on climate science, the Paris Agreement relies on process.

As we will see later in the chapter, other standards, such as the SBTi Corporate Net-Zero Standard, enable corporations to set a net-zero target. The SBTi standard is a framework for companies against which to set credible, science-based net-zero emissions targets, both near-term and long-term, for limiting global warming to 1.5°C. But so far, there has not been a unilateral framework for countries prior to COP26, which took place in Glasgow, Scotland, in 2021, for ratification of the **Paris Rulebook**.

The finalization of the Paris Rulebook provides the framework and guidelines for the implementation of the Paris Agreement. It is a significant milestone after many years of negotiations.

Consistent with the objectives in the Paris Agreement, more than 120 countries have now pledged to reach net zero around the mid-century.

As of mid-2024, at least 27 countries—including Germany, Canada, the United Kingdom, and France—had a law or legislation proposed to ratchet down their carbon emissions to net zero by 2050. The problem is that all of these countries combined account for only 8% of total global emissions.

The very largest emitters have begun to signal their ambitions. The EU has enacted the EU Taxonomy Climate **Delegated Act (DA)**. China and Russia have declared a national commitment to get there by 2060, while India has introduced its first long-term net-zero goal by 2070. Since 2017, the US has formally withdrawn, returned, and withdrawn again from the Paris Agreement. As the second-highest emitting country, these shifts in commitment and potential impact on progress are concerning. However, to date, no other country has followed suit.

EU regulatory leadership

By 2050, Europe plans to become the first climate-neutral continent and to make the EU's economy sustainable (Price 2018). In the summer of 2021, the EU met to discuss climate and energy targets for 2030 and how to reach the objectives of the European Green Deal. The European Council approved the **Commission Delegated Regulation (EU) 2021/2139**, which confirmed into EU law the adoption of **Technical Screening Criteria (TSC)** for activities that contribute substantially to the climate change mitigation and adaptation objectives, as well as **The Taxonomy Regulation (EU) 2020/852**, which created the EU Taxonomy classification system.

The EU has seen the need to redirect money toward sustainable projects to make our environmental systems more resilient against climate and environmental shocks.

The EU Taxonomy acts as a central piece to the European Green Deal puzzle to classify whether an economic activity is considered environmentally sustainable. To use a common language and a clear definition of "sustainable," a standard classification system, the "EU Taxonomy," was formed. As outlined in *Figure 1.7*, the EU Taxonomy outlines six environmental objectives to provide policymakers, companies, and investors with a standard set of definitions of what can be classified as ecologically sustainable:

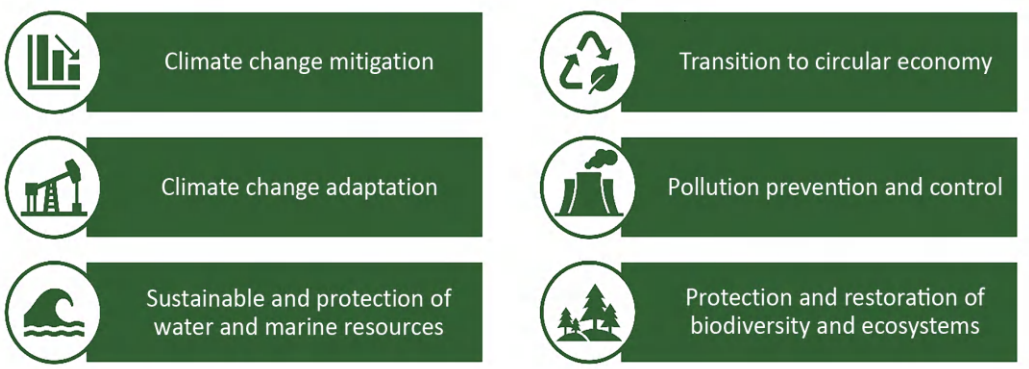


Figure 1.7 – The EU Taxonomy: six environmental objectives

The EU Taxonomy regulation establishes six environmental objectives:

- Climate change mitigation
- Climate change adoption
- The sustainable use and protection of water and marine resources
- The transition to a circular economy
- Pollution prevention and control
- The protection and restoration of biodiversity and ecosystems

The sectors that the EU Taxonomy currently covers are listed as follows:

- Agriculture, forestry, and fishing
- Manufacturing
- Electricity, gas, steam, and air conditioning supplies
- Water, sewage, waste, and related remediation
- Transportation and storage
- ICT
- Buildings

- Financial and insurance activities
- Education, health, arts, and other services

A company is considered "large" and falls under the **Corporate Sustainability Reporting Directive (CSRD)** if it meets at least two of the following three criteria on two consecutive balance sheet dates:

- An annual net turnover exceeding €50 million
- A balance sheet (total assets) exceeding €25 million
- An average of more than 250 employees during the **Financial Year** (**FY**)

The directive also applies to other entities, including the following:

- **Listed SMEs**: Companies listed on an EU-regulated market (except micro-enterprises) are included, though with a delayed compliance timeline
- **Non-EU parent companies**: Companies outside the EU must report if they generate a net turnover of more than €150 million within the EU and have a large EU subsidiary or a branch with a net turnover of over €40 million

The CSRD's reporting deadlines are staggered based on the company's size and category. The timeline was updated by the EU's "Omnibus Proposal" in 2025, which delayed reporting for many companies (European Commission 2025). The current implementation schedule is as follows:

- **For FY 2024 (reporting in 2025)**: Companies that were already subject to the previous **Non-Financial Reporting Directive** (**NFRD**)
- **For FY 2027 (reporting in 2028)**: All other large EU companies that meet the "large undertaking" criteria
- **For FY 2028 (reporting in 2029)**: Listed SMEs (except for micro-undertakings)
- **For FY 2028 (reporting in 2029)**: Non-EU companies meeting the revenue thresholds

In May 2024, EU authorities adopted the **Corporate Sustainability Due Diligence Directive** (**CSDDD**). The directive requires companies to adopt and implement effective due diligence policies. These policies must identify, prevent, mitigate, and end actual and potential human rights and environmental harms in their operations, those of their subsidiaries, and those of their business partners related to their chain of activities. Companies are also required to adopt and effectuate a transition plan for climate change mitigation aligned with the Paris Agreement's objective of limiting global warming to 1.5 °C.

The EU Taxonomy is a foundational tool for the European Green Deal. It will have far-reaching impacts on countries even outside the EU due to their interlinked value chains and global economic markets.

GHG Protocol Corporate Standard

Various standards have been developed over the past two decades to ensure consistency and comparability in carbon footprint reporting, with the **GHG Protocol Corporate Standard** and **ISO 14064 series** remaining the most widely used and internationally accepted frameworks. Recognizing the growing need for transparency and comparability, the **World Resources Institute** (**WRI**) and the **World Business Council for Sustainable Development** (**WBCSD**) released the original GHG Protocol Corporate Standard in **2001**, which quickly became the global benchmark for corporate GHG accounting. Since then, both frameworks have evolved. The **ISO 14064 standard** was revised in **2018**, strengthening requirements for the quantification, verification, and reporting of GHG emissions. More recently, in response to growing scrutiny around **Scope 3 emissions and double counting**, the GHG Protocol began a multi-year update process in **2023**, with new draft versions of the Corporate Standard and Scope 3 Standard expected by **2025.** These revisions aim to address gaps related to value chain emissions, mitigation accounting, and alignment with climate target-setting frameworks such as **SBTi**. As regulatory and investor expectations rise—especially under frameworks such as the **CSRD**—the importance of using up-to-date, standardized carbon accounting methodologies has only increased.

By 2016, 92% of Fortune 500 companies reporting to the **Carbon Disclosure Project** (**CDP**) had already been using the GHG Protocol as the basis for their reporting. In 2024, this was over 24,800 companies—accounting for about 66% of global market capitalization (CDP 2024).

The carbon disclosure was 96% higher than in 2020 and 135% higher than when governments signed the Paris Agreement on climate change in 2015. In 2023, disclosing companies accounted for 94% of the **Financial Times Stock Exchange Group** (**FTSE**) 100, over 86% of the S&P 500, and 54% of the Hang Seng in China. In total, this accounted for over two-thirds of global market capitalization (CDP - Disclosure Data Fact Sheet 2023). A public declaration on ESG ambition and emissions reporting is an important lever to accelerate companies toward greater sustainability.

The GHG Protocol defines how to count carbon and defines the so-called outlining of what you can trust. The GHG Protocol is composed of three different scopes of emissions, which are illustrated in *Figure 1.8*:

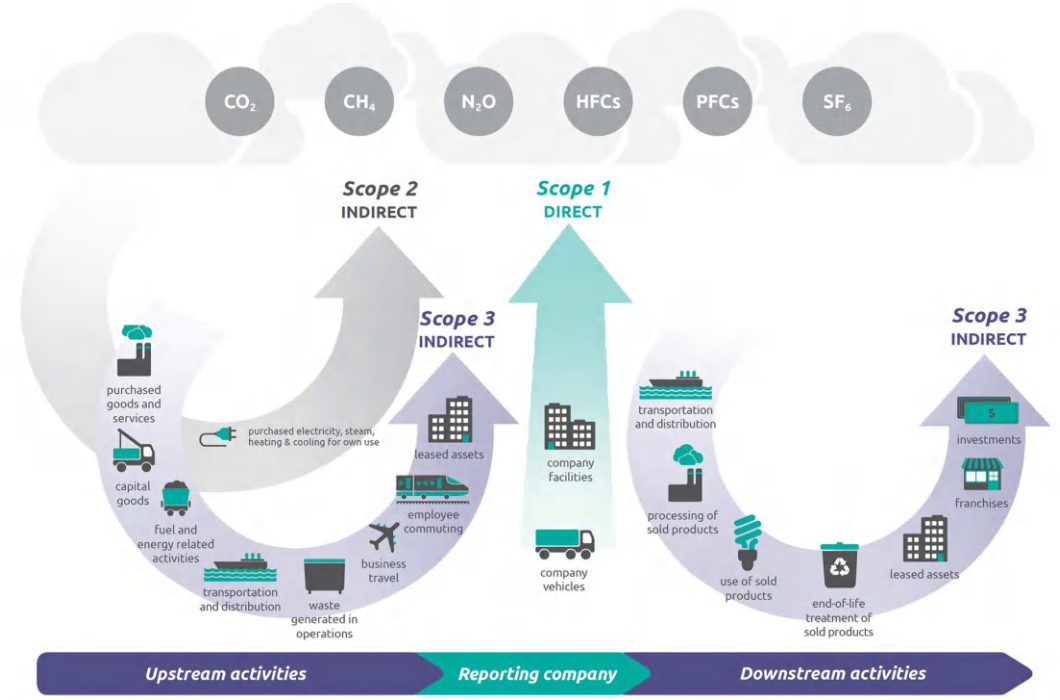


Figure 1.8 – The three scopes of GHG emissions (World Resources Institute n.d.)

Scope 1 includes your direct emissions from owned and controlled sources such as facilities, equipment, mobile assets such as vehicles, and onsite landfills.

Scope 2 includes indirect emissions that other companies have generated to supply the reporting company with energy, such as electricity, heating, and cooling.

Scope 3 focuses on indirect emissions along the entire value chain of a company. It goes far beyond the emissions recorded in Scopes 1 and 2. It accounts for both your upstream and downstream emissions across your entire value chain. They occur outside the organization, for example, in the supply chain or during production or travel. Scope 3 emissions are, on average, 11.4 times higher than a company's operational emissions (Scope 1 and Scope 2); therefore, there is a need to create transparency around these emissions. Companies will fall short in their ambitions to reach net zero unless they also take a severe claim to reduce their Scope 3 emissions.

On March 21, 2022, the US **Securities and Exchange Commission (SEC)** proposed rules to enhance and standardize climate-related disclosures in their registration statements and periodic reports, which would enable investors to assess their risk exposure when making their investment decisions (SEC 2022). In March 2025, the SEC voted to end its support of the rules. This decision followed intense legal challenges from state attorneys general, trade groups, and industry stakeholders who asserted that the rules exceeded the SEC's statutory authority and imposed undue burdens on businesses.

Scope 4 focuses on avoided emissions reduction that can be achieved through utilizing a particular product or service. Products and services that can have a significant avoided-emissions effect are employee commuting, teleconferencing, energy footprint reduction, and waste management. In *Chapter 6*, *Data Centers and Cloud*, we will look at a case study from EcoDataCenter where they achieve net-positive results by feeding back excess heat and water to a combined heating and cooling water plant, which, in turn, avoids burning coal and gas for the district heating of private houses and industrial production. Scope 4 is not currently established in standard GHG reporting, but it has been a topic of discussion since 2013, when the Scope 4 taxonomy was originally introduced. Since the 2020 pandemic and working from home becoming the new normal, discussions have reignited that Scope 4 for GHG emissions has become a necessity. *Figure 1.9* highlights more clearly what falls into the respective classification buckets. In the coming chapters, we will also define a sustainable IT taxonomy and what items fall into the respective categories:

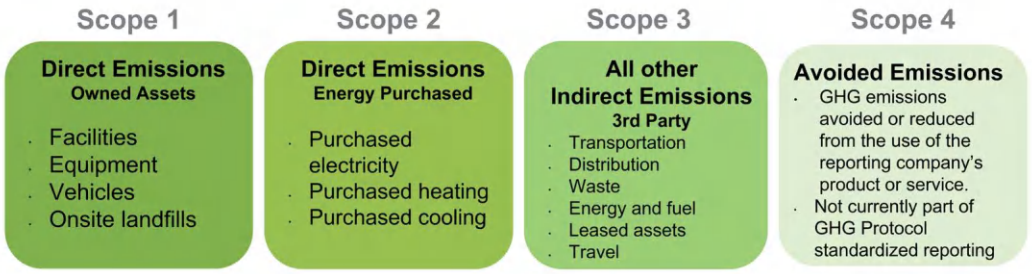


Figure 1.9– Carbon emission scope classification

For most companies, including technology companies, the main drivers of carbon emissions lie primarily in Scope 3. Without accounting for Scope 3 emissions, calculating their carbon footprint would not give a complete picture. A report by the German Global Compact Network (Global Compact Network Germany n.d.), as shown in *Figure 1.10*, outlines the scope of emissions by industry. For carbon-intensive sectors such as automotive and manufacturing, you can see that Scope 3 emissions amount to 79–87% of the total value chain emissions.

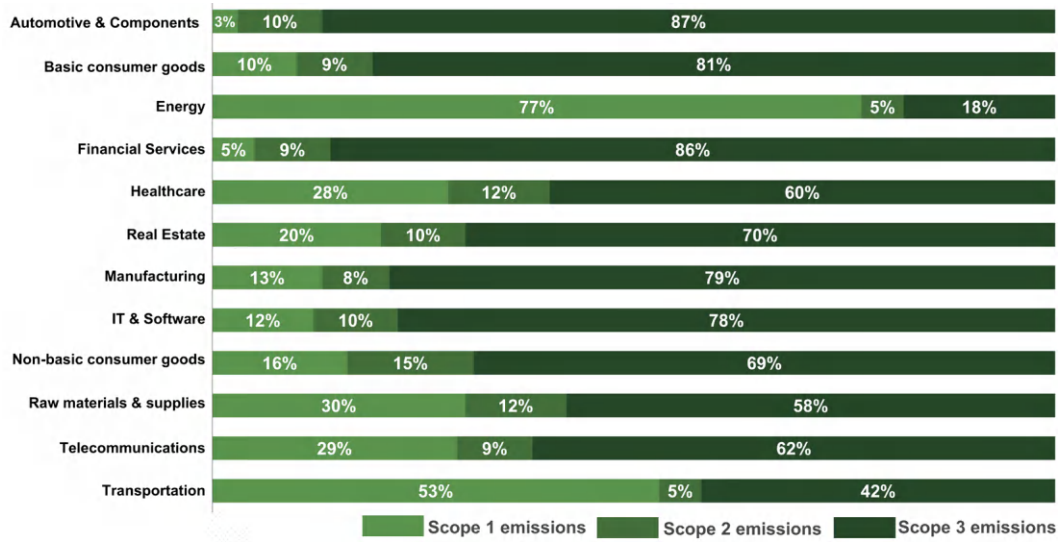


Figure 1.10 – Scope emissions by industry

Since 2001, the GHG Protocol Corporate Standard has been used for numerous corporate reports. The GHG Protocol Corporate Standard defines the reporting requirements for Scope 1 and Scope 2 emissions and recommends including Scope 3, although it is neither strictly required nor specifically defined. Since a considerable proportion of corporate emissions occur within Scope 3, and since there was no uniform standard to compare companies, a new standard was introduced in 2011, called the GHG Protocol Scope 3 Standard. The Scope 3 Standard introduced 15 categories within indirect Scope 3 emissions for companies to report on.

Later in the book, we will return to the GHG protocols as we define our own sustainable IT emission taxonomy and start working out our own current state CO_2 baseline.

Science-based targets

The primary objective of the SBTi Corporate Net-Zero Standard is to enable corporations to set net-zero targets consistent with limiting the global temperature rise to 1.5°C. These targets are aligned with proven methodologies within climate science, and the standard includes the guidance, criteria, and recommendations that companies need to set science-based targets.

The primary focus of COP26 was the critical target of limiting global temperatures to rising to 1.5°C by halving global emissions by 2030. Additionally, it was also where the Net-Zero Standard was officially launched. This key target is well within the critical requirements of SBTi's Corporate Net-Zero Standard.

The Corporate Net-Zero Standard has four essential requirements:

- **Focus on rapid, deep emission cuts**: Focusing on cutting carbon emissions is the most effective and scientifically sound way of limiting the global temperature rise to 1.5°C. Limiting global warming should be the overarching priority for companies embarking on the journey. The Corporate Net-Zero Standard covers the entire value chain emissions, including those products and services produced by their processes (Scope 1), purchased electricity, heating, and cooling (Scope 2), and emissions generated by suppliers and end users (Scope 3). Scopes 1, 2, and 3 must be disclosed separately.
- **Set near- and long-term targets**: Companies must set both near-term (five-year time frames) and long-term science-based targets. Companies must publicly commit themselves to halve emissions by 2030 and, by 2050, decarbonize completely. Additionally, an assessment and communication of progress is required to enhance accountability.
- **No net-zero claims until long-term targets are met**: A company can only be considered to have reached net zero if the long-term target has been fulfilled.
- **Go beyond the value chain**: The SBTi recommends companies dive deeper into their value chain and make investments outside their science-based targets to help mitigate and accelerate climate change elsewhere.

So, what is the impact and commitment on SBTis, you might ask? Over 10,500 companies worldwide are leading the zero-carbon transition by setting emissions reduction targets (Sciencebasedtargets.org n.d.). About 57% of Europe's largest public companies have pledged to reach net zero by 2050. However, only 16% of the world's largest companies are on track to net zero (Accenture 2024).

Emerging biodiversity frameworks

While biodiversity-related reporting frameworks are not yet as established as the GHG Protocol, momentum is building with several notable standards taking shape:

- The **Taskforce on Nature-related Financial Disclosures** (**TNFD**) offers a market-driven, science-based recommendation framework for organizations to identify, assess, and disclose nature-related dependencies, impacts, risks, and opportunities, structured across four familiar pillars—governance, strategy, risk and impact management, and metrics and targets—mirroring the design of the **Task Force on Climate-Related Financial Disclosures (TCFD)**

- **GRI 101**: Biodiversity 2024 is the latest GRI Topic Standard, effective from 1 January 2026, guiding organizations on how to report on biodiversity-related impacts and management through structured disclosures (e.g., policies, management practices, site-specific measures
- **Science-Based Targets for Nature** (**SBTN**), although still emerging, is gaining traction as organizations start adopting science-based nature targets

These emerging biodiversity frameworks are increasingly being integrated into broader regulatory landscapes, such as the CSRD, particularly through ESRS E4 ("Biodiversity and Ecosystems"). To report, companies will require geospatial location identifiers, ecosystem condition metrics, supply-chain data, and biodiversity footprinting (Globalreporting.org 2024).

To support frameworks such as TNFD and GRI 101, companies will also require analytics platforms capable of processing both qualitative and quantitative biodiversity indicators—such as land area disturbed, ecosystem health, or offset effectiveness—especially to manage stakeholder expectations and demonstrate compliance. SBTN's target-setting also necessitates systems to track performance over time, akin to climate emissions dashboards

Sustainability trends

Sustainability has become a global trend, and it can no longer be ignored. Here are some of the most relevant sustainability trends to consider as you start thinking about forming your own sustainable IT agenda:

- **AI as a tool for sustainability**: AI is increasingly leveraged for predictive insights, resource optimization, and climate risk modeling. It enables faster decision-making in areas such as energy grid balancing, emissions forecasting, and precision agriculture. With the rise of agentic AI—systems that can autonomously plan, execute, and adapt actions without constant human prompts—AI's sustainability impact is accelerating. These AI agents can integrate with enterprise systems and IoT sensors to continuously monitor operations, automatically initiate corrective actions, and orchestrate multi-step processes such as optimizing supply chains, adjusting renewable energy loads, or triggering maintenance before equipment failure. When designed responsibly, AI helps companies drive efficiency and reduce environmental risk.

- Climate adaptation and resiliency: Companies are recognizing that climate change poses an increasing risk to business operations through losses or disruptions due to extreme weather events, temperature extremes, and flooding. Businesses are starting to factor these impacts into strategy, operations, finance, supply chain, physical infrastructure, and products and services. For example, Mastercard, one of the companies profiled in this book, has a "climate risk and resilience team" led by a climatologist that is making infrastructure and vulnerability assessments, and updating facilities to withstand more extreme conditions and events (Mastercard 2024).
- **Carbon-conscious digital infrastructure**: The growing energy and water footprint of digital systems—including generative AI models and global data center expansion—has prompted a shift toward carbon-aware computing, low-impact architectures, and sustainable cloud operations. Organizations are embedding energy KPIs into cloud procurement and workload scheduling to minimize emissions and improve digital value delivery per watt.
- **Responsible procurement and sustainable supply networks**: Procurement is emerging as a key sustainability lever. Enterprises are revising sourcing criteria to account for supplier emissions, ethical labor, digital rights, and resource efficiency. This shift reduces long-term risk while enhancing brand value and resilience across global value chains.
- **Circularity and lifecycle planning**: Circular economy principles are now integrated into IT and manufacturing value chains, with a focus on designing for reuse, repair, and recycling. Digital product passports and AI-powered asset tracking add traceability and transparency, increasing the lifetime value of equipment and reducing material dependency.
- **Renewable energy transition**: Energy usage amounts to 73.2% of global GHGs (Ritchie 2020), where the most significant share comes from energy use in industry (24.2%), energy use in residential and commercial buildings (17.5%), and transportation (16.2%). The transition from fossil fuel energy to renewable energy is inescapable. As data centers are a large energy consumer, this is a crucial trend. Electrification of the energy and transportation sectors is a must.
- **Shift to sustainable products**: Consumer behavior and purchasing power are powerful change levers. Consumers are increasingly seeking out sustainable products and leaving non-sustainable products on the shelf. A report from PwC suggests that 85% of consumers seek out environmentally and socially responsible products (PwC 2024). With consumers' rising expectations of sustainable brands, the report highlights that they are willing to pay a 9.7% sustainability premium despite concerns regarding the cost of living and inflation. Making the switch to supply the market with sustainable products and services under a sustainable brand will become table stakes to doing business in the future.

- **Sustainability as a value multiplier, not a cost center**: Leading enterprises have shifted from viewing sustainability as a compliance burden to a source of strategic advantage. Integrating sustainability into product design, operations, and customer experience increasingly delivers brand trust, market differentiation, and cost avoidance, especially in energy, materials, and logistics.

While the momentum in sustainability trends remains strong in most regions of the world, the global landscape is increasingly shaped by geopolitical complexity. Trade tensions, resource nationalism, AI policy divergence, and energy security concerns have led to uneven progress, regional pullbacks, and, in some cases, regulatory resistance to ESG mandates. For sustainability strategies to endure, they must be flexible, value-aligned, and regionally adaptable—able to navigate both acceleration and resistance in a turbulent global environment.

Transitioning to a circular economy

Another long-term trend is the transition to a circular economy, which is likely to move faster with the increasing move to digitization and automation than in previous transformations. As we discussed earlier in the chapter, we are already consuming Earth's resources 1.75 times faster than the planet can replenish them. In our current way of living, finite raw materials are extracted or non-virgin plastics are used. The products are manufactured and shipped to a distribution point. The customer buys and uses the products once, and at the end of the product's lifetime, it is discarded with limited reusability or recycling—the process is linear. In a circular economy, we move from a linear process to a circular one. We stop producing waste in the first place. Nature itself—the circle of life—inspires the circular economy concept. Species are born, grow, decline, and die. Our remains rot in the ground and are eventually regenerated, continuing the cycle.

We have surpassed a yearly global consumption rate of 100 billion tonnes of materials. Currently, the global economy is only 6.9% circular, leading to an extensive circularity gap (Circularity Gap Report 2025). Less than 7% of materials, such as minerals, fossil fuels, metals, and biomass, used in a year are refurbished, repurposed, or recycled. Out of the 100 billion tonnes, 93.1% or 93.1 tonnes follow a linear model.

It is abundantly clear that we cannot continue consuming these finite resources at this rate and disposing of them without any afterthought. We need to switch from linear to circular practices and turn theory into practice. You could argue that the transition to the circular economy has the potential to be a big game changer, but many aspects need to be right first: it requires robust ecosystems and infrastructures and skills that can support the refurbishing, remanufacturing, and recycling processes. Legislation is needed that enforces a second life for products, new business models, and a mentality shift across the whole of society toward usage models and not consumption models.

Figure 1.11 illustrates the difference between the linear economy and the circular economy. In the linear economy, we continue to deplete Earth's natural resources, and once they have reached their end of life, they end up in a toxic landfill somewhere instead of being recycled. In the circular economy, we take a minimal amount of finite resources and create a regenerative process flow that continues to live as long as possible:

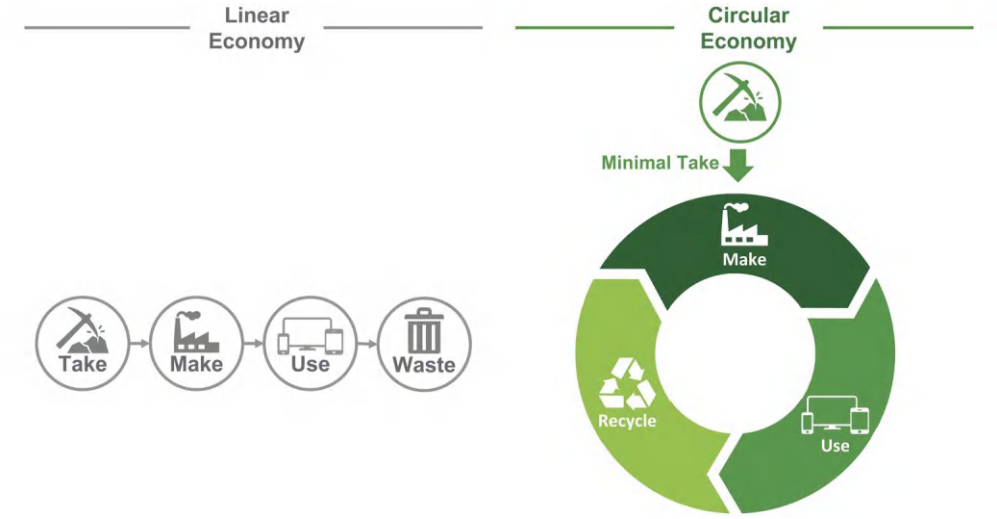


Figure 1.11 – From a linear economy to a circular economy

All industries need to shift from a linear model to a circular model and become more regenerative in every aspect of their value chain. Concerns about climate change mean the transition to a circular economy is gathering pace (Jensen 2022). The Ellen MacArthur Foundation (*What is circular economy?* n.d.) has defined three principles driven by design. These principles are rapidly gaining traction and are often referenced as the circular economy's core pillars.

These three circular economy principles are listed as follows:

- Designing out waste and pollution
- Keeping products and materials in use
- Regenerating natural systems

In addition to these three principles, it also requires good biological and scientific skills to understand the basic chemical processes and the use of materials, as well as careful designs for a second life. With increased societal pressure and strengthened political support, the circular economy will be a dominant force to be reckoned with in the next decade, as we transform from a linear model to a circular model (Jensen 2022).

For example, the EU aims to transition to a circular economy to make Europe cleaner and more competitive (European Commission 2020). This action plan announced initiatives along the entire lifecycle of products. The primary target is for the resources being used to stay within the EU economy for as long as possible. The new action plan requires promoting circular economy processes, targeting how products are designed, encouraging sustainable consumption, and preventing waste.

Gartner predicts that within a decade, in the 2030s, the circular economy will be the only economy (Johnson and Steven Steutermann 2019). Switching from a linear to a circular economy requires our supply chains to use minimal virgin materials and produce zero waste. Expectations from investors, customers, employees, and governing bodies are evident. In *Chapter 12*, *Sustainability by IT*, we will dig into many great circular economy examples where IT unlocks excellent opportunities for a more sustainable future.

For many companies, taking the initiative on climate boils down to risk. Failure to meet emission goals can bring unpleasant consequences from regulators, shareholders, employees, customers, and suppliers. As Larry Fink, CEO and chairman of BlackRock, stated in his corporate letter to corporate CEOs and investors in his company: "*The transition to a net-zero economy will change company's business models at the core. There is not a single company that won't be affected and if for those that don't adapt will see their business endure and valuations diminish rapidly*." Companies need to start focusing on *profits through purpose instead of profits aside from purpose*. Those companies that fail to adapt and innovate are often doomed to failure.

The climate impact of the IT industry

On the surface, you might think that the usage of IT has a positive impact on the environment due to less business travel and commuting to work. Additionally, there is the use of videoconferencing tools from Microsoft and Zoom, leveraging supply chain management software from **SAP** and **Oracle**, leveraging digital twin technology for predicting asset failure, the use of Adobe Sign and Docusign for eSignatures, and countless other cloud solutions that are available at your fingertips. The ICT industry contributes to a large percentage of overall energy consumption, CO_2 emissions, and e-waste, but it is also part of the solution of enabling remote working, process efficiencies, and energy efficiencies. With roughly 68.7% or 5.64 billion of the global population now on the internet, the immense activity is stacking up alongside the massive e-waste from computers, tablets, and smartphones, resulting in a whopping 62 million tonnes of e-waste generated globally each year (DataReportal 2025) (Global E-waste Monitor 2024).

Today, we take access to the internet, surfing on the web, hanging out on social media, or spending downtime on our streaming platform of choice for granted. Most of us don't think about the environmental impact of digital activities. We tend to associate environmental impacts only with more visible sectors, such as aviation, utilities, or agriculture.

Various studies estimate that the world's digital ecosystem (including data centers) contributes 2–4% of global greenhouse gases—on par with the entire aviation sector, which is 2–3% of global CO_2. (World Bank Group, 2024)

According to Lawrence Berkeley National Laboratory, US data centers consumed 176 **terawatt-hours (tWh)** of energy in 2023, which is expected to double or triple by 2028 (US Department of Energy 2024). US data center energy consumption is on par with 16.7 million homes, or roughly 4.4% of annual US electricity use. With the increased use of digital services, there is a massive increase in worldwide energy consumption, and some researchers predict that it could rise to 8–10% of the world's energy consumption in the next decade.

The lifecycle of ICT equipment also has a significant impact on sustainability-related areas such as e-waste and the use of natural resources and rare minerals. For example, servers used to run services and devices such as smartphones, tablets, and computers to consume services containing finite and toxic materials lead to massive heaps of **e-waste** and require an enormous amount of energy. Let us look at a couple of examples, such as a typical laptop and smartphone.

A recent laptop computer from Dell (the Dell Pro 14 Premium) emits 244.23 $kgCO_2e$ over an expected product lifetime of four years. (This and other energy and emissions data associated with specific products in this book are derived from calculations by carbon data service provider Rejoose and are specific to hardware deployed in the UK.) Manufacturing represents 89.6% of total emissions, transportation is 4.8%, usage is 5.0%, and end-of-life processing is 0.6%. The yearly energy demand is 15 kWh, which also impacts the environment depending on whether it is powered by renewable energy or fossil fuels (Rejoose, April 2025).

An Apple iPhone 16 smartphone (128 GB) emits 56 $kgCO_2e$ over an expected product lifetime of three years. This model uses 100% recycled tungsten and 100% recycled rare earth elements, which is a positive sign of keeping finite virgin resources to a minimum. Similar to the Dell laptop, manufacturing represents 80% of total emissions, transportation is 3%, end-of-life processing is <1%, and usage is 18% (Apple 16 Product Environmental Report 2024).

The environmental impact of laptops and smartphones is not insignificant. Along with a docking station, 1–2 monitors, a keyboard, and a mouse, they are standard equipment for a knowledge worker worldwide. If you are a technology leader with thousands of employees, your organization's environmental impact from IT adds up quickly. Annually, the world is generating 62 million metric tonnes of e-waste, according to the Global E-Waste Monitor 2024 Report. Over the last five years, we have seen a 16% increased rate. Even more tragic is that 77.7% e-waste is improperly recycled in countries with no recycling facilities. Therefore, technology leaders need to start thinking about new ways to apply circular practices to processes so that products do not go into e-waste. In the coming chapters, we will look at more examples and use cases regarding how to address this ICT issue.

With exponential technologies on the rise, such as AI, the metaverse, robotic process automation, and cryptocurrencies, the need for more computing power, storage, and energy will continue to surge.

Polarization and the need for courageous leadership

In today's polarized environment, advancing sustainability goals—especially those intertwined with **Diversity, Equity, and Inclusion** (**DEI**) and responsible AI—requires a new level of tact, courage, and strategic communication. While still broadly supported by corporate stakeholders, these initiatives have become flashpoints in public discourse. Political backlash, shareholder activism, and media scrutiny have made it more difficult for companies and institutions to speak openly about their environmental and social commitments without facing reputational or even financial consequences. The United Nations Global Compact 2025 CEO survey shows that only 50% of CEOs feel comfortable talking about their sustainability progress publicly (UNGC 2025). This has fueled a phenomenon known as *greenhushing*, the reluctance to publicly promote sustainability goals, typically accompanied by the removal of pages from corporate websites and changes to terminology. But the politicization has also resulted in tangible retreats. Of 1,000 global companies surveyed in 2024, 12.5% have ended or reduced investment in their DEI programs, and 11% of the remainder say they are likely to eliminate them by the end of 2025. The number one cited reason was political (Resume.org 2025). Financial Times research shows that 20% of the 50 largest companies in the US have delayed or scaled back their climate commitments, and only 8% are increasing them (Financial Times 2025).



For IT leaders, the realization that sustainability is a political challenge as well as an operational one can have a chilling effect. Yet, *the need for sustainable and equitable technology leadership has never been greater*. Climate indicators are worsening, we have fallen behind on the pace to meet Paris Agreement goals, and the demand for AI is outstripping our collective ability to govern it responsibly. Ignoring these challenges or sidelining them to avoid political blowback is not a neutral act—it's a decision with *long-term implications for the resilience, integrity, and impact* of our organizations. What's required now is a form of leadership that's both courageous and diplomatic: one that can navigate headwinds without retreating from principle.

Diplomatic discourse does not mean watering down purpose—it means learning to frame sustainability in ways that resonate across political divides and business priorities. It means showing how environmental and social responsibility drive innovation, resilience, and shareholder value. It means modeling transparency and accountability not just to signal virtue but to demonstrate competence. Above all, it means leading with lived experience, strategic clarity, and moral clarity—especially when the path forward is uncertain.

Ron Guerrier exemplifies this kind of leadership. His journey—from growing up in a Haitian immigrant household grounded in community, his career trajectory from repossessing cars for auto dealers in the streets of Chicago to CIO of that same automaker's financial arm, his CIO Hall of Fame honors, and his purpose-driven move to become CTO of Save the Children—embodies what it means to lead with both courage and credibility. In the following essay, Guerrier makes the case for why equity is essential to sustainable digital transformation and offers a deeply personal and practical roadmap for leaders navigating this pivotal moment.

Courageous leadership rooted in equity: building a sustainable digital future

From Haitian Roots & Chicago Grit to Davos – A Full-Circle Moment

I come from a culture that knows how to make brilliance out of scarcity. Being Haitian means knowing how to create with less, how to adapt, how to survive—and how to thrive without waiting for permission. Innovation in my world was never optional. It was embedded in how we lived, how we learned, and how we lifted each other through the most dire circumstances so that our children and grandchildren could contribute to society as doctors, lawyers, artists, and technology leaders.

Growing up in a Haitian household, the values were clear: education was non-negotiable, hard work was a given, and contributing back to your community was expected. These weren't just words—they were the operating system of our daily lives. So, when I think about courageous leadership today, especially in the context of technology and sustainability, it's not a trend. It's a return to the fundamentals I grew up with: purpose, grit, and responsibility.

That's why Dr. Payal Arora's work in *From Pessimism to Promise* resonates so deeply with me. She writes that "*the Global South is not waiting to catch up—it is already ahead in its ability to adapt, to innovate with limited resources, and to harness AI in meaningful ways.*" Her research reframes the narrative: it's not about rescuing the underserved; it's about learning from them.

I saw this firsthand during my travels, work, and recent conversations at the World Economic Forum in Davos. While Silicon Valley may dominate headlines, it's often the underserved, the overlooked, and the underestimated—like my Haitian community—that demonstrate the true ingenuity.

This lived experience, this cultural inheritance, is the foundation of how I lead—and why I believe courageous leadership rooted in equity is what will shape a sustainable digital future. Our highest potential digital asset, AI, needs to evolve responsibly and equitably.

What does courageous leadership mean in tech today?

To lead courageously in tech means being willing to confront systems built without everyone in mind—and choosing to invest the time and money in them. It means challenging the status quo, even when it's profitable. It means advocating for the underserved while in rooms where those voices are absent.

Today's sustainability challenges—whether environmental, digital, or social—are interconnected. Courage is understanding that sustainability is not just about carbon—it's about people. It's about making sure the tools we build serve humanity in its fullest expression, not just its most privileged.

But courageous leadership also starts within. Leaders must be willing to look inward, to be vulnerable, and to acknowledge their own unconscious biases. That includes recognizing how their own intersectionality—across race, gender, class, culture, and lived experience—affects how they perceive and lead others. True change starts when we realize that we are all shaped by the systems we seek to transform. Owning that truth doesn't diminish leadership—it strengthens it.

This belief informs my doctoral work at the University of Southern California, where I explore the intersection of AI governance and digital equity. I use Bronfenbrenner's ecological systems theory to examine how tech ecosystems—from policy to product—affect underserved communities. And I lean on Bandura's social cognitive theory to consider how AI systems "learn" from our collective behavior—for better or worse.

As a board member of SustainableIT.org, I've also advocated for a foundational principle across AI systems—one inspired by medicine's Hippocratic Oath: a commitment by technology leaders to "do no harm." Just as doctors are sworn to safeguard life, technologists must commit to building tools and systems that center on fairness, accountability, and human dignity. Responsible AI governance must become the professional standard—not an optional feature.

Building a culture of inclusive innovation at HP

During my tenure as global CIO at HP, courageous leadership meant designing systems of opportunity. It meant asking not just what we built but who was building it—and who benefited.

We created a gender-balanced leadership team. We partnered with **Historically Black Colleges and Universities (HBCUs)** to deepen the talent pipeline. We set measurable goals to ensure our US IT workforce reflected the demographics of the country. And we didn't stop at internal culture—we pushed to diversify our suppliers, bringing in more vendors from underrepresented backgrounds (CIO.com 2022).

This work wasn't charity. It was strategic. Diverse teams are more innovative. Inclusive ecosystems are more resilient. The result? Stronger business outcomes, deeper employee engagement, and a culture of innovation that could sustain itself.

Transforming the public sector in Illinois

As the secretary of innovation and technology for the State of Illinois, I inherited legacy systems, outdated infrastructure, and entrenched resistance to change. But I also saw a massive opportunity: a technology team with a can-do attitude to use technology as a platform for equity.

We secured a $420 million appropriation to expand broadband access to underserved communities. We transitioned over 50,000 state employees to remote work during COVID in record time. We organized the state's first Diversity Supplier Technology Day to open doors for minority- and women-owned tech businesses.

What made this courageous? We acted quickly, transparently, and inclusively—often in the face of political and institutional friction. We made decisions with the long-term impact in mind. We didn't just modernize; we made modernization equitable.

Purpose-driven technology at Save the Children

Today, I serve as chief technology officer for Save the Children, a role that brings together everything I believe in: innovation, sustainability, and human-centered design.

We're using digital tools and AI to deliver aid faster, predict needs better, and ensure children around the world have access to life-saving resources. But we're also doing it with integrity—prioritizing data privacy, responsible AI governance, and sustainable infrastructure.

In fragile and resource-constrained settings, technology must be resilient, ethical, and inclusive by default. There's no margin for error when a child's life is on the line.

The five tenets of courageous, sustainable IT leadership

Across all these roles, I've learned that courageous leadership in sustainable IT isn't a job title—it's a daily discipline. Here's the framework I carry with me:

- **Purpose before product**: Don't build tech for tech's sake. Build it to solve real human problems.
- **Systemic awareness**: Use a wide lens. Every decision affects the broader ecosystem—policy, community, and environment.
- **Inclusion is innovation**: Diversity isn't a side project. It's the engine of creativity, sustainability, and resilience.

- **Accountability is courage**: Own your platform. Measure what matters. Correct course when needed.
- **Invest beyond the org**: Support nonprofits, academic institutions, and grassroots orgs. Innovation doesn't live in boardrooms alone.

A call to action: redefining the future of tech leadership

We're at a crossroads. Technology can entrench inequity or dismantle it. It can widen the divide or bridge it. The path we take depends on who's leading—and how boldly they're willing to lead.

Courageous leadership rooted in equity is how we build a digital future that is not only sustainable but just. It's how we ensure the next generation doesn't inherit the same systemic blind spots embedded in today's code.

And it's how we turn the pessimism of the past into the promise of the future.

Ron Guerrier, CTO, Save the Children

Summary

As we reach the end of this chapter, if you were not already aware, you now have a better understanding of the great challenge humanity has in front of us to curb the climate crisis, and the determined and courageous leadership needed to meet the challenge. As you learned earlier in the chapter, the environmental impact of technology is one of the most well-kept secrets of the IT industry. As of 2025, the IT and aviation industries accounted for approximately the same percentage of global energy-related carbon emissions. However, due to the expected increase in data centers and data-intensive services such as AI, streaming, and cryptocurrency, carbon emissions from the IT sector could surpass those of the aviation industry by 2030. That is why there is a step change needed toward sustainable IT practices. The purpose of this book is not to explain the intricacies of *why* we have a climate crisis, but what we can do as technology leaders to focus on the *what* and the *how*.

Solving the climate crisis can seem complicated to grasp and also feel like an overwhelming task. It requires a collective effort from individuals, corporations, organizations, and policymakers. To relate to what needs to get done, I (Niklas) tend to fall back on the definition of the "top three for humanity" (Rockström and Klum 2012), as outlined by Johan Rockström and Mattias Klum in their book *The Human Quest: Prospering Within Planetary Boundaries*.

The top-three-for-humanity definitions outline what we need to transition to:

- 100% climate-neutral energy and transportation
- Healthy and sustainable food for all
- A circular economy

Most of the work needed in the next decade might feel like a daunting and impossible task. As a technology leader, I want to be part of the solution to solve the most significant challenge that humankind has ever encountered. I firmly believe that IT can play an essential role in transitioning to a sustainable future. We have seen how digital disruption has reshaped the S&P 500 in the past 25 years.

The fact that you are also holding and reading this book shows that you have an invested interest in making a long-lasting change beyond your company or organization's operating environment to create a future for a sustainable way of living and working within the constraints of planet Earth. Further, you presumably have the intent and the courage Ron Guerrier spoke of to promote a sustainability agenda in your company and industry.

In the next chapter, we will go deeper into the concept of sustainable IT. What are the main drivers and critical considerations for a sustainable IT plan, and what is the importance of embedding sustainable IT into the overall corporate sustainability agenda?

Further reading

- Intergovernmental Panel on Climate Change (IPCC): `https://www.ipcc.ch/`
- United Nations – Sustainable Development Goals (SDG): `https://sdgs.un.org/goals`
- Polman, P. and Winston, A. (2021) *Net Positive: How Courageous Companies Thrive by Giving More Than They Take*, Harvard Business Review Press
- Gates, B. (2022) *How to Avoid a Climate Disaster*, Allen Lane
- Doerr, J. (2021) *Speed & Scale*, Penguin Random House UK
- Sekol, M. (2024) ESG Mindset: Business Resilience and Sustainable Growth, Google Books
- Hedstrom, G. (2025) Navigating Sustainable Growth: A Roadmap for Boards and Corporate Leaders, Sustainable Growth Navigator Books

Bibliography

- Accenture. 2024. *Only 16% of Largest Companies on Track for Net Zero Goals with Nearly Half Seeing Increased Emissions, Accenture Analysis Finds*. https://newsroom.accenture.com/news/2024/only-16-of-largest-companies-on-track-for-net-zero-goals-with-nearly-half-seeing-increased-emissions-accenture-analysis-finds.
- Apple. 2024. *Apple 16 Product Environmental Report. September 9, 2024*. https://www.apple.com/environment/pdf/products/iphone/iPhone_16_and_iPhone_16_Plus_PER_Sept2024.pdf.
- Brundtland Commission. 1987. *Our Common Future*. http://www.un-documents.net/ocf-02.htm#:~:text=With%20minerals%20and%20fossil%20fuels,few%20future%20options%20as%20possible.
- CDP. 2023. *CDP - Disclosure Data Factsheet 2023*. https://cdp.net/en/insights/cdp-2023-disclosure-data-factsheet.
- CDP. 2024. *World's biggest companies eye $5 trillion in climate opportunities, doubling previous estimates*. https://www.cdp.net/en/press-releases/worlds-biggest-companies-eye-usd5-trillion-in-climate-opportunities-doubling.
- CGR. 2025. *Circularity Gap Report 2025*. https://www.circularity-gap.world/2025.
- CIO.com. 2022. *HP gets intentional about contracting with Black IT providers*. https://www.cio.com/article/306414/hp-gets-intentional-about-contracting-with-black-it-providers.html.
- Datareportal. n.d. *Digital Around the World. Global Digital Insights*. https://datareportal.com/global-digital-overview.
- Digiconomist.net. 2025 *Bitcoin Energy Consumption Index*. https://digiconomist.net/bitcoin-energy-consumption.
- EDGAR/JRC. 2024. *Per capita carbon dioxide (CO_2) emissions from fossil fuels in India from 1970 to 2023 (in metric tons)*. Statista. https://www.statista.com/statistics/606019/CO_2-emissions-india/.
- Ellen MacArthur Foundation. n.d. *What is the meaning of a circular economy and what are the main principles?*. https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview.
- European Commission. March 2020. *Circular economy action plan*. https://ec.europa.eu/environment/strategy/circular-economy-action-plan_en.

- European Commission. 2025. *Commission simplifies rules on sustainability and EU investments, delivering over €6 billion in administrative relief*. https://ec.europa.eu/commission/presscorner/detail/en/ip_25_614.
- European Commission. 2024. *GHG emissions of all world countries*. https://edgar.jrc.ec.europa.eu/report_2024.
- Fankhauser, S., S. M. Smith, M. Allen, et al. 2021. *The meaning of net zero and how to get it right*. Natural Climate Change. https://www.nature.com/articles/s41558-021-01245-w.
- Financial Times. 2025. *Top U.S. Companies Walk Fine Line on Climate*. https://www.ft.com/content/43548347-8940-40e2-a557-c1e3c10d8f10.
- Ginér, G., K. Schindall, M. Kubin-Hardewig, P. Tanskanen, R. Fernandez, M. Alnuhait, E. Blanco, and S. Nordbrand. 2022. *Strategy Paper for Circular Economy: Network Equipment*. GSMA. March 01. https://www.gsma.com/solutions-and-impact/connectivity-for-good/external-affairs/gsma_resources/strategy-paper-for-circular-economy-network-equipment/.
- Global Carbon Project. 2024. *Per capita carbon dioxide emissions worldwide in 2023, by country (in metric tons)*. Statista. https://www.statista.com/statistics/270508/CO_2-emissions-per-capita-by-country/.
- *Global Compact Network Germany*. n.d. https://www.globalcompact.de/en/.
- Globalreporting.org. 2024. *GRI 101: Biodiversity 2024*. https://www.globalreporting.org/media/n5lf4o5x/faqs-biodiversity_external_final_updated-oct-2024.pdf.
- Great Place to Work. 2025. *Workplace ESG: How ESG Factors Shape Employee Engagement*. https://www.greatplacetowork.com/resources/blog/workplace-esg-environmental-social-governance-employee-experience.
- IEA. 2025. *AI is set to drive surging electricity demand from data centres while offering the potential to transform how the energy sector works*. April 10. https://www.iea.org/news/ai-is-set-to-drive-surging-electricity-demand-from-data-centres-while-offering-the-potential-to-transform-how-the-energy-sector-works.
- IPCC.ch. 2022. *Climate Change 2022 Impacts, Adaptation and Vulnerability Summary for Policymakers*. https://www.ipcc.ch/report/ar6/wg2/resources/press/press-release/#:~:text=The%20Summary%20for%20Policymakers%20of%20the%20Working%20Group%20II%20contribution,Working%20Group%20II%20in%20numbers.
- IPCC. 2023. *AR6 Synthesis Report: Climate Change 2023*. https://www.ipcc.ch/report/sixth-assessment-report-cycle/.

- IPCC. 2013. *Climate Change 2013: The Physical Science Basis*. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press. https://www.ipcc.ch/report/ar5/wg1/.
- *IPCC.ch*. 2022. *AR6 Synthesis Report: Climate Change 2023*. https://www.ipcc.ch/report/sixth-assessment-report-cycle/.
- *IPCC.ch*. 2021. *IPCC Sixth Assessment Report*. https://www.ipcc.ch/report/ar6/wg1/.
- ITU/unitar. 2024. *The global E-waste Monitor 2024*. https://ewastemonitor.info/the-global-e-waste-monitor-2024/.
- Jensen, Henrik Hvid. 2022. *5 circular economy business models that offer a competitive advantage*. World Economic Forum. January 27. https://www.weforum.org/agenda/2022/01/5-circular-economy-business-models-competitive-advantage?utm_source=linkedin&utm_medium=social_scheduler&utm_term=Circular+Economy&utm_content=29/01/2022+05:00.
- Johnson, J. and S. Steutermann. 2019. *Preparing for 2029, When Consumer Product Supply Chains Cannot Produce Waste*. August 08. https://www.gartner.com/en/documents/3956095.
- Kelly Services. 2025. *Sustainability Attracts Talent: Why Values-Driven Companies Win at Hiring*. https://www.kellyservices.us/news-and-insights/sustainability-attracts-talent.
- Kraaijenbrink, Jeroen. 2019. *What The 3Ps Of The Triple Bottom Line Really Mean*.
- https://www.forbes.com/sites/jeroenkraaijenbrink/2019/12/10/what-the-3ps-of-the-triple-bottom-line-really-mean/.
- Lacis, A. A., G. A. Schmidt, D. Rind, and R. A. Ruedy. 2010. *Atmospheric CO_2: Principal control knob governing Earth's temperature. Science, 330(6002)* 356–359. https://www.science.org/doi/10.1126/science.1190653.
- Mastercard. 2024. *Meet the climatologist mitigating extreme-weather risk all over the map*. https://www.mastercard.com/news/perspectives/2024/meet-the-climatologist-mitigating-extreme-weather-risk-all-over-the-map/#:~:text=Since%20joining%20Mastercard%20in%20July,heat%20instead%20of%20absorbing%20it.
- NASA. n.d. *Global Mean CO_2 Mixing Ratios (ppm): Observations*. https://data.giss.nasa.gov/modelforce/ghgases/Fig1A.ext.txt#:~:text=1987%20348.93%201888%20294.1%201938%20311.0%20Sites,1995%20360.67%201896%20294.9%201946%20310.3%201996 and https://science.nasa.gov/earth/explore/earth-indicators/global-temperature/.

- NOAA. 2025. *Annual carbon dioxide peak passes another milestone*. Reported in Scripps Institution of Oceanography and University of Southern California San Diego. https://scripps.ucsd.edu/news/annual-carbon-dioxide-peak-passes-another-milestone#:~:text=For%20the%20first%20time%2C%20the,3.6%20ppm%20over%20last%20year.
- Price, T. 2018. *'Generation Green': how millennials will shape the circular economy*. Environment Journal. https://environmentjournal.online/waste-recycling/generation-green-how-millennials-will-shape-the-circular-economy/#:~:text=The%20drive%20to%20adopt%20circular,balance%20of%20society%20is%20shifting.
- PwC. 2024. *Consumers willing to pay 9.7% sustainability premium, even as cost-of-living and inflationary concerns weigh: PwC 2024 Voice of the Consumer Survey*. https://www.pwc.com/gx/en/news-room/press-releases/2024/pwc-2024-voice-of-consumer-survey.html.
- Rejoose. 2025. Data for Dell Pro 14 Premium. Generated April 29, 2025. https://rejoose.com/.
- Resume.org. 2025. *1 in 8 Companies Are Scaling Back DEI Commitments in 2025, Many Cite Political Climate*. https://www.resume.org/research/1-in-8-companies-are-scaling-back-dei-commitments-in-2025-many-cite-political-climate/.
- Ritchie, H. 2020. *Sector by sector: where do global greenhouse gas emissions come from?* https://ourworldindata.org/ghg-emissions-by-sector.
- Rockström, J. et al. 2017. *A roadmap for rapid decarbonization.* Science 355.6331, 1269–1271. https://pure.iiasa.ac.at/id/eprint/14498/1/Rockstr%C3%B6mEtAl_2017_Science_A%20roadmap%20for%20rapid%20decarbonization.pdf.
- Rockström, J. and M. Klum. 2012. *The Human Quest: Prospering Within Planetary Boundaries*. Langenskiöld. https://books.google.com/books/about/The_Human_Quest.html?id=5sLWMgEACAAJ.
- Rockström and Gaffney. 2021. *Breaking Boundaries – The Science of Our Planet*. London: Penguin Random House. https://www.penguinrandomhouse.com/books/659581/breaking-boundaries-by-johan-rockstrom-author-owen-gaffney-author-and-greta-thunberg-foreword/.
- SAP LeanIX. 2024. *Only 40% of companies feel prepared to comply with ESG regulations*. https://www.leanix.net/en/company/press/only-40-percent-of-companies-feel-prepared-to-comply-with-esg-regulations#:~:text=Bonn/Boston%2C%20March%2012%2C,their%20involvement%20is%20too%20low.

- Sciencebasedtargets.org. n.d. *Companies taking action*. https://sciencebasedtargets.org/companies-taking-action.
- Sciencedirect. 2025. *How does ESG performance affect stock returns? Empirical evidence from listed companies in China*. https://www.sciencedirect.com/science/article/pii/S2405844023035272.
- SEC. 2022. *SEC Proposes Rules to Enhance and Standardize Climate-Related Disclosures for Investors*. March 21. https://www.sec.gov/news/press-release/2022-46.
- SEC. 2025. *SEC Votes to End Defense of Climate Disclosure Rules. U.S. Securities and Exchange Commission*. https://www.sec.gov/newsroom/press-releases/2025-58.
- United Nations Environment Program. 2025. *Emissions Gap Report*. https://wedocs.unep.org/20.500.11822/48854.
- United Nations Global Compact. 2025. *UNGC CEO Study 2025*. https://info.unglobalcompact.org/ceo-study-2025.
- US Department of Energy. 2024. *DOE Releases New Report Evaluating Increase in Electricity Demand from Data Centers*. https://www.energy.gov/articles/doe-releases-new-report-evaluating-increase-electricity-demand-data-centers.
- World Economic Forum. 2024. *Global Risks Report*. https://www.weforum.org/publications/global-risks-report-2024/.
- World Resources Institute. n.d. https://www.wri.org/.

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2

Rise of Sustainable IT

> *Education is the most powerful weapon you can use to change the world.*
>
> *Nelson Mandela*

In this chapter, you will first learn about the main drivers of a sustainable IT plan and its importance in implementing sustainable IT into the overall corporate sustainability agenda. Then, we will dig into three concepts: *sustainable IT*, *sustainability in IT*, and *IT for society*. Finally, we will examine IT's **Environmental, Social, and Governance** (**ESG**) considerations.

The main objectives of this chapter are to introduce you to sustainable IT in depth, understand how it interlinks with the overall corporate sustainability agenda, and learn what critical ESG considerations exist for IT. Learning about the sustainable IT maturity model will enable you to assess your starting point, define your target state, identify gaps, and define your direction of travel toward a more sustainable IT practice.

In this chapter, we will cover the following topics:

- Main drivers toward a sustainable IT agenda
- Embedding sustainable IT into the overall corporate sustainability agenda
- Sustainability in IT, sustainability by IT, and IT for society
- ESG considerations for IT

By the end of this chapter, you will have learned about the main drivers of a sustainable IT agenda. You will understand the difference between the three key concepts: sustainability in IT, sustainability by IT, and IT for society. Finally, you will have gained more in-depth knowledge of what ESG considerations exist for IT.

What is sustainable IT?

As defined by the nonprofit professional association SustainableIT.org, sustainable IT is the strategic leadership of enterprise technology to minimize its negative and maximize its positive impacts on the environment and society. Launched in 2022 and led by IT executives, the nonprofit SustainableIT.org's growth and accomplishments have been a proxy for the momentum and achievement of IT sustainability over the same three-year period. **Ralph Loura, Chairman of the Board, SustainableIT.org**, describes its launch and impact:

> I'm Ralph Loura, and it's my honor to share the story of SustainableIT.org—an initiative born from the conviction that technology leaders must lead the charge on sustainability, not stand on the sidelines. It all started, as many good stories do, with a group of people sharing a meal and sharing stories of what was working and what they were struggling with in their work and personal lives. These people happened to be a set of technology executives, and among other things, one of the common struggles of the evening was a sense that they all wanted or were being asked to do something about sustainability, but they weren't sure how to go about it to achieve meaningful outcomes.
>
> Among the leaders at the table was technology entrepreneur Jedidiah Yueh, founder and former CEO of Delphix, now Perforce. Jed was inspired by the conversation and reached out to a few others to discuss how to fill this need, and a few short months later, SustainableIT.org was incorporated. This was 2022, and it was apparent almost immediately that an organization founded by and for technology leaders committed to reshaping how enterprise digital transformation can—and must—serve both business and the planet was something people needed and could get behind.
>
> Our mission is clear: define practical, industry-specific sustainability programs; author the frameworks, standards, and certifications that empower IT departments; and elevate awareness across the ESG pillars through education and recognition. We've published the inaugural SustainableIT.org Standards—a pioneering, IT-focused set of 240 ESG metrics aligned with GRI and SASB—to provide a common lexicon and reporting baseline for global enterprises. In June 2025, we published the *IT Toolkit for Responsible and Sustainable AI – A Field Guide for Implementation at Scale*.

Developed and vetted by more than 50 volunteer IT executives and AI experts, it launched with models, frameworks, principles, and, most importantly, step-by-step practical guidance for operationalizing responsible AI goals.

In my time on the board, I've witnessed remarkable progress—especially in forging influential partnerships. We've joined forces with Deloitte to assess IT capability maturity and elevate the most relevant KPIs. We've teamed up with Human-I-T to repurpose end-of-life corporate IT devices for disadvantaged communities. Our IT-tailored sustainability standards have been incorporated into ServiceNow's sustainability data management platform. We've established ongoing partnerships with the TBM Council, the Green Software Foundation, and SustainableArchitectures.org to accelerate sustainable IT asset management, software engineering, and architecture design worldwide. These alliances are not mere symbolic gestures; they reflect steadfast commitments to bring sustainability into enterprise digital DNA.

But at the heart of this organization lies community—genuinely building a global network of leaders exchanging best practices, shining a spotlight on outstanding sustainability achievements with our **SustainableIT Impact and Responsible AI Impact Awards**, and convening best practices summits from Boston to London and New York to Davos. In my view, visibility and recognition are for more than applause; they are a powerful catalyst for adoption and scaling.

From a simple social gathering emerged a common cause, engaged community, tangible deliverables, and clear purpose. It reminds me of a catchphrase from the 80s TV series *The A-Team*: "I love it when a plan comes together!"

SustainableIT.org stands at the intersection of IT leadership and planetary stewardship. Together, we're redefining what it means for technology to serve sustainability—through standards, education, metrics, and collaboration. I'm proud to chair this board and grateful to the community of leaders driving this next wave of responsible digital transformation.

Ralph Loura, Chairman of the Board, SustainableIT.org

SustainableIT.org is not alone in offering support for IT and **Information and Communications Technology (ICT)** industry leaders. *Table 2.1* lists various nonprofit sustainability organizations relevant to IT, with one being more than 20 years old. As AI has exploded and prepares to scale, its need for responsible and sustainable governance has prompted the creation of additional organizations devoted to its responsible governance:

Organization	Founded	Headquarters Country	Focus	Website
SustainableIT.org	2022	USA	Sustainable IT, responsible and sustainable AI	`https://sustainableit.org`
Green IT Collective	2004	France	Green IT, responsible digital and eco-design	`https://www.greenit.fr/`
Institut du Numérique Responsable (INR) France	2018	France	Sustainable IT	`https://institutnr.org`
Belgian Institute for Sustainable IT (ISIT-BE)	2020	Belgium	Sustainable IT	`https://isit-be.org`
Swiss Institute for Sustainable IT (ISIT-CH)	2020	Switzerland	Sustainable IT	`https://isit-europe.org`
ISIT Europe (Network)	2014 (network), 2018 (France institute)	Europe	Sustainable IT	`https://isit-europe.org`
Green Software Foundation	2021	International	Green software, sustainable AI	`https://greensoftware.foundation/`
Partnership on AI	2016	USA	Responsible AI	`https://partnershiponai.org`
AI for Good/ITU UN	2017	Switzerland	Ethical and sustainable AI	`https://aiforgood.itu.int`

Organization	Founded	Headquarters Country	Focus	Website
Responsible AI Institute	2020	USA	Responsible AI governance, risk, and trustworthiness	`https://responsible.ai`
Center for Responsible AI – New York University	2019	USA	Interdisciplinary responsible AI research, policy, and training	`https://airesponsibly.net/`
Coalition for Sustainable AI	2024	France	AI alignment with sustainability goals	`https://www.sustainableaicoalition.org/`

Table 2.1 – Nonprofits dedicated to sustainable IT and responsible AI

As ESG has become a mainstream business issue, the pressure on technology leaders to assume responsibility is mounting. Not only have CEOs expected the CIO to be the primary catalyst in executing business strategy in the coming years, but the ask is also to embed sustainable IT practices into the fabric across the whole organization.

Sustainability in IT, sustainability by IT, and IT for society

As ESG has become a mainstream business issue, corporations are being pushed by mounting regulations and stakeholder pressure to present transparent ESG reporting, assume responsibility for climate change, and deal with it holistically across the entire company. IT is no exception. Technology leaders are tasked with shining a light on the environmental and social impacts of IT and taking tangible steps toward a sustainable IT practice. On top of running your environment securely and stably, the ask is to embed sustainability into the fabric of the whole IT organization. As we saw in *Chapter 1*, IT's impact is not insignificant. Three leading examples of IT's impact on the environment are illustrated in *Figure 2.1*:

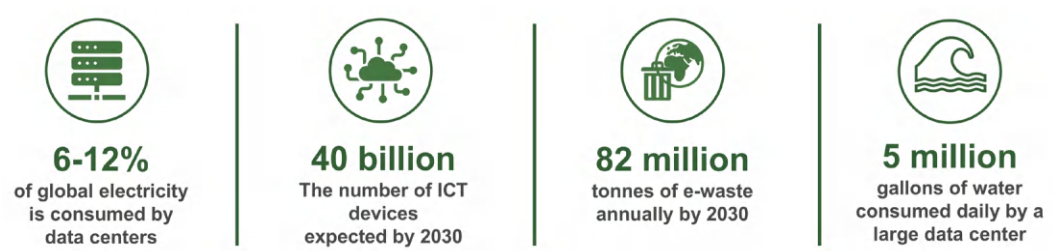


Figure 2.1 – Leading examples of IT's impact on the environment

Let's explore these leading examples of IT's impact on the environment:

- Data centers will consume about 1 to 2% of the world's energy in 2025, and this is rising rapidly (Deloitte Insights 2024).
- The number of devices is expected to reach 40 billion in 2030, producing 80% of carbon dioxide during manufacturing (IoT Analytics 2024).
- 62 million metric tonnes of **electronic waste** (**e-waste**) were generated worldwide in 2022, an increase of 82% since 2010. Estimates say we will reach 82 million metric tonnes by 2030 (Global E-waste Monitor 2024).

IT is a significant enabler of long-term sustainability efforts and business success, and also has considerable influence over business strategy and operations. Sustainable IT, or green IT, has many different meanings depending on whether you are a manufacturer, manager, or user of technology. In the simplest definition, sustainable IT is the manufacture, management, use, and disposal of IT to meet our present needs without compromising the ability of future generations to meet their own needs.

Before we get into the how-to section of the book in *Part 3*, *How Do You Accelerate Sustainable IT?*, and start defining our carbon emissions baseline, it is essential to make clear distinctions. We need to differentiate sustainability in IT from sustainability by IT and IT for society.



Figure 2.2 – Sustainability in IT, sustainability by IT, and IT for society

Let us look at the definitions, based on descriptions by Gartner Senior Director Analyst Marta Muñoz Méndez-Villamil:

- **Sustainability in IT – your footprint**: This focuses on making IT itself more sustainable in what it consumes, emits, or wastes. It emphasizes circular practices, such as recyclability, energy efficiency, and regenerative design:
    - Goals: Minimize the negative environmental impact and social harm (labor conditions, equity, and data privacy) of IT operations and its supply chain
    - Direct effect: Lowers IT's CO_2 emissions and resource consumption and contributes to social equity
- **Sustainability by IT – your handprint**: This is about using IT as a lever to enable positive sustainability impact beyond your own department and its operations. By building innovative solutions, business models, and applications, IT enables the enterprise and industries (yours and ICT) to operate more sustainably:
    - **Goals**: Advance enterprise and industry progress on goals for climate action, circularity, equity, ethical sourcing, human rights, and data privacy.
    - **Indirect effect**: IT solutions amplify and accelerate sustainable outcomes by enabling the broader enterprise to achieve its sustainability goals and compliance with regulations. These impacts occur indirectly, as IT helps transform business models, processes, and decision-making across the value chain.
    - **Why "handprint?"**: These actions extend your reach and *multiply your impact*.
- **IT for society – your heartprint**: IT and the enterprise create direct, positive societal impact, going beyond business performance or compliance. It is giving back to society, improving lives, fostering equity, and strengthening communities:
    - Goals: Promote digital literacy, accessibility, and inclusiveness, shrinking the digital divide globally and locally
    - **Direct effect**: Measurable benefits to people and communities, such as improved digital access, stronger data protection, and more equitable participation in the digital economy

Sustainability in IT simply pertains to anything you use internally to run your enterprise, such as owning data centers, managing cloud providers, developing software, managing the lifecycle of your hardware, optimizing your energy consumption, or managing your e-waste. A few examples of sustainable IT are illustrated in *Figure 2.3*:



Figure 2.3 – Sustainability in IT examples (direct CO_2 emission reduction)

Sustainability by IT is what you develop for internal use and commercial use by your customers, providing a product or solution that targets a specific sustainability need. Sustainable solutions enabled by IT can be applied within various industries. Here, the use cases are endless, but in *Figure 2.4*, we have outlined 10 key areas: *carbon emission reporting*, *ESG risk management*, *sustainable sourcing and manufacturing*, *eco-friendly transportation*, *energy-efficient buildings*, *energy resource management*, *hybrid work*, *eco-friendly travel*, *development of e-services*, and *product as a service*.



Figure 2.4 – Sustainability by IT (indirect CO_2 emission reduction)

We will return to these key areas in *Chapter 12*, *Sustainability by IT*, where we have devoted a whole chapter to exploring them in much greater detail. Water resource management and water availability risk could certainly be their own categories in this framework, but we address these topics in the book under the headings of energy resource management and energy-efficient buildings, where IT has direct influence over what happens to our water resources. Water is also an important topic in *Chapter 6*, *Data Centers and the Cloud*.

It is also worth mentioning that the EU's **Recovery and Resilience Facility** (**RRF**) targets both environmental sustainability and digitalization. Through 2026, the RRF requires that at least 37% of these COVID recovery funds be spent on climate and environmental objectives, such as the following:

- Renewable energy deployment and grid modernization
- Energy efficiency upgrades for buildings and industry
- Circular economy investments
- Sustainable transport (e.g., electric vehicle infrastructure)

A minimum of 20% of funds must be allocated to digital projects, driving IT modernization and innovation, including the following:

- 5G and broadband expansion to reduce the digital divide
- Cloud and cybersecurity infrastructure for governments and businesses
- Digital skills training programs for the workforce
- Support for SMEs in digital adoption and data-driven innovation

This has made the RRF a catalyst for the handprint of sustainable IT, as many funded digital projects are tied to ESG reporting, smart infrastructure, and circular business models.

IT for society is the altruistic side, where you positively impact your people, community, and society. There are different ways to positively impact society using IT by donating IT equipment, employee time, or money and running specific initiatives to improve digital equity and inclusion. Just as with sustainability by IT, the use cases are endless, but in *Figure 2.5*, we have outlined a few key areas: organizational enablement, social responsibility programs, women in tech, and sustainability hackathons.



Figure 2.5 – Examples of key focus areas in IT for society

Now that we have a better understanding of what sustainable IT, sustainability by IT, and IT for society are, and we have looked at some examples for each, we need to explore and understand the **Greenhouse Gas (GHG)** emission taxonomy and how it translates into a sustainable IT taxonomy.

Sustainable IT Greenhouse Gas Emission Taxonomy

The previous chapter dove into the GHG standard protocol and looked at the three different forms of emissions—Scopes 1, 2, and 3. As Scope 4 is not yet officially part of the GHG protocol, it has been omitted from the taxonomy for now. As you may recall, the GHG protocol defines how to count carbon and represents the so-called outlining of what you can trust. The definitions for a respective scope may be ambiguous within IT and technology. Therefore, we present a *Sustainable IT Greenhouse Gas Emission Taxonomy©* (Sundberg, Sustainable IT Greenhouse Gas Emission Taxonomy 2021) to make it easier to relate to and digest:

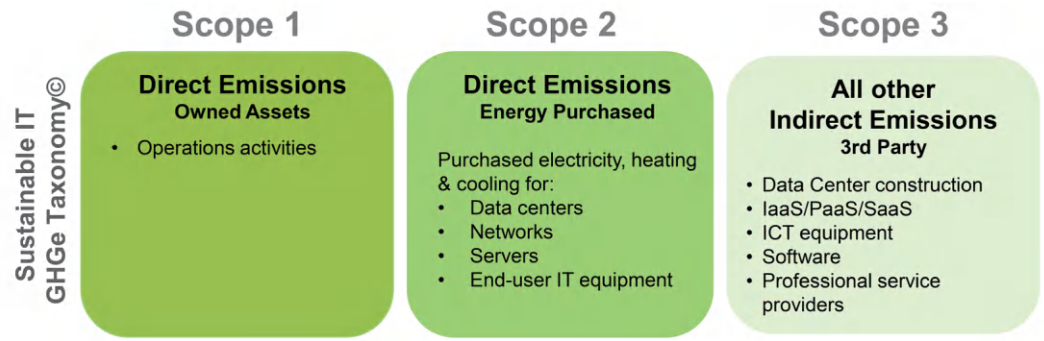


Figure 2.6 – The Sustainable IT Greenhouse Gas Emission Taxonomy© (Sundberg, Sustainable IT Greenhouse Gas Emission Taxonomy 2021)

The taxonomy follows the same principles as the overall GHG Protocol Corporate Standard, but we have related each scope category to IT and technology instead of giving more general definitions:

- **Scope 1** is your direct emissions from owned and controlled sources such as data centers (local and global), enterprise networks, and operations activities.
- **Scope 2** includes indirect emissions that other companies have generated to supply the reporting company with energy, such as electricity, heating, and cooling for their data centers, networks, servers, and end user IT equipment.

- **Scope 3** focuses on indirect emissions along the entire value chain of a company. It goes far beyond the emissions recorded by Scopes 1 and 2. They occur outside the organization, such as cloud consumption with **Infrastructure as a Service** (**IaaS**), **Platform as a Service** (**PaaS**), and **Software as a Service** (**SaaS**) and ICT equipment such as user devices (computers, smartphones, and tablets), printers, access networks, data centers, enterprise networks, and operator activities. On-premises software you use is developed and licensed to you by a third party. Professional services providers provide services to build, operate, and run your IT environment. If they sit offsite and not onsite in your locations (for example, in India), everyone has a local emission footprint that should be accounted for.

As we saw in *Chapter 1*, *Our Most Significant Challenge Ahead*, Scope 3 emissions are 11.4 times higher than a company's operational emissions (Scope 1 and Scope 2) on average, and IT and technology are no exception. Whether you are a venerable business with a long IT legacy or a start-up company with no legacy, you need to understand your starting point and where you are going.

If you are an old company and the general trend is to move your own data centers to cloud hyperscalers and have a professional network provider running your worldwide enterprise network, this is a significant shift from Scopes 1 and 2 to Scope 3.

If you are a start-up company, you will probably not start building up your own data center estate and enterprise networks unless it is your core business. Therefore, most of your GHG emissions will land in Scope 3 from the start.

Regardless of whether your GHG emissions reside in Scope 1, 2, or 3, your responsibility is to minimize your overall emission impact. Just because you are offloading your own Scopes 1 and 2 emissions to someone else, does not mean that you are not responsible for it. Legislation such as the EU taxonomy and **Corporate Sustainability Reporting Directive** (**CSRD**) requires you to report your entire scope, including Scope 3.

As we move further into the book, you will discover that different levers can be used depending on which scenario and scope you are trying to address. For example, suppose most of your emissions reside in Scope 3. In that case, vendor management and IT procurement are essential for putting pressure on your vendors to disclose honest and transparent environmental reporting, following your sustainable IT policies, vendor code of conduct, and circular economy principles. In *Chapter 11*, *Leveraging Your Buying Power*, we have dedicated a chapter to further detailing these core concepts.

In the next section, we will look closely at the importance of connecting sustainable IT to your overall corporate sustainability strategy in this rapidly changing business environment.

Corporate sustainability and sustainable IT

As we saw in *Chapter 1*, *Our Most Significant Challenge Ahead*, company longevity on the S&P 500 is rapidly declining. Companies that cannot adapt to rapid changes in macrotrends, such as electrification and sustainability, will likely be relegated to the graveyard of corporate failures. Sustainability has become a recurring boardroom topic, and 45% of global CEOs say that due to climate disruption and AI, their companies will not last a decade without transforming themselves, and they are "extremely concerned" about environmental damage and climate change (Birch, Kate, Sustainability Mag 2024).

As the demand for companies has shifted toward fulfilling the needs of a broader spectrum of stakeholders, such as employees, customers, partners, ecosystems, and communities, and not just the shareholder needs, ESG has become a mainstream business issue. As noted in *Chapter 1*, *Our Most Significant Challenge Ahead*, the trend toward positioning sustainability as a value multiplier, not a cost center, is taking hold, and indeed, a strong link between sustainability and business value may be a requirement for further momentum.

Recognizing this, the Sustainability Value Creation Partnership conducted a survey of 320 business leaders between November 2024 and January 2025 globally across corporate finance, IT, and sustainability functions. The goal was to identify sustainability value drivers, the most commonly achieved value attributed to sustainability, and factors elevating that value. There was broad agreement that sustainability creates value for the business. However, respondents also noted significant gaps and challenges. While two-thirds said sustainability is very important to commercial success, only 37% said sustainability was very integrated into decision-making within their organization.

Among 12 different ways in which sustainability creates value for organizations, the highest value drivers were brand, stakeholder relationships, and partnerships. While powerful, these "soft" drivers can be difficult to demonstrate. More "bottom-line" value drivers, such as innovation, sales growth, and cost savings, were less common. In the private sector, where quantification is expected, reliance on softer metrics can limit corporate willingness to invest in sustainability transformation, ultimately slowing progress.

The 37% of respondents who reported an advanced level of integration of sustainability factors in their business decision-making had a significantly higher impact from the 12 value drivers overall. These "advanced integrators" particularly eclipsed the rest of the respondents in the hard-value, tangible value types (GlobeScan, et al. 2025).

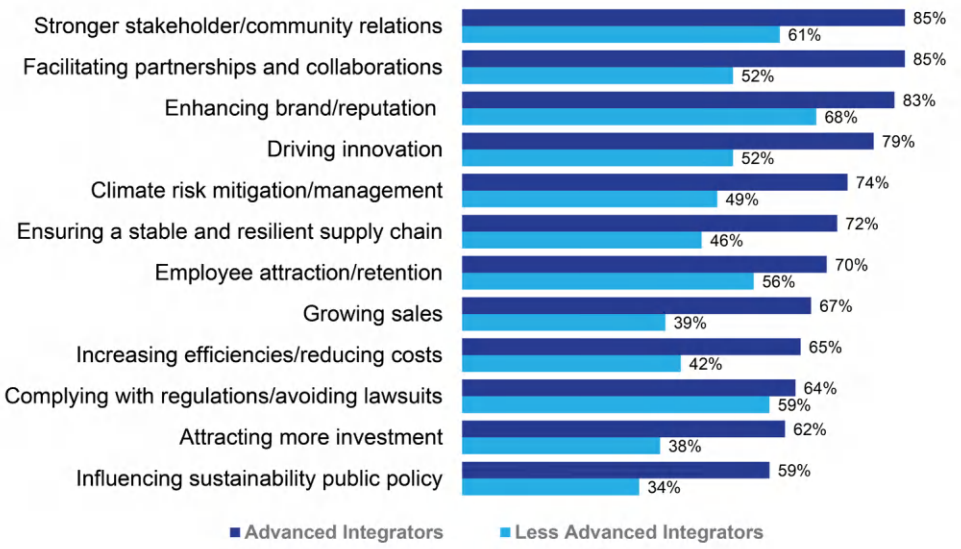


Figure 2.7 – Percentage rating each action as delivering "high value" or "very high value" for their organization (4 and 5 on a 5-point scale). Source: Sustainability Value Triangle survey, 2025

Notably, advanced integrators were much more likely to have strong partnerships between finance, IT, and sustainability. Co-ownership of the sustainability agenda between these functions was frequently raised as a valuable way of driving stronger impact. This alone is a valid argument for IT to be at the sustainability strategy table and a co-leader of its execution. Other key differentiators included the following:

- More resources to drive sustainability
- More access to high-quality sustainability data
- More likely to view mandatory reporting as a driver of value creation rather than a distraction
- More likely to be applying AI to sustainability initiatives (though this is still uncommon)

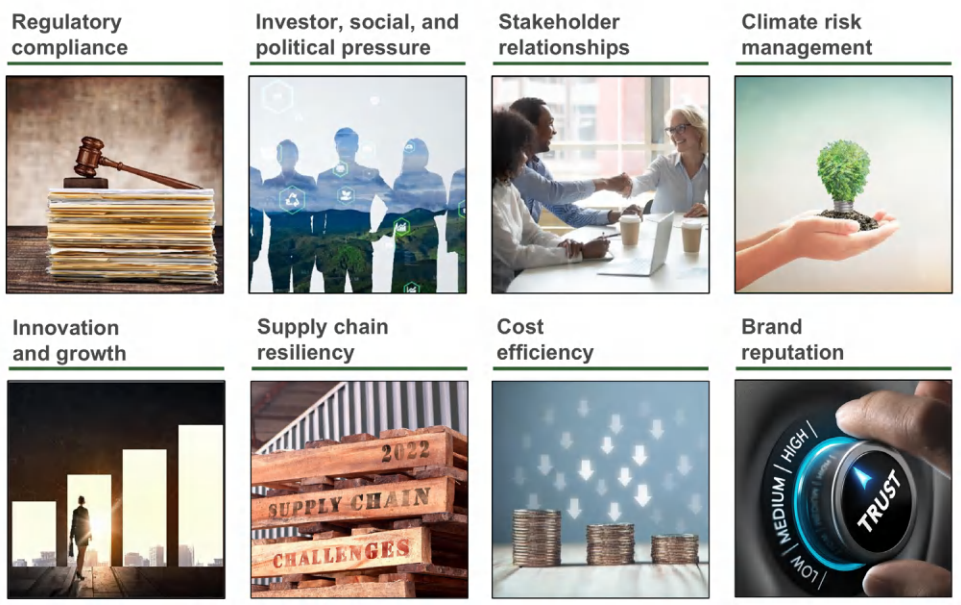


Figure 2.8 – Value drivers for corporate sustainability investment

Let us look at some of the value drivers in brief:

- **Compliance**:
    - Increased pressure through new and emerging international sustainability legislation. Forces companies to provide accurate and transparent reporting and disclose of climate risk to the public.
    - **Examples**: The European Green Deal, EU Taxonomy, Paris Agreement, Clean Air Act, Montreal Protocol, **German Supply Chain Act (GSCA)**, European **Artificial Intelligence Act (AI Act)**, California's Climate Corporate Data Accountability Act and Voluntary Carbon Market Disclosures (AB 1305).
- **Attracting investors**:
    - Increased pressure from key stakeholders to act and improve transparency, detailed sustainability reporting, and disclosure
    - **Examples**: The **SBTi**, **Carbon Disclosure Project (CDP)**, **Value Reporting Foundation**, **CSRD**, and **Task Force on Climate-Related Financial Disclosure (TCFD)**

- **Stakeholder relationships**:
    - Both B2B and B2C dynamics are raising the bar for corporations to conduct sustainable, ethical, and social business.
    - **Examples**: B2B customers are increasingly asking suppliers to comply with one of the 200+ ESG rating agencies, such as **EcoVadis**, **NQC qualifications**, **Sustainalytics**, **S&P**, and **Bloomberg**. Also, having your supplier adhere to your supplier code of conduct policies sends a powerful message that you are serious about ESG policies. **Cisco**, **Apple**, **Microsoft**, and **Salesforce** are examples of ICT companies that have set high requirements on their suppliers to comply with environmental protection. Beyond the technology industry, **Nestlé**, **Schneider Electric**, **IKEA**, and **Unilever** are among the large companies adhering to strong codes of conduct for suppliers.
- **Climate risk management**:
    - Expectations are rising for companies not only to manage climate risks within their own operations but also to build responsible, resilient business ecosystems. This requires sustainability investments and circular economy practices that generate measurable climate impact improvements across the entire value chain (Scopes 1, 2, and 3). By embedding resiliency into strategy, companies can mitigate exposure to physical risks (extreme weather, resource scarcity, and infrastructure damage) and transition risks (policy shifts, carbon pricing, and market disruption), while strengthening long-term competitiveness.
    - **Examples**: Apply circular design principles, lower energy consumption, switch to renewable energy sources, lower water intensity, focus on supply-chain working conditions and human rights, remove conflict minerals, reduce hazardous materials, and keep e-waste to a minimum.
- **Innovation and growth**:
    - Develop new sustainable B2C and B2B products to drive new revenue streams and top-line growth. According to PwC's *Second Annual State of Decarbonization* report, among the 4,163 companies whose climate disclosures were analyzed, 83% reported investing in low-carbon or sustainable product development, and those efforts are already translating into tangible upside. Products featuring sustainability attributes can achieve revenue growth of 6 to 25% compared to comparable products without such emphasis (PwC 2025).

Also negating the assumption that people will not pay more for sustainable products, the 2024 Sustainable Market Share Index™ showed that products marketed as sustainable drove 41% of the growth in consumer-packaged goods from 2013 to 2024, despite only constituting 23.8% of market share. Products marketed as sustainable achieved a 5-YR CAGR of 12.4% vs. 6.8% for the total CPG market and just 5.4% for conventionally marketed products (NYU Stern 2025).

- The World Economic Forum cites research from Boston Consulting Group highlighting that businesses incorporating sustainability into their strategic frameworks are 1.4 times more likely to achieve innovation breakthroughs, paving the way for unique product development, operational efficiencies, and market differentiation (World Economic Forum 2025).
- **Examples**: Sustainable building construction and management, electrification of the transport sector, development of renewable energy sources and storage, reducing water intensity in agriculture, investing in plant-based foods, and moving away from selling a product to selling "as a service."

- **Supply chain resiliency**:
  - Corporate supply chain emissions are, on average, 26 times greater than their operational emissions, making them an important target for environmental actions such as route optimization and localized sourcing. Supply chain disruptions as a result of climate change cost businesses $162 billion annually, which is 2.9 times greater than the $56 billion estimated cost to mitigate these risks, according to an HSBC report (HSBC 2024).
  - **Examples**: Finding local suppliers, diversifying suppliers, sourcing sustainable raw materials, and enabling circularity in the supply chain to minimize risks of material shortages due to geopolitical tensions.
- **Cost efficiencies**:
  - Focus on driving efficiency, reducing complexity, and improving quality and speed to reduce cost
  - **Examples**: Drive efficiency through intelligent automation, reduce complexity by rationalizing applications and infrastructure, design and execute on quality metrics, and adopt an agile mindset across the entire organization

- **Brand reputation**:
    - Enabling trust and reputation is essential. On average, a company's perceived sustainability contributes to 3% of brand equity, amounting to $193 billion in brand value for global top 100 brands (Kantar 2024). This report goes on to show that brands with high sustainability contribution to their value have achieved 20% greater brand growth over four years than those with low sustainability contribution to value. Sustainability influences brand equity by 6% overall—specifically, 5.4% through demand/volume and 6.5% through margin/pricing power. Scandals related to poor ESG practices have been costly for companies and senior executives, and in recent times, several large companies have come under the spotlight for this.
    - **Example**: German asset management firm **DWS**, majority-owned by **Deutsche Bank**, was accused of overstating the ESG credentials of its investment funds. In April 2025, German prosecutors fined DWS €25 million ($27 million) after concluding that the firm was guilty of greenwashing by making misleading statements about its ESG-related practices. The prosecutors found that statements such as being an "ESG leader" and having ESG as an "integral part of our DNA" did not reflect the reality of the business's organization (Reuters 2025). In the US, DWS reached a settlement with the US **Securities and Exchange Commission (SEC)** over similar greenwashing allegations, agreeing to pay a $19 million fine for misleading statements about its ESG integration policies and processes (SEC 2023). The greenwashing scandal also led to the resignation of DWS's CEO, Asoka Woehrmann, in June 2022, who stated the allegations had become a "burden."

Now that we have taken a closer look at eight key drivers for a corporate sustainability plan, let us shift our focus to IT and what drivers for a sustainable IT agenda exist.

Drivers for a Sustainability IT agenda

Although technology solutions can and are being used to help solve sustainability challenges, the IT industry contributes significantly to the world's environmental impact in terms of energy and water consumption, GHG emissions, and e-waste. These impacts span the entire IT systems lifecycle, from raw materials extracted for technology hardware to manufacture, transportation, usage, and end of life. IT's direct influences on social sustainability include accessibility of technologies and tools and inclusiveness of system design, which impact the digital divide. Automation has always impacted jobs and roles, but AI adoption takes this to a new level of worker displacement and skills obsolescence.

Governance is the most familiar sustainability territory for IT, with its focus on data protection and cybersecurity, business resilience, and other risk management. However, the risks have multiplied and accelerated, threatening to outstrip IT's capacity to respond. The following are recent data points quantifying some of technology's major sustainability impacts.

IT sustainability impact

The following environmental impacts span the lifecycle of IT equipment:

- **Energy consumption**
    - The production and use of digital devices, data centers, and ICT networks combined account for an estimated 6 to 12% of global electricity use (UN Trade and Development 2024).
    - In 2025, data centers are projected to use 536 TWh (2% of global electricity), which is equal to powering 50 million US homes or the consumption of a mid-sized country (Deloitte 2024).
    - The annual energy consumption of Bitcoin mining is approximately 175 TWh annually. This astronomical consumption falls between that of Australia and the Netherlands, countries with 28 and 18 million people, respectively (Digiconomist 2025).
    - In their base case scenario, the International Energy Agency predicts global electricity consumption for data centers will double to around 945 TWh by 2030, representing just under 3% of total global electricity consumption. This is more power than the entire nation of Japan consumed in 2023 (903 TWh). Under a "lift-off case" scenario, which assumes stronger AI adoption and more resilient infrastructure, global electricity demand from data centers could reach over 1,700 TWh by 2035, accounting for around 4.4% of global electricity demand (IEA 2025). The energy consumption in this scenario represents the following power equivalencies:
        - **All US homes**: More than enough power to run all 147 million US households for a year
        - **European Union**: Roughly three-quarters of the EU's current annual electricity consumption
        - **Global cities**: Comparable to over six years of electricity consumption for a major metropolis such as Tokyo (279 TWh/year)

- **Carbon emissions**:
    - Various studies estimate that the world's digital ecosystem (including data centers) contributes 2–4% of global GHGs—on par with the entire aviation sector, which is ~2–3% of global CO_2 (World Bank Group 2024)
    - US data centers emitted 105 $MtCO_2e$ in 2023—about 2.18% of national emissions; that's like adding 22 million passenger cars (assuming ~4.8 t CO_2 per car/year) (Guidi, Gianluca, et al. 2024)
- **Water consumption**:
    - Large data centers can consume up to 5 million gallons per day, equivalent to the water use of a town populated by 10,000 to 50,000 people (EESI 2025).
    - A single chip fabrication plant can use around 10 million gallons of UPW per day, akin to the water usage of 33,000 US households (EESI 2025).
    - Multiple studies estimate AI's global annual water consumption to reach between 4.2 billion and 6.6 billion cubic meters (1.1–1.7 trillion gallons) by 2027. This is 4 to 6 times the annual water usage of a country such as Denmark.
    - Based on the companies' own environmental reports, Microsoft data centers increased water use by 34%, and Google by 20%, in just one year (2021–2022) due to AI demands.
- **Critical minerals and materials scarcity**:
    - IT hardware manufacturing depends on a complex network of mined metals and critical materials. Key components such as batteries, circuit boards, and processors rely heavily on lithium, cobalt, nickel, copper, and rare earth elements such as neodymium and dysprosium. Growing global demand for these resources will increase the negative impacts on the environment from their mining, including soil erosion and contamination of water supplies.
    - Many of these resources are geographically concentrated, with production often dominated by a few countries, including China, which controls over 60% of rare earth refining capacity. This creates significant supply chain vulnerabilities and geopolitical risk.

- **E-waste**:
    - 62 million metric tonnes of e-waste were generated globally in 2022. This volume of e-waste in 2022 would fill 1.55 million 40-tonne trucks, enough to form a line around the equator. Less than one quarter (22.3%) of the e-waste produced was documented as having been formally collected and recycled (Global E-waste Monitor 2024). A computer with batteries contains hazardous substances, including lead, mercury, and cobalt, as well as chemicals such as phthalates, synthetic musks, and alkylphenols. When these end up in landfills at high concentrations, they pose a risk to human health.
    - Generative AI could add 1.2–5 Mt of e-waste by 2030, up to 12% of global totals (Nature Computational Science 2024). This is due to more frequent hardware refresh cycles as generative AI models grow in size and complexity each year, driving shorter lifespans for servers, GPUs, and storage devices.

The following are social IT sustainability impacts:

- **Job displacement from automation and AI**:
    - 40% of employers expect AI to reduce their workforce due to AI automation (World Economic Forum 2025).
    - AI could impact nearly 40% of global jobs. In advanced economies, 60% of jobs may be impacted by AI, with roughly half benefiting from AI integration, while the other half could face some degree of replacement, lowering labor demand and wages (IMF 2024).
    - Amazon warns that AI will reduce its white-collar workforce over the next few years (June 2025).
- **Skills obsolescence**:
    - 75% of workers were using AI in 2024; 45% fear replacement (AIPRM 2024)
    - 46% of employees fear their skills will be obsolete within five years, with 29% expecting it to happen even sooner (Kahoot! 2024)
- **Digital divide and inequitable access**:
    - Nearly one-third of the global population—2.6 billion people—are offline as of 2024–2025. About 1.8 billion of these offline people live in rural areas. Roughly 40% of people globally do not own a smartphone (ITU 2024).

- Only 1 in 100 people in low-income countries have fixed broadband access—the median price of an entry-level mobile broadband subscription amounts to 8.6% of average income, a share 22 times larger than in high-income countries (0.4%) (Internet Society Pulse 2023).
- Micro-, small-, and medium-sized enterprises in India struggle with AI deployment due to high costs, widening tech inequality (The Economic Times 2025).
- Women are significantly underrepresented in adopting AI tools—20 percentage points less likely than men to use ChatGPT in similar roles. Women hold just 33% of AI roles globally and only 26–29% of data and AI positions (Otis, Nicholas G, et al., Harvard Business School 2024).
- 24% of Black workers are in occupations with >75% automation potential, versus 20% of White workers. Additionally, 53% of Black workers fear AI job loss in the next five years, compared to 39% of White workers (McKinsey 2023).

The following are governance IT sustainability impacts:

- **Business resiliency:**
  - 50% of corporations reported being affected by extreme weather (floods, heatwaves, or storms) in the past three years (Marsh 2024).
  - Climate change disruption to supply chains directly affects delivery times, increases costs, and reduces output. These disruptions are projected to cause $81 billion in economic damage, rising to at least $122 billion when including downstream effects such as industry output and consumer impacts (Nature 2023).
- **Cybersecurity risk:**
  - Nearly 50% of executives believe generative AI will advance adversarial capabilities such as phishing, malware, and deepfakes (Statista 2025)
  - The number of confirmed data breaches in 2022 was 5,212, up from 4,145 in 2021 (Verizon 2022)
  - Impacted records reached 22 billion in 2022 (publicly disclosed breaches) (Cyber Security Hub 2022)
  - The average global cost of data breaches reached $4.88 million in 2024, a 10% rise from 2023 (IBM 2024)
  - The EU General Data Protection Regulation fines reached a cumulative €5.88 billion in 2025, with Meta, Amazon, TikTok, and LinkedIn receiving the highest fines (Data Privacy Manager 2025)

The picture is clear. IT is far from sustainable, and it is essential to find new ways to deliver sustainable IT and be an enabler of sustainability. A recent global survey - State of Sustainability Readiness Report 2024 (IBM 2024 - by IBM surveyed 2,800 business leaders on their plans to increase investments in technology to advance their companies' sustainability efforts. The survey found that 88% of leaders plan to increase investment in IT for sustainability in 2025. The primary transformation drivers are as follows:

- Brand reputation (57%)
- Energy cost (54%)
- Business resilience (52%)
- Regulatory pressure (42%)

Sustainable IT or green IT is not a new concept, but with an increased focus on sustainability, these concepts have become front of mind for many technology leaders. Nearly 90% of a company's sustainability-related strategy decisions are influenced by IT (Letemple and Craven 2021). So, there are many opportunities to make a long-lasting impact on the sustainability agenda.

A recent study conducted by Dell (Dell Technologies Survey 2025) with 750 business and IT decision-makers reveals the following:

- 82% of leaders believe that sustainability is a key component of their organization's business strategy, while 75% also consider AI/generative AI to be essential.
- 95% of firms say they have an enterprise-wide sustainability strategy. Respondents chose IT asset lifecycle management as the fourth priority, after reducing the organization's carbon footprint, increasing energy efficiency, and regulatory requirements.
- 81% agree they need the help of a third-party to achieve sustainability goals.

Although we see a significant increase in carbon emissions from IT, the issue has not come to a tipping point where sustainable IT is viewed as a priority. In the next section, we will look closely at some ESG considerations for IT.

ESG considerations for IT

Earlier, we looked at drivers for a sustainable corporate agenda; let us look at some ESG considerations for IT. The five key areas—financial value, non-financial value, risks (physical and transition risks), employee engagement, and readiness—are illustrated in *Figure 2.9*:



Figure 2.9 – ESG considerations for IT

When assessing these five areas and assessing your own sustainable IT plan, there are several key questions that you should consider.

Financial value

Ensuring long-term value creation is critical to ensuring a corporation's financial value. There are financial value opportunities in working with the top line, your revenue, and the bottom line from a cost perspective.

One of the largest studies to examine financial return associated with ESG performance was released in 2023 by Kroll, a global financial and risk advisory firm headquartered in New York City (Kroll 2023). The Kroll ESG and Global Investor Returns Study examined whether companies with strong ESG practices deliver better financial performance. Using data from more than 13,000 publicly traded companies across 4 major regions and 12 industries, the study tracked stock returns (dividends plus capital appreciation) over the 2013–2021 period. ESG ratings were provided by MSCI, a leading ratings provider.

To analyze performance, the study applied ESG sustainability ratings from MSCI (`https://www.msci.com/data-and-analytics/sustainability-solutions/esg-ratings`) and grouped the rated companies into three categories based on performance in managing ESG risks and opportunities: leaders, averages, and laggards. The study then compared the returns of hypothetical portfolios made up of companies in each group.

The following are key findings:

- Globally, ESG leaders achieved an average annual return of 12.9%, versus 8.6% for laggards, representing nearly a 50% performance advantage for companies with strong ESG practices
- US companies showed similar results, with leaders returning 20.3% annually compared to 13.9% for laggards
- These results were consistent across most industries and regions, which refutes claims that ESG outperformance is driven solely by tech-sector weighting
- Western European companies were more advanced in ESG maturity: at the time of the study, one-third of companies in that region were rated as leaders, compared to 10% in North America and 6% in Asia

The study provides robust evidence that companies prioritizing ESG and sustainability practices tend to deliver superior financial returns, making a strong case for investors and corporate leaders to view sustainability not as a cost but as a source of competitive advantage and long-term growth.

One example is Unilever, the British multinational consumer goods company. Its **Unilever Sustainable Living Plan (USLP)**, launched in 2010 and formally concluded in 2020, demonstrated that it is possible to deliver strong business results while advancing social and environmental goals. While the USLP did not fully achieve every target, it transformed Unilever's culture and processes, embedding sustainability into product innovation, supply chain management, and brand strategy. The initiative provided enduring strategic lessons and introduced systems-level thinking that has influenced the entire organization and broader industry.

Building on this legacy, Unilever introduced the Unilever Compass, which takes a more focused, systems-change-oriented approach to drive sustainable growth. The Compass zeroes in on areas where Unilever can create the greatest impact—such as climate action, human rights, and equitable value chains—while aligning closely with global ESG frameworks and stakeholder expectations (Unilever 2020).

Circularity

The overall trend is moving from a linear to a circular process. Infinite growth on a finite planet is simply not possible. Profits should come from solving the world's problems, not creating them. Therefore, you should consider your circular maturity.

The following are key questions to ask yourself:

- What are the critical circular industry trends shaping the future agenda?
- What is your level of circularity today?
- What product offerings can be transitioned into service offerings (i.e., as a service)?
- What is the percentage of your total top line today and where should it be in the future?
- How can IT unlock opportunities to switch from a linear to a circular economy?

Return on Sustainability Investment (ROSI)

ROSI is a method to assess the environmental, societal, and economic impacts of investment. It is a significant shift from viewing sustainability as a cost to instead seeing it as a source of value. The 2024 *Sustainable Market Share Index*™, a report released by the NYU Stern Center for Sustainable Business, found that although sustainability-marketed products only make up 18.5% of the market, they have contributed to one-third of the growth in **Consumer Packaged Goods** (**CPG**) since 2013 (Kronthal-Sacco and Whelan 2024).

Imperial College Business School's Leonardo Centre on Business for Society found that strategically relevant sustainability initiatives—such as new product development, organizational transformation, and ecosystem partnerships—drive higher financial returns—specifically 2.67% higher annual risk-adjusted returns, equating to a 40.58% cumulative excess return over 13 years. Conversely, companies focused on low-maturity, advocacy-only actions—such as surface-level campaigns or reputation-driven programs—saw lower returns and higher risk. These findings are based on the Leonardo Centre's GOLDEN Sustainability Dataset, comprising roughly 1 million initiatives disclosed by 12,000 companies across more than 60 countries, extracted from 50,000 reports spanning 3 decades. Using advanced natural language processing, initiatives were classified by type of action ("what"), intended outcome ("why"), and beneficiary stakeholders ("for whom"). The financial analysis linked these initiatives to the stock performance of 983 listed firms in North America and Europe between 2010 and 2022, with portfolios sorted by advocacy, preparation, and transformation signals and rebalanced monthly. Risk-adjusted returns were measured using Sharpe ratios, and robustness was tested against the Fama–French three-factor model. Results showed that high-maturity, transformational initiatives not only yielded superior excess returns but also carried lower risk compared to low-maturity advocacy portfolios or ESG ratings benchmarks (Imperial Business School 2024).

The following are key questions to ask yourself:

- Do you have a framework in place to assess sustainable investments?
- What measures and KPIs are taken to bridge the gaps between sustainability strategies and financial performance?
- How can sustainable investments be made within IT to drive the sustainability agenda forward, grow the top line, and improve the bottom line?

IT cost and value optimization

Technology leaders are constantly under pressure to unlock the value of IT at an increasingly lower cost. There are typically three ways to drive down IT costs: cost-cutting, cost optimization, and value optimization. IT cost-cutting is reactionary, considering short-term gains and immediate reductions. Cost optimization consists of more structured improvements over time, focusing on improving efficiency, increasing productivity, and shifting IT spending. Value optimization is about delivering business outcomes and unlocking value. Typically, value optimization focuses on growing top-line growth rather than improving the bottom line. However, both occur in larger organizations that can't keep up with the growing op-ex costs of IT, so part of the strategy includes reducing technical debt within major programs.

Fortunately, there is no contradiction between driving a sustainable IT plan and IT cost and value optimization.

In fact, there are several ESG direct connections to IT transformation, such as keeping technology current to ensure cybersecurity, and tech modernization strategies (i.e., migration to cloud and digital enablement), which have environmental considerations.

The following are key questions to ask:

- Where can we improve efficiency?
- Where can we improve productivity?
- Where can we shift spending?

Hardware longevity

ICT equipment significantly impacts Scope 2 when used in energy, heating, and cooling, and Scope 3 in manufacturing, transportation, and recycling. The management of ICT equipment tends to be linear, but it is paramount to switch to circular management of ICT equipment. According to a study by the Capgemini Research Institute, 89% of organizations recycle less than 10% of their ICT equipment (Capgemini 2021). Only 22% of small IT and telecommunications equipment was documented as collected and recycled (Global E-waste Monitor 2024). This is a massive opportunity for improvement. If you are a global company with thousands of employees, changing your approach to managing your IT hardware can significantly impact your carbon reduction plan year after year.

The following are key questions to ask yourself:

- How long is your typical hardware refresh cycle for computers, servers, monitors, and network equipment?
- What is your current process for managing the lifecycle of your ICT equipment?
- Do you have a process in place to prolong the life of the ICT equipment, such as replacing laptop batteries or replacing cracked smartphone screens?
- Do you have a safe and well-proven methodology to remove data?
- What circularity can your **IT Asset Disposition** (**ITAD**) vendor achieve?
- Do you receive any carbon credits from your ITAD vendor?
- Is there an opportunity to buy refurbished equipment from the start to reduce your carbon emissions significantly?

Energy reduction

As cited forecasts suggest, the energy required for ICT equipment will continue to accelerate in the next decade. As 75% of total global emissions come from burning fossil fuels, it is paramount to switch to renewable energy sources such as geothermal, wind, water, and solar. The opportunity to reduce power use within IT spans four main categories: ICT production, data centers, network equipment, and end user equipment.

The following are key questions to ask:

- What is our total energy consumption today?
- What share of renewable energy is utilized from total energy consumption?
- What is our data center's **Power Usage Effectiveness (PUE)**?
- What savings can be derived from reduced water usage and e-waste generation?
- What is the energy consumption of our end user equipment?
- What percentage of end user equipment is turned off at night?

Lean operations

Technology leaders should ask themselves what their future IT operations should look like. What adaptations are needed to mitigate changing conditions due to the climate?

The following are key questions to ask yourself:

- What changes do I need to make to my operating model to reduce risk?
- How can I most effectively decarbonize my operations?
- Which key areas need to be focused on to decarbonize efficiently and effectively?
- Where does decarbonization raise the cost and where does it lower it?
- Which vendors should I effectively use that can enable us to decarbonize?

Non-financial value

Ensuring long-term value creation is critical to ensuring a corporation's financial value. Especially when it comes to sustainability, there are several opportunities to unlock significant non-financial value. Let us look at a few key areas.

Improved brand perception

As we saw earlier in the chapter, brand reputation is a top-three driver for enterprises to invest in sustainability (GlobeScan, et al. 2025). Companies with a robust and purposeful mission and vision tend to have strong brand perceptions. It enables product and brand differentiation, strengthens employer branding, and gives access to capital such as green bonds.

Patagonia, the outdoor apparel brand, has long embedded environmental and social responsibility into its core business strategy. Its dedication to sustainability has not only helped reduce its footprint but also reinforced its brand as a trusted, authentic leader in ethical business practices. One example is the company's "Worn Wear" program, which encourages customers to repair, share, and recycle gear.

Academic and marketing analyses note that Patagonia's sustainability-led branding has contributed to building strong consumer trust and loyalty, positioning the company as a reliable and responsible market leader (Wong, Yin Angel. 2025).

A recent case study highlights how Patagonia's impact strategy—rooted in minimizing environmental harm and promoting fair labor—serves as a powerful differentiation tool. Through transparent practices, environmental advocacy, and consistent messaging, Patagonia has cultivated a brand image deeply aligned with sustainability and integrity. The privately held company's revenues are estimated to have increased by 5.5 times from 2008 to 2022, driven by repeat purchases at premium prices (Causartist 2025).

The following are key questions to ask yourself:

- Does your company have a robust and purposeful mission and vision?
- Is sustainability at the heart of your mission?
- How strong is your employer branding today?
- What do you need to do to set yourself apart?

Attracting like-minded customers

As we saw previously, within CPG, sustainability-marketed products contributed to one-third of the growth since 2013. Being at the forefront of delivering sustainable products and solutions is crucial for attracting like-minded customers.

As more products become connected through the **Internet of Things** (**IoT**) and integrated with **robotics**, IT will have an increasingly significant footprint on the lifecycle of products and solutions delivered to customers and end users. These technologies enable smarter, more efficient systems—from connected home devices to industrial robotics—but they also introduce new sustainability challenges, including energy consumption, e-waste, resource use, and ethical considerations such as labor displacement and safety.

Ensuring that physical and digital products, including IoT-enabled devices and robotics systems, are designed, deployed, and managed sustainably will be paramount to a company's long-term competitiveness and ongoing success. Companies that fail to address the sustainability impacts of these technologies risk falling behind competitors and losing the trust of both customers and regulators.

The following are key questions to ask yourself:

- What is your share of sustainable products and solutions today?
- Do you know what your emissions are from your physical and digital products?
- Do you have a process to certify your products and solutions as sustainable?
- Do you know the Scope 1, 2, and 3 emissions associated with your physical and digital products, including IoT devices and robotics systems?
- Have you measured the energy consumption of robotics and IoT systems during their use phase and modeled how this scales globally?
- What processes are in place to reduce e-waste from end-of-life connected devices or robotic components?

Attracting and retaining talent

Globally, we are at a skill shortage in several functions or sectors. As the war on talent is heating up, companies must find new ways to attract and retain talent. Access to IT skills remains a top priority for technology leaders year after year. AI in particular is creating the world's biggest tech skills shortage in over 15 years (Nash Squared/Harvey Nash Report 2025).

Different generations also have other demands. Today, Millennials make up roughly 36% of the workforce in the US. Millennials come with varying requirements than previous generations. They seek out purpose-led companies with strong **Corporate Social Responsibility** (**CSR**) where they can be a contributing factor. Among Millennials, 64% won't take a job if their employer doesn't have a strong CSR policy (Fortune 2024).

A clear majority of Gen Z employees prioritize meaningful work over financial gain. According to Deloitte's 2025 Gen Z and Millennial Survey, approximately 89% of Gen Zers view having a sense of purpose as essential to their job satisfaction and overall well-being (Deloitte 2025). Complementing this, a Monster.com survey referenced in a January 2025 SHRM article reveals that 74% of Gen Z workers rank purpose at work as more important than a paycheck (SHRM.org 2025).

Employee activism is becoming more widespread. A clear example was when 1,000 **McKinsey and Company** consultants asked the firm to disclose their clients' CO_2 emissions and called for them to discontinue doing business with the world's greatest polluters in an open letter (Beals 2021). This situation is not unique to McKinsey and Company, and employers should expect employees to speak out against them when they are not living up to the set-forth ESG standards and public commitments.

You should ask yourself what you need to do to set yourself apart and attract and retain the stars of tomorrow:

- What is your attractiveness in the job market? What is your share of Millennials?
- Are you falling short on your CSR values, resulting in an inability to attract and retain talent?
- Are you able to close your internal skills gap or are you forced to rely on partners?
- Do you have an internal program to upskill employees?

Positive impact on society

Companies are increasingly expected to have a positive impact on society. Within IT, this is more commonly referred to as *IT for society* or *Tech4Good*. Moving from a shareholder supremacy business model to a multi-stakeholder business model is imminent. Companies can no longer compete and stay in business solely by being profitable and only serving shareholder needs. The scope has increasingly become wider, forcing companies to become socially, environmentally, and ethically responsible and help many stakeholders, such as employees, customers, partners, the communities in which they operate, and society. As an example, at the inauguration of **Salesforce.com**, founder **Marc Benioff** introduced the **1-1-1 model**, which commits 1% of Salesforce equity, technology, and employee time to improving education, equality, and the environment for everyone. Since then, 18,000 companies have followed suit and introduced similar programs (Pledge 1%. n.d.).

The following are key questions to ask yourself:

- What positive impact does your company have on society?
- Do you have an internal program for employees to regularly donate their time to a specific cause?
- Do you have a program to leverage suppliers in less-wealthy countries or areas?
- Do you have a mechanism to donate old IT equipment to charities, schools, or individuals?

Reducing IT complexity

IT complexity is synonymous with high IT costs, a slow pace of innovation, and compliance challenges. IT complexity is an inhibitor to operational excellence driving efficiency and effectiveness. Large global companies are complex, with multiple geographic locations, different divisions and business units, and diverse business processes, so it should be no surprise that they also have a complex IT landscape. Although there is no definitive count, analysis of various sources and data points indicates that large, billion-dollar-plus enterprises today manage between 650 and 1,100 applications, depending on scope and inclusion (e.g., SaaS versus all enterprise applications).

In the highest tiers, the most complex organizations may oversee up to 3,400 applications. Reducing the number of applications in your application portfolio is an efficient, cost-saving venture. It is also a significant contributing factor to reducing your GHG emissions in terms of reduced energy consumption, reduced hardware, and storage. We will examine the topic of application rationalization further in *Chapter 7, Applications and Architecture*.

The following are key questions to ask yourself:

- Do you have a high IT complexity within your enterprise?
- How many applications do you have within your enterprise?
- How are you identifying and tracking shadow IT?
- Do you actively work with **Application Portfolio Management** (**APM**) and application rationalization?

Risks

As highlighted in *Chapter 1, Our Most Significant Challenge Ahead*, the World Economic Forum highlights in the 2024 Global Risks Report that extreme weather was the most significant risk t facing humanity, (Global Risks Report 2024). With the war between Israel and Hamas, and the continuance of Russia's war with Ukraine, state-based armed conflict bumped weather to No. 2 in 2025. Transitioning to net zero is the most potent strategy to mitigate these risks. Companies are increasingly exposed to ESG risks that can translate into economic loss, stranded assets, and inaccurate valuation. The risk areas are divided into physical and transition risk categories. Physical risks are acute or chronic, as in more frequent and severe adverse natural events such as droughts, floods, heatwaves, and wildfires. Transition risks are the changes in response to climate change issues such as climate policy shifts, consumer preferences, and emerging new technology. Both categories need to be managed to make an orderly net-zero transition to a new sustainable state and set up companies for long-term business success.

If we look closer at business risk, cyber incidents have been ranked as the #1 business risk since 2020 (Allianz Risk Barometer 2025). During the COVID-19 pandemic, cybercrime increased by 600%. In February 2022, national cybersecurity agencies issued joint statements to strongly advise businesses to strengthen their security resilience after observing increased cybercrime activity again due to the Russian invasion of Ukraine. In 2024, the CrowdStrike outage also underscored the global economy's dependence on secure IT systems. Besides the imminent cyber incident risks, several risks are connected to climate change, for example, natural catastrophes such as flooding, drought, wildfires, energy shortages, and pandemic outbreaks. Managing your ESG risks as part of your overall enterprise risk management framework is essential.

The following are key questions to ask yourself:

- What changes do you see from a climate change perspective?
- Is your company engaging in scenario-based planning to model various scenarios?
- Are clients abandoning you due to poor sustainability and sustainable IT practices?
- Do you envision the risk of asset loss or property destruction due to natural catastrophes such as flooding, drought, or wildfires?
- Does energy dependency challenge access to renewable energy sources?
- What is your sensitivity to rising material costs or energy prices?
- How resilient are your critical systems to a major cyberattack or global outage, such as the 2024 CrowdStrike incident?
- Do you have a cyber incident response plan that is regularly tested and updated for emerging threats?
- How well are your vendors and supply chain partners protected against cybersecurity breaches?

In *Chapter 12*, *Sustainability by IT*, we will explore some of these use cases further in terms of Earth insights, wildfire risk analysis, and water availability.

Employee engagement

Sustainability is a team effort. It is not enough for a few people, companies, or governments to acknowledge the problem; executive commitment and employee engagement must be firmly established.

It is about developing a culture centered around sustainability, raising awareness, educating, and activating employees in IT and across the enterprise. In 2024, at the SustainableIT.org Summit and Impact Awards event in Hamburg, tourism company **TUI Group's Isabelle Droll**, who leads IT sustainability for the tourism company, was asked about educating staff on sustainability and the effectiveness of compulsory training: "Our conviction was if we want to make a change in IT, we need to educate all our people because not all of them have an understanding of the 17 UN Sustainable Development Goals, for example. So, we created training modules with deep-dive possibilities on data centers, on a circular economy, and with a quiz at the end. You're not fired if you're not completing the training, but you will get reminder after reminder and lots of pushes. We have reached more than 80% of our employees doing this. We now see employees actively asking what they can do to contribute to the sustainability strategy."

The training itself, an e-learning "Sustainability Academy," augmented with lunch and learns and tech workshops, was developed with minimal budget, leveraging internal resources and expertise. A master's thesis student played a pivotal role in developing the content, conducting a survey among IT colleagues and synthesizing information from various sources. The training material was compiled from a mix of expert interviews, online courses, and literature

on sustainability. Collaboration with TUI's HR department and other stakeholders ensured the training was aligned with broader corporate objectives and accessible to all relevant parties. The training was designed to be a concise, 30-minute e-learning module, making it easily accessible and manageable to complete.

Did it drive a sustainability culture? Perceptions point to yes, even though IT teams are distributed across multiple business units. Among the 2,000-person IT staff, 93% perceive sustainability as strategically relevant for the company, and 80% perceive sustainability as strategically important within their working area of IT. Three-quarters of the staff say they would like to get actively involved in the company's sustainability initiatives (SustainableIT.org 2024).

Additionally, the training modules are designed to be dynamic, ensuring they stay up to date with the latest advancements in both IT and sustainability. For example, TUI recently introduced a training module on AI and sustainability to help colleagues understand how AI can support environmental goals and how to use it responsibly.

Training resources are readily available and may cost little more than a few weeks of a team member's time, notes **Kerry O'Donnell**, one of this book's technical reviewers, who implemented IT sustainability training while at Estée Lauder Companies: "You can investigate LinkedIn learning and other free online courses and leverage your HR's existing learning platform to package and host your sustainability courses and track completions." Kerry adds that while green practitioner or other certifications may be the individual's objective, the goal is staff sustainability-awareness, "and a mindset that carries through when they buy, build, run, or enhance technology in their daily work."

As happened at TUI Group, education typically leads to a desire by IT employees to engage directly in solutions. At appliance manufacturer Electrolux, IT employees had a strong awareness of their cloud infrastructure's power consumption. To engage them directly, they were presented with a challenge to delete as much of their cloud-stored content as possible. Employees with the most deletions over the course of a month would win the *Cloud Challenge*. Simple initiatives such as this that are visible and engage individuals directly are great ways to start with only the resources you already have in your organization.

At Schneider Electric, education and awareness campaigns have been crucial for embedding sustainability into the company culture. A dedicated SharePoint site for employees contains the quarterly results for the company's Green IT Program, a Green IT Library, an "I have an idea!" link, which any employee can use to submit an idea, links to trainings, upcoming Green IT events, and other information. The Green IT site and social campaigns have contributed to a significant increase in internal engagement, from 25,000 impressions in the early years to 350,000 impressions recently. Schneider Electric has taken steps to provide all employees and others with meaningful ways to make a difference through their own actions. One approach is a formal sustainability research project opportunity through its Electrifiers Program, which includes a subdomain specifically for Green IT. One recent project launch is focused on the emissions associated with the usage stage of software (SustainableIT.org 2024).

Engagement at ABN AMRO Bank in the Netherlands took the form of a series of competitive hackathons. The first, in 2023, was a two-day event involving approximately 150 participants (mostly from IT staff and a few from business) organized into 10 teams. Each team, composed of product owners and their selected DevOps engineers, chose one or two applications from their portfolio. The teams then competed on ways to adapt or rearchitect the applications to consume less energy, minimize data and compute resources, and thereby reduce carbon emissions. We will take a closer look at this and other hackathons in *Chapter 12*, *Sustainability by IT*.

While training and team competition can engage IT staff in the sustainability cause, how do you embed sustainability mindsets into their day-to-day roles? One way is to thread sustainability into your project management methodology. A project-focused sustainability framework to consider is **Projects Integrating Sustainable Methods (PRiSM)**, developed by GPM Global in 2013. Based on the P5 Standard—**People, Planet, Prosperity (Profit), Process, and Product**—PRiSM can elevate outcomes by ensuring that sustainability is embedded from planning through deployment and beyond. Here is an example:

- **People**: Evaluate how digital transformation or automation impacts workforce inclusion, upskilling, and stakeholder equity
- **Planet**: Monitor energy consumption, e-waste potential, and lifecycle impacts of hardware and software components
- **Prosperity**: Assess long-term value—not just immediate ROI but considering sustainable operational savings and brand trust
- **Process**: Incorporate ethical, transparent governance—such as data privacy, cybersecurity standards, and responsible AI practices

- **Product**: Ensure that IT deliverables are designed with modularity, repairability, accessibility, and environmental efficiency in mind

PRiSM can help project leaders consider the following:

- How does this project impact people, planet, and prosperity?
- Are sustainability risks and opportunities managed throughout?
- Is the project aligned with corporate sustainability goals?
- How do we measure and report sustainability performance?

Another IT route toward the destination of sustainability culture is through circularity and a zero e-waste goal. In fact, CIOs say that reducing e-waste is a great starting point for sustainability because it doesn't typically require new investment and provides a very visible and tangible impact. Circularity in general is reinforced by 9Rs thinking (Kirchherr, et al. 2017): *R0 – Refuse, R1 – Rethink, R2 – Reduce, R3 – Reuse, R4 – Repair, R5 – Refurbish, R6 – Remanufacture, R7 – Repurpose, R8 – Recycle, and R9 – Recover*, as illustrated in *Figure 2.10*. We will return to this model later in the book since it is a valuable tool for introducing circular thinking into the fabric of your organization:

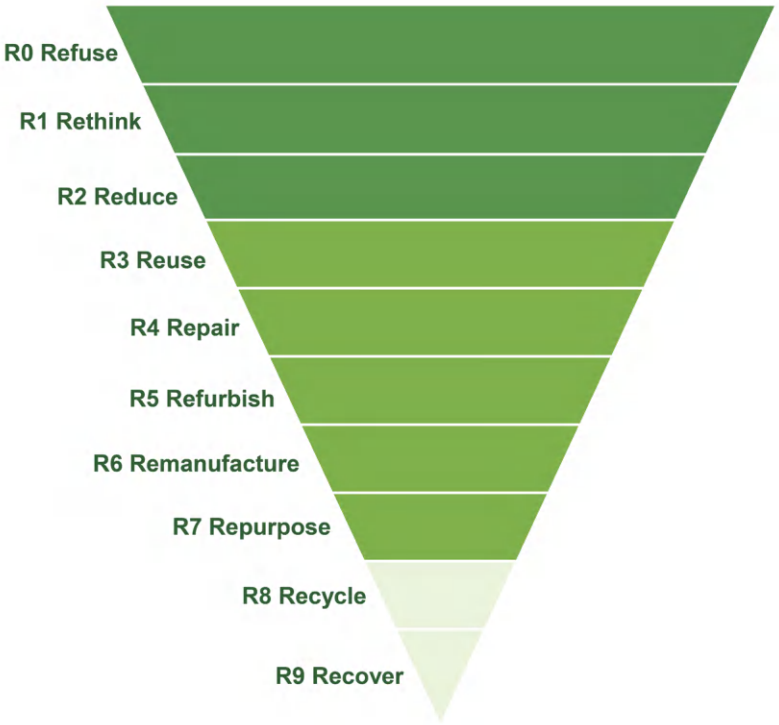


Figure 2.10 – 9Rs circularity framework

Your company's sustainability and ethics can significantly impact talent retention and attraction. By embedding this thinking into the minds of employees, they will start to make more purposeful decisions that can positively impact your company's IT GHG emissions and financial impact.

These are six simple things you can ask your employees to do:

- Turn IT equipment off during non-working hours
- Reduce data storage
- Limit paper-based printing and promote e-services
- Prolong the life of ICT equipment by avoiding extreme temperatures, direct sun exposure, and damage during transportation
- Use fit-for-purpose software and non-AI alternatives when appropriate
- Ask employees to First assess the necessity of new devices (e.g., second and third monitors), and to consider buying refurbished ICT equipment
- Adopt a sustainability-first mindset when creating and innovating new products and services
- Get trained in writing efficient, well-structured AI prompts, which consume less computational power

Readiness

The final ESG consideration for IT is readiness. As companies are coming under increased pressure, as a technology leader, so will you. Assess honestly and earnestly—what is your readiness? Do you have the proper structure, people, processes, and technology capabilities to start? What do you need to be able to establish traceability and an emission baseline reliably? Do you have an emission reduction plan in place? If the answer is no, do not worry. That is what this book intends to do—enable you to take concrete steps toward a more sustainable IT practice.

What does a sustainable IT organization look like?

We have discussed the rationale and drivers for corporate and IT sustainability, their respective value drivers, and the differentiators that amplify that value. We posed many questions to consider at the start of the journey. But what constitutes a sustainable IT function—what are its prime characteristics? SustainableIT.org has created a simple graphic of 12 prime characteristics (which can also serve as goals), distilled from a much larger model of 240 IT-tailored topics and metrics (SustainableIT.org 2024).

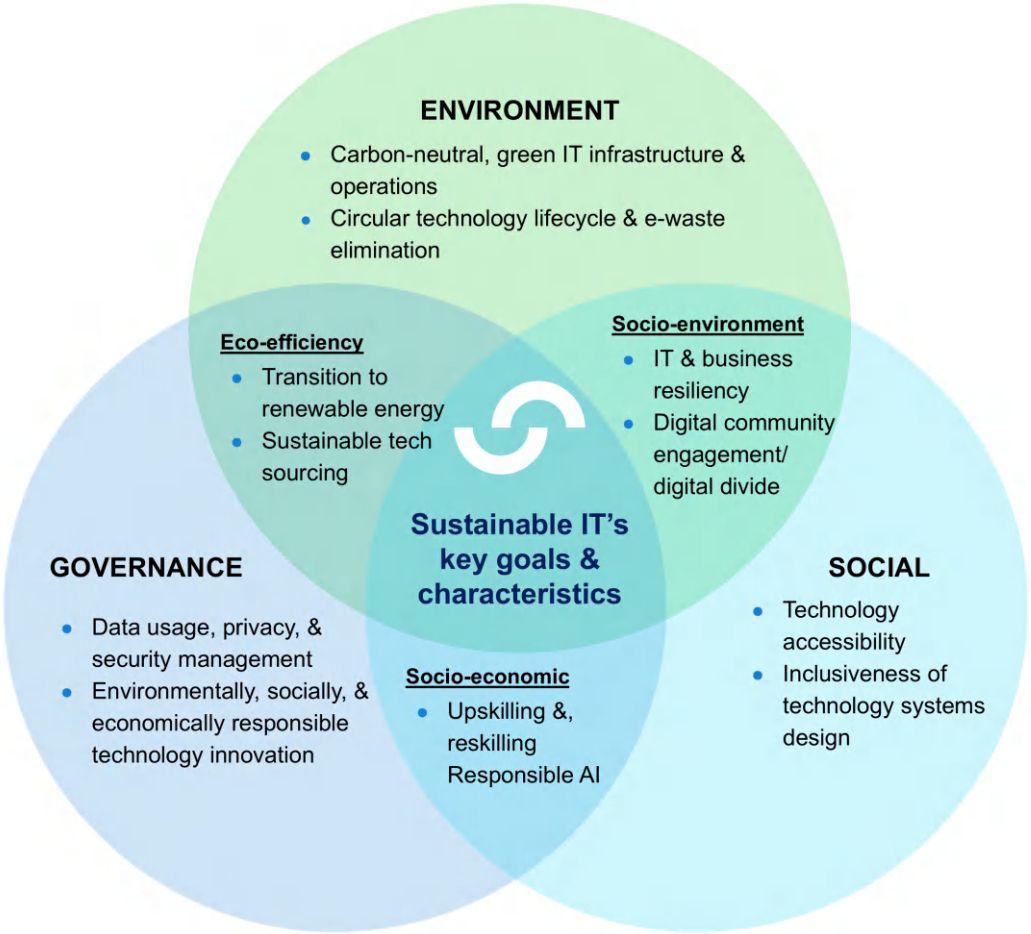


Figure 2.11 – The target characteristics of a sustainable IT function

Each circle represents a core sustainability pillar, with two prime characteristics under each, and three additional "intersection" areas where the domains overlap.

The **environmental dimension** emphasizes decarbonizing IT operations and building circular technology lifecycles that minimize e-waste. The **social dimension** highlights accessibility and inclusivity, ensuring technology benefits diverse communities and avoids exacerbating digital inequities. **Governance** focuses on data privacy, security, and responsible innovation.

Where these pillars intersect, we see more advanced characteristics emerge:

- **Eco-efficiency**, such as renewable energy transitions and sustainable tech sourcing
- **Socio-environmental practices**, including IT and business resiliency and digital community engagement
- **Socio-economic responsibilities**, such as upskilling and deploying AI responsibly

Many IT organizations have long experience in the governance goals, but lag in the environmental and social domains. The visual makes this gap tangible and shows that achieving sustainable IT requires balanced progress across all three ESG pillars, ultimately embedding sustainability into IT's culture, strategy, and daily operations.

Summary

In this chapter, you have learned about the main motivators and value drivers of a sustainable IT agenda. We understood the difference between the three key concepts: sustainable IT, sustainability by IT, and IT for society. Finally, we gained more in-depth knowledge of what ESG considerations exist for IT.

We will now enter *Part 2* of this book. It will start with an introductory chapter introducing some critical areas of sustainable IT practice. The following chapters will be devoted to the data center and cloud, application and data, IT hardware management, energy resource management, vendor management and IT procurement, and sustainability by IT.

Bibliography

- AIPRM. 2024. *AI in the Workplace Statistics 2024*. `https://www.aiprm.com/ai-in-workplace-statistics/`.
- Allianz. 2025. *Allianz Risk Barometer 2025*. `https://commercial.allianz.com/content/dam/onemarketing/commercial/commercial/reports/Allianz-Risk-Barometer-2025.pdf`.
- Beals, Monique. 2021. *McKinsey employees angered over firm's work with world's top polluters*. October 27. `https://thehill.com/business-a-lobbying/578802-mckinsey-employees-angered-over-firms-work-with-worlds-top-polluters`.
- Birch, Kate, Sustainability Mag. 2024. *PwC CEO Survey: Sustainability Takeaways From Leading Execs*. January 18. `https://sustainabilitymag.com/sustainability/pwc-sustainability-takeaways-from-worlds-leading-ceos`.

- Capgemini. 2021. *Sustainable IT*. https://www.capgemini.com/wp-content/uploads/2021/07/Sustainable-IT_Report-2.pdf.
- Causeartist. 2025. *Case Study: Patagonia*. https://www.causeartist.com/case-study-patagonia/.
- Cyber Security Hub. 2022. *The biggest data breaches and leaks of 2022*. https://www.cshub.com/attacks/articles/the-biggest-data-breaches-and-leaks-of-2022.
- Data Privacy Manager. 2025. *20 biggest GDPR fines so far*. https://dataprivacymanager.net/5-biggest-gdpr-fines-so-far-2020/.
- Deloitte. 2025. *2025 Gen Z and Millennial Survey*. https://www.deloitte.com/global/en/issues/work/genz-millennial-survey.htm.
- Deloitte. 2024. *As generative AI asks for more power, data centers seek more reliable, cleaner energy solutions*. https://www.deloitte.com/us/en/insights/industry/technology/technology-media-and-telecom-predictions/2025/genai-power-consumption-creates-need-for-more-sustainable-data-centers.html.
- Digiconomist. *Bitcoin energy consumption worldwide from February 2017 to May 19, 2025 (in terawatt hours)* [Graph]. In Statista. https://www.statista.com/statistics/881472/worldwide-bitcoin-energy-consumption/.
- EESI. 2025. *Data Centers and Water Consumption*. https://tinyurl.com/3zzh2w6x.
- Fortune. 2024. *CSR is a core business function. It's time to treat it that way*. https://fortune.com/2024/05/07/csr-is-a-core-business-function-its-time-to-treat-it-that-way/.
- Global E-waste Monitor. 2024. ITU/unitar. *Electronic Waste Rising Five Times Faster than Documented E-waste Recycling*. https://ewastemonitor.info/the-global-e-waste-monitor-2024/.
- *Global Risks Report*. 2024. World Economic Forum. https://www.weforum.org/publications/global-risks-report-2024/.
- GlobeScan, Accounting for Sustainability, SustainableIT.org, ERM Sustainability Institute, Salesforce. 2025. *Sustainability Value Triangle*. https://globescan.com/2025/02/27/sustainability-value-triangle/.
- Guidi, Gianluca, etc. 2024. *Environmental Burden of United States Data Centers in the Artificial Intelligence Era*. https://arxiv.org/pdf/2411.09786.
- HSBC. 2024. *Strengthening the chain: Transform the Norm*. https://cdn.cdp.net/cdp-production/cms/reports/documents/000/007/890/original/CDP_HSBC_Report_2024.pdf?1727343420.

- IBM. 2024. *Cost of a Data Breach Report 2024*. https://www.ibm.com/reports/data-breach.
- IBM. 2024. *State of Sustainability Readiness Report 2024*. https://tinyurl.com/ct3fuba2.
- IEA. 2025. *AI is set to drive surging electricity demand from data centres while offering the potential to transform how the energy sector works*. https://www.iea.org/news/ai-is-set-to-drive-surging-electricity-demand-from-data-centres-while-offering-the-potential-to-transform-how-the-energy-sector-works.
- IMF. 2024. *AI Will Transform the Global Economy. Let's Make Sure It Benefits Humanity*. https://www.imf.org/en/Blogs/Articles/2024/01/14/ai-will-transform-the-global-economy-lets-make-sure-it-benefits-humanity.
- Imperial Business School. 2024. *Corporate Sustainability and Shareholder Returns: The Role of Business Impact Maturity*. https://www.imperial.ac.uk/business-school/faculty-research/research-centres/leonardo-centre-business-society/publications-reports/corporate-sustainability-and-shareholder-returns/.
- Internet Society Pulse. 2023. *One-Third of the Global Population Remains Offline*. https://pulse.internetsociety.org/blog/one-third-of-the-global-population-remains-offline.
- ITU. 2024. *Measuring digital development: Facts and Figures 2024*. https://www.itu.int/itu-d/reports/statistics/facts-figures-2024/.
- Kahoot! 2024. *Training for the future of work*. https://kahoot.com/training-for-the-future-of-work/.
- Kantar. 2024. What is the sustainability value case for brands? https://tinyurl.com/yjjxhd38.
- Kirchherr, et al. 2017. *Conceptualizing the Circular Economy: An Analysis of 114 Definitions*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3037579.
- Kroll. 2023. ESG and Global Investor Returns Study. https://www.kroll.com/en/reports/cost-of-capital/esg-global-investor-returns-study.
- Kronthal-Sacco and Whelan. 2024. *Sustainable Market Share Index. NYU | STERN - Center for Sustainable Business*. https://www.stern.nyu.edu/sites/default/files/2024-05/2024%20CSB%20Report%20for%20website.pdf.
- NYU Stern Center for Sustainable Business. 2025. *Sustainable Market Share Index™*. https://tinyurl.com/3hb35kkf.

- Marsh. 2024. *The business case for climate resilience*. https://www.marsh.com/en/risks/climate-change-sustainability/insights/business-case-for-climate-resilience.html.
- Nature. 2023. *Systemic risks from climate-related disruptions at ports*. https://www.nature.com/articles/s41558-023-01754-w.
- Nature Computational Science. 2024. *E-waste challenges of generative artificial intelligence*. https://tinyurl.com/583dkcjj.
- Otis, Nicholas g., et al, Harvard Business School. 2024. *Global Evidence on Gender Gaps and Generative AI*. https://www.hbs.edu/ris/Publication%20Files/25-023_8ee1f38f-d949-4b49-80c8-c7a736f2c27b.pdf.
- McKinsey. 2023. *The impact of generative AI on Black communities*. https://www.mckinsey.com/institute-for-economic-mobility/our-insights/the-impact-of-generative-ai-on-black-communities.
- Nash Squared/Harvey Nash Report. 2025. *AI creates the world's biggest tech skills shortage in over 15 years, finds Nash Squared/Harvey Nash report*. https://tinyurl.com/yuautnnt.
- Pledge 1%. n.d. Home page. *About Us*. https://www.pledge1percent.org/about-us/.
- PWC. 2025. PwC's Second Annual State of Decarbonization Report. https://www.pwc.com/us/en/services/esg/library/decarbonization-strategic-plan.html.
- Reuters. 2025. *Deutsche Bank-owned asset manager DWS fined $27 million for greenwashing*. https://www.reuters.com/sustainability/german-asset-manager-dws-fined-25-mln-eur-greenwashing-case-2025-04-02/.
- SEC. 2023. *Deutsche Bank Subsidiary DWS to Pay $25 Million for Anti-Money Laundering Violations and Misstatements Regarding ESG Investments*. https://tinyurl.com/3s24zrha.
- SHRM.org. 2025. *How to Attract Gen Z Workers with Purpose-Driven Workplaces*. https://www.shrm.org/enterprise-solutions/insights/how-to-attract-gen-z-workers-with-purpose-driven-workplaces.
- SustainableIT.org. 2024. *IT Standards for Environmental, Social, and Governance Sustainability*. https://www.sustainableit.org/standards/it-esg-standards.
- SustainableIT.org. 2024. *Schneider Electric's Sustainable IT Journey*. https://members.sustainableit.org/knowledgebank-mfe#/knowledgebank/4/668c5249bba5b6009d661012/0 (Access restricted to SustainableIT.org members only).
- SustainableIT.org. 2024. *TUI Group's Sustainable IT Journey*. https://members.sustainableit.org/knowledgebank-mfe#/knowledgebank/4/668c449cbba5b6009d660f2a/1 (Access restricted to SustainableIT.org members only).

- Statista. 2025. *Concerns about generative AI's impact on cybersecurity worldwide in 2024*. https://www.statista.com/statistics/1448275/global-concerns-about-genai-s-impact-on-cybersecurity/.
- The Economic Times. 2025. *Digital Divide: MSMEs struggle to tap into AI revolution as high costs block access*. https://tinyurl.com/2rfj9x49.
- UN Trade and Development. 2024. *Digital Economy Report 2024*. https://unctad.org/publication/digital-economy-report-2024.
- Unilever. 2020. *Making sustainable living commonplace for 8 billion people*. https://www.unilever.com/news/news-search/2020/making-sustainable-living-commonplace-for-8-billion-people/.
- US Securities and Exchange Commission. 2023. *Deutsche Bank Subsidiary DWS to Pay $25 Million for Anti-Money Laundering Violations and Misstatements Regarding ESG Investments*. https://www.sec.gov/newsroom/press-releases/2023-194#:~:text=%E2%80%9CImportantly%2C%20those%20AML%20obligations%20require,ESG%20integrated%20products%20were%20accurate.
- Verizon. 2022. *Data Breach Investigations Report 2008 – 2022*. https://www.verizon.com/business/resources/reports/2022-dbir-data-breach-investigations-report.pdf.
- Wong, Yin Angel. 2025. *A Study on the Effectiveness of Patagonias Sustainability-Driven Brand Strategy*. https://www.researchgate.net/publication/392542103_A_Study_on_the_Effectiveness_of_Patagonias_Sustainability-Driven_Brand_Strategy.
- World Bank Group. 2024. *Measuring the Emissions and Energy Footprint of the ICT Sector: Implications for Climate Action*. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099121223165540890/p17859702a98880540a4b70d57876048abb.
- World Economic Forum. 2025. *The Future of Jobs Report 2025*. https://www.weforum.org/publications/the-future-of-jobs-report-2025/digest/.
- World Economic Forum. 2025. *Unlocking green growth: Sustainability as a key driver of corporate innovation*. https://www.weforum.org/stories/2025/01/unlocking-sustainability-green-growth-innovative-strategies/.

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Part 2

What Are Sustainable IT Practices?

If *Part 1* explores why we must act, *Part 2* turns to what IT can do. It offers a roadmap for integrating sustainability into every layer of enterprise technology. Its 10 chapters equip you with the frameworks, standards, and examples needed to build a credible, measurable, and future-ready sustainable IT practice—one that balances environmental stewardship, social inclusion, and business resilience in the digital age.

Each chapter introduces proven strategies, standards, and implementation models that help align IT operations with net-zero and circular-economy goals. You'll find clear guidance on how to measure digital infrastructure emissions, apply GreenOps and lifecycle governance to cloud workloads, master hardware lifecycle planning, and employ standard metrics and tools to establish baselines and track progress.

Part 2 consists of the following chapters:

- *Chapter 3*, *The Fundamental Building Blocks of a Sustainable IT Practice*
- *Chapter 4*, *Responsible and Sustainable AI Governance*
- *Chapter 5*, *Social Sustainability: Accessibility, AI, and the Digital Divide*
- *Chapter 6*, *Data Centers and the Cloud*
- *Chapter 7*, *Applications and Architecture*
- *Chapter 8*, *Data*
- *Chapter 9*, *IT Hardware Management*
- *Chapter 10*, *Energy Resource Management*
- *Chapter 11*, *Leveraging Your Buying Power*
- *Chapter 12*, *Sustainability by IT*

3

The Fundamental Building Blocks of a Sustainable IT Practice

> *We will move to a low-carbon world because nature will force us or because policy will guide us. If we wait until nature forces us, the cost will be astronomical.*
>
> *Christiana Figueres*

In *Part 1* of the book, we focus on the *why* – why is climate change an imminent threat to humanity? – and understand the role sustainability plays in the transition toward a more sustainable future. *Part 2* of the book focuses on the *what* – what are the critical building blocks of a Sustainable IT practice?

In this chapter, you will learn about the critical building blocks of a Sustainable IT practice. This is an introductory chapter of *Part 2*, *What Are Sustainable IT Practices?*, of the book. It introduces the subsequent chapters, where we will go to great lengths to explore each key topic. This chapter will give you an introduction to the critical aspects of IT-led sustainability, as well as a preview of the rest of the chapters in *Part 2*. We start with a sustainable IT reference model that we will apply throughout the chapters, helping to orient you within the broad spectrum of IT-led sustainability.

Other topics covered will include the following:

- Sustainability team roles and skills
- Standard metrics tailored for measuring IT's ESG impact
- Responsible AI governance
- IT social sustainability
- Multiple aspects of sustainable IT infrastructure, including data centers and the cloud, applications and architecture, data governance, IT hardware, and energy resource management
- The leverage you have for vendor sustainability
- Technology's role in enterprise sustainability

The main objective of this chapter is to introduce you to the essential aspects of IT sustainability and the primary focal points of sustainability by IT and for IT. The chapter features contributions on ESG measurement from Fiona Leibundgut, Zurich-based digital sustainability advisor; Dr. Berndt Pilgram, an AI governance expert, on responsible AI; and Ahmad Antar, Harvard instructor, on social sustainability. By the end of this chapter, you will have learned about the primary high-level concepts you can directly apply, impact, and influence within the environmental and social sustainability pillars. You will also have a clear view of the roles, levers, and great opportunities IT teams have for leading sustainability transformation within their function and across the enterprise.

This chapter sets the stage for a deeper dive into each of these areas in the chapters that follow.

The unprecedented growth of IT

As we saw in the previous chapters, IT has an impact on the environment, but also has a series of direct and indirect impacts. The entire ICT sector emits around 1.5-4% (World Bank 2024) of global greenhouse gases, and data centers account for 2% of global electricity use and greenhouse gas emissions (Deloitte Insights 2024). The environmental impact will increase significantly unless we find other, more sustainable ways to deliver IT.

In the last decade, we have seen massive growth in internet traffic and data center workloads. We have observed a two-fold increase in internet users and a 15-fold increase in global internet traffic (Kamiya 2021). Fortunately, due to significant improvements in energy efficiency, the energy to power data centers worldwide has remained flat at around 1-2%.

Figure 3.1 illustrates the growth in internet traffic between 2015 and 2023, data center workloads, and data center energy use:

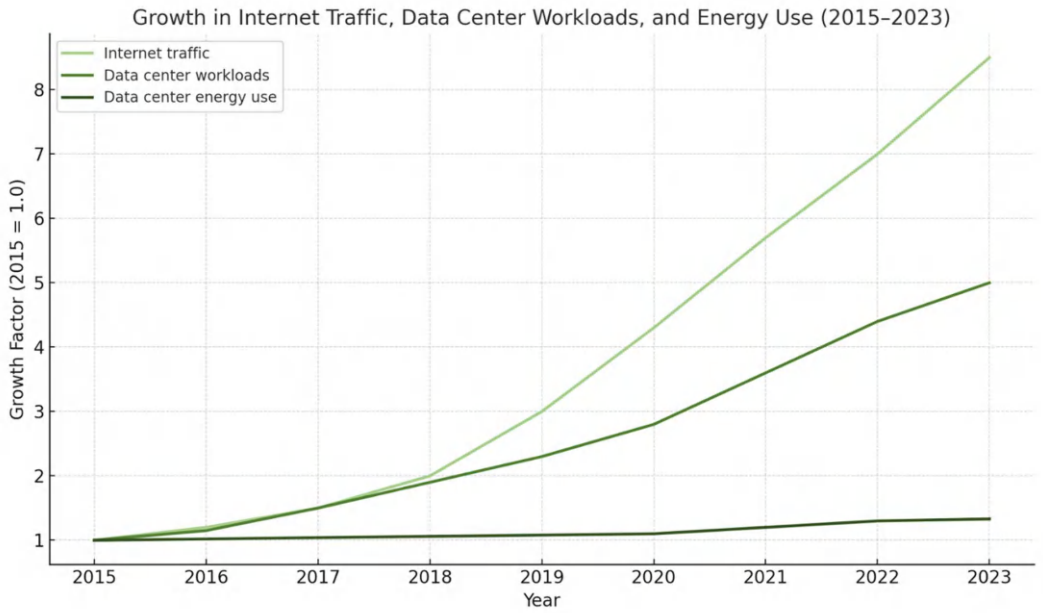


Figure 3.1 – Increase in internet traffic, data center workloads, and data center energy use, 2015–2023 (IEA, 2024)

Although digitalization, hyperconnectivity, and the **Fourth Industrial Revolution (4IR)** bring positive outcomes for the environment, unfortunately, they have the potential to become significant emitters of greenhouse gases. The increased need for digital services also translates into new data centers, computer power, storage, network equipment, and end-user IT equipment such as notebooks, smartphones, and tablets to operate them. Today, IT is far from sustainable.

We fully recognize that each starting point and nature of business is different; therefore, your journey forward will look different. The important thing is to carefully assess what key actions you will require to set yourself on a trajectory toward a more sustainable future. This chapter will dig deeper into those core concepts and dissect how you can make more conscious, sustainable decisions.

Sustainable IT reference model

In this book, we will cover a wide range of topics spanning many IT disciplines. To be able to follow along, we will reference the **Sustainable IT reference model**© frequently throughout the book (© Sundberg, Pastore 2025) illustrated in *Figure 3.2*:

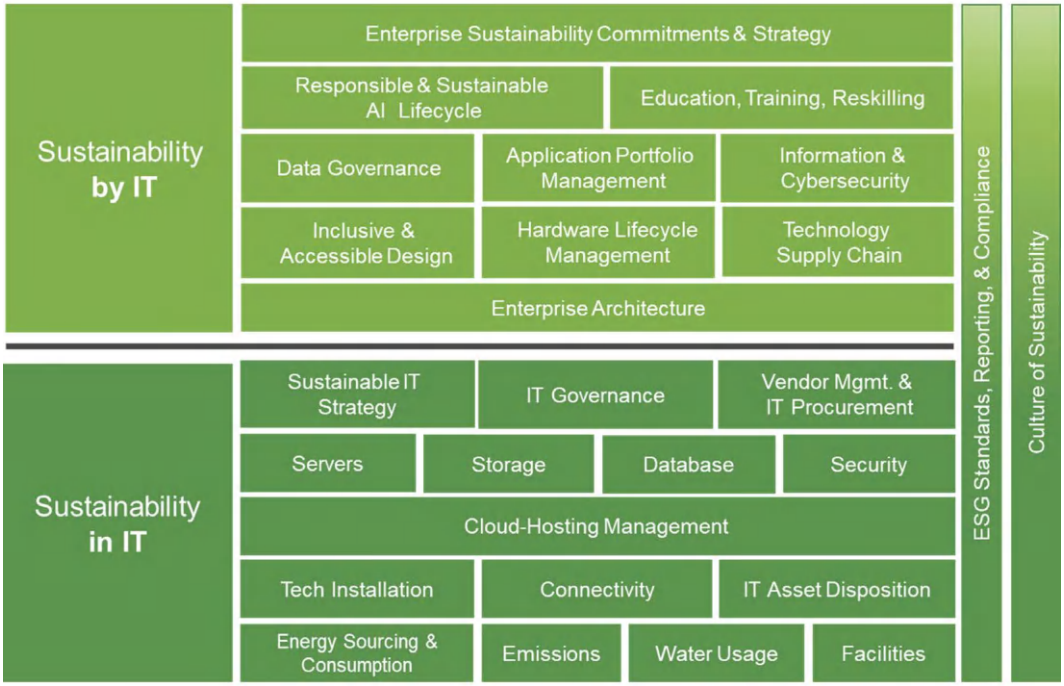


Figure 3.2 – Sustainable IT reference model

The sustainable IT reference model encompasses the key topics regarding sustainability in IT that we will cover throughout the book. The reference model consists of two primary focus areas for IT, and two overarching responsibilities. Let us look at their respective obligations for IT organizations:

- The enterprise that has committed to sustainable transformation and operations depends on IT to lay a foundation of sustainable enterprise architecture – the blueprint for future business infrastructure. Enterprise operating processes, including system design, hardware lifecycles, tech supply chain, data and application governance, and cybersecurity, all must be optimized for the enterprise to achieve its ESG sustainability goals. As the transformational power of artificial intelligence begins to take root, the technology's responsible governance becomes crucial. Nothing will succeed without the proper training and reskilling of employees and other stakeholders.

- Within the IT function itself, sustainability must start with a strategy and set of governance rules. The technology infrastructure that supports enterprise applications and tools – the servers, databases, and security – must be managed sustainably. Installation, connectivity, and asset disposition likewise must be built and executed with sustainability criteria embedded. These are enabled by sustainable management of the fundamental resources of energy, water, and general facilities.
- These elements are sometimes labelled "green IT," a catch-all term that can be applied to IT sustainability programs in general. However, it is important to acknowledge that sustainability in IT is more than just the E in ESG. As we shall see, vendor management and procurement impact social issues such as child labor, as well as environmental factors. IT asset disposition can help close the digital divide in underserved communities, as well as keeping e-waste out of landfills. Reductions in energy and water use in data centers can reduce the strain on supply, benefiting farmers and municipalities dependent on these resources. However, actual environmentally focused green IT programs are often the first formal strategic sustainability effort launched by IT functions, so we will explore examples later in this chapter.
- ESG reporting and compliance requirements span the model because both IT and business colleagues must contribute to the reporting data required, facilitating its availability and ensuring its accuracy and auditability. Most pundits anticipate that sustainability data will eventually reach parity with financial data in terms of the regulatory standards and rules for reporting to which it is subjected.
- A changed culture is the only way to guarantee a robust and lasting state of sustainability across the enterprise and within IT. It must become a natural way of doing business and executing your role, not a one-off project or add-on set of tasks (the way companies typically start on the journey). Culture change requires ongoing education, clear goals from the top, meaningful opportunities to contribute from the bottom up, and sustained commitment in the form of targeted resources and group and individual incentives.

Each area of the reference model has associated capabilities that fulfil an essential role in forming a sustainable IT ecosystem. As we move through the book, these essential capabilities will be defined and explored.

IT sustainability teams and skills

In *Chapter 1*, *Our Most Significant Challenge Ahead*, we looked at examples of employee education and engagement in IT sustainability. Now we'll consider the skills and roles needed to execute IT's sustainability strategy and responsibilities. Typically, there is one IT executive who takes accountability for technology-led or enabled sustainability programs. In most cases, this is not the IT C-suite-level officer, but a direct report. In large, federated companies, the leader responsible may be the CIO of a division, ideally with strong relationships to the other division CIOs.

Following is an example of a job posting for an IT sustainability leadership position, adapted from an actual posting from a hospitality company in 2024. It is a hybrid role that blends IT systems implementation, vendor management, and sustainability leadership. It represents a progressive shift where IT is no longer just an enabler but a strategic driver of corporate sustainability. While several elements stretch beyond traditional IT leadership (e.g., carbon reduction and environmental impact metrics, sustainability networks, and training), the core of the role is well-suited to technologists who understand hospitality systems and are eager to take on a broader environmental mission. The description wisely targets those with technical fluency and a passion for sustainability-driven innovation.

TECHNOLOGY SUSTAINABILITY LEADER JOB DESCRIPTION

About the role

In charge of integrating sustainable technology practices and coordinating solutions such as Smart Thermostat, Food Waste Management, Digital directory, Skip the clean, Digital F&B, and any other services or products, including innovation sustainability opportunities. This role will be responsible for developing and implementing strategies that enhance environmental sustainability through innovative technology solutions.

Reporting lines and key interactions

VP Global Guest Technology & Innovation | Manager, Global Technology Sustainability

Key interactions

- Internally: Tech for facility teams, brands' tech leaders, sustainability team, operations, digital, technology & services, procurement, digital factory, loyalty, security, etc.
- Externally: Suppliers, sustainability forums, focus groups on technology sustainability

Responsibilities

- **Strategy**: Develop and implement a comprehensive technology sustainability strategy that aligns with the group's overall environmental goals.
- **Drive sustainability projects**: Identify opportunities for reducing the environmental impact of our technology operations, including energy management, waste reduction, and resource optimization.
- **Expertise and enhancements**: Provide technical and functional expertise on sustainable tools used in hospitality, and prioritize and define with the HUBs. Research and introduce innovative technology solutions that contribute to sustainability, such as renewable energy sources, energy-efficient hardware, and eco-friendly software applications.
- **Stakeholder engagement**: Partnership with Guest Tech procurement on preferred rates and service levels for hospitality-based technology, defining new business models and service offerings. Collaborate with IT and operational departments to integrate sustainable technologies into everyday practices, partnerships, and potential innovation programs with key start-ups and vendors in the market.
- **Industry trends and networking**: Responsible for forming a sustainability champion community and defining the technology standard guidelines to be used and adapted by the HUBs. Participate in industry forums and networks to represent the hospitality group in sustainability discussions.

- **Compliance**: Monitor and report on the effectiveness of sustainability initiatives, providing insights and recommendations for continuous improvement.

Main complexity/critical issues
• Finalize Smart Thermostat pilot and deploy it at eligible sites. • Alignment with the sustainability team on Guest Technology sustainable initiatives to provide environmental sustainability through innovative technology solutions. • Drive tech sustainability projects according to OKRs and KPIs and encourage business and IT teams to follow the standards. • Educate and train staff on sustainable technology practices and their benefits. • Improve overall company carbon emissions and produce new innovative ideas to improve the overall result. • Stay abreast of emerging trends in technology and sustainability, applying best practices to our operations.

Dimensions

Nature

a. Sustainability knowledge
b. Hospitality facility operations knowledge
c. Hospitality technology

Amount

a. Project/build/implement
b. All facilities globally
c. All brands globally
d. All sustainable guest-facing technology used in facilities
e. All projects involving guest technology and innovation

Profile

Typical background

a. Degree in environmental science, IT, sustainability, or a related field
b. 5 years of experience in a similar role, preferably in the hospitality or technology sector
c. Experience in hospitality technology, very good knowledge of the central organization, and good relationships with the key vendors in the market

Competencies

a. Strong collaborative and communication skills
b. Bringing forward proposals/proactive
c. Curiosity
d. Resilience
e. Customer-centric and focused on delivering results
f. Research

The preceding job posting is for a dedicated position, with the majority, if not all, of the focus on sustainability. Our research shows that when IT has sustainability-dedicated staff, usually a small team of 4 or fewer individuals, they achieve stronger results. Out of a dozen different success factors, having a dedicated team ranked No. 4 for positive impact (SustainableIT.org 2025).

However, dedicated sustainability staff within IT remains a tough sell. Funding and time compete directly against other transformation projects – in particular, AI adoption and scaling. IT organizations that have managed to fund sustainability teams have applied the following strategies and justification:

- Carve the roles out of IT's existing budget. Assign work to contractors to free up dedicated team members for sustainability work.
- Associate team efforts with cost savings. C-suite officers will often back dedicated resources that will deliver savings through sustainability transformation. One obvious example is data center energy efficiency. GreenOps applied to cloud environments should also deliver savings. Both will lead to company carbon footprint reductions across Scopes 2 and 3.

- If there is a mandate for green company products and services, technology enablement can justify dedicated IT resources. Calculating the environmental footprint of thousands of products over their lifecycles using multiple methodologies will not happen without IT's continuing engagement.
- ESG sustainability data is a multi-headed beast that needs to be captured, tamed, delivered, and maintained. Without accurate and timely collection and management of data, companies will not be able to report effectively or efficiently to regulatory agencies, risking the embarrassment of noncompliance and fines. This challenge requires full-time attention from IT.
- In companies with primarily digital products, IT represents at least 40% and as much as 95% of the company's total carbon footprint. To meet corporate climate commitments, IT must actively manage its own emissions, energy, and water consumption.

In short, dedicating IT individuals (as well as funds) to sustainability requires a clear perspective on why IT should be involved – that is, making a sound business case for IT's ongoing active role. Having said this, we often hear from forward-focused CIOs who, in the long run, don't want or expect to have dedicated sustainability personnel. Their ultimate goal is for sustainability to be a routine aspect of all roles and the natural way of doing technology design, development, deployment, and delivery.

Another essential step for IT teams with ESG responsibilities is to structure their roles and reporting relationships in relation to corporate sustainability offices or governing committees (if any). Many IT organizations start working on sustainability in their own silo, independent of the sustainability office. This never lasts long, however. Eventually, IT's efforts come to the attention of the sustainability office, either through necessity or because IT has proven its ESG credibility through major wins. Then what typically happens is IT provides a liaison to the sustainability team, involved in strategic and tactical planning and oversight. IT's role in relation to enterprise sustainability becomes codified and formally integrated in the larger ESG ecosystem. This integrated state is the ideal, not only because it synchronizes ESG programs and initiatives enterprise-wide, but it also may free up centralized sustainability resources for IT purposes.

At Stanford Health Care, a private, nonprofit organization, IT began its sustainability journey like many others have – focusing on its own domain. Subsequently, IT was adopted as a pillar of the company's sustainability program, officially launched in 2022 with an affirmation statement from the Stanford Health Care Board of Directors. This led to a new blended and strategic relationship structure that specified IT's sustainability roles and their interactions with the Sustainability Office and its governance. *Figure 3.3* depicts this structure.

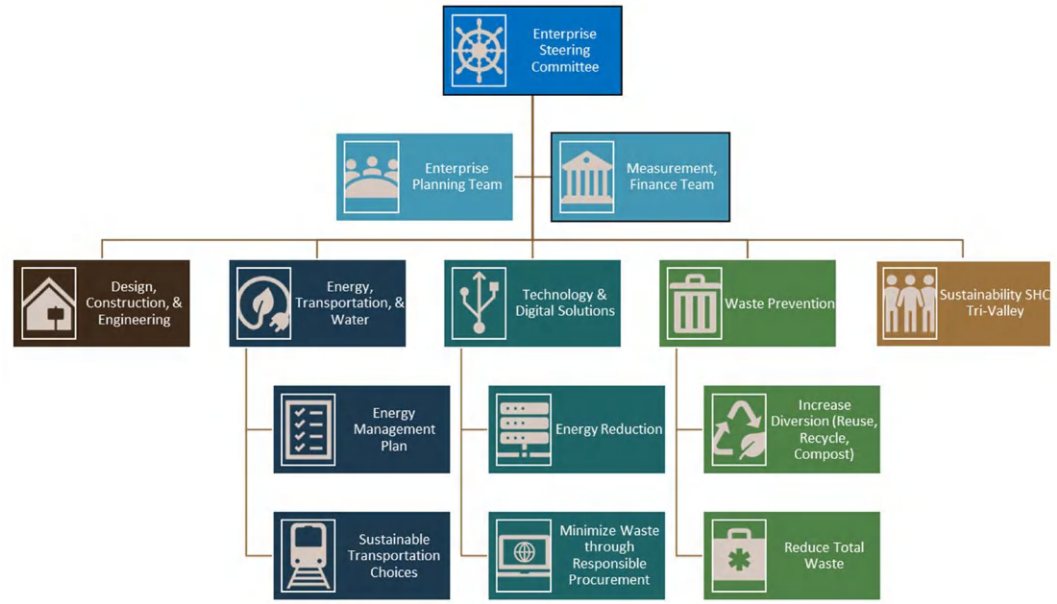


Figure 3.3 – Sustainability governance structure at Stanford Health Care (Source: Stanford Health Care)

In this model, top IT leaders (the CTO and chief enterprise architect) hold seats on the steering committee, chaired by the Senior Vice President and Chief of Facilities, General Services, and Sustainability Officer, which represents multiple operating groups across Stanford's medical enterprise and focuses on strategic direction. The Planning team, also with cross-representation, is the "engine" that facilitates work groups and ensures appropriate levels of project support, re-sourcing, and tracking of outcomes, and is chaired by the Executive Director of Sustainability. The creation of the group was an important signal of the enterprise-level commitment to sustainability, connecting and enabling key workstreams in the institutional design to maximize the impact and inclusion of innovative work in all departments. The five work groups drive sustainability outcomes in their respective areas of expertise, report progress, and openly discuss challenges and opportunities. IT's work group has teams dedicated to energy, e-waste, and procurement. The work group also incorporated Technology and Digital Solutions' own steering committee members, who govern the function's internal ESG program. This governance group is a carry-over from the original IT-specific sustainability leadership model.

While there is no chapter in the book dedicated to IT sustainability staffing and skills, there are several case studies that include details on leadership and execution. As stated earlier, in most cases, IT's current teams must incorporate sustainability into their current roles. If you are a technology procurement leader, then you should add ESG criteria to your vendor assessments, RFPs, and master services agreements. If you are an Enterprise Architect, then you will apply multiple ESG considerations to your architecture designs. For IT staffers, it isn't a traditional role versus a sustainability role. It is sustainability within the next generation of traditional roles.

Standard metrics for IT ESG

One of the most tried and true expressions quoted by IT leaders is, "*You can't manage what you don't measure*," a maxim attributed (more or less accurately) to management guru Peter Drucker. The statement holds true for sustainability both in IT and across the enterprise. IT leaders must leverage a consistent set of ESG metrics that are relevant to their fundamental processes and performance areas. Standardized metrics empower IT leaders with a uniform foundation on which to build an action plan for sustainability in their functions, enterprises, and industries.

To be most effective, metrics must be applied at increasingly elevated maturity levels—from ad hoc, manual efforts to fully automated and embedded implementations.

In this section, we will look at the goals and maturity levels of IT sustainability measurement and a case study on a company's three-year measurement journey, both provided by **Fiona Leibundgut**, a **Zurich-based Digital Sustainability Advisor with SparkIT Consulting**. Then we will have an introduction to SustainableIT.org's IT-tailored sustainability standards taxonomy.

The how and why of sustainability measurement

Performance measurement of IT sustainability is a holistic view of two dimensions:

1. **Measure to reduce**: Quantifying the environmental footprint of the technology estate (lifecycle analysis)
2. **Measure to act**: Tracking efforts that embed sustainability into IT operations and behaviors (e.g., training and awareness KPIs)

Both are essential for building a robust IT sustainability capability and are closely related. Accurately measuring your technology footprint helps prioritize action for maximum impact.

Measure to reduce

Many companies calculate IT-related environmental emissions annually to meet regulatory or reporting requirements. This is typically done by applying an emission factor to total IT spend – producing a spend-based estimate of greenhouse gas emissions.

While this satisfies compliance, it offers limited value for decision-making. Here's why:

- **Spend ≠ emissions**: Price is not a reliable proxy for environmental impact due to market dynamics, negotiations, and pricing strategies. When IT's budget is cut, reported emissions will typically drop, but that is not actual decarbonization. Likewise, when IT spending increases, reported emissions will spike as well, even if operational efficiency has improved. The ESG measurement challenge is to mature beyond cost-based accounting and invest in activity-based measurement systems that track and report real decarbonization outcomes.
- **Narrow focus**: Limiting calculations to GHG emissions neglects broader environmental impacts such as water consumption, raw material extraction, and electronic waste.
- **Lack of lifecycle insight**: Spend-based measurements fail to account for environmental impacts across the full lifecycle of IT assets.

To truly reduce your IT footprint, you need to understand what causes emissions, where they occur across the lifecycle, and when they happen. This approach – lifecycle analysis, aligned with ISO 14001 – provides actionable insights far beyond a single emissions figure.

A lifecycle analysis is vital for the following:

- Prioritizing high-impact actions
- Tracking progress
- Demonstrating success
- Communicating with stakeholders

Measure to act

Not all performance measurement metrics are emissions-based. Metrics that track financial impact, vendor behavior, training, and adoption of good practices are equally important to direct efforts where they matter most, provide feedback loops for continuous improvement, and demonstrate progress to executives and stakeholders.

Key performance metrics in these categories include the following:

- **Financial metrics**: Sustainability often correlates with cost efficiency and can thus be a powerful incentive for leaders to invest. Metrics may include CapEx/OpEx impact of sustainability initiatives and total investment in sustainability-focused innovation.
- **Vendor sustainability metrics**: The bulk of IT's footprint often lies in Scope 3 emissions (purchased goods and services). Partnering with vendors is critical for shared success. Metrics may include company-level commitment (e.g., EcoVadis scores); partnership-level commitment (e.g., joint sustainability plans, governance structures); and product- or service-level insights (e.g., product carbon footprints).
- **Good practice adoption**: Track the adoption of sustainability best practices – most of which drive measurable impacts. Metrics may include percentage of virtualized workloads, asset reuse and materials recovery, and use levels of sustainable procurement practices.
- **Training, engagement, and culture**: Enabling teams is essential to embed sustainability into IT culture. Metrics may include training adoption (e.g., percentage of users completing basic training); training availability (e.g., provision of role-based courses); and percentage of staff certified in Green Software Foundation practices.

Measurement maturity

Achieving effective performance measurement takes time. The maturity model described in *Chapter 13*, *Get Started Today*, defines performance measurement as the use of metrics for targeting goals, tracking progress, and reporting technology-driven transformation impact. Let's break down the five stages of maturity for performance measurement.

Beginning: There is no significant technology sustainability performance tracking. This includes the following:

- No IT metrics defined
- No IT sustainability measurement
- No reporting

When getting started, it is typical to have a rough estimate of total CO_2e emissions calculated by the sustainability team for regulatory reporting. The calculation is: Total IT Spend x Emission Factor = Total IT Emissions, and is categorized in Scope 3: Purchased goods and services.



Note

If you run on-premises data centers, it's likely that these are covered in Scopes 1 and 2 for owned locations and energy consumed, as well.

This is a spend-based estimation and is good enough for compliance. As mentioned earlier, a spend-based estimate is inadequate for impact – what you need is an activity-based calculation done in the form of a **Life Cycle Assessment (LCA)**.

Unstructured: Limited technology sustainability baseline metrics and tracking have been applied in isolated areas or initiatives:

- Limited metrics defined
- Isolated measurement conducted
- Reporting ad hoc or limited to specific initiatives

Typically, at this stage, there is limited commitment from leadership and only a small budget available, so begin with a small, manageable scope (e.g., a business unit or country) to perform your first activity-based LCA.

At this maturity level, you will most likely employ a manual data collection process, which you can carry out either by yourself using the calculation methodology described in *Chapter 13*, *Get Started Today*, or with the help of a third-party tool, depending on your budget. At a minimum, the outcome of the calculation activity should tell you the CO_2e for the selected scope; any other metrics are a bonus at this stage.

Use the findings of the calculation to build internal awareness and support from IT leadership. The tangible results help clarify the need for prioritized action and raise awareness much better than generic data.

Defined: Technology sustainability performance metrics are tracked, reported, and assessed on an ongoing basis:

- Key IT metrics are defined and mapped to the strategic vision
- A measurement program is defined
- IT metrics are regularly reported

At this stage, you should be able to calculate a full baseline of your company's IT emissions using a representative global scope with the same mostly manual data collection as in the previous stage. It needs to be comprehensive enough to be able to set measurable targets and launch strategic initiatives. Because the effort is still largely manual, the reporting frequency will be low (once or twice per year).

Managed: Technology sustainability performance measurement is largely automated, incorporates third-party data, and is continuously adjusted for improved accuracy:

- An IT performance metrics framework is applied
- Automated measurement; vendors/suppliers are integrated into the metrics program
- Widescale reporting and messaging (e.g., board, employees, shareholders, media, potential hires)

At this maturity level, you will transition to integrated, automated performance measurement. Data is collected and displayed in a centralized dashboard, with a higher frequency (e.g., monthly). Your company's enterprise ESG reporting tool is a robust platform for enterprise-wide ESG reporting, but most likely not designed to directly measure the emissions from internal IT operations, making it necessary to use a specialized platform for deep IT sustainability analysis.

There are multiple options for automated data display, which are outlined in *Table 3.1*:

Display Type	Pros	Cons
In-house BI dashboard	• Low cost • Customizable	• High development effort • Needs maintaining • Need to develop or buy a database of sustainability data (e.g., manufacturer PCFs or ResilioDB)
CMDB, FinOps, or observability tool – (e.g., ServiceNow, Flexera, Nexthink)	• Low learning curve • Sustainability data managed and updated by vendor	• Still being developed, may lack full feature set • May require additional licensing costs • Evolving maturity

Specialist IT sustainability tools (e.g., Aguaro, Fruggr, Verdikt, Resilio Tech)	• Tailored and specialized in IT sustainability data – more likely to have additional metrics (e.g., water consumption and mineral/metal use) • Sustainability managed and updated by vendor	• Additional licensing cost

Table 3.1 – IT sustainability metrics display alternatives (Leibundgut 2025)

In this integrated and automated view, you should now be able to filter the data as needed, map it to your organization, and derive valuable insight into the recommended actions. You may still "only" be looking at CO_2e data; however, ideally, the dashboard includes insight into water consumption and mineral/metal use, as well as e-waste totals. Additionally, the tool should help you run simulations to help make strategic decisions, e.g., evaluating the impact of a potential cloud migration.

Optimized: Enterprise and industry standard metrics are fully automated, assessing performance across the value chain and providing accurate insights to external and internal stakeholders:

- Metrics regularly refined and improved; standardized industrywide
- Measurement program fully automated
- IT results integral to enterprise reporting and messaging

Reaching this highest maturity level means sustainability is a native feature of digital operations, embedded in automated IT governance, DevOps workflows, and decision-making tools. Insights enabled by these embedded metrics drive strategic change and are shared across the business and with external stakeholders.

Spend-based estimates have been replaced by activity-based calculations across the entire IT landscape, and these are used by the sustainability teams for corporate reporting.

The future of performance measurement

As IT sustainability matures, performance measurement is shifting from retrospective reporting to real-time, predictive, and impact-oriented insights. Emerging tools increasingly integrate AI/ML to forecast environmental impact, optimize workloads dynamically, and recommend actions proactively.

Effective performance measurement will continue to combine precision in environmental measurement with thoughtful tracking of actions, investments, and culture. Measurement maturity is a journey from basic compliance to strategic influence, and it takes time and calculated investment.

To wrap up this introduction to IT sustainability metrics, here is a case study that illustrates a timeline and approach for implementing metrics.

Case study: A three-year metrics implementation journey

A large global industry player with sustainability objectives including a net zero commitment for 2050 and additional focus on resource preservation started its journey towards sustainable IT with a data-driven approach. The company has more than 100,000 employees worldwide and therefore a significant IT footprint to support its operations. Identifying the most impactful IT areas and quantifying their footprint across the service lifecycle was instrumental in defining a clear IT sustainability strategy and driving efforts in the right direction.

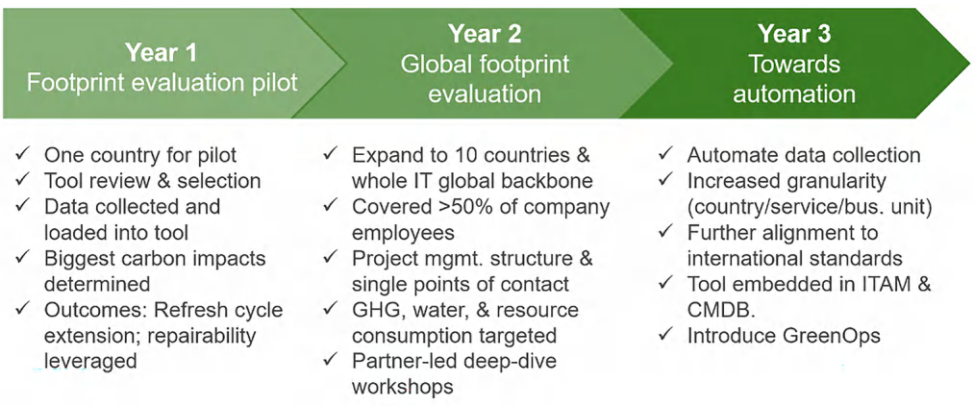


Figure 3.4 – Company timeline for IT sustainability measurement

Year 1 – IT environmental footprint evaluation pilot

The company initiated its first IT environmental footprint evaluation in one country. A quick RFP was conducted to review existing tools on the market and select one that would best support the company's sustainability objectives (science-based, multi-criteria approach, GHG protocol breakdown, aligned with existing standards).

Focusing on a limited scope (about 3% of the company's size) and a single country simplified and accelerated the data collection phase, which still took about two months to complete. All inputs were reviewed and loaded into the selected tool to evaluate the local IT footprint. The results provided a strong foundation for local and global teams to understand the IT services breakdown and their environmental impact. PCs and data centers were identified as the most significant contributors. The commitment of the local team, along with external expertise and tools, created momentum to turn learnings into action and launch local sustainability initiatives such as prolonging PC lifespans and increasing smartphone repairability.

Year 2 – Global IT environmental footprint evaluation

In the second year, the same approach was scaled up to the global IT organization. The entire global IT backbone (PC, network, cloud) was part of the study, as well as local data for 10 countries across Asia, Europe, and the Americas. This represented more than half of the group employees across all regions. Based on the learnings from year 1, a project management structure was set up, and a **single point of contact** (**SPOC**) was identified in each of the participating organizations. This team met on a regular basis to speed up data collection and, most of all, drive increased sustainable IT adoption once results were released. This was made possible by the network of SPOCs as they gained insights throughout the project, supported by external partners providing methodology and expertise.

The results were then reported at the group level, with a focus on carbon, water, and resource consumption, as well as GHG protocol breakdown. Most of the IT footprint was driven by Scope 3 Category 1, from purchased goods and services, especially data centers and servers, followed by PCs and monitors.

During the second phase of the project, a strong focus was placed on turning data into action, and the external partner ran deep-dive workshops with each of the participating organizations. This helped identify bottom-up actions supporting the global sustainable IT strategy and mobilized teams on local initiatives.

Year 3 and beyond – Towards automation

From a tool perspective, the focus for year 3 is on automating data collection and providing more granular data (country/service/business unit). Embedding the tool in the existing IT landscape (CMDB, ITAM) will also help drive adoption while keeping a lean IT architecture and empowering people across the organization with dependable data to inform reduction actions.

Continued alignment with international standards and regulations, and robust methodology will support seamless integration into corporate sustainability reporting, suitable for regulatory requirements. This should be complemented by practices such as GreenOps, enabling businesses to drive continuous sustainability improvements based on environmental data and their measured footprint.

Key learnings:

- Measuring is a means, not the end. Sustainability's primary focus is and should remain on reducing the environmental footprint, and there are clear means to get there. Metrics can certainly help to raise awareness, point out the most significant areas for improvement, and help fine-tune the approach, but they will not reduce the footprint unless turned into actions.
- There is no fully accurate metric (yet). We can easily be tempted as IT professionals to seek fully accurate, automated, and granular sustainable IT metrics. We should remain humble and recognize that, while there are good foundations and increasing market maturity, no one can provide a fully accurate measurement yet.
- People are a sustainable IT accelerator. The involvement of internal stakeholders such as IT team members and executives, or business and sustainability colleagues, will ensure project visibility, data ownership, and enable you to turn the data into actions across the organization. External partners, such as tool providers or sustainable IT experts, will ensure strong methodology, expertise, and will help your organization accelerate its sustainable IT journey in line with market best practices.

Fiona Leibundgut, Digital Sustainability Advisor, SparkIT Consulting

Today, there is a complex web of semi-overlapping sustainability standards at various levels of maturity. Global organizations most frequently use a mix of the GRI, SASB, and TCFD reporting frameworks to guide their sustainability reporting, while vertical industries such as telecommunications use industry-specific standards from ISO and other institutions. Today's mainstream reporting frameworks are not refined enough to allow technology teams to easily take direct action on sustainability. They do not offer a relevant, consistent set of topics or metrics applicable across IT functions in multiple industries and of multiple sizes.

Recognizing this gap, the founding members of SustainableIT.org convened a working group to research existing corporate ESG reporting standards being used for assessing, tracking, and "disclosing" a company's ESG *current state* to regulatory bodies and the public. Their mission was to adapt and tailor the relevant metrics for IT and create new ones to fill gaps. The result was a set of 240 topics and metrics that provide a consistent way of measuring and communicating IT ESG in any region, industry, and size of company. After thorough review and onsite testing by several companies, the standards were released publicly in early 2023 and updated in 2024. The complete taxonomy, as well as an introductory overview, can be accessed on SustainableIT.org's official page for this book: `https://www.sustainableit.org/sustainable-it-playbook`.

Companies from industries as diverse as tourism, banking, and utilities have either adopted the standards for IT reporting or aligned their original metrics with SustainableIT's taxonomy to maximize industry consistency. Jody Elliott, head of IT risk and sustainability at National Grid, says "*It was really a fantastic set of standard metrics for use in driving business decisions, and they came along in time to validate what we were thinking.*" ServiceNow, a software-as-a-service provider that helps organizations automate and manage workflows for various enterprise operations, incorporated the full set of standards into its sustainability data management platform.

Figure 3.5 shows the primary ESG topics of the standards taxonomy, which represent all the key areas of sustainability that IT is capable of influencing either within the function or across the enterprise.

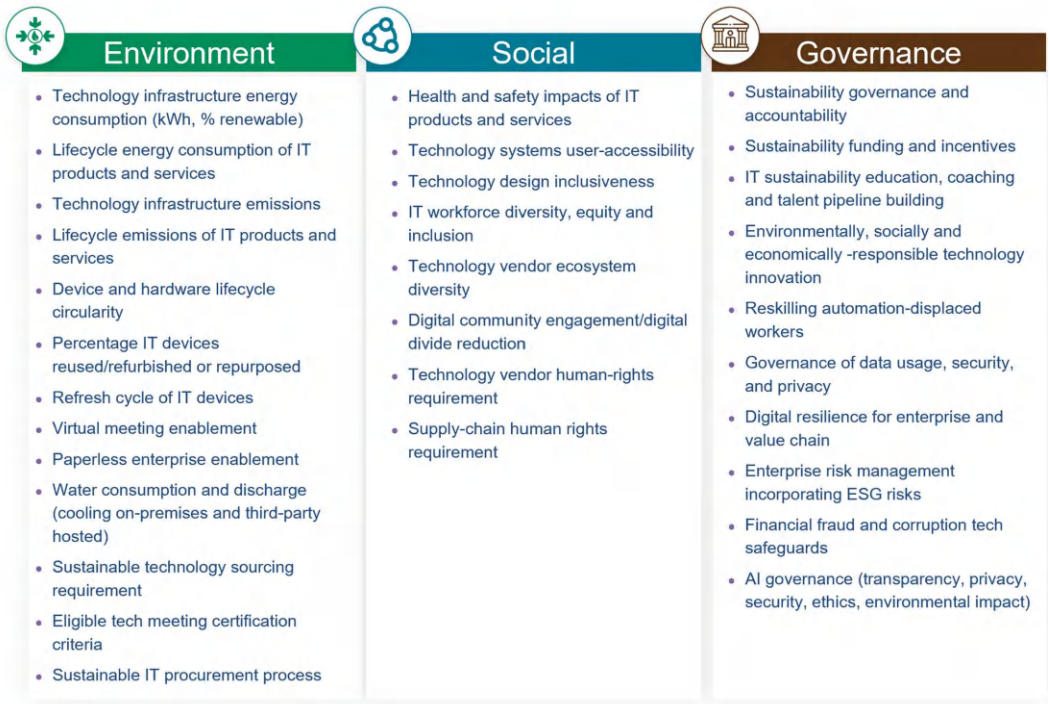


Figure 3.5 – Primary ESG standard topics for IT (Source: SustainableIT.org.)

Throughout the chapters that follow, we will present the most relevant metrics from the SustainableIT.org standards for the various topics covered. They will be listed in tables following the chapter summaries. These metrics can be applied to establish baselines or track progress in improving IT's sustainability impacts. The standards are formatted in the same manner as the GRI, each with a unique code that represents the metric family. Referencing the codes helps ensure consistency across distributed IT organizations in the same enterprise and supports standardization in IT benchmarking and reporting between companies.

The metrics will be presented in tables that indicate topic family, specific topics, and units of measure. We will also see the most relevant global ESG reporting standard or UN SDG to which the IT metric most closely maps (if any). This mapping better enables IT leaders to align their metrics with those that may be in use at the corporate level for reporting, promoting consistency. *Figure 3.6* provides an explanation of the coding and an example of how the topics and metrics nest hierarchically.

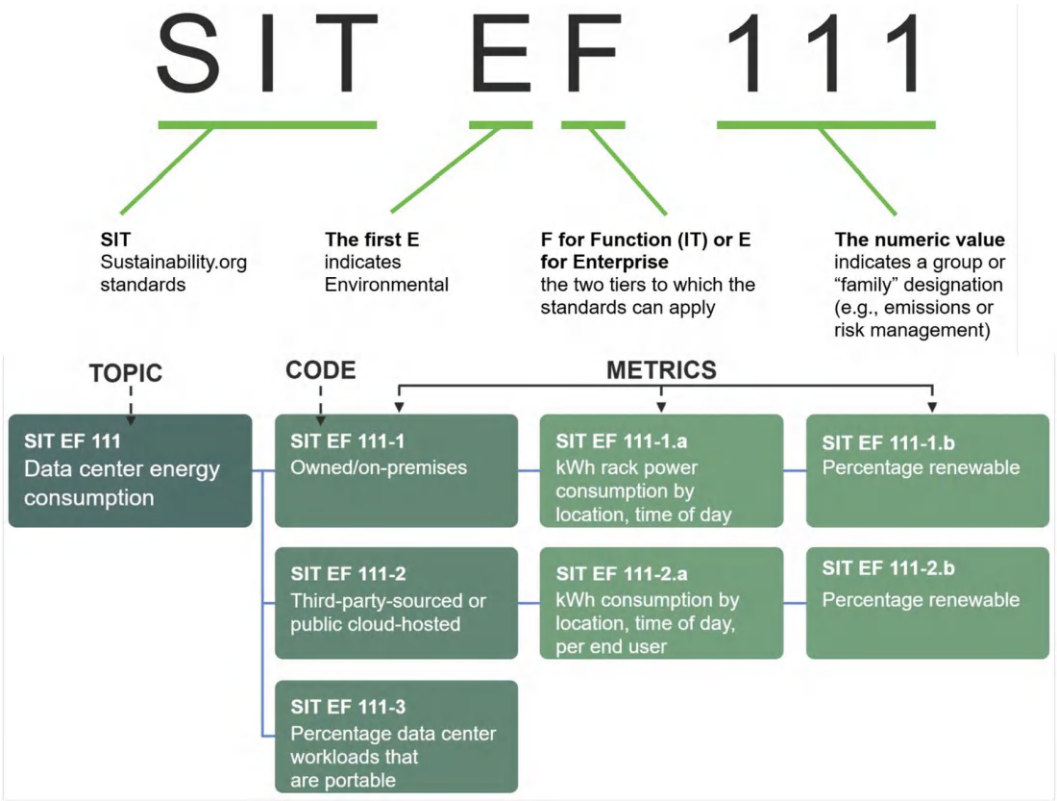


Figure 3.6 – SustainableIT standard metrics coding explanation and sample of nested hierarchy

Responsible and sustainable AI Governance

Advanced artificial intelligence technologies available to enterprises today offer revolutionary innovation opportunities. **Generative AI (GenAI)** systems and their large language models are transforming the creation of content with unprecedented speed and scope, while agentic AI embeds autonomous decision-making and execution into revolutionized workstreams.

However, the design and use of these tools pose considerable risks for the environment, equity, trust, security, and privacy. To optimize the benefits and minimize the risk of negative impacts, organizations must operationalize the principles and practices to govern AI systems responsibly and sustainably throughout their lifecycles.

Dr. Berndt Pilgram, an expert in AI governance and cybersecurity and current **Product Data & Information Security Governance Lead at Fresenius Medical Care**, describes the role of IT in governing AI:

> As artificial intelligence becomes embedded in business and society, the governance of these technologies has emerged as a critical concern. AI governance ensures that AI systems are developed, deployed, and monitored ethically, legally, and aligned with societal values. For IT leaders, the responsibility encompasses technical, strategic, and organizational aspects, with a growing emphasis on the environmental impact of AI systems due to their increasing energy consumption.
>
> At its core, AI governance includes the structures, policies, and practices that guide the responsible use of AI systems. AI acts as a socio-technical system—its influence reaches beyond the digital realm, impacting real-world institutions, communities, and the environment.
>
> Irresponsible development and misuse of AI systems can significantly harm individuals, groups, and businesses. Potential consequences include biased algorithmic decisions, privacy violations, discrimination, and economic exclusion. Additionally, an often-overlooked risk is environmental damage. For instance, training a single large AI model can emit as much carbon as five cars do over their lifetimes (Hao 2019). This highlights the increasing necessity of considering sustainability as a fundamental aspect of **responsible AI** (**RAI**) development.
>
> **Environmental sustainability: a critical dimension**
>
> The environmental impact and carbon footprint of AI systems are considerable. Data centers supporting AI systems consume significant energy. Furthermore, the high-performance computing resources required for training AI models and accessing data use electricity at an ever-increasing rate. According to the Council on Foreign Relations, the environmental costs of AI systems include energy-intensive training processes, electronic waste from infrastructure upgrades, and the ecological implications of rare-earth mining for hardware components.

As noted in SustainableIT.org's overview for the 2025 IT Toolkit for Responsible and Sustainable AI, emissions generated in the GenAI lifecycle, from training through usage, are staggeringly high compared to other technologies.

Training state-of-the-art "frontier" AI models grew 4X to 5X per year between 2010 and 2024 (EPOCH AI 2024). OpenAI's GPT-3 training is estimated to have used 1,287 megawatt-hours of energy (equivalent to 120 average U.S. households' yearly consumption) and generated 552 tonnes of carbon emissions (equivalent to the yearly emissions of 120 U.S. cars). (Patterson, et al 2021.)

Note that these are only estimates, and it is extremely difficult to calculate AI model energy and emissions during the development cycle.

AI's impact on water and e-waste is also alarming, as noted in *Chapter 2*, *Rise of Sustainable IT*:

- Multiple studies estimate AI's global annual water consumption to reach between 4.2 billion and 6.6 billion cubic meters (1.1–1.7 trillion gallons) by 2027
- GenAI could add 1.2–5 Mt of e-waste by 2030, up to 12% of global totals (Nature Computational Science 2024)

Thus, AI governance must integrate sustainability by design. This involves the following:

- Choosing AI models that are fit-for-purpose or not choosing AI at all if it is not necessary for performance purposes or doesn't add significant value
- **LCAs** for AI models and infrastructure environmental impacts
- Promoting energy-efficient algorithms and hardware
- Encouraging green cloud solutions and carbon-footprint reduction strategies
- Embedding environmental impact assessments into the AI development lifecycle

Frameworks such as the OECD AI Principles (OECD 2024) explicitly call out the need to consider impacts on "people and planet" as a core dimension of AI system classification. Sustainability is no longer a secondary concern; it's a governance imperative.

The role of IT leaders: from enablers to stewards

IT leaders are uniquely positioned to drive and execute AI governance. As the guardians of the technological stack, they decide not only how IT and AI systems are designed and hosted, but also how they are implemented and maintained. This includes decisions about infrastructure, data pipelines, model design, and vendor selection—all of which affect an organization's AI footprint. It is paramount for AI governance to choose the right leaders and hold them accountable, as highlighted in the AI Governance Profession Report 2025 (IAPP and Credo AI 2025).

Establishing AI governance requires a strategy aligned with the business strategy and the organization's vision and mission. This includes the following:

- Defining AI governance principles and aligning them to ethical and environmental priorities
- Implementing risk management frameworks (e.g., NIST AI RMF or ISO 42001) to assess and mitigate technical and sustainability risks
- Building cross-functional teams that include ethicists, sustainability officers, information security and privacy experts, and data scientists to oversee the AI lifecycle
- Developing monitoring systems that track performance, energy consumption, and environmental impact

IT leaders are responsible for establishing accountability by promoting transparency and auditing practices to build trust within the organization and with external parties.

AI principles and operationalization

A principle in AI governance is a fundamental guideline that sets expectations, boundaries, and values for the responsible development and use of AI technology. These principles act as foundational guidelines for decision-making, ensuring that AI data governance practices align with legal, ethical, operational, and environmental objectives. Two of the most fundamental principles are ESG sustainability and data integrity, defined here by SustainableIT.org:

- **Sustainability**: AI applications are designed, deployed, and managed to meet enterprise standards for **environmental, social, and governance** (**ESG**) impact
- **Data integrity**: AI application data is appropriate, authorized, transparent, secure, resilient, privacy-compliant, and as unbiased as possible

Transitioning from AI governance principles to actionable practices requires transparent implementation. The "Professionalizing Organizational AI Governance" report (IAPP and EY 2023) highlights the necessity for operational maturity, where AI governance is integrated into organizational routines rather than merely recorded on paper.

Some practical steps include the following:

- Requiring sustainability KPIs in AI project charters
- Enforcing environmental impact reviews during AI design phases
- Prioritizing energy-efficient model architectures (e.g., pruning, quantization)
- Using cloud providers that commit to net-zero emissions
- Operationalizing principles through metrics, KPIs, and reporting
- Encouraging federated learning and other methods that reduce data transfer and compute needs
- Equipping and upskilling IT teams and partners

Incorporating these measures into an organization's DevOps or MLOps workflows ensures governance is not a bottleneck but a catalyst for innovation.

Call to action

As we move inevitably toward the time when it becomes accepted and routine for AI systems to influence hiring, healthcare, security, and climate forecasting, the stakes are too high to ignore adequate AI governance. The promise of AI must not come at the cost of social equity, individual autonomy, or environmental sustainability.

IT leaders must recognize their roles as technical experts, ethical stewards, and advocates for environmental sustainability. Governance should be seen as a critical leadership opportunity, not merely as a compliance exercise. With the right frameworks, collaboration, and foresight, AI can serve both people and the planet.

SustainableIT.org has published valuable resources, including award-winning AI implementation examples, in its AI Toolkit for Responsible and Sustainable AI. These resources serve as a guideline for adopting and enacting RAI.

Dr. Berndt Pilgram , Product Data & Information Security Governance Lead, Fresenius Medical Care

The responsible AI guidelines Dr. Pilgram refers to, which he and more than 50 other practitioners and experts helped develop and vet, will be explored in depth in *Chapter 4*, *Responsible and Sustainable AI*. The chapter features insights from Capgemini Invent and Accenture on AI environmental sustainability. Additionally, we include portions of a step-by-step "runbook" of environmental actions and tools developed by the members of SustainableIT.org. We will explore RAI governance frameworks from Rackspace Technologies and Stanford Health Care, and best practices derived from winners of SustainableIT.org's 2025 RAI Impact Award. Other tools include RAI governance lifecycle and ecosystem models, a questionnaire for environmental impact assessment, and an agentic AI onboarding guide.

IT social sustainability

The majority of IT ESG sustainability programs focus first and primarily on environmental impact. Governance sustainability is considered something IT already addresses through data security and privacy protections, general cybersecurity, fraud alert and prevention systems, and business resilience programs. Social sustainability, the third pillar of ESG, is generally not a focus for IT, with the exception of certain institutions such as universities, which prioritize it. However, IT leaders must realize that social sustainability is directly impacted by their technology vendor choices and practices, their in-house system design, and their engagement, or lack thereof, with local and global communities.

Specifically, IT has the power to drive positive change in human rights, inclusivity, and accessibility. Indeed, of the 17 United Nations Sustainable Development Goals referenced in *Chapter 1*, *Our Most Significant Challenge Ahead*, only six of the 17 are directly associated with the environment. The rest, or 65%, are social and economic goals. Since the SDGs are the universal North Star for sustainability programs, social sustainability must be prominent on IT's agenda.

Ahmad Antar, **Instructor, Harvard Sustainability Graduate Program and sustainable AI evangelist**, uses the first edition of this book in the course he teaches on IT sustainability at Harvard each summer. He supported the idea of more social sustainability content in the second edition, so we thought it appropriate for him to write an in-depth overview of social sustainability for IT here, establishing the focus for *Chapter 5*, *Social Sustainability: Accessibility, AI, and the Digital Divide*, on technology inclusiveness, accessibility, and human rights:

The majority of IT ESG sustainability programs focus first and primarily on environmental impact. Governance sustainability is considered something IT already addresses through data security and privacy protections, general cybersecurity, fraud alert and prevention systems, and business resilience programs. Social sustainability, the third pillar of ESG, is generally not a focus for IT, with the exception of certain institutions such as universities, which prioritize it.

While the environmental pillar, often termed Green IT, garners the most attention in sustainable IT, the social pillar demands equal attention. This imperative stems from the recognition that environmental initiatives are inextricably linked with social equity and responsible governance. For IT leaders, achieving genuine sustainability is a multifaceted endeavour that cannot compartmentalize environmental actions from social considerations.

Moreover, prioritizing the social pillar within sustainable IT is not merely an exercise in corporate altruism. Rather, it reflects a pragmatic response to an evolving web of complex regulatory frameworks and heightened stakeholder expectations. Integrating principles of social sustainability – such as digital inclusion, equitable access, and ethical technology deployment – has emerged as a powerful strategic differentiator for companies, especially in an increasingly polarized sociopolitical climate. In such a contentious environment, a commitment to values such as **diversity, equity, and inclusion (DEI)** offers organizations a critical competitive advantage. Prominent corporations, including Apple, Costco, JPMorgan Chase, and Deutsche Bank, have publicly reinforced their DEI strategies, positioning social responsibility as a driver of long-term business value through talent retention, innovation capacity, and reputational strength.

Conversely, ignoring the social pillar of sustainable IT – even amid progress on environmental metrics – risks engendering ethical blind spots, reputational harm, and ultimately, an incomplete and unsustainable strategy. IT leaders must therefore realize that social sustainability is directly impacted by their technology decisions, products, and practices. Specifically, IT has the power to drive positive change in human rights, inclusivity, and accessibility. (See *Figure 3.7* for an overview of the dimensions of IT social sustainability.)



Figure 3.7 – Social responsibility in IT: dimensions, strategies, and standards

Human rights

As societies undergo a profound digital transformation, the role of **Information Technology (IT)** as a pivotal enabler of human rights is becoming increasingly evident. Technological advancements offer significant potential to enhance transparency, accountability, civic participation, and individual empowerment. In this context, it is imperative for IT leaders to adopt a human-centric approach to technology development – particularly with the rise of transformative innovations such as GenAI – to ensure these tools support, rather than undermine, the exercise of fundamental rights.

A rights-based approach to IT governance serves to align the benefits of digital progress with the safeguarding of essential civil liberties. Such an approach enables organizations to proactively mitigate the human rights risks associated with emerging technologies, including artificial intelligence and big data, while reinforcing protections for civil society, investors, and other key stakeholders. Technology practitioners can draw upon a number of authoritative policy frameworks and guidelines to embed human rights considerations into their IT strategies and operations. Notable examples include the following:

- The B-Tech Project, developed by the **United Nations Human Rights Office (OHCHR)**, in alignment with the UN Guiding Principles on Business and Human Rights (UN 2020).
- **Human Rights and Environmental Due Diligence (HRDD/HREDD)** obligations emerging from the European Union (European Union 2024).
- **OECD Due Diligence Guidance for Responsible Business Conduct (OECD** 2018).
- Recommendations for companies on Artificial Intelligence and Human Rights, drafted by the UN Global Compact (United Nations 2024).
- Fundamentals of a Human Rights-Based Approach to Generative AI, published by **Business for Social Responsibility (BSR** 2025).

Beyond compliance, the promotion of human rights within IT offers strategic benefits, including enhanced reputation, strengthened risk management, improved employee engagement, and alignment with broader societal expectations. By integrating human rights principles into the design and deployment of IT systems, leaders are uniquely positioned to drive long-term, inclusive value for all and help shape a digital future grounded in dignity, equity, and accountability.

Inclusivity

In today's society, digital inclusion transcends technical limitations; it represents a matter of social justice and ethical responsibility, aligning with evolving expectations of consumers. Digital exclusion disproportionately impacts disadvantaged and marginalized populations—those burdened by economic hardship, health disparities, or environmental challenges. Alarmingly, nearly one-third of the global population remains without internet access (ITU 2024). These disparities manifest across various dimensions, including urban versus rural settings, gender, income levels, and age groups.

Aside from the connectivity issue, the rise of AI has exacerbated concerns regarding the digital literacy gap and the absence of inclusive strategies to address it. Moreover, digital inclusion is increasingly threatened by algorithmic bias, as decision-making processes shift from human judgment to machine learning systems. These exclusionary dynamics further deepen the digital divide, with consequences that span socioeconomic status and individual well-being.

In a corporate setting, inclusive IT practices offer a broad range of benefits. These include enhancing digital literacy, safety, and wellness, while advancing diversity, equity, and empowerment among both internal and external stakeholders. Consequently, IT leaders must adopt an intentional approach to fostering digital inclusion, thereby contributing to bridging the digital divide. This commitment should be reflected in actionable policies and practices that ensure products and workplaces are accessible and welcoming to individuals of all backgrounds and abilities. Here are some practical strategies to make that happen:

- **Inclusive design**: Adopt a purposeful design methodology that extends beyond business requirements to authentically reflect the diverse needs, abilities, and preferences of users. Integrating inclusive design principles throughout the product development lifecycle helps brands to resonate with a broader spectrum of communities.
- **Responsible AI**: Champion the development and deployment of AI systems that are fair, equitable, and beneficial to all. This entails utilizing training data that is representative, diverse, and balanced, and ensuring that AI tools do not reinforce societal biases. In addition, IT leaders can even take a thoughtful approach by advocating for an equitable adoption of AI to help level the playing field and close the digital divide.
- **Digital literacy**: Promote workforce upskilling and reskilling through comprehensive programs aimed at enhancing AI fluency. These initiatives should foster curiosity, reduce anxiety, and cultivate a culture of continuous learning. Furthermore, inclusive AI education should extend to the broader communities in which organizations operate, recognizing that digital literacy is increasingly essential in the age of AI.
- **Digital equity**: Your IT teams can work with organizations that are making a difference in regions and communities that lack connectivity and modern technology access. For example, IEEE Connecting the Unconnected runs challenges to support connectivity for the more than 2.9 billion people without internet access (`https://ctu.ieee.org/`).

The UNDP's AI Hub is working to establish AI public and private partnerships with African nations (`https://www.aihubfordevelopment.org/`). Human-I-T.org is collecting, refurbishing, and providing IT hardware with service and support to disadvantaged communities in the US and abroad.

Accessibility

Ensuring digital platforms are accessible to both consumers and employees with disabilities has become a critical component of corporate social responsibility. Digital accessibility refers to the design and development of modern technologies – such as websites, mobile applications, and software – in ways that are usable by individuals with diverse impairments, including visual, auditory, neurological, motor, and cognitive disabilities.

According to the **World Health Organization** (**WHO**), around 1.3 billion of the global population experience a form of disability (WHO 2022). Despite this, an estimated 95% of web pages contain errors that violate the **Web Content Accessibility Guidelines** (**WCAG 2**), thereby creating significant barriers for users with disabilities (WebAIM 2025). As such, IT leaders have a vital role to play in advancing digital inclusivity and promoting social equity.

Beyond providing an inclusive user experience, digital accessibility also presents a critical compliance obligation. Failure to meet accessibility standards may result in legal consequences and reputational harm. In the United States alone, a lawsuit related to violations of the **Americans with Disabilities Act** (**ADA**) is filed approximately every two hours as of 2024 (UsableNet 2025). To mitigate these risks, organizations must align their digital solutions with established accessibility regulations, including Section 508 of the Rehabilitation Act, the ADA, and the European Accessibility Act (EN 301 549).

In addition to mitigating legal and compliance risks, investing in digital accessibility makes sound business sense. It can enhance brand reputation, attract and retain talent, expand market reach, and foster consumer trust. More importantly, it reflects a broader commitment to doing what is ethically right. To embed accessibility into technology planning, IT leaders are encouraged to adopt the following strategies:

- **Prioritize accessibility early ("shift left" approach)**: Integrate accessibility considerations at the initial stages of product development rather than treating them as retrospective fixes

- **Leverage AI for accessibility**: Utilize AI-driven tools to automate tasks related to design, development, testing, data generation, scanning, and defect remediation – complemented by human oversight to ensure quality.
- **Foster an accessibility-first culture**: Build awareness across the organization through standardized training, executive sponsorship, regular communication, celebration of wins, and embedding accessibility into core values.

By embracing digital accessibility as a strategic priority, organizations not only fulfil their ethical and legal obligations but also position themselves for sustainable growth and innovation in an increasingly inclusive digital world.

Charting a human-centric tech future

As digital technologies continue to permeate every aspect of modern society, the imperative to advance social sustainability assumes heightened significance. Social responsibility in IT is no longer a peripheral concern but a fundamental pillar for achieving long-term business success, enhancing brand reputation, attracting talent, getting ahead of regulations, and contributing meaningfully to societal well-being. Not to mention, the rise of AI sheds light on how the IT landscape should focus more on supporting human rights, inclusiveness, and accessibility. IT CxOs stand at the forefront of this transformation. Their leadership is crucial for integrating not only environmental, but also social considerations into every facet of IT, from strategic planning, design, development, operation, and responsible disposal of the technology. By embracing ethical innovation, prioritizing RAI, fostering a digital inclusion and accessibility-first culture, promoting digital literacy, and meticulously managing their digital carbon footprint, IT leaders can chart a purpose-driven digital future that is not only efficient and innovative but also equitable, inclusive, and truly sustainable for all.

Ahmad Antar, Instructor, Harvard Sustainability Graduate Program and sustainable AI evangelist

In *Chapter 5*, *Social Sustainability: Accessibility, AI, and the Digital Divide*, we will explore these challenges further and outline how IT can drive social sustainability both directly and through its influence over the tech industry. National Grid, Cognizant, and Edifecs will share insights on tech-driven social sustainability programs. Tools include standard metrics for accessibility, inclusiveness, and community engagement. In addition, there is a persona-based literacy framework and a social sustainability questionnaire for vendors.

IT infrastructure sustainability

It's no coincidence that green IT focal points include data centers and the cloud, applications and data, IT hardware management, energy resource management, and vendor management. Together, these domains make up the majority of IT's environmental impact, and each is a prime lever for the IT team to directly control. As such, we will be devoting chapters of this book to each. Here, however, are introductions that set the context.

Data centers and the cloud

In 2024, data centers globally devoured over 400 TWh of electricity, roughly accounting for 1.5% of global consumption (IEA 2025, Deloitte Insights 2024). This does not include crypto mining, which roughly consumed 175 TWh of electricity in 2024. Data centers and network links are the engine room of the digital economy, providing the backbone of connectivity and the internet as we know it today. Data centers are very resource-intensive, and the demand keeps surging, so it is critical to set a path toward a sustainable digital infrastructure.

No matter whether you house your servers, storage, or network equipment in your own data centers, outsource them to a hosting provider, or place them with one of the global cloud hyperscalers such as **Microsoft Azure**, **Amazon Web Services**, or **Google**, it is probably one of your most resource-intensive operations. Moving from on-premises to the cloud comes with several business benefits, such as a higher speed of innovation, agility, and global scalability, along with several sustainable IT benefits, such as access to renewable energy compute and storage, higher resource utilization, and hardware efficiency. But...

Optimizing your data center and cloud operations is one of the biggest unlocks to ensure the transition to a sustainable IT practice by utilizing modern best practices and renewable energy sources.

In *Chapter 6*, *Data Centers and Cloud*, we will go to great lengths to cover how you can optimize your data center and cloud workloads by improving power and cooling efficiency, hardware efficiency, and compute utilization, and ensuring you are running on renewable energy.

The chapter includes insights into how to determine your cloud Scope 3 emissions and optimize the sustainability of your cloud compute. You will also better understand the challenges and tactics of collaborating on sustainability with hyperscalers, drawing on the experience of GreenOps experts Mark Butcher of Posetiv Cloud Ltd and James Hall of Greenpixie. Additionally, we present a case from EcoDataCenter, which is one of the first data center providers in the world that can offer its customers net-positive hosting.

Tools in this chapter include data center CO_2 and power usage effectiveness calculations, a data center scorecard, assessment criteria for cloud vendors, and standard sustainability metrics for on-premises and cloud-hosted data centers.

Applications and architecture

In today's rapidly changing business environment, having a flexible IT landscape is a crucial enabler in driving digital business transformation. Unfortunately, it is not always the case that the existing IT environment can meet these new demands. Corporations, organizations, and governments tend to have hundreds of applications, or even thousands, for a number of reasons. These types of applications can range from legacy **Enterprise Resource Planning (ERP)** systems, **Customer Relationship Management (CRM)** systems, HR systems, payroll systems, and **Manufacturing Execution Systems (MES)** to homegrown custom-built applications or even legacy mainframe systems. This is due to the accumulation of applications over time, strategic business initiatives, the adaptation of new technology, mergers and acquisitions, shadow IT initiatives, and organizational changes. The proliferation of AI models and AI-embedded tools is now adding to this complexity. Unsurprisingly, a significant part of IT budgets is spent on developing, operating, and managing applications. Most organizations move onto net-new applications and have a "deploy and forget" mentality. Operating budgets are often assumed to remain flat, yet without application rationalization, they go up year over year. There is a huge savings potential in rationalizing your application portfolio from a cost perspective and cutting your emissions. A report from Infosys suggests that as much as $2 million can be generated in cost savings due to application rationalization (Infosys 2018).

Managing your application portfolio is a complex endeavor, from prioritizing hundreds or thousands of applications to the solution architecture and managing the efficiency and effectiveness of a single application. There are also significant benefits in introducing sustainable software development practices to reduce resource consumption. In *Chapter 7*, *Applications and Architecture*, we explore how to achieve sustainability targets with **Enterprise Architecture (EA)**, application portfolio management, and sustainable software development. Tools related to portfolio management include asset registry examples, TIME analysis, principles for sustainable software engineering, and standard sustainability metrics for applications and software development.

We will hear from SustainableArchitectures.org Chair Lisa Pratico on how to maximize the role and impact of your enterprise architects in driving sustainability. **Asim Hussain, Executive Director, Green Software Foundation**, provides insights on sustainable software development and the Software Carbon Intensity Metric. EA tools provided include 10 principles for sustainable architecture, a maturity model, and a framework for EA sustainability.

Data

Data has become the fuel of modern enterprise, driving innovation, automation, personalization, and compliance. Yet the vast – and exponentially growing – volume of data generated, stored, and analyzed by organizations also presents a major sustainability challenge. In 2025, the world is projected to generate more than 180 zettabytes of data, up from just 2 zettabytes in 2010—a 90-fold increase in 15 years (World Economic Forum 2024):

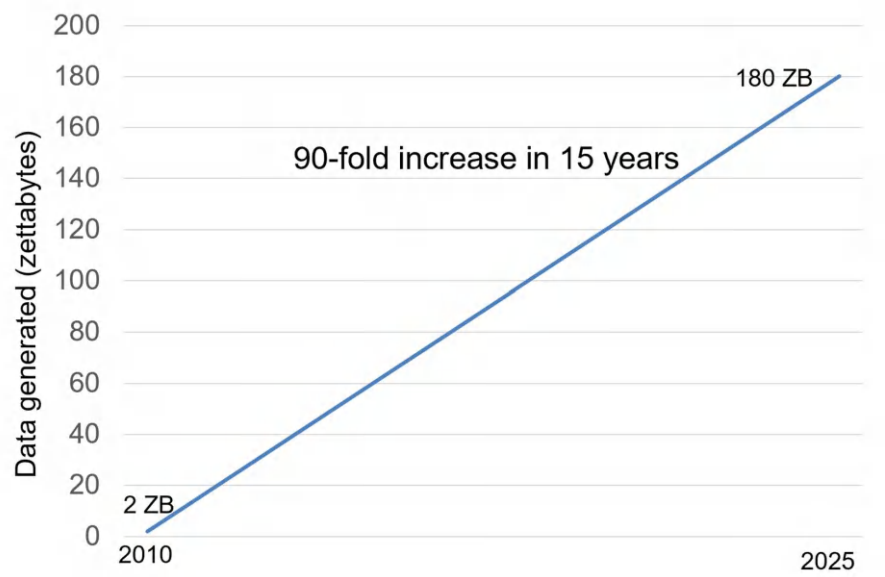


Figure 3.8 – Data proliferation from 2010-2025

Data storage emissions are approaching, and by some estimates have exceeded, carbon emissions levels of the world's commercial airline industry (Substack.com 2025; EdgeRed Analytics 2025). Every byte of data stored and moved carries with it an environmental cost – energy, water, materials, and emissions – across the entire lifecycle of the IT infrastructure that supports it.

The most recent estimates for the electricity used to store 1 **terabyte** (**TB**) of data in a data center range from 6 kWh to 300 kWh per year. This depends on the type of storage (hard drives versus solid-state drives), redundancy levels, and the efficiency of the data center's infrastructure. Greenly estimates emissions of 40 kg of CO_2e per TB stored in a US data center, factoring in significant improvements in the energy efficiency of data centers compared to previous estimates (Greenly 2024). Regardless of the exact totals, reducing and minimizing archival data volumes and optimizing storage architecture (e.g., SSD flash, high-density racks, cold archiving) will lower both energy costs and ESG risk.

Enterprises must now grapple with a dual mandate: harnessing the power of data to drive ESG insights and reporting while managing their environmental and social footprint. The challenge is compounded by the explosion of data-intensive technologies such as AI, IoT, and high-resolution analytics, which can drive both opportunity and unsustainable demand. A recent analysis of language models (20M to 13B params) found their development and training released 493 metric tonnes of CO_2, and used 2.77 million liters of water—comparable to powering 98 US homes for a year and providing one person's water for 24 years (Morrison, Jacob, et al. 2025).

These impacts don't stop at the data center—they cascade outward, affecting supply chains, user devices, and societal equity. *Chapter 8*, *Data*, explores these interconnections, focusing on how IT leaders can address the environmental implications of the enterprise data landscape. That includes reviewing the full lifecycle of data – from generation, storage, and processing to archiving and deletion – with a sustainability lens. The concept of "data minimalism" is introduced as a discipline to reduce unnecessary storage and computing overhead, while aligning with principles of digital sobriety and emissions-aware design.

Yet the importance of data to ESG isn't only about curbing its negative impacts—it's also about unlocking its potential. Data is now the bedrock of environmental and social governance decision-making. It feeds dashboards, informs KPIs, and populates mandatory disclosures for frameworks such as CSRD, SEC Climate Rule, and GRI. Organizations cannot report progress on carbon, water, DEI, or circularity goals without high-quality, timely data. This makes IT indispensable for ESG reporting, responsible for managing the data pipelines, systems integration, and access mechanisms that enable transparency, trust, and regulatory compliance. Whether tracking cloud emissions, monitoring e-waste, or managing supplier social compliance data, IT's architecture and governance decisions will determine the quality, granularity, and actionability of ESG insights.

Moreover, in an era where AI and automation can amplify either bias or benefit, data governance has become a pillar of ethical responsibility. In *Chapter 8*, *Data*, we will explore how to ensure data quality, provenance, and governance practices that not only enhance ESG disclosures but uphold RAII practices, as outlined in frameworks such as the NIST AI Risk Management Framework (NIST 2023) and ISO/IEC 42001 (ISO 2024).

Mitigating the environmental impacts of data proliferation will be a key focus in *Chapter 8*, *Data* and we will highlight multiple strategies for sustainable dataset management in a case study on **Choice Hotels International**. Wil will also provide KPIs and tools to operationalize five fundamental principles of RAI data governance. Since AI models and applications are responsible for much of the recent data proliferation we are experiencing, we provide a runbook of actions, tools, and KPIs to operationalize sustainability principles for AI data governance. Additionally, we include a set of standard metrics for data sustainability.

The chapter will also address the enterprise need for effective ESG-specific data and how IT can lead the effort to establish a centralized data platform that provides actionable information to decision-makers. **ServiceNow** and **Mastercard** provide guidance and examples of this.

IT hardware management

With the entire ICT sector emitting around 2-4% (World Bank 2024) of global greenhouse gases, ICT equipment is a major contributing factor. Additionally, the sector is a major contributor to surging e-waste, including the mining of finite earth metals, but also social implications such as poor working conditions in factories and human rights violations. Just like our business models need to transition from a linear economy to a circular economy, IT needs to do the same. IT is constantly under cost pressure to deliver more with less, and transitioning to circular IT hardware management helps maximize the value of IT investments, reduce the use of natural resources, and minimize e-waste.

Throughout the entire lifecycle of IT assets, sustainable practices can be applied to design durable and modular products, remove hazardous substances from the manufacturing process and the product itself, prolong the product lifecycle, buy energy-efficient products, upgrade, refurbish, and minimize waste. Additionally, prolonging the longevity of IT hardware leads to tangible financial benefits by reducing the overall spending on buying new equipment. Many of these circular solutions exist today, and we will explore how they can be utilized.

Roughly 80% of greenhouse gas emissions occur in technology's manufacturing phase. This means that before you receive a new laptop, tablet, or smartphone in your hand, 80% of the greenhouse gas emissions have already been consumed by producing the device. During the device's lifetime, 14%–16% of the total greenhouse gas emissions are consumed. The emission of greenhouse gases during the usage phase is very much dependent on the end user's access to renewable energy or not. If the device is powered by fossil fuel, it will have significantly higher greenhouse gas emissions than if it were powered by hydro, wind, or solar energy. Additionally, it is essential to understand that for end-user ICT equipment, such as computers, tablets, and smartphones, most carbon emissions come from embodied carbon emissions due to the data centers serving them with Google AI and ChatGPT searches, social media interactions, the storage of documents, the streaming of media, and more. Today, the way we make, use, and recycle ICT equipment tends to follow a linear path instead of a circular one, and there exist very few financial incentives for hardware manufacturers to make the transition. As noted in *Chapter 2*, 62 million metric tonnes of e-waste were generated worldwide in 2022, and the projection is for this total to reach 82 million tonnes by 2030 (Global E-waste Monitor 2024).

The single most contributing factor to reducing greenhouse gas emissions of ICT equipment is prolonging the hardware's longevity for as long as possible. Today, most computer manufacturers and telecommunications companies make it easy for people to acquire new computers, tablets, and smartphones every 2 to 3 years, and do not put nearly enough focus on takeback or buyback schemes. According to TCO Certified, greenhouse gases can be reduced by up to 23.5% by prolonging the lifespan of a product by 1 year (TCO Certified 2025).

Chapter 9, *IT Hardware Management*, will explore how circular IT hardware management practices can solve many pressing sustainability challenges from a social and environmental perspective and, at the same time, deliver financial benefits on the bottom line. We will provide instruction on how to compare the sustainability of hardware (servers, laptops, tablets, and smartphones) via lifecycle carbon assessment data and awareness of vendor commitments and practices. The chapter also features detailed guidance on how to work effectively with IT asset disposition service providers. Tools include the 9R circularity framework, a hardware sustainability scorecard, and standard metrics for hardware sustainability.

Energy resource management

Resource management is the practice of improving the resource efficiency of energy, water, and materials – to do more with less. As we saw in *Chapter 1*, *Our Most Significant Challenge Ahead*, the energy sector accounts for 24 gigatonnes of CO_2 emissions, which is more than one-third of the total number of emissions per year. This is primarily because energy sources draw from fossil fuels such as coal and oil instead of renewable energy sources such as wind, solar, water turbines, and geothermal. By 2035, global energy consumption is projected to double. Making the switch from fossil fuels to renewable energy sources is paramount to staying within the 1.5°C targets, while, at the same time, meeting the surging demand in the next 10–15 years. There is a close link between energy and water. 90% of global power generation is water-intensive (UN, 2015), and the energy sector accounts for 10% of total global freshwater use (IEA 2024). Having water as part of the strategic plan while moving to renewable energy sources is key.

Additionally, ensuring efficient resource utilization is a key topic because IT assets tend to be underutilized, and by optimizing them, a vast amount of energy and natural resources, such as rare minerals, metals, and plastics, can be saved.

Chapter 10, *Energy Resource Management*, will help you better understand the energy consumption from IT assets and how you can measure your energy consumption patterns, particularly those of end-user devices. From there, we look at actions that can reduce your energy consumption and emissions and improve energy efficiency. Depending on where you operate globally, access to renewable energy sources might be scarce, but we will explore different ways to mitigate that gap. Tools in this chapter primarily help you to calculate energy consumption.

Leveraging buying power

The financial sector has a significant impact on financial markets by controlling access to capital. Similarly, vendor management and IT procurement play a significant role in transforming your vendor landscape. As the general trend moves toward "as-a-service models," the shift of greenhouse gas emissions moves from internal Scopes 1 and 2 to external Scope 3. Just because you get rid of something internally and transition it to a vendor does not mean that you are not still responsible for your entire value chain, including Scopes 1, 2, and 3. Using different levers to drive down greenhouse gas emissions would be best. Leveraging your buying power is essential to transform your entire value chain from your hardware, software, and professional service providers. It starts by asking tough questions, enforcing a stricter vendor code of conduct, and imposing challenging sustainability requirements in bids and master service agreements. Additionally, it requires fostering a collaborative, corrective, and innovative environment with those providers to find ideas and solutions with a more positive environmental and social impact.

Chapter 11, *Leveraging Your Buying Power*, will explore the different levers available to you to transform your vendor portfolio into a sustainable ecosystem.

The chapter includes case studies from global financial services company BNP Paribas, tourism company TUI Group, and appliance maker Electrolux on how they engage vendors to reach their sustainability targets. There is also a detailed case on deploying AI-assisted supplier sustainability education and support.

Tools and examples provided in the chapter include hardware and data center sustainability scorecards, an entry form for a vendor sustainability award, and master services agreements stipulating hardware and cloud sustainability requirements for vendors.

The collaboration of procurement teams is essential to achieving our goals. So, we will check in with **Camilla Cederquist**, **head of sustainability programs and circular business development at Atea Sustainability Focus**, who will share her latest research on sustainable IT procurement.

Sustainability by IT

In *Chapter 2*, *Rise of Sustainable IT*, we made a distinction between sustainable IT and sustainability by IT. Although this book primarily focuses on IT-led sustainability, it is also important to understand how sustainability by IT can unlock innovation for sustainable business models. Sustainability by IT is what you develop for internal customers and commercial use for your customers, providing a product or solution that targets a specific sustainability need. Sustainable solutions enabled by IT and technology can be applied to various industries. Here, the possibilities and use cases are endless, and we could easily dedicate a whole book to this topic.

However, to at least get a taste of the topic, in *Chapter 12*, *Sustainability by IT*, we will be covering a few examples of companies taking major steps toward a circular economy, including one from appliance maker Haier. The role of AI in driving sustainability will also be a key focus.

Summary

In this introductory chapter to *Part 2* of this book, we provided overviews of essential building blocks of IT sustainability and introductions to the chapters that follow. It should give you a feel for what key topics will be covered within each chapter. Either read each chapter in chronological order or jump to the most relevant chapters. We fully recognized that each starting point might be different when we started with this chapter. Therefore, you should also focus on different solutions that will accelerate your journey toward a sustainable IT practice.

Circling back on the sustainable IT reference model that was introduced earlier in the chapter, *Figure 3.3* highlights how the chapters in *Parts 2* and *3* are interlinked with the reference model. Hopefully, this should enable you to understand how the different building blocks fit together:

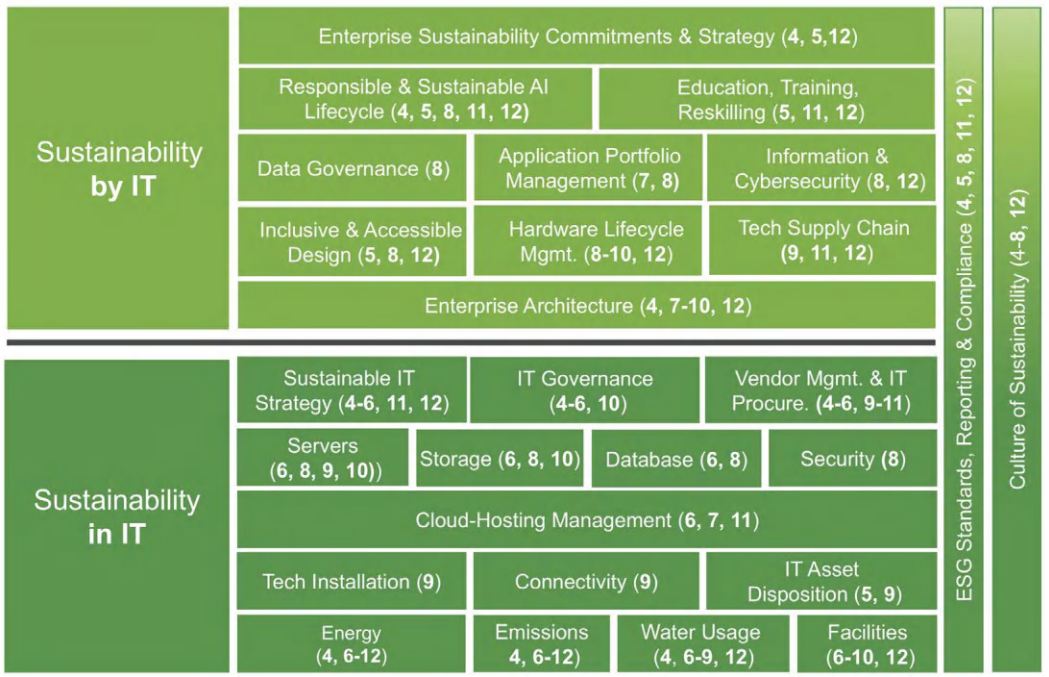


Figure 3.9 – Chapters interlinked with the reference model

Next, let us dig deeper into these critical concepts. Each chapter represents different opportunities to unlock the potential for your path toward building a sustainable IT practice, starting with *Chapter 4*, *Responsible and Sustainable AI*.

Bibliography

- Council on Foreign Relations, 2022, *Artificial Intelligence's Environmental Costs and Promise*. `https://www.cfr.org/blog/artificial-intelligences-environmental-costs-and-promise`.
- Deloitte Insights, 2024, *As Generative AI Asks for More Power, Data Centers Seek More Reliable, Cleaner Energy Solutions*. `https://www2.deloitte.com/us/en/insights/industry/technology/technology-media-and-telecom-predictions/2025/genai-power-consumption-creates-need-for-more-sustainable-data-centers.html`.

- EdgeRed Analytics. 2025, *Data's Carbon Footprint: A Growing Concern*. https://edgered.medium.com/datas-carbon-footprint-a-growing-concern-a44573dbb345.
- EPOCH AI, 2024, *Training Compute of Frontier AI Models Grows by 4-5x per Year*. https://epoch.ai/blog/training-compute-of-frontier-ai-models-grows-by-4-5x-per-year.
- Greenly, 2024, *What is the Carbon Footprint of Data Storage?*. https://greenly.earth/en-us/blog/industries/what-is-the-carbon-footprint-of-data-storage?utm_source=chatgpt.com.
- Kamiya, George, 2021, *Data Centres and Data Transmission Networks*. https://www.iea.org/reports/data-centres-and-data-transmission-networks.
- IAPP, 2025, *AI Governance Profession Report 2025*. https://iapp.org/resources/article/ai-governance-profession-report/.
- IAPP, 2023, *Professionalizing Organizational AI Governance Report*. https://iapp.org/resources/article/professionalizing-organizational-ai-governance-report-summary/.
- IEA.org, 2024, *Data Centres and Data Transmission Networks*. https://www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networks.
- IEA.org, 2025, *Energy and AI - World Energy Outlook Special Report, April*. https://www.iea.org/reports/energy-and-ai.
- IEA.org, 2024, *Energy is vital to a well-functioning water sector*. https://www.iea.org/commentaries/energy-is-vital-to-a-well-functioning-water-sector.
- Infosys, 2018, "Case study: SAP success stories life sciences." *Infosys*. https://www.infosys.com/industries/life-sciences/case-studies/Documents/SAP-success-stories-life-sciences.pdf.
- Morrison, Jacob, et al., 2025, *Holistically Evaluating the Environmental Impact of Creating Language Models*. https://arxiv.org/pdf/2503.05804.
- Nature Computational Science, 2024, E-waste challenges of generative artificial intelligence: https://l1nq.com/XVVyw.
- OECD, 2024, *OECD AI Principles Overview*. https://oecd.ai/en/ai-principles.
- OpenAI, 2018, *AI and Compute*. https://openai.com/index/ai-and-compute/.
- Patterson, et al., 2021, *Carbon Emissions and Large Neural Network Training*: https://arxiv.org/abs/2104.10350.
- SustainableIT.org, 2025, *The Sustainable IT Maturity Model© V2.1*. https://members.sustainableit.org/knowledgebank-mfe#/knowledgebank/2/645001cf9394f9d361f53e34/0. (Access restricted to SustainableIT.org members only.)

- SustainableIT.org, 2025, *IT Toolkit for Responsible and Sustainable AI*. https://www.sustainableit.org/insights.
- Substack, 2025, *Do Data Centers Generate More Greenhouse Gas Than Commercial Aviation?*: https://sustainableai.substack.com/p/do-datacenters-generate-more-greenhouse.
- TCO Certified, 2025, *New guide! Circularity and IT products*, May 2025. https://tcocertified.com/news/new-guide-circularity-and-it-products/.
- The Decoder, 2023, *GPT-4 Architecture, Datasets, Costs and More Leaked*: https://the-decoder.com/gpt-4-architecture-datasets-costs-and-more-leaked/.
- UN, 2015, *Water and Energy*, March 13. https://www.un.org/waterforlifedecade/water_and_energy.shtml.
- World Bank Group, 2024, *Measuring the Emissions & Energy Footprint of the ICT Sector*. https://documents1.worldbank.org/curated/en/099121223165540890/pdf/P178597712a98880541a4b71d57876048abb.pdf.
- World Economic Forum, 2024, *Data volume is soaring. Here's how the ICT sector can sustainably handle the surge*: https://www.weforum.org/stories/2024/05/data-growth-drives-ict-energy-innovation/#:~:text=One%20hundred%20and%20eighty%2Done,system's%20capacity%20to%20deliver%20it.

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4

Responsible and Sustainable AI Governance

> *"Big tech firms recklessly pursuing profits from AI … the community international does not have strategies … to ensure that the technology benefits also economies in developing countries, reducing the digital divide."*
>
> *António Guterres, UN Secretary-General*

In *Part 1* of the book, we saw the impact of technology on environmental sustainability, as well as the social challenges of job displacement, skills obsolescence, and equitable access. The explosion of generative AI, spurred on by the democratization of public tools such as OpenAI's ChatGPT, is amplifying this impact exponentially, as noted in *Chapter 2*, *Rise of Sustainable IT*. This raises the stakes for AI system lifecycle governance that prioritizes **environmental, social, and governance** (**ESG**) sustainability. Like it or not, IT leadership will shoulder much, but not all, of this governance responsibility, given that AI is fast becoming inextricably woven throughout the fabric of enterprise technology and that data is the basis of its effectiveness.

In this chapter, Rackspace Technology, Stanford Health Care, and SustainableIT.org will share models for GenAI and agentic AI governance. We will hear from Accenture on mitigating AI's environmental footprint and measuring its impact. Also focusing on environmental sustainability, Capgemini Invent will map out the greening of AI that will usher in the "eco-digital era" of business.

We will walk through nine essential **responsible AI** (**RAI**) leadership principles and step-by-step actions for operationalizing them. This is just one example of playbook-style content we will present from SustainableIT.org's RAI Working Group, developed by more than 50 volunteer practitioners over 6 months in 2025. Version 1 of their publications can be accessed at `https://www.sustainableit.org/sustainable-it-playbook`. In this chapter, we will cover the following topics:

- The case for responsible AI Leadership principles and governance models for RAI
- Case studies for AI governance
- AI's environmental imperative
- RAI best practices from award-winning implementations
- Standard metrics for RAI performance



RAI, as an acronym for **responsible AI**, has become commonplace. Hence, we will be using this acronym in this book, with an exception in certain places where using the full form makes more sense.

This chapter's sustainable IT reference model perspective, as illustrated in *Figure 4.1*, will primarily cover governance practices for a responsible and sustainable AI lifecycle, with an emphasis on AI's data center-based environmental impact – energy, emissions, and water consumption. AI's social sustainability governance will be addressed in *Chapter 5*, *Social Sustainability: Accessibility, AI, and the Digital Divide*. There are also many governance challenges specific to AI system data, which will be addressed in *Chapter 8, Data*.

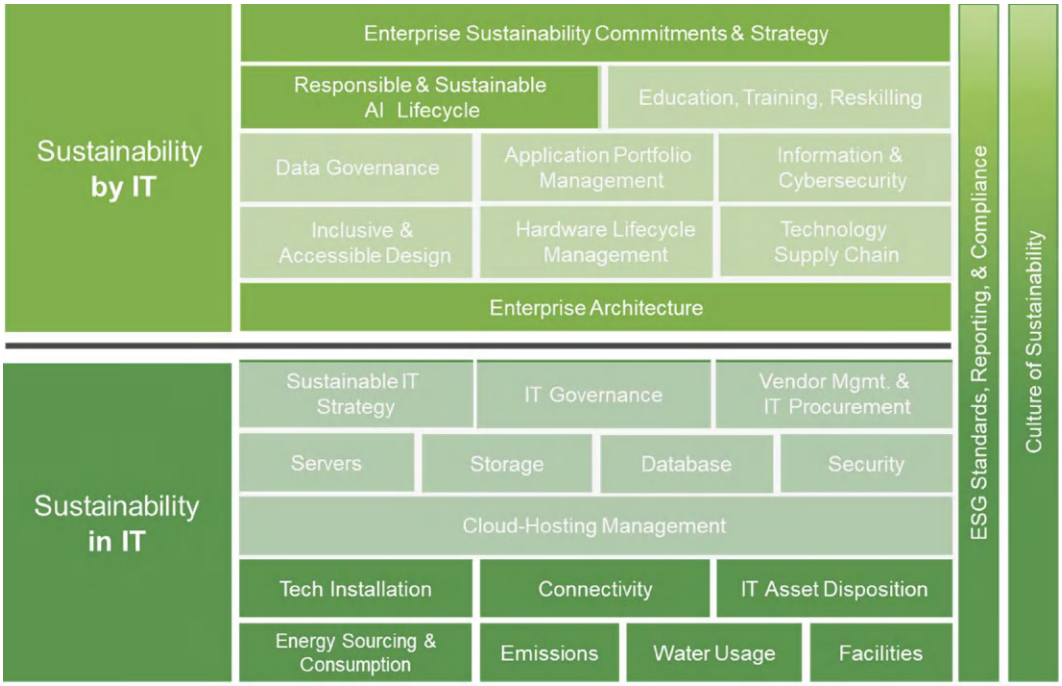


Figure 4.1 – Sustainable IT reference model – Chapter 4 focus

By the end of the chapter, you will have learned about critical AI governance goals and actions applied to AI systems, their data, and their users. You will also gain real-world insights from companies that won SustainableIT's **Responsible AI Impact Award** in June 2025.

The case for RAI

RAI refers to the governance and operational discipline that ensures AI systems are developed, deployed, and maintained in ways that align with legal, ethical, and organizational standards. It includes oversight practices, risk management, compliance, and lifecycle accountability across systems and teams. **Sustainable AI** is differentiated by its focus on ESG impacts, including the limiting of non-renewable energy consumption, water usage, and carbon emissions footprint. It also incorporates social and governance sustainability. Fundamentally, sustainable AI focuses on the *impact on the planet and society*. RAI focuses on making sure the *right processes* are in place to enable AI sustainability as well as optimize the value of the tools.

Most AI system users have little to no idea of the energy consumption and emissions instigated by their prompts, nor do they anticipate the biases inherent in their data and propagated by their outputs. The following is a brief rundown of the dimensions of some of AI's primary business risks:

- **Resource demand** – The technology required to operate GenAI and systems using **large language models (LLMs)** has an outsized appetite for electricity and water.

  Data centers in Phoenix consume approximately 1.5 gigawatts of power (Stanford University 2025). This is approximately the same amount of energy that would power 1.2 million U.S. homes for a single day, or a city the size of Scottsdale, Arizona, for over 10 days.

  The cooling requirements of AI data centers lead to high water consumption. ChatGPT, for example, uses about two liters of water for every 10 to 50 queries (The Times 2024). At the high end of the range, this would be enough water to fill 16 Olympic-sized swimming pools every day.

- **Climate degradation** – The emissions generated in the GenAI lifecycle, from training through usage, are shockingly high compared to other technologies.

  OpenAI's GPT-3 training is estimated to have used 1.3 gigawatt-hours of energy (equivalent to 120 average U.S. households' yearly consumption) and generated 552 tonnes of carbon emissions (equivalent to the yearly emissions of 120 U.S. cars) (Patterson et al. 2021). OpenAI's GPT-4 is said to be 10 times larger (The Decoder 2023).

  Multiple studies estimate AI's global annual water consumption to reach between 4.2 billion and 6.6 billion cubic meters (1.1–1.7 trillion gallons) by 2027. This is 4 to 6 times the annual water usage of a country such as Denmark. Based on the companies' own environmental reports, Microsoft data centers increased water use by 34%, and Google by 20% in just one year (2021–2022) due to AI demands. GenAIcould add 1.2–5 Mt of e-waste through 2030, up to 12% of global totals (Nature Computational Science 2024).

- **Ethics** – The use of GenAI's creative abilities raises rights and ownership dilemmas for intellectual property and data. The misuse of GenAI for deep fakes and other forms of misinformation can cause personal and societal harm. The ability of GenAI systems to synthesize existing material in its creation of content raises the risk of violations of intellectual property copyrights and introduces uncertainty to ownership of data. GenAI's ability to create increasingly convincing deepfake images has corporations concerned, but perhaps not concerned enough. Less than 50% of IT and cybersecurity leaders surveyed in a 2024 study believe GenAI will advance adversarial capabilities such as phishing, malware, and deep fakes (Statista 2025).
- **Digital equity** – The so-called democratization of AI, beginning with OpenAI's ChatGPT tools, does not mean that AI systems and benefits are equitably accessible. Approximately 2.6 billion people globally remain without internet access, a fundamental barrier to equitable access to AI technologies (Reuters 2024).
- **Urban vs. rural disparity** – In the U.S., generative AI uptake is higher in urban/educated/affluent counties, disadvantaging rural regions. For instance, one study found urban areas reaching 18.2% adoption compared to 10.9% in rural areas for AI writing tools (Daepp, M., Microsoft Research 2024).

    Women are significantly underrepresented in adopting AI tools – 10 to 20 percentage points less likely than men to use ChatGPT in similar roles (Otis, Nicholas et al. 2024). A review of various studies showed the number of women adopting AI tools was 10–40% smaller than the share of men adopting these tools (Working Knowledge 2025).

- **Job displacement and skills obsolescence** – AI's ability to automate not only tasks but entire roles requires businesses to consider retraining and upskilling employees to avoid socially harmful mass job displacement. In 2024, 75% of workers were using AI, and 45% feared replacement (AIPRM 2024). About 46% of employees fear their skills will be obsolete within 5 years, with 29% expecting it to happen even sooner (Kahoot! 2024).

    40% of employers expect AI to reduce their workforce due to AI automation (World Economic Forum 2025). AI could impact nearly 40% of global jobs. In advanced economies, 60% of jobs may be impacted by AI, with roughly half benefiting from integration of AI into their work, while the other half could face some degree of replacement, lowering labor demand and wages (IMF 2024).

- **Security and privacy** – AI-driven automation and decision-making can propagate errors or biases at scale, compounding the damage of a security incident if undetected. Because AI models often rely on large volumes of sensitive, proprietary, or personally identifiable information, they expand the attack opportunity for data breaches, theft, and misuse. Adversarial actors can exploit vulnerabilities by poisoning data or injecting prompts to extract confidential information or corrupt system outputs.
- **Integrity** – The veracity of AI system output cannot be taken for granted. Examples of biased data and outputs have been widely reported in the past several years (*Table 4.1*). This is a tangible risk for companies adopting these systems. According to an IBM survey from 2021, 85% of organizations believe that AI bias can harm brand reputation and customer trust, while 68% fear legal consequences stemming from biased outcomes (IBM 2021).

AI lifecycle stage	Type of bias	Description	Example
Model training	Sampling bias	Training data does not represent the population it will serve	**COMPAS recidivism algorithm**: Trained on U.S. criminal justice data, disproportionately flagged black defendants as higher risk than white defendants (PoPublica 2016)
	Historical bias	Data reflects existing societal inequalities and stereotypes	**Amazon hiring algorithm**: Downgraded résumés with the word *women's* due to historical data favoring men (Reuters 2018)
	Label bias	Human annotations reflect subjective judgments or inconsistent standards	Annotators labeling customer complaints about "service speed" as less severe when written by younger demographics
	Measurement bias	Features chosen or data collection systematically misrepresent reality	Using U.S. ZIP codes as a proxy for creditworthiness embeds socioeconomic and racial segregation

AI lifecycle stage	Type of bias	Description	Example
Development	Preprocessing bias	Data cleaning, augmentation, or transformation steps introduce skew	Removing "outliers" in speech datasets excludes non-native accents and dialects
	Representation bias	Certain groups are underrepresented in benchmarks or test sets	**Facial recognition systems**: Higher error rates for darker-skinned women (MIT Media Lab 2018)
	Confirmation bias in model design	Developers unintentionally design models to confirm assumptions	Forecasting model tuned assuming industrial users dominate energy demand
Use/deployment	Interaction bias	User interactions reinforce biased outcomes over time	Microsoft Tay chatbot learned and amplified racist and sexist language from Twitter interactions (BBC 2016)
	Automation bias	Overreliance on AI recommendations, ignoring context	Doctors overly relying on AI triage systems, accepting false negatives in rare diagnoses
	Feedback loop bias	Model outputs influence future data, entrenching bias	**Predictive policing systems**: Deployed in certain neighborhoods, reinforcing arrest data and bias (The Guardian 2016)
	Cultural bias	System performance skewed by cultural norms not accounted for	Sentiment analysis marks *that's sick* as negative, despite a positive slang meaning

Table 4.1 – Bias types and examples across the AI system lifecycle

If avoidance of these negative impacts does not inspire urgency to apply a responsible approach to AI, then the upside of a sustainable AI portfolio should be an added incentive. By stepping forward to propose and implement responsible strategies and practices, IT organizations will directly contribute to the future competitiveness of their enterprises. Essential benefits include the following:

- **Increased confidence in AI technology** – Implementing ethical usage principles aligns AI applications with the company's values and ethical standards, increasing corporate confidence in AI-derived decisions and actions.
- **Customer trust and loyalty** – AI outcomes that are fair, transparent, and explainable help build corporate, customer, and institutional trust in business decisions. This will help maintain long-term customer loyalty and company reputation.
- **Advancement of environmental goals** – Conducting environmental sustainability due diligence not only advances the company's sustainability goals, but it improves competitiveness in markets where environmental stewardship is – or will soon become – highly valued.
- **Future-ready workforce** – By prioritizing AI literacy and human-first AI principles, companies equip their current and future workforce to engage effectively with AI technologies.
- **Optimized innovation and efficiency** – By adhering to a RAI governance framework, companies can more freely tap AI's potential without the distrust, delays, fines, and other consequences of poorly governed technology rollouts.

Guiding and operationalizing responsible transformation isn't simple, or even common in the case of AI. Responsible governance is assumed to be an impediment to AI uptake. Yet, IT leaders who have operationalized RAI principles across the AI system's lifecycle say they accelerate deployment of effective AI models and reduce time wasted on dead ends.

Leadership principles for RAI

While there are a multitude of ethical and inclusive standards and frameworks for AI deployment, few cover the entire ESG spectrum, particularly environmental. SustainableIT's RAI Working Group began to address this gap in September 2024 with the release of nine ESG principles for IT to use as guiding rules for RAI lifecycle leadership (SustainableIT.org 2025). They are defined here, each with a hypothetical example of a practical application:

- **Risk assurance** – AI application risks to business stakeholders, operations, policies, compliance, and strategic goals are thoroughly assessed and mitigated across the lifecycle.

Example: In an HR recruitment platform, risk assurance involves identifying and mitigating potential biases in resume screening algorithms that might disproportionately exclude candidates from underrepresented groups. Ongoing audits and human oversight help ensure compliance with diversity policies and anti-discrimination laws.

- **Sustainability** – AI applications are designed, deployed, and managed to meet enterprise standards for ESG impact.

  Example: A retail company deploying AI for demand forecasting includes sustainability constraints in model design, such as minimizing waste from overproduction. Model training is conducted using low-carbon cloud services, and carbon intensity per inference is tracked for reporting. See the *Operationalizing RAI* section later in this chapter for details on how to operationalize the environmental aspects of this principle.

- **Ethical alignment** – AI applications align and comply with organizational ethical standards and business values.

  Example: A financial services firm introduces a customer-facing chatbot and ensures its responses reflect company values, such as transparency and integrity. The chatbot avoids aggressive upselling tactics and provides disclosures when recommending products, aligning with ethical standards for client trust.

- **Data integrity** – AI application data is appropriate, authorized, transparent, secure, resilient, privacy-compliant, and as unbiased as possible.

  Example: A health tech company building a predictive care model ensures that patient data is anonymized, sourced with explicit consent, and validated for accuracy. Data lineage logs document sources and transformations, enabling compliance with HIPAA and GDPR.

- **Trusted outcomes** – AI-driven results, recommendations, and decisions are accurate, fair, safe, and explainable.

  Example: In a fraud detection system for a payment processor, trusted outcomes require models to provide confidence scores and decision explanations. When transactions are flagged, investigators and customers are given specific reasons to support clarity and recourse.

- **AI literacy** – Stakeholders are prepared to effectively leverage AI applications technically, operationally, and in alignment with governance and strategic goals.

Example: A logistics company rolling out AI-driven route optimization trains drivers, dispatchers, and planners on how the system works, how to interpret its suggestions, and when to override them, facilitating adoption, trust, and effective human-AI collaboration.

- **Human-first AI** – AI development and deployment policy prioritizes augmentation of existing roles and upskilling and redeployment of impacted workers.

  Example: A publishing firm deploying AI summarization tools for editorial work uses them to assist editors rather than replace them. The company creates training programs to help staff work with AI tools and focus more on creative and investigative tasks.

- **Equitable impact** – AI benefits are equitably distributed and accessible to stakeholders, avoiding intentional or unintentional exclusion of disadvantaged groups.

  Example: A city government uses AI to recommend locations for new public services but ensures that the model includes equity-weighted criteria, so underserved neighborhoods are prioritized. Community stakeholders are engaged in validating outputs to ensure inclusivity.

- **Responsible innovation** – As AI is used to reimagine business models, products, and processes, the resulting innovations align with environmental, social, ethical, and governance standards.

  Example: A consumer electronics company leverages AI to design customizable energy-efficient devices. The innovation strategy includes lifecycle assessments and fair labor standards for suppliers, aligning tech development with ESG commitments.

Some principles, including risk assurance, sustainability, data integrity, and responsible innovation, are more squarely within IT's domain of control and influence. Others may be led by the sustainability office or HR, but IT should provide support in the form of executable processes, automation, or AI subject matter expertise. The principles' greatest impact will come from operationalizing them, and this is also IT's toughest challenge. Making them more than aspirations – through integration in operations – they become tangible, executable, and measurable. We will explore steps for operationalizing principles later in this chapter and again in *Chapter 8*, *Data*.

There is promising news from a study by the Info-Tech Research Group (at the time of authoring this book): 31% of survey respondents have implemented AI principles in their organizations to address possible risks associated with AI applications. Another 24% are in the process of doing so. None of nearly 1,000 respondents viewed AI principles as an impairment to AI-enabled innovation (Info-Tech Research 2025).

Governance models for RAI

Principles are durable directional markers for governance. IT leaders eat governance for breakfast, but parts of RAI governance may have an unfamiliar taste – for example, data bias recognition and mitigation, environmental impact mitigation through AI model selection and data storage rules, and monitoring deployed systems for "model drift."

There are tools and standards to help IT with these specialized areas of governance, including ISO/IEC 42001, a certifiable management system for AI governance programs, which debuted in December 2023 (ISO.org 2023). But it is up to you and your business peers to develop the governance processes and apply performance metrics to track what good AI governance looks like. Timing is also crucial – you cannot succeed if you are constantly chasing after use cases and patching governance holes after the fact. Choice Hotels built its governance framework prior to launching multiple waves of AI tool deployment and development. **Company CIO Brian Kirkland** articulates the approach that works for his organization: "*We let people run fast within a framework that protects them, with the goal of having governance that enables us to move fast rather than slow down.*"

In this section, we will review governance model fundamentals and real-world examples of AI governance models, structures, and processes from Stanford Health Care and Rackspace Technology.

AI lifecycle governance

The principles of RAI span the full circular lifecycle of an AI system. SustainableIT.org depicts this in its toolkit by an AI development cycle integrated with the IT DevOps lifecycle (SustainableIT.org 2025). *Figure 4.2* depicts the AI development lifecycle and its intersection with the enterprise DevOps model, where AI models are integrated, deployed, and monitored. In the AI development cycle, once a validated AI model passes its sustainability impact assessment and gets a "go" green light, it progresses into the DevOps cycle's build stage, where it may be further customized for specific use cases or integrated with existing systems. Post-deployment monitoring may reveal the need for changes, which will cycle through the DevOps plan and code lifecycle phases and possibly back into the AI development circle if the changes are significant enough.

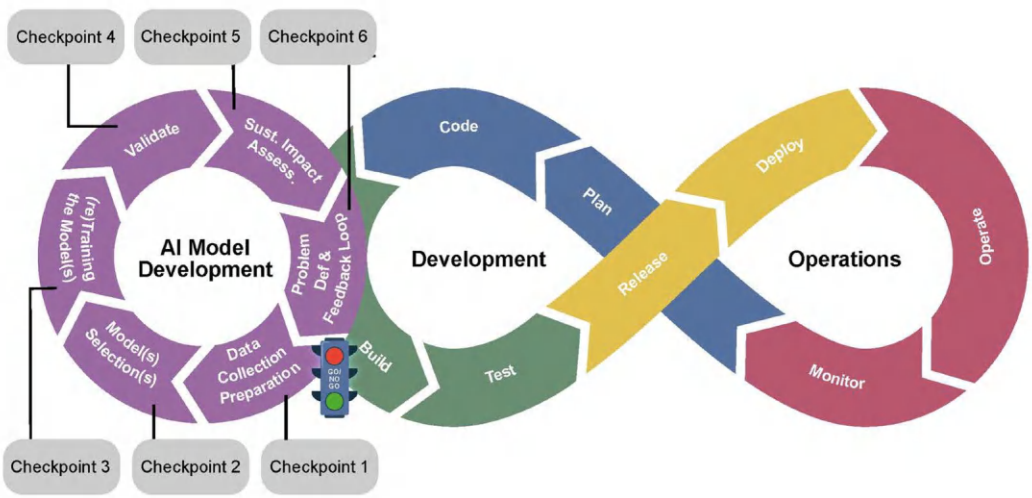


Figure 4.2 – ESG checkpoints applied to the RAI governance lifecycle

The lifecycle also included six ESG sustainability checkpoints and actions mapped to stages of the AI development cycle:

- **Checkpoint 1 – Understand the problem**:
    - What are we trying to do/solve?
    - Is an AI solution appropriate?
    - What should AI achieve?
    - What is the necessity and feasibility?
    - Assess feedback or obtain new data to improve the use case

- **Checkpoint 2 – Raw data gathering and preprocessing**:
    - Licensed and privacy-compliant
    - Pre-model quality and bias audits
    - Cleaning, labeling with human-in-loop
    - Transformation, splitting low-footprint formats
- **Checkpoint 3 – Choose AI models/algorithms**:
    - Fit-for-purpose, energy efficient
    - Transparent, interpretable
    - Pretrained models assessed for bias and harm potential
- **Checkpoint 4 – Train model responsibly**:
    - Ethical and inclusive training data
    - Resource-aware hyperparameter tuning
    - Performance, fairness, energy demand monitoring
- **Checkpoint 5 – Evaluate on test sets and proofs of concept (PoCs)**:
    - Outcome accuracy and fairness
    - Cost/risks: operational and ESG
    - Impact on sustainability KPIs
- **Checkpoint 6 – Host, use, and monitor model**:
    - Low-carbon cloud or green infrastructure
    - Risk safeguards, documentation, and explainability APIs
    - Monitor performance, fairness, and drift to improve the model

In *Figure 4.3*, an IT Sustainability Impact Assessment is sequenced into the model, with the primary application stages being validated in the AI development lifecycle, and deployed and monitored in the DevOps cycle.

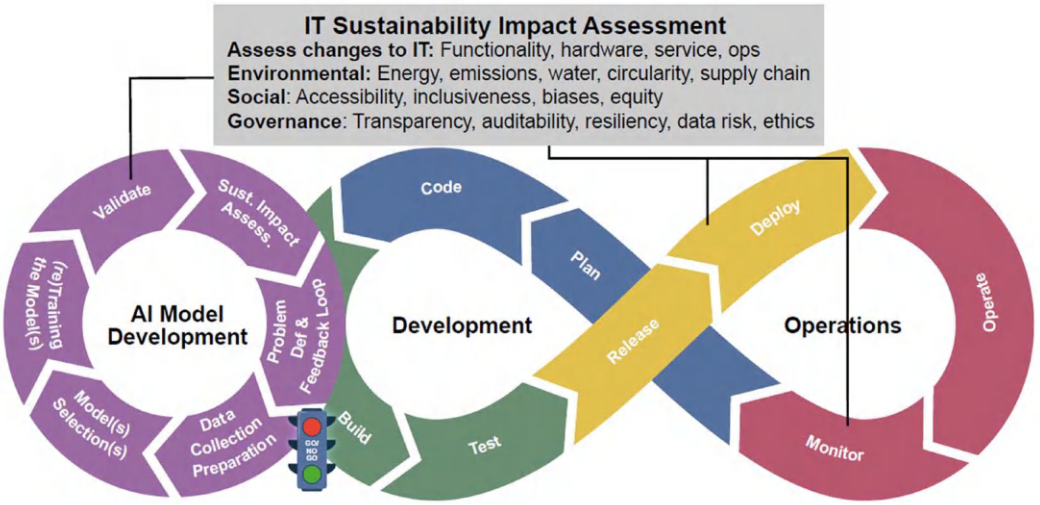


Figure 4.3 – Sustainability Impact Assessment applied to the AI governance lifecycle

Case study: Stanford Health Care's AI lifecycle governance

An example of full lifecycle RAI governance has been implemented at Stanford Health Care, helping to facilitate the development and deployment of more than 40 AI-based applications as of mid-2025. The AI efforts were led by **Dr. Michael Pfeffer, Chief Information and Digital Officer**. Early rollouts revealed that neglecting governance causes greater operational and ethical issues later. Rigorous, multi-stage reviews have now become an integral part of responsible innovation at Stanford Health Care. While the lifecycle scrutiny does sometimes slow down AI buildouts, that is by design, says **Chief Enterprise Architect Anurang Revri**. AI PoCs and experimentation can still proceed at a fast pace because they are not subject to the assessment at that stage. However, for a full rollout, the right set of assessments, decisions, and ongoing monitoring is required.

Stanford Health Care has backed up its RAI commitment with mandatory training for all staff. In addition to AI basics training for all employees, two specialized courses have been developed for managers, clinical leaders, and IT staff. The first course focuses on basic AI foundations at Stanford Medicine, and the second dives deeper into implementation with steps involving the incorporation, monitoring, and evaluation of AI in the workflow. This growing competency ensures that AI risks are identified early and AI opportunities are pursued responsibly. Education is positioned as an ongoing investment in resilience, not just a compliance exercise.

The institution's formal AI governance structure (*Figure 4.4*) spells out three layers of oversight and the associated responsibilities. On the left are the contributions expected from the four governing bodies (middle), and the titles of the individuals involved are on the right. The governance structure is by no means top-down. The high-risk AI decisions are approved by the executive committee. The lower risk solutions can be approved by the IT and informatics leadership group with an inform to the executive committee. A significant part of the governance is thought leadership, education, and best practices for the entire organization.

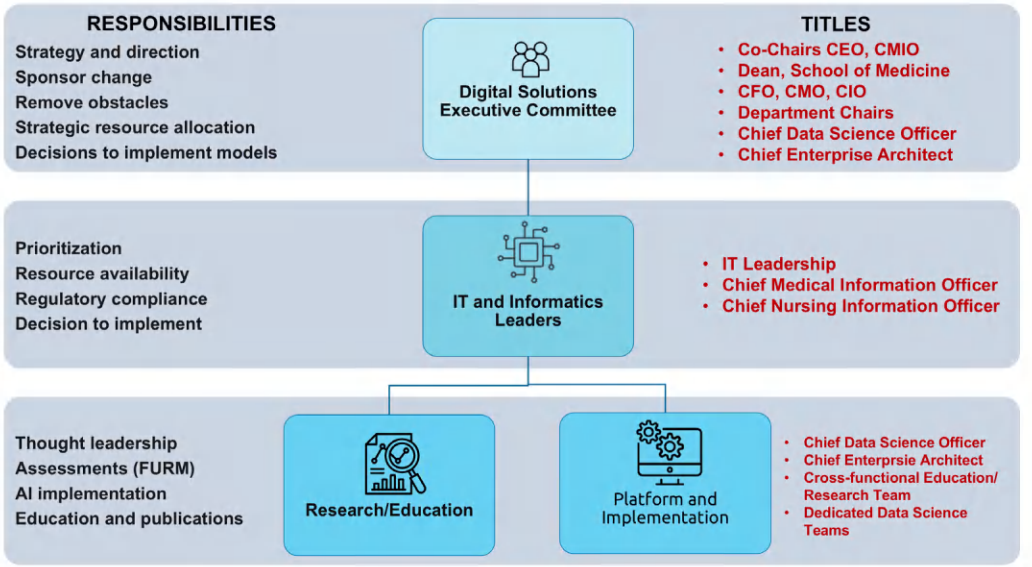


Figure 4.4 – Stanford Health Care AI governance structure

The governing bodies use a **responsible AI lifecycle (RAIL)** process to oversee the incorporation of AI models in software applications supporting both clinical and operational work. The design of this process was led by the chief data scientist to emphasize value, accountability, ethics, and monitoring in the use of AI in healthcare at Stanford. A simplified version of the framework is shown in *Figure 4.5*. Following the RAI framework is a shared responsibility among the teams in IT and involves close interaction among four key constituent groups: operations; IT applications, data, and infrastructure; governance; and the IT **digital solutions (DS)** team.

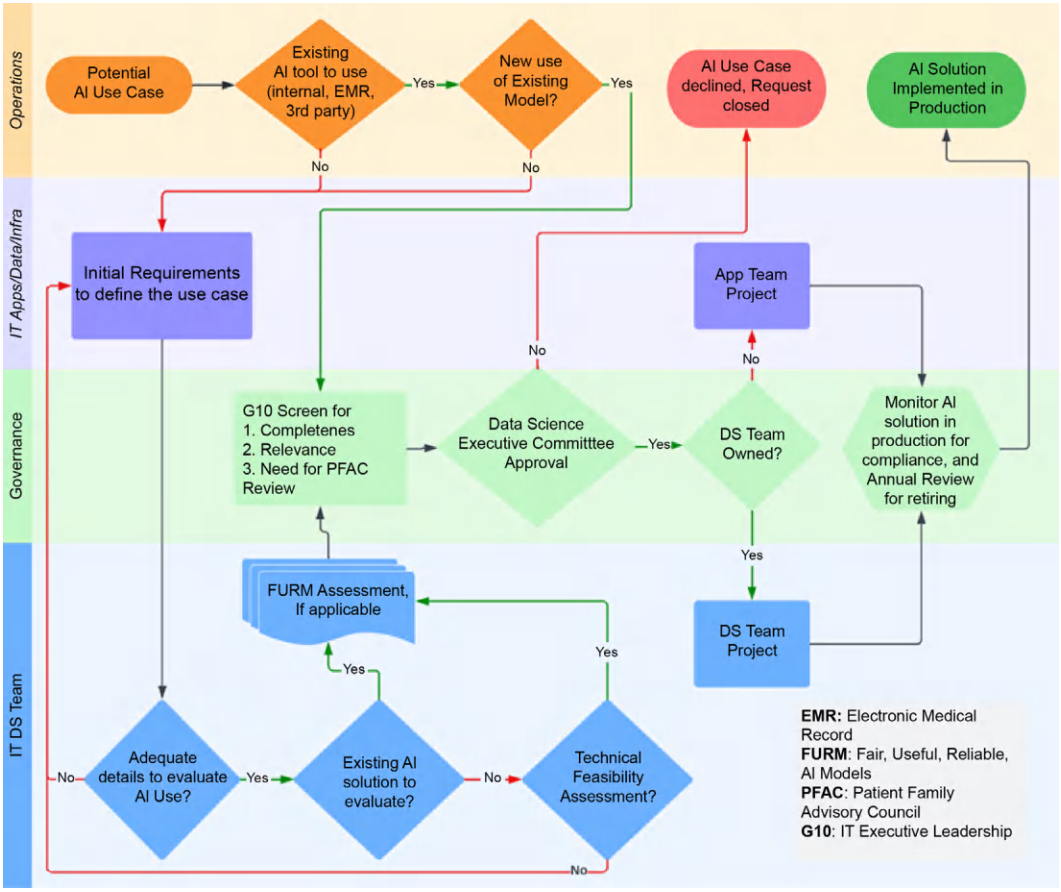
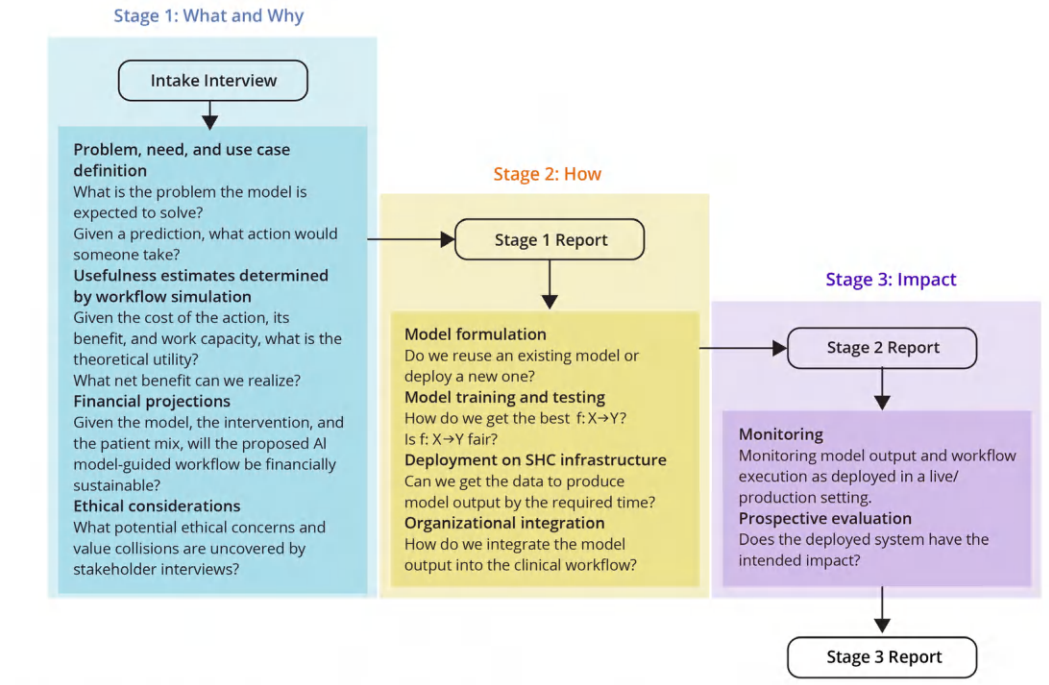


Figure 4.5 – Stanford Health Care RAIL

AI initiatives are assessed before deployment at scale for their alignment with ethical, operational, and financial criteria when applied to clinical and operational settings. AI use cases that originate from various stakeholders, including clinicians and IT teams, are evaluated through governance channels across multiple stages and decision points.

The organization employs the **Fair, Useful, Reliable Models (FURM)** assessment framework to evaluate AI models. *Figure 4.6* is a schematic of the assessment process. The three-stage process ensures that AI applications solve real problems, integrate effectively into workflows, and maintain performance through ongoing monitoring. "*It's not just about the technology itself, but how AI models interact with decision-making protocols and impact patient care*," says **CTO Christian Lindmark**.



AI = artificial intelligence, SHC = Stanford Health Care.
Note: fi X→Y denotes a function that maps some values of X to some values of Y.

Figure 4.6 – FURM assessment methodology

Although the FURM assessment covers predictive models well, a new way to evaluate generative AI models led by Dr. Nigam Shah, Stanford Health Care's Chief Data Science Officer, is underway. It includes developing a taxonomy of clinical tasks, a truth set of responses on a representative dataset. This can then be used to benchmark various models or evaluate solutions using GenAI capabilities. *Figure 4.7* shows a sample of a language model leaderboard for various clinical tasks.

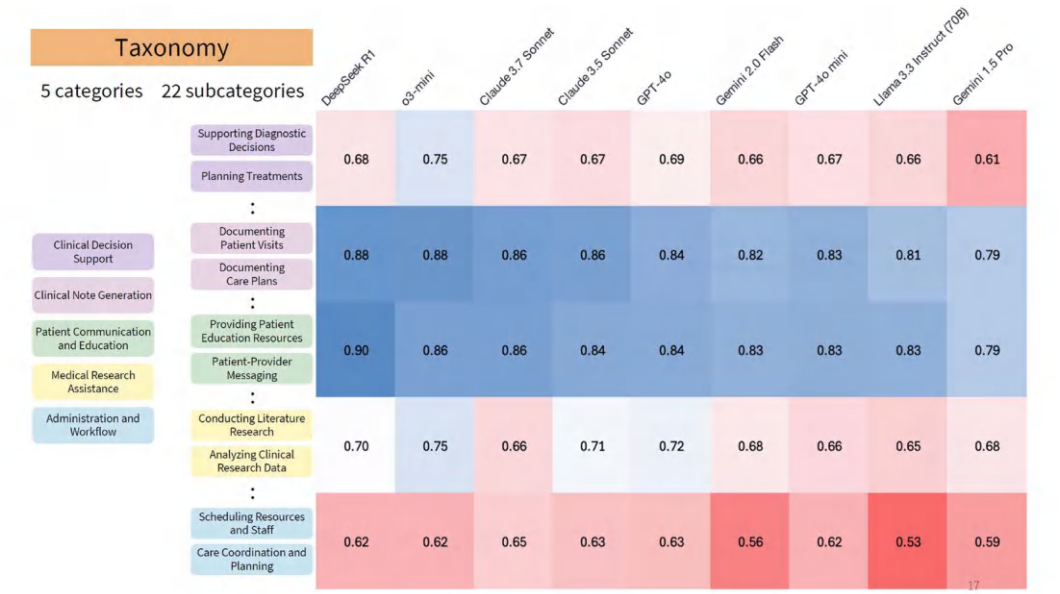


Figure 4.7 – Evaluation of LLMs for clinical tasks

An area of governance with which IT is not typically experienced is ethics, although health care organizations have long addressed this principle. The ethical review identifies potential dilemmas, including the safety of the AI tools being implemented. Without that oversight in scaling, AI can amplify disparities, says Chief Architect Revri. Stanford's review includes input from ethics and legal teams, checking that models are transparent, equitable, and aligned with patient rights. AI initiatives are evaluated by Stanford's School of Law and Data Science Executive Committee, which advises on potential biases and ethical risks. Corporate legal offices can provide enterprises with the same type of checkup.

With many AI models coming from external vendors, Stanford Health Care has formalized requirements for ongoing vendor accountability. Vendors must submit regular monitoring reports demonstrating continued model accuracy, fairness, and ethical compliance. Christian reinforces this by stating, "*We work with all our strategic vendors… and hold them to the same governance expectations as our internal teams.*"

Stanford also reserves the right to audit third-party models post-deployment. This recognizes that risks from AI extend beyond initial implementation and that healthcare organizations must demand transparency and continuous validation from partners.

As organizations deploy more AI applications, monitoring these systems will become increasingly difficult – a concern already under consideration at Stanford. "*Right now, we can monitor 50 AI models, but in the future, organizations will have hundreds or even thousands of models. How will we have the resources needed to monitor them?*" asks Christian. One solution may be automated AI performance monitoring to detect model drift, hallucinations, and unintended consequences. AI oversight mechanisms can accommodate increasingly AI-driven workflows while ensuring compliance. Models provided and operated by third parties will require periodic statements that attest to monitoring performed by the vendor.

What's certain is that RAI governance will continue to be demanding and dynamic, requiring ongoing reevaluation and updates. The key is to have accountable teams and structures in place to handle this rapid evolution.

Our next AI lifecycle governance case study takes us from healthcare to high tech.

Case study: How Rackspace Technology onboards AI

Rackspace Technology provides a robust perspective on AI governance capabilities and a unique but logical governance analogy to the onboarding of a new employee. The IT services management company developed its three-part AI governance model named **AI Target Operating Model (ATOM)**. Its three aspects are (1) guidance, which provides architectural principles and decision checklists to aid decentralized decision making, (2) guardrails, which are controls and automation to prevent accidental and intentional misuse, and (3) the cross-functional governance structure to manage risk and keep everything aligned with evolving standards, regulations, and societal expectations.

Powering ATOM is a set of governance capabilities targeted to AI. The five main categories are the following:

- **Strategy and innovation** – Align AI with the business objectives, accounting for growth, risk, and sustainability
- **Secure AI platform** – Ensure a robust, scalable, and secure AI platform to build next-generation applications
- **Supply chain of data** – Provide accurate, bias-free data to train and infer the right data-driven decisions and information

- **AI product development** – Rethink design and development of applications, infusing user experience and accessibility
- **AI operations** – Monitor, manage, and operate AI business solutions at scale reliably and responsibly

These categories of governance and their enabling capabilities are illustrated in *Figure 4.8*.

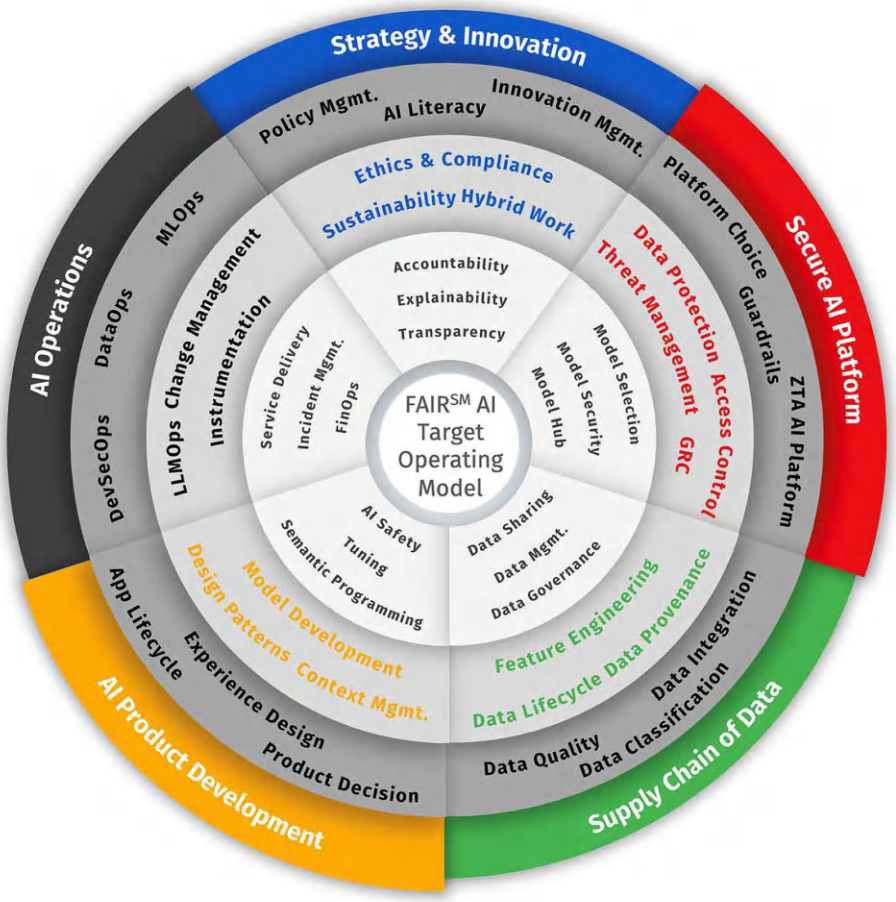


Figure 4.8 – Rackspace Technology's AI governance capabilities

If all the governance aspects of RAI seem overwhelming, a materiality assessment for stakeholder importance and business impact can help with prioritization, just as it does for the IT-tailored ESG metrics introduced in *Chapter 3*, *The Fundamental Building Blocks of a Sustainable IT Practice*. In Rackspace's case, the assessed governance principles are divided into environmental, economic, and equitable (social), as shown in the *Figure 4.9* sample matrix.

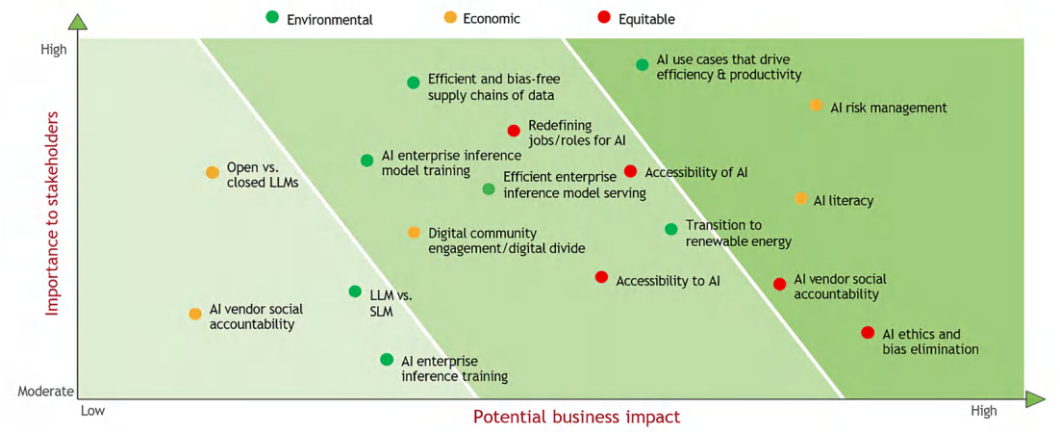


Figure 4.9 – Sample materiality matrix for AI governance practices and principles (Rackspace Technology)

Once materiality is fully assessed and priorities agreed upon, it will be easier to determine what ESG design requirements should be applied to AI development. Srini Koushik, Rackspace's former president of AI, technology, and sustainability, advises IT leaders to establish ESG **non-functional requirements** (**NFRs**) for AI. This means explicitly treating environmental, social, and economic impacts as a design and operational constraint that must be considered alongside traditional quality attributes such as performance, reliability, and security. Koushik is now the founder and CEO of Right Brain Labs.

An NFR defines how a system performs its functions, rather than what it does. When sustainability is included as an NFR, it signals that the system must be designed, built, and operated in ways that minimize negative sustainability impacts and ideally contribute to positive outcomes. NFRs such as the examples that follow would apply to any technology system, but in the context of AI at scale, they will have potentially more impact than they would for a traditional tool or system:

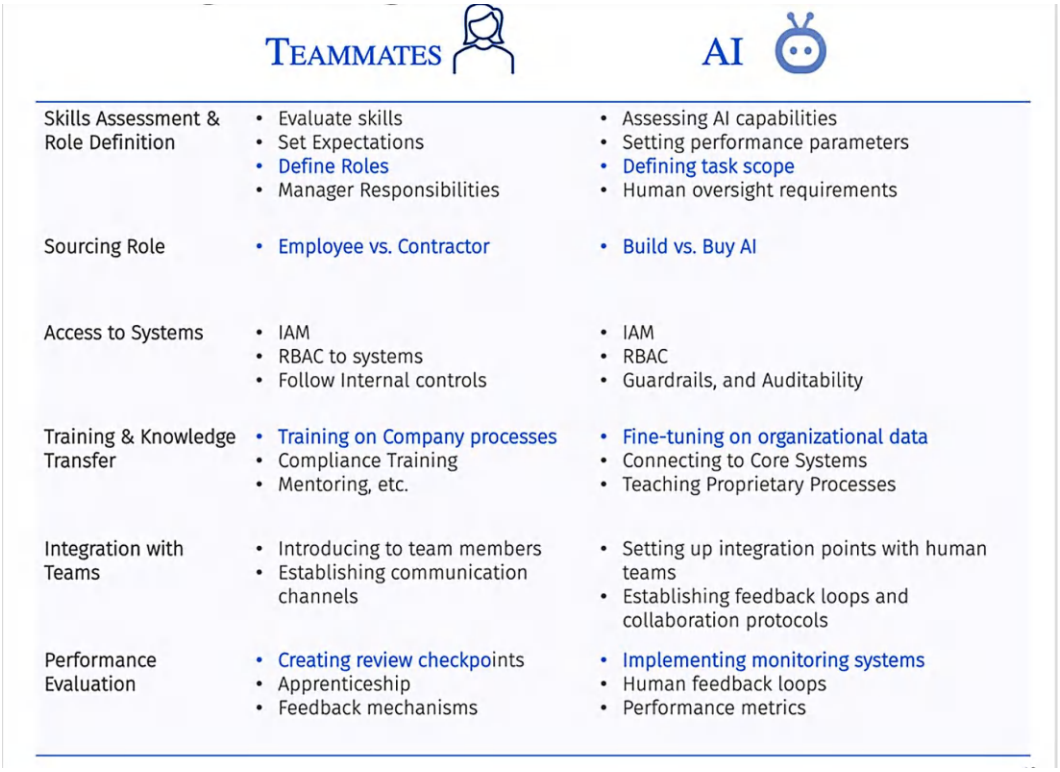
- The model shall not exceed X kWh during training and X kWh/year during inference
- The AI system shall be deployed only on data centers with ≥75% renewable energy
- The solution shall support periodic sustainability audits and impact disclosures
- Data collection must comply with data minimization principles to avoid storage waste

While design parameters such as NFRs are important to have in place, most AI is coming into companies via third-party vendors' software products or services. Introducing AI tools into the workplace should be handled similarly to onboarding a new employee, Koushik recommends. This analogy underscores the importance of integrating AI within an organization's existing guidelines and ensuring it complements and enhances the workforce rather than supplanting them. This requires thorough due diligence of AI-driven applications, determining whether they align with company values, comply with regulatory requirements, and fit seamlessly into business processes. Koushik noted that some candidates for AI implementation were denied because they failed to meet ATOM's guidance on what is acceptable to run on company systems.

Extending governance to agentic AI

As organizations move beyond traditional AI implementations toward agentic AI systems (autonomous agents that can take actions and make decisions) Rackspace's ATOM governance model has evolved to address new complexities, notes Ben Blanquera, Rackspace's Vice President of AI and sustainability. Unlike generative AI tools that respond to prompts, AI agents are embedded directly into business processes and operate with varying degrees of autonomy.

The governance approach for agentic AI again draws its inspiration from onboarding new employees, more literally in the case of agentic tools. These systems must be treated as organizational teammates rather than mere tools. Just as onboarding a new employee involves skills assessment, role definition, and integration protocols, embedding AI agents demands similar rigor. This includes defining clear task scopes, establishing performance parameters, and implementing human oversight requirements that align with the agent's level of autonomy (*Figure 4.10*).



	TEAMMATES	AI
Skills Assessment & Role Definition	• Evaluate skills • Set Expectations • Define Roles • Manager Responsibilities	• Assessing AI capabilities • Setting performance parameters • Defining task scope • Human oversight requirements
Sourcing Role	• Employee vs. Contractor	• Build vs. Buy AI
Access to Systems	• IAM • RBAC to systems • Follow Internal controls	• IAM • RBAC • Guardrails, and Auditability
Training & Knowledge Transfer	• Training on Company processes • Compliance Training • Mentoring, etc.	• Fine-tuning on organizational data • Connecting to Core Systems • Teaching Proprietary Processes
Integration with Teams	• Introducing to team members • Establishing communication channels	• Setting up integration points with human teams • Establishing feedback loops and collaboration protocols
Performance Evaluation	• Creating review checkpoints • Apprenticeship • Feedback mechanisms	• Implementing monitoring systems • Human feedback loops • Performance metrics

Figure 4.10 – Onboarding and embedding agentic AI tools compared to human teammates © 2025 Rackspace Technology. Graphic reproduced with permission. All rights reserved

The collaborative nature of agentic AI introduces additional governance considerations across three modalities: supervisor-to-agent interactions (where humans direct AI actions), agent-to-agent collaboration (where multiple AI systems coordinate), and swarm behaviors (where agents operate collectively). Each modality requires specific guardrails, monitoring mechanisms, and accountability frameworks.

Implementing agentic AI governance requires concrete actions across six key areas:

- Conducting thorough skills assessments to evaluate AI capabilities and set performance parameters while defining clear task scopes and human oversight requirements
- Making strategic sourcing decisions between employee-like versus contractor-like AI relationships and build-versus-buy choices
- Establishing proper access controls through **identity and access management (IAM)** and **role-based access control (RBAC)** systems with appropriate guardrails and auditability

- Providing comprehensive training on company processes and compliance requirements while fine-tuning agents on organizational data and teaching proprietary processes
- Facilitating smooth integration by introducing agents to team members and establishing communication channels, along with feedback loops and collaboration protocols
- Creating robust performance evaluation systems with regular review checkpoints, monitoring systems, human feedback loops, and clear performance metrics

Stanford Health Care, Rackspace Technology, and other companies recognize the risks of ungoverned AI but also want to avoid having IT be a roadblock to AI-based innovation. That means walking a fine line between controlling and facilitating the AI opportunity. AI governance does not slow innovation. In fact, the Info-Tech Research survey cited earlier in this chapter found that "*no respondents viewed AI safeguards as an impairment to innovating with AI.*" Instead, organizations see governance as an accelerator that facilitates value and builds the trust required to scale AI responsibly.

AI's environmental imperative

It is no coincidence that environmental sustainability is called out in the leadership principles. In the initial rush to experiment with GenAI, there were plenty of warnings and guidance about potential data biases and ethical abuses, both from watchdog organizations and the tech companies themselves, such as IBM and Microsoft. In comparison, there were few alarms sounded about AI's impact on the environment, and the general public was unaware of AI's thirst for power until news reports of Microsoft's plan to resurrect the Three-Mile Island nuclear power plant in the U.S. Now, it is heartening to see that large influential consultancies such as Accenture and Capgemini are focusing research and services on the environmental challenges of the AI lifecycle. They both share research insights and action plans in this section.

In this section, **Sanjay Podder**, **Managing Director and Global Lead for Technology Sustainability Innovation at Accenture**, shares his perspective on extending sustainable technology strategies to address the AI revolution. Sanjay is a thought leader within the sustainable IT space and a founder and steering member of the **Green Software Foundation** (**GSF**).

> **The AI efficiency paradox**
>
> Technology has become a fundamental driver of sustainability for organizations. Fifty-five percent of the world's 2,000 largest companies by revenue have reduced their operational emissions since 2016, but only 16% of them are on track to reach net zero in operations by 2050 (Accenture 2024). And now we face an unprecedented extra challenge: artificial intelligence, while promising to revolutionize sustainability across industries, is creating its own environmental footprint.

AI's share of global power consumption is set to rise from 0.2% in 2024 to 1.9% by 2030, a 48% compound annual growth rate. By 2030, AI data centers will consume 612 terawatt-hours of energy annually (equivalent to Canada's total electricity consumption) and 3.02 billion cubic meters of fresh water. Carbon emissions for AI may account for 3.4% of total global emissions, an 11-fold increase in one decade (Accenture 2025).

It's the irony of our era: the same technology that represents a generational leap in efficiency and capability could jeopardize the very sustainability goals it's meant to support.

Four imperatives for sustainable AI scaling

Success requires strategic action across four key areas:

1. **Deploy smarter silicon** – Shift AI workloads to energy-efficient architectures such as compute-in-memory technologies, which can reduce AI inference power use by up to 20x. Deploy AI at the edge to cut cloud dependency and carbon emissions while improving performance.
2. **Decarbonize data centers** – Optimize through dynamic scaling, smart load balancing, and strategic location choices. Emerging solutions include nuclear-powered data centers using small modular reactors, advanced cooling systems, and circular water solutions, achieving 50–70% water savings.
3. **Use AI thoughtfully** – Deploy task-specific models rather than defaulting to LLMs for every use case. More importantly, strategically use AI to drive decarbonization, from HVAC optimization, reducing energy use by 25%, to predictive logistics, cutting transport emissions.
4. **Embed AI governance-as-code** – Track AI carbon intensity alongside traditional KPIs, implement carbon-aware infrastructure selection, and participate in developing AI sustainability standards rather than waiting for rigid compliance mandates.

Redefining AI intelligence: the sustainable AI quotient

We need to shift from asking only "How powerful is our AI?" to "What are we getting for the resources we're investing in AI?" This requires a new metric: the **Sustainable AI Quotient (SAIQ)** – a measure of how efficiently AI systems convert money, electricity, carbon, and water into actual performance.

SAIQ is calculated as a weighted sum of the following:

- **Unit cost** – Dollars per token
- **Electricity** – Megawatt-hours per token
- **Carbon emissions** – Tonnes of CO_2e per token
- **Water** – Cubic meters per token

The lower the SAIQ, the more efficient and responsible the AI system.

Organizations can adjust the weights given to each dimension according to their priorities, whether emphasizing cost efficiency, energy resilience, or environmental impact.

The path forward

Sustainable AI is not a constraint; it's a catalyst for innovation, efficiency, and resilience. By embracing the principles of SAIQ and scaling responsibly, companies can future-proof their technology strategies and build ecosystems that are both intelligent and regenerative.

This is the next evolution of sustainable IT. The CIO, together with the full C-suite, must now lead the charge, turning AI from an operational liability into a source of environmental advantage.

For more information, visit `https://www.accenture.com/us-en/insights/sustainability/powering-sustainable-ai`.

Sanjay Podder, Managing Director and Global Lead for Technology Sustainability Innovation, Accenture

By translating AI efficiency into a multidimensional metric (spanning cost, electricity, carbon, and water), SAIQ offers CIOs and sustainability leaders a way to evaluate AI systems beyond raw performance, reframing the discussion around accountability and long-term value. Much like power usage efficiency standardized conversations on data center efficiency, SAIQ has the potential to become a unifying benchmark for sustainable AI deployment. As enterprises experiment with compute-in-memory technologies and edge AI to cut their footprint, pairing those advances with a metric such as SAIQ, we will be able to measure and compare the sustainability of our AI estate. If you are unfamiliar with **Compute-in-Memory (CIM)**, it is a class of processor architecture that performs data processing directly within memory arrays, instead of shuttling data back and forth between separate compute units (CPU/GPU/accelerator) and memory storage. By embedding simple arithmetic and logic operations into the memory cells themselves, CIM reduces the "memory wall" problem, where data movement consumes far more energy and time than the computation itself.

Our next expert perspective on AI environmental sustainability comes from Capgemini. The research and consulting firm has developed a framework for measuring and reducing AI's environmental footprint and tips for applying it to drive the "greening of AI." The essentials are described here by **Fabian Schnippering, Manager of Sustainable IT and Business Technology**, at **Capgemini Invent**:

The eco-digital era: why AI must go green

Organizations today face two defining challenges. First, the pressure to rapidly digitalize. 70% of organizations believe that digitally driven business models will be key to growth. Second, the push to become more sustainable, as 64% have sustainability on their C-suite agenda. These parallel demands shape what is termed the eco-digital era, which contrasts with the traditional digital economy, as shown in *Table 4.2*.

TRADITIONAL DIGITAL ECONOMY	EMERGING ECO-DIGITAL ECONOMY	WHY IT MATTERS
Limited exploration of digital's value to business	Doubling of the size of the eco-digital economy within the next five years	The size of the emerging eco-digital economy is expected to nearly double from $16.6 trillion today to $32.9 trillion in 2028
Sustainability as a standalone, nice-to-have pursuit	Sustainability as a must-have, powered by digital technologies	Digital technologies contribute more to reducing emissions than their own carbon footprint
Limited exploration of new revenue streams	Software and digital platforms drive emergence of new revenue streams	Capgemini research found that automotive OEMs' software-based revenue could triple from $181 billion (2021) to $640 billion by 2031
Ad-hoc use of technology for driving efficiency	Emerging tech (e.g., gen AI, SynBio, quantum) boosts innovation, productivity, and decision-making	In 2023, Microsoft launched 365 Copilot, the gen AI-powered assistant, across all its apps and services
Individual organizations working in silos	Collaboration and partnerships across industries give rise to digital ecosystems	Frank Loydl, CIO at Audi AG: "The outcomes [of collaboration] are evident: significant quality improvements, enhanced speed, expanded service capabilities, and the creation of new business models."
Changes in skills demand driven by digitalization	Increased demand for a diverse mix of talent and new ways of working	The CDO at a telecom company: "Talent is a critical factor for navigating the new economy [...] Without the right culture and talent, we will never be able to make progress."

Table 4.2 – Traditional digital economy vs. emerging eco-digital economy (Capgemini 2024)

Success in this era depends on integrating digital and sustainability goals. One technology sits at the center of this dual transformation: AI. Its rise – especially the proliferation of generative AI – presents unprecedented opportunities and critical sustainability risks.

According to Capgemini research, 66% of organizations expect GenAI to help cut GHG emissions by at least 10% in the next 3–5 years. Yet, half of those same organizations report that GenAI has already increased their emissions (Capgemini Institute 2025). While executives sense this impact, including hidden costs such as water consumption, which is estimated to reach up to 6.6 billion liters by 2027 for training LLMs (Li, Shaolei, 2023), only 12% currently measure it (Capgemini 2025). The main barriers are limited transparency from providers, low awareness, and high complexity.

This underscores a critical insight: There is currently a lack of awareness about AI's environmental impact. Expectations are high, insights are limited, and mitigation efforts are sparse. A wide range of stakeholders must be considered, each with distinct and sometimes conflicting needs and expectations regarding privacy, performance, and usability. Navigating these layers requires a structured foundation, combined with practical know-how.

The following sections introduce a practical framework developed by Capgemini Invent to help organizations measure and reduce AI's footprint effectively. It aims to bring clarity and enable action – regardless of maturity level or infrastructure landscape.

A practical framework to measure and reduce AI's footprint

To act on AI's environmental footprint, organizations need a way to quantify impact, identify hotspots, and drive improvement. The framework presented here meets this challenge by translating lifecycle science into tangible decision-making tools (Capgemini Invent 2024).

Its core purpose is to tackle the biggest barrier to sustainable AI: the lack of measurable insights. The framework works in three ways:

1. Visualizes AI's footprint across compute, storage, and network in dashboards tailored to business and technical audiences
2. Standardizes measurement, allowing easy comparison across AI projects
3. Guides action, showing where even small design shifts – such as trimming model size or batching requests – deliver high-impact results

The framework has four consecutive layers, each deepening insight into AI emissions (*Table 4.3*):

	Description	Objective
Layer 1 Data & Hardware Snapshot	Using data from cloud providers or on-premise systems, organizations can calculate their hardware emission impact numbers.	This allows them to analyze their environmental impact across compute, storage, and network hardware.
Layer 2 Use Case Clustering	All use cases are grouped by type (e.g., generative vs. traditional AI), user base, and model size.	Mapping each use case to a predefined cluster reveals associated usage patterns making their impact transparent and comparable.
Layer 3 Portfolio View	All use case clusters are aggregated into a single heat map	This view shows the cumulative impact of choices across departments and enables focused interventions
Layer 4 Scenario Explorer	Decision-makers can simulate interventions exploring what-if scenarios, boundaries of impact, and strategies for trade-offs.	This forward-looking approach fosters continuous improvement.

Table 4.3 – Four-layer framework for assessing and optimizing AI infrastructure impact (Capgemini Invent, 2024)

This modular structure makes the framework adaptable. For instance, it was applied to a synthesized enterprise combining structural insights of the 2,000 largest global firms. Key findings included the following (*Table 4.4*):

Emission Share	Model Size	Smarter Prompting
Generative AI accounted for the largest share of emissions with up to 99.9% despite being only 29% of total use cases	Architectural decisions like model size alone can increase energy usage per inference by up to 186x.	Smarter prompting and reduced usage cut energy by up to 32% while achieving the same with hardware alone would require 500x efficiency gains.

Table 4.4 – Key sustainability insights from a hypothetical Global 2000 enterprise AI portfolio (Capgemini Invent 2024)

Moreover, experience from practice has revealed the following application tips:

- Inventory your existing AI use cases thoroughly. Understanding your current baseline is essential to identifying high-impact opportunities and tracking improvements.
- Conduct workshops to cluster use cases where data is missing. When organizations don't yet have full measurement data on the environmental footprint of individual AI projects, they should group similar use cases together for analysis rather than treating each one in isolation.

- Prioritize "high-impact, low-effort" interventions. Quick wins, such as optimizing model parameters or scheduling workloads, can yield immediate benefits with minimal resource investment.
- Establish a recurring review process. Iterating regularly ensures that the framework adapts to evolving portfolios, technologies, and organizational priorities.

This framework functions as a "Sustainable AI Steering Kit" – modular, actionable, and scalable across different maturity levels. Its flexibility enables organizations to start small, adapt to their specific context, and expand as needed. A European IT service provider with over 5,000 employees and over one million clients provides an example of the four-level framework's relevance.

As GenAI adoption accelerates, the IT service provider expects a significant rise in energy and resource demands, especially since up to 90% of energy use occurs in data centers. This aligns with industry projections: GenAI's emissions share is set to nearly double from 2.6% to 4.8% in 2 years, and global data center electricity demand is expected to rise from 460 TWh in 2022 to 1,000 TWh by 2026 (Capgemini 2025). While concrete cost increases have not materialized yet, initial measurements indicate a rising energy footprint, especially in inference workloads. The provider operates fully owned data centers, creating clear responsibility for emissions.

In response, the provider launched a green AI strategy to scale GenAI use while managing environmental impact and compliance risk. The strategy is grounded in operational practice and feeds into the four-level framework, which evolves as use grows. At this stage, the project example focuses on building foundational capabilities, such as transparency, measurement, and infrastructure insights, rather than portfolio-wide optimization. This reflects the provider's current maturity level and the strategic intent to first establish a robust operational baseline before scaling broader interventions.

Strategic steps toward sustainable AI integration

While the four-layer framework offers a strong foundation for assessing and managing the environmental impact of AI systems, many organizations face challenges in turning these insights into concrete action. To bridge the gap between assessment and implementation, we present six strategic steps. These span all four framework layers and showcase two exemplary additional operational enablers, helping organizations move from high-level ambition to practical, measurable outcomes:

1: Data and hardware snapshot through lifecycle and baseline assessment

The customer began with a systematic evaluation of energy use and emissions across all AI-relevant departments, focusing on assessing environmental impacts from compute, storage, and data center infrastructure. The assessment revealed missing data structures and limited AI integration into the existing IT architecture. The resulting baseline identified environmental hotspots and enabled targeted planning of interventions.

1a: Monitoring and transparency (operational enabler)

To close transparency gaps, energy sensors were installed in data centers and connected to automated interfaces for real-time tracking of energy use and emissions. This addressed a key challenge from the GenAI sustainability study, which found that 64% of enterprises struggle to measure AI energy use. Continuous data collection enabled clustering, decision-making, and the setup of green IT data ecosystems.

2: Use case clustering

AI use cases were grouped by model size, user group, and domain. This revealed patterns and enabled benchmarking of emissions intensity. Clustering improved visibility across the AI landscape and supported governance for prioritizing optimizations.

3: Portfolio review

The clustered use cases were compiled into a portfolio view and visualized as heat maps. This revealed overlaps, high-emission models, and underused resources. The portfolio perspective helped align departments and focus optimization efforts.

3a. Infrastructure-centered interventions and software optimization (operational enabler)

Based on portfolio findings, infrastructure and software interventions were deployed. Hardware was optimized to reduce inefficiencies and improve output ratios. The power supply was partially decarbonized through photovoltaics and revised electricity contracts. Software measures included modular architectures, sustainable data practices, and differential compression, expected to cut energy use by up to 14%. Documentation was improved to support reuse, and awareness features were added to inform users of environmental impact. While foundational work was prioritized, further clustering and portfolio steering will follow.

4: Scenario explorer with 360° continuous impact review

Dedicated metrics were set up to track the environmental impact of AI activities. These included energy profiles by model, processor utilization, and emissions based on energy consumption converted to CO_2 equivalents. Existing data was enriched through modeling scenarios to simulate trade-offs in system performance, energy demand, and emissions. This supported planning and continuous improvement aligned with sustainability goals. The review is considered 360° because it combines historical data, real-time monitoring, and forward-looking modeling to provide a full view of AI's footprint.

First results show changes in architecture (e.g., open source or quantized models) and platform development. The use case validates the framework's relevance and shows how a structured, data-driven approach can support scalable AI sustainability. *Table 4.5* maps customer pain points, strategic objectives, and project examples to each framework layer.

#	Layer	Context	Objective	Customer pain points	Project examples
1	Data and hardware snapshot	Emissions are calculated using data from cloud or on-premises systems	Enables analysis of environmental impact across compute, storage, and network	• No centralized tracking • Limited AI integration into core IT architecture	Baseline assessment
					Lifecycle assessment and utilization
					(Sustainability / IT) data strategy
					AI maturity assessment
1a	Monitoring and transparency	Data is collected for each use case	Enables clustering where transparency is lacking	• Use case data is not readily available	Green IT strategy
					Collaborative data ecosystems (CDE)
					Gap Analysis
2	Use case clustering	Use cases are grouped by type, user base, and model size	Reveals usage patterns and makes the impact transparent and comparable	• No central contact or structure for use case preparation and categorization	Use case evaluation framework

#	Layer	Context	Objective	Customer pain points	Project examples
3	Portfolio view	All clusters are shown in a single heat map	Shows cumulative impact across departments and guides interventions	• Limited cost-benefit visibility hampers prioritization	Use case prioritization GenAI value cases accelerator for trust, cost, and scalability
3a	Infrastructure and S software interventions	Interventions are selected based on heat map findings	Targets "high-impact, low-effort" areas with minimal cost	• Unclear implementation paths within infrastructure and key stakeholders (e.g., co-hosting partners)	Data center optimization Data pipeline enhancement Sustainable software benchmark
4	Scenario explorer	Decision-makers simulate interventions and trade-offs	Supports continuous improvement through forward-looking analysis	• Weak data foundation for forecasting • Low transparency on model-related costs	Eco tool AI kit for cost and ecological simulation of AI setups IT-benchmarking and forecast

Table 4.5 – Four-layer AI sustainability framework with real-world application examples

Conclusion and recommendations for implementation

AI can accelerate sustainability goals. The presented framework helps translate ambition into action by creating transparency, guiding intervention, and connecting decisions to impact.

Based on industry insights and project use cases, we recommend five key actions:

- **Start with a baseline:** Conduct a one-time assessment of your AI and IT-related carbon footprint. Use this to define priorities and select tools for continuous measurement and monitoring.

- **Assess maturity and build a strategy:** Evaluate where your organization stands in terms of sustainability integration across AI and IT. Define a roadmap that links operational improvements with regulatory and strategic goals.
- **Reduce AI lifecycle impact end-to-end:** Address environmental impact across the full AI lifecycle, from data acquisition and model training to deployment and usage. Integrate sustainability into development environments, model selection, and infrastructure design to ensure a fit-for-purpose selection and responsible scaling of AI capabilities.
- **Operationalize eco-design and delivery standards:** Introduce eco-design principles into your delivery methodologies. Equip teams with tooling to measure impact and track progress through real metrics.
- **Engage suppliers as partners:** Don't treat supplier sustainability as a checkbox. Set shared goals, track mutual progress, and leverage collaboration to improve both efficiency and environmental impact.

The use case shows that sustainable AI is possible, even in constrained environments with self-hosted infrastructure and complex compliance needs. The transformation takes place when organizations embed sustainability into culture, strategy, and delivery, so each decision contributes to a broader shift and enables additional cost savings, increased trust, and efficiency.

Special thanks and acknowledgement go to Felix Caspari, Henning Klasmeier, Fabian Brack, and the Capgemini Inventive and sustainable IT lead, Günther Reimann, for their valuable contributions and expertise in shaping this section.

Fabian Schnippering, Manager of Sustainable IT and Business Technolog, Capgemini Invent

AI's environmental impact is not a vague future risk but a current and growing operational challenge. Leaders cannot afford to rely on assumptions or supplier claims; transparency, measurement, and intervention must be designed into AI portfolios now. Capgemini's four-layer framework translates lifecycle science into actionable tools that executives and architects can apply as enterprise sustainability strategists who bring structure, measurable insight, and continuous improvement into every AI initiative.

Operationalizing responsible AI

Responsible and sustainable AI principles are just aspirations if they are not converted to actions and embedded in operational procedures and, ultimately, the IT culture. Companies must recognize the risks and rewards of AI governance and take steps to turn intentions into repeatable, consistent action. A McKinsey survey of 750 leaders across 38 countries shows an encouraging consistency in corporate investment in RAI operationalization as well as a correlation between investment and AI maturity. Specifically, most organizations surveyed, regardless of size, intend to invest more than $1 million in the coming year in RAI pursuits. These funds are going toward hiring RAI talent, technical systems to support RAI compliance, and legal or professional services. The survey also identified "a strong positive correlation" between levels of investment and RAI maturity, as measured by McKinsey's AI Trust Maturity Model, which rates strength in four broad areas: AI strategy; risk management; data and technology; and operating model, talent, and change management (McKinsey & Co. 2025).

With or without the support of new talent and service providers, it will ultimately be IT's job to deconstruct each RAI commitment into critical action steps. The rest of this section contains core elements of a "runbook" for operationalizing AI environmental sustainability. It was created and vetted by IT leaders as part of SustainableIT's RAI Toolkit (SustainableIT.org 2025). The runbook's recommended actions span the AI system lifecycle; for organizational purposes, we've split the actions into two parts: system design and development, and system deployment and monitoring. While you may take these steps in a different order or simplify some actions, following this basic approach will help embed any RAI principle into IT's operating model. Another RAI runbook example is included in *Chapter 6*, *Data*.

Sustainable AI runbook part 1: System design and development

The following steps, actions, KPIs, and tools are intended to help operationalize AI environmental sustainability principles in the design phases of the AI lifecycle. Here, the emphasis is on determining that AI is the right fit for the use case (the most sustainable AI is no AI). It also ensures that sustainability is embedded in the architecture of AI systems, not retrofitted after development. It also provides steps for evaluating the sustainability impact of systems so that your organization can make a go-forward decision with full knowledge of the system's expected impacts.

Step 1: Conduct a fit-for-purpose evaluation

Perform the following actions:

- Determine whether the proposed use case merits traditional, generative, or other forms of AI.
- Consider whether an LLM is necessary for the AI application. More sustainable alternatives use considerably less energy and permit AI applications to run on lower-powered devices, potentially reducing hardware churn and e-waste impact:
    - Small language models and narrow, domain-specific models
    - Model pruning, quantization, and distillation techniques that shrink LLMs without significantly losing performance
    - **Retrieval-augmented generation** (**RAG**), which combines a smaller base model with an external database or search system
    - On-device and edge AI models, which run locally on devices (phones, laptops, and IoT) instead of in massive cloud servers

Utilizing LLM alternatives can have a significant impact on energy demand and carbon footprint with only slight performance compromises (*Table 4.6*).

Option	Typical carbon footprint	Energy demand	Performance trade-off
LLMs	Very high (training: hundreds of tonnes CO_2e)	Extremely high during inference	Very broad and versatile
Small language models	Very low to moderate	Low	Narrower capabilities
RAG with small models	Moderate	Low to moderate	Strong performance for info retrieval
Edge/On-device AI	Very low	Very low	Limited by device capacity

Table 4.6 – AI model types and their differentiators

An example of this evaluation is the implementation of a customer support chatbot on a company's website. Such a chatbot will generally conduct very short and simple conversations that do not require a broad scope and advanced reasoning. They do, however, need to access company policies such as the return policy. That being the case, a small retrieval-augmented model is most suitable.

Step 2: Embed sustainability into AI's architecture

Sustainability must be embedded into the design phase of AI systems – not as an afterthought, but as a foundational set of parameters that guide technical decisions from the outset. This requires moving beyond reactive mitigation and toward intentional design choices that anticipate environmental and social risks while maximizing long-term value.

By defining sustainability objectives early in the development process, such as minimizing compute waste, extending hardware lifecycles, enabling equitable access, and ensuring model reuse, organizations can reduce unnecessary trade-offs later and avoid lock-in to high-impact architectures. These actions not only align AI development with ESG commitments but also contribute to more resilient, cost-efficient, and future-ready AI systems.

The following practices provide a blueprint for embedding sustainability directly into the architecture, workflows, and operational design of AI applications:

- **Apply design-for-sustainability (DfS) principles**:
    - Choose models that meet the "minimum viable intelligence" needed for the task
    - Avoid overtraining or overfitting, which leads to unnecessary compute use
    - Design for graceful degradation; systems should remain effective with smaller retrained models or reduced input
- **Prioritize low-impact compute architectures**:
    - Deploy workloads on energy-efficient chipsets (e.g., SLM-optimized CPUs or TPUs)
    - Use cloud-native autoscaling to reduce idle compute and emissions
    - Architect inference pipelines to minimize storage and retrieval redundancy
- **Plan for model and infrastructure longevity**:
    - Build modular AI applications to extend the reuse of models across use cases
    - Align model development timelines with expected hardware refresh cycles to reduce premature obsolescence
    - Use hardware lifecycle planning tools to flag AI-induced upgrade pressures early
- **Define sustainability acceptance criteria**:
    - Add sustainability gates to technical review checklists (e.g., "Will this increase cloud emissions?")

- Require justification for GenAI model use and energy consumption estimates from prior model runs or from benchmarks in model cards (e.g., OpenAI, Hugging Face, etc.), and model profiling tools
- Establish baseline model efficiency thresholds (e.g., gCO_2e/inference caps) by combining performance benchmarking and carbon estimation tools, which correlate runtime and hardware usage to CO_2e

Step 3: Conduct sustainability impact assessment

To operationalize sustainable AI, organizations must assess not only whether an AI system can perform a task, but whether it should, given its ESG consequences. While AI systems can generate positive ESG value, they can also introduce significant sustainability risks through their energy use, carbon emissions, hardware demand, bias, or lack of explainability. Understanding these impacts early allows teams to make smarter, more responsible design and deployment decisions.

A sustainability impact assessment is a structured evaluation of a proposed AI system's potential environmental, social, and governance impacts across its lifecycle, before and during development, and after deployment. In this case, the goal is to determine whether the system contributes to or detracts from environmental sustainability goals of the organization using a mix of qualitative judgment and quantitative indicators (e.g., emissions, energy and water use, and compliance readiness). This assessment supports informed decision-making and enables sustainable design trade-offs aligned with enterprise values and regulations.

The assessments do not need to be complex or time-consuming. When integrated into routine review workflows, such as during model selection, architecture design, or pilot evaluation, they can become a lightweight but powerful gatekeeper. To avoid analysis paralysis, assessments should be scoped to focus on the most material ESG dimensions relevant to the organization's stated sustainability priorities. Not all metrics are equally relevant for every use case.

Where possible, these assessments should be fast-tracked through:

- Checklists and pre-approved model classes (e.g., low-impact SLMs)
- Pilot-stage measurement tools for estimating energy, emissions, or fairness
- Use of standardized questionnaires and dashboards to simplify documentation
- Reusing known metrics from similar applications already deployed

Table 4.7 shows a representative questionnaire for an environmental sustainability impact assessment that should be conducted during the development phase of an AI system's lifecycle, and then revisited during the deployment and monitoring phases, as shown in *Figure 4.6* earlier in this chapter.

Question	Response	Notes / Justification
What is the estimated carbon footprint per inference?	~0.08 gCO_2e/inference	Estimated using CodeCarbon with emissions factor from Electricity Map and model runtime profiling
Is the model deployed on low-carbon infrastructure (cloud/data center)?	Yes – deployed in Google Cloud's `europe-west4` region (carbon-free energy >90%)	Region selected based on the GCP Carbon-Free Energy % dashboard and availability of sustainability SLAs
Does the model use energy-efficient architecture (e.g., SLMs and pruned LLMs)?	Yes – model uses a distilled transformer architecture with quantization	Chosen to reduce compute requirements and improve energy efficiency without sacrificing performance
Has model size been minimized or optimized (compression or distillation)?	Yes – original 3.4B parameter model compressed to 800M via distillation	Compression achieved a 75% reduction in storage and inference cost
What is the estimated energy consumption for training and inference?	Training: ~120 kWh; Inference: ~0.02 kWh per 1,000 inferences	Based on GPU logs and cloud usage data from Azure Sustainability Calculator
Are water usage or cooling impacts relevant and measured?	Yes – estimated 0.5 L/kWh based on the region's Water Usage Effectiveness, totaling ~60 liters during training	Water estimate derived using regional water usage data from the data center provider's ESG report

Table 4.7 – AI system sustainability impact assessment questionnaire

The next section outlines how to perform a targeted environmentalsustainability impact assessment using common metrics.

Environmental impacts and metrics

There are four basic environmental metrics for IT, AI included – energy, emissions, water, and e-waste. These are often referred to as "hidden" impacts because they are difficult to isolate from other non-AI technology systems running in data centers or the cloud. However, organizations with solid data center and cloud baselines can estimate and track changes associated with AI deployment. The fundamental impacts are as follows:

- **Energy consumption rate** – Energy (kWh) used for AI model training and inference
    - **How to collect** – Use cloud provider usage dashboards (e.g., Amazon CloudWatch or Azure Monitor) or on-premises power metering tools. For storage and data transfer, use cloud billing data to quantify GB transferred and stored.
- **AI carbon footprint** – GHG emissions ($kgCO_2e$) associated with compute, storage, and data transmission.

    How to collect – Obtain energy consumption data as described previously, then multiply energy usage by grid-specific carbon intensity factors or emissions coefficients provided by cloud providers or regional electricity authorities.
- **Water consumption rate** – Water used for data center cooling (liters or m^3).

    How to collect – Request **Water Usage Effectiveness (WUE)** from cloud providers or use estimated WUE x energy usage.
- **E-waste generation rate** – Mass (kg/year) of electronic waste tied to early device retirement for AI capacity.

    How to collect – Track hardware replacement cycles and categorize AI-driven refreshes. Estimate device weight using vendor specs.

The following are applicable environmental impact metrics that may be selected for use depending on the priorities of the organization in terms of topic materiality, regulatory reporting requirements, risk appetite, sustainability commitments, and other factors. This list is more exhaustive than the broader ESG metrics from SustainableIT's standard taxonomy – these are listed at the end of this chapter (additional metric categories can be found in the full version of the runbook – see the bibliography):

- **Carbon impact** – For an accurate perspective, totals should include emissions caused by the AI application's compute, storage, and data movement. Metrics may include the following:
    - **Total inference carbon footprint** – Estimate carbon emissions for a single inference – including compute and retrieval – based on the number of input and output tokens processed (gCO_2e/inference)
        - **How to collect** – Estimate with CodeCarbon or similar, which may require

          AI token count × compute profile × energy/carbon intensity
    - **Lifecycle carbon footprint** – Full estimate including training, deployment, maintenance, and updates over the AI model's intended lifetime ($kgCO_2e$)
        - **How to collect** – Calculate with **Life Cycle Assesment (LCA)** tools with inputs across training, deployment, and updates
    - **Software carbon intensity score** – Emissions per unit of functionality delivered by the AI model (e.g., gCO_2e per 1,000 inferences)
        - **How to collect** – Use the SCI specification from the Green Software Foundation (emissions per 1,000 inferences)
- **Data generation and storage efficiency impact** – How efficiently the AI application generates new data (output) and stores models, logs, and artifacts. Metrics may include the following:
    - **Embodied carbon of storage** – Emissions ($kgCO_2e$) embedded in physical storage hardware use and lifecycle
        - **How to collect** – Use vendor LCA data + storage capacity deployed
    - **Model size** – Disk space (MB, GB) required for the deployed AI model (smaller sizes reduce storage burden)
        - **How to collect** – Obtain the binary file size of the trained model
    - **Dark data ratio** – Percentage of data that is generated but remains dormant and unused in a certain time period
        - **How to collect** – Analyze access logs and storage activity to compare total data generated against inactive data over a defined period

    - **Cold/hot storage proportion** – Percentage of data kept in "hot" (high-energy) versus "cold" (low-energy) storage tiers; more cold = more efficient
        - **How to collect** – Calculate percentage split of storage classes (e.g., AWS S3 Standard vs. Glacier)

- **Infrastructure lifecycle impact** – The demand for new, more powerful hardware necessitated by AI applications, as well as overprovisioning for the AI portfolio. Potential metrics include the following:
    - **Hardware refresh rate** – Percentage of AI-related devices replaced annually (separate AI-driven refreshes from standard IT refresh)
        - **How to collect** – Obtain annual procurement logs and compare against AI-specific needs
    - **Compute density increase** – Percentage of upgrades to higher-compute-density devices (e.g., CPU to GPU, GPU to TPU/ASIC) necessitated by AI systems
        - **How to collect** – Calculate and compare changing levels in deployment from CPUs to GPUs/TPUs
    - **Average utilization rate** – CPU/GPU/TPU utilization percentage post-AI deployment; low utilization (<40%) suggests over-provisioning, worsening environmental impact
        - **How to collect** – Monitor usage logs across time with tools such as NVIDIA-SMI or Prometheus
    - **Hardware overprovisioning ratio** – Deployed capacity versus average needed capacity (a high ratio means unsustainable hardware sizing)
        - **How to collect** – Calculate total provisioned capacity ÷ average peak use

It is vital to understand that these metrics do not exist independently of each other. For instance, consider a data center using an open-loop cooling system. On the one hand, the cooling effect by itself might lead to an increase in efficiency of the GPUs and thus to lower energy consumption and lower GHG emissions. On the other hand, an open-loop cooling system wastes significant amounts of water, which can exacerbate water scarcity in areas with already stressed water systems.

Once sustainability positive and negative AI impacts have been assessed and estimated, organizations can qualitatively score the AI system's "sustainability justification" (i.e., will the environmental cost of deploying the AI system justify the benefit it creates?). The trade-off between the AI system's environmental sustainability impact and its performance (accuracy, efficiency, and speed), coupled with the organization's risk tolerance, will all factor into the decision to deploy, scale, redesign, or refuse the application. And since responsible governance carries on after deployment, the opportunity to further mitigate negative impacts and accentuate positives should be part of the AI lifecycle strategy.

To help provide the data for these metrics, check out resources and tools applicable to AI sustainability across the ESG spectrum (company and product names referenced in this list are for informational purposes and are not an endorsement by SustainableIT.org or its members and partners):

- **Supplier sustainability and ESG ratings platforms** – Services such as EcoVadis provide independent, standardized ESG performance ratings of suppliers across industries. For AI governance, these ratings help organizations ensure that AI system providers, cloud vendors, and hardware manufacturers align with sustainability goals and reduce risk exposure in the AI lifecycle:
    - **EcoVadis** – `https://ecovadis.com/`.
    - **CDP (formerly Carbon Disclosure Project)** – `https://www.cdp.net/` (not a rating per se, but tech companies report emissions, water, and supply chain disclosures through CDP, often used in vendor evaluations)
- **ESG automated data collection and reporting platforms** – Platforms from ServiceNow (ESG Management), IBM (Envizi), and Salesforce (Net Zero Cloud), aligned with reporting standards, help companies measure, manage, and report ESG performance. Within AI governance, they facilitate transparency around sustainability metrics, ethical use, and alignment with regulations:
    - **ServiceNow ESG Management** – `https://www.servicenow.com/products/esg-management.html`
    - **IBM Envizi** – `https://www.ibm.com/products/envizi/resources`
    - **Salesforce Net Zero Cloud** – `https://www.salesforce.com/net-zero/cloud/?`

- **ESG performance and risk management software** – Tools such as Datamaran or SpheraCloud help identify, assess, and monitor environmental, social, and governance risks. In AI governance, they support decision-making by mapping sustainability risks related to AI development, such as energy consumption, labor impacts, and regulatory exposure:
    - **Datamaran** – `https://www.datamaran.com/`
    - **SpheraCloud** – `https://sphera.com/spheracloud-platform/`
- **Software carbon assessment methodologies** – Certified open source tools such as the Cloud Carbon Footprint Methodology or the ISO-certified SCI specification will help consistently quantify emissions associated with software, including AI systems, and progress against reduction targets:
    - **Cloud Carbon Footprint Methodology** – `https://www.cloudcarbonfootprint.org/docs/methodology/`
    - **SCI specification** – `https://sci.greensoftware.foundation/`
- **AI carbon impact calculators** – Tools such as CodeCarbon, EcoLogits, and ML CO_2 Impact Tool estimate the greenhouse gas emissions from training and running GenAI models:
    - **CodeCarbon** – `https://codecarbon.io/`
    - **EcoLogits** – `https://ecologits.ai/latest/`
    - **ML CO_2 Impact Tool** – `https://mlCO₂.github.io/impact/`
- **AI data minimization tools** – NIST offers an *AI Minimization Toolkit* to help machine learning model developers determine the minimal level of detail required for newly collected data to make accurate predictions with an AI model. Other frameworks and tools include IAPP's *Supporting Data Minimization in AI* and AI Now Institute's *Data Minimization as a Tool for AI Accountability*:
    - **NIST AI Minimization Toolkit** – `https://www.nist.gov/privacy-framework/resource-repository/browse/guidance-and-tools/ai-minimization-toolkit`
    - **IAPP** – `https://iapp.org/news/a/federated-learning-supporting-data-minimization-in-ai/`
    - **AI Now Institute** – `https://ainowinstitute.org/spotlight/data-minimization`

Now, we move from operationalizing sustainability for the design and development stages of the AI system lifecycle to the deployment and monitoring stages.

Sustainable AI runbook part 2: System deployment and monitoring

The following are some of the actions and tools that can help operationalize sustainability in the latter stages of the AI system lifecycle. Here, the emphasis is on active management of AI system energy demands and infrastructure impacts on the environment, as well as effective system monitoring and continuous improvement.

Step 1: Mitigate environmental impact

Perform the following actions:

- **Prioritize AI workload placement by carbon intensity** – Run AI compute in cloud regions or on-premises data centers powered by renewable energy. Use carbon-aware workload orchestration to route model training and inference jobs to the lowest-carbon infrastructure available.
- **Optimize and right-size AI models** – Apply techniques such as model pruning and distillation to reduce the computational and energy demands of large-scale models without sacrificing accuracy.
- **Implement hardware efficiency standards** – Require AI workloads to run on energy-efficient hardware (e.g., GPUs or TPUs with lower energy-per-operation ratings).
- **Implement hardware lifecycle management** – Avoid premature end-of-life caused by model size escalation by extending the lifespan of AI-specific hardware through reuse, resale, or repurposing practices.
- **Apply sustainability criteria in vendor evaluations** – When selecting cloud, colocation, or SaaS providers for AI workloads, evaluate environmental credentials, including renewable energy sourcing, sustainability certifications, and climate-related transparency reporting.
- **Have an AI lifecycle data exit strategy** – Establish decommissioning protocols and data retirement criteria to prevent potential leakage and increase stakeholder trust.
- **Have an AI lifecycle hardware exit strategy** – Establish decommissioning protocols that prioritize circular economy principles and consider future uses for hardware.
- **Automatic dark data processing** – Establish automatic rules and procedures for deleting or achieving dormant and unused data after a certain period of time.

Step 2: Establish monitoring mechanisms

AI system sustainability must be monitored after implementation because there will be systemic changes as new data enters the system and AI models "learn." Selective monitoring should be applied to impact areas corresponding to the enterprise's highest priority sustainability goals. Automated data collection and dashboards are best practices from corporate sustainability programs that should be applied to AI systems' sustainability. The following is a representative list of monitoring tools:

- **Cloud provider APIs** – APIs from cloud providers, such as Google Cloud's Carbon Footprint API, Microsoft's Azure Sustainability Calculator, and Amazon's Customer Carbon Footprint Tool, can facilitate energy and emissions monitoring for AI workloads:
    - **Google Carbon Footprint API** – `https://cloud.google.com/carbon-footprint`
    - **Microsoft Sustainability Calculator** – `https://azure.microsoft.com/en-us/blog/microsoft-sustainability-calculator-helps-enterprises-analyze-the-carbon-emissions-of-their-it-infrastructure/`
    - **Amazon Carbon Footprint Tool** – `https://aws.amazon.com/aws-cost-management/aws-customer-carbon-footprint-tool/`
- **Data center infrastructure management (DCIM)** platforms (e.g., Vertiv Environet Alert and Schneider EcoStruxure) – For on-premises AI infrastructure, these provide continuous monitoring of data center resource sustainability via sensors and a centralized dashboard for automated alerts and sustainability KPIs:
    - **Vertiv Environet Alert** – `https://www.vertiv.com/en-us/products-catalog/monitoring-control-and-management/software/vertiv-environet-alert/`
    - **Schneider EcoStruxure** – `https://www.se.com/us/en/product-category/4100-power-metering-and-energy-monitoring-systems/`
- **NVIDIA Data Center GPU Manager (DCGM)** – For GPU-intensive AI systems, this provides real-time telemetry for energy use, thermal stress, hardware degradation, and utilization efficiency: `https://developer.nvidia.com/dcgm`
- **Kubernetes-based resource monitors** (e.g., Prometheus with GPU and Power Exporters) – For containerized AI workloads, these provide continuous monitoring of resource usage: `https://prometheus.io/docs/introduction/overview/`

True automation of monitoring typically requires integration of these tools into MLOps, ITOps, or infrastructure monitoring pipelines – not just manual dashboards. Hybrid setups (on-premises AI + cloud AI) will need combined cloud-native and on-premises approaches for full visibility.

Step 3: Define and implement continuous improvement processes

Results of monitoring must be actionable, fueling ongoing improvement to AI models and their application. A key early step is to assign responsibility for monitoring of primary AI sustainability impacts, mitigation efforts, and commitments. Ensure that monitoring is coordinated with enterprise audits and integrated into a feedback loop for actions that will support the continuous improvement of the AI lifecycle sustainability. Establish threshold-based alerting and escalation protocols defining sustainability thresholds (e.g., energy use per inference, carbon intensity, and bias scores). Configure alerts to notify responsible teams when thresholds are exceeded, triggering reviews or model rollbacks.

Perform the following actions:

- Incorporate monitoring findings into AI lifecycle reviews, feeding results directly into design and governance gates to close the feedback loop and drive design-phase improvements in future AI projects.
- Incorporate sustainability criteria specific to AI systems into vendor and partner evaluation criteria, such as model efficiency metrics (e.g., FLOPs, gCO_2e/inference), emissions data per AI workload or service, and use of renewable energy in data centers.
- Benchmark sustainability performance against internal and external standards.
- Regularly compare monitored sustainability performance (e.g., compute intensity and energy efficiency) against enterprise baselines, industry benchmarks (e.g., MLCommons), or best-practice targets to identify areas for advancement.
- Implement corrective action plans based on monitoring outcomes, with accountable owners, deadlines, and follow-up assessments.

Step 4: Institutionalize learnings and raise sustainability maturity

Continuous improvement should evolve beyond corrective actions to support strategic capability building. By embedding sustainability insights into strategic planning and organizational processes, enterprises can elevate AI sustainability from reactive compliance to innovation leadership.

Perform the following actions:

- **Incorporate sustainability insights into AI strategy planning** – Use trends from monitoring to guide investment in sustainable AI tools, model architectures (e.g., small/efficient models), or infrastructure choices for future projects

- **Create an AI sustainability performance scorecard** – Develop an executive-level dashboard aggregating environmental, fairness, and governance indicators for all AI projects, to inform leadership decisions and accountability
- **Include sustainability metrics in individual and team performance reviews** – Tie RAI performance to KPIs for teams managing model development, infrastructure, and governance
- **Host quarterly AI sustainability review forums** – Gather cross-functional stakeholders (e.g., ESG, IT, data science, and procurement) to review performance, share lessons learned, and set new improvement targets
- **Submit annual AI sustainability impact statements** – Contribute AI-specific disclosures to broader ESG reporting processes or publish standalone summaries to increase stakeholder transparency and credibility

There is, obviously, a lot more to environmental sustainability governance of AI and IT in general, but we hope this runbook excerpt helps provide a sense of direction and some seminal actions to drive success. You can access the full IT Toolkit for Responsible and Sustainable AI on this book's website: `https://www.sustainableit.org/sustainable-it-playbook`.

We conclude this chapter with examples of companies that have established RAI goals and practices at the enterprise level as they scale and multiply AI use cases. The organizations cited were honored with SustainableIT's RAI Impact Award, recognizing their success in responsible design and deployment of valuable AI tools and platforms, either commercial or internal.

Responsible AI best practices from award-winning implementations

When I (Richard) planned the first RAI award for IT in April of 2025, we weren't sure that anyone would have an AI implementation or initiative they would be comfortable subjecting to judgment. The criteria were broad, requiring demonstrated value and responsible and sustainable design and deployment at scale. I was surprised and heartened to see a strong commitment to AI sustainability, applied in practical, repeatable ways. In fact, many of the winners had implemented robust responsible governance platforms to facilitate ongoing AI development and deployment internally. Likewise for the winners who were tech vendors, who built sustainability into their AI products and services from the outset. The following synopses and analyses of the award-winning initiatives are derived from the official award report (SustainableIT.org 2025):

- **Cognizant (Trust Framework for lifecycle governance)** – The company aligned its internal and client-facing AI initiatives to its eight modern RAI principles and standards, and operationalized them through the TRUST™ Framework across all stages of AI lifecycle governance. It has implemented more than 100 AI use cases across internal deployments. Its centralized GenAI governance architecture – aligned with ISO/IEC 42001 – supports auditability, promotes model reuse, and reduces redundant compute, advancing both performance and sustainability goals.
- **Footprint Intelligence (ESG automation platform)** – Footprint Intelligence built a lean, high-accuracy platform for ESG reporting using AI agents to reduce the time companies spend on reporting and data integration. Time and resources can now be invested in measures and strategic initiatives in organizations to drive change, which are enabled by the platform and data intelligence.
- **Harvard University IT Organization (AI sandbox and governance framework)** – Harvard's "AI Sandbox" enables safe GenAI experimentation among faculty and staff. Use of the application is governed by a cross-university policy and system guardrails that ensure privacy, security, and appropriate use. More than 4,000 users participated in its first year, helping scale responsible AI exploration while maintaining institutional safeguards.
- **IFS (AI for sustainable field operations)** – IFS integrated AI into its **planning and scheduling optimization (PSO)** engine to reduce fleet emissions while improving service efficiency. This AI-driven solution was designed to manage complex mobile workforces. Used by industries such as telecoms providers with field teams of 10,000+ engineers, PSO applies agentic AI to dynamically schedule tasks based on real-time data inputs such as traffic, job urgency, and technician availability. It doesn't rely on fixed rules; instead, it uses a blend of proprietary and open source algorithms to continuously optimize schedules. Average travel distance dropped 37.1%, with a corresponding reduction in emissions, dramatic gains in technician productivity, and reduced job costs.
- **Kuehne+Nagel (K.AI platform and RAI policy)** – Kuehne+Nagel launched K.AI, an internal AI platform backed by an RAI policy to guide GenAI adoption in logistics. A standout innovation is their model for risk classification of AI use cases and automated risk-adjusted governance. Accuracy in document scanning surged from 65% to 95%, and responsible GenAI now drives pricing and ETA models.

- **osapiens (compliance AI for regulations and sustainable growth)** – osapiens developed expert-sized, quantized AI models to automate risk assessments across complex supplier networks and supply chains. Its lean one-platform approach ensures low compute impact, and outputs are human-auditable. The platform enables transparency, efficiency, and compliance with regulations such as CSRD, EUDR, or LkSG. With more than 25 solutions, it ensures secure pseudonymized data flows. Clients achieve scalable ESG integration with lower emissions and high accuracy.
- **Rackspace Technology (FAIR framework and GenAI assistants)** – Rackspace's FAIR initiative governs the responsible design of enterprise GenAI assistants across HR, legal, and IT. The most responsible feature is the human-in-the-loop oversight, plus retraining workflows that avoid model drift. GenAI assistants delivered 30% productivity boosts, 80% service staffing reductions, and high satisfaction while retaining human decision authority.
- **SAP (Embedded AI for sustainable operations)** – SAP integrates RAI into its product stack to accelerate customer ESG goals, from emissions declarations to recruiting equity. It matches model selection to energy use and hosts fine-tuned LLMs efficiently. Time to draft ESG reports dropped 80%, and circular economy use cases are now supported by embedded AI.
- **SAP Garden (Digital Sustainability Experience) Special Collaboration Award** – The SAP Garden Digital Sustainability Experience enables sports fans to learn about their mobility sustainability results associated with their coming to the stadium in a gamified, educational, and interactive way – including an option to invest in German forest projects to foster biodiversity. It also generates Scope 3 data for the facility, encouraging fans can reduce emissions collectively – one game at a time. The application was developed by Footprint Intelligence.
- **ServiceNow (sustainable IT and ESG automation)** – ServiceNow embedded sustainability intelligence into its IT operations platform, enabling real-time tracking of emissions, energy use, and circular IT asset flows. RAI actions include lifecycle transparency, Scope 3 monitoring, and governance-aligned emissions dashboards. The platform allows IT leaders to align procurement and infrastructure operations with ESG goals.
- **Stanford Health Care (RAIL and MedHelm)** – Stanford Health Care's RAIL framework governs the responsible development of over 40 AI tools across clinical and operational use cases. Its three-stage FURM process ensures fairness, usefulness, reliability, and monitoring. By embedding risk assessments and lifecycle checkpoints, Stanford operationalized sustainable AI at scale while ensuring regulatory readiness and clinical safety. **Medical Holistic Evaluation of Language Models** (**MedHelm**) is a recently introduced evaluation framework tailored for assessing LLMs on real-world medical and healthcare tasks.

- **TUI Group (ESGenius AI chatbot)** – TUI's "Grace" chatbot uses GenAI to answer complex ESG queries across legal, finance, and sustainability domains. Governed by a closed-loop feedback model and vetted data sources, Grace improves regulatory accuracy and response time. It has reduced ESG task durations, enhancing cross-functional compliance and communication.

Best practices in RAI governance

A few broad best practices associated with RAI governance were employed by most, if not all, of the winners. These included the following:

- **Structured controls are essential and feasible for scale** – Every winner embedded structured governance processes to manage the most material aspects of risk, compliance, ethics, and environmental sustainability in their AI programs. Here are three examples:
    - Cognizant operationalizes its RAI standards (Safe and Reliable, Transparent and Explainable, Human-Empowered, Secure and Privacy-Enhanced, Fair and Inclusive, Accountable and Auditable, Scalable, and Sustainable) using the TRUST™ Framework – a practical, capability-driven model applied throughout design, delivery, and continuous monitoring of AI systems to embed guardrails, risk management, and accountability at scale.
    - Rackspace Technology developed the comprehensive FAIR™ framework with its ATOM, which includes five key pillars: strategy and innovation, secure AI platform, data supply chain, AI product development, and AI operations. This structured approach enabled them to transform AI into a core capability while maintaining responsible practices.
    - Stanford Health Care implemented a three-stage FURM model to assess fairness, usefulness, reliability, and monitoring, enabling consistent scaling across 40+ AI tools.
- **Training and AI literacy elevate responsible use** – Awardees uniformly invested in widespread AI literacy to ensure ethical usage and foster innovation. We will introduce AI literacy guidance in *Chapter 5*, *IT Social Sustainability*, in the context of its essential role in achieving social sustainability. Here are two examples:
    - Rackspace Technology upskilled 97% of employees through a program that includes four levels of AI literacy and is mandatory for all new joiners. It forms a part of the company's annual compliance training to ensure regular recertification.

    - Cognizant mandated organization-wide education on RAI principles and TRUST™ governance practices, linking training completion to empowerment in AI-led roles, driving both compliance and productivity.

- **Environmental sustainability is a core design objective** – Several programs aligned AI energy-use practices with emissions reduction strategies. Two examples come from software vendors:
    - Footprint Intelligence deploys energy-optimized models hosted on renewable-powered infrastructure, minimizing environmental impact during AI inference.
    - SAP is working toward fine-tuning hosted LLMs and model matching to use cases, considering energy efficiency. These insights are being included in benchmarking activities.

Other, more situational best practices were utilized as well:

- **Cross-functional AI governance** – AI oversight includes legal, privacy, IT, business, and sustainability stakeholders to ensure broad accountability.
- **Lifecycle-based oversight** – Governance models explicitly manage AI risk at each stage from development to post-deployment, avoiding gaps and associated risk.
- **Sustainability by design** – Design choices (e.g., model selection, infrastructure, and usage caps) are informed by carbon reduction targets.
- **Human in the loop** – This ensures traceability, override control, and accountability.
- **Agentic AI studio for reusable components** – This democratizes agent creation, enabling low-code configuration with governance guardrails (cost, explainability, and accessibility).
- **Centralized RAI architecture** – This enforces the reuse of approved LLMs to ensure consistent, transparent, and well-governed AI deployments while reducing token overuse, improving efficiency, and minimizing energy waste across applications.
- **Quantized expert models with emission tracking** – Use leaner AI models with tracked compute usage to support scalable ESG risk and regulatory compliance.
- **GenAI sandbox environment** – This provides a secure space for faculty and staff to explore generative AI tools with built-in privacy protections.
- **Gamified stakeholder engagement for Scope 3 emissions** – Most enterprises struggle to assess their Scope 3 emissions in an accurate way and often fail to engage customers, suppliers, and employees effectively in the data-gathering process. A gamified, interactive experience can succeed in driving individual-level carbon awareness and fostering positive behavior change.

Collectively, the winners achieved impressive business results while also implementing strong governance controls over AI, proving that responsibility and value can go hand in hand. Quantitative benefits realized include emissions reductions of up to 37%, ESG reporting time reductions of 60%, AI-assisted document processing accuracy gains from 65% to 95%, and productivity increases of up to 30%. Several organizations reported cost savings between 30% to 76% in targeted processes, as well as accelerated hiring, software development, and AI experimentation cycles.

Summary

In this chapter, you have learned how we can govern AI responsibly and sustainably across its entire lifecycle. As an introduction to the topic, we explored the growing environmental and social footprint of AI – especially generative models – and the urgent need for governance frameworks that integrate ESG considerations. The chapter highlighted how RAI is not just about ethics or fairness, but also about minimizing energy use, water consumption, carbon emissions, and e-waste while promoting transparency, inclusivity, and human-centered design.

You were introduced to nine RAI leadership principles, developed by SustainableIT.org, that guide organizations in building trustworthy and sustainable AI systems. These principles offer a blueprint for translating corporate sustainability values into AI governance practice. By now, you understand the need to operationalize RAI principles across the full development and deployment lifecycle. Examples from Rackspace Technology and Stanford Health Care illustrated how to embed sustainability into AI design, deployment, and monitoring. You learned about Rackspace's ATOM governance model, Stanford's FURM assessment, and the use of materiality matrices and non-functional requirements to embed sustainability into technical and strategic decisions.

We explored new concepts in the SAIQ and Green AI and explored environmental metrics, from carbon intensity per inference to embodied carbon in hardware. Capgemini and Accenture's frameworks showed how companies can quantify AI's footprint and reduce it across compute, storage, and infrastructure. You also were introduced to RAI best practices embodied in 13 award-winning AI implementations, including the use of structured controls, humans in the loop, and secure AI sandboxes and agentic studios. Finally, you were exposed to several metrics for measuring the performance of sustainable AI efforts.

Here are some summary recommendations:

- Establish a cross-functional AI governance structure that includes IT, legal, ethics, and sustainability experts.
- Embed environmental and social sustainability assessment into the AI system design, deployment, and monitoring lifecycle.
- Establish sustainability as an NFR in AI system development (and all IT system development, for that matter), ensuring that environmental and social impact are addressed from the outset.
- Treat agentic AI with structured onboarding and oversight, as with human team members.
- Apply energy-aware architecture criteria to AI design, favoring smaller, fine-tuned models, sparse architectures, or low-power alternatives when model size is not critical to performance.
- Track and report environmental impacts per model and deployment, including energy usage, carbon emissions, and water consumption. Use metrics such as CO_2e per inference or token.

We've just scratched the surface of what it means to lead with responsibility and sustainability in the age of AI. As an IT or business leader, you are now better equipped to ask the right questions, assess risk, and steer your organization toward AI systems that are not only innovative and transformative but also do so in an environmentally and ethically responsible way.

In the next chapter, *IT Social Sustainability*, we will further explore RAI governance, this time from the perspective of equitable access and the digital divide.

Appendix: Standard IT metrics for RAI performance

Table 4.8 shows metrics for RAI governance from SustainableIT Standards Taxonomy V1.2 (SustainableIT.org 2023) and are recommended by members of the non-profit organization for use in establishing a baseline and tracking progress in responsible governance of enterprise AI at scale.

Category	Topic	Metric	Related global standards
SIT G 400 Technology & Innovation	G 430 AI governance	G 430-1: Approach to minimize negative economic, environmental, and social impacts from AI-enabled products and services	ESRS G1, G2 SDG 7, 9, 17
		G 430-1.a: Approach to limit AI algorithm training energy consumption	
		G 430-2: Incidents of failure to comply with AI policies or procedures, over a time period	
		G 430-3: Approach to identify and reduce bias in AI analytics	
		G 430-4: Major risk areas identified for data-based bias and remediation steps taken	
		G 430-5: Percentage AI algorithms or ML models trained using anti-bias methodologies	

Table 4.8 – SustainableIT Standards Taxonomy metrics applicable to RAI governance (source: SustainableIT.org)

Further reading

- **OECD AI Principles (2024 update)** – Intergovernmental guidance updated in 2024 that centers on human rights, accountability, and sustainability for trustworthy AI: `https://oecd.ai/en/ai-principles` OECD AI.
- **NIST AI RMF: GenAI profile** – A practical profile to operationalize responsible GenAI, explicitly including "environmental impact and sustainability" as a measure: `https://nvlpubs.nist.gov/nistpubs/ai/NIST.AI.600-1.pdf` NIST Publications.
- **International Standards for AI and the Environment** – An overview of standards activity and guidance connecting AI with environmental sustainability across the ICT ecosystem: `https://www.itu.int/dms_pub/itu-t/opb/env/T-ENV-ENV-2024-1-PDF-E.pdf` ITU.
- **Software Carbon Intensity (SCI)**, now an ISO Standard – The Green Software Foundation's SCI methodology reached ISO status, giving teams a recognized way to quantify software (including AI) emissions: `https://greensoftware.foundation/articles/sci-specification-achieves-iso-standard-status/`.
- **SCI Technical Specification (GSF)** – The living spec for calculating software carbon intensity you can adopt in tooling and pipelines: `https://sci.greensoftware.foundation/`.
- **Energy and AI** – Global analysis of AI-driven electricity demand growth and grid implications, with country and technology breakouts: `https://www.iea.org/reports/energy-and-ai/energy-demand-from-ai`.
- **Executive Summary, Energy and AI** – A concise entry point to IEA's findings (e.g., regional consumption shares), useful for slides and briefs: `https://www.iea.org/reports/energy-and-ai/executive-summary`.
- **Powering Sustainable AI** – Quantifies AI's prospective energy, carbon, and water footprint and lays out a four-pillar playbook (silicon, data centers, use case design, and governance): `https://www.accenture.com/us-en/insights/sustainability/powering-sustainable-ai`.
- **Explained: GenAI's Environmental Impact** – A research-grounded explainer on lifecycle impacts, hotspots, and mitigation strategies for GenAI. `https://news.mit.edu/2025/explained-generative-ai-environmental-impact-0117`.
- **AI Act** (application timeline and guidance) – Official page detailing the EU AI Act's phased obligations, including GPAI transparency and risk controls relevant to sustainable deployment: `https://digital-strategy.ec.europa.eu/en/policies/regulatory-framework-ai`.

- **Google 2024 Environmental Report** – Corporate transparency on AI's environmental footprint (energy, water) and decarbonization strategy, useful as a model for reporting practices: https://sustainability.google/reports/google-2024-environmental-report/.
- **Responsible Use of GenAI in Research** (European Commission 2025) — Practical guidance urging institutions to track and minimize GenAI's environmental impact alongside ethical use: https://research-and-innovation.ec.europa.eu/document/download/2b6cf7e5-36ac-41cb-aab5-0d32050143dc_en.
- **World Economic Forum: Artificial Intelligence's Energy Paradox** – A synthesis of risks and solution pathways (efficient hardware, carbon-aware operations) for reconciling AI growth with climate goals: https://reports.weforum.org/docs/WEF_Artificial_Intelligences_Energy_Paradox_2025.pdf.
- **Best Practices and Strategic Takeaways from the Responsible AI Impact Awards**, SustainableIT.org: https://drive.google.com/file/d/1qpEbU9ILbeu6tTYVcFvyr795Ft3PNuHa/view?usp=sharing.
- **IT Toolkit for Responsible and Sustainable AI**, SustainableIT.org: https://drive.google.com/file/d/1qpEbU9ILbeu6tTYVcFvyr795Ft3PNuHa/view?usp=sharing.
- **Responsible AI Governance Lifecycle**, SustainableIT.org: https://drive.google.com/file/d/1qpEbU9ILbeu6tTYVcFvyr795Ft3PNuHa/view?usp=sharing.
- **Responsible AI Leadership Framework and Principles**, SustainableIT.org: https://drive.google.com/file/d/1qpEbU9ILbeu6tTYVcFvyr795Ft3PNuHa/view?usp=sharing.
- **The AI Sustainability Runbook**: https://drive.google.com/file/d/1qpEbU9ILbeu6tTYVcFvyr795Ft3PNuHa/view?usp=sharing.

Bibliography

- Accenture. 2024. *Destination net zero: Fast-tracking progress*. https://www.accenture.com/us-en/insights/sustainability/destination-net-zero.
- Accenture. 2025. *Powering Sustainable AI*. https://www.accenture.com/us-en/insights/sustainability/powering-sustainable-ai?c=acn_glb_fy25poweringthemediarelations_14236911&n=mrl_0625.
- AIPRM. 2024. *AI in the Workplace Statistics 2024*. https://www.aiprm.com/ai-in-workplace-statistics/.
- BBC News. 2016. *Tay: Microsoft issues apology over racist chatbot fiasco.* https://www.bbc.com/news/technology-35902104.

- Capgemini Invent. 2024. *Exploring the Sustainable Scaling of AI Dilemma: A Projective Study of Corporations' AI Environmental Impacts*. https://tinyurl.com/3y9dnwc6.
- Capgemini Research Institute. 2025. *Developing Sustainable Gen AI*. https://www.capgemini.com/de-de/wp-content/uploads/sites/8/2025/01/Capgemini-Report-Developing-responsible-Gen-AI_2025.pdf
- Capgemini Research Institute. 2024. *The eco-digital era*. https://www.capgemini.com/insights/research-library/the-new-digital-economy-research/
- Daepp, M., Microsoft Research. 2024. *The Emerging AI Divide in the United States*. https://tinyurl.com/5d8xrxf2.
- IBM. 2021. *Global AI Adoption Index*. https://filecache.mediaroom.com/mr5mr_ibmnews/190846/IBM%27s%20Global%20AI%20Adoption%20Index%202021_Executive-Summary.pdf
- IMF. 2024. *AI Will Transform the Global Economy. Let's Make Sure It Benefits Humanity*. https://www.imf.org/en/Blogs/Articles/2024/01/14/ai-will-transform-the-global-economy-lets-make-sure-it-benefits-humanity
- ISO.org. 2023. *ISO/IEC 42001:2023*. https://www.iso.org/standard/42001#:~:text=ISO/IEC%2042001%20is%20the,AI%2C%20balancing%20innovation%20with%20governance.
- Kahoot! 2024. *Training for the Future of Work*. https://kahoot.com/training-for-the-future-of-work/
- Li, Shaolei. 2023. *Making AI Less Thirsty: Uncovering and Addressing the Secret Water Footprint of AI Models*. https://tinyurl.com/srwftsmz.
- McKinsey & Co. 2025. *Insights on RAI from the Global AI Trust Maturity Survey*. https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/tech-forward/insights-on-responsible-ai-from-the-global-ai-trust-maturity-survey.
- MIT Media Lab. 2018. *Project Gender Shades Results*. https://www.media.mit.edu/projects/gender-shades/results/.
- Nature Computational Science. 2024. *E-waste challenges of generative artificial Intelligence*. https://l1nq.com/XVVyw.
- Otis, Nicholas g., et al. Harvard Business School. 2024. *Global Evidence on Gender Gaps and Generative AI*. https://www.hbs.edu/ris/Publication%20Files/25023_52957d6c-0378-4796-99fa-aab684b3b2f8.pdf.
- Patterson et al. 2021. *Carbon Emissions and Large Neural Network Training*. https://arxiv.org/abs/2104.10350.

- ProPublica. 2016. *Machine Bias.* https://www.propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing.
- Reuters. 2018. *Amazon scraps secret AI recruiting tool.* https://www.reuters.com/article/us-amazon-com-jobs-automation-insight-idUSKCN1MK08G/.
- Reuters. 2024. Comment, *Together we can end the digital divide that disenfranchises 2.6 billion people*. https://www.reuters.com/sustainability/society-equity/comment-together-we-can-end-digital-divide-that-disenfranchises-26-billion-2024-09-17/.
- Stanford University. 2025. *Thirsty for power and water, AI-crunching data centers sprout across the West.* https://andthewest.stanford.edu/2025/thirsty-for-power-and-water-ai-crunching-data-centers-sprout-across-the-west.
- Statista. 2025. *Concerns about generative AI's impact on cybersecurity worldwide in 2024*. https://www.statista.com/statistics/1448275/global-concerns-about-genai-s-impact-on-cybersecurity/.
- SustainableIT.org. 2024. *SustainableIT Standards Taxonomy V1.2*. https://www.sustainableit.org/standards/it-esg-standards.
- The Decoder. 2023. *GPT-4 Architecture, Datasets, Costs, and More Leaked*. https://the-decoder.com/gpt-4-architecture-datasets-costs-and-more-leaked/.
- The Guardian. 2016. *Predictive policing practices labeled as 'flawed' by civil rights coalition.* https://www.theguardian.com/us-news/2016/aug/31/predictive-policing-civil-rights-coalition-aclu.
- The Times. 2024. *Thirsty' ChatGPT Uses Four Times More Water Than Previously Thought.* https://www.thetimes.com/uk/technology-uk/article/thirsty-chatgpt-uses-four-times-more-water-than-previously-thought-bc0pqswdr.
- World Economic Forum. 2025. *The Future of Jobs Report 2025*. https://www.weforum.org/publications/the-future-of-jobs-report-2025/digest/.
- Working Knowledge. 2025. *Women Are Avoiding AI. Will Their Careers Suffer?* https://www.library.hbs.edu/working-knowledge/women-are-avoiding-using-artificial-intelligence-can-that-hurt-their-careers.

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5

Social Sustainability: Accessibility, AI, and the Digital Divide

> *"AI represents a never-before-seen opportunity for technology to benefit humankind in every way, and we have to act intentionally to make sure populations don't get left behind"*
>
> *Francine Katsoudas, Chief People, Policy, and Purpose Officer, Cisco, and founding member of the AI-Enabled ICT Workforce Consortium.*

In *Chapter 4*, *Responsible and Sustainable AI Governance*, we delved into approaches to **responsible AI (RAI)** lifecycle governance. Among the nine RAI principles we reviewed, several were focused on social sustainability goals, including accessibility, literacy, and a human-first approach. In this chapter, we will explore these social aspects of RAI, as well as their implications for technology and automation in general. Responsible AI Impact Award winner, Cognizant, will share its AI sustainability risk assessment process, which addresses several social risks. We will have a case study from IT asset disposition company Human-I-T and its customer National Grid, on how they are not just keeping end-of-life tech hardware out of landfills, but placing renewed equipment in the hands of students and workers in underrepresented regions, helping to shrink the digital divide. Another detailed example comes from Edifecs (acquired by Cotiviti in March 2025), which will share how the IT function drives digital literacy in multiple villages in India.

In this chapter, we will cover the following topics:

- IT system inclusivity and accessibility
- Assessing and governing the social risks of AI systems
- Persona-based AI literacy
- How IT can shrink the digital divide
- A social sustainability questionnaire for your tech vendors
- Metrics for IT social sustainability performance

This chapter's sustainable IT reference model perspective, as illustrated in *Figure 5.1*, starts with *sustainability in IT*—IT's sustainability strategy and governance must include social as well as environmental goals and actions. Most of these actions impact the enterprise (*sustainability by IT*), specifically, inclusive and accessible systems design and responsible AI governance. The chapter also touches on hardware disposition, vendor management, employee training, and contributing to a sustainability culture.

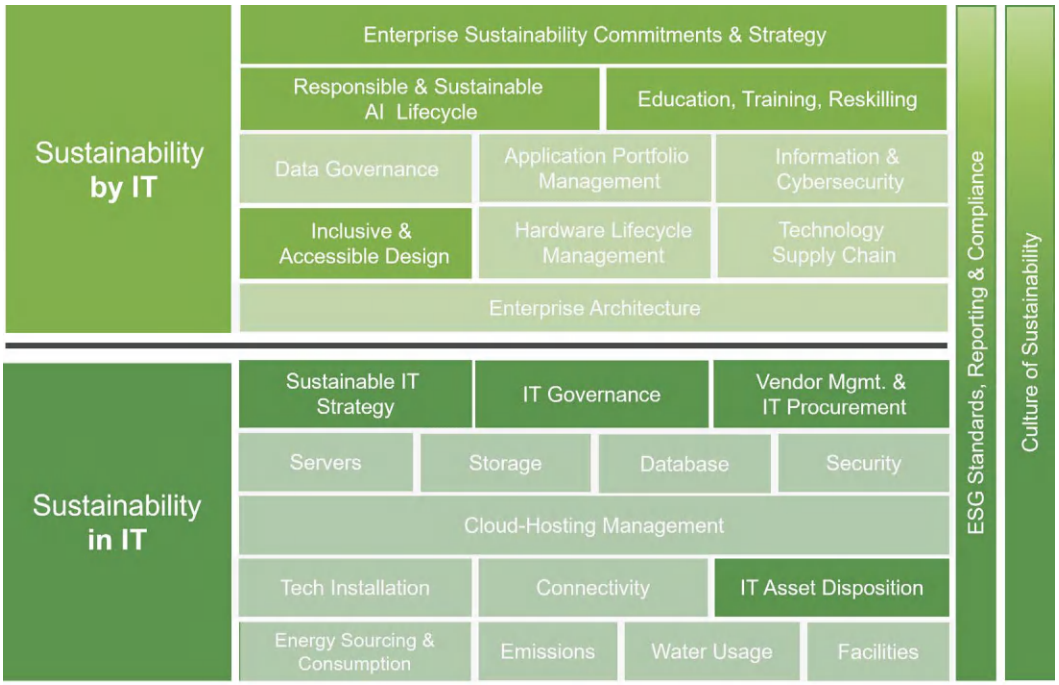


Figure 5.1 – Sustainable IT reference model – Chapter 5 focus

By the end of the chapter, you will have learned about essential aspects of IT-led social sustainability and critical social governance goals and actions applied to AI systems.

Accessibility and inclusiveness by design

For IT, social sustainability has direct implications for system design—both for its inclusivity and accessibility. IT teams must commit to designing and delivering human-centric solutions that personalize experiences on any device so that everyone, regardless of age or ability, has equal access to innovation.

IT developers may not realize the significant number of potential customers, employees, and other stakeholders who face barriers when interacting with systems that are not designed with accessibility in mind. Over 2.2 billion people worldwide have vision impairment. Of those needing assistive devices (e.g., screen readers or magnifiers), only 14.5% have access to them (IHOPE 2022). 1.5 billion people are suffering from hearing loss (WHO 2024).

IT teams and their business peers must also realize that accessibility is not just for people with disabilities, but also to accommodate users across a widening range of locations and conditions, and to engage an aging population. By 2050, 1.6 billion people will be over the age of 65, roughly double the number in 2021, according to UN projections (UN 2023). Add that to the 1.3 billion people with disabilities, and it makes obvious economic sense to optimize accessibility (WHO 2023). Designing for accessibility is designing for nearly two-thirds of humanity (*Figure 5.2*).

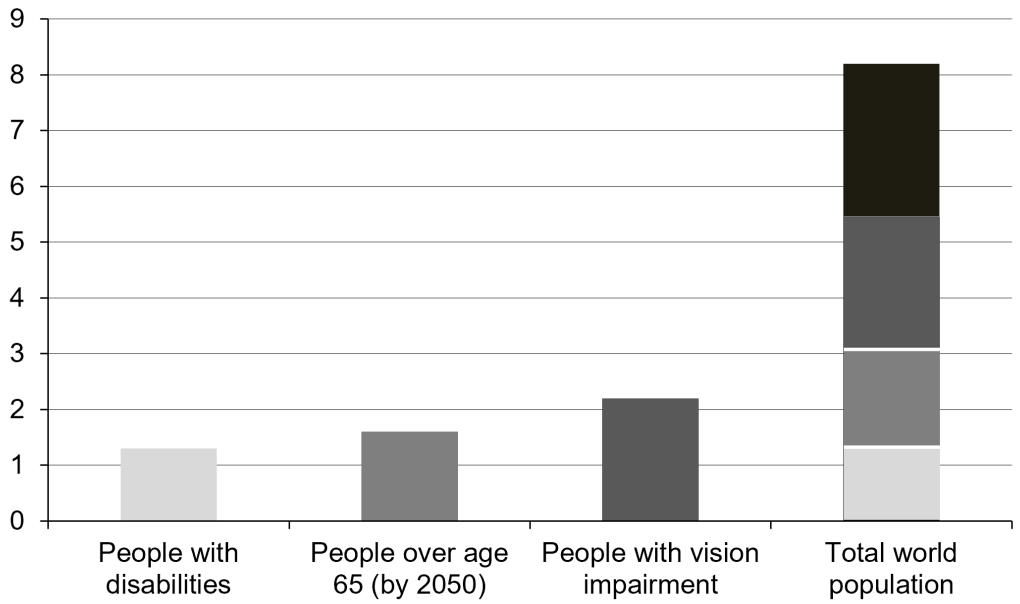


Figure 5.2 – Population with impaired abilities versus the total world population

There are also legal drivers—193 countries have signed on to the UN's Convention on the Rights of Persons with Disabilities, which stipulates the use of assistive tools in conjunction with information and communications technology. In the US, federal-court lawsuits over website accessibility have increased by 4X since 2017. Social sustainability standards for web-based tools and content date back to 2008, and are articulated in **Web Content Accessibility Guidelines (WCAG)** 2.0 (WC3 2023). They call for tools to be **perceivable, operable, understandable, and robust (POUR)** for all users, regardless of their abilities.

Typical challenges that IT must overcome include a lack of policy and governance related to accessibility, the perspective that accessibility is a compliance issue rather than a business driver, and the perception that accessibility is less important than privacy and security. Also, IT has typically addressed accessibility during system testing—a more efficient and effective approach is to embed accessibility considerations into the early design process (SustainableIT.org 2023).

Fundamental approaches to embed social sustainability into early IT processes include the following:

- Incorporate accessibility program management and accessibility-focused roles
- Adopt design techniques that account for users of all ability levels
- Use coding best practices and techniques for accessibility and include strategies for unit testing during development
- Conduct quality assurance testing for accessibility compliance and compatibility with assistive technologies
- Build accessibility checks into DevOps pipelines
- Train IT staff and business owners on how to enable, configure, and support accessibility features, and make user manuals, training materials, and helpdesk resources accessible in alternative formats
- Use accessibility scanning tools (e.g., Axe, WAVE, and Lighthouse) and complement with manual testing for real-world conditions

For **software-as-a-service (SaaS)** and packaged applications, these steps will help ensure that the tools meet your accessibility and inclusion criteria:

- Require vendors to demonstrate conformance with WCAG 2.1 AA (or higher), EN 301 549 (EU standard), and Section 508 (US). Include accessibility in scorecards alongside price, security, and performance.

- Request current **voluntary product accessibility template** (**VPAT**) documentation and review vendor accessibility roadmaps (`https://www.itic.org/policy/accessibility/vpat`).
- Favor vendors who have undergone external accessibility testing and certification, not just self-assessments.
- Require vendors to verify compatibility with screen readers, captioning tools, keyboard navigation, and voice input software.
- Negotiate SLAs that commit vendors to maintain and improve accessibility features as standards evolve.
- Make accessibility a standing agenda item in SaaS governance committees.
- Involve employees or customers with disabilities in pilot testing SaaS solutions.

A simple place to start is recognizing where accessibility features are already available and making sure they are enabled, such as Bluetooth conference room technology for the hearing-impaired. Accessibility development and design should be used as criteria for vendor and product selection. AI's ability to enhance accessibility and inclusiveness should also be explored, while ensuring that AI systems are not exacerbating harmful biases. There are tools that can be used for design, testing, and screening, but human oversight and input will still be necessary. *Table 5.1* lists categories and examples, but this is not an endorsement of cited tools or companies.

Tool type/purpose	**Examples/notes**	**Use cases & caveats**
Automated accessibility scanners/linters/audits	Aaxe (Deque): Integrates into development workflows and browsers for automated checks (`https://www.deque.com/axe/`) Microsoft Accessibility Insights: Both automated + guided manual tests (`https://accessibilityinsights.io`) WAVE: Browser-based page-level audit tool (`https://wave.webaim.org/`)	Use these to get a first-pass accessibility report. Useful for catching common violations (missing alt text, low contrast, or misuse of Accessible Rich Internet Applications). But automated tools cannot catch all issues (especially context, usability, and meaning); you still need manual and user testing.

No-code/low-code test automation/ QA tools	TestSigma: Allows non-technical teams to write accessibility tests without code (`https://www.audioeye.com/`) BugBug.io: Codeless automation, although not exclusively for accessibility (`https://bugbug.io/`) AI-augmented no-code testing platforms – These can be extended or configured to incorporate accessibility rules	These tools help embed accessibility checks into QA pipelines, especially where teams may lack deep coding expertise. But they'll only catch issues that are encoded in rules; human/contextual issues still need review.
Design/ prototyping tools with built-in accessibility features	Many UI/UX design tools (Figma, Adobe XD, Sketch, etc.) now include contrast checkers, color-blindness simulators, and plug-in integrations to flag accessibility issues Microsoft's Inclusive Design Toolkit: Methodology and templates for inclusive design processes (`https://inclusive.microsoft.design/`)	Use during prototyping and early design phases to catch accessibility issues before handoff to developers.
Authoring/ content tools with accessibility guidance	Content management systems (CMSs), WYSIWYG editors, and Learning Management Systems (LMSs) that enforce or guide accessible content (e.g., prompts to add alt text, semantic tags, etc.) ATutor: Learning Content Management Systems (LCMS) with full WCAG AA compliance and content-authoring prompts for accessibility (`https://atutor.github.io/`)	Helps with content (not just code) adherence to accessible practices.

Hybrid/overlay/ remediation platforms	Some platforms provide accessibility widgets or overlays to supplement accessibility on top of existing systems. ADACertify: Combines AI scanning and manual audit and user tools widget (text resizing and contrast) (`https://adacertify.io/pricing/widget/`)	Accessibility overlays are controversial (they may mask underlying structural issues).
	WAI-ARIA libraries and authoring practices: These can be used to add accessibility semantics to UI components (`https://www.w3.org/WAI/ARIA/apg/`) Data Navigator: A toolkit aiming to make visual data structures (graphs, charts) more accessible via underlying navigation structures and alternative input modes (`https://arxiv.org/abs/2308.08475`)	Useful when building advanced UI or data visualizations; often require developer integration.

Table 5.1 – Accessibility tool types and examples

Accessibility by design incorporates inclusivity. The general consensus among researchers, diversity advocates, and industry analysts is that diversity in IT staffing has seen incremental progress over the past three decades—but overall, efforts have fallen short of their stated goals, especially when measured against the pace of change in the industry and the demographics of the broader population. While there have been high-profile initiatives and public commitments to improve representation, especially in terms of gender and race, the numbers show persistent underrepresentation of women, black, Latino, indigenous, and other historically marginalized groups in technical and leadership roles. According to recent diversity reports from major tech firms, women still make up less than 30% of the global tech workforce, and the percentages are significantly lower for black and Hispanic employees in technical roles—often remaining in the single digits.

While diversity in IT staffing has not lived up to its aspirations, inclusive design offers a proactive and systems-level approach to advancing social sustainability through the very tools and systems we build. Successful organizations such as IBM, Microsoft, Google, Adobe, Apple, and Salesforce embed inclusiveness from the ground up in their tech product development and internal systems—starting with user stories, extending through participatory design, and validated through diverse usability testing. They treat accessibility, fairness, and cultural inclusion not as afterthoughts or compliance burdens, but as sources of innovation and trust.

Inclusiveness starts with a clear commitment to design principles and continues through performance evaluation. Concrete steps include the following:

1. **Inclusive design principles adoption**:
    - Microsoft's Inclusive Design Toolkit promotes "*designing for one, extending to many*," encouraging teams to design for users with permanent, temporary, or situational disabilities.
    - Apple uses inclusive design practices to ensure accessibility is considered at all stages (e.g., VoiceOver, AssistiveTouch).
2. **Bias mitigation in AI/ML systems**:
    - Implementation of fairness audits and adversarial testing (e.g., IBM's AI Fairness 360 or Google's What-If Tool).
    - Ensuring diverse and representative training datasets; applying techniques such as de-biasing or reweighting. See *Chapter 7*, *Applications and Architecture*, for much more detail on governing AI data for integrity and social sustainability.
3. **Inclusive requirements gathering**:
    - Co-design or participatory design sessions with diverse stakeholders, including people with disabilities, older adults, neurodiverse individuals, and non-native language speakers.
    - Scenario planning that explores unintended consequences and exclusion risks.

4. **Workforce enablement and governance**:
    - Embedding accessibility and inclusion KPIs into engineering performance reviews and product scorecards.
    - Creating dedicated roles (e.g., accessibility program manager, inclusive design lead, etc.).

Timing is critical – inclusivity is most effective when embedded upstream, during system origination and early-stage planning:

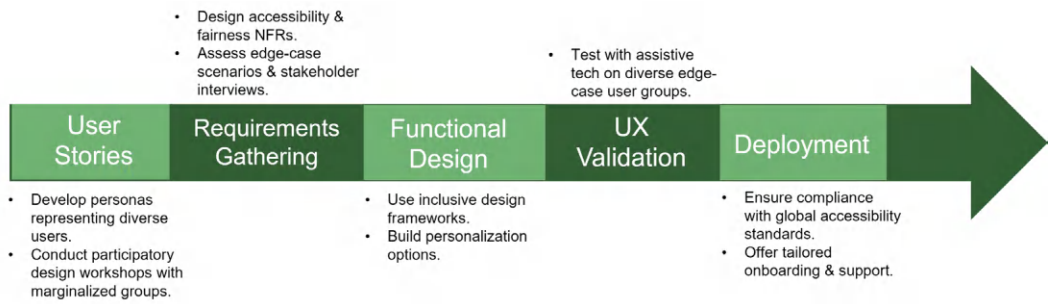


Figure 5.3 – Building inclusivity steps into upstream design stages

Let's move our focus toward the social promise and peril of AI.

The social promise and peril of AI

GenAI is already proving its value in enhancing captioning and audio description, as well as in testing the accessibility of websites and digital products. For starters, AI can enhance data integrity through advanced validation, encryption, and anomaly detection. Machine learning models, when designed and audited responsibly, can identify and reduce biases, leading to fairer outcomes for diverse groups. Companies as diverse as eBay and TD Bank have released AI-based tools to assist with web-browsing and accessible web design.

But AI systems trained on biased data can perpetuate and exacerbate biases. Broader social risks include those stemming from widespread job loss, skills obsolescence, and an unprepared incoming workforce. Although "democratized" through OpenAI and other consumer-focused AI services, there is a real risk of AI widening the digital divide. Most fundamentally, AI's risk to public safety must also be an IT governance consideration. AI's impact (positive and negative) on the enterprise's targeted sustainability goals must be evaluated, applied, and/or mitigated. *Table 5.2* lists common social sustainability goals and AI's potential positive and negative impacts:

Social sustainability goal	**Positive AI impact**	**Negative AI impact**
Ethical supply chain management	AI can monitor supplier practices, detect human rights violations (e.g., forced labor), and support responsible sourcing audits.	Over-reliance on automated supply chain analysis can miss nuanced, qualitative human rights issues, and opaque AI systems may hide unethical sourcing.
Non-discrimination	AI can help track and analyze metrics, flag bias in recruitment and promotions, and support more inclusive practices.	AI can embed and amplify discrimination, particularly if biased historical data is used.
Human rights and digital ethics	AI can help monitor online platforms for human rights violations, detect harmful content, and ensure freedom of expression protections.	Surveillance AI, if improperly governed, can infringe on privacy rights, contribute to authoritarian practices, and undermine trust.
Safe, trustworthy, and compliant AI	Safe, trustworthy, and compliant AI systems can help to improve human safety and create confidence in AI-based systems.	AI applications, if unsafe, could cause hard to people, for example, in an autonomous vehicle or industrial factory robot. Mishaps can also be costly and damage company reputation.
Workforce opportunity and disruption	AI can automate repetitive tasks and augment human capabilities, fostering reskilling and the creation of new, higher-value roles in data, ethics, and AI oversight.	AI may displace workers, accelerate skill obsolescence, and increase job insecurity—especially for low-wage, routine, or white-collar operational roles.
Digital inclusion and equity	AI can extend access to education, healthcare, and digital services in underserved regions; assistive AI can improve accessibility for people with disabilities.	AI may deepen the digital divide if access to AI tools and literacy is limited to wealthier, urban, or digitally mature populations, excluding marginalized groups.

Table 5.2 – AI systems' impact on social sustainability goals

IT organizations can help lead enterprise social impact mitigation from AI by participating in the following actions:

- **Conduct inclusive design and accessibility reviews** – Ensure that AI applications are co-designed with diverse user groups and tested for accessibility standards to minimize exclusion and digital inequity.
- **Audit for bias and fairness** – Apply fairness toolkits (see the following list) throughout development and deployment to identify, document, and reduce demographic disparities in model outcomes.
- **Require sustainability SLAs for AI vendors** – Mandate environmental impact disclosures, ethical AI policies, and compliance with ESG standards (e.g., ISO 14001, and GHG Protocol) in third-party AI vendor contracts.
- **Embed social governance gates in AI lifecycle reviews** – Insert formal checkpoints for sustainability risk evaluation during design, procurement, deployment, and scaling phases, with documented go/no-go decisions.
- **Develop AI literacy and training programs for all levels of the workforce** – Deliver tiered learning tracks that include foundational AI understanding, ethical use, and domain-specific applications to ensure that workers at all skill levels are not left behind. See more on literacy later in this chapter.
- **Partner with educational institutions and community organizations** – Support inclusive talent pipelines through internships, apprenticeships, and credentialing programs targeted at underserved populations, including rural, low-income, and minority communities.
- **Plan workforce transitions** – Establish upskilling, reskilling, and internal mobility to address job displacement risks caused by AI automation, especially in operational roles.
- **Fund and support public access to digital infrastructure and tools** – Advocate for and invest in community tech hubs, affordable internet access, and device donation programs to reduce disparities in digital access.
- **Incorporate low-bandwidth and mobile-first design** – Ensure that AI applications are optimized for use in bandwidth-constrained environments and on lower-cost mobile devices to increase reach and accessibility.

The following are resources and tools applicable to AI social sustainability governance (company and product names referenced in this list are for informational purposes; their inclusion is not an endorsement):

- **Fairness, bias, and social risk tools**: Frameworks and fairness indicators from **TensorFlow**, **Google**, and **IBM** (**AI Fairness 360**) assess whether AI models produce biased or unfair outcomes. Tools such as **Fairlearn** audit trained AI models for disparate impacts across demographic groups. **FAT Forensics** is a Python toolkit for auditing fairness, accountability, and transparency, with built-in explainability tools. **Aequitas** is an open source bias and fairness audit toolkit that helps stakeholders understand model risk from a social impact perspective:
    - TensorFlow: `https://www.tensorflow.org/tfx/guide/fairness_indicators`
    - Google Fairness Indicators: `https://research.google/blog/fairness-indicators-scalable-infrastructure-for-fair-ml-systems/`
    - IBM AI Fairness 360: `https://ai-fairness-360.org/`
    - Fairlearn: `https://fairlearn.org/v0.12/about/index.html`
    - FAT Forensics: `https://fat-forensics.org/`
    - Aequitas: `https://github.com/dssg/aequitas`
- **Explainability tools**: Tools can help ensure that AI output and decision-making are explainable to stakeholders, a key goal in developing and maintaining trust in technology and applications. Examples include IBM's **AI Explainability 360**, a toolkit to support the interpretability and explainability of AI models. Other common explainability models are **DARPA XAI**, **SHAP**, and **LIME**. **Microsoft InterpretML** is an open source library for training interpretable models and explaining black-box systems using methods such as SHAP and LIME. Structured and standards-based documentation tools for explainability include IBM's **FactSheets** for AI, NIST's **AI Risk Management Framework**, and **ISO/IEC 42001**:
    - IBM AI Explainability 360: `https://github.com/Trusted-AI/AIX360`
    - DARPA XAI: `https://www.darpa.mil/research/programs/explainable-artificial-intelligence`
    - SHAP: `https://shap.readthedocs.io/en/latest/example_notebooks/overviews/An%20introduction%20to%20explainable%20AI%20with%20Shapley%20values.html`
    - LIME: `https://lime.readthedocs.io/en/latest/`
    - Microsoft InterpretML: `https://github.com/interpretml/interpret`

    - IBM FactSheets – `https://arxiv.org/abs/1808.07261`
    - NIST AI Risk Management Framework: `https://www.nist.gov/itl/ai-risk-management-framework`
    - ISO/IEC 42001: `https://www.iso.org/standard/81228.html`

- **Data integrity monitoring tools**: Responsible AI governance requires monitoring of AI output quality and accuracy. Tools available for this purpose include **WhyLabs AI Observatory**, a platform for monitoring data and model quality in production environments, helping detect drift, anomalies, and reliability issues. **Arize AI** offers tools to monitor performance degradation, data drift, and fairness breakdowns across diverse segments. **Evidently AI** is a toolkit for evaluating, monitoring, and visualizing machine learning model performance, including drift and integrity metrics:

    - WhyLabs AI Observatory: `https://whylabs.ai/`
    - Arize AI: `https://arize.com/`
    - Evidently AI: `https://evidentlyai.com/`

Case study: Socially responsible AI governance at Cognizant

Digital consulting and outsourcing company Cognizant, a winner of the SustainableIT.org 2025 Responsible AI Impact Award, has developed a pragmatic and repeatable approach to evaluate the potential risks of AI systems and projects, with the goal of enabling ethical and transparent development and deployment of AI systems with built-in safeguards to protect fundamental rights. The overall best practice is how Cognizant integrates its AI risk assessment directly into its IT project management and system design processes, ensuring that social responsibility for equity and fairness is addressed early on and consistently in the project lifecycle. Their example provides a strong model for other IT organizations seeking to build human-centric AI—not just through compliance, but through embedded operational discipline.

Cognizant's **Abhaykumar Kukreja**, **Corporate IT Responsible AI leader/associate VP**, shares details of the organization's responsible AI governance:

> Cognizant's approach was to build a cross-functional, responsible AI working group that had representations from IT, security, privacy, legal, multiple service lines, and regulatory groups. With a charter and the use of Agile methodology, the group built principles and practical implementation guidelines, as well as a risk-based approach to implementing the guidelines. The principles and guidelines take into account global regulations such as the EU AI Act, the Colorado Act, and so on.

Enhancing the risk management framework

Risk categorization of AI-related project work is critical in building end-to-end governance, as these projects can have varied risk profiles based on the use case. Cognizant built and implemented an RAI risk assessment framework, which evaluates the potential risks of AI systems and projects. This framework enables the ethical and transparent development and deployment of AI systems with built-in safeguards to protect fundamental rights, especially of high-risk applications that may impact safety, privacy, and non-discrimination.

There are four risk categories (based on EU AI Act guidance) that are used to determine risks:

- **Unacceptable risk (prohibited)** – These are manipulative, exploitative, and social control practices that result in an unacceptable risk to health, safety, or fundamental rights. The EU AI Act lists out such practices that are prohibited and banned.
- **High risk** – AI systems that may significantly impact product, health, safety, or fundamental rights are classified as high risk. These systems are subject to stringent requirements related to risk and impact assessments, documentation, and monitoring.
- **Limited risk** – Systems that are designed to interact with people or generate/manipulate content are considered limited risk. Transparency requirements apply in this category, such as clearly informing users that they are interacting with a machine or labeling certain AI-generated content to make the user aware of the same.
- **Minimal risk** – Most AI systems fall into this category and face no mandatory requirements under the EU AI Act, but companies can voluntarily adopt codes of conduct. Examples include spam filters or AI-enabled video games.

Cognizant's RAI risk assessment framework includes a set of questions to be answered in the initiation and planning phase of the project lifecycle to determine project risk.

Correlating risk category to implementable responsible AI guidelines

Our responsible AI principles and associated guidelines are correlated to the risk category of the proposed AI system. As an illustration, let's work with the *fair and inclusive* principle, defined next, and broken into four sub-principles:

- **Ensuring AI is fair and inclusive** – For AI to be most effective, it should reflect the broad perspectives of individuals, our clients, and communities. We follow these guiding principles to help ensure that our AI systems are fair, unbiased, and representative of varied groups of people:
    - **Engage diverse perspectives (1.1**) – Bring varied perspectives into the design phase to proactively identify and address biases in data, algorithms, and user interfaces, and anticipate unintended consequences to ensure that the system is fair and representative. Engage with a diverse set of users and incorporate feedback before and throughout the development of an AI system.
    - **Define fairness and inclusivity goals (1.2**) – Design the AI system using concrete goals for fairness and inclusion across anticipated use cases and monitor these goals over time as they evolve. Design your algorithms and objective function to reflect fairness goals.
    - **Minimize biases (1.3)** – Take steps appropriate for the given use case to identify and help address the risk of any inequities, unacceptable biases, or lack of inclusivity. Check the datasets, AI system performance, and outputs for unfair biases, and analyze their performance. Understand how the AI system could result in unfairness and which measures should be taken to resolve this.
    - **Promote accessibility (1.4)** – Design the AI system to be accessible and beneficial to a wide range of users, including those with disabilities, as well as those from various cultural and socioeconomic backgrounds.

    For each of the sub-principles, there is a set of guidelines. The *Minimize biases (1.3)* sub-principle, for example, has the following practical guidelines:

    - Ensure the dataset is representative, reliable, and relevant, excluding discriminatory features (1.3.1)
    - Identify and analyze protected characteristics for bias assessment and prevention (1.3.2)
    - Identify and mitigate potential unfairness in AI systems (1.3.3)
    - Establish clear criteria and accountability for data labeling and prompt engineering to prevent unfair outcomes (1.3.4)

We repeat this process for every principle and sub-principle. In addition, for each of the guidelines, we document the expectations of the project team based on the complexity of the use cases. The use cases should be evaluated across a minimum of three to four complexity levels (simple complexity to high complexity). Each complexity level must be defined using examples that include auditable artifacts. The following are project-team expectations associated with the dataset guideline (*1.3.1*) of the *Minimize biases* sub-principle. They are sorted into three use case complexity levels:

- Simple complexity use cases (known models, API integration):
    - Third-party risk management vendor/product onboarding process.
    - Captured in a third-party risk management system. This is part of the current data governance process.
    - Captured in the architecture review board review checklist.
- Medium complexity (multiple known models; additional agents):
    - Third-party risk management vendor/product onboarding process.
    - Captured in a third-party risk management system. This is part of the current data governance process.
    - Captured in the architecture review board review checklist.
- High complexity (build new LLM/SLM):
    - Build all documentation for algorithm logic, data sources, dataset usage, integration, and output validation.
    - The percentage of total data used for training, testing, production, and so on to be presented as part of the architecture review board checklist.

Review/enhance process/framework/control points

The success of our approach depends on making our process/framework/control points AI knowledgeable. The strategy is to leverage existing frameworks and processes and factor in the responsible use of AI for project delivery and support. Here are some examples of processes and frameworks that may need to be enhanced or augmented (not exhaustive, as every organization is different):

- **Project/program management** – It is essential to enhance the tools and products used for project/program management with an additional responsible AI risk assessment framework. It is important to incorporate the changes upfront in the initiation/planning phase to assess the AI-related risk of the project.

- **Architectural design considerations** – Embedding intelligence and RAI principles in the process is critical to scaling and repeatable execution while also leveraging the existing institutional expertise and processes. It is critical to review and enhance the architectural design checklist for responsible and sustainable AI. Considerations should include the following:
    - Decision framework for using LLMs/SLMs
    - Incorporating input filtering (Azure AI Foundry safety filter settings) for safety and malformations to reduce the utilization of tokens and CPU
    - Appropriate caching using technology such as Redis Cache to reduce the number of queries to be sent to the LLM/SLM, optimizing token usage
    - Evaluating social impact by conducting AI system impact assessments for high-risk projects and building appropriate feedback mechanisms
    - Utilizing agentic frameworks for specific functional verticals to reduce token usage for LLMs
    - Refining LLM via prompt-flow engineering (Azure AI Foundry Prompt Flow/LangChain) for optimizing the use of tokens to improve the efficacy of models
    - Building a robust user profiling process to confirm social aspects of diversity incorporated into the utterance and prompt engineering design
- **Delivery framework** – Enable the development and architectural framework with additional traceability for AI/GenAI. For example, add a tag to the Jira storyboard for all stories that are related to AI/GenAI. This will assist in tracking the projects that have an AI/GenAI component and also in audit and reporting.
- **Third-party risk management/vendor onboarding** – For AI/GenAI, the probability that an external vendor product or software would be used is extremely high. To ensure that there is end-to-end accountability and traceability for responsible AI use, vendor products must be subject to scrutiny similar to in-house development projects. We ask AI/GenAI-related questions while onboarding new vendors or products to determine whether the product/artifact was developed responsibly.
- **New technology onboarding process (security and architecture)** – Most organizations have processes for onboarding new technology, and typical evaluations are from a security and architecture point of view. For AI, these processes need to be expanded to include LLMs/SLMs, tooling for observability/monitoring, code-assist technology, and so on.

Beyond the establishment of AI principles and policies, operationalizing responsible governance requires practices and structures to oversee AI activities. Establishing a working/steering committee provides oversight and guidance on AI projects. These committees must have a diverse range of stakeholders, including but not limited to privacy, legal experts, security, technology, and representatives from affected business/service lines. The objective is to stay abreast of the changing landscape of regulations and the maturity of the industry.

Conducting regular internal audits of AI systems helps identify and address potential risks and biases. Audits should assess the fairness, transparency, and compliance of AI technologies. Standardization and uniformity of project execution and alignment with the EU AI Act facilitate compliance from the outset. Following these practices made Cognizant the first IT services organization to get the ISO42001:2023 (AI Management System) certification.

Providing education and training to developers, users, and stakeholders about responsible AI practices is essential. This includes raising awareness about ethical considerations, legal requirements, and best practices for AI development and deployment. A good starting point could be policy, principles, guidelines, and risk management. Later on, the organization should develop a persona-based curriculum.

Finally, responsible AI governance must be adaptive and flexible to accommodate rapid technological advancements. Continuous monitoring and updating of policies and practices will be necessary to maintain relevance and effectiveness.

Abhaykumar Kukreja, Corporate IT Responsible AI Leader/Associate VP, Cognizant

Cognizant's process demonstrates that AI risk assessment for social sustainability does not require a separate governance track—it can and should be embedded into the standard IT delivery model. Their approach optimizes these outcomes:

- Minimizes friction and enhances adoption by embedding responsible AI risk management into existing enterprise delivery frameworks (e.g., Jira, architecture boards, and vendor management).
- Ensures that social risks such as bias, exclusion, and algorithmic unfairness are addressed upstream, when design choices are still flexible.
- Reduces friction by adapting requirements to levels of risk and use case complexity. This enables proportionality, consistency, and auditability in socially responsible AI delivery.

It is worth reiterating Abhaykumar's point about staff education. The IT department at large needs to understand the new AI responsibilities as new models come on board and systems start to scale. It would be helpful to partner with the communications or HR learning teams to get the word out.

AI literacy enables social sustainability

Cognizant and other responsible AI adopters realized early on that broad-scale AI training would be an imperative to effective and sustainable use of these transformative tools at scale. Enterprise-wide AI literacy is particularly vital to social sustainability, which demands that AI systems promote fairness, inclusivity, and equity. Ongoing education for employees helps them recognize and correct biases proactively and design systems that are deliberately accessible to the widest range of users and customers. The following material is excerpted from the *Persona-based Literacy Guide for Sustainable AI* (SustainableIT.org 2025).

What role should IT play in fomenting AI literacy? IT departments possess a comprehensive understanding of how AI systems are developed, deployed, and maintained—knowledge needed for educating internal stakeholders about AI's capabilities, risks, and sustainability impacts. In fact, given their central position at the intersection of data governance, system design, and operational implementation, IT executives are uniquely positioned to guide cross-functional literacy programs that align with enterprise AI frameworks. IT can make certain that training reflects both technical realities and responsible governance practices—helping business units, legal teams, and executive sponsors make informed, ethical, and sustainable decisions.

AI literacy training must be tailored to different personas; the three most fundamental ones are everyday users or AI generalists, specialists or AI experts, and executives, including the organization's AI sponsors. Workshops and training modules tailored specifically to these personas will be more likely to engage them and instill AI possibilities, limitations, and risks germane to their roles and responsibilities. The matrix in *Table 5.3* suggests persona-focused topics for AI literacy programs spanning the knowledge maturity spectrum from basic awareness to integration of responsible AI practices, to future-readiness and innovation.

Persona	AI sustainability awareness	Responsible AI integration	AI future focus & innovation
Everyday users/AI generalists	Basic AI concepts and limitations AI's ESG impacts (energy use, carbon emissions, biases) How GenAI may affect jobs and equity in society—the company's AI ethics policies and sustainability goals Understanding the risks emerging at the intersection of AI and copyright	How AI can improve or streamline their tasks ethically Following guidelines for responsible AI use (data privacy and avoiding bias) Adapting workflows to include human oversight of AI Communicating issues (e.g., flagging biased outputs)	How their roles might evolve with GenAI and agentic AI augmentation and co-working New opportunities to apply AI for positive impact (e.g., automating tedious tasks to focus on creative work) Continuous learning mindset to keep up with AI tools Being an "AI advocate" for sustainable practices in their team
Specialists/AI experts	Deeper understanding of AI's environmental footprint, such as the carbon cost of model training AI equity, ethics, and fairness issues (bias in data/models) Regulatory and compliance basics (AI regulations, data laws, copyright, and other IP laws) The company's responsible AI standards and ESG commitments	Design and development practices for responsible AI (fairness, transparency, accessibility, and privacy by design) Efficient ML techniques (model optimization, Green AI) to cut energy use AI governance processes (model documentation, review, and audit trails) Cross-functional collaboration (work with domain experts and ethicists) in AI projects Copyright compliance and risk management	Emerging tech and methods (privacy-preserving ML, federated learning, etc.) for sustainable AI Innovative applications of AI for ESG (e.g., AI for climate analytics and inclusive services) Foresight on AI trends (next-gen models, regulations, etc.) to future-proof systems Mentoring others and shaping the company's R&D directions toward "AI for Good"

Persona	AI sustainability awareness	Responsible AI integration	AI future focus & innovation
Executives/AI sponsors	Strategic overview of AI capabilities and limitations ESG risks and opportunities of AI (carbon footprint, and social impact on workforce and customers) Case studies of AI failures (ethical or reputational) and successes in industry Landscape of AI governance standards (e.g., OECD or NIST principles) and relevant regulations	Integrating AI into business strategy and processes safely (governance frameworks, risk controls) Change management for AI adoption (reskilling workforce, and updating policies) Ensuring responsible AI governance: oversight committees, audit mechanisms, and alignment with corporate values (UN SDGs, etc.) Balancing innovation with compliance (e.g., approving AI projects that meet sustainability criteria)	Vision for AI-driven business models that align with sustainability (e.g., AI-enabled services for stakeholders with bandwidth limitations) Long-term workforce planning (new roles, retraining programs for the AI age) Ecosystem building: partnerships in AI ethics and sustainability, influencing industry standards Continuous learning via executive courses or futurist briefings to steer the company in the AI era

Table 5.3 – Suggested subjects by persona and AI maturity level

IT and the digital divide

The digital divide refers to the gap between individuals, households, communities, organizations, or regions that have reliable access to—and the skills, affordability, and support needed to effectively use—today's ICT tools such as 5G internet connectivity, mobile internet, and digital services such as chatbots, and those that do not. We apply the term beyond physical access to include quality of connections, digital literacy, accessibility for people with disabilities, language localization, and the ability to derive meaningful social and economic benefit from digital participation.

The disparity numbers are startling to most. Nearly one-third of the global population – 2.6 billion people – were offline in 2024–2025. About 1.8 billion of these offline people live in rural areas. About 40% of people globally do not own a mobile phone (ITU 2024).

The disparities are starker when viewed through the lens of income. High-income countries have 93% of their populations on the internet; only 27% are connected in low-income countries. Only 1 in 100 people in low-income countries have fixed broadband access – the median price of an entry-level mobile broadband subscription amounts to 8.6% of the average income, a share 22 times larger than in high-income countries (0.4%) (Internet Society Pulse 2023). The gender gap in lower-middle-income and low-income countries reveals that internet access by women trails access by men by as much as 15 percentage points (World Bank Group 2023). *Figure 5.4* shows the percentage of income-based populations that lack digital access, derived from International Telecommunications Union reports.

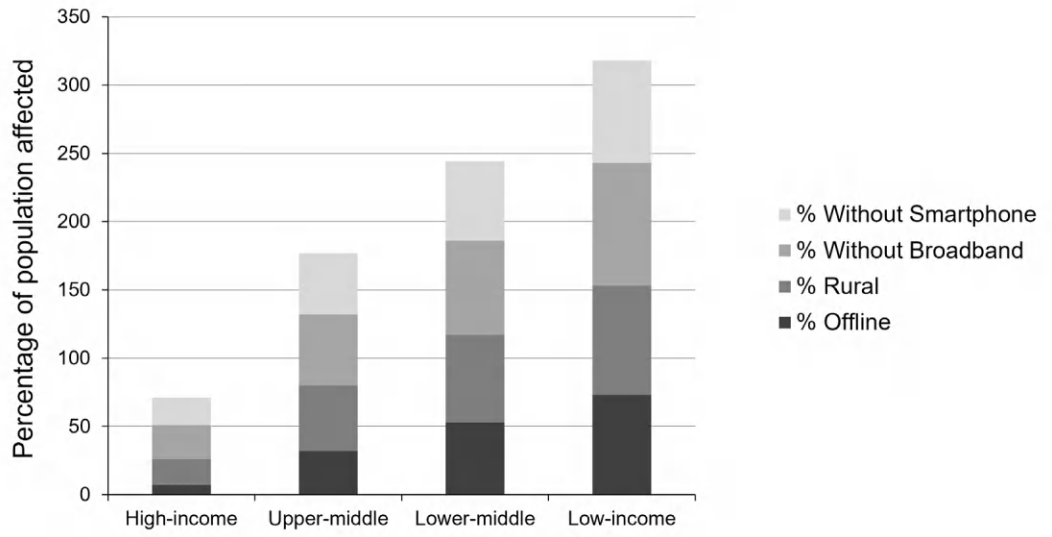


Figure 5.4 – Global digital divide by income bracket

Encouragingly, many of these disparities are improving year to year, mostly due to the decreasing costs of the technology. Modern digital technologies—including cloud platforms, mobile applications, data analytics, generative and agentic AI, and automation—have the potential to be powerful equalizers. These tools can deliver education, healthcare, employment, and financial services to previously underserved populations. Mobile-first applications, digital identity systems, telemedicine, and adaptive learning platforms are already expanding access in areas where traditional infrastructure is limited. AI can further enhance these efforts by enabling real-time translation, personalizing learning content, or enhancing accessibility for users with disabilities.

These same technologies can also exacerbate existing inequalities if access, affordability, and skills are not equitably distributed. High-speed internet, updated hardware and mobile devices, and digital literacy remain out of reach for many low-income, rural, or marginalized groups. As enterprises shift more services online or rely on AI-driven systems to make decisions, those without consistent digital access or abilities may face new barriers in applying for jobs, accessing public services, or managing their health. In this way, the digital transformation that you are enthusiastically leading in your organizations can unintentionally leave entire communities further behind, reinforcing systemic social and economic divides.

The role of IT leaders in bridging the digital divide

Corporate CIOs and technology industry leaders have multiple levers they can pull to narrow the divide and lower barriers. One high-impact strategy that actually will cost your organization nothing is to donate end-of-life IT assets, such as laptops, tablets, and smartphones, to nonprofits and community organizations that refurbish and distribute them to under-resourced schools, job seekers, and elderly populations. Instead of disposing of retired hardware through standard asset disposition channels, forward-thinking companies are building **IT asset disposition (ITAD)** programs that include circular economy principles and social sustainability goals, enabling technology to find its way to those most in need.

By leveraging enterprise partnerships, internal expertise, and surplus resources, companies can create enduring infrastructure that supports digital participation and inclusion in tangible, localized ways. CIOs can support or even partner in establishing community tech centers in areas with limited access to devices or the internet. These hubs offer shared digital access, technical support, and training opportunities for students, job seekers, small business owners, and others who may lack connectivity or skills at home. Even in the US, there are regions where residents have limited broadband access. CIOs at companies located in their regions can help to improve access for their neighbors.

What they can't control directly, IT leaders can certainly influence through their buying power. Leaders should be knowledgeable about the sustainability practices of their primary tech suppliers, particularly in their global labor practices and local community engagement. With their investment choices, they can support vendors with strong social sustainability programs and results, and pressure those that need to improve. Later in this chapter, you will find a social sustainability questionnaire for your vendors and related metrics. *Chapter 11*, *Leveraging Your Buying Power*, delves further into vendor sustainability criteria.

The following short cases exemplify these approaches. They are based on the author's (Richard) previously published case study and SustainableIT Impact Award report, respectively (SustainableIT.org, 2024 2025).

Case study: Edifecs digital community centers

Edifecs is a healthcare technology company dedicated to improving healthcare outcomes through efficient data exchange and administrative cost reduction. The company was acquired by Cotiviti in March 2025. Founded and headquartered in Bellevue, Washington, in 1996 with offices in Atlanta and Punjab, India, Edifecs serves healthcare payers and providers by streamlining administrative processes and enhancing data accuracy. Sustainability is embedded in its corporate ethos, influencing both its internal operations and industry-wide solutions. The company has won numerous sustainability awards and accolades, including SustainableIT's Global Impact Award in 2024.

Without the personal commitment of employees, sustainability policy and framework adherence and attention to sustainability metrics reported in the company's dashboard can easily lapse. People need to see the impact of their actions to gain and maintain their invested interest. From early on, Edifecs prioritized community-driven sustainability programs, with its **digital community centers (DCCs)** in India playing a vital role. The program began with an employee's simple request to donate a used laptop for a family member and has since expanded into a formal initiative in partnership with the RoundGlass Foundation. "*That small act of generosity snowballed into a full-fledged program that has impacted entire communities*," says *Ravi Soin, former Edifecs CIO and ESG lead, and now CIO and CISO for Smarrtsheet*.

The centers provide digital literacy training, access to technology, and educational resources for underserved communities, helping bridge the digital divide. Since 2021, the company has donated IT equipment to establish 45 DCCs, impacting over 780 children across 22 villages. These centers have not only bridged the digital divide locally but have also transformed lives.



Figure 5.5 – Inside a community center supported by Edifecs

The company has also implemented structured processes for end-of-life IT asset retirement, refurbishment, and donation to minimize waste, with totals available via the company's sustainability data dashboard. *Figure 5.6* shows the totals for 2023.

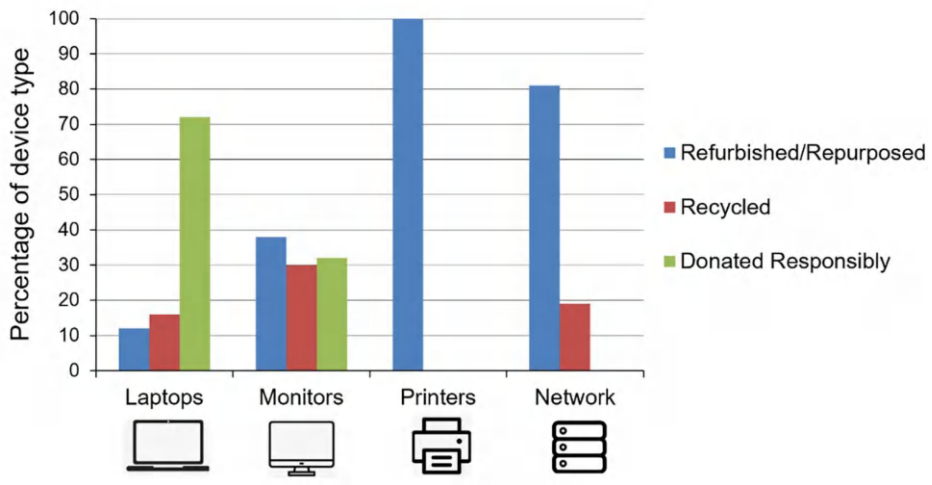


Figure 5.6. – Edifecs end-of-life asset disposition by hardware category and disposition type (2023).

Case study: OTTO supply chain transparency and diversity

OTTO, provider of the largest German e-commerce platform of the same name, is part of the internationally active Otto Group. Based in Hamburg, Germany, it operates companies worldwide in the retail, e-commerce, financing, logistics, and mail-order sectors. It has set up its human rights due diligence process in accordance with the United Nations' Guidelines for Business and Human Rights. A particular focus is on the supply chains of goods for its own and licensed brands, for which it has significant opportunities for influence. Measures are designed to achieve continuous improvements and range from audits and certifications to training measures at the facility level.

To assess and improve working conditions, OTTO and the Otto Group target living wages, safe working conditions, freely chosen employment, child-free production, freedom of association and collective bargaining, and reasonable working hours. The initial step was to create transparency about the supply chain. Business partners were obliged to disclose the facilities that produce for any company within the Otto Group and provide data that is recorded in a supply-chain database. The company has data on nearly 100% of final production facilities. In 2022, OTTO was able to identify about 2,000 previously unknown facilities in the deeper supply chain, significantly increasing transparency. All social requirements are backed by measurable indicators, which allows OTTO to derive measures and decisions based on data and to track progress in production conditions.

Although some may see such robust data-based transparency rules as a bureaucracy, the OTTO IT team and CIO Dr. Michael Müller-Wünsch regard them as a solution. Nevertheless, databases consume energy and create emissions, so members of IT are currently researching data minimalism in design principles and architectures, building Green Software Foundations templates into their design playbook.

OTTO is committed to diversity with a special focus on engaging women in tech professions. To achieve this, the company has initiated various programs, including **Develop<Her>**, which aims to spark interest among girls and women in pursuing a career in IT. The project was initially launched by OTTO's pioneering women's network, **Plan F**. In addition, OTTO promotes diversity with **#experience**, a consortium that focuses on the interests of employees over 50, as well as with its **MORE** network for LGBTQI+ inclusivity.

This next case study describes how IT can use its end-of-life digital assets to shrink the digital divide by equipping underserved communities with technology to which they would otherwise lack access. Specifically, we will learn how power utility company National Grid collaborated with a non-profit ITAD company to prepare and donate thousands of digital devices to people in need.

The ITAD company Human-I-T was founded in 2012 by Gabe Middleton and James Jack in California, its mission born from the realization that millions of Americans lacked access to computers and high-speed internet while, simultaneously, a vast amount of e-waste was being disposed of in landfills daily. The organization started by collecting and redeploying IT hardware in the Los Angeles area, but is now operating nationally and has partnerships with service providers in other countries as well. The following figure depicts Human-I-T's ITAD lifecycle, which, unlike traditional ITAD, addresses social sustainability by introducing digital inclusion services:

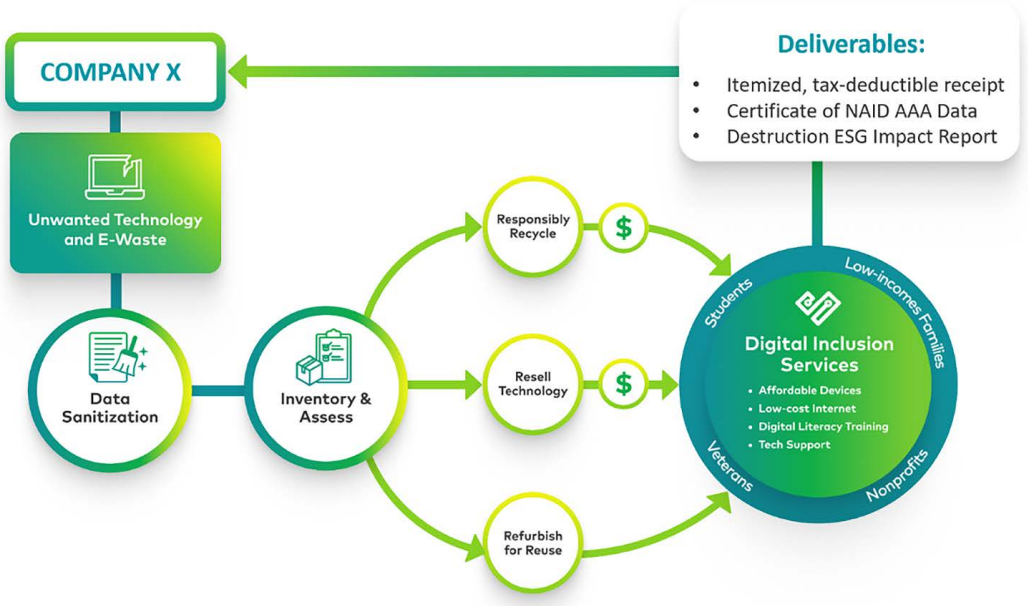


Figure 5.7 – Human-I-T's ITAD lifecycle (source: Human-I-T.org)

Next, we will learn how National Grid achieved a paradigm shift through its work with Human-I-T.

Case study: How National Grid transformed ITAD into a channel for social impact

In 2024, National Grid made a radical shift in thinking about ITAD, from viewing it as a waste management problem to seeing it as an opportunity for social transformation. Rather than simply focusing on recycling rates and resale values, the company began asking a different question: How could their end-of-life IT assets create meaningful change in people's lives?

As a major utility company with operations across the US and UK, National Grid manages thousands of IT assets annually. With an estimated 7,000 to 8,000 devices cycling through their organization each year, the company faced a significant responsibility in determining how to handle these assets sustainably.

The challenge was clear: how could National Grid align its ITAD practices with ambitious sustainability goals while maximizing social benefit? Traditional e-waste providers offered recycling and resale options, but these approaches felt increasingly inadequate for an organization committed to a broader vision of sustainable IT leadership, one that prioritized social impact alongside environmental impact.

This case study explores how, by partnering with Human-I-T, National Grid discovered that sustainable ITAD has the potential to transform what was once considered waste into tools that can change lives, careers, and entire communities.

Beyond traditional ITAD

National Grid's previous approach to ITAD followed a conventional model: partnering with a standard e-waste provider focused primarily on resale and recycling. While this arrangement functioned adequately from an operational standpoint, the metrics revealed a story of missed opportunities.

Despite handling thousands of devices annually, only 17% were being reallocated to charitable causes. The recycling rate stood at 50%, meaning half of all equipment was broken down for materials rather than finding a second life. Most critically, National Grid had limited visibility into the actual social impact of their donated devices–they knew quantities but not outcomes.

"*While we were doing good, we felt that there was more that we could do*," recalls **Jody Elliott, Head of IT risk and sustainability at National Grid**. This sentiment captured the growing disconnect between the company's values and its ITAD practices. While financial returns from resale provided some charitable funding, there was no direct line between National Grid's assets and the people whose lives could be transformed by technology access.

The transformation began with a fundamental realization: these assets, despite carrying zero book value on their balance sheets, held tremendous social value that was being left unrealized. National Grid aligned its ITAD strategy to its broader sustainability framework, building on its commitment to the UN Sustainability Goals and its responsible business charter. When the UK government launched the **IT Reuse for Good Charter** – asking organizations to prioritize device reuse over recycling to address the digital divide – National Grid became one of the first signatories.

This represented a paradigm shift from metrics-driven to purpose-driven ITAD. Rather than optimizing for resale revenue or minimizing disposal costs, National Grid began viewing each device as an opportunity to enable digital inclusion and community empowerment.

"*Our responsibility should be to ensure that we maximise the use and the benefit of those assets beyond our consideration*," explains Elliott. "*We felt that was the right thing that organizations should be doing and that we should, given that we have the capability and the responsibility to ensure that happens*."

Throughout this transformation, security remained non-negotiable. Any new partner would need to maintain full compliance with industry-leading security standards and rigorous data sanitization protocols. The challenge was finding a partner who shared National Grid's vision that ITAD could be more than a transaction.

When National Grid evaluated potential ITAD partners, they sought more than security compliance and operational capability. They needed a partner whose core purpose aligned with their vision of technology as a force for social good, and they found it immediately in Human-I-T.

"*It was the messaging. It was understanding. It was really that central message of the good that's going to be done*," explains Elliott. "*And it was very clear through the engagement that that was the sole purpose of the organization that connected the social responsibility to our values*."

Brandon Smith, Vice President of IT ESG at Human-I-T, states, "*What made this partnership work wasn't just alignment of mission, it was shared operational discipline. National Grid had the strategic clarity to prioritize reuse, and we had the infrastructure to deliver measurable, secure outcomes at scale.*"

The partnership delivered immediate operational advantages. Where the previous model relied on quarterly bulk pickups – leaving hundreds of devices accumulating in storage rooms – Human-I-T implemented weekly collections from day one. This shift eliminated multiple risks: fire hazards from battery accumulation, fraud vulnerabilities, and asset tracking challenges. As Elliott observed, "*It not only enables us to donate faster, but also limits our risk of maintaining or collecting these assets in large numbers in locations that could impact our additional controls around finance, security, and data*."

The numbers tell a compelling story. National Grid's reuse rate soared from 50% to over 90%, with 2,800+ devices donated by the end of the first quarter of the partnership alone. "*A donation every week in the US since the 10th of January*," Elliott emphasizes. With 7,000–8,000 devices cycling through annually, this consistency translates to thousands of opportunities for digital inclusion each year.

But the most profound transformation occurred within National Grid's culture. The utility's **IT sustainability governance lead, David Welling**, captures this shift: "*[Our staff] is actually clearing [the devices] earlier so that they have more utility. Each device is now understood for what it truly represents*."

"*That device could change somebody's life*," Elliott reflects, "*could change their career, change their social mobility.*"

The partnership exceeded all expectations. "*They've not just enabled us to achieve what we wanted to do*," Elliott concludes, "*they've enabled us to accelerate extremely quickly to where we want to be*."

"*When organizations treat ITAD as a final step, they miss the beginning of the story. We designed our partnership with National Grid to track not just where devices go, but what they do—who they empower, who gets connected, and what doors are opened as a result*," says Smith.

Lessons for sustainable ITAD leadership

National Grid's transformation offers critical insights for IT leaders seeking to reimagine their approach to asset disposition. The journey begins with organizational alignment, a lesson Elliott emphasizes strongly: "*With all sustainability initiatives, you need to have alignment with your CIO, your division, and the strategy. You need to have alignment with your Chief Procurement Officer on vision and strategy*."

This alignment enables organizations to move beyond traditional vendor evaluation. When selecting an ITAD partner, the focus must shift from operational metrics to organizational mission. "*Selecting a partner for this type of work, it's important to connect to understand the vision of the partner*," Elliott advises. "*It's not about tracking performance alone – it's about doing good*."

Due diligence takes on new dimensions in this context. Beyond verifying security certifications and operational capabilities, organizations must validate social impact claims. Welling warns of the reputational risks: "*If you collaborate with an organization that isn't genuinely fulfilling its promises, a narrative can quickly develop suggesting that you are not truly delivering on your own sustainability commitments*."

"*Mission without accountability is a liability. The organizations we work with are looking for a process they can trust, audit, and defend in front of their boards*," adds Smith.

This experience has reshaped how National Grid defines value in ITAD. True sustainable IT transcends environmental metrics to encompass social equity and community empowerment. The partnership proves that organizations can maintain rigorous security standards, achieve cost objectives, and create meaningful social impact simultaneously.

"*That one device that we pick up there may be the one device that changes somebody's life*," Elliott reflects. This understanding represents the new paradigm for sustainable ITAD, where IT leaders view asset disposition not as waste management but as an opportunity to extend technology's beneficial impact into communities that need it most.

"*We're watching the definition of sustainable IT evolve in real time. The next generation of IT leaders won't just ask how to dispose responsibly, they'll ask how to create equity through infrastructure they already control*," says Smith.

Social sustainability in tech procurement

Socially sustainable technology procurement refers to the process of selecting and acquiring technology products and services in a way that actively promotes human rights, fair labor practices, community wellbeing, and digital inclusion across the full lifecycle of a vendor relationship—from manufacturing and supply chain through usage, end-of-life, and reuse. It goes beyond price, performance, and delivery to ensure your organization's technology investments do not cause or perpetuate social harm and ideally generate positive social value.

The end-goal for assessing a tech vendor's social sustainability practices is to gain visibility, reduce risk, and create shared value across your IT supply chain. By aligning tech sourcing with ESG and UN Sustainable Development Goals, your procurement investments will drive social benefits in measurable ways while avoiding reputational, regulatory, or operational risk from association with forced labor, unsafe factories, or discrimination. Through your assessment and influence on vendor behavior, your organization will help drive systemic change.

When it comes to the social sustainability of your tech vendors, don't assume that corporate procurement is taking care of this evaluation. Research shows that tech procurement professionals are behind the curve in incorporating sustainability criteria into their vendor requirements (ICTC 2024). However, there may be some social sustainability requirements for procurement at the corporate level, most likely health, safety, and labor rights. Be sure to check and align with these for your technology procurement assessment. Third-party sources of criteria and assessment include the following:

- EcoVadis Sustainability Assessment Questionnaire: `https://www.coolset.com/academy/ecovadis-your-guide-for-a-platinum-score`
- UNCTAD Voluntary Sustainability Standards: `https://unctad.org/publication/voluntary-sustainability-standards-and-sustainable-development-due-diligence`

- IFC Performance Standards (World Bank Group): `https://www.ifc.org/content/dam/ifc/doc/mgrt/ifc-performance-standards.pdf`
- Drive Sustainability SAQ 5.0: `https://www.drivesustainability.org/wp-content/uploads/2022/12/SAQ-5.0_DS-Format_EN_clean.pdf`

The following template is a social sustainability questionnaire for use with any tech vendor (there should also be environmental and governance sustainability criteria and questions in parallel with this social assessment). Your organization will need to decide how assessment responses will influence investment decisions. Will certain answers disqualify a vendor? Will a score of 100% positive be required for deals? What expectations should be made (e.g., for small or disadvantaged companies)? Ultimately, an IT organization should be able to say what percentage of vendor spend or business is conducted with organizations that have been assessed and have met the sustainability requirements.

Template: Technology vendor social sustainability impact questionnaire

This questionnaire is designed to assess your organization's practices and commitments in the following social sustainability impact areas:

- Digital upskilling and reskilling of local and underserved communities
- Labor rights and fair working conditions
- Health and safety in materials and minerals handling
- Accessible and inclusive technology design
- Community engagement and responsible innovation

Please respond to each item below and attach relevant documentation as indicated:

1. Digital Upskilling/Community Capacity Building

1.1 Do you currently run or support any digital skills training programs in the communities where you operate?

- Yes
- No
- If yes, please describe the program's goals, curriculum (e.g., digital literacy, AI/data, STEM), target audience, and impact to date.

1.2 Do you partner with local schools, universities, nonprofits, or government agencies to provide digital access or learning opportunities?

- Yes
- No
- If yes, list partners and initiatives.

1.3 How many individuals have received digital training or upskilling through your programs in the past 12 months? (Please disaggregate by gender and age group if possible.)

2. Labor Rights & Working Conditions

2.1 Do you comply with the core ILO labor standards (e.g., prohibition of forced labor, child labor, discrimination, and freedom of association)?

- Yes
- No
- Not applicable (please explain)

2.2 Do you conduct regular third-party social audits of your facilities or Tier 1/2 suppliers?

- Yes
- No
- If yes, provide a summary of findings and corrective actions (if any) from the last 12 months.

2.3 Do you provide fair wages, contracts, grievance mechanisms, and freedom of association to your workers, including in overseas locations?

- Yes
- Partial
- No

3. **Health & Safety in Materials and Minerals Sourcing**

3.1 Do your operations involve the use or sourcing of conflict minerals (e.g., tin, tungsten, tantalum, or gold) or rare earth elements?

- Yes
- No
- If yes, please describe your due diligence and traceability measures (e.g., RMI participation, OECD alignment).

3.2 Do you ensure safe handling of toxic or hazardous materials across your supply chain?

- Yes
- Partial
- No
- Please attach any health & safety protocols, MSDS documentation, or training records.

3.3 Have there been any recorded workplace injuries or safety incidents related to materials handling in the past 24 months?

- Yes
- No
- If yes, please provide a summary and mitigation efforts.

4. **Inclusive & Accessible Technology Design**

4.1 Do you follow inclusive design or universal design principles in your product development process?

- Yes
- No
- In development
- Please describe how you incorporate user diversity (e.g., language, age, disability) into your UX/UI or hardware design.

4.2 Do your products conform to any accessibility standards (e.g., WCAG 2.1, EN 301 549, Section 508)?

- Yes
- Partial
- No

4.3 Do you include people with disabilities or underserved user groups in your user testing or design reviews?

- Yes
- No
- If yes, please provide examples or documentation.

5. **Local Social Engagement and Community Impact**

5.1 Do you invest in community centers, technology hubs, or digital access points in the regions where you operate?

- Yes
- No
- If yes, describe infrastructure investments, partners, and community reach.

5.2 Have you implemented any programs that promote digital inclusion for women, youth, or marginalized populations?

- Yes
- No
- Please detail program name(s), geography, and participant outcomes.

5.3 Do you have a process to engage with community stakeholders regarding the social impacts of your technology?

- Yes
- No
- If yes, describe engagement methods (e.g., consultation sessions, grievance platforms, local advisory groups).

5.4 Do you have a program for reusing or donating end-of-life technology hardware (e.g., laptops, phones, networking equipment) to underserved or digitally excluded communities?

- Yes
- No
- If yes, please describe the program, list recipient organizations or regions, and indicate the approximate volume or number of devices donated in the past 12 months.

6. Supporting Documentation Checklist

- Labor and human rights policy
- Community investment strategy
- Training materials or curriculum outlines
- Accessibility design guidelines
- Third-party audit or impact reports

- Conflict minerals due diligence report
- Digital inclusion program outcomes

Vendor social sustainability scorecard

Finally, as we have gone through the different levers you can use to reduce your carbon intensity, let us look at how we can summarize these critical metrics in a social sustainability vendor scorecard:

Description	Metric	General Requirement	United Nations Sustainable Development Goals Alignment
Inclusive & accessible technology design	% products meeting accessibility standards	Universal design & inclusion of diverse users in development & testing	3. Good health & well-being 10. Reduced Inequalities
End-of-life hardware circularity	%	Donation programs to underserved communities	9. Industry, innovation & Infrastructure 12. Responsible consumption & production
Digital divide reduction & digital upskilling	Scope & reach	Digital access improvement & skill development programs	12. Responsible consumption & production 13. Climate action
Labor rights & working conditions	% suppliers audited & compliant	Compliance with ILO Core Labor Standards	8. Decent work & economic growth 10. Reduced inequalities
Vendor sustainability assessments	% assessed & compliant	Documented sustainability criteria for vendor onboarding & monitoring	12. Responsible consumption & production 17. Partnerships for the goals

Figure 5.8 – Vendor social sustainability scorecard

Additional scores can be included to cover local community investment and engagement, conflict-free and safe sourcing of upstream minerals, and health and safety in the supply chain.

Summary

In this chapter, you have seen how enterprise IT can be a powerful driver of social sustainability—ensuring that technology is inclusive, accessible, equitable, and protective of human rights across its lifecycle.

We began by reinforcing that AI is only the latest example of a technology with significant potential social consequences. We revisited the human-first AI principle from the responsible AI leadership principles and expanded into the broader responsibilities of IT functions in addressing issues such as workforce impact and digital equity.

You learned how IT teams can assess and mitigate social risks across the IT landscape. This included guidance on conducting social impact assessments of AI systems. You also learned about the economic and societal value of designing systems that serve aging populations and people with disabilities.

We also explored how to evaluate technology vendors' social sustainability performance, and you were presented with a template for adaptation.

Here are a few summary recommendations:

- Assess all new and existing IT systems for accessibility and alignment with global inclusivity standards, and apply standard metrics to track progress
- Integrate AI literacy training into workforce development, tailored by role and exposure
- Ensure that your AI systems are assessed for social risks, including workforce disruption, bias amplification, and exclusion
- Design and deploy technology that serves marginalized or underserved communities, including the elderly and people with disabilities
- Evaluate your IT and AI vendors for social sustainability practices, including community investment, labor practices, and product accessibility
- Include the donation of refurbished equipment in your circularity strategy

As this chapter concludes, you should now see IT not only as an enabler of digital transformation, but also as a lever for social equity. You are equipped to ensure your technology organization creates inclusive, human-centered systems that serve both your enterprise and society.

In the next chapter, we will begin a multi-chapter exploration of IT infrastructure sustainability, beginning with your application portfolio and architecture.

Appendix: Standard metrics for IT social sustainability

Assessing and reporting IT's social sustainability efforts and outcomes requires documenting approaches or the extent (scope) of adoption of recommended or required practices. Digital community engagement metrics skew toward impact quantities, such as the number of people engaged, trained, or equipped in a program. The nature, longevity, and scope of the engagement should be recorded and updated periodically. *Table 5.4* lists metrics for inclusion, accessibility, and community engagement.

Category	Topic	Metric	Related Global Standards
SIT S 100 Social and Economic Inclusion	S 110 Technology Accessibility (i.e., accommodations to facilitate access/usage for all)	S 110-1 Approach to ensure constituent accessibility to IT products and services (e.g., websites, virtual collaboration platforms, chats, e-docs, applications in general)	Voluntary Product Accessibility Template (VPAT-WCAG, U.S. Section 508, EN301 549) (`https://www.w3.org/WAI/standards-guidelines/wcag/`) SDG 3, 8, 10
		S 110-2 Accessibility criteria and extent of application to systems design and engineering	
		S 110-3 Extent of adoption of assistive technology (e.g., text-to-speech tools)	
		S 110-4 Extent of adoption of Web Content Accessibility Guidelines	
		S 110-5 Extent of intentional adoption of simpler technologies accessible to non-technologists (e.g., low-code/no-code)	

SIT S 100 Social and Economic Inclusion	S 140 Technology Inclusiveness (e.g., consideration of diverse groups in the development lifecycle)	S 140-1 Inclusiveness approach, categories, and criteria applied to IT systems design and engineering	Voluntary Product Accessibility Template (VPAT-WCAG, U.S. Section 508, EN301 549) (`https://www.w3.org/WAI/standards-guidelines/wcag/`) SDG 3, 8, 10
		S 140-2 Extent to which inclusiveness considerations factored into systems origination and early design (i.e., user stories, requirements gathering process, validation, user experience, and functional design)	
SIT S 100 Social and Economic Inclusion	S 150 Digital community engagement (i.e., tech-centric interaction with local businesses, institutions charities, and causes)	S 150-1 Type and extent of tech-oriented engagement with communities (e.g., tech donations, digital literacy or IT skills training, "coding for good")	GRI 413-1 ESRS S3 SDG 10, 11
		S 150-2 IT budget for community engagement allocated/spent over time period S 150-3 Outcomes of principal engagement efforts—quantifiable and unquantifiable	
		S 150-4 Approach to overcome digital divide, preventing underserved communities from accessing critical technology (i.e., technology products and services related to education, jobs, and healthcare)	

Table 5.4 – SustainableIT Standards Taxonomy metrics for social and economic inclusion (source: SustainableIT.org)

Metrics for vendor social sustainability start with how you hold vendors accountable. A robust set of assessment criteria should be documented, as well as validation and monitoring procedures. Numeric measures describing the percentage of vendors meeting criteria and investment levels in sustainable businesses are classified in the SustainableIT Taxonomy under **EF** for **Environmental Function**, but they actually apply across the ESG spectrum (*Table 5.5*).

Category	**Topic**	**Metric**	**Related Global Standards**
SIT S 200 Sourcing Social Accountability	S 210 Technology vendor social accountability	S 210-1 Approach to assess, monitor, and hold accountable technology vendors for social requirements compliance	GRI 205, 414-1 ESRS S2 SDG 10
		S 210-2 Social sustainability criteria or requirements for IT vendors (describe questions or assessment factors)	
		210-3 IT vendors having a significant risk of child or forced labor and human rights violations, and how the risk is addressed	
		S210-5 Exceptions made for small or otherwise disadvantaged vendors that may not be able to meet all requirements	

Category	**Topic**	**Metric**	**Related Global Standards**
SIT EF 400 Sourcing	EF 410 Software sourced sustainably (i.e., vendors, manufacturers, and supply chain)	EF 410-1 Percentage of and degree to which vendors meet requirements; also, percentage of requirements met by each primary vendor	GRI 308-1, 2 SDG 9, 13, 17
		EF 410-2 Percentage of software licenses or instances sourced sustainably	
		EF 410-3 Percentage of total spend to sustainable sources	
	EF 420 Hardware and devices sourced sustainably (i.e., vendors, manufacturers, and supply chain)	EF 420-1 Percentage of installed base sourced sustainably	
		EF 420-2 Percentage of new purchases sourced sustainably over the time period	
		EF 420-3 Percentage of total spend to sustainable sources	

Table 5.5 – SustainableIT Standards Taxonomy metrics for tech sourcing social sustainability (Source: SustainableIT.org)

Further reading

- SustainableIT.org. 2023. *IT Standards for Environmental, Social, and Governance Sustainability*. https://www.sustainableit.org/standards/it-esg-standards.
- United Nations. 2020–2024. B-Tech Project Foundational and Supplemental Papers, The **Office of the High Commissioner for Human Rights (OHCHR)** for implementing the **United Nations Guiding Principles (UNGPs)** on business and human rights in the technology space:
    - *An Introduction to the UN Guiding Principles in the Age of Technology*, September 2020. https://www.ohchr.org/en/documents/tools-and-resources/introduction-un-guiding-principles-age-technology.
    - *Taking Action to Address Human Rights Risks Related to End-Use*, September 2020. https://www.ohchr.org/sites/default/files/Documents/Issues/Business/B-Tech/taking-action-address-human-rights-risks.pdf.
    - *Access to remedy and the technology sector: basic concepts and principles*, January 2021. https://www.ohchr.org/sites/default/files/Documents/Issues/Business/B-Tech/access-to-remedy-concepts-and-principles.pdf.
    - *Access to remedy and the technology sector: understanding the perspectives and needs of affected people and groups*, January 2021. https://www.ohchr.org/en/business/ohchr-accountability-and-remedy-project/phase4-accessibility-dissemination-implementation.
    - *Advancing Responsible Development and Deployment of Generative AI*, November 2023. https://www.ohchr.org/sites/default/files/documents/issues/business/b-tech/advancing-responsible-development-and-deployment-of-GenAI.pdf.
    - *Taxonomy of Human Rights Risks Connected to Generative AI*, November 2023. https://www.ohchr.org/en/documents/tools-and-resources/taxonomy-generative-ai-human-rights-harms-b-tech-gen-ai-project.
    - *UNGPs Compass: Fostering Business Respect for Human Rights in AI Governance and Beyond*, April 2024. https://www.ohchr.org/en/documents/tools-and-resources/ungps-compass-fostering-business-respect-human-rights-ai-governance.
    - *Toolkit for Venture Capital Limited Partners: A Six-Step Framework for Engaging General Partners on Human Rights*. September 2024. https://www.ohchr.org/sites/default/files/documents/issues/business/b-tech/Human-Rights-Toolkit-Venture-Capital-General-Partners.pdf.

- Sonnenberg, S., Lim, Y., Mason, L., Jo, E. S., Choi, S., & Lee, S. (2023). *A Human Rights-Based Approach to AI for Tech Startups and Global Normative Governance*. http://dx.doi.org/10.2139/ssrn.4880112.

Bibliography

- European Commission. 2024. *The EU Artificial Intelligence Act*. https://artificialintelligenceact.eu/.
- Grand View Research. 2024. *IT Asset Disposition Market Summary*. https://tinyurl.com/2s3dsbmb.
- ICTC. 2024. *Building a Sustainable ICT Ecosystem*. https://ictc-ctic.ca/reports/building-a-sustainable-ict-ecosystem.
- IHOPE. 2022. *Access to Assistive Technology for People with Visual Impairment*. https://ihopejournalofophthalmology.com/access-to-assistive-technology-for-people-with-visual-impairment/.
- Internet Society Pulse. 2023. *One-Third of the Global Population Remains Offline*. https://pulse.internetsociety.org/blog/one-third-of-the-global-population-remains-offline.
- ITU. 2024. *Measuring digital development: Facts and Figures 2024*. https://www.itu.int/itu-d/reports/statistics/facts-figures-2024/
- SustainableIT.org. 2023. *Technology Accessibility and Inclusion by Design*. https://members.sustainableit.org/knowledgebank-mfe#/knowledgebank/4/652577a58ba42588484b442b/0 (Access restricted to SustainableIT.org members only).
- SustainableIT.org. 2025. *How Edifecs Integrates Sustainability into Core Business Strategy*. https://members.sustainableit.org/knowledgebank-mfe#/knowledgebank/4/67d44f9fbaaade009d0cd29d/0 (Access restricted to SustainableIT.org members only).
- SustainableIT.org. 2025. *Persona-based Literacy Guide for Sustainable AI*. https://drive.google.com/file/d/1qpEbU9ILbeu6tTYVcFvyr795Ft3PNuHa/view?usp=sharing.
- SustainableIT.org. 2023. *Technology and Accessibility Inclusion by Design*. https://members.sustainableit.org/knowledgebank-mfe#/knowledgebank/4/652577a58ba42588484b442b/1 (Access restricted to SustainableIT.org members only).
- SustainableIT.org. 2024. *Standards Taxonomy V1.2* https://www.sustainableit.org/standards/it-esg-standards?.

- SustainableIT.org. 2024. *SustainableIT Impact Awards 2024*. https://members.sustainableit.org/knowledgebank-mfe#/knowledgebank/4/674e3b098bd76f0a0fb85b4f/1 (Access restricted to SustainableIT.org members only).
- United Nations. 2023. *Leaving No One Behind In An Ageing World*. https://www.un.org/development/desa/dspd/wp-content/uploads/sites/22/2023/01/2023wsr-chapter1-.pdf.
- WC3. 2023. *Introduction to Understanding WCAG 2*. https://www.w3.org/TR/UNDERSTANDING-WCAG20/intro.html
- World Bank Group. 2023. *Digital Progress and Trends Report*. https://openknowledge.worldbank.org/server/api/core/bitstreams/b6125358-fb1c-47bb-a6e7-4896b2152904/content.
- World Health Organization. 2023. *Disability*. https://www.who.int/news-room/fact-sheets/detail/disability-and-health.
- World Health Organization. 2024. *Assistive Technology*. https://www.who.int/news-room/fact-sheets/detail/assistive-technology.

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6

Data Centers and the Cloud

> *If data centers and other digital infrastructure are 100% renewably powered, our increasing reliance on the internet can accelerate our transition to a renewably powered economy. But, if our growing digital infrastructure is built in the opposite direction, locking us into a dramatic increase in the demand for electricity from coal and other dirty sources of energy that are changing our planet's climate, it will be far more costly and take an unnecessarily long time to reach a renewably powered economy.*
>
> *Greenpeace*

The main objective of this chapter is to introduce you to the sustainable digital infrastructure within the data center and cloud realm, its sustainable IT benefits and risks, and how to properly manage both. We start with data centers, including how to measure energy consumption and consider critical factors such as location. A case study example from EcoDataCenter illustrates a net-positive data center ecosystem.

Turning to cloud-hosted environments, we will identify the complexities and gaps in cloud sustainability data. **GreenOps** (short for **Green Operations**) expert Mark Butcher will walk us through the sustainability upsides and challenges of cloud computing, detailing strategies for minimizing the environmental footprint of your cloud-hosted compute while reducing costs at the same time. Mark will share tips on how to evaluate cloud service providers for sustainability, particularly in measuring emissions. This chapter will also touch on the role of third-party tools and services, such as Greenpixie, which provide data services for cloud ecosystems.

More specifically, this chapter will cover the following topics:

- How to measure data center energy and emissions
- Sustainability factors, including location, energy and water consumption, and the impact of AI
- Data center metrics and scorecards
- Roles and accountability in your cloud ecosystem
- Understanding and managing the cloud's Scope 3 complexity
- Maximizing sustainability through cloud lifecycle governance
- Leveraging third-party tooling

From the sustainable IT reference model perspective, in this chapter, we will primarily cover *Sustainability in IT*, zeroing in on IT infrastructure and its environmental footprint and cloud governance.

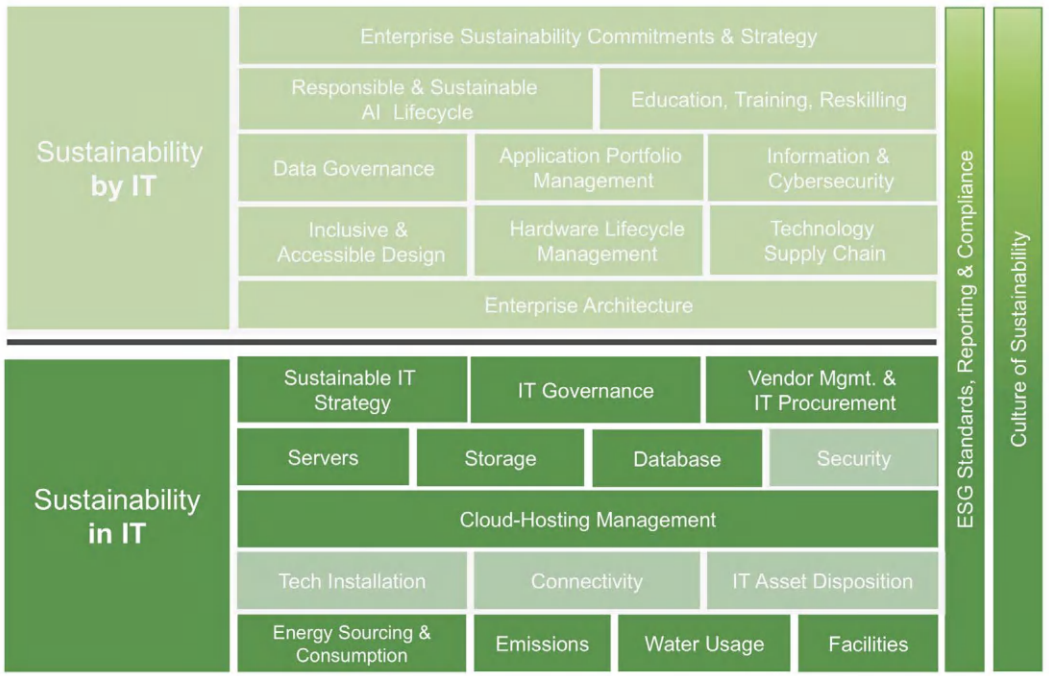


Figure 6.1 – The sustainable IT reference model – Chapter 6 focus

By the end of this chapter, you will have learned about sustainability factors affecting your data center's environmental footprint (including the added demands of AI computing), the steps to minimize it, and the metrics to track progress.

You will better understand cloud computing governance models, including GreenOps, deployment considerations, and cloud service areas of responsibility. You will have gained insight into the complications and shortcomings of cloud emissions reporting and how to compensate with public and third-party tools.

Data centers: The backbone of our connected world

Today, data centers worldwide represent the information backbone of our increasingly digitized world. The forecast is that the global data center market will nearly double in this decade and become a $652 billion industry in 2030, up from $384 billion in 2025 (Grand View Research 2025). Data centers have become crucial to business operations. In particular, the recent pandemic forced many companies to adapt quickly and migrate their on-premises services to the cloud to cater to the demand of an increasingly distributed workforce. In the last two years, there has been a race to close the accelerated gap for digital transformation, and the demand for the cloud, AI deployments, and consequently data has increased exponentially.

Data centers provide computing facilities to large entities, such as online social networks, cloud computing services, online businesses, hospitals, and universities (Brady, et al. 2013). Data centers entail a cluster of interconnected resources through communication links, hosting applications, storing data, and providing other services, such as cloud computing services (Khan, Othman, and Khan 2013). Data centers and network links are the engine room of the digital economy, and they provide the backbone of connectivity and the internet as we know it today.

Data center operations, for obvious reasons, are energy-intensive. To operate efficiently, they need to be regulated to a certain temperature (15–32°C), which requires investment in advanced cooling equipment. In 2024, data centers globally devoured over 400 TWh of electricity, and were predicted to consume 536 TWh in 2025 which roughly accounts for 2% of global consumption (IEA 2025, Deloitte Insights 2024). The tech industry alone accounts for roughly 3 to 9% of the world's electricity consumption, depending on the statistics and models used to calculate it (World Economic Forum 2024, IFRI 2025). Bitcoin alone consumed a staggering 0.5% to mine digital currency (CoinLaw 2025), or 154 TWh based on 30,856 TWh total electricity consumption for 2024 (Ember 2025).

The rising demand for computing power and data storage presents a significant environmental challenge, as roughly 60% of the global energy mix comes from fossil fuels resulting in **carbon dioxide** (CO_2) being released into the atmosphere (IEA 2025). The number of connected devices is expected to reach 41.1 billion by 2030. The data generated is expected to grow fourfold, from 123 zettabytes in 2023 to 394 zettabytes by 2028 (Statista 2024).

As the demand for their services has been rising rapidly, data-intensive technologies such as AI, robotics, autonomous vehicles, and distributed manufacturing systems have increased energy demand in the form of electricity, heating, and cooling. These technologies also require more sophisticated hardware specifications on **graphics processing units (GPUs)** and **central processing units (CPUs)** to do more elaborate computations and image processing. Data centers are a very resource-intensive operation, and the demand keeps surging, so it is critical to set a path toward a sustainable digital infrastructure.

Many organizations rely on older, legacy, and enterprise data centers and equipment for their data storage and processing needs. Unfortunately, this approach presents several sustainability challenges. Legacy data centers and their equipment use more power and generate more heat than modern state-of-the-art data centers that have been built with sustainability in mind from the start. For example, upgrading from a legacy mainframe to a modern server environment can be the path to a lower carbon footprint. It is also important to be mindful of the hardware refresh cycles since up to 80% of carbon emissions are spent during the manufacturing stage. This is usually referred to as embodied carbon and will be covered in detail in *Chapter 9*, *IT Hardware Management*. Most data centers are still primarily powered using fossil fuels. At 24 gigatonnes per year, more than one-third of the global total, the power sector is the single largest source of carbon emissions. Data centers are an organization's second-largest energy consumer, with 40% of this energy taken up by cooling equipment (Deloitte 2024).

Their increasing demand has clear implications for our global energy demand going forward, mainly since most of the energy originates from fossil fuels and accounts for one-third of the total global emissions. As we see clear indications that electricity consumption will keep surging, we as technology leaders have an ethical and moral responsibility to meet this demand by supplying solutions that stem from sustainable IT practices. Continuing to run IT as usual is no longer an option. Let us take a closer look at the main factors that impact the carbon footprint within a data center.

Location

The main factor impacting your data center footprint is the location of your servers due to access to renewable energy. However, with the rapid growth of renewable energy options around the world, this picture is likely to change rapidly in the coming years, although admittedly, not as fast as we need it to. The same algorithm will emit 32 times more CO_2e if the workload is run in India than in Québec (Canada) or Sweden. As illustrated in *Figure 6.2*, where you place your workload and draw your energy from has a massive impact on your carbon intensity.

Carbon intensity of electricity generation expresses **greenhouse gases (GHG)** emitted per unit of generated electricity, measured in grams of CO_2 equivalents per kilowatt-hour. The data shown is for 2023/2024 (Ember 2025).

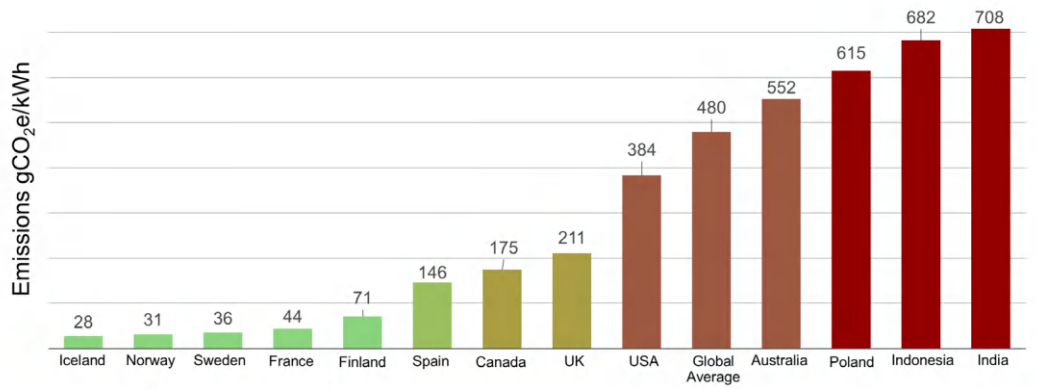


Figure 6.2 – Placement of the workload impacts your CO_2e significantly (2024 data)

Why is that the case, you might wonder? Well, the share of renewable energy sources such as solar, wind, and hydro (water) is available to a higher degree in countries such as Canada, Norway, and Sweden. This does not mean that renewable energy sources are not available in carbon-intensive countries. In the US, there are already several energy grids available where you can get down to as low as 24g CO_2e/kWh (Electricity Maps 2025).

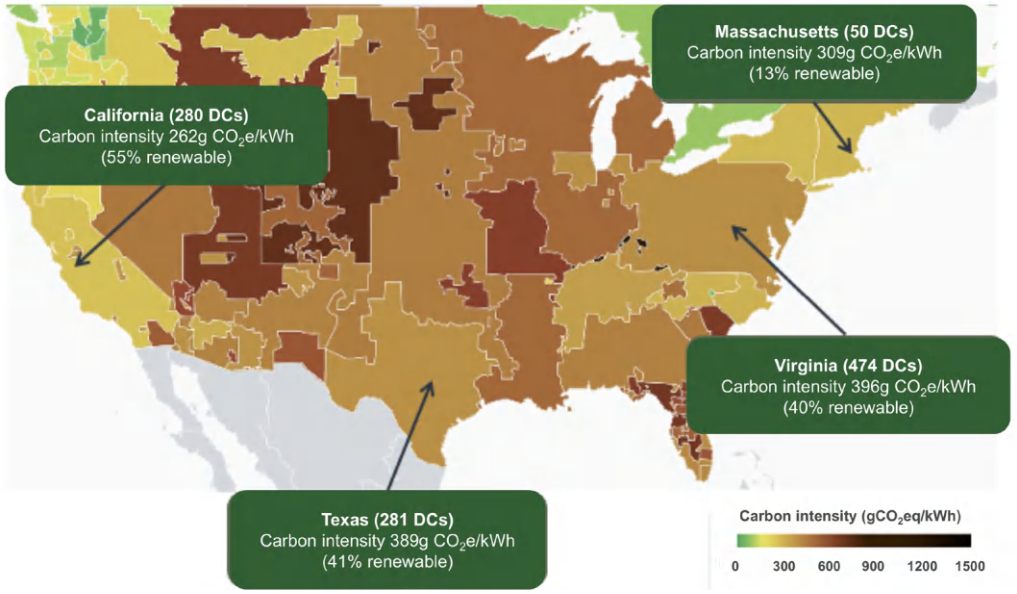


Figure 6.3 – Variations in carbon intensity across the US (source: Electricity Maps)

Also, since the war in Ukraine, the EU has taken decisive steps to end its dependency on Russian gas and has introduced the **REPowerEU plan** (European Commission 2022). The plan is to reduce dependency on fossil fuels and fast-forward the green transition.

Still, you need to choose carefully and put those requirements on your energy providers or cloud vendors to ensure that they deliver their products and services from renewable energy sources. It is critical to send a clear message to the providers about your intentions to fulfil your net-zero commitments. However, building the necessary infrastructure for renewable energy sources takes time and resources. Some of the materials, minerals, and their processing take place in remote countries such as China or Russia. Given the current geopolitical situation, this is likely to affect the ability to scale up renewable sources.



What are your physical power mix and coal intensity?

If you are interested in understanding your physical power mix and your coal intensity in a particular region or country where you run and operate your data centers, visit the **ElectricityMap** (`https://app.electricitymap.org/map`) for more details.

Selecting the best location for your cloud-hosted computing

Although it is not always the case, many cloud providers offer the option to select the location of data centers. This is primarily due to the **Schrems II** decision in July 2020. The **Court of Justice of the European Union** (**CJEU**) declared that the **EU-US Privacy Shield** for personal data was no longer lawful. You can move workflows across cloud regions depending on access to renewable energy consumption and store your data within a specific region or country. This is not just fueled by environmental purposes but mainly due to data privacy concerns and the need to have better visibility and control of what continent or country your data is stored and processed in.

Additional guidance, along with a location decision matrix, is provided next by **Mark Butcher, Director of Posetiv Cloud Ltd**. Mark is based in London and is an expert in GreenOps and cloud sustainability. We will hear much more from Mark later in the chapter regarding sustainability in the cloud.

> Regional variations in grid carbon intensity can be substantial; two data center regions from the same cloud provider may differ by more than 500% in operational carbon impact, depending on the local energy mix. Similarly, water scarcity is highly location-dependent, and placing high-water-use workloads in water-stressed regions compounds environmental risk.

While customers cannot dictate how a provider sources and uses energy or water, they can make informed choices where the provider offers multiple regional options. This requires the following:

- **Access to transparent data**: Few providers publish granular, verifiable data on regional energy mix or water use. Where it is missing, customers should challenge vendors for disclosure or use independent datasets to inform decisions.
- **Integration into workload planning**: Location should be considered during architecture and migration planning, not after deployment. "Lift-and-shift" migrations without location review often lock in higher-carbon, higher-water-impact footprints.
- **Balancing latency, compliance, and sustainability**: In some cases, compliance or performance needs constrain regional choices. Here, the goal is to minimize environmental impact within the available options and to challenge the assumption that a single region must host all workloads.
- **Using external impact models**: Where providers only supply limited information, practitioners can use third-party carbon intensity data (e.g., Ember, ElectricityMaps) and water risk datasets (e.g., WRI Aqueduct) to guide region selection.

The following are examples of regional carbon intensity and water-stress variations:

- **Norway**: 31 gCO_2e/kWh due to nearly 100% hydroelectric generation; low water stress
- **France**: 44 gCO_2e/kWh thanks to nuclear dominance; low water stress in most regions
- **UK**: 211 gCO_2e/kWh; moderate water stress in the South East
- **Singapore**: 499 gCO_2e/kWh, largely fossil-based generation; high water stress
- **Poland**: 615 gCO_2e/kWh due to coal-heavy grid; moderate water stress
- **Texas (USA)**: 355 gCO_2e/kWh with significant fossil generation; increasing drought risk
- **California** (USA): 290 gCO_2e/kWh; severe water scarcity in many regions

The following table is one example of a cloud location selection decision matrix:

Factor	Weight (Example)	Low-Impact Example	High-Impact Example	Practitioner Action
Grid carbon intensity	40%	Norway (31 gCO_2e/kWh)	Poland (615 gCO_2e/kWh)	Prefer low-carbon regions where latency/compliance allows
Water stress	25%	Norway, France	Singapore, California	Avoid water-stressed regions for water-intensive workloads
Latency to users	15%	France (close to EU users)	US regions for EU users	Balance low-carbon choice with acceptable latency
Compliance requirements	10%	Any compliant low-carbon region	Restrictive local-only rules	Engage legal early to explore flexibility in region choice
Cost	10%	Competitive low-carbon regions	High-cost low-carbon regions	Include carbon/water impact in total cost analysis, not just price/unit

Table 6.1 – Decision matrix example for sustainable cloud location

Based on the weightings and factors in this matrix, an IT leader seeking to establish a sustainable data center or cloud-hosting location would prioritize regions with low grid carbon intensity and low water stress, while balancing latency, compliance, and cost considerations. In practice, location-aware planning is most effective when embedded into governance gates for new deployments and major changes. This shifts sustainability from an afterthought to a core part of workload placement strategy.

Mark Butcher, Director, Posetiv Cloud Ltd.

Energy consumption

The second-largest factor contributing to your carbon emissions is the data center's energy consumption. Energy consumption is a closely watched indicator of environmental sustainability.

Primarily, energy consumption within data centers stems from three factors:

- Servers
- Cooling
- Power distribution and **uninterruptible power supply (UPS)**

Memory power draw is a huge source of waste because the energy consumption depends on the memory available, not the actual usage; only requesting the necessary memory is a painless way to reduce GHG emissions.

The **Green Grid organization** has introduced a few key benchmarks, and the most used is **power usage effectiveness (PUE)** (Brady, et al. 2013). PUE can be defined as the total electrical power supplied to the data center divided by the power consumed by IT equipment:

$$PUE = \frac{Total\ facility\ energy}{IT\ equipment\ energy}$$

The lower the value of PUE, the more efficient the data center is. The lowest theoretical number is 1.0, and the closer the PUE is to this number, the smaller the overhead incurred. However, some argue that if the heat can be recovered and used for heating nearby households, a PUE number as close to 1.0 is not crucial since it replaces other energy sources such as coal and gas. Later in the chapter, we will look at a case study from *EcoDataCenter*, which recovers the heat and sends it back out on the grid for district heating. As illustrated in *Figure 6.4*, the average enterprise data center sits around a PUE of 1.56%, which means that 56% is overhead. In an average small data center, the PUE sits at 2.0, which means a staggering 100% overhead will be wasted (Khaliq uz Zaman, et al. January 2019). However, the problem primarily centers around the utilization of the data center and not so much around the energy being spent. Therefore, a data center with a poor PUE could improve its numbers by optimizing the existing workload or adding additional workloads. Utilizing the cloud hyperscalers only generates an overhead of between 1.10 and 1.15 PUE, which means only 10–15% of the energy will go to waste:

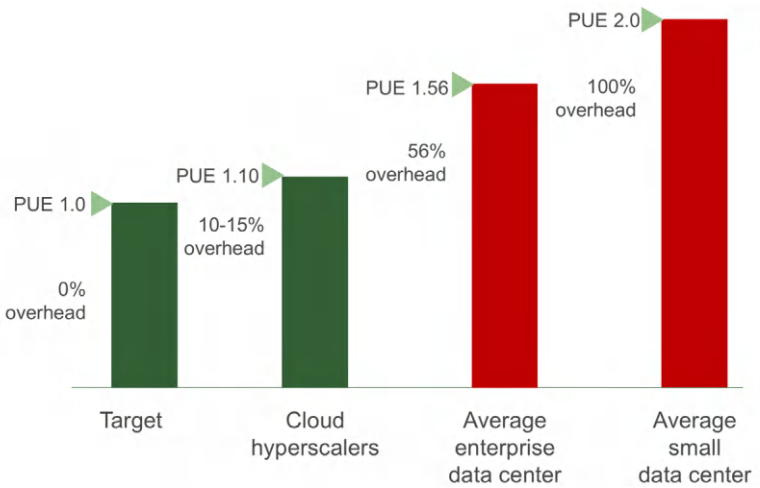


Figure 6.4 – PUE comparison

We are all going to have different starting points. If you are a large global enterprise with thousands of servers, you have probably gone through a consolidation phase several times. Your PUE will probably be around the industry average of 1.56. This means that you still have a significant opportunity for improvement to drive down your PUE closer to 1. The PUE gives us a clear indicator of where we sit on this scale and what actions we can take. In some cases, such as edge data centers, which are small data centers located close to the edge of the network, where latency and portability are more important than economies of scale, a higher PUE than the industry average might be acceptable.

If you are a start-up company, your default option is probably to partner with one of the cloud vendors from day one instead of investing in your infrastructure. Fortunately, this means that your PUE will be low right out of the gate, no matter what cloud vendor you choose; therefore, your PUE should be closer to 1.10. Remember, where you place your workload can still significantly impact your carbon intensity.

Moving to the cloud is not an option for some workloads due to legacy, privacy, security, or legislative reasons. Therefore, you need to work with your existing infrastructure estate to improve the energy overhead. Regardless, it is essential to track your PUE over time to ensure that you make stepwise improvements to reduce your overall overhead.

Water management

Water is now a first-class constraint for digital infrastructure. Cooling is the obvious driver, and AI-optimized facilities are pushing much higher heat densities—making many sites significantly more water-intensive than traditional data centers. Practically, that means water must be planned with the same rigor as energy, managing the "inbound" cooling water and the "outbound" flows (heat, chilled water, and discharge) as part of day-to-day operations. Large data centers can consume up to 5 million gallons per day, equivalent to the water use of a town populated by 10,000 to 50,000 people (EESI 2025).

AI is also creating new water stress as the systems scale. Freshwater demand from AI workloads could reach 1.7 trillion gallons annually by 2027—more than 50 million gallons per hyperscale data center (Hao, Karen 2024). Other analysis of model-training water consumption shows that a single large-model training can evaporate 700,000 liters of fresh water, rising into the 4–6 billion m^3/year range (Pengfei, Li, et al. 2023). These figures elevate water from a compliance metric to a strategic siting and architecture issue for any organization scaling AI.

The race to scale AI is also driving new data center builds. The Guardian reports that Google, Amazon, and Microsoft are operating 38 data centers and developing 24 more in regions of water scarcity and the potential for water deprivation—an increase of 63% (SourceMaterial 2024).

Water scarcity is highly location-dependent; placing high-water-use workloads in water-stressed regions compounds environmental and operational risk. As Mark Butcher recommended earlier in this chapter, use third-party datasets such as WRI Aqueduct (`https://www.wri.org/aqueduct`) during data center region selection and explicitly weight water stress (e.g., 25%) in placement decisions. This will help in avoiding high-stress regions such as Singapore or drought-prone parts of California for water-intensive services when latency/compliance allows. It is also important to be aware of trends. The Water Resources Institute published a projection of water stress levels for 2050, assuming a 2.4– 4.8°C temperature increase through 2100, as shown in *Figure 6.5*. Estimates in 2023 showed 25 countries are experiencing extremely high water stress, meaning they withdraw over 80% of their renewable freshwater resources annually. In 2050, the number rises to 51 of the 164 countries and territories analyzed suffering high to extremely high water stress, which is 31 percent of the population (Statista 2024).

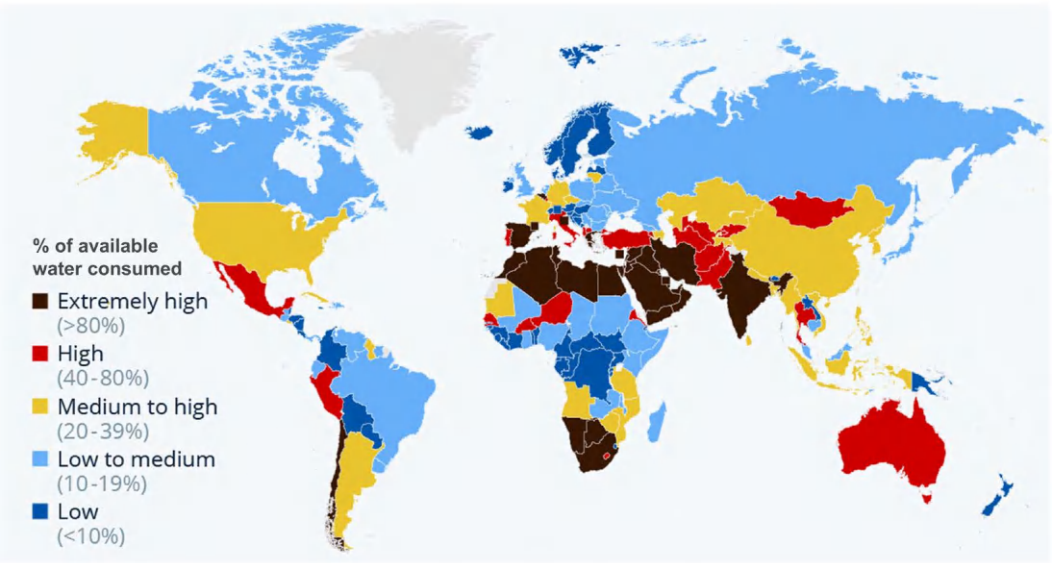


Figure 6.5 – Water stress levels in 2050 (map by Statista 2024)

The **Water Usage Effectiveness (WUE)** metric is a sustainability indicator developed by The Green Grid to measure how efficiently a data center uses water in delivering IT services. It is defined as the annual site water usage divided by the total IT equipment energy consumption **(liters per kilowatt-hour, L/kWh)**. WUE captures water consumed for cooling, humidification, and onsite power generation, helping operators understand trade-offs between energy and water efficiency strategies. For example, evaporative and adiabatic cooling systems can reduce electricity use (improving PUE) but increase water consumption, which WUE makes visible. By tracking WUE alongside PUE, data center operators can balance energy and water impacts to optimize overall environmental performance. In practice, a low WUE indicates better performance (*Table 6.2*):

WUE Range (L/kWh)	Performance Level	Typical Cooling Approach	Comments
≤ 0.2	Good/excellent	Air-cooled chillers, direct/indirect free cooling, closed-loop systems	Minimal or no water used; often seen in hyperscale facilities in cooler climates or where air-side economization is possible
0.3 – 0.6	Average	Evaporative cooling, hybrid cooling towers	Balanced trade-off between energy and water efficiency; common in many modern enterprises and colocation data centers
≥ 1.0	Poor	Traditional open-loop cooling towers, water-intensive evaporative systems	High water dependency; may pose sustainability and operational risks in regions with water stress

Table 6.2 –WUE ranges for data centers

The industry average for data centers is reported to be 1.8 or 1.9 L/kWh (EESI 2025). Among hyperscalers, **Amazon Web Services (AWS)** reports its 2024 WUE to be 0.15 L/kWh globally, a 40% improvement from 2021 (Amazon 2025). Microsoft reported a WUE of 0.30 L/kWh globally in 2024. Among its fully owned and operated data centers, WUEs ranged from 1.52 in Arizona to 0.02 in Singapore and Ireland (Microsoft n.d.). Google's overall water usage for its data centers increased by 28% between 2023 and 2024, reaching 8.1 billion gallons. Google reports that its water stewardship projects replenished 64% of its freshwater consumption in 2024, compared to 18% in 2023 (Google 2025). All three companies have committed to being water-positive by 2030.

Where feasible, data centers should capture wastewater and surplus heat and route them into district heating/cooling or nearby industrial processes to further reduce both water withdrawals and local fossil heating needs (see the next section for an example of this). There are somewhere between 60 and 100 data centers worldwide currently exporting heat to district systems or nearby loads, with the vast majority in Europe (Uptime Institute 2023). Still, this is a tiny minority of the estimated 11,800 data centers in operation worldwide (Statista 2024).

On the technology side, the fastest sustainability wins can come from cooling redesign. Traditional air and chilled-water cooling methods are struggling to keep up with the heat densities generated by high-performance GPUs and AI accelerators, prompting hyperscalers to invest in liquid cooling, direct-to-chip cooling, and immersion cooling technologies. For example, Microsoft has deployed two-phase immersion cooling in production environments, submerging servers in dielectric fluid to enable higher performance with less space and water use. Similarly, Google and Meta have begun adopting cold plate liquid cooling in new AI data centers to reduce fan energy and improve thermal efficiency. These methods can reduce cooling power consumption by up to 30% and drastically lower water usage, especially when paired with heat reuse systems.

Direct research shows that by 2026, 38.5% of data centers will use some form of direct liquid cooling, up from 20% in early 2024 (The Register 2024). As this shift scales, it could meaningfully curb the growth in data center energy and water use—even in the face of AI's rising demands—potentially stabilizing cooling-related emissions by the end of the decade.

Finally, treat water like a governed metric, not a footnote. The chapter's scorecard and SustainableIT taxonomy call for tracking: percentage of water withdrawn from high-stress regions, water intensity (ML per facility m^2 over time), and megaliters discharged by location/destination/treatment level—for both owned and third-party facilities—and aligning disclosure to GRI 303 and ESRS E3. Make these requirements part of sourcing and region selection and review them in the same governance cycles as energy and cost.

Biodiversity impacts

Data centers and cloud infrastructure exert growing pressure on biodiversity and local ecosystems. Siting large facilities often requires extensive land clearing, which can fragment habitats, disrupt species migration patterns, and reduce ecological resilience. In water-stressed regions, withdrawals for cooling can compete directly with freshwater ecosystems, intensifying local biodiversity loss. Construction materials such as concrete, steel, and lithium-based batteries also carry upstream impacts tied to mining and resource extraction, frequently affecting sensitive ecosystems in supplier regions.

Conversely, carefully designed facilities can reduce harm and even create ecological benefits. Design features such as water retention ponds, wildflower meadows, and permeable pavements can help. Siting examples include co-locating data centers with district heating to reduce fossil fuel use, capturing wastewater for reuse in agriculture, or siting facilities on previously degraded industrial land. Embedding biodiversity considerations into site selection, supplier assessments, and impact reporting will help align digital infrastructure growth not only with net-zero goals but also with nature-positive outcomes, consistent with the Kunming–Montreal Global Biodiversity Framework and emerging disclosure standards such as the **Taskforce on Nature-related Financial Disclosures** (**TNFD**).

France's CDC Biodiversité, as part of the **Global Biodiversity Score** (**GBS**) methodology, developed a way to calculate a biodiversity footprint. **Mean species abundance** (**MSA**) measures the impact of a data center on local species. It reflects the average abundance of species in an area compared to their abundance in an undisturbed ecosystem. The unit of measure is **abundance score per square kilometer**, or **MSA/km²** (Open Compute Project 2024).

It's important to realize that biodiversity impacts are far more material upstream from data center construction and utilization—as much as 95% of impact, according to estimates by Arup (Arup 2025). Therefore, the most effective biodiversity stewardship will be integrated into cloud and SaaS selection and hardware selection, refresh cycles, and circularity programs.

Case study: Net-positive data centers

As we set a high and ambitious goal toward a net-zero future, some companies are taking an even bolder stance and setting a net-positive ambition for their data center business, including companies such as **Equinix**, **atNorth**, **EcoDataCenter**, and **Bahnhof** from data center infrastructure providers such as **Schneider Electric** and **Alfa Laval**. Together with utility providers such as **Stockholm Exergi**, **Vattenfall**, and other utility providers, excess heat and wastewater are captured from data centers and pushed back to the utility provider, who can then pass it on to the district heating network for heating residential, commercial, and industrial facilities, creating a net-positive equation. Let us take a closer look at the Swedish data center provider EcoDataCenter, which has paired up with the municipality of Falun and the **Falun district heating and cooling** supplier to create a net-favorable ecosystem:

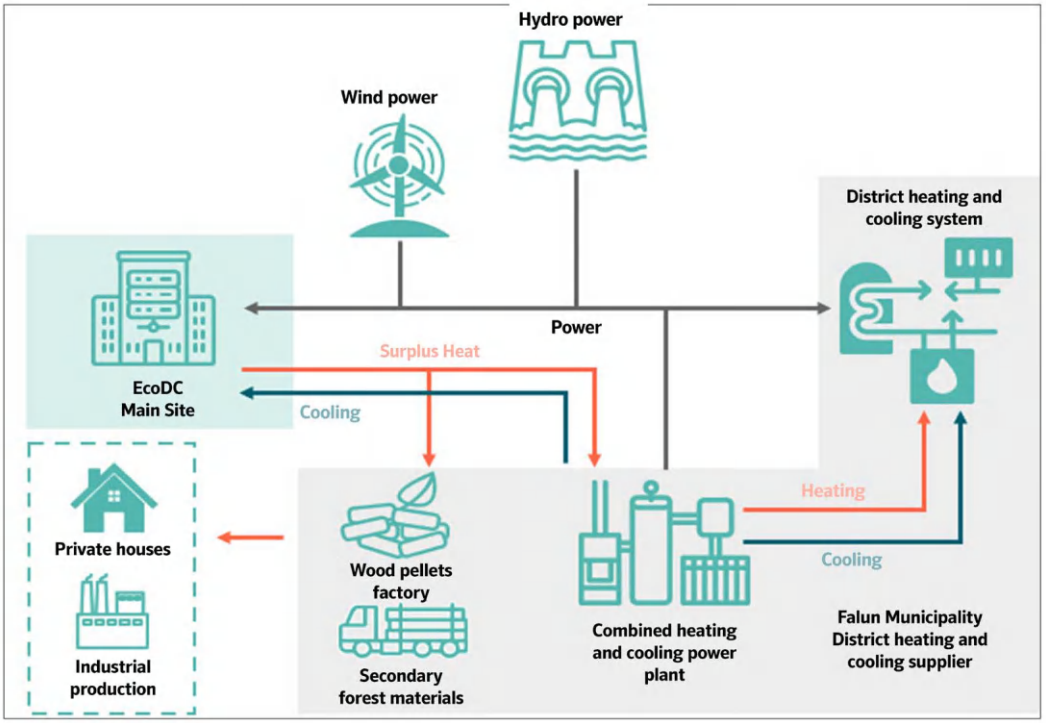


Figure 6.6 – The EcoDataCenter ecosystem with Falun municipality district heating and cooling (image courtesy of EcoDataCenter)

The data center has been placed strategically adjacent to the district heating and cooling system facilities and a wood pellet factory to create a net-positive ecosystem. A similar premium location would be in a more densely populated area where the excess heat could be captured and funneled into the district heating network for heating. EcoDataCenter has expanded the campus—building 1C was commissioned in 2024, and 1D is being commissioned in 2025. The data centers are built with the following critical design principles:

- The construction of data centers should be built sustainably from land, design, materials, construction, connectivity, technology installations, and lifecycle management, including end-of-life circular practices.
- The data centers should be powered with 100% renewable energy.
- There should be a responsible use of resources by capturing surplus heat and water.

- Captured surplus heat should be fed back to the heating and cooling plant to be redistributed to private houses or industrial production or be used to power the nearby wood pellet factory. For existing data centers, it is unfortunately not that simple to rearchitect a building to be able to funnel back excess heat through additional piping. Also, depending on the location, the data center needs to be in a densely populated area for it to make sense to capture the excess heat and redistribute it into the district heating network. In Boden, in the northern part of Sweden, where the population density is scarce, they built a giant 300-square-meter greenhouse to increase food production from crops in the north by leveraging excess heat from local data centers (Boden Business Park 2023).

So, how can this ecosystem be net-positive, you might ask? Let us look at EcoDataCenter's emission flow and the numbers behind it that encapsulate the entire lifecycle:

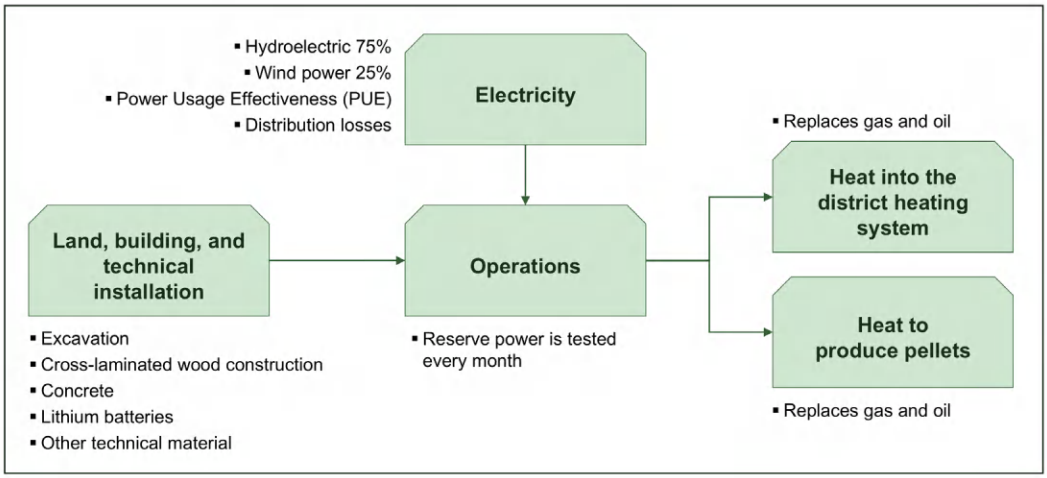


Figure 6.7 – EcoDataCenter's emissions flow

Let us briefly discuss each point:

- **Land, building, and technical installation**: Let us start from the left-hand side with the construction of the data center. In EcoDataCenter's calculations, everything is accounted for in their CO_2 emission calculation by seeking out land, excavation, building materials such as cross-laminated wood, concrete, lithium batteries for backup, and other technical materials.

- **Electricity**: Once the data center is operational, EcoDataCenter's data centers are powered by renewable energy sources with a grid mix of 75% hydroelectric and 25% wind power. PUE is monitored continuously to ensure the effective use of the energy overhead. Since the surplus heat is captured, having as low a PUE as possible is not necessarily an absolute target since downstream actors are dependent on the excess heat.
- **Operations**: Operations are responsible for running the data center to ensure an optimal grid mix of renewable energy. There is monthly testing of reserve power generators to ensure business continuity in a grid failure. They ensure that the inbound flow of energy and cooling and the outbound flow of surplus heat and cooling are optimal. Reserve power consists of diesel generators, which are part of the overall calculation.
- **Downstream actors**: The surplus heat is fed back to either the district heating and cooling system or the nearby wood pellet factory. The surplus heat is fed back into the district heating system and pushed out to the grid to private houses or industrial production. If the grid is saturated, the surplus heat is fed into the wood pellet factory to power the production of wood pellets. Capturing the excess heat significantly reduces the cost of electricity since it can be regenerated and resold for a second use, avoiding fossil fuels such as oil and gas.

Now that we have walked through each of the different actors, let us look at how this translates into numbers and how they play out between scopes 1, 2, 3, and 4. *Table 6.3* illustrates the CO_2 equivalent calculation per kilowatt-hour consumed. This includes all phases of the data center lifecycle:

Emissions per kWh	**Greenhouse Gas (GHG) Protocol**			**Total**	**Avoided Emissions**	**Total**
Scope	1	2	3		4	
Land	-	-	0	0	-	0
Building	-	-	0.1	0.1	-	0.1
Tech installation	-	-	1.1	1.1	-	1.1
Operations	1.3	-	0.9	2.2	-	2.2
Power	-	10.5	0	10.5	-	10.5
Heat reusage	1.7	-	-	1.7	-48.9	-47.2
Total	**3.0**	**10.5**	**2.1**	**15.6**	**-48.9**	**-33.3**

Table 6.3 – The CO_2 equivalent calculation

In the preceding table, only **Operations** and **Heat reusage** fall under scope 1. The electricity used to power the data center falls under scope 2, and land, building, technology installations, and third-party operations fall under scope 3. The building is made from wood instead of concrete and cement, which also results in a low emission value for the building itself.

These categories sum up to a CO_2 emission of 15.6 grams per kilowatt-hour. In Sweden, 1 kilowatt hour amounts to 27 grams of CO_2 emissions. So, in this case, our emissions are close to half of the average. So, where does the net-positive effect come in? It comes in under scope 4, which is best known as avoided emissions. Scope 4 is not formally part of the GHG Protocol, but it is under review. Since the surplus heat is fed back to the power grid and reused to power private houses, industrial production, and the wood pellet factory, using coal and gas for heating is not needed, resulting in avoided emissions.

This methodology has been audited by **Carbon 3 IT Ltd**, a UK-based sustainable IT consultancy firm.

So, what can we learn from this example? Achieving net-positive from your data center and cloud operations requires forward-looking and meticulous planning. It begins long before you start construction on your data center to ensure that the inbound and outbound flow of scarce resources, such as energy and water, has been carefully planned. It is possible to retrofit an existing data center to capture surplus heat and cooling, but it might be very costly.

As mentioned earlier, there are other data center providers that leverage the same technique to capture excess heating and feed it back to the district heating network. As of 2025, all major hyperscalers (Google, Microsoft, Meta, and AWS) have launched or are expanding heat reuse projects in Europe, joining colocation providers such as Equinix and Digital Realty. While not yet universal, heat reuse is now a public commitment and operational reality for hyperscalers in suitable regions, marking a significant shift from earlier years. They primarily focus on optimizing energy and water use for cooling and ensuring access to renewable energy.

Data center sustainability scorecard and standard metrics

Finally, as we have gone through the different levers you can use to reduce your carbon intensity, let us look at how we can summarize these critical metrics in a data center sustainability scorecard:

Description	Metric	General Requirement	United Nations Sustainable Development Goals Alignment
Energy Consumption	GWh $MtCO_2e$	CUE Carbon Usage Effectiveness	7. Affordable & Clean Energy 13. Climate Action
Renewable Energy	%	REF Renewable Energy Factor	7. Affordable & Clean Energy 9. Industry, Innovation & Infrastructure 12. Responsible Consumption & Production
Power Usage Effectiveness	PUE	PUE Power Usage Effectiveness	12. Responsible Consumption & Production 13. Climate Action
Sustainable Water	WUE	WUE Water Usage Effectiveness	6. Clean Water & Sanitation
Waste Management	Tonne %	ERF - EDE Energy Reuse Factor Electronics Disposal Efficiency Reduce – Reuse - Recycle	12. Responsible Consumption & Production
Biodiversity	MSA/km^2	DC site biodiversity analysis	14. Life Below Water 15. Life on Land

Table 6.4 – A data center sustainability scorecard

You should be aware of five key areas and six critical KPIs for managing your energy, water, and waste. These standardized KPIs are ISO certified (ISO/IEC 30134 2027/8 EN 506001-3). The right-hand side of the preceding figure also highlights how each key area is connected to the United Nations' 17 **Sustainable Development Goals (SDGs)**. This will enable you to track and follow up on your progress toward a sustainable IT practice. These are the essential requirements you should also put on your IT service provider or cloud provider to disclose.

Up to this point in the chapter, we have largely explored on-premises data center sustainability as a direct responsibility of the internal IT function. But as we know, most companies (unless in highly regulated industries) are moving away from owned data center assets to cloud-hosted or co-located arrangements. For the balance of this chapter, we will focus on cloud-hosted computing.

Sustainability in the cloud

The sustainability landscape of cloud and data center infrastructure has undergone a shift in the past few years. While the original premise—that migrating from on-site data centers to the public cloud can reduce energy consumption and carbon emissions—still holds true in many respects, the context has grown more complex, particularly due to the explosive rise of GenAI workloads and the corresponding infrastructure boom among hyperscale cloud providers.

The conventional wisdom is that you will reap the following sustainability advantages through the actions and capabilities of your cloud providers:

- Reduction in IT's carbon footprint
- Access to renewable energy sources and low-carbon grids
- Proactive AI-enabled monitoring to improve efficiency and reduce emissions through predictive and prescriptive maintenance
- Reduction in e-waste through responsible lifecycle management of data center hardware equipment, such as servers, storage, routers, and switches
- Higher utilization of **carbon-free energy** (**CFE**) and other asset utilization

But the focus on sustainable cloud operations has taken a back seat in the race to scale AI infrastructure. Hyperscalers are rapidly building AI-optimized data centers equipped with power-hungry GPU clusters to meet surging enterprise and consumer demand. These AI-specific data centers, while more compute-efficient per workload, are significantly more energy and water-intensive overall. The **International Energy Agency** (**IEA**) estimates that after globally consuming 460 **terawatt-hours** (**TWh**) in 2022, data centers' total electricity consumption could more than double to 1,000 TWh in 2026 (IEA 2024). Furthermore, cooling requirements are intensifying. A 2024 study by Deloitte emphasized that hyperscalers are actively seeking more sustainable, lower-water cooling solutions in response to criticism that their AI data centers are depleting local water resources and contributing to grid instability in high-demand regions (Deloitte 2024). As noted earlier in the chapter, AI-driven workloads could push freshwater demand to 1.7 trillion gallons by 2027—equivalent to over 50 million gallons per hyperscale data center.

In 2024, Google acknowledged its total GHG emissions increased by 13% year-over-year, citing the growth of its AI operations, and stated it would likely not meet its 2030 net-zero target (Google Environmental Report 2024). Microsoft emissions rose by about 30% since 2020, (Trellis 2024), which industry observers say is mainly due to emissions from data center construction and energy use associated with AI training workloads.

Despite these challenges to hyperscaler sustainability, IT's global transition from on-premises data centers to the public cloud continues to accelerate. According to Gartner (Gartner 2024), public cloud spending is expected to increase by 21.5% in 2025, reaching $723.4 billion. Before exploring sustainability strategy and governance of your cloud compute, it is essential to understand the different actors and who is responsible for your impact as a cloud customer. *Figure 6.8* highlights the areas of responsibility within hybrid cloud services:

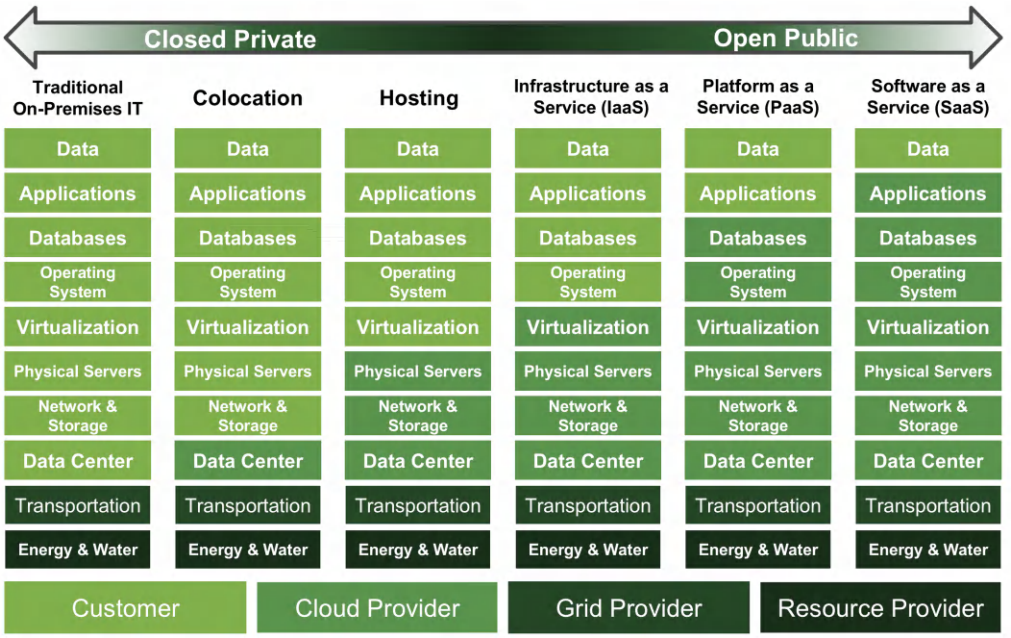


Figure 6.8 – Areas of responsibility within cloud services

There are four primary actors: the **customer**, **data center and cloud provider**, **utility provider**, and **resource provider**. On the left-hand side, we have the traditional on-premises delivery model in a private cloud, utilized and managed by only one organization. The more you move to the right-hand side, the more you share resources with other organizations, and the cloud provider takes on more and more responsibility. In a traditional model, the customer is essentially responsible for everything from energy and water resource providers to the data on top of the stack. In the SaaS model, the customer is only responsible for the data. The cloud provider is responsible for selecting the resource providers, along with the data center setup, all the way up to the application layer. Because of regulatory requirements such as the **General Data Protection Regulation (GDPR)** within the EU, managing your data gathering, profiling, harvesting, and analytics is critical from a data privacy and data security perspective. A data breach can have massive consequences both from a financial and reputational perspective.

We will now look at the complexities of cloud carbon metrics, an area that IT leaders consistently cite as one of their top challenges and frustrations in advancing sustainability in IT.

Measuring cloud-provider emissions

IT leaders need access to accurate data on their cloud-hosted compute, including the vendor's Scope 2 and 3 emissions, because this information is central to understanding the true carbon footprint of their digital operations. Scope 2 emissions—those from the electricity used to power cloud data centers—directly influence an organization's reported IT energy impact, while Scope 3 emissions from upstream activities such as hardware manufacturing, infrastructure supply chains, and downstream customer use often represent the majority of total cloud-related emissions. Without this transparency, IT executives cannot fully account for their share of emissions in ESG disclosures, nor can they make informed choices about workload placement, vendor selection, or cloud optimization strategies that align with corporate sustainability goals.

Under the EU's CSRD/ESRS E1, companies must disclose gross Scope 2 emissions and material Scope 3 by category. These requirements necessitate that enterprises obtain their cloud providers' electricity mix, REC/PPAs, and upstream hardware and data center impacts. In the US, California's SB 253 (Climate Corporate Data Accountability Act) compels large companies doing business in the state to publicly report Scopes 1, 2, and 3 with third-party assurance beginning with 2026 filings (Scope 3 reporting on 2026 data begins in 2027). Again, this requires cloud vendor emissions data and methodologies

All three of the most dominant cloud hyperscalers—**AWS**, **Microsoft Azure**, and **Google**—provide a solution to understand carbon emissions and tools or recommendations to reduce your carbon footprint. However, their respective methodologies in terms of GHG scope completeness, calculation approach, and coverage of services differ significantly, which frustrates comparability. The following table, based on public sources, describes the carbon accounting methods and tools available from the three cloud hyperscalers (see *Further reading* at the end of the chapter for links to the tools):

	AWS	**Microsoft Azure**	**Google Cloud Platform**
Carbon neutrality goals	AWS is matching 100% of global electricity use with renewables (2023) and targets net-zero carbon by 2040.	Azure is carbon-neutral and aims for 100% renewable energy by 2025 and carbon-negative by 2030.	GCP is carbon-neutral today and aims to run on CFE by 2030.

Reporting tool	The **Customer Carbon Footprint Tool (CCFT)**, generally available via the AWS Billing & Cost Management Console.	Emissions Impact Dashboard for Azure (Power BI app), generally available for Azure and Microsoft 365.	Carbon Footprint tool, public preview, accessible in-console with exports to BigQuery/Sheets.
Methodology and coverage	CCFT v2 includes Scopes 1 and 2 (GHG Protocol, ISO 14064) and models emissions for full AWS services—Scope 3 coming in the future.	Covers Scopes 1, 2, and 3 using a methodology validated by Stanford (2018). Available via Power BI; historical data automatically recalculated.	Based on GHG Protocol; covers Scopes 1 and 2 (location-based and market-based electricity), and selected Scope 3 (embodied emissions of equipment/buildings, T&D losses, fuel extraction/transport).
Insights and exports	Provides region- and service-level emission breakdowns, trend analysis, on-premises versus AWS savings, forecasted emissions, and exports via S3/BI dashboards.	Offers tracking of actual versus avoided emissions, Azure portal "Carbon Optimization" insights with filters by subscription/resource group/emission type.	Provides dashboards for monthly emissions trends with breakdowns by account, project, region, and product/SKU. Shows location- and market-based Scope 2.
Granularity and frequency	Per AWS Region and service; updated monthly with up to ~three months delay.	Granularity by subscription, resource group, and so on; Power BI refresh frequency depends on your setup, historical data included.	Granular by billing account, project, region, product; both market- and location-based, updated with ~21-day delay; energy use measured at machine level; Scope 2 location-based calculated hourly.
Cost	Free to access, data exports likely incur usage costs (e.g., S3, Athena, QuickSight).	Free to use, but Power BI Pro license required (trial available).	Free to use; BigQuery export may incur fees depending on usage.

Table 6.5 – Cloud provider carbon footprint tool comparison

It is essential to have a holistic view of your landscape as a company, but with limited integration capabilities between the vendor offerings, you will need to assemble that view yourself using third-party tools. The most well-known open source option, **Cloud Carbon Footprint** (`http://www.cloudcarbonfootprint.org/`), provides capabilities to measure, monitor, and reduce your cloud carbon emissions. First published in 2019 by Thoughtworks, it uses cloud billing and usage data to translate compute, storage, and networking consumption into energy demand, then applies regional grid carbon intensity factors to estimate CO_2e.

The advantages are as follows:

- **Transparency and open source**: The tool and methodology are open source, allowing scrutiny and customization by enterprises
- **Cross-cloud comparability**: Provides a consistent approach across major providers, even before all vendors had customer-facing carbon tools
- **Granularity**: Uses workload-level data (e.g., VM size, instance hours) to provide detailed breakdowns

The disadvantages are as follows:

- **Estimation, not measurement**: Relies on generalized assumptions (e.g., server utilization, power usage effectiveness, embodied emissions), which may not reflect the provider's actual efficiency data
- **Lagging precision versus vendor tools**: Hyperscalers now provide measured or modeled carbon data using internal telemetry, which tends to be more accurate than external estimates
- **Scope 3 coverage**: Limited—mostly Scope 2 with some modeled Scope 3; does not comprehensively include upstream/downstream lifecycle emissions

Other public methods for estimating cloud emissions include the following:

- **GHG Protocol ICT Sector Guidance** (in development, used as reference by hyperscalers): `https://ghgprotocol.org/sites/default/files/2023-03/GHGP-ICTSG%20-%20ALL%20Chapters.pdf`
- **International Telecommunication Union (ITU) standards** (e.g., ITU-T L.1410 and L.1470 for ICT lifecycle and net-zero pathways): `https://www.itu.int/rec/T-REC-L.1410/en`; `https://www.itu.int/rec/T-REC-L.1470/en`
- **Life Cycle Assessment (LCA) databases** (e.g., ecoinvent, IEA factors) for embodied and grid emissions: `https://ecoinvent.org`; `https://www.iea.org/data-and-statistics`

Third-party paid tools and services have also entered the market in recent years to meet the needs of IT sustainability managers, particularly around Scope 3 reporting, including cloud compute. One such organization is Greenpixie, founded in 2021 and based in London. Their **Head of GreenOps**, **James Hall**, provides a deeper dive into the inherent complexities of cloud Scope 3 and how to overcome these challenges:

The complexities of cloud Scope 3

Scope 3 in the cloud is broad, opaque, and structurally fragmented. Cloud providers often report their own Scope 3 emissions in aggregate, but they rarely pass that data through to customers. Why? The reason lies in the nature of cloud itself: ephemeral, pooled, and abstracted. To offer accurate customer-level Scope 3 estimates, a provider would need to disclose granular details about the physical servers underpinning workloads—the chipsets, power draw, cooling systems, and refresh cycles. This data is deeply sensitive, as it exposes not only infrastructure strategy but potentially pricing margins and efficiency differentials.

The further upstream you go in emissions modeling, the harder it becomes to link those numbers to decisions practitioners can actually take. A DevOps engineer or FinOps analyst trying to optimize a running workload won't know what to do with the upstream aggregate data typically available from hyperscalers. The data feels abstract, unconnected to action. And yet, making no effort to include Scope 3 leads to a carbon blind spot of significant proportion. That's why third-party tooling exists—not to replace cloud dashboards, but to fill in their blind spots with transparency, consistency, and actionability.

Organizations with multi-cloud environments must reconcile different data sources. When carbon data from different cloud providers is based on divergent scopes, assumptions, and accounting rules, comparing footprints becomes an "apples to oranges" exercise. One report might include embodied carbon, while another omits it entirely. Some clouds include Scope 3 upstream emissions; others do not. This lack of standardization frustrates sustainability teams and creates inconsistencies that undermine both benchmarking and internal reporting. What's needed is a comparability layer—either through a standard framework or through third-party platforms that apply a consistent methodology across providers. Without this, multi-cloud sustainability is held back by incompatible truths.

Another challenge lies in location data. While cloud providers disclose the region name in billing metadata, most carbon intensity datasets only provide data at the national level. So, even if a customer knows their workload runs in "UK South," they can't accurately map that to a local carbon factor. This matters because the carbon intensity of electricity can vary significantly even within a country. Ireland, for example, has a grid carbon intensity that's nearly twice as high as London's.

Even if you could get that data, it still wouldn't tell you what proportion of energy comes from on-site renewables. Providers default to market-based accounting—claiming 100% renewable coverage by purchasing PPAs and RECs, rather than sharing real-time grid mix data. There's also a strategic reason behind this opacity. If cloud providers openly disclosed that, say, Sweden has 10 times lower carbon intensity than Frankfurt, customers might rush to migrate. That would overload certain regions and underutilize others—undermining the careful economics of infrastructure distribution.

So, we're left in a strange place. The best data sits inside the hyperscalers, but they won't share it. And the public data we do have doesn't match the resolution needed for real optimization. That's why third-party tools are essential—not just for modeling, but for bridging the mismatch between what customers want to optimize and what providers are willing to disclose.

Estimating embodied carbon in the public cloud

Embodied carbon is often ignored in cloud discussions—not because it's unimportant but because it's hard. Think of it as the Scope 3 of your Scope 3: emissions from the manufacturing, transport, and disposal of the servers you're renting, not owning.

The public cloud makes this incredibly difficult. You're renting slivers of infrastructure, not full machines. To apportion embodied emissions accurately, you'd need access to **product carbon footprints (PCFs)** or LCAs for each physical server family. And you'd need to know which hardware your workload actually uses.

That's information the providers won't give you. It's commercially sensitive—exposing chip selection, lifecycle, and potentially even margins. So, what's the result? Embodied emissions go uncounted in most customer-facing dashboards.

And yet, that doesn't mean you can't start. For IaaS workloads, provider documentation often reveals the chip family—Intel, AMD, or Graviton. That can be matched to public studies on average server manufacturing emissions. It's not perfect, but it's a beginning.

At Greenpixie, we refer to this as shared embodied carbon: the upstream emissions from physical infrastructure, amortized across thousands of virtual workloads. Even an approximate estimate—clearly framed with assumptions—is better than omission. Because leaving embodied carbon out doesn't make it go away. It just hides a huge chunk of the real impact.

When cost and carbon diverge

One of the strengths of the cloud is that cost and usage are intrinsically linked. You pay per GB stored, per compute-hour consumed. So, in many cases, reducing waste lowers both cost and carbon. It's a useful overlap—at least at first.

But as soon as you dive deeper, divergences emerge. Not all compute hours are equal. A VM running on an Intel chip might emit more carbon than one on an ARM-based Graviton, even if the price can be similar. In some cases, cloud providers will even steer customers toward cheaper but less energy-efficient chips through pricing structures or reservations. That's where cost becomes a misleading proxy for carbon. RIs or savings plans can reduce costs without reducing usage. You can appear to be optimizing financially while your emissions stay flat—or even rise, as shown:

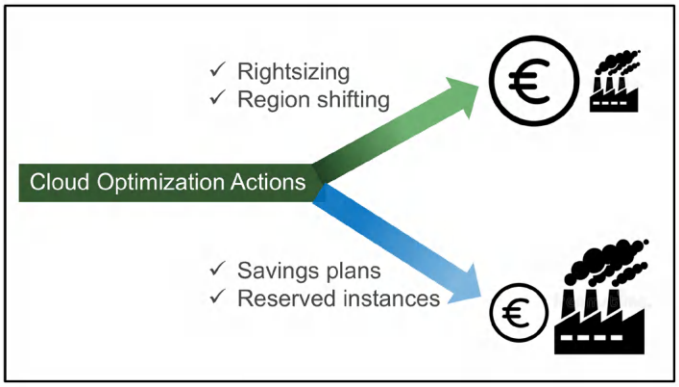


Figure 6.9 – Cloud optimization can lead to diverging costs and carbon levels

Carbon-aware actions such as region shifting or rightsizing may not deliver cost savings, especially when greener regions are more expensive. That's why carbon needs its own optimization metrics. Think grams of CO_2e per dollar, or CO_2e delta per action. The cost-optimal decision isn't always the climate-optimal one—and you need to see both.

Using carbon in cloud unit economics

We advocate strongly for treating carbon as a currency—not just because it sharpens decisions, but because it aligns with how financial leaders think. Finance teams aim to uncover their unit economics: cost per user, margin per product, and revenue per transaction. These KPIs guide resource allocation, highlight inefficiencies, and track improvements even when top-line metrics grow. Sustainability data should enable this.



You don't need to show that your emissions are going down overall—sometimes they won't. But you should be able to show that per customer, per dollar, or per VM-hour, your operations are becoming more efficient.

To do that, carbon data must match cost data in its granularity and trustworthiness. That means per-resource, hourly, or mapped to business units or product lines. That's what enables meaningful trendlines and carbon-aware KPIs. The FinOps Foundation's standard KPI set for cloud sustainability is a good starting point—and I was proud to help develop it—but what we need next are the metrics that enable action, not just measurement.

Architecting your cloud is like architecting a building. A hundred years ago, buildings weren't held to today's standards of insulation, ventilation, or efficiency. Now, those outdated buildings are being retrofitted—or demolished—at enormous cost. Cloud infrastructure will be the same. Just because it's virtual, doesn't mean it's exempt from physical constraints. It consumes real electricity. It runs on real hardware. And its architecture will shape your carbon legacy for decades.

The cloud has a shared responsibility model. The provider builds the infrastructure. But you decide how to use it. That's your Scope 3. That's your carbon accountability. You can either address it now—while the tools are available and the incentives are rising—or wait until energy constraints, regulation, or reputation force you to act under pressure.

James Hall, Head of GreenOps, Greenpixie

Getting a solid handle on your cloud carbon metrics is a significant achievement in the quest for IT carbon footprint accuracy and transparency. However, it is only one aspect of cloud sustainability governance. Achieving the full potential of the cloud's environmental benefits requires holistic lifecycle governance of your cloud estate and relentless vendor management. We asked **Mark Butcher**, **director of Posetiv Cloud Ltd.** in London, an expert in GreenOps and cloud sustainability, to share his guidance for ensuring the most sustainable outcomes in the cloud.

Maximizing cloud sustainability through lifecycle governance

The environmental outcome of a migration to the cloud depends on multiple variables: workload design, usage patterns, chosen regions, and the degree to which provider efficiency gains outweigh the additional demand that cloud often encourages. Poorly planned migrations can increase emissions, particularly when "lift-and-shift" approaches carry forward inefficient architectures or lead to over-provisioning in the new environment.

Sustainability gains are far more likely when migration is used as an opportunity to do the following:

- Rationalize and modernize applications before moving them, removing obsolete services, and reducing total footprint
- Rearchitect for the cloud, taking advantage of elasticity, serverless computing, and other technologies that support efficient consumption
- Right-size and clean up before migration so unused capacity and redundant data aren't moved unnecessarily
- Embed autoscaling and consumption-based patterns into the architecture to prevent idle resources from running post-migration

Under the GHG Protocol, emissions from public cloud use are always reported as Scope 3, typically within Category 1 (*Purchased goods and services*). This means operational control over metrics such as PUE, WUE, CUE, and REF remains with the provider.

Cloud users cannot directly change how a data center is run, but they can influence outcomes by doing the following:

- Selecting providers and regions with demonstrably lower carbon intensity and water impact, based on disclosed metrics
- Using location-based grid carbon intensity data to compare potential hosting locations
- Including sustainability criteria in procurement scoring and contract negotiations, focusing not just on the sustainability of the provider as an entity but, more importantly, on the sustainability-related services they offer, the data they can/will report, and the methodology they use to provide this data
- Requesting greater transparency from providers and factoring their willingness to share detailed metrics into sourcing decisions

Where providers disclose relevant data and metrics, these should be incorporated into workload placement modeling. In practice, this data is often incomplete or aggregated, so modeling may require supplementing disclosures with independent grid carbon data and water scarcity information. The goal is to make the most informed choice possible at the point of migration, recognizing that selection and influence, not direct operational control, are the levers available to customers.

Full-service lifecycle approach

Most cloud sustainability programs focus heavily on optimization, that is, improving efficiency after workloads are already running. While this can deliver measurable savings in both cost and emissions, it often addresses symptoms rather than causes. By the time a workload reaches production, many of the most consequential decisions affecting its environmental footprint have already been made.

A stronger approach and a common theme in this chapter is to "shift left": embedding sustainability into the earliest stages of service design and procurement, ensuring waste is avoided rather than mitigated. This demands a full-life-cycle perspective that connects technology decisions with cultural accountability, governance standards, and procurement behaviors.

The full-life-cycle perspective links technology decisions to cultural accountability, governance standards, and procurement behavior. In a mature GreenOps approach, this requires a clearly defined operating model that links lifecycle stages to specific owners, data inputs, and measurable outputs. This means integrating FinOps, TBM, ITAM, ITOM, and procurement so that sustainability signals are visible and acted upon in the same governance cycles that already manage spend, risk, and compliance.

Sustainability should be woven into each phase of the service lifecycle. This is not about bolting on reporting at the end, but instead making environmental impact a key decision criterion. Across the lifecycle, sustainability must be recognized as a **non-functional requirement (NFR)** on par with performance, security, and compliance. This means it should be present at every decision point, from ideation and design to procurement, build, operations, and end-of-life, and owned at the appropriate leadership level, not delegated away as a delivery detail. *Table 6.6* links lifecycle stages to key sustainability actions, with owners and risk anti-patterns.

Lifecycle Stage	Key Sustainability Actions	Ownership & Governance	Common Risks/Anti-Patterns
Ideation & Business Case	Assess whether the service is needed; explore reusing or extending existing platforms; include environmental impact in business case approval.	Product owner, business sponsor, enterprise architecture (EA) review board.	Building new services when an existing capability could be reused; ignoring environmental cost in ROI models.
Design & Architecture	Apply sustainability design principles; avoid over-replication of data; model workload placement with location-based carbon intensity data; plan for elastic scaling.	Architecture teams, cloud governance board.	Over-engineering for edge cases; choosing high-carbon regions for latency gains that don't materially impact users.
Development & Build	Optimize code and queries; size container and VM requests appropriately; select service tiers based on real needs.	Development leads, DevOps, FinOps.	Defaulting to oversized resources; relying on "we'll optimize later" thinking.
Testing & Deployment	Limit non-production environment sprawl; schedule auto-shutdown for idle systems; share test environments where possible.	QA leads, DevOps, platform team.	Persistent idle test environments; unmanaged snapshots.
Operations	Monitor carbon and cost data together; automate right-sizing and scaling; review resource usage regularly.	Operations leads, GreenOps function, FinOps.	Excessive alerts lead to ignored inefficiencies; siloed sustainability and cost management. Limits optimization.
End-of-life	Actively decommission unused workloads; archive or delete data efficiently; ensure asset recovery aligns with circular economy principles.	Service owner, operations, ITAM/ITAD.	Orphaned resources; keeping stale workloads "just in case."

Table 6.6 – Cloud workload lifecycle sustainability actions, ownership, and risks

The following figure illustrates a lifecycle with critical sustainability gates embedded:

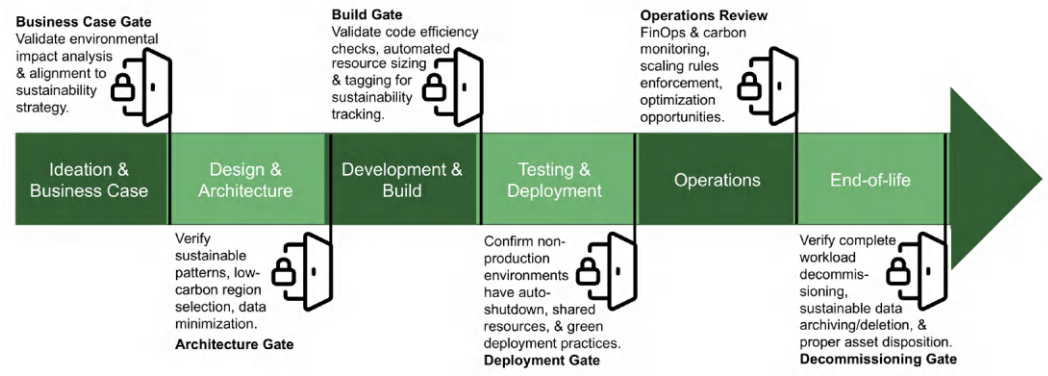


Figure 6.10 – Build sustainability gates into system lifecycle governance

Each lifecycle phase should have defined roles accountable for both the environmental and financial impact of their decisions. This is not the responsibility of a sustainability team alone; it sits across product owners, architects, developers, and operations. KPIs must reflect this shared responsibility, with metrics tied to decision points, not just end-state reporting. Data must be actionable and tied into existing systems of record and enterprise dashboards/tooling, not siloed away and isolated in separate sustainability tooling. For example, an architect's KPIs could include the percentage of designs that meet sustainable architecture standards, while a product owner could be measured on the proportion of workloads reusing existing capability.

To make lifecycle sustainability stick, it must be enforced through governance mechanisms that already exist in most enterprises:

- Architecture review boards should include sustainability criteria in all solution approvals, with decisions, where possible, tied to measured metrics based upon how your organization actually designs, builds, and deploys applications and services, not some fictitious nirvana operating state
- Procurement and contract processes should mandate the disclosure of relevant environmental metrics and allow them to influence vendor selection
- Change and release processes should include sustainability impact checks, particularly when scaling or expanding service scope

Unlike with on-premises data centers, where metrics such as PUE, WUE, CUE, and REF are under your operational control, in the cloud, they are under the provider's control. But as a customer, you can influence outcomes by choosing providers, services, and regions with better performance, where such data is disclosed. Where it isn't, practitioners should request it and use location-based carbon intensity data to estimate likely impact.

The critical step is acting on this data early, rather than producing it purely for compliance reporting. Here is an example:

- Avoid migrating to regions with significantly higher carbon intensity
- Choose service tiers or architectures that have demonstrably lower idle consumption
- Forecast environmental impact alongside cost to support business case decisions

Optimizing cloud operations

Once cloud workloads are in production, operational optimization should be approached as a continuous, measurable discipline rather than a sporadic clean-up exercise. This is where FinOps and GreenOps intersect: the same levers that drive down cost can also reduce environmental impact, provided they are tracked and managed with the same rigor as financial performance.

As shown in *Figure 6.11*, GreenOps is a continuous process employing technology, techniques, and business practices to maximize energy efficiency and minimize waste in IT infrastructure—especially the cloud:

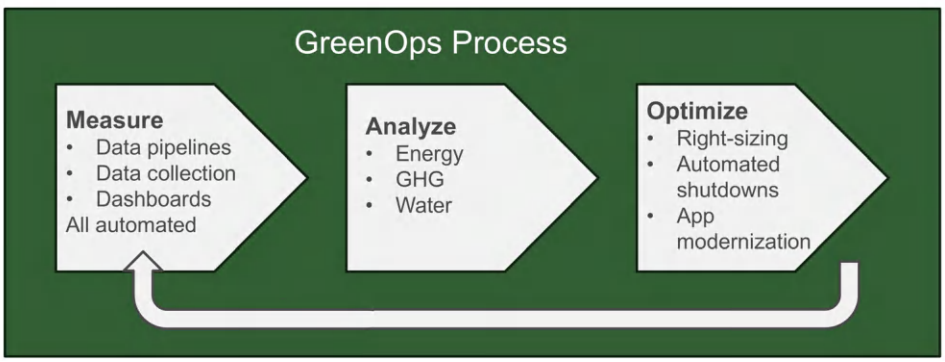


Figure 6.11 – GreenOps cycle (courtesy of Mark Richter)

A practical way to embed this is to align optimization with the routine operational governance cycle already familiar to FinOps practitioners. This ensures that environmental efficiency is addressed alongside cost, risk, and performance in every review. This intersection of FinOps and GreenOps informs sustainable value decisions across your cloud infrastructure:

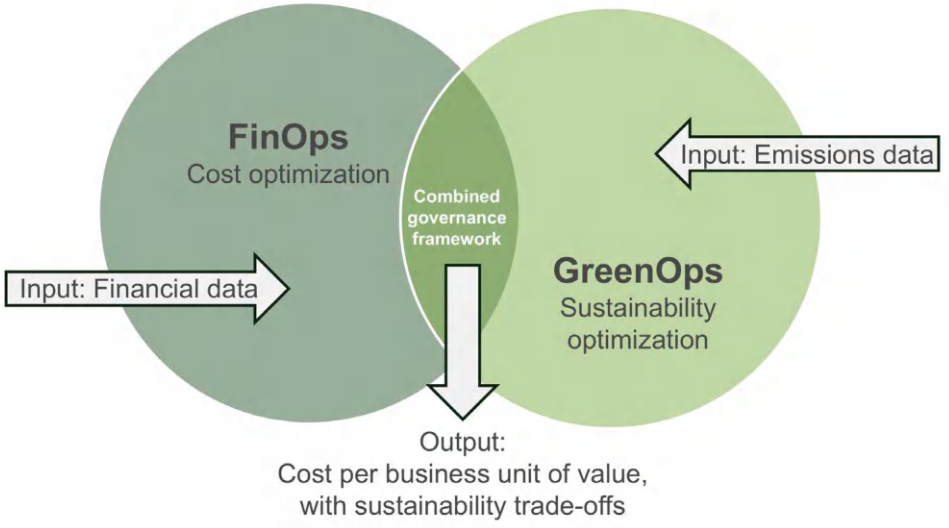


Figure 6.12 – The intersection of GreenOps and FinOps informs sustainable value optimization in cloud environments

Examples of typical optimization areas of focus include the following:

Focus Area	Optimization Actions	Sustainability Link	Example Metrics
Dev and test environments	Schedule automatic shutdown outside working hours; use hibernation where possible; downsize or share environments.	Reduces idle compute and storage footprint.	Percentage of hours dev/test runs idle; tCO_2e avoided per month.
Storage optimization	Delete unused volumes; tier older data to cold storage; reduce redundant backups; enable lifecycle rules.	Cuts unnecessary energy use and storage hardware demand.	TB removed or tiered; energy and tCO_2e saved.

Focus Area	Optimization Actions	Sustainability Link	Example Metrics
Right-sizing and auto-scaling	Match instance sizes to actual demand; tune auto-scaling rules; review scaling schedules regularly.	Improves resource utilization efficiency.	Average CPU/ memory utilization; tCO_2e per unit workload.
Idle resource elimination	Identify and decommission unused or low-utilization resources; enforce tagging policies.	Prevents "orphaned" workloads from consuming power.	Number of idle resources removed; cost and tCO_2e avoided.
Network and data transfer efficiency	Minimize inter-region/cross-cloud transfers; redesign for local processing; use content delivery networks effectively.	Reduces network energy use and associated emissions.	GB transferred avoided; estimated tCO_2e reduction.
Workload modernization	Refactor to serverless or containerized models; adopt managed services where they improve efficiency.	Reduces idle capacity and improves scaling efficiency.	Cost and tCO_2e per transaction or request.

Table 6.7 – Sustainable operations actions and metrics

These optimizations should be embedded in business-as-usual governance through the following:

- Monthly/quarterly integrated FinOps and GreenOps reviews combining cost, utilization, and environmental metrics
- KPIs that track both spend per unit of business value and tCO_2e per unit of business value
- Automation to enforce rules (e.g., auto-shutdown for non-productive, orphaned resource detection)
- Feedback loops into budgeting and forecasting, ensuring efficiency gains are locked in and influence future designs

When handled this way, optimization becomes part of the operational fabric rather than a separate and often isolated sustainability project, ensuring every dollar and every tonne of CO_2e is continuously accounted for and improved over time.

Cloud cost reports often surface financial inefficiencies, but they rarely expose the full spectrum of waste, especially when the environmental impact is hidden behind aggregated metrics or incomplete reporting. Sustainability metrics, when collected at the right level of detail, can reveal inefficiencies invisible in purely financial analysis, such as the following:

- Underutilized reserved instances (RIs) that consume capacity without delivering proportional business value
- Orphaned storage volumes and snapshots persisting long after workloads have been decommissioned
- Idle compute resources in over-provisioned auto-scaling groups or misaligned development environments
- Excessive inter-region traffic

The integration of GreenOps and governance should encompass EA as well. Embedding GreenOps in EA ensures sustainability is not an afterthought but a core architectural requirement guiding how workloads, data, and infrastructure are designed, deployed, and governed.

One of GreenOps' strengths is its data-driven feedback loop—measuring cloud, data center, and application emissions to guide optimization. EA provides the **governance and data integration layer** to unify this sustainability feedback with business and IT performance data, enabling holistic decision-making (e.g., cost, carbon, and capacity together). Effective GreenOps not only identifies cost inefficiencies and sustainability impacts but also traces them back to their root causes, whether they stem from poor forecasting, "just-in-case" provisioning, procurement rules that incentivize overspending and overprovisioning, or design choices made without sustainability in mind. *Table 6.8* provides examples of waste symptoms and their root causes and preventive actions.

Waste Signal	Likely Root Cause	Preventive Action
Low average utilization on long-term RIs	Over-purchasing due to inaccurate forecasting or "use it or lose it" budgeting	Use rolling forecasts; purchase smaller increments; review RI coverage quarterly
Large volumes of unused storage or old snapshots	Lack of lifecycle policies; poor tagging and ownership	Implement automated storage lifecycle rules; enforce tagging with ownership attribution
High levels of idle compute	Over-provisioned scaling rules; inflated performance requirements	Tune auto-scaling; validate requirements through performance testing; embed sustainability in design reviews

Waste Signal	Likely Root Cause	Preventive Action
Significant inter-region or cross-cloud traffic	Poor workload placement; architecture drift	Architect for locality; review placement decisions during change control
Persistent growth in non-production environments	Environments left running; no clear decommissioning process	Schedule off-hours shutdown; introduce environment lease policies

Table 6.8 – Waste root causes and prevention

Apply the following strategies to convert metrics into meaningful action:

- **Set clear thresholds and triggers**: Define acceptable utilization, cost-per-unit, and carbon-per-unit baselines. Any workload breaching these should prompt review.
- **Integrate into governance**: Make metric review part of architecture boards, change control, and quarterly FinOps and GreenOps cycles.
- **Demand justification for high-impact workloads**: Require business and technical leads to explain why a service exceeds its environmental targets, and to present a remediation plan.
- **Targeted interventions**: Actions might include moving workloads to regions with lower grid carbon intensity, rearchitecting to reduce idle capacity, or refining storage strategies to reduce unnecessary replication.
- **Close the loop**: Feed learnings from waste elimination into design standards, procurement criteria, and forecasting models to avoid recurrence.

When sustainability data is used in this way, it stops being a reporting afterthought and becomes an operational control mechanism, one that reduces cost, improves efficiency, and embeds sustainable decision-making into the fabric of IT operations.

Lifecycle governance, culture, and accountability

Lifecycle thinking only works if governance, culture, and accountability mechanisms ensure it is applied consistently. Without these, even well-intentioned sustainability strategies will degrade into isolated efficiency efforts, losing impact over time. Governance is what converts sustainability ambitions into binding operational requirements, ensuring that sustainability principles are embedded across the full service lifecycle.

True accountability starts at the top. CIOs, CTOs, and business sponsors must take direct accountability and responsibility for delivering sustainable-by-design services. This requires the following:

- Making sustainability criteria mandatory in all investment cases, procurement processes, and architecture reviews
- Carrying sustainability KPIs on their own scorecards, with progress reviewed as part of normal performance management
- Ensuring program and portfolio governance includes environmental impact as a standing agenda item, not an optional add-on

Too often, sustainability is delegated to operational teams who lack the budgetary authority or early-stage influence to make high-impact changes. To close this gap, do the following:

- Assign environmental decision-making authority to those controlling budgets and priorities
- Require leaders to sign off on sustainability trade-offs that increase long-term impact
- Hold both decision-makers and implementation teams jointly accountable for outcomes, ensuring governance decisions align with operational realities

Environmental accountability must be embedded into existing governance workflows, not treated as a separate parallel track:

- Architecture reviews should include sustainability checks before design approval
- Change control must assess environmental impact alongside cost, risk, and performance
- Procurement should evaluate vendors on transparency, reporting quality, and environmental performance
- Project and program management must track sustainability as a core NFR through delivery milestones

We will go into more detail on mapping accountability to your team later in this section.

Overcoming the cloud's metric challenges

In the cloud context, your sustainability goals—tracking, reporting, and actioning—are complicated by the quality of the data that providers make available, including energy and water consumption, and Scope 3 emissions. Figures often look authoritative but can hide significant gaps: inconsistent scope boundaries, lack of workload-level attribution, reliance on averages, omission of embodied emissions, and opaque methodologies. These weaknesses make it impossible to rely on provider data as the sole basis for decision-making.

The right approach is to treat provider-supplied data as an input, not the single source of truth. Where quality, coverage, or granularity is inadequate, practitioners should challenge vendors to improve transparency and align with recognized standards. If the vendor cannot or will not provide the necessary detail, supplement their data with independent measurement and modeling.

This can be achieved through the following:

- Commercial sustainability platforms that integrate cloud usage and emissions factors at a workload or resource level
- Consultancy-led LCAs that bring in independent verification
- Open source tools that model emissions based on usage, grid intensity, and lifecycle factors when budgets are limited

By combining vendor engagement with independent validation, organizations can build a more complete and defensible view of their cloud environmental footprint. The following table summarizes common weaknesses in provider data, what to look for, and how to work around these gaps:

What Providers Typically Report	**What's Missing/ Common Weaknesses**	**How to Work around It**
Annual carbon footprint at account level	Workload-level attribution, real-time data	Challenge provider to supply workload or service-level data; if not available, tag workloads and correlate usage/cost internally, using independent tools or datasets where possible
Emissions from electricity consumption (Scope 2)	Embodied carbon (Scope 3), network, storage, and cooling emissions	Push provider for full Scope 1–3 coverage; if missing, apply lifecycle emission factors from recognized standards (e.g., ISO 14067) using commercial or open source modeling tools
Global or regional averages for carbon intensity	Site-specific, location-based carbon intensity	Request location-based data for each site; where absent, overlay provider region with national grid datasets via independent platforms
PUE, WUE, or other efficiency metrics (where disclosed)	Full ISO 30134 metric set, including REF and ERE	Require a full metric set in RFP/vendor reviews; use industry benchmarks or external data sources to fill gaps

What Providers Typically Report	What's Missing/ Common Weaknesses	How to Work around It
Annual or quarterly updates	Monthly or real-time data	Request higher-frequency data; if unavailable, develop internal estimations from utilization trends, validated with third-party measurement tools
Emissions factors	Lack of clarity on which factors are used and their source	Demand documented methodology and factor sources; where unclear, replace with trusted public datasets or independent calculation platforms
Calculation approach	Heavy reliance on market-based reporting rather than location-based	Request both sets of figures; default to location-based for operational decisions and validate with independent grid intensity datasets
Methodology documentation	Often vague, incomplete, or poorly written	Insist on clear documentation and, where possible, independent assurance; if not available, document internal assumptions and calculation boundaries
Embodied emissions inclusion	Inconsistent or entirely missing Scope 3 treatment	Request explicit inclusion and methodology; if absent, calculate embodied carbon independently for hardware and infrastructure lifecycle using open source or commercial LCA tools

Table 6.9 – Making cloud provider data actionable

Pressing a hyperscaler for better sustainability data does not need to be confrontational. The most effective approach is to frame the request in terms of shared objectives. Better data enables more accurate forecasting, more efficient workload design, and a stronger sustainability narrative for both customer and provider. The following are practical steps you can take:

1. **Prepare specific asks**: Request data at a defined level (e.g., workload, region, or service) and on a defined cadence, so the provider can see the scope.
2. **Reference recognized standards**: Anchor your request to established frameworks such as ISO 30134 or the GHG Protocol ICT sector guidance, making it harder to dismiss as "custom" or niche.

3. **Demonstrate mutual benefit**: Show how better data will improve your own efficiency, reduce unnecessary consumption, and therefore lower the provider's operational load.
4. **Propose a pilot**: If the provider resists, suggest a limited trial where a subset of workloads is monitored in more detail to demonstrate feasibility.
5. **Make it part of procurement and renewals**: Document the requirement in RFPs, contract renewals, and service reviews to ensure it becomes a business expectation, not an ad hoc request.

The goal is not simply to expose shortcomings in the data, but to create a clear path for improvement that aligns with both parties' operational and sustainability objectives.

Measuring the sustainability of cloud services should begin with what is within the organization's control, not with an assumption that providers will supply complete and transparent data. Public cloud vendors rarely deliver ISO 30134-aligned metrics beyond an occasional aggregated PUE figure, often published on a marketing web page rather than in a form that is workload-specific, consistent, or independently verifiable. Metrics such as WUE, CUE, REF, and ERF are almost never provided to customers, meaning direct operational comparison between providers is largely impossible.

This reality means sustainability measurement in the cloud needs to prioritize the design, location, and consumption decisions that organizations can influence. The focus should be on developing and tracking metrics that capture the sustainability impact of choices across the entire lifecycle, from architecture and procurement to in-life optimization and retirement.

Practical, controllable metrics include typical examples such as the following:

- **Idle resource elimination**: Percentage of provisioned resources with no meaningful workload
- **Right-sizing efficiency**: Proportion of workloads operating within target utilization thresholds
- **Storage optimization**: Alignment of storage classes, retention policies, and deduplication to actual need
- **Region and service selection impact**: Quantifiable emissions difference between chosen and lowest-carbon available options
- **Data transfer efficiency**: Avoided inter-region or unnecessary network traffic through design choices

These measures should be integrated with established FinOps cost and utilization reporting, so sustainability is evaluated in the same operational context as financial performance. For example, tracking emissions per transaction, per user, or per business unit helps determine whether environmental efficiency is improving alongside service growth.

By combining verifiable internal metrics with external inputs, organizations can build a normalized, decision-ready view that links environmental impact directly to cost, utilization, and business value, moving sustainability from a reporting exercise to an operational discipline.

Putting cloud emissions data to work

As mentioned, obtaining useful Scope 3 emissions data for your cloud-hosted and hybrid environments is a challenging but not impossible exercise. Once acquired, it is up to IT to govern and apply it in a way that supports effective action. In this section, we will drill down into emissions data governance priorities, GreenOps, and tools that can help.

Priority 1: Tagging and attribution

Effective tagging is the foundation. Without consistent, enforced tagging standards, emissions data cannot be reliably allocated to specific applications, services, environments, or business units. This allocation is essential for creating persona-based KPIs that link environmental impact to the teams and decision-makers who can influence it. For example, a product owner should see the carbon impact of their application in the same dashboard as usage and cost data, making sustainability part of their accountability.

Priority 2: Granularity and comprehensiveness

Too many reporting processes aggregate emissions at an account or subscription level, masking inefficiencies. Instead, practitioners should push for reporting down to the workload, environment, and service level, aligning this granularity with the organizational maturity to act on it. There is little value in tracking emissions at the application level if the organization lacks the operational capability or mandate to respond, but there is even less value in keeping data at a level so coarse that no one feels responsible.

As discussed earlier, cloud provider sustainability reports are rarely complete or transparent enough for meaningful decision-making. Practitioners should document these limitations and, where possible, challenge providers to improve transparency. Where gaps remain, apply modeling, internal estimation, and third-party reporting tools. Procurement teams should embed these requirements into supplier scorecards and renewals, making better-quality data a contractual expectation.

Priority 3: Integration

Environmental metrics should sit alongside financial and utilization data in the same reporting and governance workflows. By combining emissions data with existing FinOps practices, organizations can quantify the environmental "cost per business unit of value" for a workload. This enables more nuanced trade-offs, such as whether to rearchitect, re-platform, or relocate a service for a better sustainability outcome.

GreenOps, like FinOps, is an operating model for cloud environments, differentiated by its integration of sustainability goals into operational governance. It aims to reduce your carbon footprint in the cloud by optimizing resource usage and improving energy efficiency.

GreenOps is a journey that can take considerable ramp-up time. Likewise, not every organization needs (or is ready for) fully integrated, real-time, application-level emissions data on day one. Maturity should grow one step at a time (*Figure 6.13*).

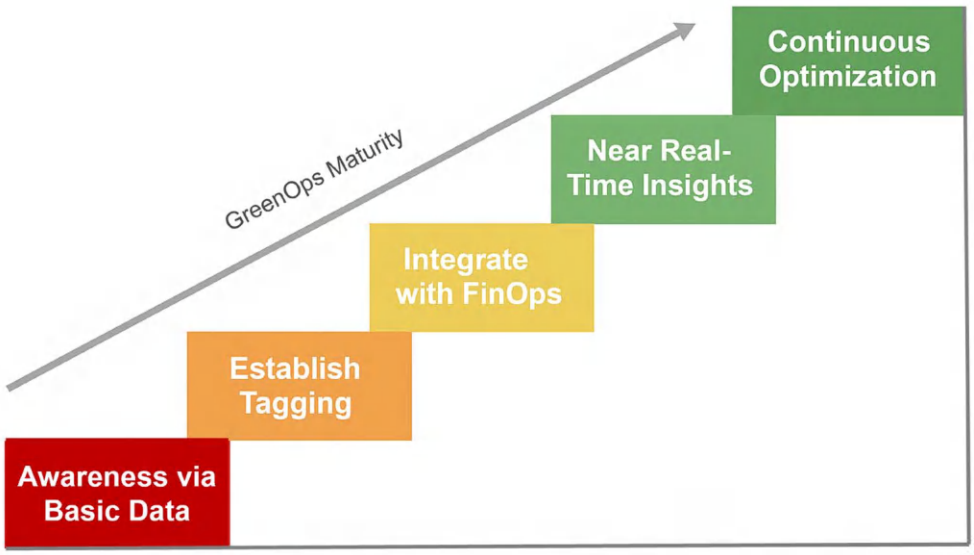


Figure 6.13 – GreenOps maturity grows with data and tagging refinement

The following table shows how capabilities typically evolve for integrating emissions data into IT operating models:

Maturity Level	Granularity of Data	Tagging Quality	Allocation Approach	Operational Integration	Decision-Making Use
Level 1 – Initial	Account or subscription level	Inconsistent or absent	Broad cost-center level	Minimal, ad hoc checks	Rarely used
Level 2 – Emerging	Service or environment level	Partially enforced in pockets	Some mapping to services	Used in isolated teams	Reactive adjustments
Level 3 – Established	Application or product level	Consistent enforcement org-wide	Full mapping to services	Integrated into FinOps reviews	Regular trade-off decisions
Level 4 – Optimized	Near-real-time workload level	Automated enforcement and audits	Dynamic mapping	Embedded in operational governance	Proactive design optimization
Level 5 – Leading	Real-time, full lifecycle coverage	Fully automated with AI/ML validation	Multi-dimensional allocation (apps, teams, personas)	Continuous optimization across portfolio	Influences external standards and supplier behavior

Table 6.10 – Maturity levels of emissions data operating model integration

This maturity approach ensures organizations build capability at a pace they can sustain, avoiding the trap of over-engineering reporting for data that never influences a decision. Once you understand your starting maturity level, the next step is to turn this awareness into measurable behavioral change across the organization. This is where persona-specific KPIs become essential; they translate abstract sustainability goals into clear expectations for the teams and individuals who make daily decisions about cloud design, procurement, and operations.

From data to discipline: Embedding accountability across roles

By mapping KPIs to relevant personas, you can make certain that the right metrics are visible to the right people at the right time. This creates a direct line from measurement capability to action, embedding sustainability considerations into the same operational cadence that already drives financial and performance outcomes.

As previously discussed, granular cloud emissions data has limited value unless it is directly tied to decision-making at the level where those decisions are made. That means allocating responsibility for both footprint and efficiency to specific personas, from engineers and product owners to procurement managers, FinOps analysts, and the CIO. This requires moving beyond aggregate, estate-wide reporting and creating a model where emissions, cost, and utilization efficiency are visible per application, per service, and per team. Tagging and allocation are the enablers here, but the goal is not the data itself; it is the ability to hold the right people accountable for making better decisions.

When implemented well, this approach changes behavior. Engineers design for efficiency because they are measured on it. Product owners prioritize features that deliver value without excess consumption. Procurement negotiates flexible, lower-carbon contracts. FinOps integrates sustainability into the same cost-performance trade-offs they already manage.

The key is to align KPIs with both sustainability impact and operational efficiency. Measuring footprint per unit of actual consumption, rather than provisioned capacity, encourages your teams to focus on efficiency of how resources are used, not just on how small or large they are at deployment.

The following table illustrates how different personas could be assigned meaningful sustainability KPIs, making environmental efficiency an operational discipline:

Persona	**Role in Cloud Sustainability**	**Example Sustainability KPIs**	**Potential Operating Impact**
Engineering team lead	Owns workload design, optimization, and ongoing performance	Average gCO_2e per vCPU-hour utilized (not provisioned) Percentage of provisioned capacity actually utilized (compute, storage, network) Percentage of idle compute time eliminated quarter-on-quarter	Uses efficiency metrics to reduce over-provisioning; focuses on improving utilization before scaling

Persona	Role in Cloud Sustainability	Example Sustainability KPIs	Potential Operating Impact
Product owner	Balances feature delivery, cost, and sustainability in service roadmap	gCO_2e per monthly active user or per API call Emissions reduction per feature improvement deployed. Percentage of features optimized for resource efficiency before launch	Avoids low-value features that drive resource usage; ensures new releases pass efficiency thresholds
Procurement manager	Evaluates and negotiates cloud contracts	Percentage of contracts scored against sustainability criteria Reduction in average carbon intensity (gCO_2e/kWh) of purchased cloud services year-on-year. Inclusion of utilization efficiency clauses in vendor SLAs	Uses historical utilization and efficiency trends to negotiate flexible capacity models instead of fixed over-provisioning
FinOps analyst	Integrates sustainability into cost management processes	Percentage of tagged resources with complete emissions attribution Emissions per $ spent (gCO_2e per £/$ cloud cost). Percentage variance between forecast and actual utilization/ emissions	Tracks whether spend is delivering high-value, efficient consumption; flags waste patterns early
CIO/CTO	Sets digital sustainability strategy and governance	Percentage of IT budget linked to measurable emissions outcomes Reduction in total cloud footprint (tCO_2e) aligned to corporate net-zero targets. Percentage of business units meeting minimum utilization efficiency thresholds	Uses combined cost, utilization, and emissions efficiency data in strategic reviews; sets cross-team efficiency goals

Table 6.11 – Cloud sustainability KPI mapping and potential outcomes

The following is an illustrative example of a cloud services sustainability dashboard with carbon KPIs and their primary persona owner:

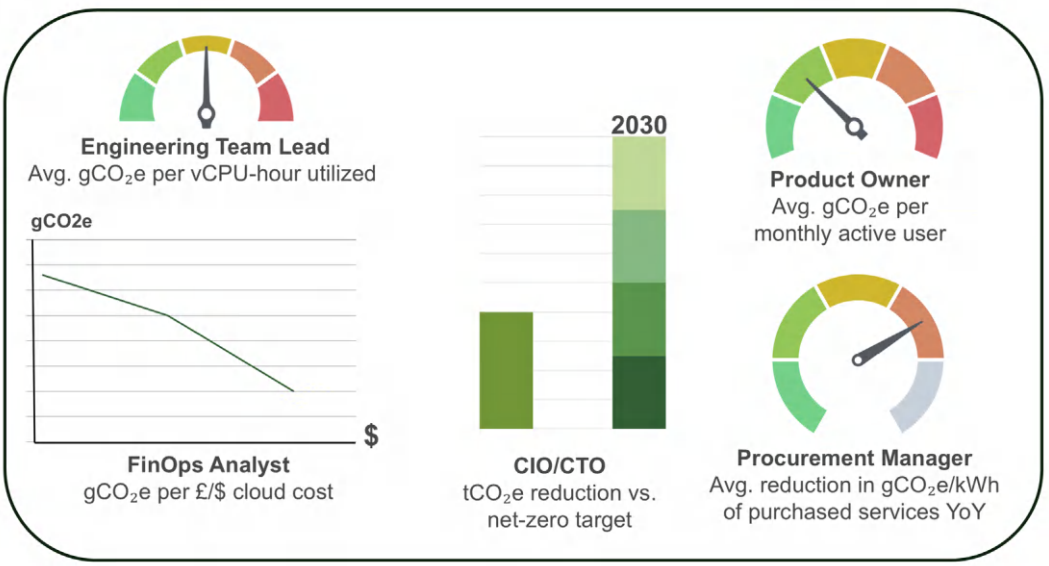


Figure 6.14 – Cloud sustainability persona-based KPIs

Given the persistent gaps in data from hyperscalers and the challenge of obtaining lifecycle energy footprints for the myriad of hardware devices that companies have installed, it's not surprising that enterprising companies have sprung up to offer tools and services to help. Let's look at this market and the factors to consider when choosing tools and services.

Tooling for cloud carbon measurement and action

Measuring cloud carbon impact has moved beyond the basic reports and data offered directly by the hyperscalers. A growing ecosystem of dedicated carbon accounting tools, open source frameworks, and FinOps or observability platforms now offers ways to collect, process, and present sustainability data. While this tooling can accelerate progress, its value depends on its ability to produce accurate, granular, and actionable insights, and on the organization's maturity in actually using them to make decisions.

There are three broad categories of tools relevant to cloud carbon management, which we will look at next.

Specialist cloud carbon reporting tools

Vendors such as Greenpixie (see James Hall's insights earlier in this chapter), Sopht, Resilio, Mikujy, Interact, Tailpipe, OxygenIT, and the open source Cloud Carbon Footprint focus specifically on calculating and reporting cloud-related emissions. These tools often offer workload-level granularity, multi-cloud coverage, and methods for estimating embodied emissions.

FinOps platforms with sustainability modules

Platforms such as Apptio Cloudability, Flexera, CloudHealth, and Anodot are primarily designed for cost management and optimization but increasingly incorporate carbon metrics. Their strength lies in combining emissions data with cost, utilization, and ownership data, enabling trade-off decisions, but sustainability is rarely their core focus.

Observability and APM tools with carbon insights

Vendors such as Dynatrace and BMC Helix are expanding their scope to include sustainability metrics alongside performance and reliability monitoring. These tools may provide real-time operational context but often depend on the same provider-supplied emissions data and inherit its limitations.

Regardless of category, most tools share similar challenges, such as the following:

- **Data gaps**: Many rely heavily on provider-supplied data that is incomplete, averaged, or market-based
- **Granularity limits**: Without quality tagging and allocation models, data remains stuck at an account or subscription level
- **Embodied emissions blind spots**: Scope 3 impacts (manufacture, transport, and disposal of hardware) are often omitted or estimated with generic factors
- **Integration issues**: Dashboards can be impressive but isolated, with no automated link to optimization recommendations, governance, or operational workflows

However, when deployed well, these tools can link emissions data to applications, services, and teams via tagging and ownership mapping. Doing this allows the integration of sustainability into FinOps and operational workflows, enabling decisions that balance cost, performance, and environmental impact (a significant win and shift in maturity). Finally, this approach supports the adoption of persona-based KPIs, giving different roles (architects, product owners, and operations leads) visibility of their direct influence on carbon outcomes.

To get value from these tools, selection should be based on more than brand recognition or dashboard design. The following framework shows some examples that could be used to evaluate candidates:

Criteria	Why It Matters	What to Look For	Red Flags
Scopes covered	A credible footprint must include Scope 1, 2, and relevant Scope 3 emissions, including embodied carbon	Explicit inclusion of embodied emissions for infrastructure; full lifecycle accounting	Scope 3 excluded or only partially covered; embodied emissions ignored
Location versus market-based factors	Affects accuracy of carbon accounting; location-based reflects the real grid mix where workloads run	Clear disclosure of whether location-based factors are used; ability to toggle between market- and location-based	Market-based only; no transparency on source of emissions factors
Use of averages	Averaged data hides variability between workloads and regions	Use of workload-specific or measured data wherever possible; low reliance on broad averages	Heavy reliance on global/regional averages with no variance
Calculation approach	Determines whether results are defensible and repeatable	Methodology aligned with recognized standards (GHG Protocol ICT sector guidance, ISO 14064, or equivalent)	Proprietary "black-box" methods without peer review or recognised alignment
Granularity of data	Enables targeted optimization and accountability	Reporting down to application, service, and team level; support for custom tagging	Only high-level totals; no ability to drill down
Data access	Determines how you can integrate the tool into your processes	APIs for programmatic access; exportable reports; integration with FinOps/ITSM tools	Report-only access; no automation or integration options
Multi-cloud coverage	Avoids tool sprawl for organizations using more than one provider	Native support for AWS, Azure, GCP, and any other relevant platforms	Single provider only; partial coverage of services

Criteria	Why It Matters	What to Look For	Red Flags
Actionability	Data must be usable to drive change	Links emissions data to cost, utilization, and ownership; supports alerts and thresholds	Standalone dashboards with no integration into governance or decision-making

Table 6.12 – Sustainability tools and services selection criteria

When the right cloud sustainability tooling is combined with disciplined data governance, role-based accountability, and a lifecycle view of decision-making, it becomes far more than a compliance report that will sit on a shelf and gather dust; it becomes a lever for cultural and operational transformation.

A summary of practitioner guidance

Sustainable cloud operations require a deliberate shift from reactive optimization to proactive, lifecycle-driven governance. This means embedding environmental considerations at the earliest stages of service ideation and design, ensuring they remain visible and measurable throughout build, run, and end-of-life phases. The following table summarizes the practices and metrics described in this section:

What to Do	Why It Matters	How to Measure/Monitor
Integrate sustainability into governance gates (architecture, change control, procurement, and project delivery)	Prevents high-impact design decisions from being approved unchecked and embeds sustainability as an NFR	Percentage of governance reviews including sustainability checks; number of rejected/modified proposals due to environmental impact
Embed lifecycle thinking—avoid waste before optimization	Design-stage decisions have the greatest influence on footprint; late fixes are more costly and less effective	Ratio of avoided versus remediated waste; measurable reduction in idle or oversized capacity at go-live
Map sustainability principles to roles and personas	Keeps accountability close to decision points and makes expectations specific and actionable	Percentage of personas with defined sustainability principles; number of decisions traced back to persona-based standards

What to Do	Why It Matters	How to Measure/Monitor
Demand high-quality, verifiable emissions data from cloud vendors	Overcomes limitations of current provider reports (averages, lack of granularity, unclear methodologies)	Percentage of workloads with granular emissions data; number of vendor reports meeting agreed quality criteria
Align sustainability metrics with business value metrics (FinOps)	Ensures environmental impact is assessed in the same decision framework as cost and performance	Combined cost, performance, and environment dashboards; percentage of decisions made using integrated metrics
Optimize live workloads continuously	Prevents footprint growth through drift, unmonitored scaling, or changing usage patterns	Reduction in idle compute/storage; percentage of workloads reviewed quarterly for optimization
Trace inefficiencies back to root causes	Avoids recurrence of design, procurement, or forecasting errors	Percentage of inefficiencies with root cause identified; number of process changes driven by root cause analysis
Fix forecasting and budgeting behaviors	Over-buying capacity (e.g., RIs) and bloated design due to budget cycles creates long-term waste	Forecast accuracy variance; percentage of budget tied to actual utilization; RI/commitment underutilization rates
Select cloud regions based on grid carbon intensity and water stress	Regional differences can be substantial and materially affect footprint	Percentage of workloads deployed in low-carbon or low-water-stress regions; estimated impact reduction from region choice
Govern AI and HPC workloads more tightly	These workloads are disproportionately resource-intensive	GPU utilization rates; model size and training frequency; percentage of AI workloads using efficiency optimization techniques
Embed sustainability triggers into operational workflows	Ensures action is taken when impact thresholds are breached	Number of automated alerts triggered and resolved; SLA adherence for remediation actions

Table 6.13 – Cloud sustainability best practices and related metrics

By embedding these practices into FinOps-style iterative cycles, sustainability becomes a repeatable operational discipline rather than a compliance task to be ignored or sidelined. The result is a cloud estate that delivers business value with the lowest feasible environmental footprint, one that stands up to regulatory scrutiny, stakeholder expectations, and the realities of a resource-constrained future.

Mark Butcher, Director, Posetiv Cloud Ltd.

Mark's insights underscore a profound challenge in modern IT: while hyperscalers own and operate the infrastructure, enterprise IT organizations remain accountable for the environmental footprint of the services they consume. This creates a dual responsibility gap. On one side, cloud providers manage metrics such as PUE, WUE, and CUE, but rarely disclose them at a level of detail that allows workload-specific decision-making. On the other, IT leaders must report and reduce Scope 3 emissions for their organizations, yet lack direct operational control. This tension makes comprehensive lifecycle governance a strategic imperative. It is the only way to ensure the cloud's promise of agility and scalability does not come at the cost of planetary health.

Summary

In this chapter, you have learned how we can make data centers and cloud environments run more sustainably. By now, you should understand the challenges of cloud emissions data and how to work around them. You've been introduced to an example of a net-positive data center and provided with a set of metrics to track your data center sustainability factors and populate a sustainability scorecard.

Hopefully, you have gained insights into how to maximize the benefits of the cloud by governing the full lifecycle of the migration rather than attempting to account for sustainability after the key decisions have already been made. Here are a few key recommendations:

- Select data center locations with low-carbon energy supply and low GHG intensity
- Consider water stress and **water use effectiveness** (**WUE**) in data center location and operating decisions
- Monitor energy consumption down to the rack level
- Move workflows across cloud regions depending on renewable energy consumption
- Integrate sustainability into governance gates (architecture, procurement, change control, and project delivery) so high-impact design decisions cannot bypass environmental review

- Embed lifecycle thinking early—rationalize and modernize applications before migration, avoid "lift-and-shift" inefficiencies, and make sustainability an NFR from design to decommission
- Map sustainability principles to roles/personas so accountability sits with decision-makers (e.g., product owners, architects, and DevOps) rather than being siloed in sustainability teams
- Demand high-quality, verifiable emissions data from cloud vendors and supplement it with third-party datasets where provider transparency is lacking
- Align sustainability metrics with business value metrics (FinOps) to ensure environmental impacts are assessed in the same decision framework as cost and performance
- Continuously optimize live workloads (right-sizing, idle resource elimination, and storage optimization) and embed these practices into routine FinOps/GreenOps governance cycles

We have just scratched the surface as we reach the chapter's end. Still, as a technology leader, you should understand the broad perspective, enabling you to start asking your vendors tough questions and identifying your direction of travel in the future in broad strokes. We invite you to delve deeper into these concepts via recommendations in the *Further reading* section that will set you on the right track.

In *Chapter 7*, *Applications and Architecture*, we will look at how you can start optimizing and decarbonizing your entire application portfolio down to a single application, followed by *Chapter 8*, *Data*, which explores sustainability and efficiency optimization through data minimization and other strategies.

Appendix: standard metrics for data center sustainability

SustainableIT's standard taxonomy metrics for data center sustainability are shown in this table, spanning energy consumption, emissions, and water usage (SustainableIT.org 2024). Biodiversity can be measured as described earlier in this chapter, monitoring **mean species abundance per square kilometer (MSA/km²)** in the region with the data center compared to that of an undisturbed habitat:

Category	Topic	Metric	Related Global Standards
SIT EF 100 Energy, Function	EF 111 Data center total energy consumption: electricity, heating, cooling	On-premises (EF 111-1): EF 111-1.a kWh rack power consumption by location, time of day, per end user	GRI 302-1, 3 TC-IM-130a.1 TC-SI-130a.1 ESRS E1 SDG 7, 9, 13, 17
		EF 111-1.b Percentage renewable: Solar, wind, geothermal, hydropower, tidal, biomass	
		EF 111-1.c ekWh per capita (end user) "energy performance by source"	
		EF 111-1.d PUE (i.e., total facility energy/IT equipment energy)	
		EF 111-1.e Percentage of data centers complying with EU Data Center Code of Conduct	
		EF 111-2 Third-party-hosted, co-located: EF 111-2.a kWh by provider, location	
		EF 111-2.b Percentage renewable: Solar, wind, geothermal, hydropower, tidal, biomass	
		EF 111-2.c ekWh per capita (end user) "energy performance by source"	
		EF 111-2.d EF 111-1.d PUE (i.e., total facility energy/IT equipment energy)	
		EF 111-2.e Percentage of data centers complying with EU Data Center Code of Conduct	
		EF 111-3 Percentage of data center workloads that are portable (can be easily run in different locations depending on power management factors)	
SIT EF 200, Emissions, Function	EF 211 Data center emissions	EF 211-1 Owned/on premises-hosted metric tonnes CO_2 by location, time of day, per end user (include servers and cooling)	GRI 305-1, 2, 3 TC-IM-130a.1 TC-SI-130a.1 ESRS E1, E2 SDG 7, 9, 13, 17

		EF 211-2 Third-party-hosted and co-location data centers metric tonnes CO_2, by provider, per end user	
SIT EE 300 Waste, Enterprise	EE 310 Water consumption	EE 310-1 Water consumption enterprise facilities: EE 310-1.c Baseline megaliters per facility m² (e.g., a data center) over time period	TC-IM-130a.2 TC-SI-130a.2 GRI 303-1,2,3,4,5 ESRS E3 SDG 9, 12, 13, 17
		EE 310-1.e Water intensity: Megaliters per facility m² (e.g., a data center) over time period	
		EE 310-1.d Megaliters discharged by location, water destination, level of treatment, over time period	
		EE 310-1.b Percentage water withdrawn from high-stress regions	
		EE 310-2 Water consumption third-party facilities	
		EE 310-2.c Baseline megaliters per facility m² (e.g., a data center) over time period	
		EE 310-2.e Water intensity: Megaliters per facility m² (e.g., a data center) over time period	
		EE 310-2.d Megaliters discharged by location, water destination, level of treatment, over time period	
		EE 310-2.b Percentage water withdrawn from high-stress regions	

Table 6.14 – Standard sustainability metrics for data center environmental impact

Further reading

1. Standards, frameworks, and sector guidance:

- *The EU Data Center Code of Conduct to improve the energy efficiency of data centers*: `https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/eu-code-conduct-data-centres-towards-more-innovative-sustainable-and-secure-data-centre-facilities-2023-09-05_en`.
- *FinOps Foundation's standard KPI library can be used by all organizations, regardless of cloud service provider, industry, size, or FinOps maturity*: `https://www.finops.org/wg/finops-kpis/`.

- *GHG Protocol standards, tools, and sector-specific guidance for measuring and reporting GHG emissions*: https://ghgprotocol.org/.
- *GHG Protocol ICT sector guidance for lifecycle carbon accounting of ICT services, including cloud and data centers*: https://ghgprotocol.org/sites/default/files/2023-03/GHGP-ICTSG%20-%20ALL%20Chapters.pdf.
- *GHG sector-specific guidance for emissions calculations, including lifecycles and product rules, and tools from GHG Protocol*: https://ghgprotocol.org/standards-guidance.
- *GSMA's guidance for ICT companies in setting science-based targets for GHG reductions*: https://www.gsma.com/solutions-and-impact/connectivity-for-good/external-affairs/climate-company-guidance/.
- *DataCenter Knowledge: A Guide to Data Center Water Usage Effectiveness (WUE) and Best Practices*: https://www.datacenterknowledge.com/cooling/a-guide-to-data-center-water-usage-effectiveness-wue-and-best-practices.

2. Research, technical papers, and books:

- *How Hungry is AI? Benchmarking Energy, Water, and Carbon Footprint of LLM Inference*: https://arxiv.org/abs/2505.09598.
- *Holistically Evaluating the Environmental Impact of Creating Language Models – Includes training, development, hardware manufacturing, and water use*: https://arxiv.org/abs/2503.05804.
- *The Unpaid Toll: Quantifying and Addressing the Public Health Impact of Data Centers – Quantifying air pollutants and economic health burden from the AI lifecycle*: https://arxiv.org/abs/2412.06288.
- *ResearchGate: Data centre sustainability – Beyond energy efficiency*: https://www.researchgate.net/publication/322468649_Data_centre_sustainability_-_Beyond_energy_efficiency.
- *Climate Neutral Data Centre Pact*: https://www.climateneutraldatacentre.net/
- *Ramboll. Biodiversity and Data Centers: What's the connection?*: https://www.ramboll.com/galago/biodiversity-and-data-centers-what-s-the-connection.
- *Open Compute Project. 2024. Data Center Facility Sustainability Metrics.* https://www.opencompute.org/documents/dcf-sustainability-metrics-final-r3-docx-pdf.

3. News, commentary, and case studies:

- *The Register: Real Datacenter emissions are a dirty secret*: https://www.theregister.com/2025/01/22/datacenter_emissions_not_accurate/.

- *Business Insider: How data centers are deepening the water crisis*: https://www.businessinsider.com/how-data-centers-are-deepening-the-water-crisis-2025-6.
- *Guardian: Draining cities dry: the giant tech companies queueing up to build datacentres in drought-hit Latin America*: https://www.theguardian.com/global-development/2025/may/22/datacentre-drought-chinese-social-media-supercomputers-brazil-latin-america.
- *Guardian: Data center emissions probably 662% higher than big tech claims. Can it keep up the ruse?*: https://www.theguardian.com/technology/2024/sep/15/data-center-gas-emissions-tech.
- *The Washington Post: Memories of deadly winter blackouts haunt the Texas data center boom*: https://www.washingtonpost.com/technology/2025/08/07/texas-law-data-centers-power-grid/.
- *AP News: As electric bills rise, evidence mounts that data centers share blame. States feel pressure to act*: https://apnews.com/article/electricity-prices-data-centers-artificial-intelligence-fbf213a915fb574a4f3e5baaa7041c3a.
- *MIT News: The Staggering Ecological Impacts of Computation and the Cloud*: https://thereader.mitpress.mit.edu/the-staggering-ecological-impacts-of-computation-and-the-cloud/.
- *MIT News: Explained: Generative AI's environmental impact*: https://news.mit.edu/2025/explained-generative-ai-environmental-impact-0117.
- *UtilityDive: Why utilities should bring water into the data center energy conversation*: https://www.utilitydive.com/news/utilities-water-electricity-ai-data-center/756804/.
- *Smart City Sweden: Stockholm Innovates District Heating with New Solutions and Renewable Sources*: https://smartcitysweden.com/best-practice/401/stockholm-innovates-district-heating-with-new-solutions-and-renewable-sources/.

4. Hyperscaler sustainability frameworks:

- *Amazon Well Architected Framework – Sustainability Pillar*: https://docs.aws.amazon.com/pdfs/wellarchitected/latest/sustainability-pillar/wellarchitected-sustainability-pillar.pdf.
- *Microsoft*: *Design methodology for sustainable workloads on Azure*: https://learn.microsoft.com/en-us/azure/well-architected/sustainability/sustainability-design-methodology.
- *Google Cloud – Cloud sustainability*: https://cloud.google.com/sustainability.

5. Tooling and reporting vendors:

- *Apptio Cloudability*: https://www.apptio.com/innovation-hub/.
- *Cloud Carbon Footprint*: https://www.cloudcarbonfootprint.org/.
- *Dynatrace*: https://www.dynatrace.com/hub/detail/carbon-impact/.
- *Flexera*: https://www.flexera.com/blog/finops/the-cloud-world-goes-greener-with-flexeras-cloud-sustainability-add-on/.
- *Greenpixie*: https://greenpixie.com/.
- *Interact DC*: https://interactdc.com/products/cloud-footprint/.
- *OxygenIT*: https://www.oxygenit.io/use-cases/quote-carbon-impact-for-future-projects.
- *Sopht*: https://sopht.com/en/.
- *Tailpipe*: https://tailpipe.ai/.
- *VMWare Tanzu Cloud Health*: https://blogs.vmware.com/vov/2023/10/31/cultivating-a-sustainable-culture-with-vmware-tanzu-cloudhealth/.

Bibliography

- Amazon. 2025. *Water stewardship*. https://sustainability.aboutamazon.com/natural-resources/water#:~:text=Employees%20spotlight-,Progress,risk%20regions%20of%20our%20operations.
- Arup. 2025. *Nature and technology: balancing data centres with biodiversity.* https://www.arup.com/en-us/insights/nature-and-technology-balancing-data-centres-with-biodiversity/.
- Boden Business Park. 2023. *Large-scale greenhouse cultivation in smart industrial symbiosis.* https://bodenbusinesspark.com/en/large-scale-greenhouse-cultivation-in-smart-industrial-symbiosis/.
- Brady, G., N. Kapur, J. Summers, and H. M. Thomson. 2013. *A case study and critical assessment in calculating power usage effectiveness for a data centre.* https://eprints.whiterose.ac.uk/id/eprint/79352/1/GBrady%20Case%20Study%20of%20PUE.pdf.
- CoinLaw. 2025. *Bitcoin Energy Consumption Statistics 2025.* https://coinlaw.io/bitcoin-energy-consumption-statistics/#:~:text=Global%20Energy%20Consumption%20by%20Bitcoin,the%20US%20total%20mining%20power.

- Deloitte Insights. 2024. *As generative AI asks for more power, data centers seek more reliable, cleaner energy solutions.* https://www2.deloitte.com/us/en/insights/industry/technology/technology-media-and-telecom-predictions/2025/genai-power-consumption-creates-need-for-more-sustainable-data-centers.html.
- EESI. 2025. *Data Centers and Water Consumption*. https://www.eesi.org/articles/view/data-centers-and-water-consumption#:~:text=While%20%E2%80%9C0%E2%80%9D%20is%20the%20ideal,a%20great%20goal%20to%20beat
- Electricity Maps. 2025. Accessed September 19, 2025. https://app.electricitymaps.com/map/live/fifteen_minutes
- Ember. 2025. *Global Electricity Trends*. https://ember-energy.org/latest-insights/global-electricity-review-2025/global-electricity-trends/#:~:text=Global%20electricity%20demand%20rose%20to,century%2C%20electricity%20demand%20has%20doubled.
- Ember. 2025. *Energy Institute – Statistical Review of World Energy 2025*. https://ourworldindata.org/grapher/carbon-intensity-electricity?time=latest&map.
- Equinix. 2022. *Green by design*. https://tinyurl.com/38pan5zj.
- European Commission. 2022. *REPowerEU: A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition*. https://ec.europa.eu/commission/presscorner/api/files/document/print/en/ip_22_3131/IP_22_3131_EN.pdf.
- European Commission. n.d. *European Climate Law*. https://climate.ec.europa.eu/eu-action/european-climate-law_en.
- Gartner. 2024. *Gartner Forecasts Worldwide Public Cloud End-User Spending to Total $723 Billion in 2025*. https://www.gartner.com/en/newsroom/press-releases/2024-11-19-gartner-forecasts-worldwide-public-cloud-end-user-spending-to-total-723-billion-dollars-in-2025.
- Google. 2024. *Google Environmental Report 2024*. https://www.gstatic.com/gumdrop/sustainability/google-2024-environmental-report.pdf.
- Google. 2025. *Google Environmental Report 2025*. https://sustainability.google/reports/google-2025-environmental-report/.
- View Research. 2025. *Data Center Market (2025 - 2030)*. https://www.grandviewresearch.com/industry-analysis/data-center-market-report.
- Hao, Karen, The Atlantic. 2024. *AI is Taking Water from the Desert*. https://www.theatlantic.com/technology/archive/2024/03/ai-water-climate-microsoft/677602/.
- IEA. 2024. *Electricity Report 2024*. https://www.iea.org/reports/electricity-2024/executive-summary.

- IEA. 2025. *Energy and AI – World Energy Outlook Special Report*. https://www.iea.org/reports/energy-and-ai.
- IEA. 2025. *Electricity*. https://www.iea.org/energy-system/electricity.
- IFRI. 2025. *AI, Data Centers and Energy Demand: Reassessing and Exploring the Trends*. https://www.ifri.org/sites/default/files/2025-02/ifri_buffard-rochegonde_ai_data_centers_energy_2025_0.pdf.
- Khaliq uz Zaman, Sardar, Atta ur Rehman Khan, Junaid Shuja, Tahir Maqsood, Faisal Rehman, Saad Mustafa. January 2019. *A Systems Overview of Commercial Data Centers: Initial Energy and Cost Analysis. International Journal of Information Technology and Web Engineering*. https://ideas.repec.org/a/igg/jitwe0/v14y2019i1p42-65.html
- Khan, A. R., M. Othman, A. N. Khan. 2013. *A Novel Application Licensing Framework for Mobile Cloud. International Conference on Future Trends in Computing and Communication Technologies, 127-131*. https://arxiv.org/abs/1401.0034.
- Microsoft. 2025 *Surplus datacenter heat will be repurposed to heat homes in Denmark*. https://local.microsoft.com/blog/datacenter_heat_repurposed/.
- Microsoft. n.d. *Microsoft Datacenters*. https://tinyurl.com/3yh5ryz2.
- Open Compute Project. 2024. *Data Center Facility Sustainability Metrics*. https://www.opencompute.org/documents/dcf-sustainability-metrics-final-r3-docx-pdf.
- Pengfei, Li, et. Al. 2023. *Making AI Less "Thirsty": Uncovering and Addressing the Secret Water Footprint of AI Models*: https://arxiv.org/abs/2304.03271.
- The Register. 2024. *More than a third of enterprise datacenters expect to deploy liquid cooling by 2026*. https://www.theregister.com/2024/04/22/register_liquid_cooling_survey/.
- Statista. 2024. *Volume of data/information created, captured, copied, and consumed worldwide from 2010 to 2023, with forecasts from 2024 to 2028 (in zettabytes) [Graph]*. In Statista. https://www.statista.com/statistics/871513/worldwide-data-created/ Statista. 2024. *Which Countries Have The Most Data Centers?*. https://www.statista.com/chart/24149/data-centers-per-country/.
- Statista. 2024. *Where Water Stress Will Be Highest by 2050*. https://www.statista.com/chart/26140/water-stress-projections-global/.
- SustainableIT.org. 2024. *SustainableIT Standards Taxonomy V1.2*. https://www.sustainableit.org/standards/it-esg-standards.

- Trellis. 2024. *Microsoft launches initiative to counter 30% rise in Scope 3 emissions since 2020*. `https://trellis.net/article/microsoft-launches-initiative-counter-30-rise-scope-3-emissions-2020/`.
- Uptime Institute. 2023. *Heat Reuse: A Management Primer*. `https://uptimeinstitute.com/resources/research-and-reports/heat-reuse-a-management-primer`.
- World Economic Forum. 2024. *Data volume is soaring. Here's how the ICT sector can sustainably handle the surge*. `https://www.weforum.org/stories/2024/05/data-growth-drives-ict-energy-innovation/`.

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7

Applications and Architecture

> *"We are at a unique stage in our history. Never before have we had such an awareness of what we are doing to the planet, and never before have we had the power to do something about that."*
>
> *David Attenborough*

In this chapter, you will learn how to optimize your entire application portfolio to run more sustainably, impacting energy consumption, resource consumption, and utilization, which will result in emitting less carbon.

The main objective of this chapter is to introduce you to achieving sustainability targets with **enterprise architecture** (**EA**), application portfolio management, and sustainable software development.

First, you will understand how to turn your sustainability strategy into action with EA. Lisa Pratico, of SustainableArchitectures.org and IASA Global, will explain why your enterprise architects must be positioned early in the development lifecycle of applications. Then, you will see what different considerations are available to optimize your application portfolio to simplify, modernize, and transform your entire application estate, which will result in a lower **total cost of ownership** (**TCO**) and **greenhouse gas** (**GHG**)/carbon emissions. After that, we will introduce you to a single hypothetical application and how it can be optimized.

In this chapter, we will cover the following topics:

- Transforming EA to help achieve sustainability targets
- Application portfolio management for sustainability
- Application rationalization for sustainability
- Sustainable software development
- Energy-efficient programming languages
- Peer organizations you can work with, including the Green Software Foundation
- Standard metrics for applications and software development

From the sustainable IT reference model perspective, we will look at how the different capabilities of application management play an integral part in building a sustainable application portfolio, starting with a solid EA foundation that can guide a software engineer in optimizing the sustainability of an individual application. Applications and architecture must be pillars of a sustainable IT strategy and governance approach, and the impacts of good strategy and governance will be felt across the IT facilities and their consumption of energy and water:

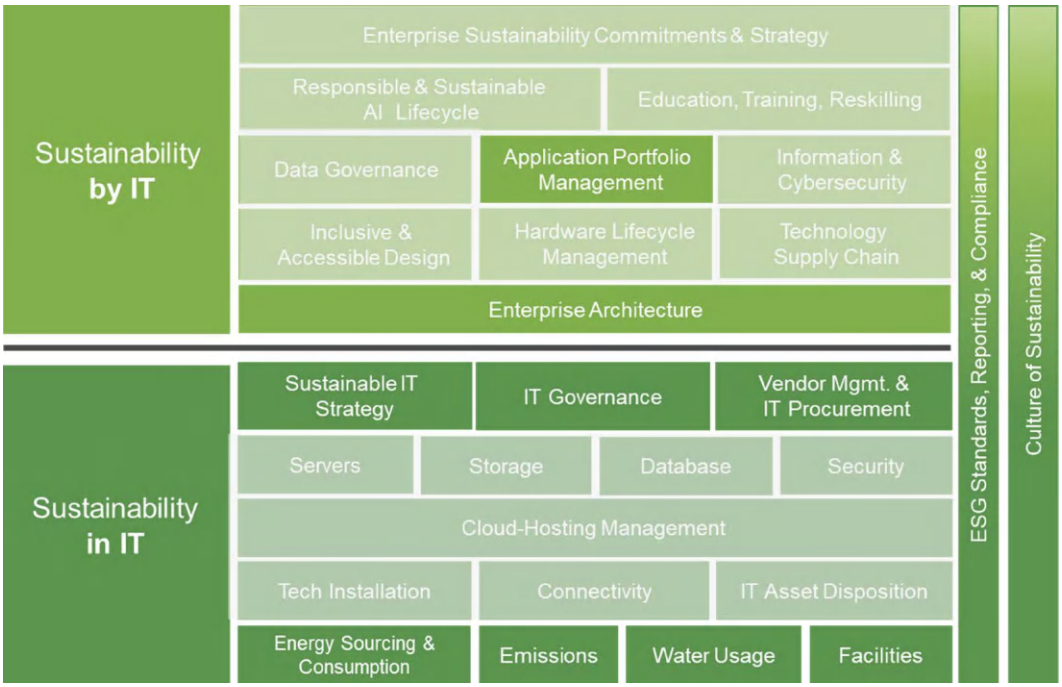


Figure 7.1 – Sustainable IT reference model – Chapter 7's focus

By the end of this chapter, you will have learned about application portfolio management and sustainable software development. You will learn about the application rationalization process, application assessment criteria, and **tolerate, invest, migrate, and eliminate** (**TIME**). Furthermore, you will understand what opportunities exist within sustainable software development for a single application, from choosing an energy-efficient programming language to key considerations during each step of the **software development lifecycle** (**SDLC**). Finally, you will learn what tools are available from the major cloud providers, including **Amazon Web Services** (**AWS**), **Microsoft Azure**, **Google**, and other cloud providers, to measure your carbon emissions in the cloud while taking a holistic approach and measuring your entire cloud estate.

The world runs on software

In an increasingly digitized world, we have come to rely more and more on software that runs in the background, running our social media sites, search engines, news outlets, streaming services, online gaming, and e-commerce. The world runs on software; how these solutions operate can significantly impact the environment regarding energy consumption and carbon emissions. In the drive toward hyper-connectivity, people, places, and things are increasingly connected through 5G and the **Internet of Things** (**IoT**). Exponential technologies such as generative and agentic AI, autonomous vehicles, **augmented reality** (**AR**), and **virtual reality** (**VR**), drones, 3D printing, digital manufacturing, and **robotic process automation** (**RPA**) increasingly require more computing and storage power through cloud computing and quantum computing. All of these emerging technologies run and operate on software, which requires access to **high-performance computing** (**HPC**), elaborate storage, and increasingly more rapid data transfer options across the network. For example, AI with **machine learning** (**ML**) and **deep learning** (**DL**) techniques requires large datasets, images, complex algorithms, and vast amounts of computing and storage to be effective.

In today's rapidly changing business environment, having a flexible IT landscape is a crucial enabler in driving digital business transformation to enable a better customer experience and unlock internal operational efficiency opportunities. Corporations, organizations, and governments tend to work with hundreds of applications and even thousands for several reasons. The sheer number of applications is usually due to strategic business initiatives, the adoption of new technology, mergers and acquisitions, shadow IT initiatives, and organizational changes. Most organizations deploy software solutions and forget about them as they need to move on to the next project/program to stay competitive. This means your OpEx costs continue to rise, as does the size of your application portfolio. This challenge has been exacerbated by digital transformation, where speed and velocity trump sound architectural designs and strategies that ensure reuse and currency.

It is not uncommon for organizations to have multiple **enterprise resource planning** (**ERP**) systems, **customer relationship management** (**CRM**), mainframe applications, integration platforms, and **business intelligence** (**BI**) platforms. Before we go any further, let us look at the definition of an application.

TechTarget defines an application as follows: *An application, also referred to as an application program or application software, is a computer software package that performs a specific function directly for an end user or, in some cases, for another application. An application can be self-contained or a group of programs. The program is a set of operations that runs the application for the user.*

As this definition suggests, applications come in many different shapes and forms, so it should be no surprise that enterprises have an overwhelming amount of them. A **LeanIX** EA insights research report from 2019 showed that 36% of billion-dollar enterprises held more than 1,000 applications in their portfolios.

Newer research cited in the following list shows lower numbers, but the impact is still high portfolio complexity and cost due to redundancy and shadow IT:

- The average number of applications grew to 101 in 2025 after years of being flat, according to Okta's *Businesses at Work* study (Okta 2025).
- The average number of SaaS portfolio applications was 342 in 2025, down from 2024's 374, thanks to consolidation (Productiv 2025).
- Zylo reports that in 2024, SaaS portfolios grew for the first time since 2021. Lines of business own 70% of SaaS spend and 50.5% of apps, while IT owns only 26% of spend and 16% of apps—fragmenting governance and driving redundancy (Zylo 2025).
- Netskope's *2024 Cloud & Threat Report* finds half of enterprise users interact with 11–33 applications per month, and the top 1% use more than 96 apps monthly—highlighting day-to-day complexity (Netskope 2024).

Not surprisingly, a sizable chunk of the IT budget is directed toward developing, maintaining, and operating applications. Some research suggests that spending in these areas can amount to as much as two-thirds of total IT spending (SpiceWorks 2024). There is a huge savings potential in rationalizing your application portfolio from a digital transformation cost perspective and radically reducing your emissions. Managing your application portfolio is a complex endeavor, from prioritizing hundreds of applications for the solution architecture and managing the efficiency and effectiveness of a single application. There are also significant benefits in introducing sustainable software development practices for a single application to reduce resource consumption, overhaul data architecture and data lifecycle management, and optimize chatty interfaces to remove excessive data transfers.

In the following subsections of this chapter, we will explore application portfolio management and sustainable software development.

Transforming enterprise architecture to help achieve sustainability targets

There is a problem with EA when it comes to sustainability, and that is a lack of capability maturity. In fact, EA is an outlier on the low end of the maturity scale, literally. SustainableIT.org researched maturity levels across 11 capabilities and characteristics for driving IT sustainability. EA came in dead last, with an average of 1.8 on a maturity scale of 1–5 (*Table 7.1*). This places companies between *Beginning* and *Unstructured* in their ability to define and embed sustainability criteria into architecture. (We will go into more detail on this maturity model in *Chapter 13*, *Get Started Today*.)

Maturity level	**Description: How mature are your technology infrastructure design guidelines and standards for sustainability?**
1 - Beginning	Technology EA generally lacks environmental and social sustainability principles for infrastructure design No sustainable architecture vision, strategy, or standards (e.g., energy efficiency, net-zero carbon, universally accessible, highly resilient)
2 - Unstructured	There are some architectural sustainability principles and plans for migration to a more sustainable model, but progress has been sporadic or slow Sustainable architecture model brainstormed, but no formal migration plan As-a-Service architecture model adopted for some IT products and services
3 - Defined	A sustainable architecture model has been fully mapped, and significant progress is underway in migration Migration to sustainable architecture mapped Future-state architecture is fully defined
4 - Managed	A sustainable architecture model is fully applied across the enterprise, and migration is progressing at or above expectations. Migration well managed Architecture model and standards are well-managed and applied enterprise-wide

Maturity level	Description: How mature are your technology infrastructure design guidelines and standards for sustainability?
5 - Optimized	Legacy and new infrastructure largely conform to sustainable architecture principles for the enterprise and reflect industrywide goals or norms All new and legacy systems conform to the sustainable model Sustainable architecture standards are industry-leading

Table 7.1 – Maturity levels for sustainable EA (source: SustainableIT.org Maturity Model)

In this section, we will hear from veteran **Chief Enterprise Architect and Chair of SustainableArchitectures.org**, **Lisa Pratico**, on EA's pivotal role in achieving sustainability targets:

Why EA must be at the front door

In a rapidly evolving digital world marked by climate urgency, regulatory pressure, and the exponential growth of AI, EA has emerged as a strategic enabler for embedding sustainability and responsible AI into the very fabric of digital innovation. Ensuring that EA sits at the front door of every technology initiative is no longer optional—it is critical to future-proofing organizations and achieving ESG mandates.

Modern enterprises are no longer defined by static IT systems. They are complex, composable ecosystems where solutions span cloud-native platforms, SaaS applications, on-premises systems, and now large-scale AI models. Without EA at the forefront, organizations risk the following:

- Fragmented technology decisions misaligned with ESG goals
- Missed opportunities to reduce carbon emissions, e-waste, and energy use
- Deployment of biased, opaque, or non-compliant AI solutions
- Inability to trace or align solutions to sustainability targets

EA provides a unique vantage point—an enterprise-wide lens to ensure that architecture designs are as follows:

- Strategically aligned with business transformation goals
- Compliant with ESG regulations and responsible AI principles
- Operationally efficient, secure, and sustainable across the solution estate

Because EA already governs architectural strategy, solution review, and technology lifecycle management, it is the logical front door for embedding sustainability and responsible AI. It sets standards and decision criteria through **architecture review boards (ARBs)**. It aligns architecture deliverables (business, application, tech, data, and security) with strategic priorities, including ESG. EA is cross-functional by design, capable of knitting together complex ecosystems across SaaS, cloud-native, and legacy platforms.

EA's role in sustainability

These four focal points align with EA's fundamental value to enterprise sustainability:

1. **Defining an ESG-aligned architecture strategy**: EA bridges business and IT strategies with ESG objectives by embedding green design principles, sustainability metrics, and responsible AI criteria into enterprise-wide architecture guidelines. This includes the following:
    - ESG-aligned capability maps and investment roadmaps
    - Architecture reviews assessing sustainability and AI ethics
    - Deployment patterns that are climate-aware and support AI transparency
2. **Orchestrating cross-disciplinary collaboration**: Sustainability and AI governance cut across silos. EA serves as the connective tissue between the following:
    - Business and sustainability leaders (e.g., CSO, CDO, and CFO)
    - Technical teams (solution architects, data scientists, engineers and developers, and cloud operations)
    - Governance bodies (ARBs, risk and compliance, and ESG committees)
3. **Delivering enterprise-grade decision support and traceability**: EA enables traceable architecture decisions aligned with ESG and AI risk frameworks, such as the following:
    - Sustainable IT principles (e.g., SustainableIT.org, SustainableArchitectures.org, and Green Software Foundation)
    - Responsible AI guidelines (e.g., NIST AI RMF, ISO/IEC 42001, and OECD AI Principles)
    - UN **Sustainable Development Goal (SDG)** alignment and carbon budgets tracked at the artifact level

4. **Enabling proactive impact modeling and optimization**: EA practices such as application rationalization, data lifecycle modeling, and technology currency planning enable measurable sustainability impact through such initiatives as the following:

    - Identifying and sunsetting high-emission applications or services
    - Designing energy-efficient, cloud-native solutions using serverless/FaaS patterns
    - Mapping AI training/inference workloads to low-carbon regions and off-peak times

    Key EA practices to operationalize IT sustainability and responsible AI are as follows:

    - **Sustainability-weighted architecture scorecards**: Evaluate all solution designs using ESG metrics (energy consumption, e-waste, carbon cost, etc.) alongside traditional criteria (cost, security, and scalability).
    - **Responsible AI architecture viewpoints**: Define dedicated architecture views that assess explainability, fairness, bias mitigation, and data minimization for all AI-powered solutions.
    - **Green reference architectures**: Develop reusable solution blueprints that prioritize resource optimization, circular IT principles, and responsible AI patterns. These blueprints would include viewpoints from business, information, security, technology, solution, and infrastructure.
    - **Architecture governance expansion**: Update governance structures to include CSO, risk, ESG, and responsible AI leads. Capture architectural decision records and sustainability KPIs.

    EA's double-win: cost efficiency and ESG impact

    EA can unlock both operational and environmental value—often through the same strategic levers. By leveraging its existing responsibilities in application rationalization, technology modernization, and cloud migration, EA can deliver dual benefits: driving down OpEx while simultaneously contributing to an organization's sustainability and ESG targets.

    EA's existing mandate: the business case for rationalization

    EA already owns critical functions that impact business cost, risk, and agility. These include the following:

    - **Application rationalization**: Identifying redundant, obsolete, or low-value applications for retirement or consolidation

- **Technology modernization**: Replacing outdated technologies with scalable, secure, and efficient alternatives
- **Cloud migration strategy**: Shifting on-premises workloads to the cloud to optimize for agility, cost, and reliability

These efforts are typically pursued to reduce technical debt, lower licensing and support costs, ensure technology currency, and free up IT resources for innovation. The result is enhanced digital resilience and reduced operational burden.

The ESG overlay: sustainability as a strategic multiplier

Layering sustainable IT and responsible AI principles onto these efforts yields environmental gains:

- **Lower emissions**: Retiring legacy applications reduces energy use and GHG emissions
- **Improved efficiency**: Right-sized cloud-native solutions optimize compute usage
- **AI governance**: Embedding responsible AI practices ensures fairness, transparency, and compliance
- **Circular IT**: Hardware decommissioning and reuse reduce e-waste and support circularity

A strategic convergence: debt elimination meets ESG outcomes

Modern EA teams must now reframe rationalization and modernization strategies not just as financial optimization exercises, but as sustainability enablers. Technical debt becomes more than a cost burden—it is an ESG liability. Rationalizing redundant applications and consolidating infrastructure not only reduces OpEx but also cuts embodied and operational carbon, reduces water and energy use, and improves ESG scorecard metrics tied to Scope 2 and 3 emissions.

Call to action: institutionalize the dual mandate

To realize this dual benefit at scale, the following actions must be prioritized:

- Update EA frameworks to include sustainability and AI responsibility in evaluation criteria
- Embed ESG-aligned metrics in rationalization and modernization roadmaps
- Train EA and solution teams in sustainable design patterns and responsible AI practices

- Capture and report double-win value to both CIO/CTO and CSO/CRO audiences

Embedding sustainability and responsible AI into EA for ethical digital transformation

Integrating EA into the design of sustainability and responsible AI initiatives ensures that digital transformation strategies are not only innovative but also ethical, scalable, and aligned with long-term environmental and societal goals. By embedding sustainability and responsible AI principles into the EA framework, organizations can proactively assess impact across the digital value chain, optimize resource usage, enforce governance, and drive accountability from ideation through execution. This alignment enables holistic decision-making that balances technological advancement with ESG outcomes, ensuring that digital innovation contributes positively to both business performance and global sustainability targets.

Organizations that integrate EA into the earliest stages of solution ideation and design will achieve superior long-term value through these outcomes:

- Reduces regulatory risk and better compliance with CSRD, SEC, ISO 14064, and more
- Market differentiation through verifiable ESG claims and transparent AI practices
- Optimized IT investments resulting from reduced carbon costs, infrastructure waste, and redundancy
- Future-proofed operations by embracing circularity and ethical AI adoption

Final thought

The digital world is now deeply intertwined with environmental and societal impact. As AI becomes more pervasive, and ESG expectations intensify, EA must lead the way—not react to outcomes but shape them. By placing EA at the front door of every initiative, organizations unlock a pathway to innovation that is efficient, ethical, and environmentally responsible.

It's time to reimagine EA not as a gatekeeper, but as a sustainability architect—designing digital futures that respect our planet and empower society.

Lisa Pratico, Chair, Sustainable Architectures and Responsible AI, IASAGlobal.org

Principles of sustainable EA

The most fundamental approach to marrying sustainability to EA is to adopt and apply a broad set of sustainability principles (preferably ones adopted by the enterprise) and determine their implications for architecture. The following are 10 general business sustainability principles tailored to EA, with defining statements, rationale, and EA implications (material sourced from the SustainableIT.org report, *Sustainability Principles for Enterprise Architecture* 2024):

1. **Sustainability primacy**: Standard sustainability principles are fundamental to all architectural decisions and designs:
    - **Rationale**: Embedding sustainability in architectural core decisions ensures a consistent approach to minimizing negative environmental and social impacts across the enterprise.
    - **Implications**: Technology standards must include sustainability principles. All architecture and software initiatives (e.g., implementation programs) are evaluated for their ESG impact. Conflicts between sustainability and other objectives are resolved in favor of sustainable solutions in accordance with the enterprise's sustainability priorities.
2. **Ethical foundation**: Sustainable architecture must be founded in ethics (i.e., data responsibility and privacy, cybersecurity and trust, digital equity and literacy, transparency, moral agency, accountability, and hedging against technology misuse):
    - **Rationale**: Ethical conduct helps establish and maintain the legitimacy and authenticity of corporate sustainability efforts and outcomes.
    - **Implications**: Ethical business conduct will be integrated into technology solutions.
3. **ESG integration in decisions**: ESG considerations are integrated into all information systems architecture decisions:
    - **Rationale**: Holistic integration of ESG factors ensures that the enterprise's technology infrastructure supports broader sustainability goals.
    - **Implications**: Decision-making processes must include ESG criteria, potentially leading to the revision of existing architectures and practices and potential trade-offs of current cost-term sustainability gains.

4. **Resource efficiency**: Systems are designed for maximum energy and resource efficiency:
    - **Rationale**: Efficient use of resources reduces the environmental footprint and operational costs.
    - **Implications**: This principle may necessitate investment in more efficient, albeit initially costlier, technologies to achieve long-term savings and environmental benefits. Metrics associated with maintaining legacy infrastructure should be used to help make the business case.
5. **Full lifecycle sustainability**: The entire lifecycle of IT systems defined within EA, from development to decommissioning, is managed with sustainability in mind:
    - **Rationale**: Considering the full lifecycle ensures that sustainability is integrated into purchasing, usage, and disposal practices.
    - **Implications**: Systems and components are selected based on their environmental impact over their entire lifecycle, not just initial costs or performance metrics. Ensuring compliance by value-chain partners necessitates updating the requirements of **statements of work (SOWs)** and licensing for sustainability.
6. **Data center and cloud sustainability**: Data centers and cloud services will prioritize renewable energy sources and energy efficiency, including green data management:
    - **Rationale**: Data centers are significant energy consumers, and this will increase with the deployment of GenAI; utilizing renewable energy and improving energy efficiency reduces the carbon footprint.
    - **Implications**: May require strategic partnerships with green data center providers and a review of cloud services for environmental impact. Cloud sustainability metrics may not be easily available, but adequate approximations can be derived with third-party and open source tools. Continuous pressure on hyperscalers should lead to better cooperation in meeting sustainability requirements.
7. **Vendor and supply chain responsibility**: Vendors and supply chain partners are selected based on their commitment to sustainability and cybersecurity, which are prerequisites for long-term sustainable supply chains:
    - **Rationale**: Sustainable practices extend beyond the enterprise, through the supply chain and vendor relationships.

- **Implications**: Procurement processes need to incorporate sustainability criteria, with requirements updated for sustainability. This may limit the pool of potential vendors but ensures alignment with ESG goals, including environmental impact and human rights. ARBs need to assess sustainability impact.

8. **Digital inclusion**: Information systems will be accessible to all, promoting digital inclusion:
    - **Rationale**: Digital inclusion ensures that the benefits of technology are shared widely, supporting social sustainability and compliance with regulations such as the **European Accessibility Act** (**EAA**) or American Web Content Accessibility Guidelines. It promotes the democratization of secure and trusted digital technologies supported by the ethical handling of data/information.
    - **Implications**: EA must stipulate that those systems be designed to be user-friendly for a diverse set of users, including those with disabilities.
9. **Sustainability innovation**: Innovation efforts will prioritize sustainability, seeking solutions that offer environmental and social benefits:
    - **Rationale**: Advancing sustainability through innovation ensures that new technologies incorporated into EA contribute positively to ESG objectives.
    - **Implications**: May require changes in how innovation projects are selected and funded, prioritizing those with clear ESG benefits. Funding models must be updated to enable investment in new technologies, including reinvestment of efficiency gains; working with third parties for grants, venture funding, and alliances; stage-gate funding; and earned value management.
10. **Continuous sustainability improvement**: The enterprise commits to continuous improvement in its ESG performance:
    - **Rationale**: Sustainability is an evolving target, requiring ongoing effort to meet changing expectations and regulations.
    - **Implications**: This principle necessitates regular review and updating of sustainability goals and strategies, incorporating new technologies and practices as they become available. Also, consider the establishment of feedback/action loops (Kaizen). Fundamentally, there must be regular measurement of outcomes to assess the efficacy of architectural design decisions.

These principles should be applied throughout the architecture layers, not only to the technology stack. *Figure 7.2* illustrates this symbolically, with architecture as the "root" system that supports and feeds the enterprise sustainability "tree."

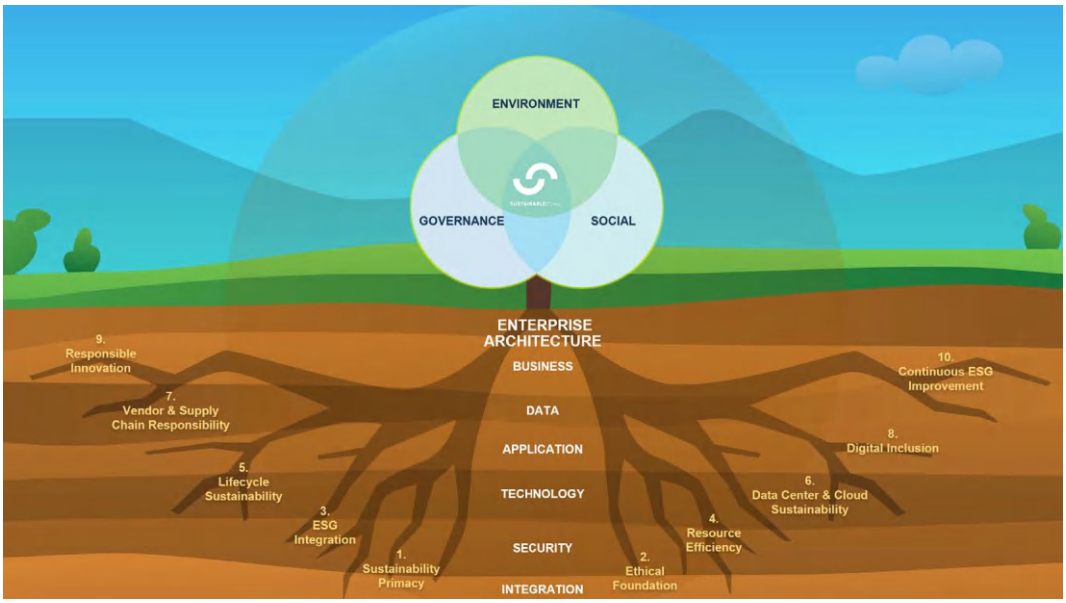


Figure 7.2 Architecture sustainability "root system" supporting enterprise ESG (source: SustainableIT.org).

While broad sustainability principles provide a good framework for architectural design, fulfilling their intent requires a more granular set of operational directives or rules to be incorporated into the architecture. The following are sustainability actions that can help operationalize these principles for key layers of EA:

- **Business architecture**:
  - **Sustainability focus**: Understanding business functions, organizational structures, and how business processes are interconnected, all to ensure that IT systems enhance business efficiency and effectiveness in compliance with enterprise sustainability objectives.
  - **Sustainability actions**:
    - Incorporate ESG sustainability objectives prioritized by the organization into the design of business processes to ensure they drive sustainable practices across the organization.

    - Optimize business processes for ESG, resolving any conflicting priorities or trade-offs by adhering to the company's own ESG agenda:

    a. **Environmental**: Aim for efficiency and sustainability, reducing waste and improving environmental outcomes
    b. **Social**: Aim for accessibility, considering a diverse workforce
    c. **Governmental**: Consider corporate ESG governance aspects such as risk management and digital resiliency

    - In outsourcing or as-a-service situations, licensing and SOW must have terms to ensure compliance with ESG requirements.

- **Data architecture**:
    - **Sustainability focus**: Structuring data storage, retrieval, and management practices to support business processes effectively in a way that complies with environmental (energy consumption, carbon emissions) and social (data integrity and security) sustainability objectives.
    - **Sustainability actions**:
        - Optimize data storage solutions for energy efficiency, leveraging cloud technologies where appropriate for better resource utilization.
        - Require responsible data management practices to reduce the amount of needlessly saved single-use or "dark data," reducing demand for electricity and water for cooling data centers.
        - Consider a hot/warm/cold data approach. Based on its lineage and level of access frequency, data can be treated differently in aspects of access and availability, with potential lower energy use and carbon emissions as a result.
    - Only compute statistics for changed data. Existing analytical data can be integrated. For example, compute revenue change only for the last month. May require a change to the CFO or finance office guidelines.
- **Application architecture**:
    - **Sustainability focus**: Defining the applications necessary for business operations, their interactions, and how they support business processes, meeting the goals of scalability, reliability, and maintainability, and supporting environmental and social sustainability objectives throughout their lifecycles.

- **Sustainability actions**:
    - Design systems to minimize energy consumption and utilize eco-friendly technologies (e.g., containerization, energy-efficient coding, algorithm efficiency, virtualization, and green APIs).
    - Adopt software engineering practices that prioritize resource efficiency and the use of green coding standards. These include shutting down systems when idle and avoiding real-time processing or dynamic content where it isn't necessary.
    - Apply efficient ML model architectures to guarantee better quality while reducing computation. ML model architecture, such as a sparse model, can improve ML quality while decreasing computation by 3x to 10x.
    - Develop a plan for the sustainable upgrade and replacement of outdated equipment and software, incorporating recycling and repurposing strategies. Adjust ROI metrics to capture the value of more energy-efficient and easily repairable/refurbishable equipment.
    - Consider circular economy aspects. Refurbished servers can be used in many cases instead of new purchases, and the resource drain and emissions caused by creating new hardware.
- **Technology architecture**:
    - **Sustainability focus**: Outlining the technical capabilities required to support the data and application architectures, ensuring that technology infrastructure is secure, resilient, scalable, energy efficient, carbon neutral, and broadly accessible by diverse stakeholders.
    - **Sustainability actions (green infrastructure and operations)**:
        - Implement strategies for energy-efficient operation across different times of day, leveraging automation to minimize energy use during off-peak hours.
        - Consider the shift in energy mix with time and other factors (e.g., increased availability of renewable energy such as solar during mid-day).
        - For cloud-hosted computing, develop clear SLAs that outline the expectations and responsibilities related to ESG goals between the enterprise and the cloud provider.
        - For infrastructure as a service, optimize usage to reduce waste, such as scaling resources dynamically based on needs.

- Consider that devices—especially those of end users—don't always need to be cutting-edge. Focus on the least common denominator to meet business and end consumer demands.

There is no need to start from scratch when designing IT infrastructure for sustainability. By leveraging existing architecture frameworks and aligning with global ESG and sustainability standards, EAs can take the lead in designing and governing sustainable digital futures. Several mature EA frameworks provide structure and rigor to support sustainability initiatives:

- **The Open Group Architecture Framework (TOGAF)**: TOGAF promotes structured architecture development through its **Architecture Development Method (ADM)**. TOGAF has explicitly extended its ADM phases to integrate ESG objectives, for example, in healthcare: Queensland Health's EA Vision 2026 uses the ADM to embed data quality and IT capabilities as drivers for ESG alignment across architecture layers (Wu et al. 2024).
- **Zachman Framework**: As a taxonomy rather than a methodology, Zachman allows sustainability-related concerns to be addressed systematically across stakeholder perspectives (planner to subcontractor) and artifacts (data, function, network, people, time, and motivation). Practitioners adapt each Zachman cell to include ESG attributes. For instance, modeling carbon-cost metadata in "what" artifacts, or social impact in "who" artifacts.
- **Department of Defense Architecture Framework (DoDAF):** Emphasizing traceability and systems-of-systems thinking, DoDAF supports modeling sustainability objectives through capability views, operational activities, and system resource consumption profiles.
- **Federal Enterprise Architecture Framework (FEAF):** Aligned with strategic outcomes, FEAF enables the modeling of sustainability goals as part of performance and service delivery metrics, reinforcing compliance and resource efficiency. **Performance Reference Model (PRM)** and **Business Reference Model (BRM)** help federal organizations model service delivery targets and performance metrics—including sustainability KPIs, carbon efficiency, and regulatory compliance indicators.
- IASA Business Technology Architecture Body of Knowledge (BTABoK): BTABoK emphasizes business capability modeling and stakeholder value delivery—two pillars that naturally align with ESG-driven architecture planning and outcomes measurement. The BTABoK is actively evolving through the SustainableArchitectures.org working group, which is formalizing architecture viewpoints and patterns that embed ESG and responsible AI into business capability models, solution templates, and governance practices tailored for sustainable value delivery.

Each of these frameworks offers levers to incorporate ESG priorities into architectural blueprints, whether through principles, views, or artifacts.

Enterprise architects should also connect their frameworks and models to well-established sustainability benchmarks and standards, such as the following:

- **United Nations SDGs**: The 17 SDGs offer a global reference for sustainability, equity, and climate action. EA teams can align architecture objectives and investments with specific SDGs—such as Goal 13 (Climate Action), Goal 9 (Industry, Innovation, and Infrastructure), and Goal 12 (Responsible Consumption and Production).
- **ISO/IEC 42001 (AI Management Systems) and ISO 14064 (Greenhouse Gas Accounting)**: These and other international standards help translate ESG strategy into architecture compliance, measurement, and continuous improvement.
- **Responsible AI Frameworks (NIST AI RMF and OECD Principles)**: Incorporate fairness, transparency, and risk mitigation into AI system architecture and lifecycle management.

Getting started: An action plan

Next, we will walk through the steps to get started designing IT architecture for sustainability:

1. **Align and train stakeholders**: For starters, EA and corporate sustainability leaders should be introduced to each other, with an explanation of their roles and how their responsibilities intersect. Training should include sustainable architecture patterns, responsible AI practices, and the use of ESG metrics in solution design and assessment. Cross-functional collaboration is key: facilitate shared ownership by aligning KPIs and incentives across IT, EA, business, and sustainability functions. Establish forums, working groups, or communities of practice to accelerate learning, share success stories, and continuously refine the sustainability architecture approach.
2. **Audit current EA practices**: Begin by conducting a structured assessment of existing EA activities to determine where sustainability principles are already present and where critical gaps remain. Review architecture artifacts across business, application, data, technology, and infrastructure domains to identify whether any sustainability-related design decisions—such as energy-efficient deployments, responsible data usage, or circular IT practices—have been formally incorporated. Evaluate governance processes, architecture review checklists, and decision logs to understand whether ESG criteria have been used explicitly in project evaluations. This audit should establish a baseline maturity level and highlight high-impact areas for improvement.

3. **Update architecture principles**: Revise enterprise-wide architecture principles to reflect environmental and social priorities. This means embedding criteria such as carbon efficiency (e.g., designing for low energy consumption and emissions), circularity (e.g., promoting reuse, modularity, and recyclability of IT assets), and transparency (e.g., traceable decision-making and AI explainability) into the foundational architectural guidelines that govern all solution designs. These updated principles should be endorsed by ARBs and adopted formally across all solution development processes, ensuring that sustainability becomes a core non-functional requirement alongside security and scalability.
4. **Leverage framework extensions**: Use enhancements to existing architecture frameworks to drive sustainable design. TOGAF's *Environmentally Sustainable Information Systems* guidance can inform how sustainability goals are embedded throughout the ADM. Similarly, cloud vendors such as AWS, Azure, and Google Cloud now include sustainability pillars in their Well-Architected frameworks—offering concrete practices such as selecting low-carbon regions, right-sizing compute resources, and monitoring emissions. Combine these with global standards such as the UN SDGs by aligning capabilities and initiatives to relevant targets, such as SDG 12 (Responsible Consumption) or SDG 13 (Climate Action). These tools help structure ESG-aligned roadmaps and architecture views.
5. **Establish sustainability scorecards**: Develop scorecards that allow EA teams to consistently evaluate architecture designs using ESG-aligned metrics. These should capture indicators such as estimated carbon footprint, energy use, e-waste impact, and social responsibility measures, alongside traditional metrics such as cost, performance, and risk. Integrate these scorecards into architecture review cycles so that sustainability outcomes are tracked and weighted in decision-making. Over time, build dashboards to report progress to CIOs, CTOs, and CSOs, enabling transparency and data-driven refinement of sustainability efforts.
6. **Identify and budget for technology gaps**: Identify current capabilities and technologies to be leveraged. Any technology gaps should be assessed and reviewed by an ARB using a decision criteria scorecard. EAs own the application and technology capability model linking business capabilities to existing technology capabilities, so they will be able to show how technology gaps will impact your financial costs to implement and operational costs to support. Then, prioritize the portfolio initiatives and allocate budget.

7. **Measure results and recommend improvements**: Establish a performance management framework to continuously assess and improve the sustainability of architecture decisions. Begin by defining baseline measurements across key ESG-aligned metrics such as energy consumption, emissions intensity, resource utilization, and responsible AI maturity. These baselines should span architecture domains—business capabilities, application portfolios, data lifecycle management, infrastructure efficiency, and team skill sets.

   Use architecture scorecards and dashboards (see *Step 5*) to model the desired future state, identify gaps, and track progress over time. Where gaps or regressions are identified, engage product owners, architects, and operations teams to collaboratively evaluate solution options. This may include the following:

   - Re-architecting applications or services to adopt more energy-efficient patterns, such as event-driven or serverless models
   - Migrating to cleaner infrastructure, such as relocating compute to low-carbon regions or platforms powered by renewable energy
   - Refactoring data pipelines to reduce redundant processing or eliminate long-term storage of unused data
   - Streamlining redundant tools or platforms to reduce technical debt and lower emissions tied to underutilized assets

ARBs should use these findings to continuously refine architecture standards, project evaluation criteria, and solution design practices. This measurement loop ensures that sustainability is not a one-time exercise but an embedded, adaptive capability that informs strategic investment and operational decision-making.

Optimizing architecture in the cloud using best practice frameworks

The major cloud vendors have recognized sustainability as a critical architecture pillar and are integrating it directly into their design frameworks:

- **AWS Well-Architected Framework**: AWS introduced a *Sustainability* pillar focused on maximizing resource efficiency and minimizing environmental impact. It covers architectural best practices for selecting energy-efficient regions, right-sizing workloads, and designing for minimal hardware impact.

- **Microsoft Azure Well-Architected Framework**: Azure promotes green architecture through workload optimization, carbon-aware coding, and emissions reporting tied to Microsoft Cloud for Sustainability.
- **Google Cloud Platform (GCP) Architecture Framework**: GCP includes guidance on choosing low-carbon regions, automating infrastructure scaling, and using its Carbon Footprint API for sustainability reporting.

By integrating these vendor-specific sustainability tools and practices into the broader EA function, CIOs and architects can drive scalable improvements across cloud, hybrid, and on-prem environments.

Cloud computing made it possible to scale computing resources and data storage in a disruptive way, giving businesses more flexibility and allowing them to better measure the total cost of ownership of their IT. As we learned in *Chapter 6*, *Data Centers and the Cloud*, there are significant environmental benefits in leveraging the cloud, from GHG emission reduction, lower energy consumption, choosing locations with access to renewable energy sources, to decreased waste. A joint study by Microsoft Corporation and WSP Global Inc. suggests that cloud computing can contribute to as much as 98% lower GHG emissions and a 93% reduction in energy consumption than traditional on-premises data centers (`https://www.microsoft.com/en-us/sustainability/azure`). This means organizations can contribute to the UN's SDGs by shifting workloads running in on-premises data centers to the cloud. Many public cloud providers today also offer tools to analyze the organization's carbon footprint in the cloud, such as the Emissions Impact Dashboard from Azure (`https://www.microsoft.com/en-us/sustainability/emissions-impact-dashboard`).

However, just as automating inefficient processes doesn't make them any less inefficient, moving energy-inefficient workloads into the cloud doesn't make them suddenly energy-efficient. That's why public cloud providers such as AWS have adopted a shared responsibility model in which the cloud provider is responsible for the sustainability *of* the cloud, and the customer is responsible for sustainability *in* the cloud. Cloud providers also apply similar shared responsibility models to areas such as security. According to this model, companies need to invest in the application, data, and technical architectures that achieve a high level of efficiency in the cloud.

Following cloud-native architectures, focusing on the optimal use of offered cloud services provides one proven method for accomplishing this:

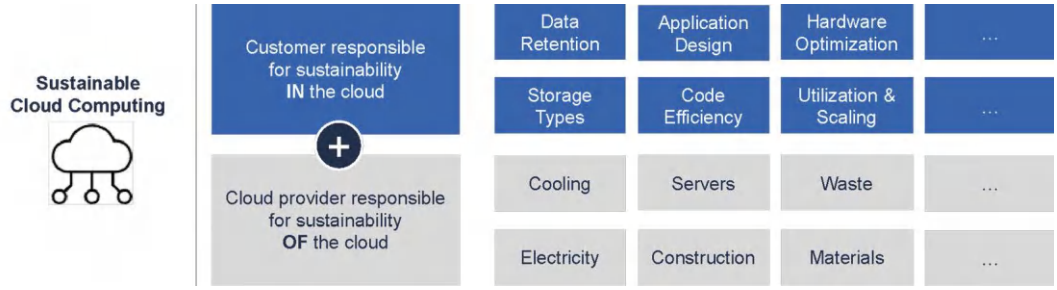


Figure 7.3 – Shared responsibility model for sustainable cloud computing

For both new and existing solutions, optimizing application and data architecture depends on the following best practices. Sources for such best practices include the AWS Well-Architected Framework Sustainability pillar (`https://docs.aws.amazon.com/wellarchitected/latest/sustainability-pillar/sustainability-pillar.html`, the Microsoft Azure Well-Architected Framework (`https://docs.microsoft.com/en-us/azure/architecture/framework/`), and the GCP design for environmental sustainability (`https://cloud.google.com/architecture/framework/sustainability`). While these frameworks reference the cloud services and tools unique to each vendor's platform, the underlying principles are universal. Since they can be applied across public cloud providers, application and data architects should follow them when assessing the current cloud portfolio. The following example questions help assess the different architecture layers:

- **Application architecture**:
    - Is the region of the cloud services best aligned with the location of the users?
    - Is the software architecture optimized for asynchronous and scheduled jobs to minimize the average resources required?
    - Are **application programming interfaces (APIs)** optimized for minimal network traffic needed for the consumers and devices (that is, the GraphQL APIs allow the consumer to define which data is needed)?
- **Data architecture**:
    - Are data retention policies in place to delete unnecessary data?
    - Are technologies used to best support storage and data access while minimizing the resource footprint (that is, SSD disks are more time-consuming than magnetic drives)?

- Is data only backed up when it is difficult to recreate or needed for compliance reasons?

- **Technology architecture**:
  - Are newer, more efficient instance types being used (that is, cloud providers regularly introduce new hardware for their computing instances)? What happens to the old hardware after its end of use? Is it refurbished and resold on the market?
  - Are managed services (for instance, databases) used in favor of self-hosted services on virtual machines to leverage optimization by the cloud provider?
  - Are high-power consumption **graphics processing units (GPUs)** only used when needed and scaled down automatically?

Now, let us look at how to take a pragmatic approach to sustainability tracking by leveraging EA.

A pragmatic EA framework for sustainability tracking

To effectively assess the different architectural layers and achieve sustainability targets, a single source of truth is recommended. The exemplary EA framework (*Figure 7.4*) allows you to manage sustainability targets across all the layers, from strategy and transformation to technical architecture. It demonstrates which types of data about the organization's EA are needed to track the improvement of the UN's SDGs (list items 1 to 3) and which data is needed to apply the cloud Well-Architected frameworks (list items 4 to 8).

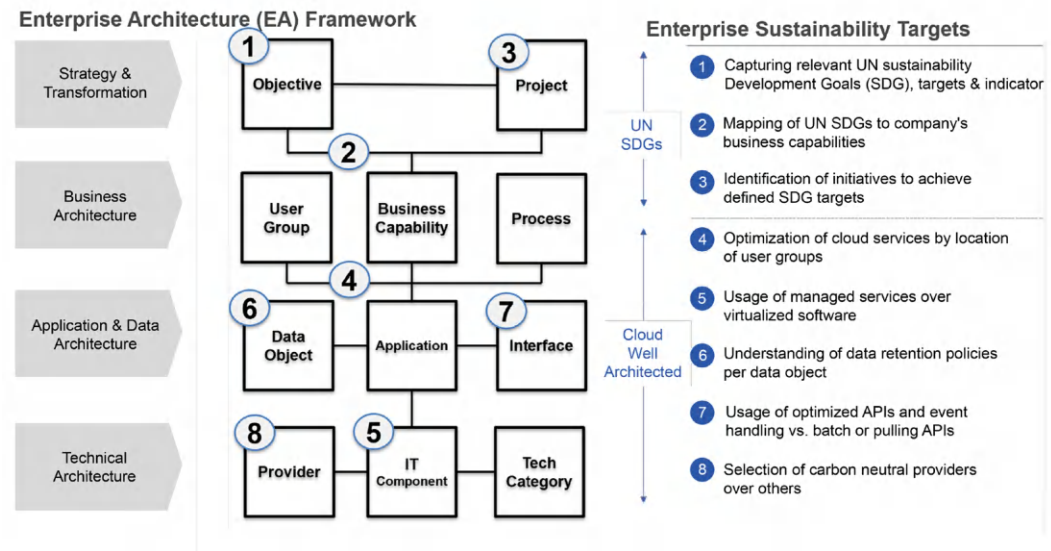


Figure 7.4 – Tracking sustainability targets in an EA framework

EA tools with a focus on ease of use and simplicity facilitate collaborative work on sustainability targets. Such tools allow leadership and experts from different functions to work together, easily extract insights, and make decisions in a data-driven way. The following table shows a representative sample (not an endorsement of the vendors or tools described):

Tool/platform	**Sustainability/ESG focus**
BTABoK Architecture Toolkit	The BTABoK provides architecture tools and techniques for evaluating sustainable impact, including sustainability strategy and governance, principles, patterns, and reporting. Working groups define tool coverage, testing methods, and architecture patterns in business, responsible AI, and data infrastructure, security/risk/compliance, metrics and GreenOps, solutions, and software (`https://btabok.iasaglobal.org`).
Orbus	OrbusInfinity's Sustainability Management Solution bridges the gap between long-term sustainability ambitions and day-to-day business decisions, operationalizing sustainability regardless of current maturity (`https://www.orbussoftware.com/solutions/sustainability-management`).
LeanIX (Enterprise Architecture /EAM)	LeanIX, in partnership with PwC, has added an ESG Capability Map and "ESG Fact Sheet" types to its EAM platform, allowing users to collect, collate, and analyze sustainability data alongside normal EA artifacts (`https://www.leanix.net/en/blog/sustainable-enterprise-architecture`).
Sparx Systems – Sustainable Enterprise Architecture Kit	Sparx provides a "Sustainable Enterprise Architecture Kit" that lets users integrate sustainability/ESG concerns (e.g., map SDG goals, track progress, and monitor ESG) into their modeling environment (`https://www.sparxsystems.us/solutions/sustainable-enterprise-architecture`).
Planview EA	While not exclusively "sustainability-native," Planview EA lets users model business capabilities, map to technology portfolios, and visualize impacts of changes (which could include sustainability metrics) (`https://www.planview.com/resources/case-study/cargill/`).

Tool/platform	Sustainability/ESG focus
ADOIT (BOC Group)	ADOIT supports EA management, alignment, and reporting, and includes collaboration, role-based access, dashboards, and tailored views (`https://www.boc-group.com/en/adogrc/solution/environmental-social-governance-esg`).
ValueBlue	ValueBlue, an enterprise architecture platform provider, does not offer sustainability solutions directly but facilitates sustainability through its platform's ability to manage ESG data, track **key performance indicators** (**KPIs**), calculate GHG emissions, and generate disclosures (`https://www.valueblue.com/`).

Table 7.2 – EA tools with sustainability features

Now that we have the basic framework in place for tracking sustainability targets, let us take a closer look at how **application portfolio management** (**APM**) can be leveraged not only to drive sustainability benefits but also to reduce complexity and lower cost.

Application portfolio management

In today's complex IT landscapes, several challenges must be managed, such as the following:

- The rapid rise of hyperconnectivity, and exponential technologies
- A flexible workforce working from anywhere
- A heterogeneous device landscape with computers, tablets, smartphones, sensors, and IoT devices
- Complex regulations such as the EU **Corporate Sustainability Reporting Directive** (**CSRD**), **General Data Protection Regulation** (**GDPR**), invalidation of the Privacy Shield agreement, and emerging legislation of consumer privacy acts are being enacted on both national and local levels
- Increased cyber threats from state-sponsored actors and cybercrime syndicates
- Sprawling application portfolios demand ever greater computing power, data storage, and network capacity; they contribute to escalating energy consumption, carbon emissions, and water usage, and amplify environmental strain on local ecosystems and biodiversity
- The increased risk of climate failure, which is our biggest humanitarian challenge to date

Managing your portfolio of applications over its lifetime should be a strategic imperative for any organization with many applications. As we saw in the previous section, if you are working in a company with a revenue of $100 million or more, your enterprise environment most likely consists of hundreds or even thousands of applications. Therefore, APM is an integral part of how an organization responds to measuring business value, cost performance, and managing risk. It is essential to set clear application portfolio optimization objectives to simplify, modernize, and transform:

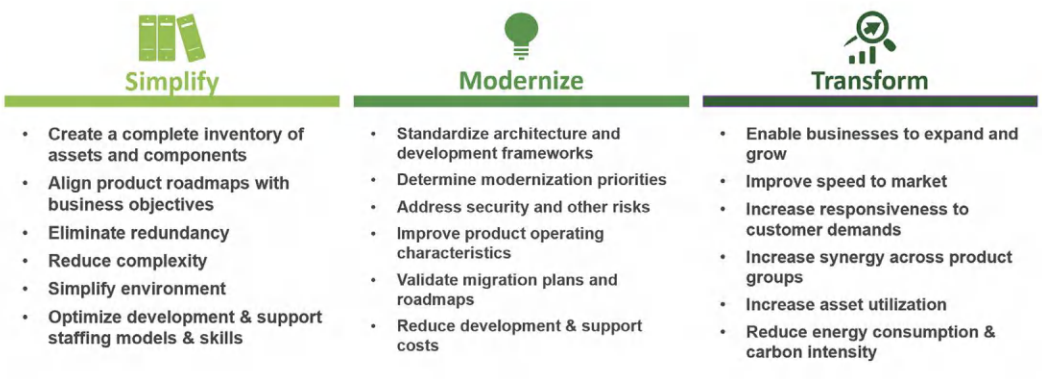


Figure 7.5 – Application portfolio optimization objectives

Once you have identified your application portfolio objectives, you can make a case to rationalize your application portfolio and unlock several benefits, such as increased business agility, reduced IT costs, reduced IT complexity, and an improved risk profile. It is best practice to include application rationalization within your APM. Through application rationalization, there are several other vital cost-saving and sustainability opportunities to be uncovered, including the following:

- Software license optimization
- Elimination and migration of applications
- Simplifies the technology stack by moving workloads from on-premises to the cloud
- Reduced maintenance, support, and operations costs
- Virtualization optimization
- Reduction of data storage, including backup and recovery
- Reduced complexity by eliminating redundancies
- Higher energy efficiencies and lower hardware utilization
- Platform standardization and next-generation architecture

Since APM and application rationalization are well-established practices, it should be no surprise that the cost base could be significantly reduced by embarking on an application rationalization journey. However, let us look at some strategic planning assumptions that you should have when you build your business case (sourced from LeanIX, 2019, unless otherwise noted):

- License costs can be reduced by 30% through license optimization once your enterprise or unlimited license agreement expires
- 52.7% of SaaS licenses go unused, costing companies an average of $21M annually in wasted spend (Zylo 2025)
- Reduce infrastructure costs by 45% through virtualization of hardware, databases, and shared storage
- 20% of operational support can be reduced
- A minimum of 10% of projects can be avoided
- Reducing the number of vendors can improve the TCO by 22% to 28%
- Reducing carbon emissions by as much as 84% to 98% by moving workloads from on-premises to the cloud if deployed using modern cloud deployment strategies and embracing MLOps to scale up or down as needed (AWS 2024; Accenture 2020; IDC 2021)

The following diagram illustrates how a cost case could be transitioned from a current to a target state, including financing the rationalization efforts:

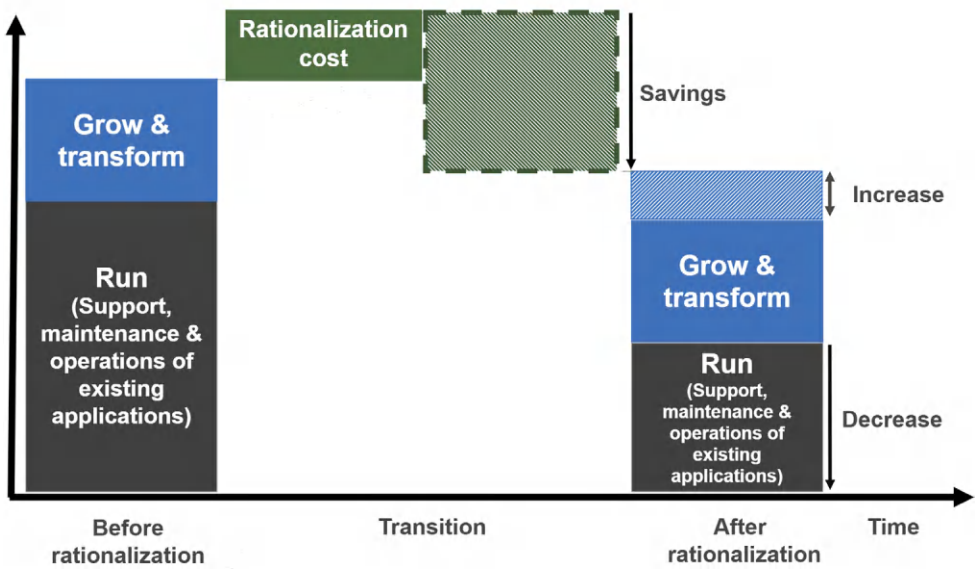


Figure 7.6 – Application rationalization before and after cost benefits comparison

However, what might be surprising are the environmental effects that can be unlocked by avoiding emissions through retired applications, improved energy efficiency, and asset utilization by moving from on-premises to the cloud, and moving workloads running on fossil fuel to renewable energy sources. Even though there is a compelling cost case, the environmental benefits are even more significant in carbon emission reduction, as shown in the following diagram:

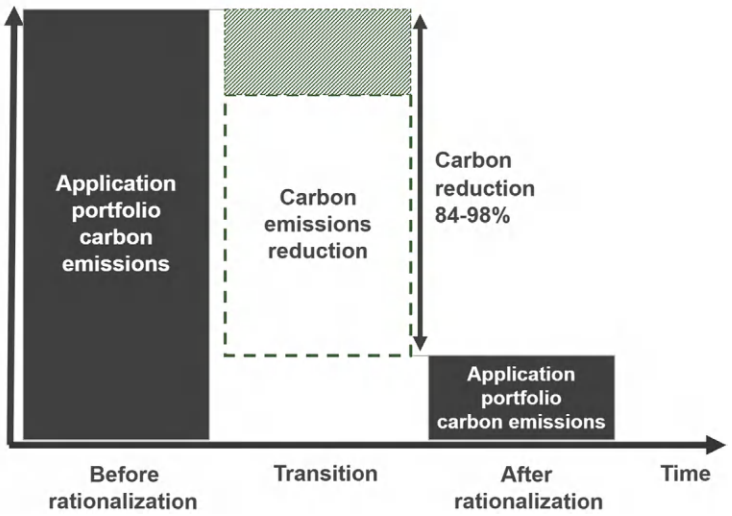


Figure 7.7 – Application rationalization before and after carbon emission reduction comparison

Application rationalization makes a compelling case from a sustainability perspective, along with the usual benefits. It may still be necessary to map rationalization to one or more business cases and calculate its ROI to acquire the funding to implement your rationalization plan. Now that we have learned about both the objectives and benefits from a traditional and sustainability perspective, let us look at the application rationalization process from start to finish.

Application rationalization process

There are several commercially and publicly available application rationalization frameworks to choose from when you decide to embark on an application rationalization journey. Since this book is centered on how you can build your sustainable IT enterprise and evaluate different methods to get there, we will not go to great lengths to explain all the application rationalization processes. We will stay at a high level and point out some of the critical sustainable IT choices that you can make along the way. However, we will point you in the right direction to explore the topic further, since application rationalization is a powerful tool to have in your sustainable IT toolbox.

Most frameworks look the same and follow a five- to six-step process. However, the ones that we have reviewed that are publicly available or from large global consulting firms lack sustainability criteria, and those have been embedded into this model.

This six-step, well-proven process, which will be outlined further here, is an iterative approach to application rationalization (*Figure 7.8*). It allows you to unlock both traditional and sustainability benefits. Please modify the model as you see fit to align with your business strategy, unique requirements, operating model, and organizational setup. If run efficiently with the right stakeholder engagement, you should be able to run a full process within 4 to 6 weeks, depending on the scope and the size of the organization.

Here, you must determine objective and key results, scope, and governance:

- **Identify key stakeholders**: Work with primary and secondary stakeholders to ensure scalability and speed, determine **objectives and key results (OKRs)**, determine the scope, establish governance, identify requirements, including sustainability requirements, and develop or refine a business capability map.
- **Distribute data collection**: Identify applications through manual or automatic discovery, map business capabilities to applications, identify application attributes, develop questionnaire templates, including sustainability-related questions, send a questionnaire to stakeholders (system owners, system managers, system architects, data protection managers, information security, and more), and validate the data collection including the **configuration management database** (**CMDB**).
- **Conduct a value assessment**: For each application in the application inventory, review business value, functional fit, technical fit, and sustainability fit. Ensure that fit for purpose is not just for the current state but for a three-year horizon. The assessment criteria are described in detail in the *Application assessment criteria* section. Review application scores, identify dependencies, identify duplicates, and highlight carbon-intensive applications. Finally, review the quality of the data.
- **Target analysis**: Conduct a target state TIME analysis and identify replacement candidates. Confirm the current-state TCO and identify cost outliers. Confirm current-state carbon emissions, identify sustainable alternatives for carbon-intensive applications, and calculate return on sustainable investment (ROSI).
- **Implementation roadmap**: Identify clusters by function or application type, analyze hosting alternatives, embed sustainability by design into your decision model, and develop a migration strategy.

- **Execute and manage the application portfolio**: The final step is to execute the implementation roadmap, establish a sleeper service to manage your application as an intermediary step toward retirement, and optimize and decommission applications. Recalibrate your application portfolio continuously and track target state objectives such as TCO, ROSI, and carbon emissions. There are EA application portfolio systems on the market that enable you to establish a single repository and automate a lot of the process. For larger legacy systems, there are EA patterns such as the strangler pattern, which offers significant benefits when migrating legacy applications to the cloud, primarily by enabling a gradual, risk-averse transition to microservices. This approach allows for continuous operation, reduced risk, and easier management of complexity compared to a complete overhaul.
- You will also need to determine when to retire applications as part of the rationalization plan. If you retire but have an ELA for five years, you will still be paying for licensing. If the application is connected to other applications tied to a business capability, you have to include the cost of reconnecting the chosen solution or new solution to the other applications in your ecosystem. This once again highlights the criticality of the EA's role in knowing the entire estate and helping manage it.

The following diagram illustrates the sustainable IT application rationalization process, which is an upgrade of the application rationalization playbook to cater to sustainability throughout the process (US Federal CIO Council 2020). It is a six-step process with an infinite loop.

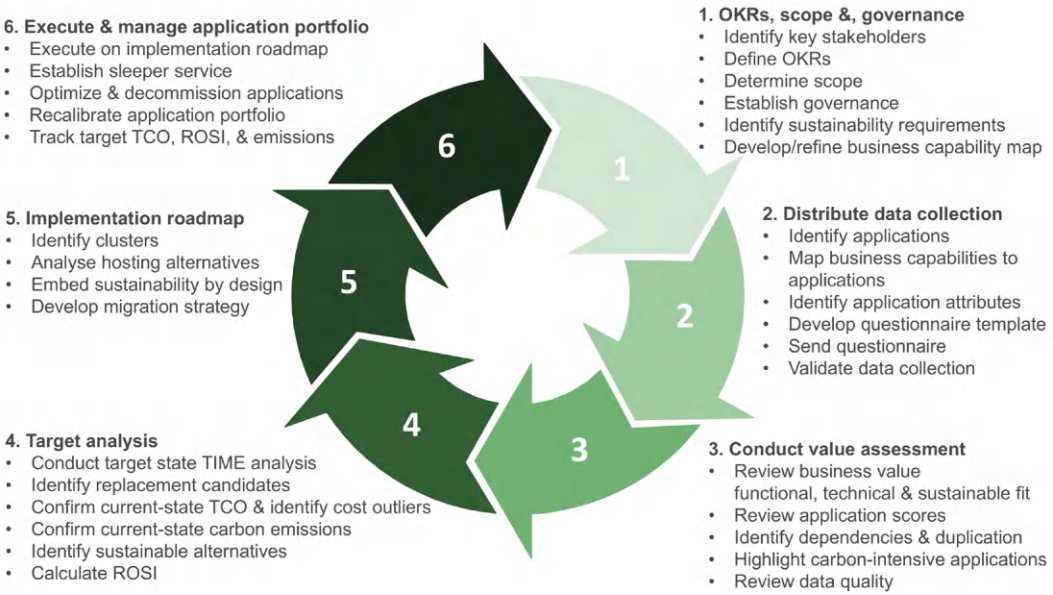


Figure 7.8 – Sustainable IT application rationalization six-step process

Once you have gone through the steps and uncovered your objectives and key results, the process should be executed continuously. A recommendation is to start small with a small set of applications with similar characteristics. It is essential to get buy-in for this process and show some early wins early on.

Let us start with the application assessment criteria. As stated earlier, we will not describe the application rationalization process in detail. Still, we would like to introduce you to how you can embed sustainability requirements into application assessment criteria and use the TIME quadrant to illustrate application cost, carbon emissions, and carbon cost.

Application assessment criteria

Your application criteria should be developed in step 2 of the application rationalization process to assess your application fit. There are six key categories that we recommend that you include in your application assessment criteria. These six categories are strategic value, functional fit, technical fit, costs, data and data protection, and sustainability. The critical attributes for each category are illustrated in *Figure 7.9*.

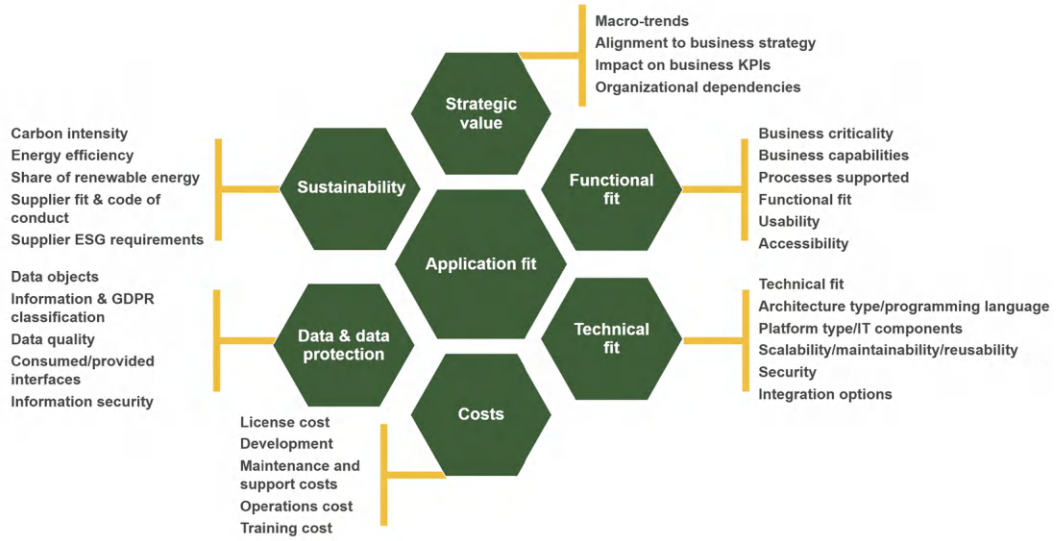


Figure 7.9 – Application assessment criteria

Let us look at each category in more detail:

- **Strategic value**: From a strategic value perspective, you should assess the overall macro trends and how they align with the business strategy. You should ask yourself what impact the application has on the business KPIs and what organizational dependencies exist both in your current state roadmap but also against your future state strategic enabler roadmap.

- **Functional fit**: When assessing the functional fit, you should assess the business criticality of the application. We use four categories to describe business criticality: mission-critical, business-critical, business-operational, and administrative service. You should ask yourself what business capabilities are supported, such as finance, supply chain, sales and marketing, **research and development (R&D)**, and so on. You should also consider what processes are supported, such as order to cash, procure to pay, forecast to plan, plan to produce, and record to report. Consider capability overlap, since one or more capabilities may be needed to execute a process. From an application perspective, break capabilities into features and identify feature overlap by application. You also need to consider what the functional fit of the application is: Does it fit the functional needs perfectly, or is the functional fit insufficient or even unreasonable? From a user experience perspective, you should assess the usability and accessibility of the application.

  Based on the functional fit criteria, a sample application registry could look as follows:

Application ID	1	2	3	4	5
Application name	ERP 1 – Finance & Operations	Sales & Service Ecosystem	Legacy ERP 2 - Finance	E-Commerce Platform	CRM Legacy Application
Business criticality	Business critical	Business operational	Business operational	Mission critical	Administrative service
Business capabilities	Finance, manufacturing, & logistics	Sales, marketing, customer service, & field service	Finance	Sales & customer service	Sales
Process supported	Order to cash, procure to pay, forecast to plan, plan to produce, record to report, & acquire to retire	Quote to cash & service to cash	Record to report & acquire to retire	Quote to cash	Quote to cash
Functional fit	Perfect	Appropriate	Unreasonable	Appropriate	Insufficient
Usability	Appropriate	Perfect	Unreasonable	Appropriate	Insufficient
Accessibility	Appropriate	Appropriate	Insufficient	Appropriate	Insufficient

Table 7.3 – Application registry – functional fit

- **Technical fit**: From a technical perspective, you should assess the technical fit of the application – that is, if it fulfills the needs or not. You should assess if the architecture type of the application is a client-server, n-tier, platform application, or web-based, and what platform it is running on, from an application server, database, or storage to on-premise, **Infrastructure-as-a-Service (IaaS)**, **Platform-as-a-Service (PaaS)**, or **Software-as-a-Service (SaaS)**. Consider questions such as the following: What programming language is it running on? Is it an energy-efficient programming language? What is the scalability, maintainability, and reusability of the application? What is the security posture of the application? Did the organization build out custom-coded features on top of the SaaS product, which will add complexity to migration or changes?

Is it connected to **single-sign-on** (**SSO**) or multi-factor authentication? Has it been penetration-tested? Does it have any underlying vulnerabilities in any of the components in the application stack? How well does the application integrate with other applications? Does it rely on **Open Database Connectivity** (**ODBC**)? What connections, stored procedures, message queues, or more modern APIs does it require?

Based on the technical fit criteria, a sample application registry could look as follows:

Application ID	1	2	3	4	5
Application name	ERP 1 – Finance & Operations	Sales & Service Ecosystem	Legacy ERP 2 - Finance	E-Commerce Platform	CRM Legacy Application
Application type	SaaS	SaaS	Client server	Client server	Client server
Application platform	SAP S/4 Hana	Salesforce	ECC 4.0	IBM WebSphere Commerce 7.0	CRM Dynamics 2011
Database	N/A	N/A	Oracle DB	IBM DB2	MSSQL 2008 R2
Middleware	N/A	N/A	Oracle SOA Suite	BizTalk 2016	BizTalk 2016
Operating system	N/A	N/A	Suse Linux	Suse Linux	Windows Server 2011
Hardware	N/A	N/A	Dell XPS, i7 2-core	Dell PowerEdge M640P	Dell XPS, i7 2-core
Cloud provider	Community cloud	Community cloud	Private cloud	Private cloud	Private cloud

Table 7.4 – Application registry: technical fit

- **Costs**: For each application, it is essential to assess your cost base, including your carbon emission cost. It would help if you tried to understand your licensing, development, maintenance, support, operations, carbon cost, and training costs for each application. Later in this chapter, you will see that when we assess the TIME quadrant, the cost criteria, including the cost of carbon emissions, can be vital in assessing whether you should invest in, tolerate, migrate, or eliminate your application.
- **Risk and compliance**: Managing your governance, risk management, and compliance requirements, such as the CSRD, GDPR, and national and local data protection legislation, is critical. For example, for GDPR, you should assess what data objects reside within your application, what information classification it has, and whether they contain any GDPR classified data. Based on the information classification, what are the information security requirements, such as access control and data portability? What interfaces are provided to consume or provide data to and from the application?
- **Data and data protection**: Managing your master data is a strategic imperative to reduce time to market, deliver operational efficiency, and improve customer experience. It is also important from the sense of meeting governance, risk management, and compliance requirements such as GDPR and national and local data protection legislation. You should assess what data objects reside within your application, what information classification it has, and whether they contain any GDPR classified data.

Based on the information classification, what are the information security requirements, such as access control and data portability? What interfaces are provided to consume or provide data to and from the application? What security measures exist for encrypting data at rest and data in flight?

- **Sustainability**: Finally, the sustainability criteria should be assessed. You should ask yourself, what is the carbon intensity of the application, energy efficiency, share of renewable energy, hardware efficiency, and the embedded carbon from manufacturing the IT hardware? In the *Sustainable software development* section, which we will see later, we will look into how to determine the application's carbon intensity and energy efficiency. What is your supplier fit? Is it a strategic or tactical vendor, or a vendor that you would like to discontinue working with? Has the supplier signed your code of conduct, and how transparent are they in their business practices? How well do your suppliers fulfill your ESG requirements? What net-zero targets have they made? What type of sustainability metrics does your vendor report on? If your vendors do not meet your sustainability requirements, do you cut them loose or do you engage with them to help them improve? In *Chapter 11*, *Leveraging Your Buying Power*, we will look further into what ESG requirements you can impose on your supplier base.

Based on the sustainability criteria, a sample application registry could look like this:

Application ID	1	2	3	4	5
Application name	ERP 1 – Finance & Operations	Sales & Service Ecosystem	Legacy ERP 2 - Finance	E-Commerce Platform	CRM Legacy Application
Carbon intensity	High	Medium	High	Medium	High
Energy efficiency	Appropriate	Appropriate	Unreasonable	Insufficient	Unreasonable
Share of renewable energy	100%	100%	0%	100%	0%
Supplier fit	Strategic	Strategic	Exit	Tactical	Exit
Code of conduct	Signed	Signed	Not signed	Signed	Not signed
ESG requirements met	Partially	Met	Not met	Partially	Not met

Table 7.5 – Application registry: sustainability

The application assessment criteria outlined earlier should give you a good idea of how you could construct your assessment criteria to be included in your questionnaire to be sent out to key stakeholders. Once the receipts have been collected, they should be documented in an application registry, either in an Excel sheet or an EA application. A simple application registry template is available at `www.sustainableitplaybook.com`, which you can download.

Now that we have outlined the application assessment criteria from several different categories, we need to bring everything together to be able to make decisions on our future state application portfolio. In the next section, we will look more closely at how TIME analysis can be leveraged to enable you to make data-driven decisions based on several different decision criteria.

TIME analysis

Once you have your application registry in place, a powerful tool to make your APM analysis come to life is to use TIME analysis. TIME was originally introduced by Gartner in the early 2010s as a strategic framework for APM. It helps organizations categorize applications based on business value and technical health to support rationalization and modernization efforts. There has been moderate uptake of TIME analysis, especially among large enterprises undertaking digital transformation or cloud migration initiatives. It is commonly used as a first-pass filtering tool during APM

There are many alternatives to set on the *X* and *Y* axes. Some put the business fit on the *X* axis and risk on the *Y* axis. We prefer setting business value on the *Y* axis and the technical fit on the *X* axis. Each quadrant represents a decision criterion to tolerate, invest in, migrate, or eliminate the application:

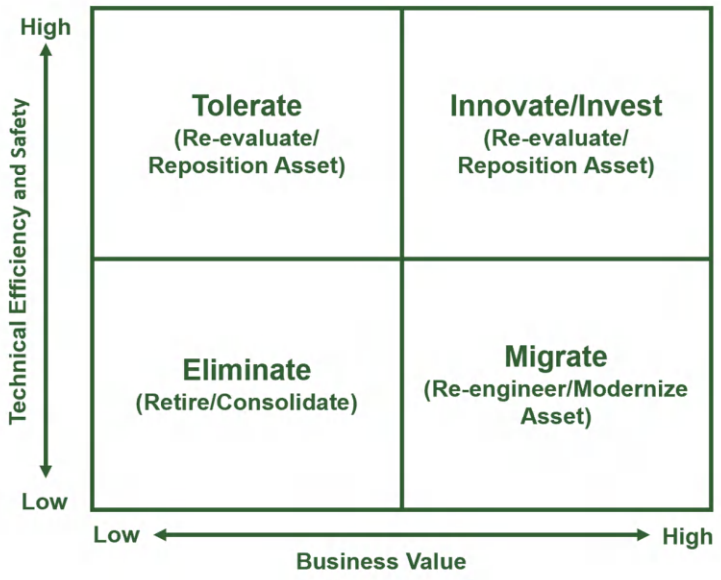


Figure 7.10 – TIME analysis quadrant

Tolerate systems that deliver business value with acceptable technical risk and cost efficiency and meet the sustainability criteria and quality.

Invest in or innovate applications that increase business processes' effectiveness and value, deliver sustainability outcomes, or leverage cross-application stovepipes, service levels, or data volumes that preclude conversion.

Migrate system applications that are critical to providing value to the business but are at high risk and high cost, including high sustainability-related costs to maintain them.

Eliminate systems that no longer deliver business value with acceptable technical risk, cost efficiency, or risk and don't meet the sustainability criteria and quality.

For each of the bubbles representing the application, we tend to use a variety of alternatives to evaluate the size of the application cost, carbon intensity, and carbon cost. *Figure 7.11*, *Figure 7.12*, and *Figure 7.13* show different views of the same hypothetical dataset:

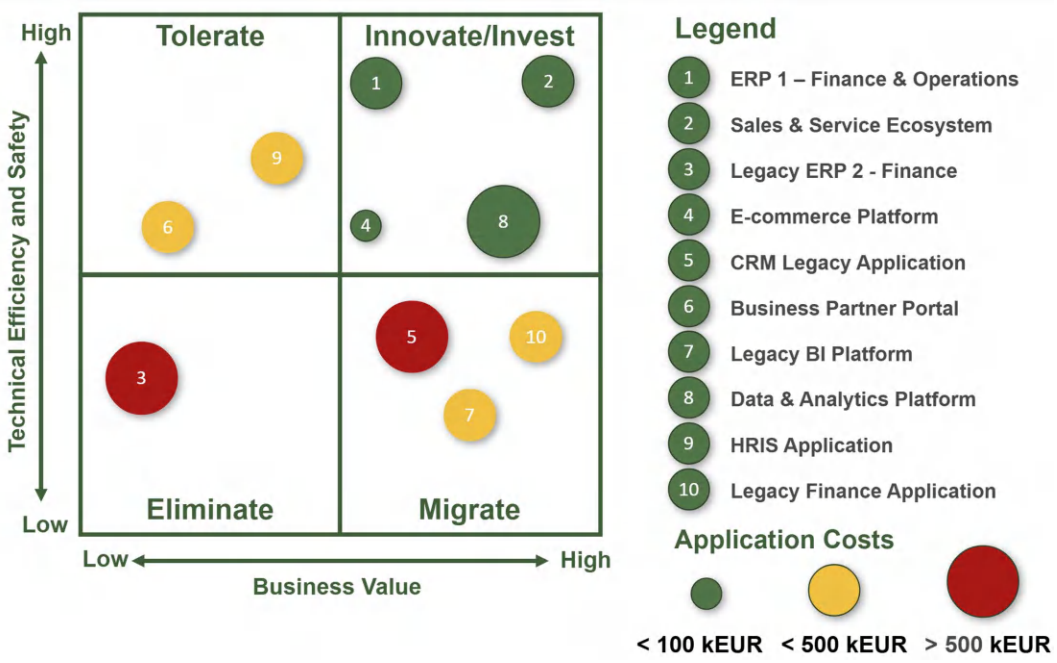


Figure 7.11 – TIME analysis application cost

In the preceding diagram, we can see that 4 applications end up in the eliminate and migrate quadrants out of the 10 applications. Four applications have been deemed to continue investing in, while two applications are being tolerated for the time being. The bubbles in the preceding diagram illustrate the size of the application cost. High cost does not necessarily mean that it should be migrated or eliminated. The application might be of high strategic value, a perfect functional fit, and a good technical fit, and may justify the high cost.

We have now replaced the application costs in our hypothetical dataset with carbon emissions:

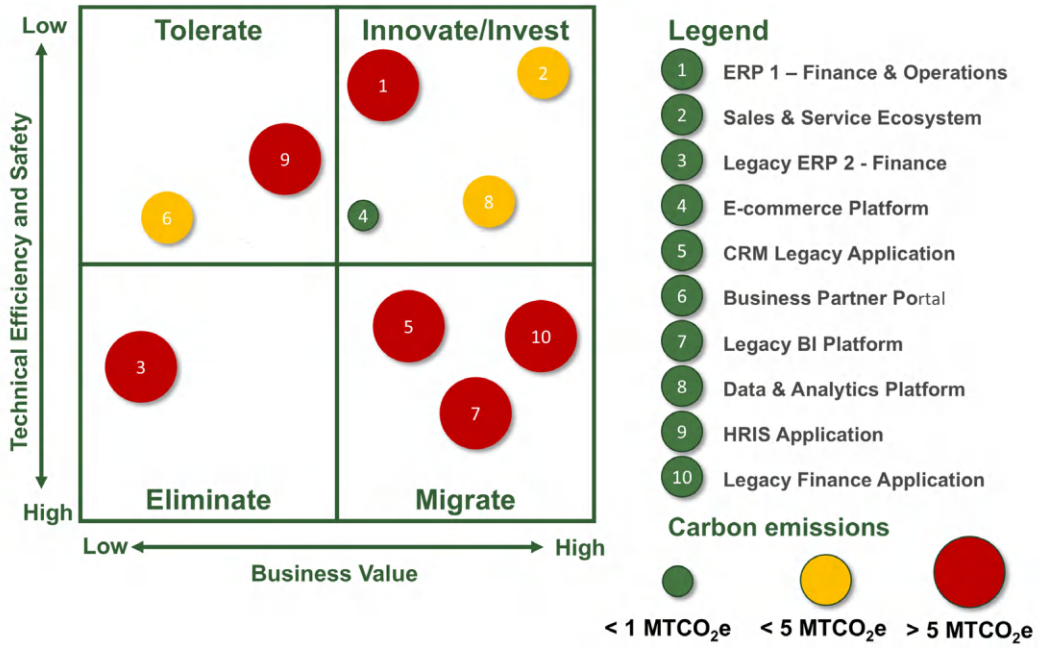


Figure 7.12 – TIME analysis of carbon emissions

The business value and the technical fit are the same. We can see that 6 out of the 10 applications emit more than 5 metric tonnes of CO_2 annually. Three applications emit less than five metric tonnes of CO_2. Only one application emits less than one metric tonne per year, which can be considered acceptable in the *green* or *sustainable* zone. Given the number of bubbles in the tolerate and invest quadrants, we should reassess the hosting options to ensure that the carbon emissions are substantially lowered. The four applications that sit within the migrate and eliminate quadrants should be taken care of. Once they have been retired or migrated, they should positively impact your carbon emissions baseline:

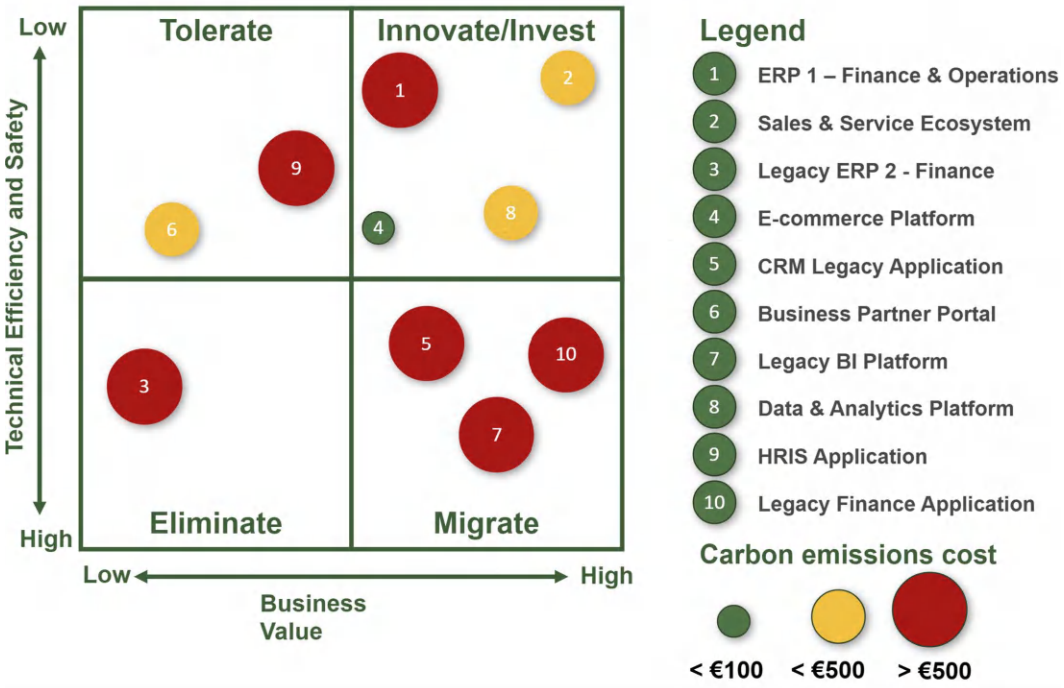


Figure 7.13 – TIME analysis of carbon costs

In the preceding diagram, we have replaced the application costs with carbon emissions costs. The business value and the technical fit are the same. For simplicity's sake, we have set the carbon emissions cost to €100 per metric tonne of carbon dioxide emissions in this example. Hence, carbon emissions per application are multiplied by the carbon emissions tax.

Just like in *Figure 7.11*, we can see that 6 out of the 10 applications have a carbon emissions cost greater than €500 per year per application. Three applications have a carbon emissions cost of less than €500 but more than €100 per year per application. Only one application has a carbon emissions cost of less than €100. Ten applications in this example may not look like much cost. Still, if you are a large organization with hundreds or even thousands of applications, this will add to the accumulated costs due to your carbon dioxide emissions. If your company has put a policy in place that your carbon emissions tax will increase year over year, this will cost a lot of money. In *Chapter 13*, *Get Started Today*, we will cover how you calculate your emissions baseline for your full IT environment.



What is a carbon fee?

- You should think of a carbon fee as a form of a carbon tax. For every metric tonne of carbon dioxide emitted, you must pay a fixed fee that gradually increases year on year. Carbon dioxide tax can be applied to anyone: individuals, enterprises, organizations, and even countries. More and more companies are starting to charge an internal carbon fee to accelerate emissions reduction and match the underlying costs of carbon abatement. The fees are often applied to operations (electricity use in data centers and factories), employee business travel, capital investments, and procurement/supply chains.
- As of 2023, 1,722 companies had implemented internal carbon pricing, with another 3,070 companies planning to do so (CFP Energy 2025). In 2024, set prices ranged from $10 to $130 per metric tonne of CO_2e. The median price was $49/tonne. Prices are climbing. 15% of companies set an internal carbon price above USD 130 per tCO_2e, up from 11% the previous year (World Business Council for Sustainable Development 2025).

Now that you have learned how you can work with your application portfolio to identify different transformative alternatives, both from a strategic value and from a sustainable IT perspective, let us take a look at how you can calculate the carbon emission and carbon intensity for a single application. We will also dig into some of the concepts that you can apply to make your software development more sustainable.

Sustainable software development

In the early days of software development, memory resources and processing power were scarce, and each line of code had to be carefully considered. This changed rapidly, though. Moore's Law—that transistor count doubles every 2 years—has guided decades of exponential growth in computing. But as we approach physical, thermal, and economic limits, the industry is transitioning to a new paradigm. Today, gains are less about raw transistor density and more about performance per watt per dollar. Advances now come from specialization (accelerators, chiplets designed to perform a specific function) and architecture innovation, rather than blind scaling. In parallel, supply constraints, energy budgets, and sustainability goals impose new challenges to growth. As a result, software engineers reclaim a decisive role: writing efficient, carbon-aware code is no longer optional but fundamental to sustaining progress in a resource-constrained future.

To conserve battery time, mobile phone end users in particular tend to turn off resource-intensive applications, and there is a constant demand for manufacturers to produce more battery-efficient products. The demand is not from the software community itself, but from hardware manufacturers and end users demanding more energy-efficient products. **EPEAT, ENERGY STAR,** and **TCO Certified** are world-leading organizations that certify IT products from a sustainability perspective to drive environmental and social change by setting strict certification requirements. These criteria get more challenging every year, which puts pressure on the IT hardware manufacturers to improve to stay in the game continuously. In *Chapter 9*, *IT Hardware Management*, we will look further into IT hardware, but for now, let us turn our focus back to sustainable software development.

Let us look at the definition of sustainable or green software, commonly used interchangeably. However, the concept of sustainability is a bit wider and encompasses the social aspects, and not only the environmental ones. In the simplest form, sustainable software is the practice of considering environmental and social aspects and carrying out the development, operations, and maintenance of software in a sustainable manner, producing a sustainable software product (Calero and Piattini 2015). Building sustainable software should reduce GHG emissions by being carbon-efficient and energy-efficient. To be considered sustainable software, three abstract characteristics need to be fulfilled:

- Throughout the SDLC, the aim should be to save resources and reduce waste, from development, operations, and maintenance to end-of-life
- Software execution should aim to maximize output while minimizing resources and waste
- Sustainable software development practices should be promoted and leveraged throughout the entire lifecycle, from inception to retirement

Let us look at some of these characteristics in more detail.

Choosing energy-efficient programming languages

As we saw earlier, the demand for more sustainable, carbon-efficient, and energy-efficient software originated within IT hardware manufacturers but has quickly gained traction within the software community. Comparing efficiencies by different programming languages might be different since it relies on several factors, such as development frameworks, software patterns, and code quality. Outside factors can also impact the execution time and the energy efficiency by the quality of the compiler, virtual machine, and network latency (Elizabeth 2017).

However, a team of researchers in Portugal studied the effects of 27 programming languages to study the relationship between speed and efficiency. Three performance variables were analyzed: energy consumption, memory consumption, and execution time (Pereira et al. 2017). These 27 programming languages are divided into 4 programming language paradigms: imperative, object-oriented, functional, and scripting.

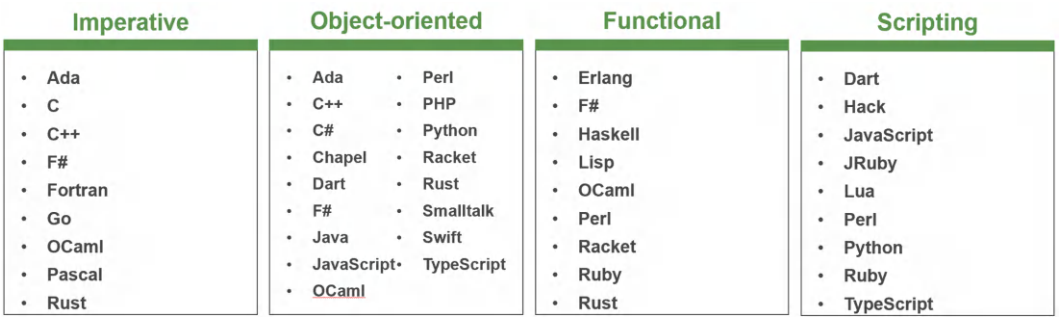


Figure 7.14 – Programming language paradigms (Pereira et al. 2017)

The study found that, on average, imperative languages such as **C** and **Fortran** used the least memory, followed by object-oriented languages such as **Java** and **C#**, functional languages such as **Haskell** and **OCaml**, and finally, scripting languages such as **Python**, **Ruby**, and **Perl**.

In terms of overall energy efficiency, compiled languages (e.g., C, C++, and Ada) consistently outperformed interpreted or runtime-executed languages, which include most scripting languages. Among object-oriented options, Java was the most energy-efficient, performing particularly well when run on optimized virtual machines.

When the researchers combined all three variables—energy, time, and memory—imperative languages again ranked highest across all combinations (energy + time, energy + memory, time + memory, and all three together). In contrast, several popular scripting languages, including JRuby, Ruby, Perl, PHP, JavaScript, and Python, were among the least efficient in the tests. The complete list can be seen here:

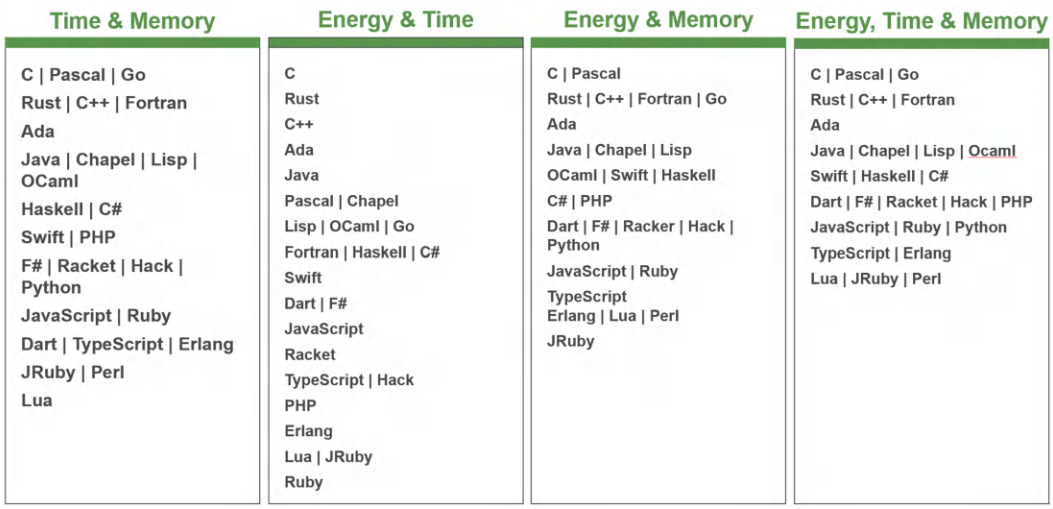


Figure 7.15 – Program language efficiency based on variable combinations (Pereira et al. 2017)

This study's results allow programmers to become more energy-aware when choosing a programming language for their applications, functions, or modules. It is also important to understand that you can write very efficient code using a scripting language and very inefficient code using an imperative language. Today, most development projects do not start from scratch, and several associated libraries are usually imported. If not careful, these imported libraries can have a significant impact on the performance of your software, so it is important to assess and choose carefully before importing them. As we will see in the next section, several other variables within the SDLC, such as the need for upgrades, can significantly impact your application's carbon intensity.

Sustainable SDLC

An SDLC consists of several critical steps: plan, code, build, test, release, deploy, operate, and monitor. A **sustainable software development lifecycle** (**SSDL**) has **sustainability by design** embedded every step of the way. In traditional software development, this process tended to follow a linear waterfall method, but in the last 10 to 15 years, DevOps has become increasingly popular. DevOps combines software development and IT operations into a continuous cycle, as illustrated in the following diagram.

DevOps originally sprang out of the Agile software development discipline. Whether your development methodology follows a linear or circular pattern, your aim should be to preserve resources throughout the entire SDLC:

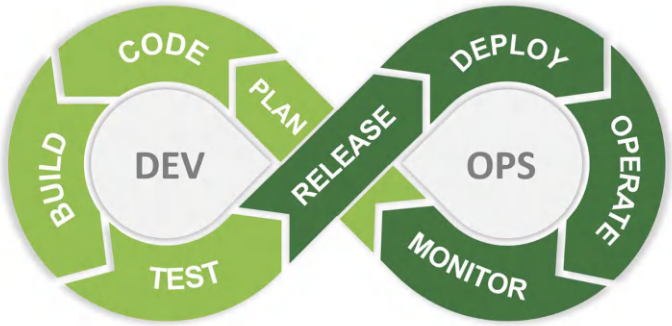


Figure 7.16 – DevOps lifecycle

Several sustainable best practices can be considered throughout the process. The aim should be to build as many carbon-efficient and energy-efficient applications as possible. The method of calculating your carbon emissions and carbon intensity will be covered in detail in *Chapter 13*, *Gett Started Today*. Let us look at what key considerations can be assessed during the planning, software design and development, and software operations and maintenance phases before learning how to engage your employees and teams.

Plan

The planning phase lays the foundation for your application and makes it easier to embed sustainability in the design from the start through proper planning and awareness. There are several key considerations to be considered during the planning phase:

- Decide on a carbon budget or carbon intensity for your application. It may not be the easiest thing to do from the start, but you should be able to set ambitious but achievable ballpark figures such as 0.5 g CO_2 per meaningful page-equivalent operation (or API call, UI transaction, etc.). That scales with a user base, but for a modest service (e.g., 100,000 monthly interactions), you might aim for 100–200 kg CO_2/year. Of course, those should be adjusted up or down depending on your architecture, energy source, and performance trade-offs.
- The important thing is to set a goal, and hopefully, that goal can be lowered as you progress through the SDLC.

- Leverage cloud technologies that can bring you several sustainable benefits: energy efficiencies, hardware efficiency, compute utilization, cloud-native application architecture, and access to renewable/carbon-free energy. Remember from *Chapter 6*, *Data Centers and Cloud*, where you learned that how you host your software and the way you leverage cloud technologies can significantly impact your CO_2 emissions. Cloud-native applications contribute to resource efficiency because they are designed to dynamically scale resources based on demand, which minimizes resource waste and reduces the overall environmental footprint.
- Choose a provider that can power your application with renewable energy, not just through carbon offsets, and provide energy-efficient configuration, monitoring, and optimization capabilities.
- Design modern architectures such as serverless architecture, **Function-as-a-Service** (**FaaS**), and microservices for energy efficiency.
- Design for a multi-cloud setup where workflows can be moved across cloud regions (location-based optimization) and even between different vendors (vendor-based optimization) to optimize your carbon intensity or utilization of renewable energy.
- If you are working with an incumbent application, explore alternative application modernization approaches such as encapsulate, rehost, replatform, refactor, rearchitect, rebuild, and replace.
- Consolidate virtual machines and containers to improve hardware efficiency and resource utilization.
- Leverage automation and **Infrastructure as Code** (**IaC**) to reduce manual labor and efficiently manage the underlying infrastructure.
- Design for efficient hyperscaling to maximize hardware efficiency.
- Design for carbon-aware time-based optimization, such as deployments, testing, backups, and more, to ensure that non-time-critical operations are executed when the carbon intensity is low.

These are some of the considerations that you should have in mind during the planning phase.

Software design and development

Several external and internal factors will determine your design and development approach:

- Choose a carbon-friendly programming language. (Choose energy-efficient software development frameworks based on your programming language(s).

- Work with energy-efficient software design patterns such as Abstract Factory, Builder, Prototype, Singleton, Stateless, and so forth.
- Aim to reuse energy-efficient software to decrease custom-made development efforts.
- While setting up your software **integrated development environment (IDE)**, consider an environment that is the most energy-efficient. Hosting it in the public cloud versus on-premises in a private cloud can play a significant role in resource efficiency and consumption.
- Leverage automation such as **continuous integration/continuous deployment (CI/CD)** to improve SDLC efficiency.
- Understand the energy efficiency of third-party libraries/APIs during the selection process.
- Minimize data amounts and multiple data stores wherever possible.
- Leverage carbon-aware/energy-efficient techniques for shaping your demand. For example, run backups or heavily automated test scripts on off-hours.
- Continuously measure and optimize the energy consumption of your development, test, and training environment.

AI is improving IT test automation by enhancing efficiency and accuracy. AI-powered tools can automatically generate test cases, analyze results, and even fix errors, leading to faster and more comprehensive testing. Here are a few testing use cases.

- AI algorithms analyze user stories, code, and design documents to automatically generate test cases, saving significant time and effort.
- AI-powered tools analyze code changes and automatically update existing test cases, reducing the manual effort required for maintenance.
- AI algorithms can optimize test execution by prioritizing tests based on their likelihood of finding defects, reducing unnecessary runs.
- Anomaly detection capabilities help identify unexpected behavior in applications, improving the accuracy of testing.
- AI can be used to automate exploratory testing, where the software is explored to discover potential issues. This can involve simulating user interactions and identifying areas for further investigation.
- AI integrates with CI/CD pipelines to provide rapid feedback on code changes, enabling continuous testing and faster releases.

These are some of the techniques that you can leverage within design and development. Regardless of what techniques you choose to apply, it is important to understand how your carbon intensity is impacted by different design and development considerations.

Software operations and maintenance

Managing your application over its lifecycle is the phase where we will most likely have the most impact. Therefore, it is important to have a long-term perspective and make sustainable decisions on how you operate and maintain your application. There are also emerging AI tools that can improve testing:

- Ensure that your environment runs on renewable energy sources.
- Continuously measure and optimize the energy consumption of your production environment. Measure the carbon intensity on applications with high change frequency.
- On the network, minimize the amount of data and the distance it must travel.
- Deploy code close to the edge to minimize network latency and minimize data transfer.
- Leverage demand shaping with built-in carbon-aware mechanisms to run batch jobs, deployments, backups, and automated test scripts during off-hours.
- Shut down non-production environments [**user acceptance testing** (**UAT**)], training, integration testing, development, and so on) when not in use, such as at nighttime, at weekends, during holidays, or when the change frequency is low.
- Continuously optimize and refactor applications and APIs to run more efficiently and reduce unused code or feature sets.
- Measure and optimize the carbon intensity of test suites.
- Rationalize applications that are not in use or can be migrated. See the section above in this chapter on application rationalization.
- Leverage automation and AI/ML (AIOps) to continuously optimize utilization, workload, power consumption, and memory size.

It is important to be able to measure your carbon intensity over time and understand the variable change. Applying some of these techniques should help minimize the carbon emission impact over time.

Sustainable software engineering summary: the 3Rs principles

As outlined previously, there are several things that you can do throughout the SDLC to create more environmentally efficient IT systems. If you were to remember only three things that you can do as a software engineer, they should be the **3Rs** principles – relocate, right-size, and rearchitect:

- **Relocate**: As we learned previously, not all energy is created equal. Where you place your workload can have a massive impact on your carbon intensity. The global carbon intensity average of electricity generated is 445 gCO_2/kWh. In Norway and Sweden, which use a large share of renewable energy, the carbon intensity drops to 25 gCO_2/kWh, which is an improvement factor of 17.8 compared to the global average (IEA 2025). With the flexibility that hyperscalers offer, it is easy to choose a low-carbon location that can also meet your information security and data privacy requirements. `electricitymap.org` is a great resource to find out in near-real time what the carbon intensity is within a country or region. We will look closer at `https://www.electricitymaps.com/` in *Chapter 10*, *Energy Resource Management*.
- **Right-size**: Right-sizing your application means you make efficient use of computing resources to translate business requirements into hardware requirements and hardware usage into a carbon footprint. It is about finding the right balance between end-to-end user experience, response time, throughput, and economical/sustainable resource consumption. Considering time-sifting daily, weekly, or monthly variations by running heavy workloads such as batch jobs at night when the carbon intensity is typically lower is also an important factor to consider. Right-sizing your applications typically requires servers with less power that are usually cheaper to acquire and lighter, which means they require less raw material and are more operationally efficient to run since they consume less energy.
- **Rearchitect**: Managing your technical debt is one of the most important things you must do to ensure the longevity of any application from a performance, security, and end user experience perspective. Unfortunately, managing your technical backlog is often overlooked in favor of functional requirements, but if it is not managed properly, it can easily mount up and introduce significant technology risks such as slow performance, unplanned downtime, data loss, or even security breaches. Not all applications are suitable to be rearchitected, but where the opportunity exists, it is important to explore more energy-efficient programming languages (as mentioned previously) and use SaaS or FaaS over servers where possible.

Employee and team engagement

On the road to becoming more sustainable, culture and change management are integral parts, and your software engineers are no different. It is essential to promote and raise awareness and make sustainable software development part of the fabric of every development team, project, or product:

- Raise awareness about sustainable software practices both internally and externally.

- Appoint sustainability champions to reinforce the message and train and empower your team members.
- Promote and reward the use of sustainable software development practices.
- Establish a carbon emission baseline and determine carbon intensity for each application. Set collective goals to radically reduce your carbon emission footprint against your carbon budget. Some companies use internal carbon taxes and link compensation packages directly to sustainability parameters.
- Promote the use of efficient and effective collaboration tools to reduce business travel and office commuting.

Activating and engaging are critical factors to change the culture and the mindset of the organization. Bringing people onto the journey and making them part of the change will enable you to collectively create a positive force within the organization.

Get involved with your peers

If you want to get involved with your peers outside your company on the topics of sustainable EA and green software, there are peer-led non-profit organizations that offer resources and opportunities to contribute. One of the newest is SustainableArchitectures.org, a nonprofit formed in 2025 under the IASA Global umbrella with a mission to advance the adoption of Sustainable IT and Responsible AI patterns and practices in the global architecture community. Its ambition is to do the following:

- Inspire commitment to sustainability across technology leadership
- Create an open community of architects dedicated to advancing sustainable architecture and operations
- Gather metrics, stories, patterns, and best practices to showcase sustainable architecture implementation successes
- Design reusable tools, frameworks, and techniques for achieving ESG-aligned goals
- Educate organizations on sustainable IT strategies
- Promote responsible AI use to meet evolving customer expectations while reducing negative environmental impacts

The **Green Software Foundation** (**GSF**) is an excellent place to start. The GSF is a non-profit organization under the Linux Foundation, bringing together organizations and individuals through various working groups and committees to advance its mission of building a trusted ecosystem of people, standards, tooling, and best practices for green software. Steering members include Avanade, BCG X, Cisco, Google, Microsoft, NTT DATA Corporation, Siemens, and UBS. You can read more at `https://greensoftware.foundation/`.

In this section, we will hear from **Asim Hussain, Executive Director of the GSF**:

> The GSF has a theory of change where we define the desired outcome as a future where there are zero harmful environmental effects from software, and for that outcome to materialize, the following needs to occur:
>
> - We need changes in tech culture so that the environmental effects of software are made a priority
> - We need changes in knowledge so that the environmental effects of software are studied, taught, and understood
> - We need changes in tooling so that the environmental effects of software are easy to act upon
>
> Adopting green software practices will not be easy or free; everything will involve some investment, which means there will always be resistance to adoption. All three pillars of *The Theory of Change* work together to accelerate the adoption of green software practices.
>
> Changing tech culture so that sustainability becomes a core priority reduces the resistance to change. It does not make adopting green software practices any easier; it changes people, so they are more willing to invest. Tooling makes adopting green software practices easier; it reduces the investment that needs to be made. Knowledge is core to everything; people working in tech need an understanding of the environmental impacts of software, as well as how to eliminate them.
>
> Today, we define green software as carbon-efficient software that emits the fewest GHGs possible. Our focus is on carbon; however, with the recent acceleration of new technologies, more attention is being paid to other environmental impacts, such as water and waste, which we must also increasingly consider.
>
> Our position is that there are only three ways an application can eliminate its carbon emissions:
>
> - **Energy efficiency**: Use the least amount of energy possible
> - **Hardware efficiency**: Use the least amount of embodied carbon possible
> - **Carbon awareness**: Do more when the electricity is clean and less when it is dirty
>
> We strive to build a trusted ecosystem of people, standards, tooling, and best practices for green software, but as we evolve as an organization, our focus is becoming more defined. At our core, we are a standard body. We bring organizations and people together to develop standards through consensus. Standards ensure that organizations and practitioners are aligned in how they define, measure, and implement sustainable practices.

They are essential for creating consistent, scalable, and measurable progress in reducing the environmental impact of software and AI systems.

While historically, software and hardware domains were developed apart from one another, with accelerated technology development, software is becoming the central thread that ties all elements together. Hence, its role as a sustainability enabler is becoming increasingly important.

To better support our goals in the evolving space, the SSI Alliance joined the GSF in December 2024. This merger marked a step toward a more unified approach in the ICT sector, where software and hardware evolve together to create more robust standards, greater interoperability, and more efficient digital infrastructure.

As part of our mission to increase knowledge, we created *Green Software Practitioner Training and Certification* (`https://learn.greensoftware.foundation/`). In March 2025, it had been completed by over 114,000 practitioners and published in 5 languages.

In addition, as part of our mission to change the tech culture, we are growing a global community (`https://meetup.com/pro/gsf`) of green software advocates, which has reached over 11,000 members worldwide.

As of April 2025, four of our projects have reached graduation, including **Carbon Aware SDK**, **Impact Framework**, **Policy Radar**, and **Real Time Energy and Carbon Standard for Cloud Providers**. This indicates that the projects are mature and stable, supported by an active community.

Finally, as part of our mission to build tooling, the GSF has developed the **Software Carbon Intensity (SCI)** specification, a methodology for calculating the rate of carbon emissions for a software system. The SCI specification has achieved ISO standard status, confirming its reliability and comparability. As measuring the carbon impacts of AI systems is becoming indispensable, we're working on extending the SCI methodology to account for the unique characteristics of AI.

We continue working to develop standards and tooling to help green software practitioners eliminate their emissions.

The foundation also provides some excellent resources that we recommend you look further into, including *Awesome Green Software* (`https://github.com/Green-Software-Foundation/awesome-green-software`) and *Patterns of Green Software Engineering* (`https://patterns.greensoftware.foundation/`).

> Over the last four years, by watching the green software space mature, I have learned that nothing in this world is more powerful than an idea. Therefore, the most effective thing we can do to help an idea spread is to write, speak, teach, and share all that we learn.
>
> *Asim Hussain, Executive Director, Green Software Foundation*

The GSF has helped "green software" evolve from a fringe conversation about power-hungry code to a disciplined movement linking engineering practices, cultural transformation, and measurable environmental outcomes.

The SCI metric that Asim refers to provides a repeatable, comparable, and auditable method for quantifying the carbon impact of software systems. By adopting SCI, CIOs and software leaders can begin to extend carbon accounting into the digital domain, making software as measurable as facilities, logistics, or hardware assets.

The ISO certification for SCI is **ISO/IEC 21031:2024**. Here is the formula:

$$SCI = ((E*I) + M) \text{ per } R$$

E (energy consumption) is energy consumed by software in kWh.

I (carbon intensity) is carbon emitted per kWh of energy, that is, gCO_2/kWh.

M (embodied emissions) is carbon emitted through the hardware on which the software runs.

R (functional unit) can be any unit of scale, such as per user or per device. It is what makes the SCI into a tool that works for every software domain, every use case, and every person.

Summary

In this chapter, you discovered how to optimize your entire application portfolio to run more sustainably and emit less carbon. You learned how EA will be the blueprint for the foundation of your sustainable IT future. You learned about benefits, costs, and emission opportunities as an introduction to application portfolio management. By now, you should have a good understanding of the application rationalization process, application assessment criteria, and TIME analysis from a cost, carbon emission, and carbon cost perspective.

Furthermore, you should understand what opportunities exist within sustainable software development, from choosing an energy-efficient programming language to key considerations during each step of the way in the SDLC. Also, you were introduced to peer organizations you can work with, including the Green Software Foundation and SustainableArchitectures.org.

Here are summary recommendations for you:

- **Energy efficiency**:
    - Start shifting out resource-intensive and inefficient legacy applications in your application portfolio to enterprise cloud solutions that can power your ERP, CRM, SCM, and e-commerce ventures.
    - Monitor energy consumption down to the application level. Use the least amount of energy possible.
    - Utilize or shift to energy-efficient application architectures such as serverless computing or FaaS.
    - Minimize data amounts and multiple data stores wherever possible.
- **Hardware efficiency**: Choose hardware wisely. Use the least amount of embodied carbon possible.
- **Carbon awareness**:
    - Utilize or shift your application portfolio to providers utilizing low-carbon grids
    - Explore time, location, and vendor-based demand shaping
    - Move workflows across cloud regions, depending on low-carbon availability

If you see a significant opportunity to reduce carbon emissions within your application portfolio or a single application, we recommend studying the concept further and downloading the book resources from `www.sustainableitplaybook.com` or exploring the *Further reading* section.

In the next chapter, we will look at how to manage data for sustainability and govern AI responsibly.

Appendix: Standard metrics for applications and software development sustainability

Energy and emissions metrics from the SustainableIT standardized metrics taxonomy listed next apply to the application portfolio as a whole and to the software development processes used to create applications. There are separate metrics for on-premises applications versus third-party hosted ones. Related service delivery metrics cover the environmental impacts of application delivery and operations. Water consumption metrics are addressed in *Chapter 6*, *Data Centers and Cloud*. Social sustainability metrics related to applications are listed in *Chapter 5*, *Social Sustainability: Accessibility, AI, and the Digital Divide* (SustainableIT.org 2024).

Category	Topic	Metric	Related Global Standards
SIT EF 100 Energy (Function)	EF 113 Application portfolio total energy consumption (avg. workloads)	EF 113-1 On premises-hosted:	GRI 302-1, 3 TC-IM-130a.1 TC-SI-130a.1 ESRS E1 SDG 7, 9, 13, 17
		EF 113-1.a kWh power consumption by location, room, time of day, per end user	
		EF 113-1.b kWh consumption for software updates	
		EF 113-1.c Percentage of portfolio running on renewable energy: solar, wind, geothermal, hydropower, tidal, biomass	
		EF 113-1.d Percentage development following green design and code practices	
		EF 113-2 Third-party-hosted, co-located:	
		EF 113-2.a kWh by provider, location, room, time of day, per end user	
		EF 113-2.b kWh consumption for software updates	
		EF 113-2.c Percentage of portfolio running on renewable energy: solar, wind, geothermal, hydropower, tidal, biomass	
		EF 113-3 Percentage using containers, microservices, serverless	
		EF 113-5 Percentage of portfolio green coded	

Category	Topic	Metric	Related Global Standards
SIT EF 100 Energy (IT Function)	EF 130 Lifecycle energy consumption of IT products and services (e.g., application operations, messaging and collaboration, service desk, security, networks, and connectivity): electricity, heating, and cooling	EF 130-1 Percentage of IT products and services having an extraordinarily high workload	GRI 302-1, 3 ESRS E1 SDG 7, 9, 13, 17
		EF 130-2 Percentage of IT products and services running on renewable energy: solar, wind, geothermal, hydropower, tidal, biomass	
Emissions SIT EF 200 (IT Function)	EF 213 Application portfolio emissions (avg. workloads)	EF 213-1 On premises-hosted metric tonnes CO_2, by portfolio, by location	GRI 305-1, 2, 3 TC-IM-130a.1 TC-SI-130a.1 ESRS E1, E2 SDG 7, 9, 13, 17
		EF 213-2 Third-party-hosted metric tonnes CO_2, by portfolio, by provider	
Emissions SIT EF 200 (IT Function)	EF 220 Lifecycle emissions IT products and services (e.g., application operations, messaging and collaboration, service desk, security, networks and connectivity). Includes electricity, heating, and cooling	EF 220-1 Metric tonnes of CO_2 by product or service	TC-IM-130a.1 TC-SI-130a.1 GRI 305-1, 2, 3 ESRS E1, E2 SDG 7, 9, 13, 17

Table 7.6 – SustainableIT standards taxonomy metrics for applications and software development

Further reading

To learn more about the topics that were covered in this chapter, take a look at the following resources:

- *The Application Rationalization Playbook*: `https://www.cio.gov/assets/files/Application-Rationalization-Playbook.pdf`.
- *Awesome green software – research, tools, code, libraries, and training for building applications that emit less carbon into our atmosphere*: `https://github.com/Green-Software-Foundation/awesome-green-software`.
- *Cloud Carbon Footprint, an emissions measurement and analysis tool. Free and open source*: `http://www.cloudcarbonfootprint.org/`.
- *Computer benchmark game*: `https://benchmarksgame-team.pages.debian.net/benchmarksgame/index.html`.
- *The Green Software Foundation*: `https://greensoftware.foundation/`.
- *AWS Carbon Footprint tool*: `https://docs.aws.amazon.com/awsaccountbilling/latest/aboutv2/what-is-ccft.html`.
- *Microsoft Azure Emissions Impact Dashboard*: `https://www.microsoft.com/en-us/sustainability/emissions-impact-dashboard?activetab=pivot_2:primaryr12`.
- *Google Cloud Carbon Footprint*: `https://cloud.google.com/carbon-footprint`.

Bibliography

- Accenture. 2020. *Cloud Migrations Can Reduce CO_2 Emissions by Nearly 60 Million Tons a Year*. `https://tinyurl.com/46nruzfd`.
- Accenture. 2020. *The Green Behind the Cloud*. `https://aecconsultoras.com/wp-content/uploads/2020/10/Accenture-Strategy-Green-Behind-Cloud-POV.pdf`.
- AWS. 2024. *Embracing Modernization with a Sustainability Focus*. `https://aws.amazon.com/blogs/migration-and-modernization/embracing-modernization-with-a-sustainability-focus/`.
- Calero, Coral, and Mario Piattini. 2015. *Introduction to Green Software Engineering*. Springer International Publishing.
- CFP Energy. 2025. *Internal carbon pricing: Climate ambition to financial strategy*. `https://www.cfp.energy/en/insights/internal-carbon-pricing-climate-ambition-to-financial-strategy`.

- Elizabeth, Jane. 2017. *Java is one of the most energy-efficient languages, Python among least energy efficient*. September 18. https://jaxenter.com/energy-efficient-programming-languages-137264.
- Gartner. n.d. *Glossary*. *Gartner*. https://www.gartner.com/en/information-technology/glossary/application-program.
- IDC and Statista. 2024. *Volume of data/information created, captured, copied, and consumed worldwide from 2010 to 2023, with forecasts from 2024 to 2028* (in zettabytes) [Graph]. In Statista. https://www.statista.com/statistics/871513/worldwide-data-created/.
- IDC. 2021. *Cloud Computing Could Eliminate a Billion Metric Tons of CO_2 Emission Over the Next Four Years, and Possibly More, According to a New IDC Forecast.* IDC. https://www.businesswire.com/news/home/20210308005095/en/Cloud-Computing-Could-Eliminate-a-Billion-Metric-Tons-of-CO2-Emission-Over-the-Next-Four-Years-and-Possibly-More-According-to-a-New-IDC-Forecast.
- IEA. 2025. *Emissions*. https://www.iea.org/reports/electricity-2025/emissions
- LeanIX. 2023. *Only 40% of companies feel prepared to comply with ESG regulations.* https://www.leanix.net/en/company/press/only-40-percent-of-companies-feel-prepared-to-comply-with-esg-regulations.
- LeanIX. 2019. *Enterprose Architecture Insights Report*. https://www.leanix.net/en/download/enterprise-architecture-insights-report-2019.
- Microsoft. 2023. *Carbon-aware computing: Measuring and reducing the carbon footprint associated with software in execution*. https://news.microsoft.com/de-ch/2023/01/10/carbon-aware-computing-whitepaper/.
- Okta. 2025. *Businesses at Work 2025*. https://tinyurl.com/27jsbk8s
- Netskope. 2024. *Cloud and Threat Report*. https://www.netskope.com/resources/reports-guides/cloud-and-threat-report-2024.
- Pereira, Rui, Marco Couto, Francisco Ribeiro, Jácome Cunha, Joâo Paulo Fernandes, and João Saraiva. 2017. *Energy Efficiency across Programming Languages - How Does Energy, Time, and Memory Relate?*. September. https://greenlab.di.uminho.pt/wp-content/uploads/2017/09/paperSLE.pdf.
- Productiv. 2025. *9 statistics IT leaders need to know in 2025*. https://productiv.com/blog/it-saas-statistics/.
- Spiceworks. 2024. *2024 State of IT: Detailed IT Budget Breakdown.* https://www.spiceworks.com/research/state-of-it-budget/.

- SustainableIT.org. 2024. *Sustainability Principles for Enterprise Architecture*. https://members.sustainableit.org/knowledgebank-mfe#/knowledgebank/2/664669cb8b642300b3806dd3/0 (Access restricted to SustainableIT.org members only.)
- SustainableIT.org. 2024. *Standards Taxonomy V1.2*. https://www.sustainableit.org/standards/it-esg-standards.
- TechTarget. 2024. *What is an application?* https://www.techtarget.com/searchsoftwarequality/definition/application.
- U.S. Federal CIO Council. 2020. *The Application Rationalization Playbook - An Agency Guide to Portfolio Management. cio.gov*. https://www.cio.gov/assets/files/Application-Rationalization-Playbook.pdf.
- World Business Council for Sustainable Development 2025. *Integrating climate with financials: Internal Carbon Pricing*. https://www.wbcsd.org/news/integrating-climate-with-financials-internal-carbon-pricing.
- World Economic Forum. 2023. *Microsoft - An internal carbon tax to cut Scope 3 emissions*. https://initiatives.weforum.org/industry-net-zero-accelerator/case-study-details/microsoft---an-internal-carbon-tax-to-cut-scope-3-emissions/aJYTG00000001Dp4AI.
- Wu, Chia-Chi, et al. *Strategic Deployment of EA Frameworks to Address ESG Challenges in Healthcare*. https://eapj.org/wp-content/uploads/2024/10/Strategic-Deployment-of-EA-Frameworks-to-Address-ESG-Challenges-in-Healthcare.pdf.
- Zylo. 2025. *2025 SaaS Management Index Report*. https://go.zylo.com/l/504631/2025-01-13/7pf53m/504631/1736803756ZiIdIz9a/saas_management_index_report_2025_final.pdf?_gl=1*1pn3ohm*_gcl_au*MTY4MzQ5MjkzMS4xNzU5Njk0NTA1.
- Zylo. 2025. *Application Rationalization Guide*. https://zylo.com/blog/application-rationalization/.

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8

Data

> *One zettabyte is 1 billion terabytes. If each terabyte in a zettabyte were a kilometer, the total would be equivalent to 1,300 round trips to the moon and back."*
>
> *Shruti Jain, Chief of Staff to EVP and GM, Security and Collaboration, Cisco*



The amount of data created, copied, and consumed in 2025 was expected to be 181 zettabytes.

In *Chapter 7*, *Applications and Architecture*, we addressed the need for application rationalization and its positive impact on organizations' energy profile. In this chapter, we will address the complementary challenge of rampant data proliferation that those applications contribute to, and the environmental impact we can have through better controls. Experts at **Perforce Delphix** will highlight multiple strategies for sustainable dataset management. Since AI models and applications are responsible for much of the data proliferation, we will dive into a runbook of actions, KPIs, and tools to operationalize five fundamental principles of responsible AI data governance.

Shifting gears from general enterprise data to ESG-specific data, we will learn how to establish a centralized data platform and dashboards that pull ESG data from diverse sources and present it as actionable information to decision makers. **ServiceNow**, **Choice Hotels International**, and **Mastercard** provide real-world insights and examples.

In this chapter, we will cover the following topics:

- How to minimize the impacts of data proliferation
- Sustainable dataset management
- AI data governance principles, actions, and KPIs
- Tools that can assist with the governance of AI data
- Centralized management of enterprise sustainability data, with examples from Choice International Hotels and Mastercard
- Standard metrics for sustainable data governance

As shown in the sustainable IT reference model (*Figure 8.1*), this chapter addresses data governance in the context of the applications and physical platforms. A sustainability culture will be reinforced by normalizing data sustainability practices and by making ESG data transparent and accessible. This will also support regulatory reporting.

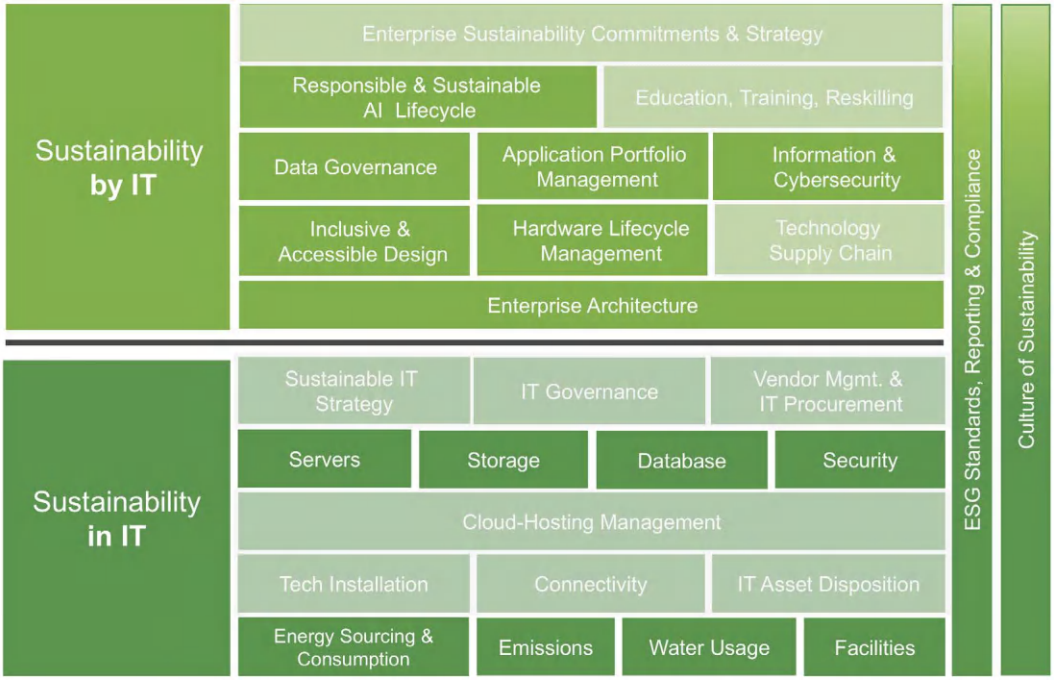


Figure 8.1 – Sustainable IT reference model – Chapter 8's focus

By the end of this chapter, you will have a better understanding of data's impact on sustainability and how IT organizations are adapting their traditional data stewardship responsibilities to govern effectively in the age of AI.

Most of the material in this chapter relates to the environmental pillar of sustainability. We will not cover the security and privacy aspects of data governance since you are already employing mature techniques and best practices for this long-standing responsibility. We do, however, include the standard metrics for data security and privacy that align with global ESG reporting standards, since they will be needed for compliance reporting by your peers in the sustainability and legal offices. Indeed, data security and privacy are ESG tenets and support the UN Sustainable Development Goals, particularly SDG 16 (Peace, Justice, and Strong Institutions) and SDG 9 (Industry, Innovation, and Infrastructure). We addressed metrics related to sustainable data centers in *Chapter 6*, *Data Centers and Cloud*. You will also find numerous KPIs specific to AI data governance listed later in this chapter.

How to minimize the impacts of data proliferation

IBM first stated in 2012 that 90% of the world's data was created in the past two years. That same year, the total amount of digital data surpassed 1 **zettabyte (ZB)** for the first time. The amount of data created, copied, and consumed in 2025 is expected to be 181 ZBs (World Economic Forum 2024). IDC predicts that the datasphere will reach 394 ZBs generated in 2028, 6 times the volume generated in 2020 (*Figure 8.2*) (IDC 2024).

However, one organization anticipates us generating 1,000 ZB by the early 2030s (DesignRush 2025).

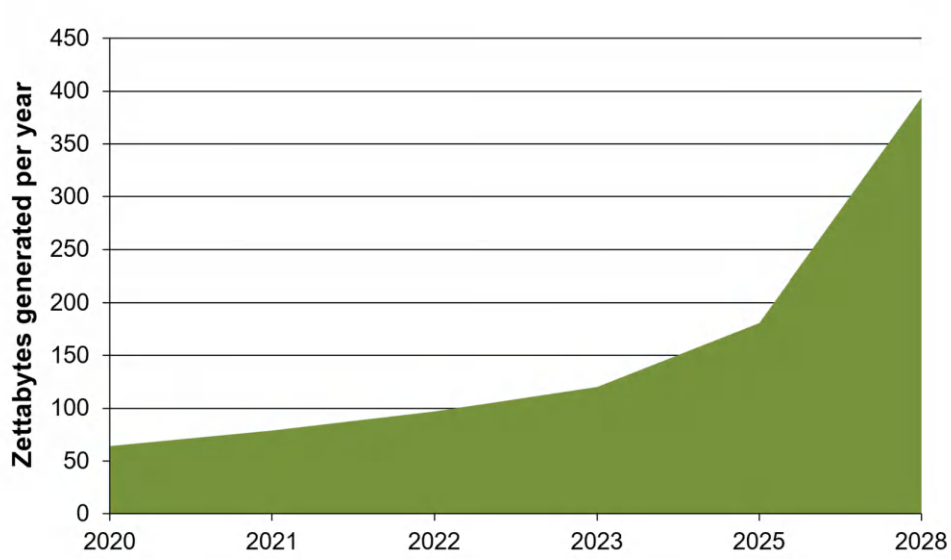


Figure 8.2 – Annual data generation

All of this data generation, usage, and storage increases electricity demand and escalates your carbon footprint. The energy consumption from data centers, cryptocurrencies, and AI could reach as much as 1,000 **Terawatt Hours (TWh)** in 2026, compared to 460 TWh today (IEA 2024). Sloppy data governance compounds the problem. Research shows that 52% of the data painstakingly collected and stored by companies is "dark data"—data that the enterprise does not actively use for analysis, decision-making, or other business purposes. It is "dark" because it remains hidden and untapped—like dark matter in space—even though it still consumes storage, energy, and risk management resources.

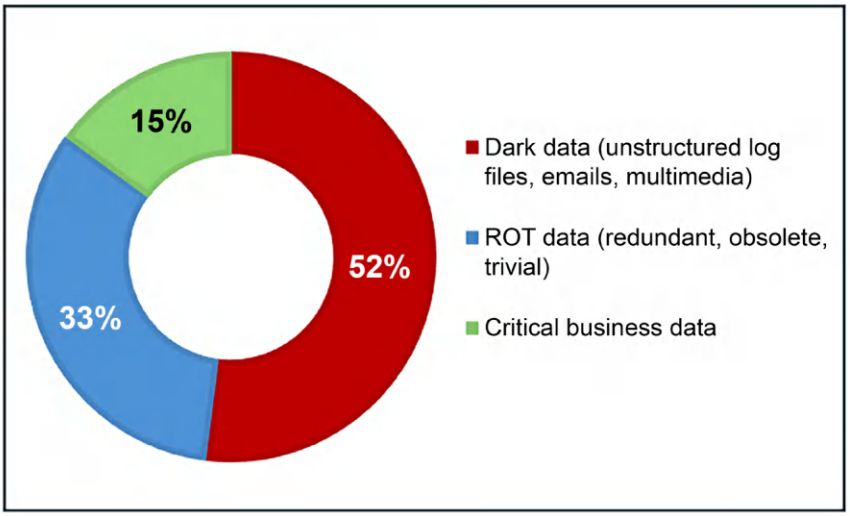


Figure 8.3 – Enterprise data is more than 50% dark (Big ID 2022).

From a sustainability perspective, this is a huge cause of concern. Companies keep adding storage rapidly and uncontrollably, and we lack adequate processes for deleting data. IT needs to establish and enforce master data and informational data guidelines, principles, and design patterns. Large companies should store a single source of truth instead of moving and copying the same data into multiple spreadsheets and databases.

"The rate of data growth and the environmental cost of data make it a big concern for sustainability," says **Jedidiah Yueh, CEO of Software.com and Co-founder of SustainableIT.org**. *"It's critical for companies to apply the rules of DevOps to data, to automate the setup and teardown of data environments used for development, testing, analytics, and AI/ML model training. By enabling ephemeral test runs, companies can reduce the environmental cost of application and data environments by over 90%."* An ephemeral test is a temporary, isolated, and disposable testing environment that is automatically provisioned and destroyed after use.

IT once employed data minimization practices to save costs. But storage costs plummeted, and so did the use of such practices. Now we need to rethink our data management practices with a focus on limiting environmental impacts and, as always, security risk. Here are some fundamentals to apply to modern data management:

Governance, policy, and culture

- Establish a "data sustainability" policy: include environmental impact as a criterion in data design and architecture reviews
- Incentivize data stewards and developers to optimize: embed sustainability KPIs into data engineering, analytics, and DevOps roles
- Educate teams on the hidden cost of data: raise awareness about the environmental impact of "data hoarding" and unnecessary model logs, checkpoints, and outputs
- Review third-party data integrations: limit real-time data feeds and APIs to only what is essential for business outcomes

Data architecture and lifecycle management

The following illustration shows sustainability criteria to apply to system lifecycle stage gates:

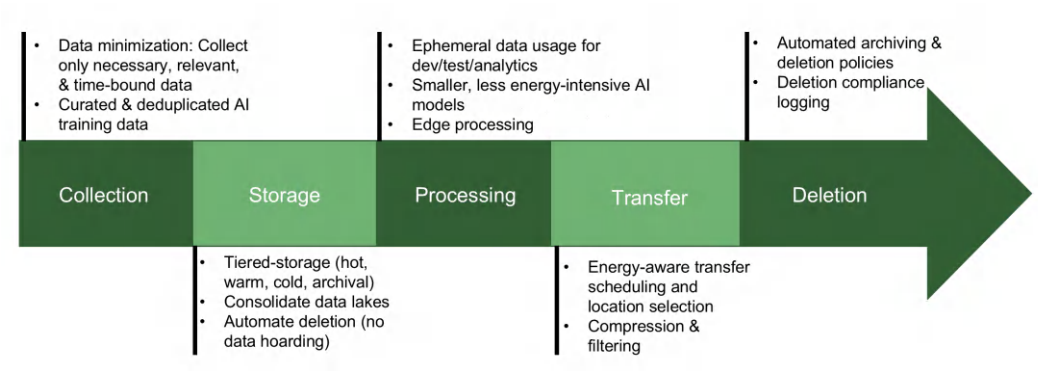


Figure 8.4 – Data lifecycle management practices for efficiency and sustainability

- Implement data minimization principles: collect only data that is necessary, relevant, and time-bound for the intended use case.
- Make non-production environments ephemeral by default: treat datasets like infrastructure: on-demand, snapshot-backed, and short-lived for dev/test/analytics; auto-teardown in CI/CD.
- Enforce strict data retention policies: automatically archive or delete data after a defined period to avoid unnecessary storage.

- Apply tiered storage strategies: use energy-efficient cold storage for data that is rarely accessed, and eliminate redundant or outdated datasets. Align storage tiers (hot, warm, cold, archival) and geo-replication policies with access frequency and RPO/RTO (recovery needs). Automate lifecycle rules to move data to lower-energy tiers over time.
- Adopt metadata-driven data governance: tag and classify data by usage, importance, and compliance requirements to better manage what is stored and processed.

Smart data practices for GenAI and IoT

- Train and fine-tune GenAI models with curated datasets: use high-quality, deduplicated training data to reduce the need for excessive compute and storage.
- Deploy edge computing for IoT: filter, compress, or analyze data at the edge to avoid transmitting and storing vast volumes of raw sensor data in the cloud.
- Use carbon-/energy-aware transfer scheduling (batch when grids are cleaner; throttle non-urgent syncs). Energy-aware algorithms can help.
- Use synthetic data selectively: generate only targeted, scenario-specific synthetic data for training AI, avoiding uncontrolled dataset expansion.
- Apply sparsity techniques in AI pipelines: compress models and remove unnecessary intermediate outputs and logs.

Sustainable IT infrastructure and operations

- Monitor the data footprint across the lifecycle: track the carbon and energy impact of data creation, storage, transfer, and deletion
- Right-size data centers and cloud usage: avoid overprovisioning by scaling compute and storage resources dynamically
- Use green cloud providers: prefer vendors with renewable energy sourcing and robust data center efficiency (e.g., low PUE scores)
- Consolidate data lakes and silos: eliminate duplicate repositories and unify data platforms to reduce unnecessary storage overhead

Now that we understand the scope of the data proliferation challenge and smart management practices we can apply, let us look at some of these in action at global hotel chain Choice Hotels International.

Case study: Sustainable dataset management at Choice Hotels

Data proliferation from data-intensive applications such as GenAI, IoT, digital photos, social media, and peer-to-peer payment services helps to make data management a centerpiece of responsible and sustainable IT operations. Yet modern enterprises still struggle with data issues, stifling efficiency and adding risk. These challenges have given rise to an entire generation of advanced technologies—Perforce Delphix being one of them—intended to store, cleanse, automate, and otherwise manage vast, interconnected webs of data. **Woody Evans**, **VP, Global Sales Engineering**, and **Matt Yeh, VP of Product Marketing**, explain how datasets can be managed sustainably, with a case example from Choice Hotels International:

A data strategy that advances energy and emissions goals

Choice Hotels International, one of the world's largest lodging franchisors, has long been recognized for its technology-forward posture. With a history of innovation that includes early cloud adoption, mobile-first strategies, and integrated AI-driven pricing systems, the company recently turned its focus toward aligning digital transformation with **environmental, social, and governance** (**ESG**) priorities.

As part of this effort, the IT organization confronted a common challenge in enterprise environments: the operational and sustainability burden of managing large, complex datasets. Like many companies, Choice Hotels relied on dozens of legacy systems and maintained hundreds of test and development environments that often included redundant or persistently stored data. This approach not only slowed development velocity but also inflated infrastructure usage and energy consumption.

In response, the company undertook a major data platform modernization effort. A core element of this initiative was the virtualization of data and automation of test environment provisioning—allowing for more ephemeral, just-in-time usage of data. Sensitive information was automatically masked, supporting global privacy mandates while reducing the surface area of exposure (*Figure 8.5*).

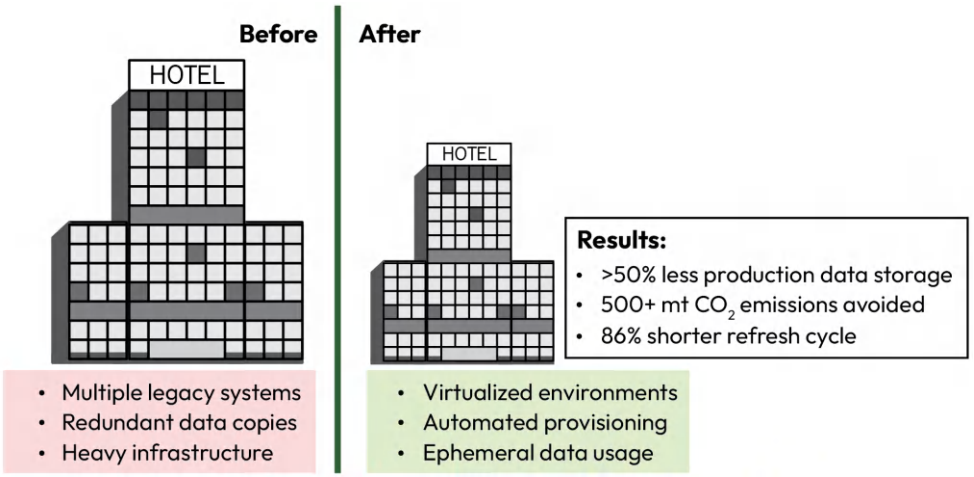


Figure 8.5 – Choice Hotels before and after data lifecycle management optimization

This shift had material results:

- Choice Hotels reduced production data storage by more than 50%, and non-production environments by over 20%—streamlining infrastructure and curbing energy-intensive data sprawl
- Refresh cycles that previously took two weeks now complete in under two days, enabling faster delivery across multiple parallel modernization efforts
- Privacy and compliance were strengthened through consistent, automated data protection practices—without slowing development

These improvements extended beyond IT operations. By consolidating data usage and transitioning workloads to the cloud, Choice Hotels avoided over 500 metric tonnes of CO_2 emissions in a single year. According to **CIO Brian Kirkland**, *"Scaling on demand not only allows us to save costs, but it drastically improves our impact on the environment through energy consumption and related carbon footprints."*

This transformation also supports downstream ESG initiatives. Property-level dashboards now aggregate and visualize utility usage—helping individual hotels monitor and reduce electricity, water, and fuel consumption. The data strategy similarly supports broader social goals, such as tracking representation and enabling programs such as HERtels by Choice, which provides support for women hotel owners.

Kirkland, who also serves as a founding board member of SustainableIT.org, sees the effort as part of a broader imperative. *"We're committed to using data and technology not just to run the business better—but to do the right thing for our customers, our communities, and our environment."*

Choice Hotels' story underscores a growing recognition among IT leaders: that sustainable dataset management is not just good governance—it's a strategic enabler of agility, compliance, and long-term business.

Universal challenges and best practices for sustainable data architecture

Having advised and architected data platform solutions for thousands of enterprise clients, we at Perforce Delphix have observed several near-universal challenges that have significant implications for environmental and governance sustainability:

- Enterprises maintain many unnecessary, redundant copies of data for development, testing, analytics, reporting, and backup purposes. For every live production dataset, they maintain 8-12 copies for non-production use cases.
- Datasets and associated cloud or data center infrastructure are typically utilized less than 10% of the time.
- Most organizations have deep concerns about data privacy and lack sufficient tools to find and protect sensitive data values such as names, email addresses, and payment information.
- Unlike the code and compute layers of the application stack, the enterprise data layer has resisted automation, resulting in wasteful operations and leakage of sensitive information.

Datasets are often heavyweight and long-lived, and downstream copies are difficult or not cost-effective to change or refresh. This leads to a lack of dataset consolidation, pipelines that have significantly more steps than necessary for software delivery, and oversized data center hardware. It also increases the cost and effort of dataset risk management. Storing, moving, processing, and protecting datasets are all energy and emission-intensive operations. Avoiding data incidents, avoiding noncompliance, and protecting datasets from exposure are all hallmarks of good data governance and will benefit both your environmental footprint, data security, and compliance, and your bottom line.

As you plan out your strategies for data governance, consider adopting these best practices:

- Use data in more of a cloud utility model so that large datasets become more elastic and can easily be virtualized, ephemeralized, or hoteled to reduce long-term energy consumption and costs
- Remove constraints that prevent data from moving at the same speed as code in any product, process, or service delivery pipeline
- Adopt technologies that enable lightweight datasets to significantly reduce the size and number of datasets that persist without compromising the utility of data
- Automate sensitive data discovery and the application of protection
- Drive data security protection by automating and increasing the number of reviews, thereby reducing noncompliance risk and time to identify security incidents
- Use high-speed data protection in conjunction with data virtualization to facilitate rapid reaction to and correction of security incidents
- Use powerful data protection to make sure that AI models are fed data that is already protected from exposure and has anti-data bias methodologies already applied

Woody Evans, VP, Global Sales Engineering, and Matt Yeh, VP of Product Marketing, Perforce Delphix

While most enterprises have automated code and compute, the data layer—with its redundancy, inertia, and security risks—remains a significant source of energy inefficiency, emissions, and governance exposure. As demonstrated by Choice Hotels and Perforce Delphix, transforming how datasets are stored, copied, and managed is a powerful lever for both ESG performance and operational agility.

AI data governance principles, actions, and KPIs

As AI rapidly infiltrates the core engines of business transformation and decision-making, it is critical to guarantee that its data is as accurate, purposeful, ethically sourced, and environmentally managed as possible. Without such oversight, organizations risk building AI on an opaque, biased, and inefficient foundation that will compromise performance, ROI, trust, compliance, and our environment.

A responsible and sustainable AI portfolio requires disciplined stewardship of data quality, transparency of data sources, and safeguards against bias and misuse. Responsible data architecture design supports scalability while avoiding unnecessary data duplication, which mitigates energy-intensive storage needs. By defining and tracking data purpose and intended usage, organizations also ensure their AI models remain auditable, explainable, and aligned with sustainability goals. The following table shows the direct impact of strong and weak data governance on common ESG goals.

Enterprise Goal	**Impact of Strong AI Governance**	**Impact of Weak AI Governance**
Ensure accurate, fair, and consistent AI outcomes	Data is validated, complete, and free of systemic bias, leading to reliable, equitable results.	Incomplete or biased data skews results, leading to discrimination or reputational damage.
Compliance with laws and regulations (e.g., GDPR, AI Act, ESG reporting)	Clear data provenance and transparent, accountable governance will streamline ESG, compliance, and risk reporting.	Untraceable or excessive data use can lead to legal violations, fines, or audits.
Support stakeholder trust and brand credibility	Transparent, explainable AI decisions and clear data governance reassure employees, customers, partners, and regulators.	Lack of transparency and unclear data handling erode confidence in the organization's use of AI.
Improve operational efficiency and decision-making	High-integrity data enables dependable analytics and efficient AI operations.	Dirty, redundant, or low-quality data slows AI pipelines and may lead to bad decisions.
Reduce environmental footprint	Governance ensures efficient data use, responsible hardware management, and low-impact processing.	Oversized datasets and inefficient pipelines increase energy use, water consumption, and e-waste.
Lower costs of AI ownership and risk mitigation	Purposeful data management reduces storage, compute, compliance, and remediation costs.	Overcollection and unmanaged data increase infrastructure spend and risk exposure.

Table 8.1 – Data governance impact on enterprise sustainability goals (SustainableIT.org 2025)

Next, we'll explore five foundational principles—**Validity & Reliability**, **Transparency & Explainability**, **Fit for Purpose & Scalability**, **Environmental Sustainability**, and **Accountability**—that collectively guide IT and business leaders in embedding ESG values into AI data practices.



Figure 8.6 – Five principles of responsible AI data governance.

As we did for the responsible AI leadership principles in *Chapter 4*, *Responsible and Sustainable AI*, we recommend actions to operationalize the data governance principles. Since the impact of data spans the full lifecycle of AI systems, our recommended actions are sorted into development and implementation/usage stages of the lifecycle. We also include KPIs for measuring data management baselines and progress, and links to tools that could help with framing or measurement (the tools are representative samples and are not endorsed by us or our publisher).

This material is adapted from the *Responsible AI Data Governance Principles and Runbook* (SustainableIT.org 2025). It is part of the IT Toolkit for Responsible and Sustainable AI, developed and vetted over six months by IT leaders and AI experts in SustainableIT.org's 50+ member Responsible AI Working Group.

Principle 1: Validity & Reliability

Data used for AI systems will be accurate, consistent, and complete, with processes in place to identify and minimize errors, gaps, and bias—especially those that may impact protected groups (e.g., race, gender, age, or disability). Data must be relevant for its intended purpose, ensuring reliability (i.e., data yields consistent results across time, contexts, and applications).

Example: If an AI hiring tool is trained on historical employee data that underrepresents women in technical roles, the system may perpetuate bias in hiring recommendations. Ensuring validity and reliability would involve identifying this imbalance and correcting it through rebalancing or supplementary data.

The following figure maps key actions to drive validity and reliability in the development and implementation stages:

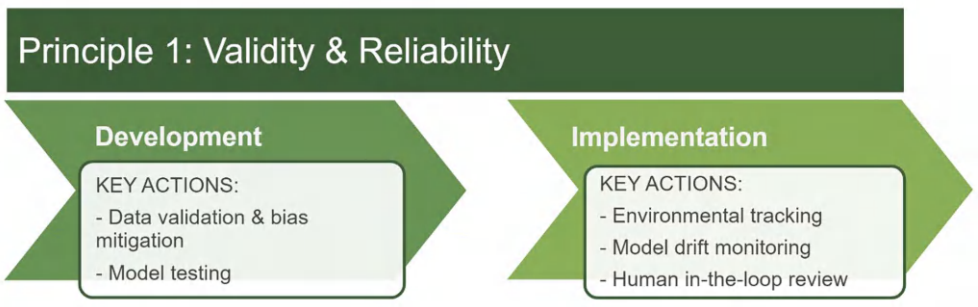


Figure 8.7 – Data validity and responsibility actions

Development actions:

- Define and enforce data quality metrics for completeness, accuracy, timeliness, and consistency across datasets. Set thresholds for acceptable variation and flag anomalies.
- Conduct cross-domain validity testing—validate models across multiple demographic, geographic, and contextual segments to detect overfitting to dominant or majority data groups.
- Simulate edge cases or biased input scenarios to evaluate whether AI explanations remain consistent, accurate, and meaningful under stress conditions.
- Investigate and review third-party AI systems and model training data for compliance with validity and inclusiveness standards and expectations.

- Develop and implement strategies to mitigate identified biases, inaccuracies, and gaps.
- Begin with the least amount of data needed to create a viable solution. Prioritize the use of the organization's own data versus augmentation with outside sources.

Development KPIs:

- Data quality score: composite metric combining completeness, accuracy, timeliness, and consistency across datasets used for AI training and inference
- Anti-bias methodologies applied to model training: percentage AI algorithms or ML models trained using anti-bias methodologies
- Fairness metric deviation: difference in model performance (e.g., precision, recall) across protected demographic groups
- Edge case handling accuracy: performance of AI systems when processing rare, extreme, or stress-test input conditions
- Cross-domain model performance variance: difference in model accuracy or reliability across different demographic or operational segments

Tools:

- Great Expectations: an open source tool for data validation (`https://greatexpectations.io/`)
- Talend Data Quality: a platform for ensuring data integrity and accuracy (`https://www.talend.com/products/data-quality/`)
- Fairness Indicators (TensorFlow) (`https://www.tensorflow.org/tfx/guide/fairness_indicators`), Fairness Indicators (Google) (`https://research.google/blog/fairness-indicators-scalable-infrastructure-for-fair-ml-systems/`), AI Fairness 360 (IBM) (`https://ai-fairness-360.org/`)
- Cleanlab: a Python library for detecting label errors, outliers, and data quality issues in training datasets (`https://docs.cleanlab.ai/stable/index.html`)
- Aequitas: an open source bias and fairness audit toolkit that helps stakeholders understand model risk from a social impact perspective (`https://github.com/dssg/aequitas`)

Implementation actions:

- Operationalize model validation checkpoints: embed checkpoints in the AI lifecycle to verify model performance under real-world data distributions and changing environments

- Implement **Human-in-the-Loop** (**HITL**) review: for high-risk use cases, integrating expert oversight to validate AI outputs
- Maintain a bias and reliability risk register: track known and emerging risks related to model validity and data quality, and link these to mitigation strategies and responsible teams
- Benchmark against representative population baselines: compare model input and output distributions against known real-world benchmarks to validate representativeness and equity
- Deploy continuous drift monitoring tools: monitor for data drift (changes in input data over time) and concept drift (changes in underlying patterns) to maintain model reliability over time
- Assess infrastructure architecture and topology: check that it is appropriate for sustainable environments

KPIs:

- Bias mitigation implementation rate: percentage of detected biases that have documented and applied mitigation strategies
- Error rate in AI outputs: percentage of incorrect or biased AI-generated outputs
- Model drift detection rate: frequency and magnitude of shifts between training and real-world data distributions
- Equity gap in model performance: absolute difference in key performance metrics (e.g., false positives/negatives) between demographic subgroups
- Discrepancy rate in HITL review: percentage of AI outputs that are modified or overturned by human reviewers

Tools:

- DeepChecks: an open-source tool for testing and validating data integrity and model reliability during development and deployment phases (`https://deepchecks.com/`)
- Data Sheets for Datasets: a standardized documentation method for ensuring transparency and accountability in dataset collection and use, hosted by Cornell University (`https://arxiv.org/abs/1803.09010`)
- WhyLabs AI Observatory: a platform for monitoring data and model quality in production environments, helping detect drift, anomalies, and reliability issues (`https://whylabs.ai/`)

- Arize AI: an ML observability platform offering tools to monitor performance degradation, data drift, and fairness breakdowns across diverse segments (`https://arize.com/`)
- Evidently AI: a toolkit for evaluating, monitoring, and visualizing machine learning model performance, including drift and integrity metrics (`https://evidentlyai.com/`)

Principle 2: Transparency & Explainability

The organization will maintain clear, traceable records of where data comes from and how it is collected, processed, and used—including any transformations, filtering, or enrichment. Explainability means designing AI systems in a way that makes their output understandable and interpretable by humans, including why certain data influenced a decision. Establishing clear ownership roles and enforcement mechanisms will facilitate responsible data stewardship.

Example: In a loan approval system, transparency requires documenting that credit history and income data were sourced from verified repositories. Explainability ensures that if a loan is denied, the applicant or reviewer can understand that the decision was based on specific data thresholds and not unrelated factors.

The following figure maps key actions to drive transparency and explainability in the development and implementation stages:

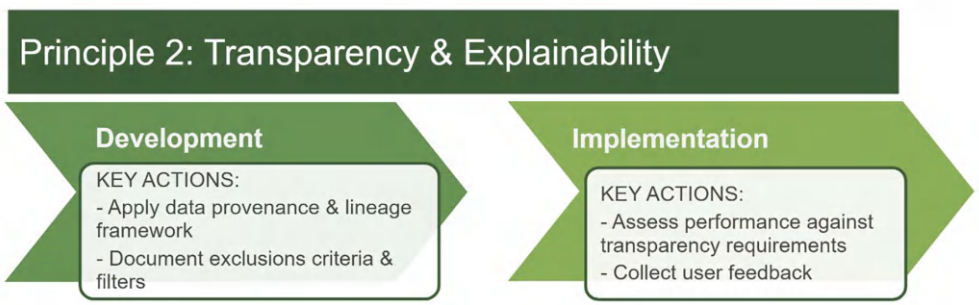


Figure 8.8 – Data transparency and explainability actions

Development actions:

- Institute a formal data provenance and lineage framework—track and document where data originates, how it was transformed, and how it moves through the AI system to ensure traceability and quality assurance.

- Document exclusion criteria and data filters—record what data was excluded during preprocessing and why—supporting transparency, reproducibility, and fairness audits.
- Require third-party or vendor AI systems to include explainability and transparency documentation as part of procurement or risk assessment processes.
- Develop "tiered explainability" by providing different levels of explanation tailored to different audiences—technical teams, executives, regulators, and end users—balancing detail with accessibility.
- Seek validation through third-party AI governance or ethics assessments (e.g., ISO/IEC 42001, NIST AI RMF) to demonstrate transparency commitments.

KPIs:

- Data provenance completeness rate: percentage of datasets with fully documented origin, lineage, and transformation history
- Data exclusion rationale coverage: percentage of datasets where exclusion rules and rationale are explicitly documented and reviewed
- Model documentation coverage rate: percentage of AI models accompanied by complete documentation, including enterprise and solutions architecture, training data description, decision rationale, and known limitations
- Number of models using standardized transparency artifacts: count or percentage of models using tools such as Model Cards, Data Sheets for Datasets, or Fact Sheets for AI applications.

Tools:

- IBM's AI Explainability 360: a toolkit to support the interpretability and explainability of AI models (`https://aix360.res.ibm.com/`)
- Explainability Tools: DARPA XAI (`https://www.darpa.mil/research/programs/explainable-artificial-intelligence`), SHAP (`https://shap.readthedocs.io/en/latest/example_notebooks/overviews/An introduction to explainable AI with Shapley values.html`), LIME (`https://c3.ai/glossary/data-science/lime-local-interpretable-model-agnostic-explanations/`)
- Microsoft InterpretML: an open source library for training interpretable models and explaining black-box systems using methods such as SHAP and LIME (`https://github.com/interpretml/interpret`)

- Data Nutrition Project: provides "nutrition labels" for datasets to promote better understanding and responsible use in AI model training (`https://datanutrition.org/`)
- Model Cards for Model Reporting: standardized template for documenting model behavior, use cases, and ethical considerations, aiding in stakeholder transparency (`https://modelcards.withgoogle.com/about`)

Implementation actions:

- Conduct regular collection and analysis of feedback from users, technical teams, and regulators regarding the clarity and comprehensibility of AI system outputs.
- Conduct periodic assessment of AI systems' performance against transparency requirements, identifying gaps and areas for improvement. Establish and utilize a feedback loop for infrastructure and GreenOps architects.
- Provide summaries or visualizations for stakeholders of how key decisions were made by AI systems (e.g., via dashboards or interactive reports).
- Maintain a documentation inventory of AI system components, including data inputs, preprocessing steps, model types, training runs, and deployment environments to support traceability.
- Make available clear data usage policies to stakeholders, ensuring they are easily understandable and accessible.

KPIs:

- Lineage governance assignment rate: percentage of AI projects with clearly assigned owners responsible for data lineage, versioning, and change tracking
- Use of interpretable model architectures: percentage of models designed for interpretability (e.g., decision trees, GAMs, attention-based networks) in use where explainability is critical
- AI decision explainability score: AI output interpretability and transparency (measured using tools such as **SHapley Additive exPlanations** (**SHAP**) or **Local Interpretable Model-agnostic Explanations** (**LIME**))
- Explanation satisfaction score: average score from internal or external users rating the clarity and usefulness of AI model explanations (via surveys or UX feedback)
- Frequency of explanation review audits: number of scheduled explanation audit reviews conducted per year to evaluate transparency effectiveness and alignment with user needs

Tools:

- FactSheets for AI (IBM Research): a structured transparency documentation approach covering AI system purpose, performance, safety, fairness, and explainability (`https://arxiv.org/abs/1808.07261`)
- Model Cards for Model Reporting: a standardized template for documenting model behavior, use cases, and ethical considerations, aiding in stakeholder transparency (`https://modelcards.withgoogle.com/about`)
- NIST AI Risk Management Framework (AI RMF 1.0): provides structured guidance for improving explainability, trustworthiness, and transparency in AI systems (`https://www.nist.gov/itl/ai-risk-management-framework`)
- ISO/IEC 42001 – AI Management System Standard (2023): a formal international standard helping organizations manage AI risk, including explainability and transparency principles (`https://www.iso.org/standard/81228.html`)
- FAT Forensics: a Python toolkit for auditing the fairness, accountability, and transparency of predictive systems with built-in explainability tools (`https://fat-forensics.org/`)

Principle 3: Fit for Purpose & Scalability

The high volume of data required to train and operate AI systems—especially in large-scale or generative applications—must be managed in a way that ensures data is both fit for purpose and scalable by design. Only data that is necessary, proportionate, and relevant to a clearly defined, lawful, and approved AI use case should be collected, stored, and processed. AI systems should be designed to scale responsibly, with data architectures that accommodate increasing volumes, varieties, and velocities without compromising security, compliance, or sustainability. Retention must be limited to what is strictly necessary, with automated lifecycle rules enforcing timely archiving or deletion.

Example: An insurance company considered training its claims AI system on 20 years of policyholder records, but found older data misaligned with current products and regulations. Using it risked legal and operational issues. Instead, the company opted for a smaller, higher-quality dataset, a better fit for the purpose, resulting in effective and efficient model performance and reduced environmental impact of storage and processing. This fit-for-purpose approach not only improved the model accuracy and reduced the processing load but also enabled the AI platform to scale more efficiently as new policy types and data streams were added.

The following figure maps key actions to drive fit for purpose and scalability in the development and implementation stages:

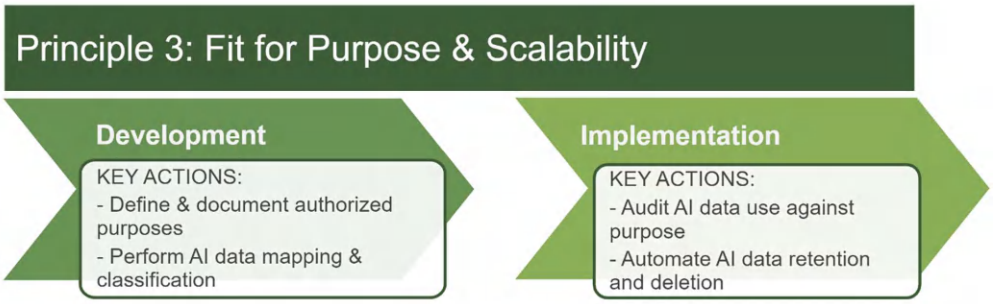


Figure 8.9 – Data fit-for-purpose and scalability actions

Development actions:

- Define authorized purposes, clearly documenting legally authorized and business-approved purposes for data use in AI systems, aligned with compliance and regulatory obligations
- Perform AI data mapping and classification, identifying what data is collected, where it resides, and how it is used, tagged with purpose, sensitivity, and retention requirements
- Implement data minimization controls in AI systems design and processes, specifying the collection of only data strictly required for the authorized purpose and discouraging "just-in-case" data hoarding
- Design AI data pipelines to be modular and scalable, supporting flexible integration of new data sources while maintaining alignment with purpose and compliance requirements
- Develop or adapt data system architecture requirements to define system scalability and management guidelines (including volume, velocity, sources, security, compliance, and retention)
- Establish system capacity planning protocols that anticipate scale in data volume, variety, and velocity, including stress testing under future load scenarios

KPIs:

- AI data minimization score: percentage of datasets where only the minimum necessary data is collected based on the defined purpose
- Purpose-mapped data coverage: percentage of datasets that are explicitly tagged with a defined and documented purpose
- Systems with data lifecycle policies implemented: percentage of enterprise systems with automated lifecycle rules (e.g., retention, archival, deletion) in place
- Scalability readiness score: percentage of AI systems with documented scalability plans addressing data volume, velocity, and integration growth

Tools:

- Tools that identify and mask sensitive data and support "compact" data – for example, Perforce Delphix (`https://www.perforce.com/products/helix-core`) and Granica (`https://granica.ai/`)
- IBM AI Privacy Toolkit (`https://github.com/IBM/ai-privacy-toolkit`)
- NIST AI Minimization Toolkit (`https://www.nist.gov/privacy-framework/resource-repository/browse/guidance-and-tools/ai-minimization-toolkit`)
- Collibra Data Catalog: enables purpose-tagging, data lineage mapping, and stewardship (`https://www.collibra.com/products/data-catalog`)

Implementation actions:

- Train staff on purpose-driven AI data use and how to apply minimization principles in daily decision-making.
- Automate AI data retention and deletion with lifecycle management tools to enforce time-bound data retention and automated deletion when data is no longer needed.
- Audit AI data use against purpose by regularly reviewing system logs and access patterns to ensure data is only used for its intended purpose. Flag deviations for review.
- Monitor and report on AI data lifecycle compliance, showing data volumes, retention status, deletion rates, and exceptions by purpose.
- Require justification and documentation for any data scope expansion.

KPIs:

- Staff training rates: percentage of relevant employees trained annually on fit-for-purpose principles and data handling responsibilities
- Data purpose alignment audit score: internal/external audit rating of alignment between data use and declared purpose over the period of usage
- Unauthorized purpose access rate: number of instances where data was accessed or used for purposes outside of the documented authorized use
- Average data retention duration: average length of time data is retained (segmented by data type)
- Data volumes: total GB/TB of data, as well as redundant, obsolete, or trivial data–identified as misaligned with any current purpose or expired, and rate of change over time

Tools:

- APP Supporting Data Minimization in AI: guidance for applying federated learning principles to minimize data use during implementation (`https://iapp.org/news/a/federated-learning-supporting-data-minimization-in-ai/`)
- AI Now Institute Data Minimization as a Tool for AI Accountability: frameworks for deploying systems that enforce minimization during real-world use (`https://ainowinstitute.org/spotlight/data-minimization`)
- Balancing GDPR & Research Insights: best practices for implementing legally compliant, purpose-limited data usage in AI (`https://www.clinicaltrialvanguard.com/article/data-minimization-balancing-gdpr-research-insights/`)
- BigID: lifecycle automation for data discovery, purpose-based retention rules, and deletion enforcement (`https://bigid.com/`)
- OneTrust Data Governance: supports purpose-based data retention scheduling, policy automation, and compliance training (`https://www.onetrust.com/solutions/data-and-ai-governance/`)

Principle 4: Environmental Sustainability

Data practices are governed to minimize environmental impact, including energy use, carbon emissions, water consumption for cooling, and e-waste across the AI lifecycle. This involves establishing the appropriate data architecture, inclusive of understanding the type of model to use, limiting unnecessary data generation and storage, optimizing data processing for efficiency, and selecting infrastructure that supports sustainability goals—such as renewable-powered data centers, water-efficient cooling systems, and hardware strategies that avoid premature obsolescence.

Example: To reduce environmental impact, an AI team reconfigures a model to run on existing hardware rather than upgrading to more power-hungry servers, reducing e-waste. They also shift model training to a cloud region with renewable energy and water-efficient cooling, cutting both emissions and water use.

Figure 8.10 maps key actions to drive environmental impact in the development and implementation stages:

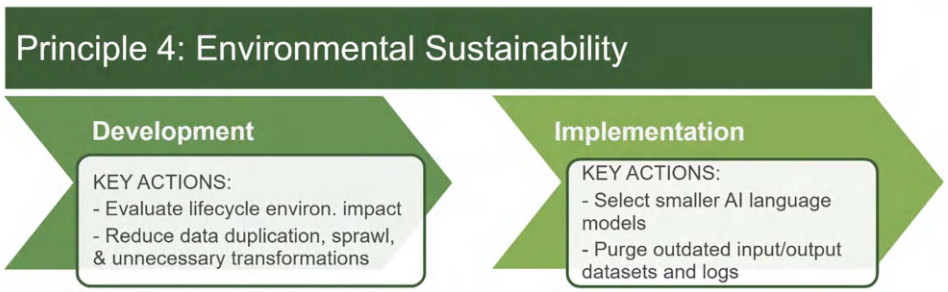


Figure 8.10 – Data environmental sustainability actions

Development actions:

- Evaluate the environmental impact of data acquisition, labeling, preprocessing, and storage workflows, including compute load and volume of data required for training
- Design data ingestion and preprocessing pipelines to reduce duplication, data sprawl, and unnecessary data transformations that increase energy use
- Embed sustainability goals into data sourcing and data governance frameworks—prioritizing lower-footprint datasets, synthetic data when appropriate, and efficient data formatting
- Periodically review training data volume, transfer rates, and retention timelines to eliminate stale or unnecessary data that increases storage and compute burden

- Evaluate sustainable alternatives to LLMs for both training and application phases based on data volume needs, performance trade-offs, and environmental impact:
- Modular AI architectures that allow selective model retraining instead of full reprocessing
- **Retrieval-augmented generation** (**RAG**) systems that rely on external databases to reduce training data loads
- Fine-tuned or distilled models that reuse pre-trained knowledge with minimal new data
- Edge-optimized SLMs that reduce reliance on centralized data centers
- Alternatives to AI, including viable existing analytic and automation tools

KPIs:

- Estimated training energy consumption per model: total **kilowatt-hours (kWh)** consumed during training of a specific model, calculated based on dataset volume, quality, and preprocessing complexity; used to benchmark and reduce energy-intensive training practices
- Low-carbon dataset processing rate: percentage of training datasets stored, processed, or preprocessed using energy-efficient or renewable-powered infrastructure (e.g., green data centers, low-carbon cloud services)
- Dataset utilization efficiency score: ratio of model performance (e.g., accuracy, F1 score) to dataset size or volume, highlighting how effectively data is used to achieve outcomes
- Preprocessing energy intensity metric – measured energy consumption (kWh) per **gigabyte** (**GB**) of data preprocessed, helping identify and reduce high-energy preprocessing tasks

Tools:

- Hugging Face Optimum: a toolkit for evaluating model size, deployment efficiency, and energy trade-offs (`https://huggingface.co/docs/optimum/en/index`)
- OpenDC: a simulator for data center energy and cooling needs (`https://opendc.org/`)
- WattTime: provides real-time data on the carbon intensity of electricity grids for optimization (`https://www.watttime.org/`)

- Microsoft Sustainability Manager: ESG dashboard for tracking sustainability metrics, including AI and cloud workloads (`https://www.microsoft.com/en-us/sustainability/emissions-impact-dashboard`)
- WhyLabs (`https://whylabs.ai/`) + Prometheus (`https://prometheus.io/`): AI observability and monitoring tools that can track resource usage
- DataHub (`https://datahubproject.io/`): open source metadata platform to manage and monitor data lifecycle impacts

Implementation actions:

- Select smaller, less resource-intensive models—such as small language models or compressed variants—for inference tasks to lower energy consumption, reduce emissions, and improve scalability without compromising essential functionality
- Equip stakeholders with the knowledge to implement efficient data strategies such as deduplication of inputs, compression of outputs, and responsible data retention to help curb unnecessary data proliferation and mitigate environmental impact
- Implement automated or manual output compression/tokenization techniques that minimize log file sizes and storage requirements
- Purge or archive outdated input/output datasets and logs from completed AI tasks to limit persistent storage energy costs and prevent data buildup
- Monitor the environmental impact of inference output size and logging practices to identify inefficiencies, enforce environmentally sound logging practices, and ensure inference processes remain aligned with sustainability targets.

KPIs:

- Total CO_2e reduction from model optimization: estimated carbon emissions (kg or tonnes CO_2e) avoided through model refinement techniques such as output pruning and data-efficient sampling, indicating the effectiveness of sustainability-driven model design choices.
- AI environmental drift score: a composite score that tracks changes in environmental resource use (compute time, memory, storage, logging volume) over time due to evolving input/output data patterns
- Output storage efficiency ratio: average number of bytes stored per inference, factoring in compression, tokenization, and logging policies; used to evaluate how efficiently inference outputs are managed for storage-related energy impact mitigation

- Water consumption score per inference: estimated water usage (liters or gallons) required for cooling per AI inference, calculated using backend infrastructure water efficiency and tied to data volume, runtime, and system location; promotes awareness of water-intensive compute loads
- Carbon intensity per AI workflow execution: actual emissions output per execution (e.g., gCO_2e/inference or per task completed), reflecting the combined environmental cost of data processing, inference, and logging

Tools:

- WattTime: tracks carbon intensity of power used for data inference tasks (`https://watttime.org/`)
- Whylogs: data logging for ML systems (`https://whylabs.ai/blog/posts/whylogs-embrace-data-logging`)
- DataHub: metadata platform for tracking the environmental impact of a data lifecycle (`https://datahub.com/`)
- Microsoft Sustainability Manager: an ESG dashboard that includes AI data use metrics (`https://www.microsoft.com/en-us/sustainability/emissions-impact-dashboard`)
- $MLCO_2$ Impact Calculator: a tool for estimating emissions from model training and inference (`https://mlco2.github.io/impact/`)

Principle 5: Accountability

Clear ownership and responsibility must be assigned for managing data integrity and risk across the AI lifecycle.

This includes compliance with internal policies and external regulations, supported by audit trails, review processes, and escalation procedures in case of issues or violations. Data security, privacy, and safety-related risk assessment, mitigation, and monitoring must be continuously updated to address the evolving demands of AI systems, such as dynamic model behavior, autonomous decision-making, and heightened regulatory scrutiny.

Example: In a healthcare AI application, accountability might involve assigning data stewards responsible for ensuring that patient data is anonymized and reviewed for quality before use. An AI ethics committee may periodically audit these processes, and a defined escalation path would be triggered if sensitive data is improperly accessed.

The following figure maps key actions to drive data accountability in the development and implementation stages:

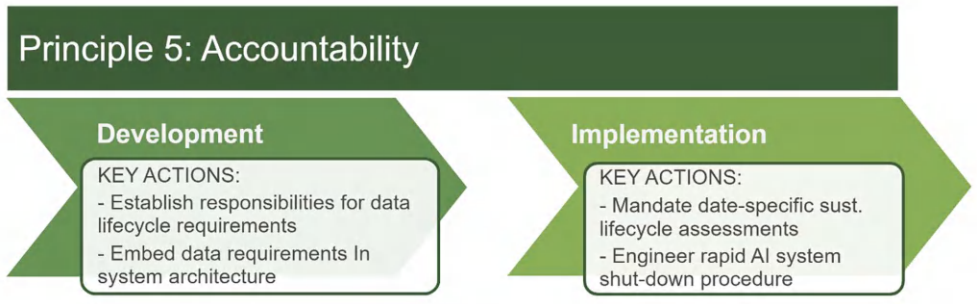


Figure 8.11 – Data accountability actions

Development actions:

- Create a cross-functional AI governance council (enterprise data architect, data scientists, legal, ethics, IT, sustainability, and business leaders) to provide ongoing data oversight and prioritization of risks
- Assign AI data stewardship roles responsible for determining data relevance, necessity, and lifecycle requirements
- Develop or adapt data and information policies that define ethical guidelines (including equity, fairness, IP protection), data privacy standards, and security protocols
- Embed responsible and sustainable AI data and information requirements into enterprise data, application, integration, and security architectures
- Integrate AI data governance checkpoints into architecture review boards, technical review boards (solution architects and engineers), DevOps or MLOps, requiring validation gates for ethics, compliance, and sustainability before deploying AI models to production

KPIs:

- AI vendor data-ethics review: percentage of AI spend on vendors reviewed for AI data ethics and inclusiveness
- Third-party AI review rate: percentage of high-risk AI models reviewed by independent external experts or ethics boards
- Alignment score with net-zero AI principles: KPI measuring consistency of AI system design and data governance with enterprise net-zero or climate action goals

- Ethical audit frequency and ethical AI data compliance score: AI model data management adherence to ethical AI principles (corporate and third-party)
- AI governance gate pass rate in MLOps: percentage of AI models that pass all governance checks (e.g., ethics, fairness, sustainability) before deployment

Tools:

- ITI's AI Accountability Framework (`https://www.itic.org/documents/artificial-intelligence/AIFIAIAccountabilityFrameworkFinal.pdf`)
- AI Governance Best Practices and Importance by Informatica (`https://www.informatica.com/resources/articles/ai-governance-explained.html`)
- OECD's AI Principles – guidelines promoting transparency and accountability in AI
- (`https://oecd.ai/en/wonk/the-ai-data-challenge-how-do-we-protect-privacy-and-other-fundamental-rights-in-an-ai-driven-world`)
- Atlan AI Governance Framework (`https://atlan.com/know/ai-readiness/ai-governance-framework/`)
- Enterprise Architecture Frameworks: TOGAF (`https://www.opengroup.org/togaf`), IASA BTABoK (`https://iasa-global.github.io/btabok/`) for sustainability and responsible AI frameworks

Implementation actions:

- Monitor and report the environmental footprint of AI workloads, tracking compute usage, **data center power usage efficiency** (**PUE**), and cloud provider emissions for training and inference tasks
- Mandate data-oriented AI sustainability **lifecycle assessments** (**LCAs**) to evaluate data's contribution to energy consumption, compute intensity, and emissions of AI systems.
- Engineer a rapid shutdown capability to avoid AI systems proliferating biased or inaccurate data and carrying out harmful actions or decisions. Automatic or manual shutdowns can be triggered at various points in the process lifecycle based on triggers such as real-time output quality scores, bias/quantiles, and safety threshold breaches. The halt should stop AI inference and training, quarantine affected data, disable downstream actions, and alert system stakeholders.
- Conduct mandatory compliance training for employees in the management and use of data and information with AI tools.

KPIs:

- AI report channels and tracking: the number of active reporting channels for AI data governance concerns and reports over time, and the percentage resolved by corrections
- Ethical audit frequency and ethical AI data compliance score: AI model data management adherence to ethical AI principles (corporate and third-party)
- AI environmental impact audit frequency: the number of audits conducted on the environmental impact of AI models (e.g., energy usage per training run)
- Remediation completion rate for AI failures: the percentage of identified biased or faulty AI data-related outcomes with completed corrective actions and documented learnings
- AI data literacy: the hours and percentage of employees trained in AI dataset management and usage compliance with regulations, standards, ethics guidelines, privacy, and security

Documentation:

- Training completion log: proof of data literacy training for staff, reducing the risk of violations and supporting audits
- Whistleblower feedback records: validates responsiveness to ethical or legal concerns
- Data quality issue log: facilitates the tracing of data problems and resolutions
- Compliance incident log: demonstrates that AI data breaches were identified, tracked, and resolved per policy
- ARB decision of record: decision log and quarterly metrics tied to architectural sustainability and responsible AI metrics

Tools:

- ISO 37002 Whistleblowing Management (`https://www.iso.org/standard/65035.html`)
- MLflow with role-based access and emergency flags – allows runtime interruption or model deactivation through API controls (`https://mlflow.org/`)

Conclusion:

The *Responsible AI Data Governance Principles Runbook* provides a practical, action-oriented guide that enables data and AI leaders to embed environmental, social, and governance considerations into every stage of the AI system lifecycle. As AI systems evolve and regulatory expectations grow, this Runbook serves as a living reference to support continuous improvement. Organizations are encouraged to adapt their recommendations to their unique contexts, share lessons learned, and contribute to the broader movement toward sustainable digital transformation.

By implementing these principles with discipline and integrity, organizations not only safeguard against ethical, legal, and environmental risks—they also strengthen resilience, earn stakeholder trust, and lead responsibly in the age of AI.

Centralized management of enterprise sustainability data

We have focused the majority of this chapter on sustainable management of enterprise data. However, there is another data challenge related to sustainability, which is the management of sustainability data itself – the metrics and reports used for regulatory compliance reporting and for decision making in the enterprise's pursuit of its ESG targets.

One of the most powerful contributions to business sustainability by IT is a centralized platform for the collection and delivery of enterprise sustainability data. In the early days of tech-enabled sustainability, IT leaders started simply by asking sustainability stakeholders how they were getting the sustainability data they needed for reporting, such as energy and emissions from specific corporate locations. More often than not, the approach was manual and tedious. This opened the door for IT to automate the capture and presentation (typically via a basic dashboard or tool such as Tableau), establishing an early partnership.

Fast forward to the more advanced implementation of a centralized sustainability data platform with automated, actual usage-based data available to a diverse set of users in or near real time. By collecting, tracking, and visualizing data related to energy consumption, emissions, and asset efficiency, IT can help organizations make informed decisions to reduce their environmental impact.

Centralized data platforms can also be leveraged to implement the controls necessary for sustainability audits. For example, National Grid treats its environmental data with the same rigor as financial data, implementing system controls, segregation of duties, and a chain of custody to ensure transparency, trust, and auditability. By integrating its data management solution with IT's **configuration management database (CMDB)**, National Grid can support regulatory compliance and facilitate continuous improvement. "We've built controls directly within the platform to ensure we're on a sound footing and can stand up to any audit," says National Grid's Elliott, referring to the utility's ServiceNow platform.

In the following essay, **Mauri Paz**, **Head of ESG and third-party risk products at ServiceNow**, explains how to leverage such platforms to operationalize sustainability:

> **Importance and benefits of a centralized data platform**
>
> A centralized data platform is a needed component of a sustainable IT strategy and program. At most organizations, sustainability and IT infrastructure data are kept in various enterprise systems, leading to data silos. These disconnected data sources hinder the ability of an organization to realize the full value that connected datasets can provide. Sustainable IT leverages large datasets from emissions, assets, energy consumption, and cloud utilization, among others, with the goal of operationalizing sustainability. Without interconnecting data, it will be almost impossible to use sustainability metrics as a guiding North Star for IT business operations, thus transforming sustainability into a value-added business initiative.
>
> In large enterprises, a centralized data repository will reduce the lag in the actionability of data. At a minimum, companies should strive to consolidate IT assets, cloud infrastructure, software, data centers, AI, and IT procurement data under a single platform of record. This centralized data collection enables near real-time decision-making regarding the usage, retirement, rebalancing, and purchase of IT and cloud infrastructure. In addition, it makes it feasible to adopt and apply the SustainableIT.org IT-tailored reporting standards and metrics.
>
> Although data centralization is a significant undertaking for large companies, it offers substantial benefits. ServiceNow's Global Impact team deployed a solution to quickly report emissions by customers based on data center utilization by customer instance, data center location, and carbon emission at each data center. This has reduced the time to respond to inquiries by customers by over 50%.

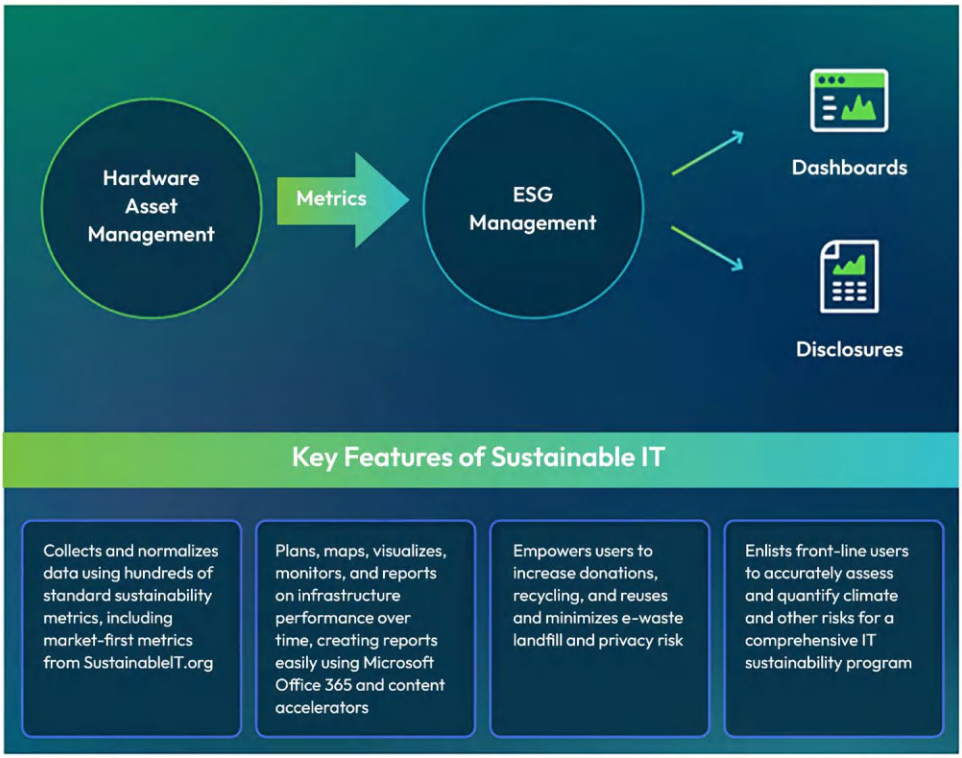


Figure 8.12 – Aspects of ServiceNow's Sustainable IT platform (Source: ServiceNow)

When deciding what datasets are needed, leaders should consider typical parameters, including energy usage, waste, water usage, source of energy (i.e., renewable versus fossil), and hours of operation. Additionally, it is crucial to gather data related to asset models, asset distribution, location, data center **power, carbon, and water usage efficiency (PUE/CUE/WUE)**, metadata on asset models, and the employee population utilizing each IT asset. Avoid collecting data that is complicated to obtain, maintain, and normalize. Some of these include chipset energy consumption, application-level energy consumption, waste recycling breakdown by material, low energy consumption assets, and unique equipment for which data is hard to obtain.

Given that data consolidation can be time-consuming, it is essential to ensure the purpose of every data point collected is to drive insights, value, and cost reduction. Many platforms, like ServiceNow, offer data integration connectors, data fabric with zero-data copy, open APIs, AI tools, and other mechanisms to reduce the overhead of connecting data sources while maintaining the necessary volume, velocity, and variety of data.

Data centralization will also drive additional value as we move into the age of AI. GenAI, as well as agentic AI, requires access to several datasets to make accurate inferences. Layering AI on top of the data discussed will benefit sustainability programs by identifying several cost-cutting opportunities that would otherwise take humans a long time to decipher.

Critical success factors

Before diving into critical success factors, it is important to consider the benefits of volume, velocity, and variety of data in the context of a successfully implemented sustainable IT program.

- Volume: an accurate, value-based model for sustainable IT requires a large volume of data to power and yield accurate analytics. Volume for the sake of volume, as stated before, is not advisable. Choose data parameters carefully and enrich that set over time to increase the volume of quality data.
- Velocity: although real-time data is always the desired goal, refreshing data on a daily or weekly basis is frequent enough to support better and faster decisions. The speed of data helps identify issues that may have been missed with less granular data collection intervals.
- Variety: most companies start with narrow datasets in siloed systems; however, the highest value can be obtained only if datasets are interconnected. This will allow deep analytics on the entire IT operation.

Data alone is not enough to ensure the success of a sustainable IT program. In many cases, collaboration across functions, teams, and departments is the difference between success and a lack thereof. For example, if the supplier team, IT team, and sustainability team work together, decision makers will better understand and identify suppliers that offer significant benefits in terms of purchasing IT assets that are sustainable and favorable to the company. A healthcare organization reduced the volume of waste from IT computer packaging by simply working with a laptop supplier to consolidate packages and parcels. Not only were cardboard and foam waste reduced, but shipping costs were also lowered. The collaboration led to a simple idea with a low execution threshold and good value to the organization.

Attaining a proper level of collaboration will require leadership involvement and support to reduce friction caused by the perceived additional work. It is crucial to have leadership buy-in at the highest level, especially on the financial side, to ensure departments prioritize the requests for data collection and provide the necessary bandwidth for the program's success. At ServiceNow, we observe that the lack of leadership involvement in some programs reduces the effectiveness and lengthens the time-to-value.

In establishing a program, IT teams should avoid one common mistake—going big! It is far better to begin with the available data, consider potential measurements, obtain leadership support, and single out a meaningful project or two to demonstrate the value of the initiative. Starting small with a high-value initiative is the most effective approach.

Many organizations choose to start with IT assets since they often provide the easiest and most impactful springboard. Companies can easily access data related to IT asset estates, nameplate consumption, asset life span, disposal methods, and user information. This small but powerful starting point can demonstrate the value of the program in 3 to 6 months. New opportunities will arise from ideas that other departments and individuals bring to the table.

To reduce the emissions footprint of ServiceNow's internal infrastructure, our team started with our already centralized asset database and the sustainability data existing on our platform. The program was implemented in a few short weeks, and we had data populated in the desired dashboards in about 2 to 3 months.

In 2024, we formed a data center operations sustainability team, collaborating with environmental teams, colocation providers, and IT partners to implement emission-reduction strategies. We started with about 50% of data centers connected, and full implementation is expected to be completed in 2026. Optimization software using wireless IoT sensors was installed across all sites to monitor temperature and humidity, with a process established to manage conditions and share results with providers. In 2026, we expect to continue this journey, incorporating AI, advanced chip-cooling technologies, and increased rack density to further reduce energy use.

In summary, we recommend beginning with what you have, proving value, and then growing the program from there. This step-by-step approach will help you reduce the time-to-value and energize the program for future phases.

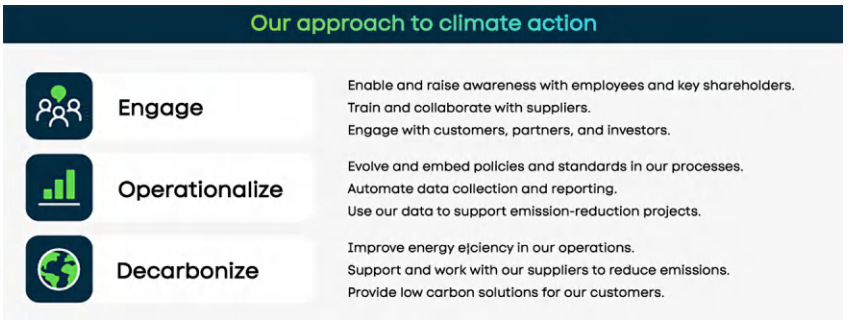


Figure 8.13 – ServiceNow's environmental sustainability approach

Implementation and adoption tips

Here are some tips to ensure the successful implementation of your sustainable IT program, based on success patterns and practices among our customer community:

- Resist the tactical approach. Begin with a clear strategy and utilize the standards framework or reference provided by Sustainableit.org. Ensure you are aligned with senior management on the goals of your program. Your stakeholders and audience need to understand why you are embarking on this journey and how to properly measure success along the way. Define the metrics carefully and ensure that they prove the value of your program to the broader organization. Leverage the community of practitioners who are in the trenches fighting the good fight.
- Don't go chasing butterflies. When it comes to data availability, identify the data sources and data types to which you currently have access. At a minimum, depending on the starting point of your project, you will need energy data, asset data, asset model data, and lifecycle assessment data for several IT assets. You will also need to identify different types of costs, such as electricity, water, cooling, carbon, asset, disposal, and so on. If you don't have all these datasets readily available, you may want to start with what you have. Do not start investing in telemetry (the technical instrumentation that measures and reports energy and water consumption) for your first project; the cost of doing that may not be easy to offset.
- Get the C-suite on board. You need to secure leadership approval and support for the program. Otherwise, it will be exponentially more complicated to achieve your objectives. As discussed earlier, without leadership's support, you are less likely to achieve the collaboration needed from other departments to prove the program's value and ensure its success.

It is also imperative to govern the use of AI across the organization as part of your sustainable IT program. AI governance concentrates not only on the compliance, fiscal, and social effects of AI utilization, but also on the environmental effects of overusing it. We strive to understand the cost versus value of each model, skill, and asset leveraging AI. Since the cost of AI is highly dependent on energy and water consumption, we recommend starting to consider these as soon as feasible. A sprawl-type adoption of AI, left ungoverned, will spiral into a major cost burden on your IT infrastructure and cloud budget.

Mauri Paz, Head of ESG and third-party risk products at ServiceNow

As Mauri makes clear, the centralized sustainability data platform is the eyes and ears of technology-enabled ESG. Without it, organizations will have to manage sustainability programs in silos, burdened with blind spots in environmental, social, and governance factors. For timely, well-informed decisions and ongoing audit-ready reporting, centralized ESG data is a must.

Another excellent example of a centralized, decision-maker-accessible data platform has been established by the IT organization for Mastercard. The company views the platform's data dashboard as such a critical asset that they have applied for a patent. It has paid off in the growth mitigation of technology energy consumption and emissions through rightsizing and right-placement, similar to the application portfolio management detailed in the previous chapter. The following details are from a Mastercard case study published by SustainableIT.org (SustainableIT.org 2025).

Case study: Mastercard's approach to sustainability data management

The foundation for Mastercard's sustainability data platform started several years ago when *"We began by asking basic but critical questions,"* recalls **Erik Lueders, Director of Sustainable Technology**. *"What do we have? Where is it? What is it doing?"* These questions launched a data journey to quantify and optimize energy use across the company's 50+ data centers globally. Mastercard's first step was aggregating granular energy and infrastructure data into a standardized platform. The dashboard (*Figure 8.2*)—now patent-pending—integrates the following:

- Real-time energy consumption (kWh) and location-based emissions factors
- Server utilization and hardware lifecycle indicators
- Carbon intensity at the program, product, and asset level
- Sustainability scoring to benchmark performance

"We didn't wait for perfect data", explains **Steven Earhart**, **Senior Principal Site Reliability Engineering**. Tech Ops Engineering, *"Best effort was good enough to get insights in front of decision-makers. We'd rather be 80% right and iterate"*. This agile approach allowed Mastercard to act fast and refine over time.



Figure 8.14 – Mastercard technology sustainability dashboard (Source: ©Mastercard)

The **Program** column refers to Mastercard organization programs, which are portfolios of product teams. **SustainabilityScore** is an average of each of the four contributing scores. Each score is a normalized 0–100 score assigned based on relative "sustainability" within that score. The **Technical Asset Score** (**TAScore**) is a function of how converged or shared the compute infrastructure is. **ResourceScore** is a metric that combines CPU, memory, and storage utilization into a single composite value. **EnergyScore** is a function of how energy-consuming the infrastructure is. **RegionScore** is based on how carbon-intensive the electric grid is in the geographical area where the infrastructure is deployed. All scores are color-coded using a **Red-Amber-Green** (**RAG**) system, where red indicates the bottom third of performance across programs. This RAG breakdown avoids fixed thresholds to encourage continuous improvement rather than static compliance.

A powerful but simple tool, the sustainability score ranges from 0–100, aggregating KPIs including energy intensity, renewable use, and hardware efficiency. The scores, updated monthly, are made visible across the infrastructure teams and executives alike. This gamified approach helped technologists better engage with the data. *"A kilowatt-hour number doesn't mean much to most engineers,"* Steven says. *"But if your score is a 10 in one region and a 90 in another, that sparks a conversation."* The scoring led to a surge in proactive engagement. *"We've been invited to more internal leadership meetings than ever,"* adds **Adam Tenzer, Senior VP, Data and Governance**. *"People want to understand their footprint and improve it."*

A key goal shared for enterprises that are product-centric (digital and physical) is establishing carbon profiles for their product-level P&Ls. Mastercard has achieved this product-level data mapping for both market-facing offerings and internal tech products. Having this data makes the data dashboard not only richer but also personalized to individual product owners accountable for their product's energy footprint. By tagging infrastructure to program owners, Mastercard can allocate energy consumption – and spotlight underutilized assets or inefficient architectures.

Asset owners' reactions to allocations have been gratifying. *"We've had teams tell us, 'That server isn't mine!'"* says Adam. *"That's the conversation we want. It improves data quality and drives action."* The energy consumption data also ties into Mastercard's broader **Technology Business Management (TBM)** framework, influencing investment decisions and creating parity between financial and environmental cost tracking.

With visibility comes action. In 2024 alone, Mastercard decommissioned over 1,200 servers—removing idle or orphaned assets, consolidating workloads, and retiring unnecessary infrastructure. *"We built a prioritized kill list,"* says Adam. *"This wasn't about abstract metrics. We showed teams exactly what wasn't being used, and the emissions and, importantly, costs attached."*

In addition, right-sizing and right-placing workloads are becoming standard. *"Why deploy a dev environment in a carbon-intensive region when you can reach greater energy efficiency and resiliency elsewhere?"* asks Steven. One real-world decision in progress: moving non-production workloads to a region where there is more availability of renewable energy.

The key takeaway from Mastercard's experience is that data transparency and iterative action can turn IT sustainability from a compliance obligation into a strategic engine of efficiency and innovation. For IT cultures that tenaciously insist that performance data be 100% accurate, the message is clear: iterating on imperfect, *good enough data* can drive powerful insights and tangible impacts.

Summary

In this chapter, you explored the urgent sustainability challenges posed by exponential data growth and the environmental cost of dark data. You learned how sustainable dataset management, supported by strong governance and efficient architecture, can reduce waste, energy use, and emissions. You reviewed practical methods to minimize data proliferation—such as data minimization, tiered storage, ephemerality, and edge processing—and saw how these methods lower carbon footprints while improving operational efficiency.

You read about Choice Hotels International's use of virtualization and automation to reduce data sprawl, and Mastercard's centralized sustainability dashboard that drives action through visibility, gamification, and program-level accountability. These cases illustrate how sustainable data practices can deliver both environmental benefits and measurable business outcomes.

Furthermore, you were introduced to the five **Responsible AI Data Governance Principles**—**Validity & Reliability**, **Transparency & Explainability**, **Fit for Purpose & Scalability**, **Environmental Sustainability**, and **Accountability**—along with recommended actions, KPIs, and supporting tools to operationalize them across the AI lifecycle. By embedding these principles into your AI and data strategies, you can reduce energy-intensive practices, ensure ethical and compliant AI outcomes, and strengthen stakeholder trust.

Here are summary recommendations for you:

- Embed data minimization and retention rules into architecture reviews to curb unnecessary data growth
- Operationalize the five Responsible AI Data Governance Principles across development and deployment
- Monitor AI data pipelines for bias, redundancy, and environmental impacts, and track KPIs for continuous improvement
- Prioritize fit-for-purpose datasets and energy-efficient models to reduce the environmental footprint
- Consolidate ESG and IT operations data into a single platform of record to support timely, audit-ready reporting
- Begin with available high-value datasets, prove value quickly, and expand your program iteratively

In the next chapter, we will look at tech hardware assets and learn how to choose the most environmentally friendly options and maximize sustainability across their lifecycles.

Appendix: standard metrics for sustainable data governance

Although this chapter has focused mainly on driving environmental sustainability through data governance, data is also germane to the social and governance pillars. Although we decided not to explore the familiar territory of data security and privacy in this chapter, we present the relevant SustainableIT.org standard metrics here for reference in supporting ESG regulatory compliance:

Category	Topic	Metric	Related Global Standards
SIT G 200 Data Governance	G 210 Data security	G 210-1 Frequency of data security policy/ procedure review and update	SASB TC-SI-230a ESRS G1 SDG 3, 17
		G 210-2 Incidents of noncompliance with data security policies/procedures, over a time period	
		G 210-3 Percentage data security incidents where root cause identified and corrective action taken, over a time period	
		G 210-4 Percentage of employees receiving mandated data security training	
	G 220 Data privacy	G 220-1 Approach to provide constituents with greater control of personal data	GRI 418-1 SASB TC-HW-230a.1 TC-SI-220a.1 ESRS G1 SDG 3, 17
		G 220-2 Approach to ensure personal data management consistent with constituent expectations	
		G 220-3 Substantiated complaints of data misuse or lack of compliance with constituents' instructions, over a time period	
	G 230 Data Usage	G 230-1 Approach to data usage governance (e.g., policy awareness/ enforcement, user consent mechanisms, training, oversight, and audits, etc.)	
		G 230-2 Data usage policy violations and constituents impacted, over a time period	
		G 230-3 Approach to provide data usage transparency to constituents	
		G 230-4 Approach to limit the environmental impact of data usage (i.e., data architecture	

Table 8.2 – Sustainable IT standards taxonomy metrics for data governance

Bibliography

- DesignRush, 2025, *How Much Data Is Created Every Day: Key Insights & Trends*: `https://tinyurl.com/3kwe5a2s`.
- IEA, 2024, *Global electricity demand rose moderately in 2023 but is set to grow faster through 2026*: `https://www.iea.org/reports/electricity-2024/executive-summary`.
- Splunk, 2025, *The State of Dark Data*: `https://www.splunk.com/en_us/form/the-state-of-dark-data.html`.
- SustainableIT.org, 2025, *Mastercard's IT Sustainability Transformation*. `https://members.sustainableit.org/knowledgebank-mfe#/knowledgebank/4/689e1a254f7fc1008398aada/3` (Access restricted to SustainableIT.org members only.)
- SustainableIT.org. 2025, *Responsible AI Data Governance Principles and Runbook*: `https://drive.google.com/file/d/1qpEbU9ILbeu6tTYVcFvyr795Ft3PNuHa/view?usp=sharing`.
- SustainableIT.org. 2024, *Standards Taxonomy V1.2*: `https://www.sustainableit.org/standards/it-esg-standards`.
- World Economic Forum, 2024, *Data volume is soaring. Here's how the ICT sector can sustainably handle the surge*: `https://tinyurl.com/4ss5wbz9`.

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9

IT Hardware Management

> *Like all major transitions in human history, the shift from a linear to a circular economy will be a tumultuous one. It will feature heroes and pioneers, naysayers and obstacles, and moments of victory and doubt. If we persevere, however, we will put our economy back on a path of growth and sustainability.*
>
> *Frans van Houten, former CEO of Royal Philips Electronics*

This chapter will teach you how to work with your IT hardware to positively impact social and environmental aspects and reduce costs.

The main objective of this chapter is to introduce how you can reimagine your approach to managing your IT hardware by exploring different opportunities. You will start by understanding the impact of IT hardware equipment and the most significant environmental impacts during the lifecycle. Then, we will look closely at circular IT hardware management and what is required from your IT enterprise and vendors to transition from a linear to a circular economy.

In this chapter, we will cover the following topics:

- Understanding the environmental impact of IT hardware equipment
- Circular IT hardware management principles and practices
- The various methodologies for measuring tech lifecycle emissions
- Strategies to reduce hardware lifecycle cost and emissions
- The sustainability role of **IT asset disposition** (**ITAD**) providers

- Choosing environmentally and socially sustainable IT hardware providers
- Metrics for IT hardware sustainability

The chapter includes a point of view from **TCO Certified**, the world-leading sustainability certification for IT products, on the importance of social responsibility in circular transition. You will also find a vendor scorecard template and roundups of the leading computer vendors' environmental and social sustainability commitments and achievements.

This chapter's sustainable IT reference model perspective, as illustrated in *Figure 9.1*, will primarily cover hardware lifecycle management, tech architecture, and the tech supply chain on behalf of the enterprise. The chapter also applies to sustainability in IT, addressing vendor procurement, ITAD, and improving IT's environmental footprint. We will look at how these capabilities interact to propel your sustainable IT plan to reduce technology's environmental footprint while positively impacting society:

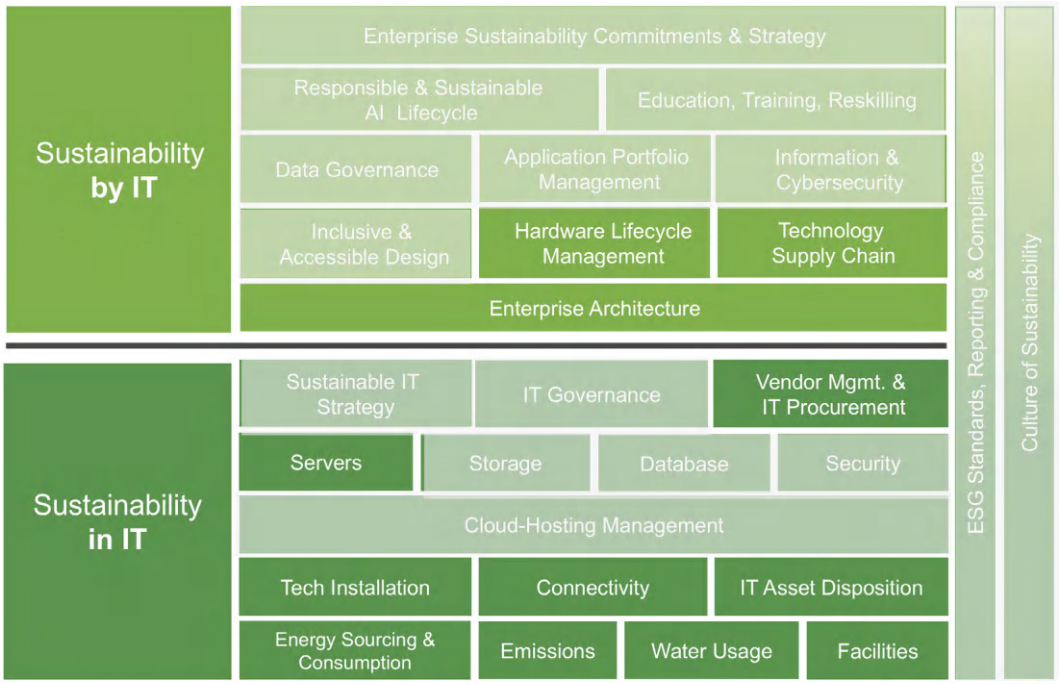


Figure 9.1 – Sustainable IT reference model – Chapter 9 focus

By the end of this chapter, you will have learned how to work with your IT hardware to positively impact social and environmental aspects and reduce costs. As an introduction to the topic, you will learn how you can reimagine your approach to managing your IT hardware by exploring different opportunities. You will also have a better understanding of the impact of IT hardware equipment and the most significant environmental impacts during the lifecycle. Finally, you will understand circular IT hardware management and what is required from your IT enterprise and your vendors to transition from a linear to a circular economy.

Determining and comparing IT hardware's carbon impact

IT hardware—from servers, network equipment, computers, monitors, tablets, and smartphones that an enterprise or organization uses—significantly impacts your Scope 2 (energy consumption) and Scope 3 (material use) greenhouse gas emissions throughout the whole lifecycle, especially during production and disposal. The extraction of raw materials, such as rare-earth metals and other materials needed in the manufacturing process when creating this equipment, can result in loss of biodiversity, depletion of finite resources, and generate enormous volumes of toxic waste. This also generates social inequalities related to using forced labor in some countries to obtain such rare metals. In many cases, finite resources such as lithium are used to manufacture smartphones and batterie. Overall, estimates indicate that producing these nearly equals or exceeds the carbon cost of using them (European Environmental Bureau 2019). The current geopolitical situation also adds to the business case beyond carbon cost. A large proportion of lithium comes from China and is processed in China or Russia. The current restrictions and geopolitical situation can become a tremendous weakness.

Unfortunately, the traditional IT hardware lifecycle process tends to be linear rather than circular. Applying a circular approach to managing IT hardware is an excellent unlock toward carbon neutrality by focusing on extending product lifetime and recirculating all materials without producing any waste. Switching from a linear to a circular economy requires our supply chains to use minimal virgin material and produce zero waste.

My (Niklas) previous employer, Gartner, predicts that within a decade, in the 2030s, the circular economy will be the only economy:

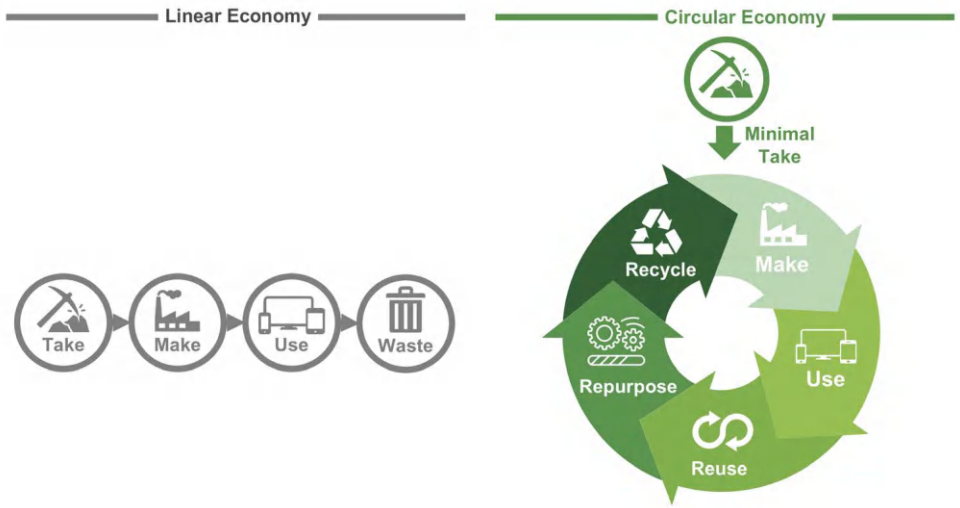


Figure 9.2 – From a linear to a circular economy

As highlighted in *Chapter 1, Our Most Significant Challenge Ahead*, the circular economy is a design paradigm that aims to eliminate waste as a phenomenon. All products, processes, and business models are designed more innovatively from the beginning so that all products can be used and maintained for longer, reused, and refurbished, if possible. When the day comes when you can no longer use the product anymore, you should be able to disassemble the product into closed cycles, where technical material is either repurposed or recycled in technical cycles and biodegradable material in biological cycles.

Achieving circularity across all material flows is critical because nothing we throw away truly goes away. Instead, we practically throw the garbage at ourselves and each other, either in physical form, in particulate form, or in the form of chemicals (Carlsson 2021).

The most significant environmental impacts during their lifecycle can be divided into five categories:

- Product design and manufacturing
- Product lifespan expansion
- Limiting energy consumption and emissions
- Circular lifecycle management
- End-of-life management

We will look closer at each of these approaches later in the chapter (and for energy management in *Chapter 10*, *Energy Resource Management*). But first, we need a grounding in the measurement methodologies and metrics we will use to calculate and compare IT device carbon footprints.

The methodologies of carbon assessment

The key data points for all types of IT hardware and end user devices are **product carbon footprint (PCF)** and full **lifecycle assessment (LCA)**. A PCF quantifies the total **greenhouse gas (GHG)** emissions associated with an IT hardware product throughout its lifecycle, expressed in **carbon dioxide equivalents (CO_2e)**. For laptops and servers, PCF is typically reported for a four-year lifecycle – smartphones, three years. LCA is a standardized method (per ISO 14040/14044) used to quantify the environmental impacts of an IT hardware product across its full lifecycle, covering four major phases: raw material extraction and manufacturing, transportation and distribution, usage, and end-of-life disposal. An LCA captures these phases to estimate multiple environmental indicators – not just GHG emissions – including global warming potential, water footprint, resource depletion, toxicity, and pollution.

Both of these metrics are essential for emissions inventories, environmental, social, and governance (ESG) disclosures, and sustainable procurement. But obtaining accurate and actionable data is not only difficult, it can also seem like a futile exercise when you realize that the numbers vary widely depending on the methodology behind them. Making matters more complex, there a several widely varying methodologies to choose from.

Why is PCF and LCA reporting difficult?

Several key challenges persist in quantifying the environmental impact of IT hardware:

- **Lack of standardization across vendors**: Each manufacturer may apply different assumptions, boundary conditions (e.g., cradle-to-gate vs. cradle-to-grave), and allocation methods in calculating emissions
- **Opacity and proprietary models**: Many hardware vendors treat LCA models as confidential intellectual property, making it hard for customers to audit or verify claims
- **Component complexity and supply-chain opacity**: IT devices consist of hundreds of components sourced from diverse geographies, often without full traceability of embedded emissions, water use, or material sourcing impacts
- **Temporal and regional variability**: PCFs can vary significantly over time (due to updates in production processes) or by location (due to grid carbon intensity), but many published figures fail to reflect these variations

- **Reporting gaps for operational use**: While embodied emissions data may be provided, many tools omit accurate energy use profiles or assume generic power usage rather than device-specific configurations or workload impacts

To address these problems, several methodologies and tools have emerged – each with distinct scopes, assumptions, and applications. Some are proprietary (e.g., used by **original equipment manufacturers (OEMs)**, while others are open or industry-aligned efforts. Third-party companies that provide data services to IT clients typically use one or more methodologies. Companies providing LCA and PCF data for this book use different methodologies. Most of the energy and emissions data associated with specific products in this book are derived from custom analysis done in April 2025 by Denmark-based carbon data service provider Rejoose, specific to hardware deployed in the UK, and by TCO Certified. Headquartered in Stockholm, Rejoose applies ISO 14044, while TCO Certified leverages PX3. You will need to standardize on a methodology or combination of methodologies that will best provide what you need. The trick is to maintain consistency for comparisons over time.

Here is a comparative table summarizing the most common approaches in use today:

Methodology/ Tool	Developer/Host	Access/Link	Strengths	Shortcomings
OEM PCF reports (HP, Dell, Lenovo, etc.)	Individual OEMs	The OEM websites	Device-specific emissions data, often third-party reviewed, aligned to ISO 14040/44	Not always comparable across brands; opaque assumptions; incomplete product coverage
Product attributes to impact algorithm (PAIA)	MIT and HP-led consortium	`paia.mit.edu`	Rapid LCA model using standard device attributes (e.g., screen size, RAM) for laptops and desktops; free and replicable	Limited to select device types; less accurate for newer or non-standard form factors

PX3 Sustainability Scoring Model	PX3 Ltd (UK-based consultancy)	px3.org.uk	Offers embedded and operational emissions data based on real-world energy use and manufacturer data; reports tailored to enterprises	Not fully transparent; methodology is proprietary; limited public technical detail
TCO Certified Edge, Climate	TCO Development	tcocertified.com	Verifies product carbon footprints using third-party reviewed LCA for monitors, laptops, and phones	Applies only to products that pursue certification; limited device category coverage
ETSI LCA Standard (ETSI ES 203 199)	ETSI (European Telecommunications Standards Institute)	etsi.org	Comprehensive method for ICT equipment LCA; telecom-focused but adaptable	Technically dense; requires significant effort to apply at product level
GHG Protocol ICT Sector Guidance (2017)	GHG Protocol / WRI / WBCSD	ghgprotocol.org	Provides guidance for calculating scope 3 emissions in ICT procurement, including hardware and cloud	Not a PCF model per se; relies on LCA data that must be sourced or estimated elsewhere
ISO 14044 (Environmental Management – LCA Requirements and Guidelines)	International Organization for Standardization (ISO)	iso.org/standard/38498.html	Internationally recognized standard for performing LCAs; forms the basis of most credible vendor PCFs	Requires LCA expertise; must be purchased for full access; does not prescribe specific modeling tools or sector customizations

ISO 14067:2018 – Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification	International Organization for Standardization (ISO)	`https://www.iso.org/standard/71206.html`	Provides a globally recognized, consistent method for quantifying and communicating PCF; includes requirements for transparency and reporting	Lacks specific guidance for IT hardware sectors; does not cover full environmental LCA factors (only GHG emissions); must be purchased to use
iNEMI LCA for Servers	International Electronics Manufacturing Initiative	`inemi.org`	Designed to standardize LCA methodology for servers in enterprise and high-performance computing contexts	Limited to servers; project still evolving; not a complete dataset or tool yet
JRC Product Environmental Footprint (PEF) methodology	European Commission / JRC	`eplca.jrc.ec.europa.eu`	Harmonized EU methodology for calculating environmental impacts across products, including ICT	Complex, requires full LCA expertise; not ICT-specific by default; tool support still emerging

Table 9.1 – Comparison of common PCF/LCA methodologies for IT hardware

As organizations advance toward science-based targets and more rigorous ESG disclosures, the need for reliable, comparable, and transparent IT hardware sustainability data is urgent. While no single method is perfect, combining vetted tools such as PAIA or PX3 with vendor disclosures and lifecycle guidance, such as the GHG protocol, enables a more credible estimation process.

Now that we appreciate the challenge of working with various measurement methodologies, let us do some comparisons between hardware types and models.

End-user hardware lifecycle assessment

Let us compare three specific end-user products – a laptop, tablet, and smartphone – from different vendors. Let us start with a laptop. The following diagram compares three similar laptops from three different hardware vendors – **Dell**, **HP**, and **Lenovo**. All three products are **TCO Certified**:

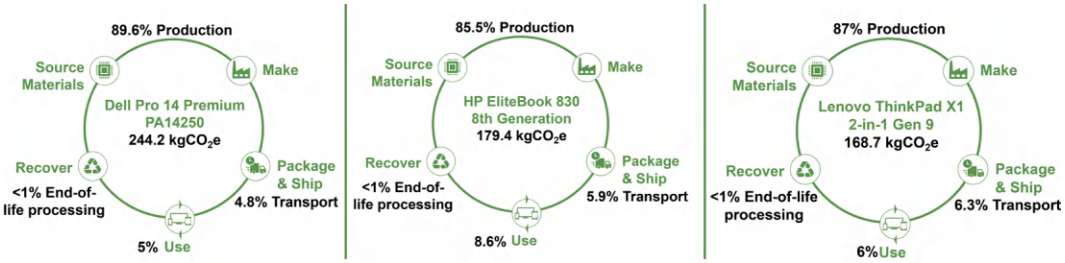


Figure 9.3 – Laptop product CO_2 lifecycle emissions comparison

Based on the LCA provided by the vendors or, as in our case, a third-party data provider, the overall emissions can differ significantly. A laptop from Dell (the Pro 14 Premium) emits 244.23 $kgCO_2e$. An HP EliteBook 830 8th Generation emits 179.4 $kgCO_2e$ (HP 2024), and a Lenovo ThinkPad X1 2-in-1 Gen 9 emits 168.74 $kgCO_2e$, all three based on an expected lifetime of 4 years. Manufacturing represents 89.6% of total emissions, transportation is 4.8%, usage is 5.0%, and end-of-life processing is 0.6%. The yearly energy demand is 15 kWh, which also impacts the environment depending on whether it is powered by renewable energy or fossil fuels (Rejoose 2025). We will now look at each of these devices in a bit more detail.

The Pro 14 Premium laptop from Dell emits 244.23 $kgCO_2e$. Manufacturing represents 89.6% of total emissions, transportation is 4.8%, end-of-life processing is 0.6%, and usage is 5.0%. The product contains 35% recycled plastics (TCO Certified 2025). The **typical energy consumption (TEC)** per year is 15.0 kWh (Rejoose 2025).

The EliteBook 830 8th Gen laptop from HP emits 179.4 $kgCO_2e$. Manufacturing represents 85.5% of total emissions, transportation is 8.7%, end-of-life processing is <1%, and usage is 8.7%% (HP 2024). The product contains 35% recycled plastics; the TEC per year is 24.4 kWh, according to ENERGY STAR.

The Lenovo ThinkPad X1 2-in-1 Gen 9 emits 168.74 $kgCO_2e$. Manufacturing represents 87% of total emissions, transportation is 6.3%, end of life is <0.7%, and usage is 6% (Rejoose 2025). The product contains 9.5% recycled plastics by weight, and the TEC per year is 12.5 kWh (TCO Certified 2025).

Let us compare the carbon emissions for each laptop over a year. We find the number of **kilograms (kg)** of CO_2 emissions per year by multiplying the TEC per year by the global average carbon intensity of 0.445 $kgCO_2$/kWh. Doing the calculations, we find that the yearly CO_2 emissions for the Lenovo ThinkPad X1 2-in-1 Gen 9 are 5.6 kg (12 pounds), Dell Pro 14 Premium 6.7 kg (14.7 pounds), and the HP EliteBook 830 8th Gen 10.9 kg (24 pounds).

Due to the difference in TEC, the carbon emissions are nearly twice as much for the HP EliteBook 8th Gen as opposed to the Lenovo ThinkPad X1 2-in-1 Gen 9. We will look closely into the carbon emissions for energy consumption in *Chapter 10*, *Energy Resource Management*.

Now, let us take a closer look at the tablet product category. The following diagram compares three similar tablets from three different hardware vendors – **Microsoft**, **Apple**, and **Lenovo**:

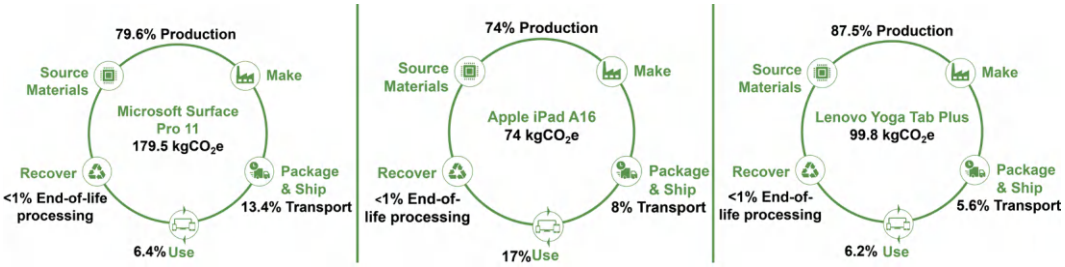


Figure 9.4 – Tablet product CO_2 lifecycle emissions comparison

Based on the LCAs provided by Rejoose and Apple, we can see that overall emissions can differ by more than 2 times between vendors over a 3-year lifespan. A Microsoft Surface Pro 11 (11th Generation) has an LCA of 179.5 $kgCO_2e$, while a Lenovo Yoga Tab Plus has an LCA of 99.8 $kgCO_2e$ (Rejoose 2025 based on deployment in the UK). An Apple iPad A16 has an LCA of 74 $kgCO_2e$ over the same lifespan (Apple 2025).

Finally, we will examine the smartphone product category. As of Q2 2025, the top five smartphone makers by shipment share were Samsung (20%), Apple (16%), Xiaomi (15%), Vivo (9%), and Transsion (9%), whereas other brands constitute a 32% share of the global smartphone market (Omdia Canalsys 2025). PCF and LCA breakdowns are available at the product model level from Samsung, Apple, and Xiaomi. Two of the most common smartphones are compared here:

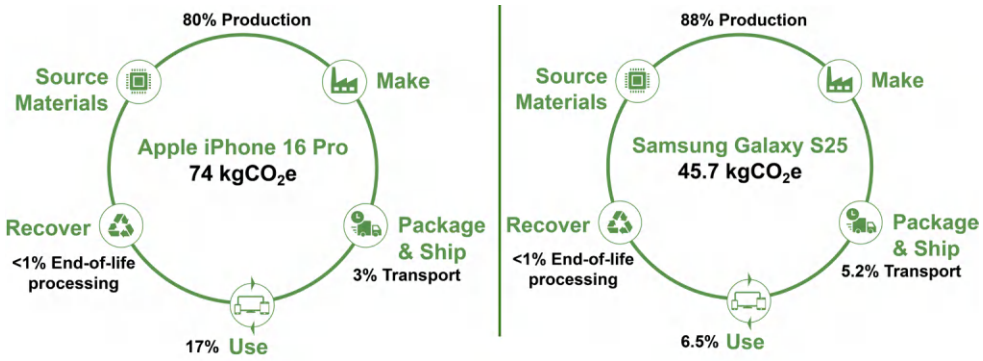


Figure 9.5 – Smartphone product CO_2 lifecycle emissions comparison

Apple's iPhone 16 Pro emits 74 $kgCO_2e$ (TCO Certified 2025), Samsung's Galaxy 25 emits 45.7 $kgCO_2e$ (Samsung 2025), and the Xiaomi 14 produces 53 $kgCO_2e$ (Xiaomi 2023). These figures are all based on an expected lifetime of three years, and the methodologies follow SO 14040/44 and PCF practices. Numbers may be higher or lower depending on how far the phones must travel. For example, shipping a Samsung Galaxy to the USA adds another 3.18 $kgCO_2e$.

Now that we have looked at the carbon emissions impact from a few categories, let us consider a concrete example from a typical global manufacturing company. It has 60,000 employees, and 60%—that is, 36,000 employees—have a designated computer. The current lifecycle hardware policy is 4 years, equivalent to the vendor warranty period. We assume that 9,000 laptops are replaced annually; no recycling or refurbishment is considered. The assumption is that the employment growth is 10% per annum. For simplicity, we have chosen Dell Pro 14 Premium as the model computer issued to all employees, and assume no significant changes to its PCF. The following diagram illustrates the projected GHG emissions over 10 years:

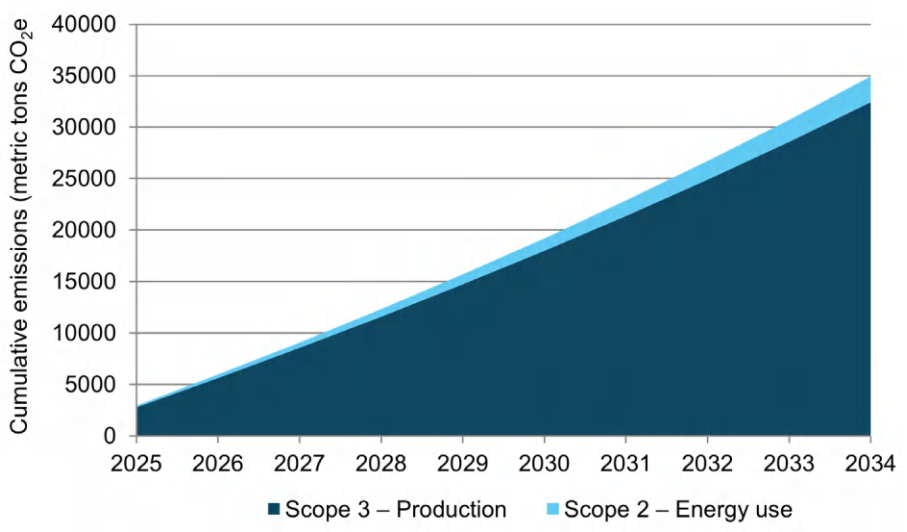


Figure 9.6 – Global manufacturing model company computer GHG emissions

Looking at the total impact just from energy usage (Scope 2) and product (Scope 3) over a 10-year cycle, the emissions are close to 35,000 metric tonnes of CO_2e ($MtCO_2e$). Roughly 7% comes from Scope 2, which is energy usage, while the remaining 93% comes from Scope 3, which is manufacturing, logistics, and end-of-life management.

This is just for one global manufacturing model company, so it should give you a good sense of the gravity of the situation. The good news is that several alternatives can be explored to reduce GHG emissions radically. Later in this chapter, we will explore ways to prolong the end user's hardware's lifetime.

Server lifecycle assessment

Now, let us look at a lifecycle assessment of a server. According to IDC, the worldwide server market generated $235.7 billion in revenue in 2024, with GPU-equipped systems accounting for more than half of the total. In Q4 2024, Dell Technologies and Supermicro were in a statistical tie for the top vendor share, followed by **Hewlett Packard Enterprise** (**HPE**), **IEIT Systems** (**Inspur**), and **Lenovo**, while **original design manufacturers (ODM)** direct suppliers represented nearly half of quarterly revenue (IDC 2025). For this example, we selected two servers from Dell Technologies and HPE.

You will discover that the PCF profile will look different from end user computing IT equipment, where most of the carbon emissions are spent in the use phase instead of manufacturing. A PowerEdge R760 server deployed in the UK emits 4,201 $kgCO_2e$ over an expected lifetime of 4 years with a yearly TEC of 4338.4 kWh. Similarly, for an HPE server, the ProLiant DL365 Gen11 Plus server emits 1,582.93 $kgCO_2e$ over a 4-year lifecycle with a yearly TEC of 1,394.6 kWh (Rejoose 2025).

We have seen the major server vendors increase warrantied lifecycles from four years to five, with the potential for extensions up to seven years. The hyperscalers are now reporting their server useful lifespans at six years. Extending server lifespans reduces the embodied carbon (Scope 3) associated with frequent hardware manufacturing and slows e-waste generation. Financially, for those of you buying servers for on-premises data centers, longer vendor-stated lifespans reduce **total cost of ownership** (**TCO**), delay refresh expenditures, and make budgeting more predictable. Those with cloud-hosted servers may benefit from more stable cloud pricing as efficiency gains are passed on. Later in this chapter, we will look closely at the sustainability and financial benefits of extending laptop life from 4 years to 5 years in a large company over a 10-year period.

Compared to a Dell Pro 14 Premium laptop, which emits 244.23 $kgCO_2e$ over a lifetime of 4 years, a Dell server emits as much as 17 times more than a standard laptop. This is a significant difference. Only one server equates to driving a car 17,400 kilometers in a passenger car, and 10 of these servers have a carbon footprint equal to what 41 hectares of forests can absorb in a year. The following diagram illustrates how the carbon emissions are distributed over the server's four-year lifecycle:

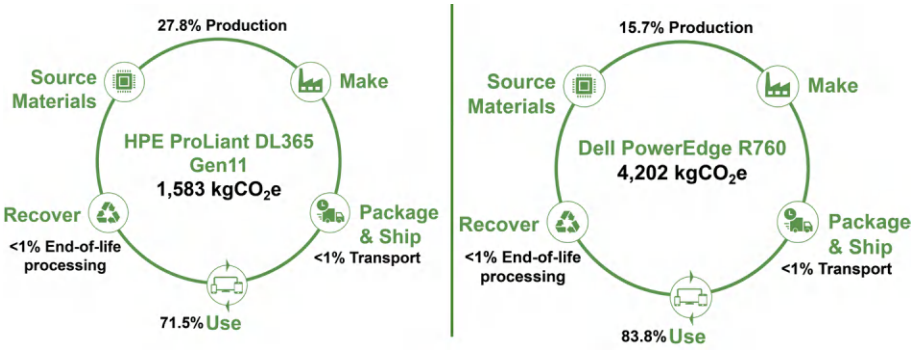


Figure 9.7 – HPE and DELL-EMC server PCF lifecycle distribution

Contrary to end user equipment, where 80% of the carbon emissions are spent during the manufacturing phase, only 10% to 30% of a server's PCF is attributed to the manufacturing phase. The 70% to 90% remaining of the PCF is consumed during the usage phase. The package and shipment and end-of-life processing are less relevant for a server.

As 70% to 90% of the server's carbon footprint is consumed during the usage phase, which can be translated into your energy consumption, this has a significant implication for your TCO since running and cooling the server far exceeds the initial price of the hardware. Therefore, buying "ENERGY STAR" certified servers is extremely important to ensure the efficient use of your enterprise servers. Furthermore, a data center/cloud provider has a significant role in lowering carbon emissions by running on renewable or low-carbon energy, leveraging hardware utilization, increasing the share of virtualization, and heat recovery, to mention a few. We explored some of these key concepts in detail in *Chapter 6*, *Data Centers and Cloud*, on optimizing your computing workload.

Next, **Mauri Paz, Head of ESG and Third-Party Risk Products** at **ServiceNow**, provides insider advice for obtaining the LCA Scope 3 data we have been citing for our hardware categories and models.

Best practices for measuring hardware Scope 3 emissions

As you can see from the preceding material, the lifecycle analysis of IT products includes Scope 3 emissions arising from just about every phase of the lifecycle except usage. Most IT asset manufacturers have LCA data available to the public via their websites; however, in many cases, not all models have one. There are big data gaps for legacy products, so if your asset estate is dated, you may need to model this information. To add to the difficulty of obtaining the data is the fact that most of the LCA and environmental disclosure documents are not easily searchable (PDF files are the norm). Once you obtain the desired report, you may also see that they tend to include energy consumption for the life of the asset and whether the asset has an ENERGY STAR rating or equivalent.

Since Scope 3 data, for the most part, is needed for successfully rolling out any sustainable IT program, it is important to understand how to collect the datasets.

The first suggestion we give is to work with your internal sustainability team. Regardless of whether they have the data, they can help you navigate the jargon and orient your team on what is available already and truly needed. It's a matter of time until you exhaust that avenue and must continue expanding the data volume by publicly available datasets, engaging with vendors directly, or creating models based on existing data you do have at your fingertips.

As mentioned earlier, many vendors provide LCA or environmental disclosure fact sheets with the needed data. Largely, these are public sources, but we have seen several manufacturers that protect this data, so it becomes available by request only.

When it gets to that stage, start with the vendors for which you have the largest volume of IT assets or the highest value to measure and mitigate. You can engage with them directly; however, it is advisable that you work with your procurement team to reach out faster to the right person within that vendor. If the volume of critical vendors is too high, we suggest that you reach out to vendors using an assessment and survey tool. This involves having a solution with a vendor portal, a set of assessments, and questionnaires that you can provide to the vendors to obtain the information you need. It is likely that the procurement, vendor risk, or sustainability team uses a tool like this within your organization already. Leverage what you already have!

Once you gather the information from vendors, don't take it at face value. It is important to verify the information and benchmark it to a certain degree to ensure it is accurate and reliable. Many times, vendors will have different methodologies that yield varying results for sustainability and sustainable IT purposes. Please note that some vendors may not have all the data you are looking for. If a major provider of IT assets lacks the data you need, you will need to work with that vendor one-on-one to obtain it. If that fails, it might drive you to consider switching vendors to achieve your objectives.

If all these avenues have been exhausted and you are able to secure a small budget to gather this data, there are consultants who have models to estimate carbon and energy consumption from IT assets. These are often specialty assets in industries such as manufacturing or banking, where data is more sparse.

> To avoid the most common mistake related to Scope 3 data, you need to understand the boundaries and assumptions of the data provided. For example, if you are looking at data for a laptop and the manufacturer calculated carbon based on shipping within the US and with a life span of 3 years, you can't ship the computers to South America and change them every 4 years without adjusting the data provided by the manufacturer; it will yield incorrect results. Make sure you normalize the data to avoid inaccurate calculations. Once again, it is best if you work side by side with your sustainability team. They understand how to read and interpret emissions factors, energy consumption, and LCAs, which will help with time-to-value for your program.
>
> *Mauri Paz, Head of ESG and Third-Party Risk Products, ServiceNow*

Hopefully, you are not overwhelmed by the complexities and scope of hardware lifecycle assessment. As we stated, you can bite off one major piece at a time and gather enough detail to make future procurement choices with sustainability included as one of the key factors.

Managing the hardware lifecycle for sustainability

Once you have the LCA or PCF data for your hardware assets, you can not only make more informed purchase choices, but you can also manage your installed assets to maximize their value as well as their lifecycle sustainability. This section describes the most impactful approaches.

Product design and manufacturing

The most crucial concept in the circular economy is design for disassembly. This means that everything is designed with excellent care so that all components and materials can be easily disassembled from each other. In the circular economy, for example, you do not want to mix materials in a way that makes them difficult to separate. Nor do you want to use forms of glue or other joining methods that make it difficult to separate the components from each other, but instead join them, for example, in various sophisticated ways, allowing the components to be clicked into each other. The design phase is crucial for creating possibilities for how to reuse the object later. It is estimated that approximately 80% of a product's environmental impact is determined in the design phase (European Commission 2022). This usually translates into roughly 80% of the greenhouse gas emissions of a product's lifecycle having already been spent before you receive a new laptop or smartphone in your hand in the manufacturing process. Therefore, it is critical to **eco-design** your products to reduce the environmental impact of your products, not only in the manufacturing process but also including the energy consumption throughout their entire lifecycle.

An electronic product follows the same lifecycle from the cradle to the grave. The lifecycle can be divided into five categories: take (extract raw materials/source materials), make, logistics (package and ship), use, and recover. This is more commonly known as **embodied carbon** – the amount of carbon pollution emitted during a product's lifecycle from creation to disposal. In addition to the embodied carbon, you also have the carbon emissions from powering the device with electricity during the use phase. The environmental impact from your embodied carbon and your electricity depends on your energy mix's carbon intensity: the more renewable energy used, the less the environmental impact.

An environmentally and socially responsible supply chain approach must be applied throughout the process of extracting raw materials, sourcing components, and manufacturing. Controls must be in place to ensure supply chain transparency, suitable working environments, anti-bribery, energy efficiency, responsible chemical management, and responsible use of sourced materials (minerals, rare-earth metals, plastics, and so on).

The following two subsections will closely examine the LCA of two IT hardware categories: end user and server equipment. Your spontaneous reaction might be that they do not differ much, but their LCA profiles are quite different.

In modern computing systems, a wide array of metals—including copper, aluminum, gallium, phosphorus, lead, tin, iron, steel, silver, gold, tantalum, mercury, and yttrium—are strategically utilized across components. Recent studies bring heightened urgency. For instance, simulated projections indicate soft gallium scarcity could begin after 2028, with physical shortages emerging by 2060, unless extraction and recycling yields—currently just 7% to 15 %—are improved to more than 50% (Springer Nature Link 2025). In parallel, national and international bodies, including the UK's Royal Society of Chemistry, now classify materials such as gallium, indium, tantalum, yttrium, arsenic, and others as "*critical raw materials*," highlighting their strategic importance and supply risk in ICT and other sectors. Furthermore, the Royal Society of Chemistry advocates global circularity efforts to "*mine waste rather than the Earth*" (BBC 2022).

In addition, a computer contains hazardous substances such as phthalates, brominated flame retardants, synthetic musks, alkylphenols, and organotins that must be managed with extreme care. These hazardous substances can cause unwanted side effects such as asthma, hay fever, eczema, and cancer (IT-recycling 2024).

Following the 1992 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, many countries have implemented regulatory restrictions prohibiting the export of electronic waste. In 2003, the EU brought the **Waste Electrical and Electronic Equipment Directive (WEEE Directive)** 2012/19/EU and the **Restriction of Hazardous Substances (RoHS) Directive** 2011/65/EU into European law.

The WEEE Directive regulates the collection, recycling, and recovery of various electronic goods. It places a "producer responsibility" on manufacturers to ensure proper collection and lifecycle management of old products and materials. The WEEE Directive covers 10 electronics categories, including IT and telecommunications equipment.

The RoHS Directive regulates European manufacturers' usage of hazardous substances in production and product inclusion on new electronic equipment being introduced in the market. RoHS stands for Restriction of Hazardous Substances (European Commission 2023). To further restrict the use of certain hazardous substances in **electrical and electronic equipment** (**EEE**), the **European Parliament** enacted an updated RoHS Directive on June 8, 2011. The sole purpose of this directive is to address the increasing global issue of e-waste and prevent the use of hazardous materials. The directive singles out 10 hazardous materials:

1. Lead (Pb)
2. Mercury (Hg)
3. Cadmium (Cd)
4. Hexavalent Chromium (Cr6+): Used in chrome plating, chromate coatings, and primers
5. Polybrominated Biphenyls (PBB): Flame retardant in plastic
6. Polybrominated Diphenyl Ethers (PBDE): Flame retardant in plastic
7. Bis(2-Ethylhexyl) Phthalate (DEHP)
8. Butyl Benzyl Phthalate (BBP)
9. Dibutyl Phthalate (DBP)
10. Diisobutyl Phthalate (DIBP)

The directive states that the use of these 10 hazardous materials in electrical and electronic equipment should be restricted during the point of the manufacturing process, with the product itself, and ensure proper release of materials within e-waste streams to prevent human health and environmental hazards.

It is worth noting here that the WEEE Directive has been widely criticized for falling short in several areas. Findings from a review by the European Commission were released in 2025 and listed several challenges to the 20-year-old regulations (European Commission 2025):

- **Scope**: Current legislation does not fully cover new waste streams rich in critical raw materials from renewable energy and digital technologies (e.g., wind turbines)
- **Collection**: Low public awareness, insufficient infrastructure, illegal trade, and inconsistent calculation methods hinder target achievement
- **Critical raw materials recovery**: Limited recycling targets fail to drive effective recovery of secondary raw materials
- **Extended producer responsibility (EPR)**: Fragmented implementation and enforcement across member states, especially in online sales
- **Treatment standards**: Only 23% of EU recycling facilities meet high-quality treatment standards, reducing the potential recovery of valuable materials

The Commission is adopting a law to establish a fully digital EU-wide waste shipment system in 2026 that will replace paper-based procedures for moving waste between member states, improving traceability, cutting red tape, and reducing illegal exports. Other improvement recommendations include the following:

- Strengthening enforcement and consistency to improve accountability and treatment across EU member states
- Expanding and updating product scope to include emerging electronics (e.g., smart devices, photovoltaics, etc.)
- Standardizing data collection and reporting to improve transparency through common methodologies and digital traceability systems
- Enhancing border controls and reuse validation to make certain that exported equipment is functional and properly documented to deter illegal waste transfers

In the US, there are various state-level producer responsibility programs, but they generally don't focus on business-generated material. US regulation includes the **Resource Conservation and Recovery Act (RCRA)**, which prevents non-households from disposing of "hazardous materials" with their regular waste. Each state then institutes additional regulations and determines how to enforce these provisions.

While we await improvements in regulatory controls, the most effective way to eliminate hazardous substances is at the point of manufacturing. While IT hardware manufacturing relies on a wide range of available chemicals, the majority of these substances have not been assessed for their potential impacts on human health or the environment. Historically, suppliers had little guidance on safer options, and restrictions tended to only eliminate the most hazardous substances without providing clear alternatives on what to use instead. The introduction of TCO Certified's **accepted substance list** (**ASL**) in 2015 offered vendors a pathway to select chemicals not only for their technical performance but also for their independently verified safety profile. This gave manufacturers a practical tool to substitute restricted substances with safer alternatives, enabling more informed decisions that support both product performance and sustainability already at the design phase. As a hardware purchaser, you can apply your buying power to influence manufacturers to maximize the use of accepted substances. *Chapter 11*, *Leveraging Your Buying Power*, will go into detail on this. Also, see related topics in the *Further reading* section at the end of this chapter.

Product lifespan expansion

Extending the lifespan of a product is one of the most critical factors in reducing GHG emissions. In today's fast-electronics mindset, we tend to apply a linear approach, treat our electronics as disposable assets, and pay little or no attention to circular practices. This approach is not sustainable in a world with finite resources and an insurmountable amount of e-waste that is continuously growing. It is worth noting that the EU has an entire initiative focused on becoming a circular region as part of the Green Deal. It has been creating several laws aimed explicitly at e-waste, such as the WEEE Directive.

We radically need to prolong the lifespan of our IT products and components while maximizing their value by minimizing resource use. Prolonging our IT products' lifespan is a significant opportunity to reduce our GHGs and resource consumption in energy, water, minerals, and metals.

Several factors can be considered to extend the product's lifetime use:

- **Product warranty**: Demand an extended product warranty to ensure a longer lifetime of the product in the first use phase.
- **Product durability**: The product should come with high durability to withstand everyday use from wear and tear.
- **Modularized assembly**: Demand components and materials that are easy to disassemble from each other and can be replaced, such as the battery, hard drive, and memory.

- **Battery longevity and replicability**: Demand guarantees above 1,000 charge cycles and the ability to quickly replace batteries.
- **Standardized connectors**: Utilize products with standardized connectors to reduce the need for multiple accessories such as power adapters, docking stations, screens, and more.
- **Data protection and security features**: Ensure that IT products can be safely refurbished and redistributed. The ability to remove data securely is critical. Different removal techniques must be used, depending on the sensitivity of the data on the storage media. We will explore them further in this chapter's *Leveraging ITAD Services* section.
- **Product-as-a-Service**: Explore the Product-as-a-Service subscription model instead of buying a product upfront. Some leasing companies and increasingly hardware vendors such as **Cisco**, **Dell**, and **HP** offer a green-leasing approach that can bring several sustainability benefits and reduce carbon footprint, recover the material, minimize e-waste, and reduce up-front CapEx spending.

Circular IT hardware management

As we saw in the chapter's earlier sections, there are some significant environmental impacts during a product's lifecycle. The switch from a linear economy to a circular economy is pivotal in transitioning to a sustainable future. In this section, we will learn how the 9R circularity framework is applied to IT. We will look ahead at new EU circularity laws that will help make circular IT hardware management more practical. We will see how AI can automate and enhance circularity actions. Finally, we will explore hardware end-of-life management. As we saw in *Chapter 1*, *Our Most Significant Challenge Ahead*, we are already consuming 1.75% of Earth's resources and not regenerating enough to live within the constraints of planet Earth. In our current way of living, finite raw materials are extracted, or non-virgin plastics are used, the products are manufactured, the products are shipped to a distribution point, the customer buys and uses the products, and at the end of the product's lifetime, it is discarded with limited reuse or recycled – the process is linear.

In the linear economy, we continue to deplete Earth's natural resources, and once they have reached their end of life, they end up in a toxic landfill instead of being recycled. In the circular economy, we take a minimal number of finite resources and create a regenerative process flow that continues to live as long as possible. The following diagram illustrates the 9R framework (Kirchherr, Hekkert, and Denise 2017) for a circular economy:

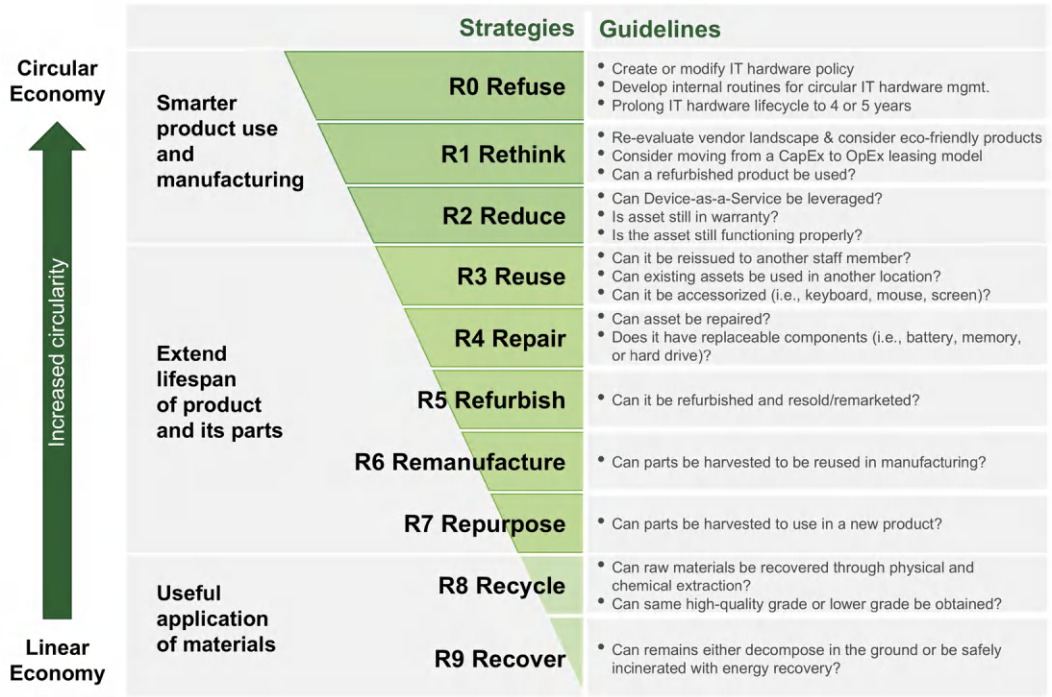


Figure 9.8 – 9R framework circular economy

The 9R framework consists of 10R strategies divided into three categories. The categories specify a more innovative product use and manufacturing, the extended lifespan of the product and its parts, and the practical application of materials. These strategies are *R0 Refuse*, *R1 Rethink*, *R2 Reduce*, *R3 Reuse*, *R4 Repair*, *R5 Refurbish*, *R6 Remanufacture*, *R7 Repurpose*, *R8 Recycle*, and *R9 Recover*. Several guidelines or critical questions can be applied for each step to inspire thinking differently. These strategies are well aligned with the circular economy's core pillars defined by the **Ellen MacArthur Foundation**:

- Designing out waste and pollution
- Keeping products and materials in use
- Regenerating natural systems

The whole idea is that the further you move from *R9 Recover* to *R0 Refuse*, the more you transition from a linear to a circular economy. The earlier in the lifecycle you can apply one of the strategies within the 9R framework, the better and the less invasive impact it has on the environment. In fact, Prof. Jacqueline Cramer (former Dutch Minister of Housing, Spatial Planning, and the Environment, and Utrecht University professor) adds an R10, *Renew* or *Redesign*, to the original 9 to emphasize design-for-circularity at the upstream stage. Let us look at how the circular economy approach can be applied within your environment:

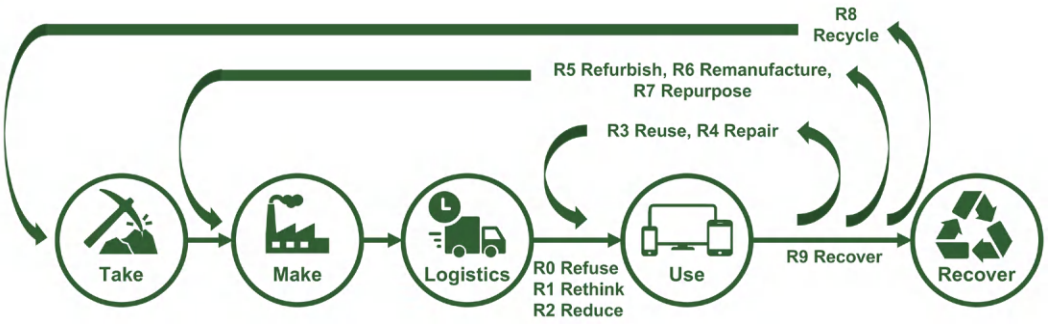


Figure 9.9 – Circular economy approach to the 9R framework

The most significant impact you can have is refusing, rethinking, and reducing strategies in the pre-use phase. Once the product is in use, reuse and repair strategies should be applied. This capability can be retained in-house or outsourced to a vendor. Once the product approaches its end of life, refurbish, remanufacture, and repurpose strategies should be applied. You will most likely need assistance from a vendor that can support the ITAD process. If all nine other strategies fail, the last phase is the recovery phase, where remains can rot in the ground or be safely incinerated with energy recovery.

Let us take a closer look at some of the guidelines that you can apply within your environment for each strategy to promote circular principles:

- **R0 Refuse**:
    - Create or modify the IT hardware policy so that it supports circular economy principles
    - Prolong the IT hardware lifecycle policy to 4, 5, or even 6 years
    - Develop internal routines for circular IT hardware management

- **R1 Rethink**:
    - Re-evaluate your vendor landscape and consider more eco-friendly products
    - Consider green IT leasing, swapping from a CapEx to an OpEx model
    - Is a new product needed, or can a used one be used?
    - Can a refurbished product be used instead of purchasing new?
- **R2 Reduce**:
    - Can **Device-as-a-Service** (**DaaS**) be leveraged?
    - Is the asset still under warranty, and can it be fixed by the supplier?
    - Is the asset still functioning correctly?
- **R3 Reuse**:
    - Can it be reissued to another staff member?
    - Can existing assets be used in another location?
    - Can it be accessorized with a keyboard, mouse, or screen?
- **R4 Repair**:
    - Can assets be repaired?
    - Does it have replaceable components – that is, a battery, memory, or hard drive?
- **R5 Refurbish**:
    - Can it be refurbished and resold/remarketed?
- **R6 Remanufacture**:
    - Can the part be harvested to be reused in manufacturing?
    - Can the materials be used in other products?
- **R7 Repurpose**:
    - Can the part be harvested for use in new products?
- **R8 Recycle**:
    - Can raw materials be recovered through physical and chemical extraction?
    - How will the quality of recycled materials compare to that of new material?

- **R9 Recover**:
    - Can remains either safely decompose in the ground or be safely incinerated with energy recovery?

EU rules for circularity

The EU law **Ecodesign for Sustainable Products Regulation** (**ESPR**) should make it more practical to manage IT hardware for circularity – chiefly **digital product passport** (**DPP**) technology, right-to-repair rules, and traceable sourcing. IT will need to help enterprises prepare to take advantage of these new rules and product features. Let's take a look.

DPPs

A central element of its circular economy action plan and EU Green Deal, DPPs are intended to promote sustainable production and consumption. A DPP is a digital record that travels with a physical product throughout its entire lifecycle, capturing key data on materials, repairability, recycling potential, and ESG attributes.

For IT hardware, this means every device—laptop, server, smartphone, and network switch—will have a digital identity accessible through a QR code or the emerging **GS1 2D barcode**. The traditional UPC or EAN barcode only encodes a **Global Trade Item Number** (**GTIN**), which uniquely identifies a product but doesn't directly carry any other data. By contrast, 2D barcodes can hold much more information. A Dell Pro 14 Premium laptop model, for example, will have a single GTIN representing its specific configuration. By scanning the code, stakeholders can retrieve standardized data such as the following:

- **Material composition**: Including critical raw materials such as rare earth elements or cobalt
- **Repairability information**: Manuals, schematics, and availability of spare parts
- **Lifecycle environmental impact**: Embodied carbon footprint, water usage, and recyclability metrics
- **Ethical sourcing data**: Origin of materials, forced labor compliance, and supply chain certifications
- **Ownership and maintenance history**: Enabling safe resale or redeployment of devices

This data empowers manufacturers, enterprises, regulators, and recyclers to make informed decisions that extend product lifespans and improve circularity outcomes, as in these examples:

- **Procurement**: Enterprises can verify sourcing claims and ESG performance before purchase

- **Maintenance**: Technicians gain instant access to repair guides and parts catalogs
- **ITAD**: End-of-life devices can be graded, resold, or recycled based on precise material and condition data
- **Regulatory compliance**: DPPs provide auditable proof of adherence to EU laws such as the Right-to-Repair Directive, the EU Critical Raw Materials Act, and forced labor bans

By digitizing the physical world of hardware, DPPs create a single source of truth for every device, enabling a level of traceability and transparency never before possible in IT lifecycle management. Outside the EU, DPPs won't be a legal obligation (yet), but buyers of DPP-enabled hardware will still gain benefits and be aligned for any future US/UK/other requirements and right-to-repair trends already advancing in multiple states. Regulated and assurance-heavy buyers (finance, public sector) who value auditable bills of material, origin, repair, and carbon data should be particularly interested in hardware with DPPs.

To prepare, CIOs and IT sustainability teams should do the following:

- Update procurement requirements to include DPP compliance clauses in vendor contracts.
- Collaborate with finance and supply chain teams to integrate DPP data into ERP and **product lifecycle management** (**PLM**) platforms
- Start mapping GTINs and serial numbers to cloud-based asset management systems
- Plan for integration with internal reporting on carbon emissions and ESG metrics
- Monitor ESPR announcements and forthcoming DPP data specifications here: `https://oneclicklca.com/en/resources/articles/first-espr-working-plan`

Right-to-repair requirements

The EU Right-to-Repair Directive will come into force by July 31, 2026, requiring manufacturers to provide accessible repair manuals, spare parts, and diagnostic tools for a wide range of IT equipment. This law is a cornerstone of the EU's circular economy transition, fundamentally changing how manufacturers design, support, and dispose of IT hardware. Requirements include the following:

- **Access to repair resources**: Manufacturers must provide repair manuals, spare parts, and diagnostic tools for a wide range of IT products, including laptops, tablets, servers, and smartphones. Uniform documentation standards must be used to ensure independent repair services and corporate IT teams can perform repairs without proprietary barriers. Scanning product DPPs should provide instant digital access to these materials.
- **Extended availability of spare parts**: Replacement parts must be available for 5–10 years after a product is placed on the market.

- **Repairability labels**: Products sold in the EU will be required to carry repairability scores, similar to France's *Repairability Index*, allowing consumers and enterprise buyers to compare devices. A laptop with a score of 8.5/10 will clearly signal that it has easily replaceable batteries, keyboards, and storage modules.

The directive requires vendors to offer and facilitate repair for consumers in the EU. Outside the EU, you won't automatically get the same statutory repair rights or warranty extensions. However, the product's repair-friendly design and parts/info availability will still be helpful to non-EU companies that want circular hardware. Procurement leaders from EU and non-EU regions alike should require their vendors to sell devices that meet or exceed EU Right-to-Repair/ESPR readiness, with documented spare-parts availability windows and public service manuals. Further, vendors should honor EU policies for parts availability, diagnostic tools, and so on globally, not EU-only.

IT teams can prepare to take advantage of the rules by requiring suppliers to deliver manuals and schematics in machine-readable formats for internal systems and support teams. Also, tech procurement teams should incorporate repairability scores (e.g., from TCO Certified) aligned to the EU repair, reuse, and upgrade standard EN45554 as a factor in procurement evaluations, requests for proposals, and vendor contracts.

Traceable materials and ethical sourcing

The EU **Critical Raw Materials Act** (**CRMA**) and **EU Forced Labor Regulation** introduce strict traceability and sourcing obligations. This includes traceability of materials used in electronics and other high-tech products. These laws are intended to secure the EU's access to key materials while eliminating human rights abuses in supply chains.

The rules focus on magnets, batteries, and electronic components, requiring a verifiable chain of custody for all materials used. Companies must provide documented provenance for critical raw materials such as lithium, cobalt, rare earth elements, and magnets. They must also assess and mitigate supply chain risks, including forced labor and environmentally harmful mining practices.

By May 2026, EU member states must create programs to increase recycling and recovery rates of critical materials, and also identify domestic sources of key minerals to reduce import dependency.

To prepare, your IT sustainability team should integrate traceability into ERP systems, mapping DPP data to procurement and asset management workflows. Consider applying automation in the form of machine learning to monitor news, social media, and regulatory feeds for emerging supply chain risks. Also, establish cross-functional processes that connect IT systems with legal and sourcing teams for real-time oversight of traceability data and related risks.

AI-powered circular IT hardware management

AI is a promising tool for circular IT hardware management, offering unprecedented visibility, predictive insights, and automation across the entire asset lifecycle. When implemented responsibly, AI helps enterprises move away from the linear "take-make-waste" model and toward a regenerative system where devices are repaired, reused, resold, or recycled with minimal waste and maximum value recovery. AI can be leveraged to automate or enhance a variety of circularity tasks:

1. **Reverse logistics and automated grading**: AI-driven computer vision and machine learning models are revolutionizing reverse logistics—the process of managing returns, repairs, and refurbishment:
    - **Automated condition assessment**:
        - Cameras and AI algorithms scan returned or retired devices to instantly identify cosmetic damage, wear levels, and component health
        - The AI assigns a grade (e.g., A, B, or C) that determines whether the device should be refurbished, resold, or recycled
        - *Example*: FedEx has piloted systems that use AI to automatically grade returned electronics, cutting processing time by 50% and increasing resale yields
    - **Routing optimization**:
        - AI predicts the most profitable or sustainable disposition path, balancing resale value, repair cost, and ESG impact
        - A device with a failing battery, but pristine casing, may be routed to a specialized refurbisher, while a heavily damaged unit goes directly to certified recyclers
2. **Predictive maintenance and lifecycle extension**: AI models are being applied to analyze streams of performance and telemetry data from endpoints such as laptops, servers, and networking gear to predict failures before they occur, enabling proactive repair and maintenance:
    - **Early failure detection**:
        - AI monitors device health indicators such as CPU temperatures, power usage, and component wear.

- Alerts are triggered before catastrophic failures occur, avoiding costly downtime and premature replacements.
- *Example*: If battery health drops below a threshold, or abnormal drain patterns are detected, AI would trigger a battery-only replacement order. AI that detects chronic app crashes or high RAM pressure would recommend a RAM upgrade versus a device replacement.

- **Lifecycle planning**:
  - Predictive analytics help IT determine optimal replacement cycles for hardware based on usage patterns and repair histories, extending lifespans where possible.
  - Supports ESG goals by reducing demand for new equipment and cutting Scope 3 emissions.

3. **Dynamic asset tracking with DPPs**: AI can work hand-in-hand with DPPs and GS1 QR codes to track assets throughout their lifecycle:
   - **Real-time monitoring**:
     - AI systems will use IoT sensors, RFID, and barcode scans to monitor the location, status, and usage of devices in real time
     - This will support compliance with EU traceability mandates by providing an auditable chain of custody for critical raw materials and components
   - **Automated ESG reporting**:
     - AI may be used to aggregate data from DPPs and other systems to produce Scope 3 emissions reports, material recovery metrics, and repair/refurbish rates. This will reduce manual reporting workloads while improving accuracy for CSRD, GRI, and other disclosure frameworks.

4. **AI-optimized procurement and inventory management**: AI can inform smarter purchasing and inventory practices that reduce waste and excess hardware:
    - **Demand forecasting**:
        - Machine learning models analyze historical usage, employee turnover, and seasonal trends to predict future hardware needs. This helps avoid over-purchasing, which often leads to idle or obsolete equipment.
    - **Sustainability-weighted procurement**:
        - AI-driven decision engines can score potential suppliers and products based on repairability, recycled content, and ESG compliance. This information can be integrated with procurement systems to automatically prioritize low-carbon, circular-friendly options.
5. **AI-enhanced recycling and material recovery**: In the final stage of the lifecycle, AI will play a critical role in maximizing the recovery of valuable materials from obsolete devices:
    - **Material identification**: AI systems can classify plastics, metals, and other materials by type and quality using hyperspectral imaging.
    - **Automated dismantling**: Robotic systems guided by AI vision can disassemble electronics faster and more precisely than human technicians. This will help ensure safe removal of hazardous materials such as lithium batteries and rare earth magnets. It also supports closed-loop recycling, in which recovered materials re-enter the manufacturing stream.

While AI offers immense potential, as we addressed in *Chapter 4*, *Responsible and Sustainable AI Governance*, and *Chapter 5*, *Social Sustainability: Accessibility, AI, and the Digital Divide*, it must be deployed sustainably, ethically, and transparently. By strategically deploying AI across reverse logistics, asset tracking, procurement, and recycling, you can unlock new levels of circularity, turning hardware management into a closed-loop, regenerative system that delivers both economic and environmental value.

End-of-life management

The disposal of IT equipment poses a significant threat to the environment. The volume of electronic waste generated worldwide in 2022 was 62 million metric tonnes, which would fill 1.55 million 40-tonne trucks, enough trucks to form a bumper-to-bumper line encircling the equator (Global E-waste Monitor 2024). Unfortunately, e-waste has become the fastest-growing worldwide waste stream, expected to grow to 82 million metric tonnes by 2030. Contributing factors to fuel this growth are the global availability of electronics and increased spending power. The following diagram illustrates the expected growth of e-waste from 2020 to 2030 based on Global E-waste Monitor data and a 2.6% Mt annual growth rate:

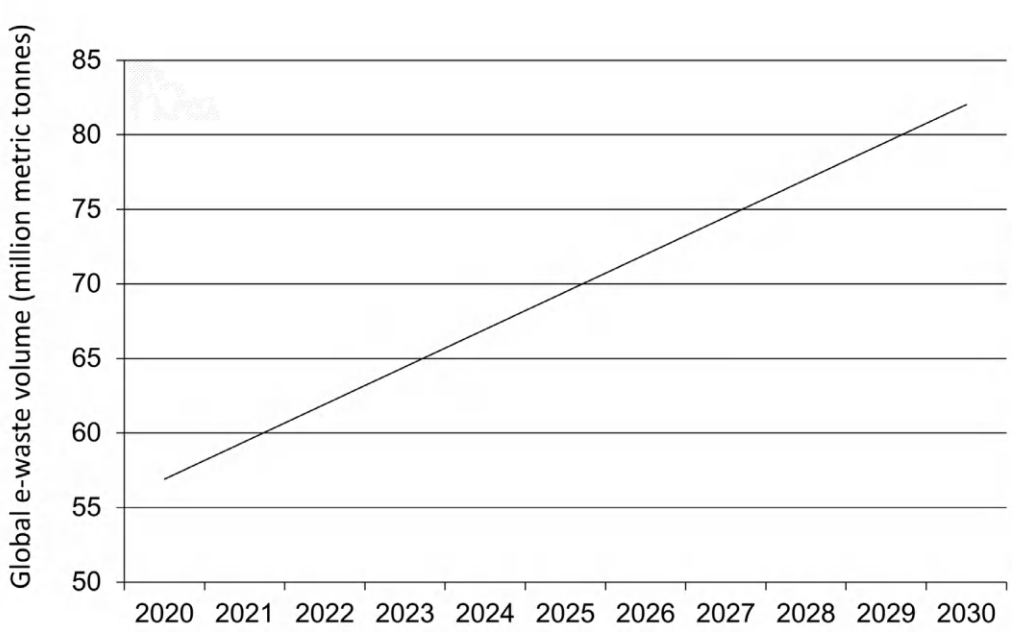


Figure 9.10 – Projected electronic waste generation worldwide from 2020 to 2030

In 2022, Asia generated the most e-waste globally, producing approximately 30 million tonnes, accounting for nearly half of the world's total. However, when measured per person, Europe led, with 17.6 kg of e-waste generated per capita—followed by Oceania (16.1 kg) and the Americas (14.1 kg). Asia's per capita contribution was 6.4 kg. Europe also had the highest documented formal collection and recycling rate at 42.8%, in stark contrast to Africa's under 1% rate, while Asia managed only 11.8% (Global E-waste Monitor 2024).

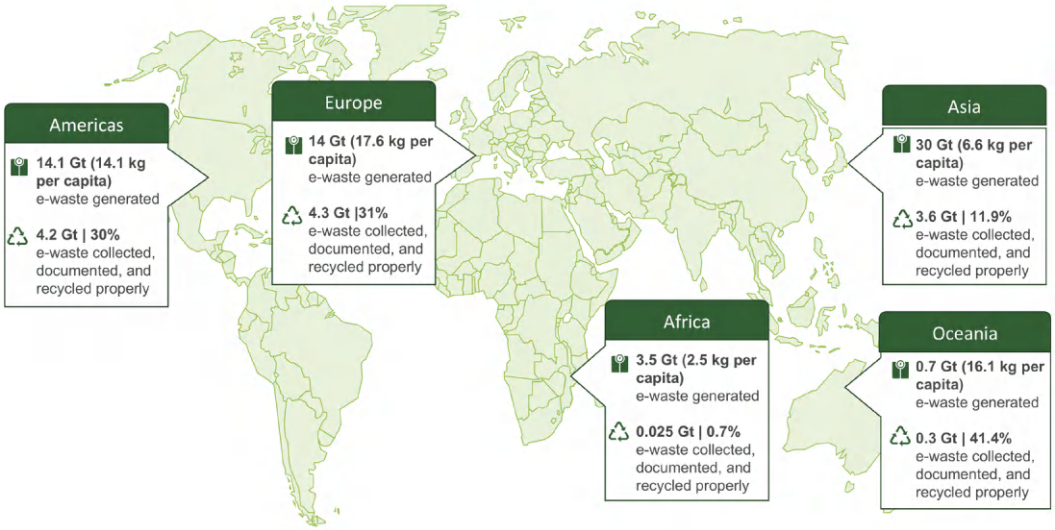


Figure 9.11 – E-waste and recycling rate per continent

It is estimated that only 22.3% of all small IT and telecommunication equipment (which includes laptops, mobile phones, GPS devices, and routers) e-waste is appropriately collected, documented, and recycled, whereas 77.7% represents undocumented e-waste flows. It is estimated that $62 billion of raw materials is wasted annually due to the lack of reusability and recycling practices (Global E-waste Monitor 2024). With global supply chain issues and geopolitical concerns, such as the war in Ukraine, there is a significant opportunity to harvest and recycle raw materials instead of extracting virgin material from the ground. Yet, this requires changes in processes, suppliers, partner networks for repair and recycling, reverse logistics, and funding.

Despite the rapidly growing rates of e-waste, many organizations do not treat it properly. According to Capterra's 2023 IT Management Survey, 80% of companies report that they recycle at least some of their IT hardware, but 29% of companies admit to discarding IT hardware via landfill, which is an improper and environmentally harmful disposal method (Capterra 2023). If you think about it, this is an eye-opening figure that shows we are not doing enough to apply circular principles to ensure that our e-waste is recycled, regenerated, and repurposed back in the IT hardware lifecycle. Instead, it ends up in a toxic landfill.

In the next section, we will take a closer look at the circular industry of ITAD, which is increasingly focusing on curbing the e-waste management problem and getting assets back in circulation through refurbishment, remarketing, parts harvesting, recycling, and disposal.

Leveraging ITAD services

With global e-waste projections for 2030 reaching 82 million metric tonnes, and electronic equipment manufacturing requiring high consumption of resources and incorrect disposal leading to the release of toxic substances, we need an asset disposition strategy that can scale sustainably, integrating data security, cost-efficiency, and measurable environmental and social outcomes.

When asked about good first steps for IT to take to make a visible impact on sustainability, I (Richard) usually respond with one acronym – ITAD. That's my answer because of three factors. It is the only sustainability practice I know that can fulfill goals in all three ESG pillars at the same time. It can be cost-neutral, so IT doesn't have to ask for funds. And it is highly visible for maximum impact – instead of invisible data, you are moving closets-full and ultimately truckloads of hardware.

ITAD refers to the business and process of responsibly retiring, repurposing, recycling, or disposing of outdated or unwanted information technology assets—such as servers, laptops, desktops, networking gear, and storage devices—while ensuring data security, regulatory compliance, and environmental responsibility.

Key components of ITAD include the following:

- Data destruction (certified wiping or shredding of drives)
- Device resale/refurbishment (to recover value)
- E-waste recycling (to prevent landfill disposal)
- Compliance with regulations (e.g., GDPR, HIPAA, R2v3, and e-Stewards)
- Environmental and social responsibility (e.g., device donation and carbon reduction)

Once largely an internal, ad hoc process handled by corporate IT teams or general waste contractors, ITAD services grew up with data protection laws (such as HIPAA and SOX in the US) and growing e-waste scrutiny. It matured in the 2010s with more global players, increasing regulatory complexity, and demand for certified, auditable, and circular processes. Certifications such as **Responsible Recycling (R2)** and e-Stewards gained adoption. Today, the roughly $25 billion ITAD market has evolved into a strategic ESG function, not just an IT service. Enterprises increasingly integrate ITAD into their carbon reduction, digital equity, and zero waste initiatives (Grand View Research 2024). Major ITAD players include ERI Direct, Sims Lifecycle Services, Iron Mountain, ERI, Apto Solutions, TES (now part of SK Ecoplant), and Ingram Micro ITAD.

ITAD's additional third dimension of sustainability is social, specifically digital community engagement. The ITAD vendor participates in or runs a program for donating your secured and renewed equipment to organizations serving communities that need more equitable access to technology. Instead of reselling the usable hardware, the ITAD puts it in the hands of underserved populations, along with training and tech support. This is the business model and differentiator for Human-I-T.org, whose case study with customer National Grid you read about in *Chapter 5*, *Social Sustainability: Accessibility, AI, and the Digital Divide*.

The ITAD industry still has hurdles to overcome—especially a general lack of awareness of ITAD services and concerns over service costs. Cascade Asset Management's 2025 ITAD Benchmarking Report highlights that companies routinely under-budget for device disposition, rarely factoring disposal costs into their hardware TCO. Dedicated disposal budgets are rare, despite the opportunity to minimize disposal costs and generate measurable value through reuse and reporting (Cascade Asset Management 2025). However, if the ITAD you work with is able to refurbish, resell, or donate your end-of-life devices through a non-profit, fees may be waived or canceled out by revenue sharing or tax deductions. You should explore options to find the one that is not only most sustainable but also most cost-effective.

There are also lingering security and liability concerns among companies that have not worked with ITADs extensively. They fear ITADs may not effectively wipe sensitive information. Donated or resold devices may still carry the company's asset tags, engravings, or even branding, and if these devices later fail, leak data, or end up in improper channels (e.g., e-waste dumps abroad), the original owner may suffer reputational harm. Industries bound by GDPR, HIPAA, PCI DSS, SOX, or FedRAMP can face strict penalties if equipment is not disposed of according to rules, and regulators may hold the original data controller responsible, even if the ITAD vendor was negligent. Companies also worry about losing visibility once assets leave their premises. Without clear, tamper-proof chain-of-custody documentation, it's difficult to prove compliance if something goes wrong.

Two primary certifying bodies remain central in ensuring quality and compliance in the ITAD space: **Sustainable Electronics Recycling International** (**SERI**) administers the R2 certification, while e-Stewards oversees its e-Stewards certification. Reputable ITAD providers also commonly uphold ISO 9001 (Quality Management), ISO 45001 (Occupational Health & Safety), ISO 14001 (Environmental Management), and ISO 27001 (Information Security Management) or SOC 2 Type 2 Certification. Importantly, these credentials should be verified per facility—not just at headquarters—to ensure compliance across the vendor's entire operational footprint (Compliance Standards 2025). Organizations should request documentation to confirm which sites are certified and which services are covered (e.g., data destruction vs. remarketing).

Companies that have traditionally required shredding of hard drives to delete sensitive data should rethink that requirement. Shredding eliminates the highest-value, most circular outcome for your PCs and servers. Shredding creates mixed metal/plastic "shredder residue," which can end up in landfills. Non-destructive data clearing and purging sanitization methods aligned to standards such as NIST SP 800-88 Rev.1 and/or IEEE 2883-2022 can deliver certified non-destructive results that would meet corporate and regulatory requirements. Work with your ITAD to determine the best options.

While compliance is foundational, more organizations are recognizing that ITAD can go beyond risk mitigation to become a proactive force for digital equity, workforce inclusion, and community reinvestment, particularly when surplus assets are redirected to underserved populations instead of commodity markets.

Let us take a detailed look at the services and processes to better understand the benefits and risks.

There is a wide variety of ITAD **services** available that can be tailored to your needs. Most of the services are listed here, but this list is not exhaustive:

- Managed deployment
- On or off-site data erasure and destruction
- Asset recovery
- IT asset valuation
- IT asset repurposing or redeployment
- Data center consolidation, migration, and decommissioning
- Recycling
- Donation

Regardless of your ITAD vendor, the **process** will look the same. As shown in the following diagram, the ITAD process consists of six steps, from collecting used IT hardware to final reporting:

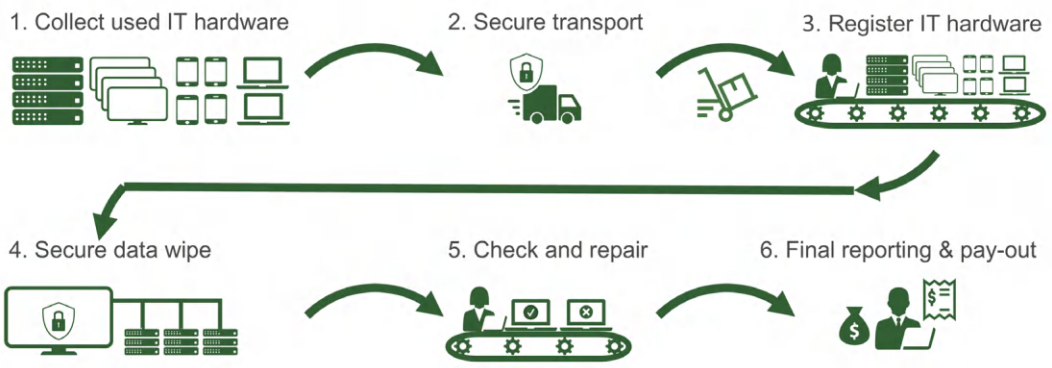


Figure 9.12 – ITAD process

These are the primary steps in the ITAD process:

1. **Collect used IT hardware**: IT hardware is collected at the customer site and audited. Depending on customer requirements, the data is sanitized before transport. The IT hardware is carefully packaged, and the outer packaging is sealed and made tamper-proof.
2. **Secure transport**: The IT hardware is securely transported to the ITAD vendor site. Ideally, the site should be as close as possible to the customer location to minimize the impact on CO_2 emissions during transportation.
3. **Register IT hardware**: Once the IT hardware has arrived, it is unpacked, registered, labeled, value-assessed, and presorted. Assets that fail the test are sent to de-manufacturing.
4. **Secure data wipe**: The data is securely wiped according to customer requirements and classification. Assets that fail the test are sent to demanufacturing. Many enterprises now require ITAD vendors to carry liability insurance to cover potential data breaches or improper disposal incidents. For additional details of data wiping alternatives available, refer to the *Data sanitization* section.

5. **Check and repair**: The IT hardware is tested, and specifications are captured. Any customer asset tags or labels are removed. The value of the IT asset is assessed, repaired, refurbished, and re-imaged. Assets that fail the test are sent to demanufacturing. Assets sent for reuse are remarketed in either B2B or B2C channels. Once sold individually or in bulk, they are redeployed and dispatched. The asset registry is updated. Assets that fail the various tests are sent for demanufacturing. Storage media is for removal and destruction. The IT hardware is dismantled, and its parts are sorted and harvested. The asset registry is updated, and any removed parts are given a parent-child identifier to ensure complete transparency. According to the WEEE Directive, parts and materials that cannot be harvested are recycled. A certificate of destruction is created.
6. **Final reporting and settlement**: The final report is produced and sent to the IT organization or customer of the ITAD vendor, and the financials are settled. Certificates provided may include a certificate of data destruction, certificate of recycling, or proof of resale. The reports should include environmental metrics such as CO_2 avoided, landfill diversion rates, and critical raw materials recovered. If hardware donations are part of the disposition, then reports should log donations as such. Increasingly, organizations are leveraging this impact data, such as digital equity outcomes, carbon savings, and reuse rates, as part of Scope 3 emissions reporting, diversity, equity, and inclusion storytelling, and broader ESG disclosures. Choosing a provider who can quantify and communicate this value clearly is becoming a key differentiator.

Keep in mind that at every step (collection, transport, wiping, and recycling), ITAD providers should maintain a documented chain of custody for compliance auditability purposes (GDPR, HIPAA, SOX, and ISO standards). For example, in 2023, ITAD vendor ERI launched its enhanced Optech CAPTURE system, designed to provide full chain-of-custody tracking throughout the IT asset disposal process. As noted in SustainableIT's 2024 SustainableIT Impact Award coverage, ERI's tracking system is accessible via mobile devices, allowing ERI technicians to log and photograph items at customer sites, providing detailed records and a signed receipt. This system provides real-time tracking to ERI customers through its customer portal.

The financial arrangements vary, but here's the general structure:

- **Customer costs (paying the ITAD)**: Companies may pay the ITAD vendor for the following:
    - Secure logistics (collection and transport)
    - Certified data wiping or media destruction
    - Processing fees for low-value or negative-value assets (e.g., CRT monitors, damaged equipment, and peripherals).

- ITAD providers will generally build any commodity revenues into these processing fees, as revenue from commodity recovery is generally minimal compared to the cost of processing equipment. These costs are typically framed as *service fees*.
- **Revenue sharing (ITAD paying the customer)**: When assets have resale value (laptops, servers, networking gear, and smartphones), the ITAD refurbishes and remarkets them. After deducting processing costs, the ITAD shares a percentage of resale revenue with the customer, though not all providers are transparent in how these are calculated. Assets with no resale value will likely incur fees.
- **Recycling commodities**: Devices with no reuse value are dismantled, and materials (precious metals, plastics, copper, aluminum, etc.) are sold into commodity markets. Revenue from commodity recovery is minimal and not commonly shared with ITAD customers.
- **Net outcome**:
    - For high-value hardware refresh cycles (e.g., corporate laptops, data center servers, etc.), ITAD programs can flip from a cost center to a profit center—customers receive a net payout
    - For older or damaged equipment, customers may incur net costs, though they still benefit from compliance, risk mitigation, and ESG reporting
    - Programs that prioritize social impact over revenue-sharing can quantify outcomes in the number of people benefiting from a company's donations.

While many ITAD processes may appear standardized, not all vendors are built to deliver the same outcomes. Some specialize in resale and recycling. Others are designed from the ground up to prioritize equitable digital access, sustainability storytelling, and long-term community benefit. The right partner depends on your goals.

A critical step within the ITAD process is how data can be sanitized safely and securely. In the next section, we will take a closer look at what requirements you need to put on your vendors.

Data sanitization

Preventing data breaches and sanitization is a critical step in the process, where the information classification of the data should guide the sanitization method. Generally, within an enterprise, government, or military, there are four to five levels of classification. The US government and military use the following classification levels: top secret, secret, confidential, **sensitive but unclassified (SBU)**, and unclassified. An enterprise may use five levels but different definitions, such as secret, confidential, restricted, internal, or public.

The **National Institute of Standards and Technology (NIST)** recommends three ways to sanitize your data: clearing, purging, or destroying. For further details of the different methods, refer to NIST SP 800-88 Guidelines for Media Sanitization at `https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-88r1.pdf`.

The following diagram illustrates how mapping the enterprise information classification levels with the different data sanitization methods may look to preserve the right level of integrity and confidentiality of the data:



Figure 9.13 – Mapping information classification versus data sanitization

Please note that this is only an example. You should always consult with your **Chief Information Security Officer (CISO)** and **Data Privacy Manager (DPM)** to discuss how to set it up within your environment.

Now that you have a better understanding of ITAD's role in the circular economy, we will look at how social factors can help drive the transition to circularity.

Social responsibility – a key unlocking circular transition

One shortcoming of the circular economy is that it almost exclusively focuses on environmental issues and puts limited focus on social issues. In this section, **Stephen Fuller**, **Senior Criteria Manager for TCO Certified**, the global sustainability certification body for IT products, shares his perspective on how social responsibility and worker rights can help leverage the circular transition:

How worker rights can help leverage the circular transition

> Circular solutions help us tackle many of today's sustainability challenges, including climate change, the depletion of scarce resources, and the destruction of natural habitats. However, a shortcoming in current circular economy plans is their lack of focus on social issues. This is not only a human tragedy; it also reduces our chances of a successful circular transition.

Respecting human and worker rights can be a powerful driver to accelerate the pace of change. By ending the exploitation of people in the IT product supply chain, we can accelerate the move to producing and consuming IT products that are genuinely sustainable.

Today, IT products are manufactured and used in a mainly linear way. We extract virgin natural resources, turn them into products, and then discard these products, often after a short period of use, replacing them with new ones manufactured in the same way. This short product lifespan creates multiple sustainability problems that need to be addressed urgently: increased GHG emissions, overconsumption of our natural resources, and enormous amounts of toxic e-waste. It also fuels unstable production cycles, with demand surging and dropping unpredictably. To meet these spikes in production, factory owners push employees into agreeing to excessive overtime, driven by the fact that their minimum wages are too low to cover even basic living costs.

Low prices come at a high cost

One reason IT products are discarded prematurely is that they are relatively cheap to buy. In reality, we pay far less than the true cost once the value of natural resource extraction and human well-being is considered. The production of a computer or a phone involves thousands of people, from miners extracting minerals to workers in final assembly factories. Compared to most industries, the IT supply chain is vast and multi-tiered. This should make these products very expensive to manufacture and purchase.

This, however, is not the case, largely because the IT supply chain depends on concentrated availability of cheap labor. Much of the world's IT manufacturing takes place in low-cost, low-wage countries, where workers are less protected and employment is less regulated. Governments are known to overlook human rights violations or relax labor regulations to stimulate business investment. As a result, wages remain low, working conditions are often poor, and abuses of labor rights and social benefits persist.

The supply chain's scale and global spread add further complexity. A single computer or a phone may contain raw materials and components sourced from hundreds of suppliers, which are often located around the globe. With so many actors involved and oversight often weak, the risks to human rights are not just difficult to manage; they are systemic.

Workers' rights help speed up the circular transition

To buy and manage IT products responsibly, we need to consider environmental, social, and circular economy practices. All these issues are linked; improving working conditions and ensuring socially responsible practices in the IT industry can help speed up the transition to the circular economy. In meetings with IT product manufacturers, I have often heard from factory management that investing in social improvements increases production costs and a reduction in revenue. It is not surprising—giving workers a living wage and social benefits will increase the cost of manufacturing. However, it is the only reasonable way to go. Apart from respecting workers' rights and promoting a safer and healthier working environment, it will make the circular take-make-use-reuse economy all the more possible.

Higher production costs translate into higher purchasing prices. This may initially be considered a drawback, but it can become one of the most effective drivers of innovation and development of longer-lasting products that users want to keep, service, and repair rather than dispose of and replace. More expensive IT devices also create stronger incentives for IT brands to explore more circular business models, such as Product-as-a-Service solutions, where the IT brand retains ownership of the product, and the user pays for functionality and value it can offer during a set period. In this way, revenue generation is no longer tied exclusively to selling as many products as possible. Instead, it becomes good business sense to manufacture durable devices designed for longevity, repair, and upgrades so that each product can be leased or used for as long as possible. This is an appealing scenario for anyone who wants to realize a circular economy.

Purchaser demand sets the process in motion

Progress will stall without strong demands on those with power and influence. In many of the manufacturing countries, local governments do far too little to enforce human rights and labor laws. This shifts the responsibility to manufacturers and brand owners to ensure their supply chains respect workers' rights and provide fair treatment.

With 25 years of experience in IT sustainability, I know that financial incentives are crucial to getting brand owners and factory management to prioritize workers' well-being and the environment over short-term economic gains. In conversations with IT brands, I've asked what is needed to accelerate sustainable practices. Their answer is almost always the same: stronger buyer demand.

By setting clear and ambitious requirements, purchasing organizations can push the industry in a sustainable direction. Criteria must be relevant, current, and go beyond legislation. To drive change and avoid the risk of greenwashing, compliance with all criteria should be verified by independent experts. Where non-compliance is found, corrective action plans must be implemented within set time frames. Continuous monitoring is essential to prevent regression.

Creating sustainable IT products is not just about recycled content or reparability. It is the whole lifecycle of the product that tells us if it is genuinely sustainable – how products are made, used, and managed at end-of-life. By integrating social considerations into this chain, we can drive circular solutions that benefit both people and the environment. If we are prepared to accept paying the true environmental and social costs of IT, the transition to circularity can become a reality that benefits everyone.

Stephen Fuller, Supply Chain Management Expert and Senior Developer of Supply Chain and Chemical Management Criteria, TCO Certified



What is TCO Certified?

TCO Certified is the global sustainability certification for IT products, empowering both IT buyers and brands to make more responsible choices. The comprehensive criteria in TCO Certified are designed to drive social and environmental responsibility and are updated continuously to push sustainability where it matters most. Compliance with all criteria is always independently verified for every product. TCO Certified is available for product categories that you can find in an office, and those that store your data (`https://tcocertified.com/about/`).

The *Roadmap for Sustainable IT* is the long-term plan for addressing issues in four key areas: climate, substances, circularity, and supply chain. By using TCO Certified, you join a global movement for sustainable IT (`https://tcocertified.com/roadmap/#climate`).

As we transition from a linear to a circular economy, we can conclude that we cannot single-handedly focus on environmental and social issues. Transitioning toward producing, consuming, and recovering IT products that are genuinely sustainable requires firm action to stop the exploitation of people in the IT product supply chain. In *Chapter 11*, *Leveraging Your Buying Power*, we will explore how you can set clear and sharp requirements to push the industry in a sustainable direction.

Making a business case for change

By now, it should hopefully be abundantly clear that the most cost-effective and sustainable way is to keep your products and materials in use for as long as possible. Earlier in this chapter, we looked at a global manufacturing model company. Over a 10-year cycle, the emissions are close to 35,000 metric tonnes of CO_2e.

We must rapidly change our approach from a linear to a circular model.

By focusing on buying IT hardware that is durable, repairable, and upgradable, you have a sizable opportunity to maximize the lifespan and reduce GHG emissions. Consider how this would play out in practice for our end user equipment. Earlier in this chapter, we learned that roughly 80% of greenhouse emissions are consumed during manufacturing. Looking at the scene where a Dell Pro 14 Premium emits 244.23 $kgCO_2e$, the manufacturing represents 89.6% of total emissions, equating to 219 $kgCO_2e$. An expected life expectancy of 4 years means that 54.7 $kgCO_2e$ is emitted yearly. By extending the product's life expectancy by 1 or 2 years, the yearly emissions decrease to 43.8 $kgCO_2e$ and 36.5 $kgCO_2e$, respectively. This is a reduction of 10.8 kg per year or 20% to extend for 1 year and 18.2 kg per year or 33% to extend for 2 years. The following diagram illustrates an example of amortizing a laptop's carbon emissions over 4, 5, and 6 years:

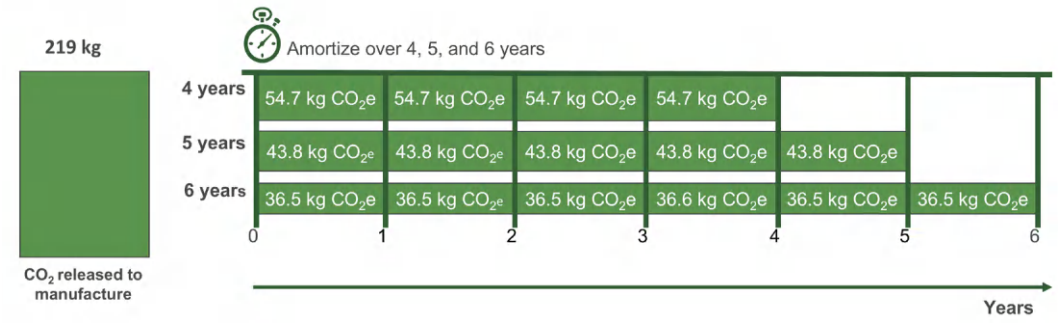


Figure 9.14 – Amortizing a laptop's carbon emissions over 4, 5, and 6 years

Extending the product lifecycle not only cuts GHG emissions but can also significantly impact your bottom line by reducing costs. Let us look at the same global manufacturing model company we looked at before, with 36,000 computers, and an existing hardware lifecycle policy of 4 years.

Suppose we consider changing our hardware lifecycle policy from 4 to 5 years; let us investigate the financial and sustainability benefits. Instead of replacing 9,000 computers every 4 years, we will now replace 7,200 every 5 years. We assume that the average global cost for a new Dell Pro 14 Premium is 950 euros. We anticipate that we will have 4 hours of efficiency gains per computer by having to replace 1,800 fewer per annum.

We also factor in a contingency factor of 10% to account for variable change, meaning that not all computers may be able to live beyond the 5-year mark. No carbon credits have been factored in by handing over your end-of-life computer to an ITAD provider to be refurbished, repurposed, or recycled:

		Cost	Efficiency	Sustainability
	Assets	**Cost - EUR**	**Support - Hours**	$kgCO_2e$
	10,000	**€950**	**4**	**54.7**
4-year lifespan volume	10000	9,500,000	40,000	547,000
Current 4-year model – Yearly lifespan volume	2250	2,137,500	9,000	123,075
Proposed 5-year model - Yearly lifespan volume	1440	1,368,000	5,760	63,072
Yearly savings		**-769,500**	**-3,240**	**-60,003**
Net yearly savings @ replacement contingency 10%		-692,550	-2,916	-54,003
Net yearly savings @ replacement contingency 25%		-577,125	-2,430	-45,002

Table 9.2 – Business case for change – end user computing

As shown in the preceding table, extending the product lifecycle by a year will give us significant benefits from a cost, efficiency, and sustainability perspective, considering variable change by factoring in a contingency between 10% to 25%. The following diagram summarizes cost savings, efficiency gains, and GHG emissions reduction potential within the contingency range:

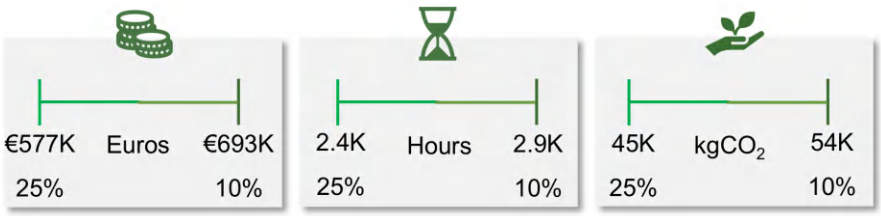


Figure 9.15 – Business case for change – summary of cost savings, efficiency gains, and GHG emissions reduction

There are several significant benefits from a cost, efficiency, and GHG emissions reduction perspective by simply prolonging your hardware lifecycle by 1 year, and revisiting *Figure 9.6*, where we observed the computer GHG emissions for the global manufacturing model company over 10 years. The following diagram illustrates how the dynamics change moving the product lifecycle from 4 to 5 years, resulting in an aggregated reduction of 7,407 $MtCO_2e$, which is a 21% reduction (34,947-27,540 $MtCO_2e$):

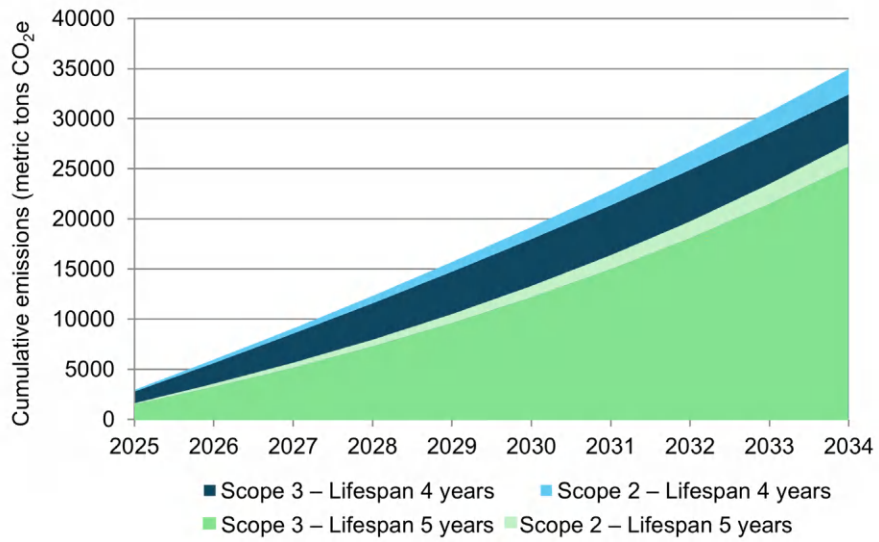


Figure 9.16 – Emissions comparison between 4-year and 5-year product lifespans

It is important to consider the human factor when extending end user device refresh cycles. There is a stigma associated with "old" tech, especially when users have newer personal equipment at home than they have in their jobs. There is also legitimate user concern over reliability and performance, which can degrade over time. Here are some approaches that have worked for IT organizations in encouraging users to tolerate extended lifespans:

- **Condition-based policy**: Use DEX/telemetry (battery stat of health, SSD health, throttling, crash rates, etc.) to defer or approve a refresh. Publish clear thresholds and performance SLAs so users trust the process.
- **Guaranteed support and loaners**: Pair longer cycles with fast-swap loaners and "no-questions battery replacement" to remove users' fear of being saddled with a tired or unstable device.
- **Transparent carbon and cost impact**: Show the CO_2e avoided and savings per deferral in a simple dashboard. Celebrate teams with the highest "keep rate."

- **Upgrade clinics**: Run periodic clinics for thermal cleaning and battery/SSD checkups by appointment. This can add 1–2 years of effective life.
- **Choice and remanufactured options**: Device-choice programs are often tied to higher user satisfaction, lower tickets, and better battery life—factors that make longer cycles feel acceptable to employees. Offer remanufactured models as one of the user device choices. Make sure the replacements are cosmetically excellent and have an equal or longer warranty.

If your company's goal is to reduce its GHG emissions by 50% through 2030, just prolonging the product lifecycle from 4 to 5 years will not take you all the way. As we saw earlier in this chapter, there are several different alternatives to be explored, such as buying more eco- and carbon-friendly hardware from the start, exploring DaaS to reduce the need for new hardware, leveraging green leasing that guarantees a CO_2-neutral impact, buying refurbished hardware, and working with an ITAD service provider.

In the next section, we will explore factors to use in selecting the most sustainable hardware vendors.

Choosing a sustainable IT hardware provider

In this section, we will take a closer look at the sustainability commitments of the top six PC vendors by the number of units shipped in 2024 (Gartner 2025). Why PCs? Because your end user computers significantly impact Scopes 2 and 3. In *Chapter 8*, *Leveraging Your Buying Power*, we will look at a more general view of what net-zero commitments the technology companies have made. As shown in the following table, roughly 86% of the market is dominated by six vendors, with Lenovo, HP, and Dell claiming the top three spots:

Rank	Manufacturer	Market Share
1	Lenovo	25.5%
2	HP	21.6%
3	Dell	16.1%
4	Apple	9.2%
5	ASUS	7.1%
6	Acer	6.9%
	Others	13.6%

Table 9.3 – Top six vendors by number of units shipped in 2024

Let us look at how they stack up against each other regarding their sustainability commitments:

Company	Carbon Footprint ($MtCO_2e$)	Carbon-Neutral Target	Net-Zero Carbon Emission Target	Renewable Energy Target	Water Target	Waste Target
Lenovo	15.1 (FY2023/2024)	-	2050	90% by FY2025/26	Reduce by 1.8 Mt FY2029/30	Maintain >90% recycling
HP	19.8 (2023)	Operations 2025	2040	100% elec. 2030	Reduce 35% 2025	Operations 2025
Dell	16.7 (2021)	-	2050	2040	Reduce 10-25% 2030*	2030
Apple	16.1 (FY2023)	2030	2030	100% manuf. 2030	100% 2030	Zero waste achieved for final assembly
ASUS	5.2 (2024)	-	2050	100% by 2035	-	-
Acer	5.8 (2023)	-	2050	100% by 2035	-	-

*Reduce by 25% in high-water stress areas, and 10% everywhere else.

Figure 9.17 – IT hardware sustainability commitment comparison

Most of the vendors have broadened their commitments since the first edition of this book in 2022. Only Apple's time frame to reach net-zero carbon emissions is near-term. Apple has also achieved zero waste in its final assembly plants. Most vendors have commitment agreements from their major suppliers toward sustainability goals. HP expects to be carbon-neutral and zero-waste in its operations in 2025. ASUS and Acer have pledged water and waste reduction, but have not set targets publicly.

Social sustainability of your computer vendors

Since IT hardware is manufactured all over the globe, with complex supply chains spanning component suppliers, contract assemblers, and logistics providers, PC vendors carry a direct responsibility for ensuring that social sustainability requirements are both clearly communicated and consistently enforced. The risks are well documented: exposure to child and forced labor, unsafe or unhealthy working conditions, excessive working hours, discriminatory practices, and inadequate wages remain persistent challenges in electronics supply chains. For you, the enterprise buyers of their products, these issues are not only a matter of corporate social responsibility but also business continuity, brand risk, and compliance with emerging due diligence regulations such as the EU **Corporate Sustainability Due Diligence Directive (CSDDD)** and national modern slavery acts.

As a result, the leading PC vendors—Lenovo, HP, Dell, Apple, ASUS, and Acer—have developed supplier codes of conduct, human-rights policies, and audit and remediation programs that aim to identify and correct labor rights violations deep in their supply chains. Many are members of the **Responsible Business Alliance (RBA)** and rely on its **Validated Assessment Program (VAP)** audits to monitor compliance with standards on working hours, living conditions, health and safety, non-toxic exposure, and worker voice mechanisms. Computer vendors are also assessed by the sustainability rating service **EcoVadis** for progress in meeting targets to eliminate forced labor recruitment practices, achieve "zero waste" certifications in supplier sites, and extend protections such as fee-free hiring and freedom of association. Learn more about the VAP here: `https://www.responsiblebusiness.org/vap/about-vap/`.

The following subsections summarize the most significant social manufacturing and supply-chain commitments each of the six top PC vendors has made, and their latest verified achievements.

Lenovo

Here are their commitments:

- 95% of suppliers by spend must complete an RBA audit every two years (VAP or equivalent by RBA-approved auditors). Ongoing.
- Prohibit forced and child labor; monitor working hours monthly with outsourced manufacturers; drive corrective actions. Ongoing.

These are the recent achievements:

- No forced-labor or child-labor violations among suppliers who completed RBA VAP audits; 56 suppliers had other major labor findings (most commonly excessive working hours) with improvements agreed
- Expanded risk-mitigation steps (e.g., engaging labor agents on RBA self-assessment questionnaires; supplier training/webinars; enhanced ESG screening
- Received the Platinum medal from EcoVadis in November 2024, placing them in the top 1% of all companies rated worldwide
- Lenovo has a *Low* sustainability risk rating of 16 on a scale of 0 to 40+ from MorningStar Sustainalytics
- In October 2025, MSCI reaffirmed Lenovo's AAA ESG rating for the fourth consecutive year, and in September 2025 Lenovo received an AA+ rating on the 2025 Hang Seng Corporate Sustainability Index, achieving the highest score in its industry on environmental and social criteria.

HP

Here are their commitments:

- Long-standing RBA member
- Supplier code aligned to RBA
- Comprehensive human rights due diligence and supplier assurance program (audits and specialized assessments)

These are the recent achievements (2024):

- 290 audits and assessments covering labor rights across operations and supply chain (includes 61 audits and further assessments)
- Human rights governance and due diligence publicly documented in HP's sustainable impact materials (2024)
- Achieved their highest ever EcoVadis score of 90 in April 2025, receiving a Platinum medal for the 15th consecutive year
- HP has a low sustainability risk rating of 11.3 from Morningstar Sustainalytics (as of November 2025).

Dell

Here are their commitments:

- Require suppliers to meet the RBA code of conduct.
- Run a robust **social and environmental responsibility** (**SER**) audit program with third-party RBA-trained auditors.
- Targeted worker-hours controls and vulnerable-worker protections. Ongoing.

These are recent achievements (FY 2025):

- 270 initial audits; 171 closure audits; 94.1% of priority findings and 73.7% of major findings closed/downgraded (cumulative)
- 88.9% of workers at audited sites did not exceed 60 hours/week; 79.7K supplier SER training hours delivered
- Awarded an EcoVadis Platinum medal in 2024 for scoring in the top 1% of companies assessed
- Dell has a *Low* sustainability risk rating of 13.9 from MorningStar Sustainalytics (as of September 3, 2025)

Apple

Here are their commitments:

- Enforce the Apple Supplier Code of Conduct across labor and human rights, health and safety, environment, ethics, and management systems; use independent third-party assessments (including unannounced). Ongoing.
- Responsible recruitment/zero fees and zero tolerance for forced labor. Ongoing.
- Supplier Employee Development Fund ($50M) to expand worker education and rights training (launched 2022; ongoing).

These are recent achievements (2024):

- 893 supplier-facility assessments (≥22% unannounced); 125 new/expanding facilities assessed pre-onboarding
- 2.5M+ workers trained on rights; 1.4M+ workers' hours reviewed weekly for compliance
- Zero instances of forced labor found in 2024; In the same year, Apple directly engaged 1.3M+ supplier employees on their workplace experience (via surveys, interviews, and grievance-channel outreach), leading to more than 7,500 corrective and improvement actions
- Apple has a *Low* sustainability risk rating of 18.9 from MorningStar Sustainalytics

ASUS

Here are their commitments:

- Full RBA member; requires safe working conditions, no forced or child labor, and compliance with the ASUS Supplier Code of Conduct; 100% of new suppliers must sign the Code-of-Conduct Compliance Declaration. Ongoing.
- Responsible mineral due diligence aligned to OECD guidance; includes child-labor risk focus (e.g., mica). Ongoing.

These are recent achievements (latest public):

- ASUS states that in 2023, 100% of key suppliers completed third-party on-site audits and required improvements; continued supplier oversight and risk-based auditing
- Public 2023 Sustainability Report and human rights statement detail the audit approach and due diligence program
- ASUS has a *Low* sustainability risk rating of 16.4 from MorningStar Sustainalytics

Acer

Here are their commitments:

- Responsible supply chain management with on-site audits
- Member use of RBA VAP
- Responsible minerals policy aligned with OECD due diligence framework. Ongoing.

These are recent achievements (2024):

- 111 on-site audits of first-tier manufacturing factories (including 32 closure audits; 3 new suppliers assessed); one supplier disqualified for SER non-compliance; >230,000 workers covered at audited sites with 4,173 worker interviews; >80% of audits conducted via RBA VAP
- Received a Platinum medal from EcoVadis for the third consecutive year as of December 2024)published August 2024)
- Acer has a low sustainability risk rating of 14.6 from Morningstar Sustainalytics (updated 2025).

In spite of these commitments and ratings, social sustainability lapses continue to happen across the vast manufacturing ecosystems of the ICT sector. For example, Dell, HP, and Lenovo self-reported supplier non-conformance incidents, such as excessive employee working hours and insufficient rest periods. KnowTheChain's 2025 ICT benchmark highlights persistent forced-labor risk management gaps across the sector (KTC 2025). A June 2024 Reuters investigation found Foxconn's Sriperumbudur iPhone plant excluded many married women from assembly roles; Apple and Foxconn acknowledged "lapses" and said corrective audits were undertaken (Reuters 2024). With the understanding that perfect compliance records will be hard to find, you should nevertheless monitor your vendors' supply chain infractions. Find out what the companies are doing to address current and future incidents, and look out for repeating patterns and lack of progress. You don't want to be an indirect supporter of human rights violations, and such failings might harm customers' reputations as well as the vendor's.

In *Chapter 11*, *Leveraging Your Buying Power*, we will examine how to apply environmental and social requirements to your vendor agreements. In the next section, we will look closely at some KPIs that can be leveraged to track and monitor your IT hardware.

IT hardware sustainability scorecard

Finally, as we have gone through the different levers you can use to reduce your carbon intensity, let us look at how we can summarize these critical metrics on an IT hardware sustainability scorecard:

Description	Metric	General Requirement	United Nations Sustainable Development Goals Alignment
Equipment Lifetime	**Years**	**Equipment Lifetime** **Years**	12. Responsible Consumption & Production 13. Climate Action
Renewable Energy	**%**	**REF** Renewable Energy Factor	9. Industry, Innovation & Infrastructure 12. Responsible Consumption & Production
Circular Economy Reuse and Repair	**%**	**Reuse and Repair** % equipment reused	12. Responsible Consumption & Production 13. Climate Action
Zero Waste to Landfill	**WUE**	**Recycle** % equipment reused	12. Responsible Consumption & Production 13. Climate Action
Hazardous Substances	**%**	**Hazardous Substances** % equipment with hazardous substances	12. Responsible Consumption & Production 13. Climate Action

Figure 9.18 – IT hardware sustainability scorecard

Most of the IT hardware manufacturing vendors report percentages on these KPIs, so it should be easy to compare them. Remember, as roughly 80% of the carbon emissions are already spent before you get your new computer, smartphone, or tablet in your hand, it is essential to understand the impact of your vendor manufacturing ecosystem and how you can work collectively to reduce the environmental and social impact. In *Chapter 11*, *Leveraging Your Buying Power*, we will take a closer look at what levers are available to place stricter environment and social requirements on your vendors.

Summary

In this chapter, you learned how to manage your IT hardware to positively impact social and environmental aspects and reduce costs. By now, you should understand the impacts of IT hardware equipment and how circular lifecycle management and lifespan extension can reduce your footprint and positively impact costs. You appreciate the complexities and limitations of the various methodologies for determining PCF and LCA. We showed elements of a sustainability business case for hardware. You now have a good starter set of metrics to apply to your hardware asset base. Finally, you should better understand what is required from your enterprise and vendors to transition from a linear to a circular economy (much more on this in *Chapter 11*, *Leveraging Your Buying Power*).

To conclude this chapter, let us look at some key recommendations:

- Procure hardware with a minimum lifecycle carbon cost, a socially responsible supply chain, and sustainably sourced raw materials.
- Demand ENERGY STAR, EPEAT, and TCO Certified labeled IT hardware to reduce both operational cost and carbon emissions.
- Explore the possibility of extending the IT hardware lifecycle policy to 4, 5, or even 6 years.
- Engage an ITAD vendor, which can enable circularity through reuse, refurbishment, and remarketing.
- Understand the share of renewable energy in your office locations. Resource management will be further explored in *Chapter 10*, *Energy Resource Management*.
- Engage your employees by raising awareness of device carbon footprint and enabling them to make conscious, sustainable choices to reduce carbon costs.
- Introduce refurbished IT hardware, such as computers, laptops, and smartphones, for ordering into your IT service catalog.

In the next chapter, *Energy Resource Management*, we will look at how we can use our scarce energy and water resources more responsibly and sustainably in IT and on behalf of the enterprise.

Appendix: Standard metrics for IT hardware sustainability

The energy, emissions, and e-waste metrics listed here apply to most classes of hardware (SustainableIT.org 2024). Note that server-specific metrics were covered in *Chapter 6*, *Data Centers and Cloud*. Sourcing metrics also appear in the following table, but most sustainable sourcing metrics will be referenced in *Chapter 11*, *Leveraging Your Buying Power*.

Category	Topic	Metric	Related Global Standards
SIT EF 100 Energy, IT function	EF 112 End user devices energy consumption (laptops/notebooks, tablets, smartphones, desk phones): electricity, heating, cooling	EF 112-1 kWh by location (on-premises, remote), time of day, per device, per end user	GRI 302-1, 3 TC-IM-130a.1 TC-SI-130a.1 ESRS E1 SDG 7, 9, 13, 17
		EF 112-2 Percentage renewable: solar, wind, geothermal, hydropower, tidal, biomass	
	SIT EF 140 Energy sourcing	EF 140-1 Percentage of energy sources controlled/influenced	SDG 7, 9, 13, 17
SIT EF 200 Emissions, IT function	EF 212 End user device emissions (laptops/notebooks, tablets, smartphones, desk phones)	EF 212-1 Metric tonnes CO_2, by location, over time period, per end user	GRI 305-1, 2, 3 TC-IM-130a.1 TC-SI-130a.1 ESRS E1, E2 SDG 7, 9, 13, 17
		EF 212-2 Average lifecycle of end user devices by type, location, user category	
		EF 212-2.1 Average emissions reduction achieved by lifecycle extension by type	

Category	Topic	Metric	Related Global Standards
SIT EF 300 Waste, IT function	EF 310 Device and hardware lifecycle circularity (e.g., servers, laptops, smartphones, desktop phones, monitors, printers, network equipment)	EF 310-1 Percentage of IT devices reused/ refurbished or repurposed by type	TC-HW-410a.4 GRI 306-3, 4, 5 ESRS E5 SDG 6, 12, 13, 17
		EF 310-2 Percentage of IT devices recycled/remanufactured	
		EF 310-3 Percentage of equipment not disposed of sustainably (i.e., landfilled)	
		EF 310-4 Percentage of device/ hardware units donated responsibly (with assurances of downstream sustainable disposal) by type, over time period	
		EF 310-5 Refresh cycle of IT devices by type	
SIT EF 400 Sourcing, IT function	EF 420 Hardware and devices sourced sustainably* (i.e., vendors, manufacturers, and supply chain)	EF 420-1 Percentage of installed base sourced sustainably	GRI 308-1, 2 SDG 9, 13, 17
		EF 420-2 Percentage of new purchases sourced sustainably over time period	
		EF 420-3 Percentage of total spend to sustainable sources	
	EF 430 Certified devices/hardware	EF 430-1 Percentage of eligible technology devices/hardware meeting ENERGY STAR®, EPEAT, and/or TCO Certified criteria	GRI 308-1, 2 TC-HW-410a.3 SDG 7, 9, 13

Table 9.4 – SustainableIT Standards Taxonomy metrics for IT hardware operations and procurement

**Criteria for sustainability within the preceding categories: carbon product footprint, ecolabel/energy certifications, renewable energy use (solar, wind, geothermal, hydropower, tidal, biomass), GHG emissions, low-carbon fuels/electric vehicles in fleet, product lifespan, commitment to recycled material in product/packaging, waste reduction, and compliance with government rules and directives.*

Further reading

To learn more about the topics that were covered in this chapter, take a look at the following resources:

- *Basel Action Network*: `https://www.ban.org/`.
- *WEEE forum*: `https://weee-forum.org/who-we-are/`.
- *Impacts and Insights: Circular IT Management in Practice. Report on circularity in the IT sector, including 33 hands-on tips on how your organization can move in a circular direction*: `https://tcocertified.com/2020-impacts-and-insights/`.
- *Circularity helps you tackle many of today's sustainability risks*: `https://tcocertified.com/circular-economy/`.
- *Protecting workers and the environment in the IT supply chain*: `https://tcocertified.com/social-responsibility/`.
- *Chemical safety: How we achieved what others claimed was impossible*: `https://tcocertified.com/news/identifying-safer-substitutions-is-the-way-forward-in-chemical-safety/`.
- *Sustainable Electronics Recycling International (SERI)*: `https://sustainableelectronics.org/`.
- *E-Stewards*: `https://e-stewards.org/`.
- *Ellen MacArthur Foundation – Artificial intelligence and the circular economy* (free registration required): `https://ellenmacarthurfoundation.org/artificial-intelligence-and-the-circular-economy`.
- *EU's Digital Product Passport: Advancing transparency and sustainability*: `https://data.europa.eu/en/news-events/news/eus-digital-product-passport-advancing-transparency-and-sustainability`.
- *GS1 US – Sunrise 2027 Initiative*: `https://www.gs1us.org/industries-and-insights/by-topic/sunrise-2027`.

Bibliography

- Acer. 2021. *Acer Earthion: our long-term commitment to the environment*. June 04. https://tinyurl.com/ynpp73fs.
- Acer. 2021. *Acer Expands Lineup of Eco-friendly Vero Products*. October 13. https://news.acer.com/acer-expands-lineup-of-eco-friendly-vero-products.
- Acer. 2021. *Acer Listed on Dow Jones Sustainability Indices (DJSI) for Eighth Straight Year in 2021*. November 18. https://news.acer.com/acer-listed-on-dow-jones-sustainability-indices-djsi-for-eighth-straight-year-in-2021.
- Apple. 2018. *Apple now globally powered by 100 percent renewable energy*. https://www.apple.com/newsroom/2018/04/apple-now-globally-powered-by-100-percent-renewable-energy/.
- Apple. 2020. *Apple 12 Product Environmental Report*. October 13. https://www.apple.com/environment/pdf/products/iphone/iPhone_12_PER_Oct2020.pdf.
- Apple. 2025. *iPad 16 Environmental Report*. https://www.apple.com/id/environment/pdf/products/ipad/iPad_A16_PER_MAR2025.pdf.
- Apple. 2022. *Apple Environmental Progress Report 2022*. *Apple*. https://www.apple.com/environment/pdf/Apple_Environmental_Progress_Report_2022.pdf.
- Apple. 2022. *Apple expands the use of recycled materials across its products*. April 19. https://www.apple.com/newsroom/2022/04/apple-expands-the-use-of-recycled-materials-across-its-products/.
- ASUS. 2020. *Operational Footprint | Climate Action*. https://csr.asus.com/english/article.aspx?id=1729.
- BBC. 2022. *Mine e-waste, not the Earth, say scientists*. https://www.bbc.com/news/science-environment-61350996.
- Capgemini. 2021. *Sustainable IT - Why it's time for a Green revolution for your organization's IT*. https://www.capgemini.com/no-no/wp-content/uploads/2021/07/Sustainable-IT_Report-2.pdf.
- Capterra. 2023. *Nearly a Third of Small Businesses Are Tossing IT Hardware Into Landfills—The Reason Might Surprise You*. https://www.capterra.com/resources/responsible-it-asset-disposition/.
- Carlsson, Rebecka. 2021. *Exponentiell klimatomställning*. https://www.rebeckacarlsson.se/thought-leadership/exponentiell-klimatomstllning-sammanfattning.

- Cascade Asset Management. 2025. ITAD *Benchmarking Report 2025*. https://cascade-assets.com/wp-content/uploads/2025-Cascade-ITAD-Benchmarking-Report.pdf.
- Compliance Standards. 2025. *ITAD Certifications Under Scrutiny: Governance, Accountability, and the Path to Enterprise Credibility*. https://compliancestandards.com/2025/08/itad-certifications-under-scrutiny-governance-accountability-and-the-path-to-enterprise-credibility/.
- Cunnie, Shawn. 2022. *IT Asset Disposition is Critical to Sustainability Goals*. January 21. https://www.missioncriticalmagazine.com/articles/93937-it-asset-disposition-is-critical-to-sustainability-goals.
- Dell. 2019. *Lifecycle Assessment of Dell PowerEdge R740*. Junie. https://tinyurl.com/2c32dzhe.
- Dell. 2022. *Progress made real FY21 ESG Report*. Dell. https://tinyurl.com/fzd6t6pf.
- Dell. n.d. *Social impact*. https://www.dell.com/sv-se/dt/corporate/social-impact.htm#:~:text=By%202030%20we%20will%20cut,2%20and%203%20by%202050.
- EU Parliament. 2011. *Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment Text with EEA relevance*. June 8. https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:32011L0065.
- CEMarking. 2011. *RoHS Directive*. June 8. https://cemarking.net/eu-ce-marking-directives/rohs-directive/.
- European Commission. 2025. *Circular Economy: New evaluation looks at how to improve WEEE Directive*. https://environment.ec.europa.eu/news/new-evaluation-looks-how-improve-weee-directive-2025-07-02_en
- European Commission. 2023. *Restriction of Hazardous Substances in Electrical and Electronic Equipment (RoHS)*. https://environment.ec.europa.eu/topics/waste-and-recycling/rohs-directive_en#:~:text=The%20RoHS%20Directive%20currently%20restricts,RoHS%20Directive
- European Commission. 2022. *Circular Economy*. https://environment.ec.europa.eu/topics/circular-economy_en#:~:text=90%25,use%20rate%20in%20the%20EU
- European Environmental Bureau. 2019. *Cool products don't cost the Earth.* https://eeb.org/wp-content/uploads/2019/09/Coolproducts-report.pdf.
- Exittechnologies. 2021. *IT Asset Disposition: A Review of the Services, Market, and Considerations*. September 27. https://www.exittechnologies.com/blog/data-center/it-asset-disposition-overview/.

- Fortune Business Insights. 2025. *IT Asset Disposition Software Market*. https://tinyurl.com/42f7pj2z.
- Gartner. 2025. *Gartner Says Worldwide PC Shipments Increased 1.4% in Fourth Quarter of 2024 and 1.3% for the Year*. https://www.gartner.com/en/newsroom/press-releases/2025-01-15-gartner-says-worldwide-pc-shipments-increased-1-point-4-percent-in-fourth-quarter-of-2024
- Gartner. 2022. *Gartner.com*. January 12. *Gartner Says Worldwide PC Shipments Declined 5% in Fourth Quarter of 2021 but Grew Nearly 10% for the Year*. https://www.gartner.com/en/newsroom/press-releases/2022-01-12-gartner-says-worldwide-pc-shipments-declined-5-percent-in-fourth-quarter-of-2021-but-grew-nearly-10-percent-for-the-year.
- Gill, Victoria. 2021. *Waste electronics will weigh more than the Great Wall of China*. October 13. https://www.bbc.com/news/science-environment-58885143.
- Global E-waste Monitor. 2024. ITU/unitar. https://ewastemonitor.info/the-global-e-waste-monitor-2024/.
- Grand View Research. 2025. *IT Asset Disposition Market Size, Industry Report, 2030*. https://www.grandviewresearch.com/industry-analysis/it-asset-disposition-market.
- 2017. *Guide to Greener Electronics*. https://www.greenpeace.org/usa/wp-content/uploads/2017/10/Guide-to-Greener-Electronics-2017.pdf.
- Greenpeace. 2017. *HP report card*. https://www.greenpeace.org/usa/wp-content/uploads/2017/10/GGE2017_HP.pdf.
- Greenpeace. 2017. *Lenovo report card*. https://www.greenpeace.org/usa/wp-content/uploads/2017/10/GGE2017_Lenovo.pdf.
- HP. 2024. *Product Carbon Footprint Report -- EliteBook 830 8th Gen. Figures converted to UK location for comparison*. https://h20195.www2.hp.com/v2/GetDocument.aspx?docname=c07525065
- HP. 2020. *HP 2020 Sustainable Impact Report*. https://www8.hp.com/h20195/v2/GetPDF.aspx/c07539064.pdf.
- HP Inc. 2021. *HP Inc. Announces Ambitious Climate Action Goals*. April 20. https://press.hp.com/us/en/press-releases/2021/hp-inc-announces-ambitious-climate-action-goals.html.
- IDC. 2025. *Worldwide Server Market Revenue Increased 91% During the Fourth Quarter of 2024*. https://my.idc.com/getdoc.jsp?containerId=prUS53264225#:~:text=Revenue%20generated%20from%20x86%20servers,over%20year%20to%20$22.5%20billion.

- *IT-recycling. 2024. Environmental pollutants in old computers and computer waste*. https://it-recycling.nl/en/blog/environmental-pollutants-in-old-computers-and-computer-waste/
- Kirchherr, Julian, M.P. Hekkert, and Reike Denise. 2017. *Conceptualizing the Circular Economy: An Analysis of 114 Definitions*. September. https://www.researchgate.net/publication/320074659_Conceptualizing_the_Circular_Economy_An_Analysis_of_114_Definitions.
- KnowTheChain. 2025. 2025 *Information and Communications Technology Benchmark Key Findings Report*. https://media.business-humanrights.org/media/documents/KTC_2025_ICT_Key_findings_report.pdf
- Lenovo. 2020. *Lenovo Sustainability Combatting Climate Change: Performance*. https://www.lenovo.com/us/en/sustainability-climate-change-performance/.
- Market Research Future. 2021. *IT Asset Disposition Market with COVID-19 impact Analysis By Service Type, Asset Type, Organization Size, End User (Banking, Financial Services, and Insurance (BFSI), IT and Telecom, Healthcare), and Region - Global Forecast to 2026. www.researchandmarkets.com*. April. https://tinyurl.com/4yzcs85f.
- Mendoza, N.F. 2020. *Global e-waste is up 21% in 5 years, causing serious environmental harm*. July 14. https://www.techrepublic.com/article/global-e-waste-is-up-21-in-5-years-causing-serious-environmental-harm/.
- Microsoft. 2021. *Ecoprofile Surface Pro 8*. https://www.microsoft.com/content/dam/microsoft/final/en-us/microsoft-product-and-services/surface/surface-pro-8/SurfacePro8_Ecoprofile.pdf.
- Morgan, Blake. 2020. *Forbes. 10 Most Sustainable Consumer Tech Companies*. https://www.forbes.com/sites/blakemorgan/2020/11/09/10-most-sustainable-consumer-tech-companies/?sh=32ee43c549a8.
- Murray, James. 2012. *EU revamps e-waste rules with demanding new recovery targets*. Aug 14. https://www.theguardian.com/environment/2012/aug/14/eu-waste.
- IDG Communications, Inc. 2020. *NO TURNING BACK. How the Pandemic Has Reshaped Digital Business Agendas*. https://services.google.com/fh/files/misc/global_idg_it_leaders_research_report.pdf.
- Omdia Canalsys. 2025. *Global smartphone market dips slightly in Q2 as vendors respond to tariffs and stagnant demand*. https://www.canalys.com/newsroom/global-smartphone-market-q2-2025

- Potting, José, Marko Hekkert, Ernst Worrell, and Aldert Hanemaaijer. 2017. *Circular Economy: Measuring Innovation in the Product Chain - Policy Report*. January. https://www.pbl.nl/sites/default/files/downloads/pbl-2016-circular-economy-measuring-innovation-in-product-chains-2544.pdf.
- Rejoose. 2025. *Product Lifecycle Carbon Emissions custom reports: Dell Pro 14 Premium, Dell PowerEdge R760, HP ProLiant DL365 Gen11, Lenovo Yoga Tab Plus (2025), Lenovo ThinkPad X1 2-in-1 Gen 9, Microsoft Surface Pro 11 (11th generation)*. Prepared April 2025.
- Reuters. 2024. *Apple supplier Foxconn rejects married women from India iPhone jobs*. https://www.reuters.com/investigates/special-report/foxconn-apple-india-women/.
- Royal Society of Chemistry. 2022. *Meet the precious metals.* https://sustainability.rsc.org/meet-the-precious-elements/.
- Ryder, Guy, and Zhao Houlin. 2019. *The world's e-waste is a huge problem. It's also a golden opportunity*. January 24. https://www.weforum.org/agenda/2019/01/how-a-circular-approach-can-turn-e-waste-into-a-golden-opportunity/.
- Samsung. 2025. *Product Environmental Report*, *Galaxy S25*. https://www.samsung.com/global/sustainability/landing_hub-file/AZUXQCVKIiwALYMV/Galaxy_S25_Environmental_Report_EN.pdf.
- Springer Nature Link. 2025. *Gallium: Assessing the Long-Term Future Extraction, Supply, Recycling, and Price of Using WORLD7, in Relation to Future Technology Visions in the European Union*. https://link.springer.com/article/10.1007/s41247-025-00125-7.
- SustainableIT.org. 2024. *Standards Taxonomy V1.2*. https://www.sustainableit.org/standards/it-esg-standards.
- TCO Certified. 2025. *Product Finder Data – Apple iPhone 16 Pro, Dell Pro 14 Premium, Lenovo ThinkPad X1 2-in-1 Gen 10*. Obtained June 2025.
- The Guardian. 2019. *Fairphone 3 review: the most ethical and repairable phone you can buy*. September 19. https://www.theguardian.com/technology/2019/sep/18/fairphone-3-review-ethical-phone.
- World Economic Forum. January 24, 2019. *The world's e-waste is a huge problem. It's also a golden opportunity*. Davos, Switzerland. https://tinyurl.com/nxycxz77.
- Tiseo, Ian. 2021. *Apple's GHG emissions 2012-2020*. May 2021. https://tinyurl.com/3pav4e27.
- Xiaomi. 2023. *Product Environmental Report – Xiaomi 14*. https://tinyurl.com/yesx459y.
- Yale University. 2022. *Almost 1,000 Companies Have Curtailed Operations in Russia—But Some Remain*. May 22. https://som.yale.edu/story/2022/almost-1000-companies-have-curtailed-operations-russia-some-remain.

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10

Energy Resource Management

> *The climate crisis is both the easiest and the hardest issue we have ever faced. The easiest because we know what we must do. We must stop the emissions of greenhouse gases. The hardest because our current economics are still totally dependent on burning fossil fuels, and thereby destroying ecosystems in order to create everlasting economic growth.*
>
> *Greta Thunberg*

This chapter will help you optimize energy resource management within your **information and communication technology** (**ICT**) equipment. You will also learn how companies managing their energy more effectively can significantly impact industrial competitiveness, energy cost structure, and Scope 2 greenhouse gas emissions.

This chapter's main objectives are to better understand the energy consumption from IT assets and, primarily, your end-user IT equipment. Second, you will start to understand how you can measure and understand your energy consumption patterns. Finally, what actions can you take to reduce your energy consumption?

In this chapter, we will cover the following topics:

- Overall transition to a low-carbon future
- Energy consumption from IT hardware
- Step-change to energy resource efficiency
- Standard metrics for IT energy sustainability

This chapter's sustainable IT reference model perspective, as illustrated in *Figure 10.1*, in the **Sustainability by IT** section, will primarily cover IT hardware lifecycle management from an energy conservation perspective, which has implications for enterprise architecture. In **Sustainability in IT**, we address technology's energy demands, infrastructure governance, and a procurement strategy for introducing more sustainable hardware. We will examine how these capabilities play an integral part in your sustainable IT plan to reduce greenhouse gas emissions from efficient energy resource management.

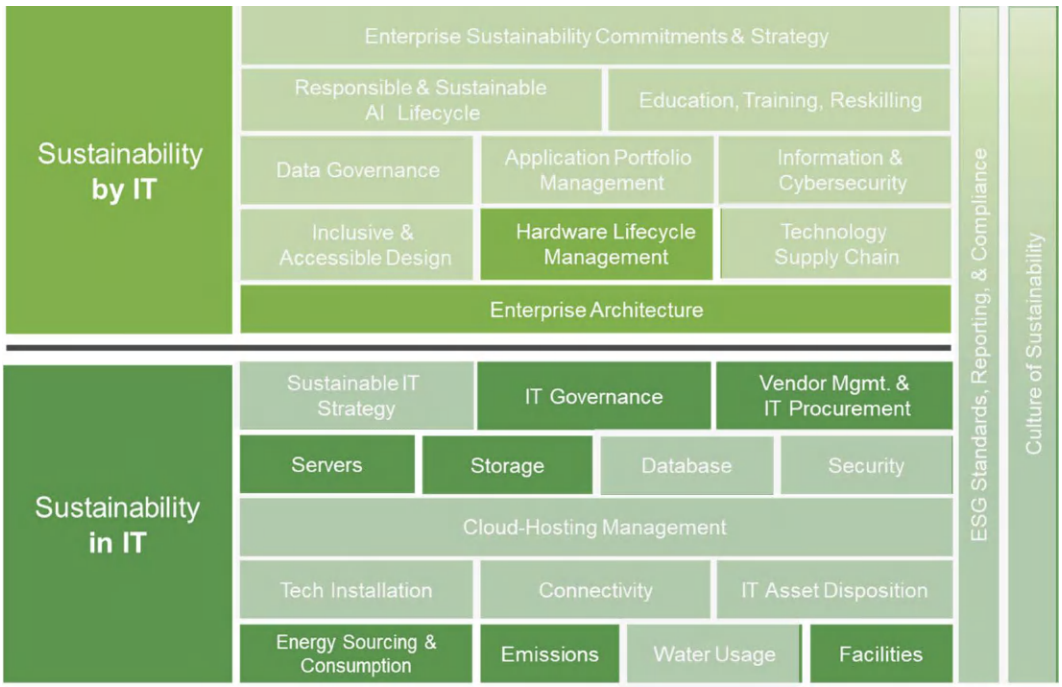


Figure 10.1 – Sustainable IT reference model – Chapter 10 focus

By the end of this chapter, you will have learned about energy mix, energy and foreign policy, and the importance of energy security within ICT. Furthermore, you will better understand the energy consumption of various ICT devices, energy consumption patterns, and how you can conduct similar calculations on your own IT equipment to calculate energy and carbon dioxide emissions. Finally, you will gain insights into how you can take action to improve your resource efficiency.

Transitioning to a low-carbon future

There are two essential aspects to consider when we refer to a low-carbon future: energy security and energy efficiency. The first factor, energy security, has been around for decades, but what does it mean? The **European Commission** and the **International Energy Agency (IEA)** define it as providing reasonably priced, reliable, and environmentally friendly energy (Müller-Kraenner 2007). Although it is a straightforward definition, can you fulfill all three variables to achieve energy security? What price are we willing to pay for energy that is also environmentally friendly? Are you able to get access to reliable energy that is environmentally friendly? The second factor is energy efficiency, where we need to ensure that we do more with less by reducing our energy demand. For every watt of energy that we produce, we need to ensure that we can stretch it further. *The greenest and cheapest energy is the energy we do not use*.

Data centers and digital infrastructure can either be a tremendous opportunity to make the transition to a low-carbon future, or they can be a significant deterrent because of the ever-increasing need for computing and storage power that will continue to accelerate. Today, there are roughly 5.5 billion people on the internet, roughly 67.98 percent of the worldwide population. Of these 5.5 billion internet users, 5.24 billion are on social media (Statista 2025). Now, there are over 33 billion connected devices, up from 13.8 billion in 2021 (Statista 2025). The servers currently powering the internet leave a giant carbon footprint behind. If the internet were a sovereign state, its electricity use would place third after the United States and China (Markkanen 2021).

Energy consumption is the most significant contributor to reducing carbon emissions over time. As we saw in *Chapter 1*, *Our Most Significant Challenge Ahead*, 43% of total emissions come from the energy sector. This is primarily because energy sources are drawn from fossil fuels such as coal and oil. Most considerations about the energy transition to a low-carbon future include renewable technologies such as wind, solar, hydropower, geothermal, and energy storage. Nuclear power is also considered a low-carbon energy source, but not renewable.

In 2010, total global energy consumption (primary energy) was about 12,600 million tonnes of oil equivalent (Mtoe), which translates to roughly 147,000 TWh/year. Electricity demand passed 30,000 TWh for the first time in 2024, reaching 30,856 TWh (Ember 2025). McKinsey projections suggest consumption will be between 32,000 and 36,000 TWh in 2030 (McKinsey 2024). As we learned in *Chapter 4*, *Responsible and Sustainable AI Governance*, the growth of AI is responsible for a significant portion of this increase.

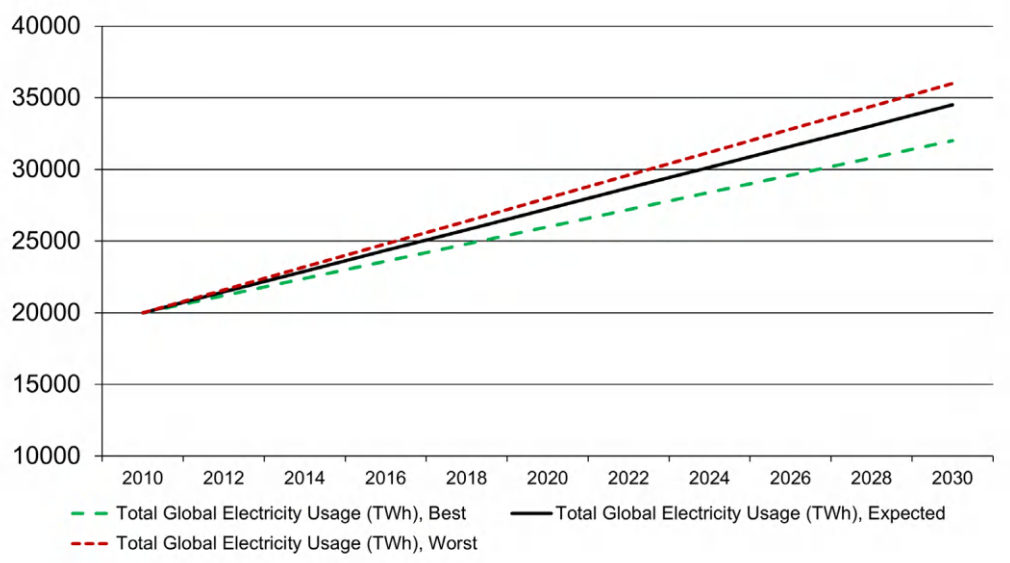


Figure 10.2 – Global electricity demand (TWh) 2010-2030, with best, expected, and worst-case scenarios

Whether the energy supply doubles or triples, supplying low-carbon energy to meet future demands will become a significant challenge. The energy transition requires fundamental changes across the whole value chain from how energy is produced, delivered, and consumed by billions of consumers and businesses in a sustainable global economy.

The energy mix

Decarbonizing the energy system requires a radical shift from today's use of fossil fuels to low-carbon energy sources. Three components comprise total energy production: electricity, transport, and heating. It is essential to understand that energy and electricity are not the same, and sometimes they are wrongly used interchangeably. Usually, you will read about quoted figures in the news on our progress on decarbonization, which primarily refers to electricity and not energy.

Under the IEA's **Net Zero Emissions (NZE)** by 2050 Scenario, the share of low-emission electricity must rise to nearly 75% by 2030. Electricity is decarbonizing rapidly—41% was generated by low-carbon sources (renewables and nuclear) in 2024, with a strong push toward 75% by 2030 under an ambitious policy (*Figure 10.3*).

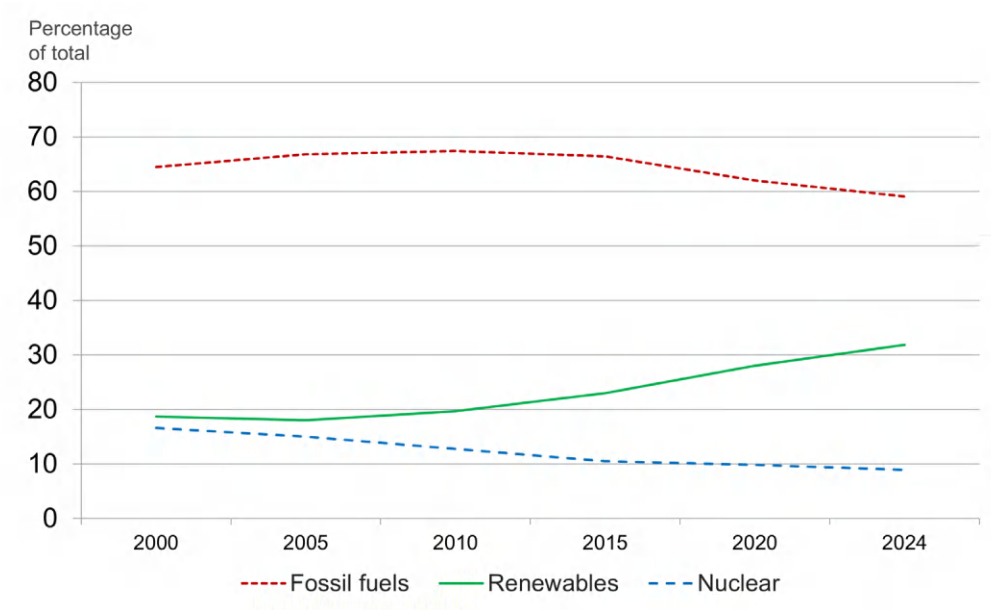


Figure 10.3 – Global electricity fuel mix 2000-2024

Looking at global total energy supply (which includes heating, transport, etc.), fossil fuels still constitute 87% of the global energy mix (Energy Institute 2025). Based on this data projection, it is equally essential that we decarbonize the entire energy system and not just electricity.

When increased regulations and ambitious clean energy goals were announced before and during the COP26 Climate Conference, it became clear that massive deployment of renewable energy was required. The share of wind and solar in the total electricity and energy mix is still low. According to the IEA, in 2023, around 96% of newly installed large-scale solar and wind capacity globally had generation costs cheaper than those of new coal and gas plants. In key markets—such as the U.S., China, India, and Germany—solar PV now delivers electricity at 1.5 to 3 times lower cost than fossil alternatives. For projects with favorable financing and high-quality resources, solar PV is now the cheapest source of electricity in history (IEA 2020).

However, one challenge with solar and wind is that energy storage remains expensive and relatively inefficient. While the cost of generating electricity from solar and wind has fallen dramatically in the past decade, storing that intermittent energy for use when the sun isn't shining or the wind isn't blowing is still a major obstacle. Further investments in battery technologies are required to allow renewables to become more reliable energy sources. Public and political opposition, principally to wind turbine installations, also threatens momentum. Recent U.S. administration actions, such as canceling Federal funding for the Grain Belt Express transmission line for renewable-generated electricity and halting the Lava Ridge Wind Project in Idaho, have constrained renewable infrastructure expansion (Washington Post 2025). Similar opposition is surfacing abroad: in New South Wales, Australia, residents have mobilized to block 250 proposed 300-meter wind turbines adjacent to the Greater Blue Mountains World Heritage Area over scenic, environmental, and tourism concerns (The Australian 2025).

The green transition and the electrification of society with its demands for fossil-free energy sources fundamentally challenge electricity supply volumes. World energy demand rose 2% in 2024, reaching a new high of 592 EJ. Although renewable energy prices are rapidly becoming cheaper and more readily available, there are also more and more reports of the lack of electricity to handle the growing needs of the industry successfully. As part of broader disruptions from events such as COVID, the war in Ukraine, extreme weather, and Middle East tensions, energy supply shortages, record energy prices, and increased volatility across international markets have become more common. Therefore, energy storage is a crucial part of the transition to optimize the use of "green electricity." With energy storage, the peaks in production are evened out simultaneously as the battery storage contributes to the electricity grid's stability—a meaningful way to prevent power shortages and succeed with the green transition.

Energy and foreign policy

Four significant players dominate the energy market reins: the United States, China, Russia, and the European Union. With the demand for decarbonizing the energy market, energy security is a foreign policy and a national security topic in the 21st century. *Figure 10.4* illustrates the percentage per capita of electricity generated by fossil fuels, nuclear, and renewables (IEA 2024) (Ritchie, H. 2024) (Ember 2025):

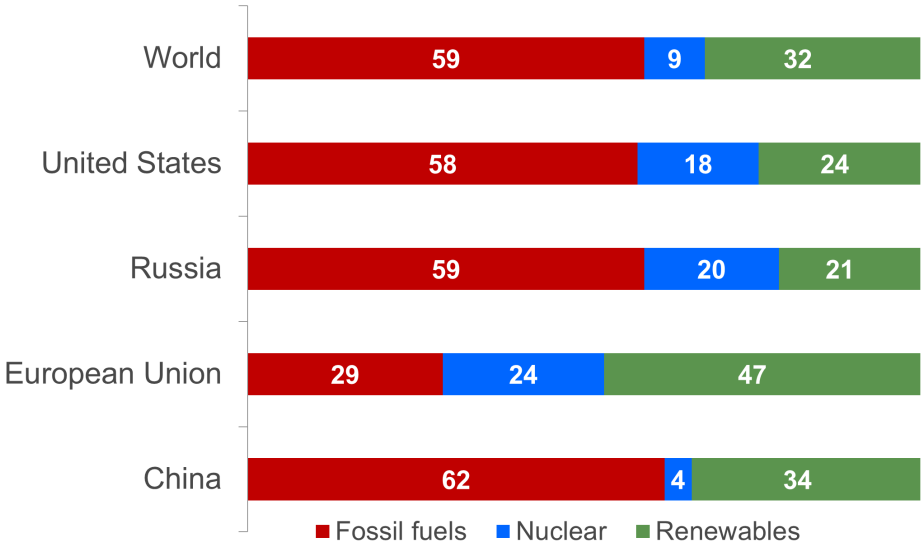


Figure 10.4 – Percentage of electricity from fossil fuels, nuclear, and renewables, per capita

All four significant players still heavily rely on fossil fuels for electricity, whereas the European Union and its 27 member states have seen renewables climb to 47%, while nuclear rose to 24%, together delivering a record 71% of electricity from low-carbon sources for the first time in EU history (AP News 2025).

With sanctions imposed on Russia by the United States and the European Union over the war in Ukraine, the energy supply has become a critical issue threatening to set in motion a European energy crisis. Russia remains a major energy supplier—in 2021, it accounted for approximately 35–45% of the EU's gas imports. By 2024, this share had dramatically declined to around 18–19%, thanks to diversification efforts under the Repower EU plan. Still, Russia supplied roughly 52 billion cubic meters of gas to the EU in 2024, about 19% of the bloc's gas imports (European Commission 2025).

In Germany, despite these supply shifts, coal-fired generation rebounded in early 2025: it rose 16% year on year and accounted for approximately 27% of electricity production, compared to lower levels previously (Clean Energy Wire.org 2025). The EU continues its commitment to end dependence on Russian gas: under the latest proposals, new Russian gas contracts would be banned from 2026, and all existing contracts must end by 2028, achieving a near-total phase-out by then.

Another continent where demand for modern energy is growing rapidly, but is also scarce, is Africa. Africa uses the least amount of modern energy per person worldwide. According to the Africa Power Transition Factbook 2024, per-capita electricity consumption across the continent averaged just 750 kWh in 2023, far below the global average of 3,150 kWh (BBHub Assets 2024). In sub-Saharan Africa (excluding South Africa), usage remains critically low—estimated at only 180 kWh per person annually, compared to 6,500 kWh in Europe and 13,000 kWh in the U.S. (CSIS.org 2025). The IEA reports that in 2023, Africa's electricity supply remained heavily dependent on fossil fuels, with only 25% generated from clean sources, well below the global average of 41% (Ember 2025).

With the global electricity supply expected to double or triple by 2030, energy security is an essential topic for domestic and foreign policy and a private sector issue, especially within ICT, where the demand is expected to rise faster than the global demand.

The importance of energy security in ICT

The most robust evidence indicates the ICT sector used about 4% of global electricity in 2020 (≈1,070 TWh) and that figure is growing—driven by data centers, networks, and end-user devices. The IEA's 2025 analysis projects data center electricity demand to roughly double to 945 TWh by 2030 (IEA 2025). Combining these with devices and other ICT loads yields a plausible central estimate for total ICT electricity use approaching 1,900–2,000 TWh by 2030, far below the 8,000 TWh once cited but still a substantial increase from 2010 levels (World Bank Group & ITU 2023). These ranges reflect ongoing uncertainty—especially how fast AI workloads scale and how much efficiency gains in hardware, cooling, and networks offset growth.

The primary growth drivers in the global ICT electricity supply forecast are fixed access wired and data center use, with data center use expected to rise to 945 TWh annually by 2030 (base case) and as much as 1,700 TWh by 2035, in which case data centers will account for around 4.4% of global electricity demand (IEA 2025). As we mentioned earlier in the chapter, data centers and digital infrastructure can either be a tremendous opportunity to transition to a low-carbon future or a significant deterrent because of the ever-increasing need for computing and storage power that will continue to accelerate. With the current data centers and servers powering the internet leaving a giant carbon footprint behind, it is pivotal for the ICT sector to transition to a low-carbon future.

Ultimately, it comes down to managing risk for the ICT sector. To protect themselves from power price volatility, reduce their environmental impact, and improve their brand reputation, ICT companies are investing considerable sums in renewable energy. In 2024, Amazon, Microsoft, Meta, and Google led the world in volume of clean energy; together they contracted 11.3 GW (American Clean Power 2025). *Figure 10.5* illustrates the breakdown of types of energy purchased by these companies in 2023 (BloombergNEF 2024).

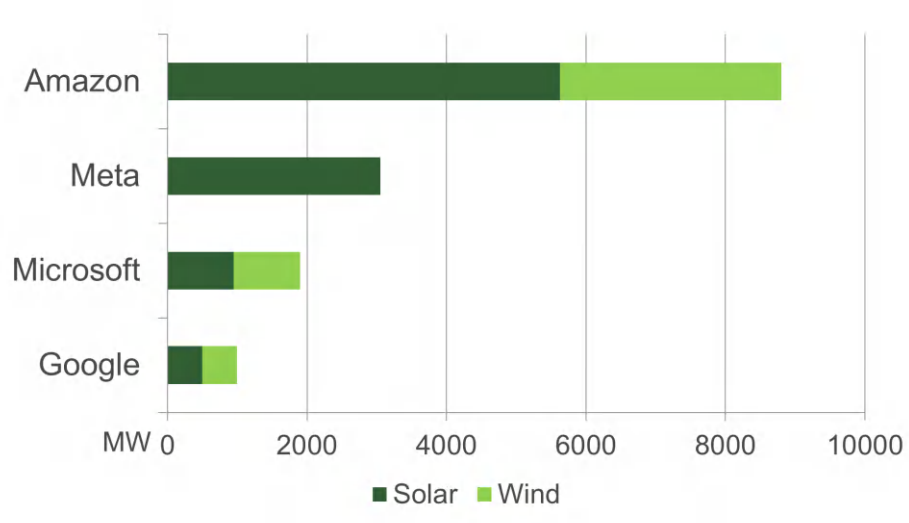


Figure 10.5 – Top ICT corporate buyers of clean energy in 2023



What is a PPA?

A power purchase agreement, sometimes known as an energy power agreement, is a legal arrangement between two parties: the seller, who produces the electricity, and the buyer, who wants to acquire the electricity. The PPA outlines all of the business parameters governing the sale of electricity between the two parties, including the start date of the project's commercial operation, the supply schedule, the consequences of underdelivering, the terms of payment, and termination. A PPA is a leading contract that establishes a generating project's revenue and credit standing, making it a crucial tool in project financing. PPAs come in various formats today, each tailored to the requirements of the buyer, seller, and financing counterparties.

Energy consumption from IT hardware

In *Chapter 9*, *IT Hardware Management*, we looked at the entire IT hardware lifecycle, from the cradle to the grave of a product. Still, in this section, we will take a closer look at energy consumption from various IT hardware devices. We will focus primarily on two categories, which make up the majority of IT's environmental footprint: end-user equipment, such as computers, smartphones, tablets, and monitors, and data centers, such as enterprise servers, storage, and network equipment. As you will discover in the following few sections, there are several things that you can do to improve the energy consumption of your ICT devices.

To assess how energy efficient these ICT devices are, we will use the allowable thresholds from **ENERGY STAR**. ENERGY STAR (`https://www.energystar.gov/`) is a program run by the US **Environmental Protection Agency** (**EPA**) and the US **Department of Energy** (**DOE**). The program promotes the efficient use of energy in electronic products and devices. The ENERGY STAR label can be found in over 75 product categories in commercial buildings, industrial plants, and residential homes.

ENERGY STAR 8.0 was finalized on October 15, 2019, and took effect on October 15, 2020. The forthcoming Version 9.0 specification was published on January 8, 2025, and took effect in October 2025. The computer scope includes desktop computers, integrated desktops, laptop computers, small-scale servers, thin clients, and workstations. ENERGY STAR-certified laptops will use approximately 50% less energy, and desktops about 70% less energy than comparable noncertified models (ENERGY STAR 2025). For servers, version 4.0 took effect on January 12, 2024. ENERGY STAR-certified servers must meet stringent criteria for efficient power supplies, advanced power management (enabled by default), real-time performance monitoring, and overall lower energy consumption in both active and idle states—with an expected energy reduction of **38%** compared to non-certified units (ENERGY STAR 2024).

Organizations such as ENERGY STAR promote energy efficiency and constantly raise the threshold for what is acceptable within a specific electronics category. This leads to electronics manufacturers constantly improving their energy efficiency to stay within the acceptable threshold to qualify for ENERGY STAR certification. A metric called **Base TEC Allowance** (kWh) is used to measure the energy efficiency of a device. **TEC** stands for **typical energy consumption**, a method of testing and comparing the energy performance of electronic products. As the name suggests, it focuses on the typical electricity consumed by a product during regular operation during a representative period. To qualify for an ENERGY STAR rating, the TEC value must not exceed a certain threshold for a particular product type.

The calculation to arrive at a particular TEC for a particular product type is quite complex and beyond the scope of this book. For additional reading on ENERGY STAR rating, refer to the *Further reading* section.

Following is a representative list of certified IT hardware devices and their yearly **kilowatt-hour (kWh)** consumption, based on ENERGY STAR and other sources:

- Desktop PC: 45-58 kWh
- Laptop: 12-21 kWh
- Tablet: 4-6 kWh
- Smartphone: 2-5 kWh
- Home gateway (router): 50 kWh
- Monitor: 13-44 kWh
- Enterprise server: 1,700-2,000 kWh

A laptop (12-21 kWh) is roughly two to four times more energy efficient than a typical desktop (58 kWh). A tablet (4-6 kWh) is almost ten times more energy-efficient than a desktop and one-third more energy-efficient than a laptop. A smartphone with standard usage, with one to two charges per day, consumes two to five kWh per year.



Not surprisingly, your largest energy consumers are IT hardware that sits in a data center that is always powered on, such as servers. Network-attached storage power demand ranges from 175 to 525 kWh per year (Ugreen 2025).

Let us look at three scenarios of a laptop, desktop, and server, commonly found in a workplace and data center setting, and calculate these electrical appliances' energy consumption and carbon emissions. Once we have the carbon emissions, we will compare them to how many trees are required to sequester the CO_2 emitted into the atmosphere.

To calculate the consumption in kWh, you must consider the following three factors:

- The capacity of your electrical device is expressed in watts
- The number of hours your electrical device runs per day
- The number of days per year your electrical appliance is in use

This leaves us with a formula to calculate the annual consumption of energy in kWh:

$$\frac{Capacity\ of\ appliance\ in\ watts}{1{,}000}\ X\ [\#\ of\ hours'\ use]\ X\ [\#\ of\ days'\ use]\ = \#\ of\ kWh$$

To calculate carbon emission in metric tonnes, you must consider two factors:

- The number of kWh (output from the preceding formula)
- Carbon intensity, in metric tonne/kWh. For simplicity, we use the global average carbon intensity of 0.000445 $MtCO_2$/kWh

This leaves us with the formula to calculate carbon emissions expressed in metric tonnes:

$$Number\ of\ kWh\ X\ carbon\ intensity\ \frac{MtCO2}{kWh} =\ Carbon\ emissions\ MtCO2$$

To calculate the number of trees required to sequester carbon emissions in metric tonnes, you must consider two factors:

- Carbon emission $MtCO_2$ per year (output from the preceding formula)
- Tree carbon sequestration rate $MtCO_2$/tree/year—for simplicity, we use a global average of 11 kg / 0.011 metric tonnes per tree per year (Akbari 2002)

This leaves us with the following formula to calculate the number of trees per year

$$\frac{Carbon\ emissions\ MtCO2}{0.011\ MtCO2\ trees\ per\ year} = \#\ of\ trees\ per\ year$$

Now, let us do a few calculations of a few different IT hardware types.

The calculation for the energy consumption and carbon emissions of a laptop

In this example, we compare two different scenarios for laptops with different energy consumption, one low scenario and one high scenario. To accurately represent your laptops, check the label on your hardware or reference the vendor website. We have picked a laptop that draws 50 W and another one that draws 100 W. Let us assume that the laptops are powered on 8 hours per day for 275 days per year. Multiplying those equals 2,200 hours per year. The factor that differs between the two laptops is how many watts it draws per hour.

Now, let us calculate yearly energy consumption, yearly carbon emission, and how many trees are required to sequester the carbon emission:

Capacity of laptop	50 – 100 watts
Hours/day	8 hours/day
Days/year	275 days/year

Table 10.1 – Assumptions for our calculation of laptop emissions

Yearly energy consumption calculation for the two laptops

Laptop low case scenario:

$$\frac{50}{1{,}000} X\ [8]\ X\ [275]\ =\ 110\ kWh$$

Laptop high case scenario:

$$\frac{100}{1{,}000} X\ [8]\ X\ [275]\ =\ 220\ kWh$$

Yearly carbon emission calculation for the respective laptop using the global average carbon intensity factor:

Laptop low case scenario:

$$110\ kWh\ X\ \frac{0.000445\ MtCO2}{kWh} = 0.049\ MtCO2$$

Laptop high case scenario:

$$200\ kWh\ X\ \frac{0.000445\ MtCO2}{kWh} = 0.089\ MtCO2$$

Calculate the number of trees required to sequester the respective laptop:

Laptop low case scenario:

$$\frac{0.049}{0.011}\ = 4.5\ trees\ per\ year$$

Laptop high case scenario:

$$\frac{0.089}{0.011}\ = 8\ trees\ per\ year$$

Next, we will look at the figures for a desktop PC.

The calculation for the energy consumption and carbon emissions of a desktop PC

In this example, we have chosen a desktop PC that draws 200 W per hour. To accurately represent your desktop, check the label on your hardware or reference the vendor website. We use the same assumption as the laptop scenario, where we assume that the desktop PC is powered on 8 hours per day for 275 days per year—multiplying those equals 2,200 hours per year:

Capacity of desktop PC	200 watts
Hours/day	8 hours/day
Days/year	275 days/year

Table 10.2 – Assumptions for our calculation of desktop emissions

Yearly energy consumption calculation for a desktop PC

Desktop case scenario:

$$\frac{200}{1{,}000} X\ [8]\ X\ [275]\ =\ 440\ kWh$$

Yearly carbon emission calculation for a desktop PC using the global average carbon intensity factor:

$$440\ kWh\ X\ \frac{0.000445\ MtCO2}{kWh} = 0.20\ kWh$$

Calculate the number of trees required to sequester a single desktop:

$$\frac{0.20}{0.011} = 18\ trees\ per\ year$$

Next, we will look at the consumption of a server, which, compared to end-user devices, requires a whole grove of trees, if not a small forest, for a year's sequestration.

The calculation for the energy consumption and carbon emissions of a server

In the scenario, we have chosen a server that draws 300 W per hour. Depending on the server's specifications, it can vary anywhere between 300 – 1,500 W per hour. Make sure you check your specifications for your servers and, if possible, the average utilization. Another factor essential to consider is the average workload. Let us assume that we are dealing with a production server powered 24 hours per day for 365 days per year. Multiplying those two factors equals 8,760 hours per year. For the following calculation, we assume 300 W per hour running at 80% total capacity:

Capacity of server	300 watts
Utilization rate	80%
Hours/day	24 hours/day
Days/year	365 days/year

Table 10.3 – Assumptions for our calculation of server emissions

Yearly energy consumption calculation for a server:

Server scenario:

$$\frac{0.20}{0.011} X\ [24]\ X\ [365]\ X\ [80\%]\ =\ 2{,}102\ kWh$$

Yearly carbon emission calculation for the server using the global average carbon intensity factor:

$$2{,}102\ kWh\ X\ \frac{0.000445\ MtCO2}{kWh} = 0.9\ MtCO2$$

Calculate the number of trees required to sequester a single server:

$$\frac{0.9}{0.011} = 82\ trees\ per\ year$$

Summary of energy consumption and carbon emissions of ICT devices

Suppose we summarize our calculations as seen in *Table 10.4*. In that case, we see that the energy consumption differs significantly depending on the number of watts drawn, but also the duration of the device, which in turn affects the carbon emissions:

ICT Device	Energy Consumption (kWh)	Carbon Emission ($MtCO_2$)	Carbon sequestration (trees)
Laptop (Low)	110 kWh	0.05	4.5
Laptop (High)	220 kWh	0.09	8
Desktop	440 kWh	0.20	18
Server	2,102 kWh	0.90	82

Table 10.4 – Summary of yearly energy consumption and carbon emissions of ICT devices

As we noted earlier in this chapter, a desktop draws four times as much electricity as an energy-efficient laptop and roughly twice as much as a non-energy-efficient laptop, which holds in our calculations. Generally, you should also notice that the yearly TEC is higher in our calculations than what the vendors give as an indication.

To put things into perspective, understanding how many trees are required to sequester the carbon emissions for each device per year differs significantly between an energy-efficient laptop that requires 4.5 trees per year to 90 trees per year to sequester the carbon emissions from a server.

Now that we have a basic understanding of the energy demand for several IT hardware devices, let us take a closer look at an end-user computing case study to understand your energy consumption patterns and how you can apply the same principle within your environment.

Understanding your energy consumption patterns

In this section, we will take a closer look at an end-user computing case study to understand our energy consumption within an enterprise better. There are also tools available on the market that can measure the energy consumption of your ICT devices in near real time, but for this case study, we will calculate all the steps manually.

In *Chapter 9*, *IT Hardware Management*, we used a model company with 10,000 computers. For this case study, we will assume that 80 percent are laptops and 20 percent are desktops. We will conduct the study over a rolling 12-month period. We assume that the company is in an expansive phase and growing with 10 percent of employees annually, and every new employee receives a laptop instead of a desktop. Regarding energy demand, we use an energy consumption constant (kWh/hour) of 0.07 for desktop computers and 0.02 for laptops when powered on, and 0.003 and 0.001, respectively, when they are in sleep mode. These energy consumption factors are drawn directly from a tool generally available on the market. We assume that the computers are powered for 168 hours per month. Since desktops consume roughly four times as much energy as laptops, we also put in place a plan to replace 50 desktops per month that are end of life with 50 laptops a month to improve energy efficiency. We do not consider that roughly 30% of computers are typically left on overnight without getting put into sleep mode. *Figure 10.6* lists the distribution of laptops over a rolling 12-month cycle. At the start of month 1, there were 10,000 laptops in all. Note that the distribution of desktops decreases by 50 every month, and the number of laptops increases by 150 per month due to an increase in employees and swapping out 50 desktops for laptops. By month 13, the number of laptops has grown to 9,800, and desktops have decreased to 1,350, amounting to 11,150:

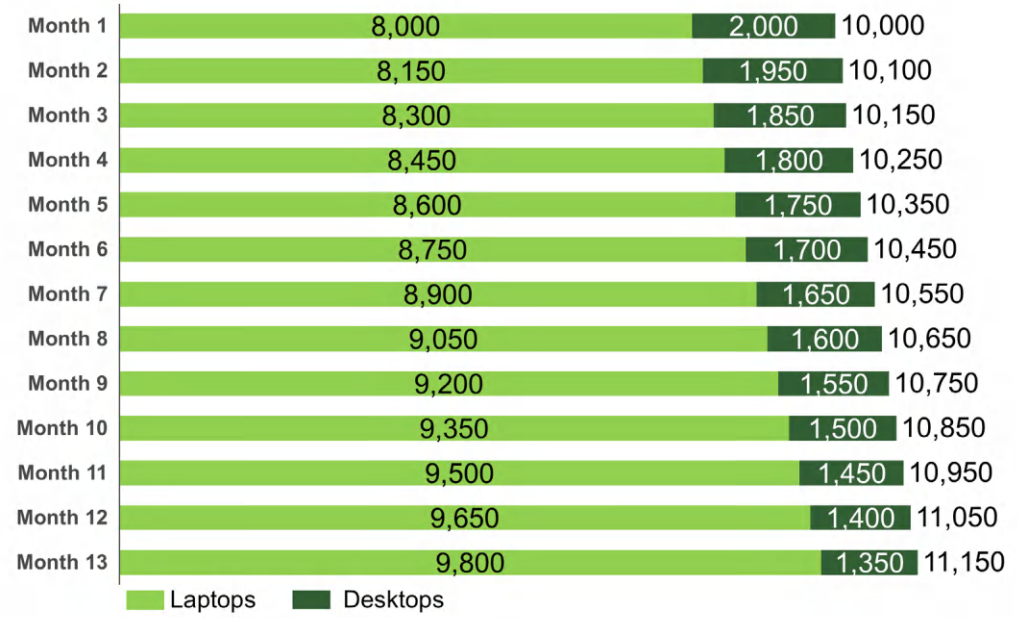


Figure 10.6 – Distribution of laptops and desktops over a rolling 12-month cycle

Let us look at the monthly energy consumption over a 12-month rolling period.

Figure 10.7 illustrates the energy consumption of the computer estate monthly broken down by laptop and desktop. The line in the graph is the accumulated energy consumption in a rolling 12-month period. The *y* axis label on the left-hand side is denoted in kWh, and the *y* axis on the right is denoted in **megawatt hours (MWh)**. Also, 1,000 kWh represents 1 MWh. The graph's bars correspond to the *y* axis on the left in kWh, and the line corresponds to the *y* axis on the right:

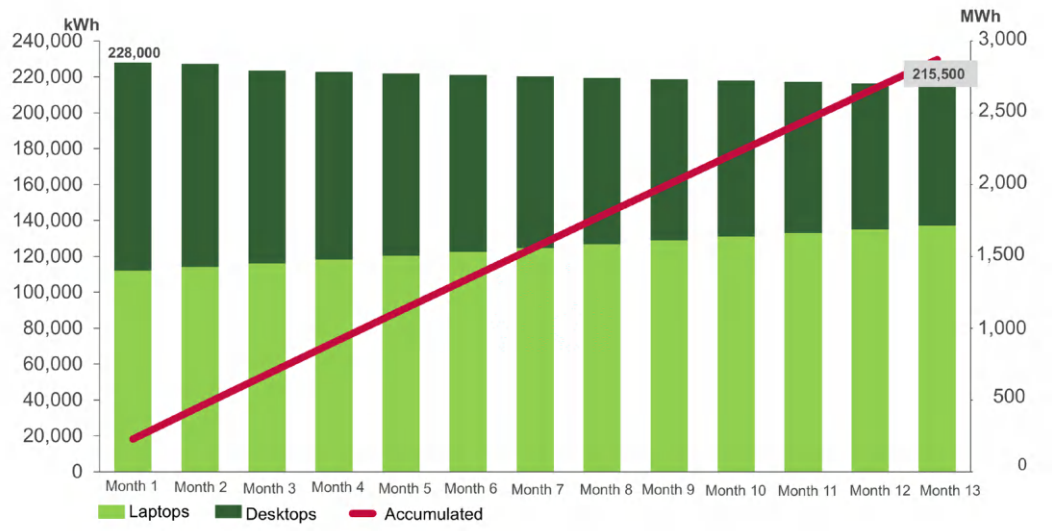


Figure 10.7 – Energy consumption over a rolling 12-month cycle

At the start of month 1, we see that although there are four times as many desktops as laptops, the energy consumption is 112,000 kWh (112 MWh) for desktops and 116,000 kWh (116 MWh) for laptops. As the distribution of desktops decreases by 50 every month and the number of laptops increases by 150 per month, the energy consumption of desktops starts to decrease, and increases for laptops. By month 13, the total energy consumption is, in fact, 12,500 (12.5 MWh) lower than it was at the start of month 1. Over a rolling 12-month period, we have consumed 2,870,000 kWh or 2,870 MWh, which the line in the graph illustrates. An average US home consumes roughly 11,880 kWh of electricity per year. This means that our yearly energy consumption for our computers amounts to roughly the equivalent of the electricity consumption of 242 US homes.

Now, let us look at the carbon dioxide emission rolling for 12 months, as illustrated in *Figure 10.8*. As we did previously, we use the global average carbon intensity of 0.000475 $MtCO_2$/kWh and multiply it by our energy consumption in kWh. We see that in month 1, our total emissions are 108 $MtCO_2$, and due to lowering our energy consumption, it has been reduced to 102 $MtCO_2$ emissions, a decrease of roughly 5.5%. The accumulated carbon emissions amount to 1,363 $MtCO_2$:

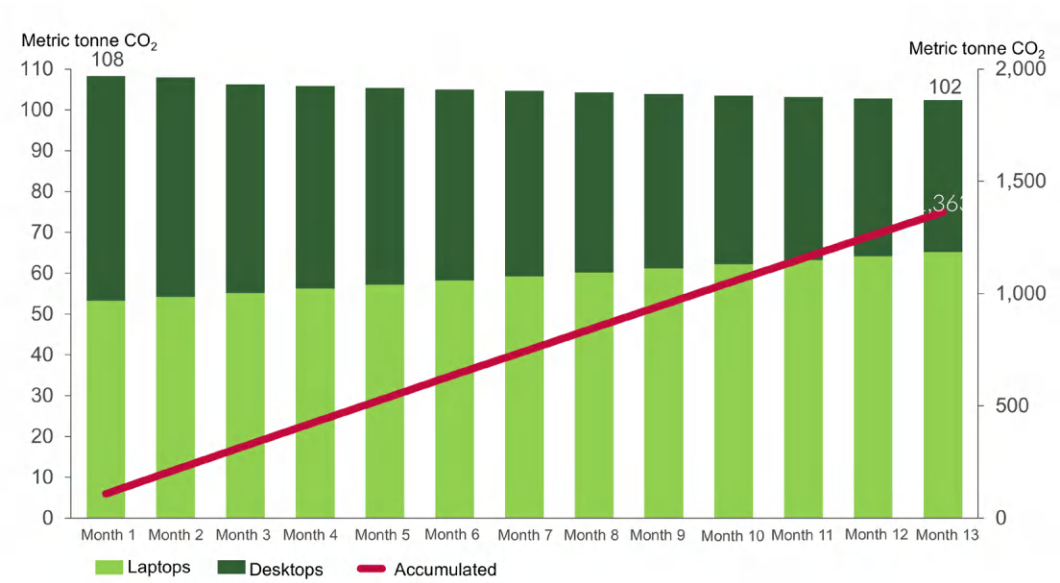


Figure 10.8 – Carbon dioxide emission 12-month rolling cycle

This is the equivalent of 294 gasoline-powered passenger vehicles driven for one year, 600,000 liters of diesel consumed, or 3,156 barrels of oil consumed.

Now that we have looked at a model company with roughly 10,000 computers, we see that the impact on energy consumption and carbon dioxide emissions is not insignificant, and this is only one company. Considering that, in 2021, there were approximately 2.7 billion PCs worldwide according to the ITU, and new PC shipments have averaged 250 million units annually for the past few years, we likely have more than 3 billion desktops, laptops, and tablets in use today. With an estimated 5.64 billion internet users worldwide in 2025, energy consumption is starting to become a significant portion of our total energy consumption (DataReportal 2025). Let us calculate the yearly energy consumption for the world's 3 billion PCs with the assumption that an average machine draws 100 watts per hour.

For the following calculation, we assume, just like the preceding examples, that the computers are powered for 8 hours per day and 275 days/year:

Number of computers	3 billion
Average capacity of computer	100 watts
Hours/day	8 hours/day
Days/year	275 days/year

Table 10.5 – Assumptions for calculating emissions of the world's PCs

Yearly energy consumption calculation of the world's computers

$$\frac{100}{1{,}000} X\ 8\ X\ 275\ X\ 3{,}000{,}000{,}000\ =\ 660{,}000{,}000{,}000\ kWh\ =\ 660{,}000{,}000\ MWh$$

$$=\ 660{,}000\ GWh\ =\ 660\ TWh$$

The figure 660 TWh is the equivalent of **293.7 million metric tonnes of carbon dioxide**, based on the 2024 global average carbon intensity of electricity production **(445 g CO_2/kWh, according to the IEA)**.

As illustrated in *Figure 10.9*, 660 TWh is equivalent to the annual electricity use of about **62.79 million U.S. households**, or roughly **42.71 %** of all U.S. households:

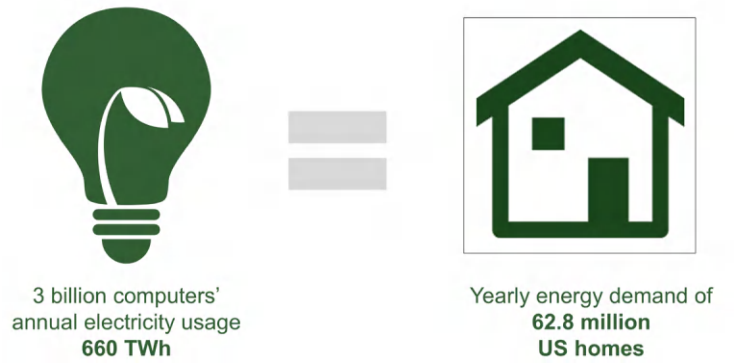


Figure 10.9 – Global energy consumption of the world's PCs in equivalent US homes powered

In *Chapter 6*, *Data Centers and Cloud*, we looked at how you could optimize resource efficiency, including energy. When you put this figure of 660 TWh in contrast to the number of US homes, you realize the sheer magnitude of energy required to power our global end-user equipment estate. If we also compare the 660 TWh as a percentage of yearly worldwide electricity consumption, which was 30,856 TWh in 2024, it amounts to 2.1%.

Now, let us look at how we can make a step-change to energy resource efficiency from our end-user equipment.

Step-change to energy resource efficiency

As we highlighted previously, *the greenest and cheapest energy is the energy we do not use*. The best way to reduce energy consumption is to do much more with less. Reducing energy consumption will save you money and reduce greenhouse gas emissions. This section will look at ways to become more energy resource efficient. As we saw in the previous section, an estate of 10,000 computers consumes almost 3,000,000 (kWh) or 3,000 (MWh) per year. With an average price of 0.13 USD per kWh in the commercial sector in the United States (US EIA 2025), this annual cost is 390,000 USD. With the recent price fluctuations in energy prices due to the global geopolitical situation, we will most likely see higher energy prices going forward. Hence, it makes sense both from a cost and an environmental perspective to become more energy resource efficient. Therefore, choosing equipment that is far more resource-efficient can have a significant impact on your bottom line.

Buy resource-efficient hardware

In all our processes, we should go in with the mindset to do more with less. To ensure that our IT equipment runs, we should aim to procure energy-certified products from **ENERGY STAR** or the **EU Energy Efficiency Rating**. The EU Energy Efficiency Rating has a scale from A (most efficient) to G (least efficient), which is easily recognized, as illustrated in *Figure 10.10*:

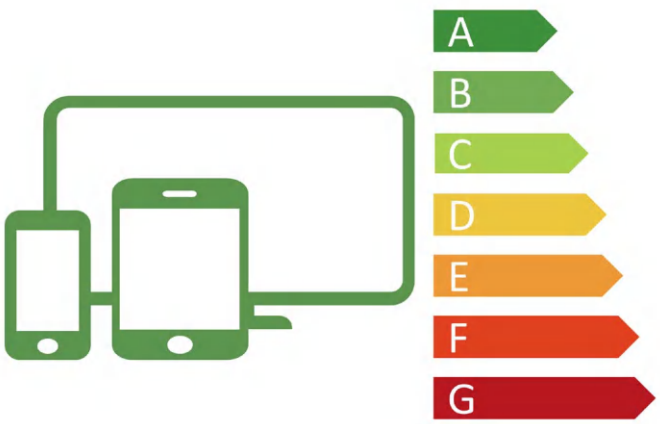


Figure 10.10 – Example of energy rating label

Before buying any hardware, check for an ENERGY STAR or Energy Efficiency Rating. Buying energy-efficient IT equipment will significantly impact your energy consumption, especially if you manage a large estate.

Take advantage of device and display settings

End-user devices come equipped with power management features. Typically, employees don't access these on their company-supplied hardware. You should aim to reduce energy usage by changing the power mode settings for these devices and providing guidance on how to set these features on your employees' BYOD hardware. *Table 10.6* illustrates the energy consumption difference between devices turned on or in sleep mode:

ICT device	Turned on kWh/hour	Sleep mode kWh/hour
Laptop	0.03–0.07 (30–70 W)	0.002–0.006 (2–6 W)
Desktop	0.08–0.15+ (80–150 W or more)	0.001–0.01 (1–10 W)

Table 10.6 – IT hardware comparison between turned on and sleep mode

By enabling sleep mode after a period of inactivity, your ICT device will only draw a fraction of energy as opposed to being fully turned on.

Deploy centralized power management (via group policies, MDM tools, or tools such as **PowerMAN**) to ensure machines go to sleep or hibernate outside work hours, or after brief idle periods.

The general recommendation is as follows:

- Turn off the monitor after 5-10 minutes of inactivity
- Turn on the computer's sleep mode after 15-30 minutes of inactivity

Keeping screen brightness at moderate or adaptive levels (especially when ambient light is adequate) can reduce display power draw. Studies suggest that reducing brightness to typical levels (versus full) can cut display energy by up to 20% (Nelson-Miller 2022).

You may find that a particular app could consume a lot of battery; you can change its settings to prevent it from running in the background. Hibernation is a feature that can help preserve battery life when you are not using the device. This feature works by saving the data in memory onto the hard drive, allowing you to completely shut down and resume where you left off without wasting power.

When managing a large set of computers within an enterprise, your best alternative is to enforce a group policy for power consumption. The power consumption properties are pushed out centrally to all clients. Centrally managing power consumption settings is a significant advantage for efficiency, consistency, and preserving energy from a corporate perspective. Still, it is also essential to make the group policies well-known to the end users.

Manage video conferencing

Video conferencing has become a dominant ICT load in many organizations. It involves simultaneous capture, encoding, decoding, rendering, and network transmission. The following practices help reduce its energy footprint:

- **Prefer audio-only (camera off) when video is not necessary**: Studies show that turning off the camera can reduce the environmental impact of a video call dramatically (e.g., by up to 96 %) (MIT News 2021). For large calls, even small savings per participant add up.
- **Limit video resolution/frame rate**: Use lower resolutions (e.g., 720p or lower) and moderate frame rates (e.g., 15–30 fps) instead of 1080p or 4K where visual detail is not critical. This reduces encoding and decoding load, network bandwidth, and energy consumption. Conferencing platforms sometimes offer "low bandwidth / eco / data saver" modes—encourage their use.
- **Check and limit default video settings**: Configure defaults so that when a meeting starts, video does not auto-enable at high resolution. Where possible, disable automatic video/camera startup. Use software settings to default to lower resolution or grayscale fallback in constrained bandwidth or power modes.
- **Avoid or limit virtual backgrounds and effects**: Virtual backgrounds, blurred backgrounds, and real-time facial effects all increase CPU/GPU load and thus power draw. Encourage plain or static backgrounds in meetings.
- **Optimize video layout settings (gallery/tile view versus spotlight/active speaker)**: Many conferencing clients render multiple video streams in gallery view or grid layout. Reducing the number of visible video tiles (e.g., showing only the active speaker) can reduce the processing load. Some clients support "hidden-gallery" or "speaker-only" modes.
- **Prefer a wired network over Wi-Fi where feasible**: Wired Ethernet connections often use lower energy per bit than Wi-Fi (less overhead, fewer retransmissions). Also, disabling wireless features (e.g., Bluetooth, Wi-Fi) when unused helps.

- **Close unneeded applications/browser tabs during video calls**: Extra background processes increase CPU load, memory usage, and power consumption—minimizing them helps the conference run more efficiently.
- **Leverage energy-aware media standards**: Emerging standards such as Green Metadata (ISO/IEC 232001-11) allow a video receiver to signal to the sender a lower-complexity bitstream to reduce decoding load and save power. In experimental settings, this has achieved energy savings of up to 90% in software decoding (Herglotz C, et al. 2023).
- **Smart, adaptive streaming/codec choice**: Intelligent clients that adapt resolution, bitrate, or encoding complexity in real time based on power, battery, or thermal headroom can reduce load during constrained conditions.

Go virtual

Exploring concepts such as **virtual desktop infrastructure (VDI)** effectively reduces end-user IT hardware equipment and preserves energy. The VDI concept separates the application software from the physical client, where all the desktop components are virtualized. The user logs into a virtual desktop running on the server side, enabling a flexible and secure desktop delivery model. Essentially, the virtual desktop is available from a computer, tablet, or smartphone. All your data is stored server-side, leading to an effective disaster recovery strategy and procedures. Moving the workload from the client to the server side diminishes the need for a powerful client computer.

Manage remaining printers

Paperless tools and policies have cut down on the number of printers, but most companies still maintain a handful in certain departments. Institute print-optional, paper-minimized operations—where every process is handled digitally if possible, and printing is reserved only for legal or operational needs. Ensure that printers are set to enter low-power or fully off mode after an idle threshold is reached. Require employees to physically go to the printer to release print jobs, minimizing print-and-forget behavior. Consider managed print services—outsourced or centralized governance of your print fleet, with energy-efficiency optimization built in. This way, you can centrally enforce defaults such as duplex, black-and-white printing, quotas, and route jobs to the most efficient device.

Explore smart tools

Smart technologies can automate system monitoring, collection of essential power management data, and in some cases the execution of policy. *Table 10.7* lists tool types, their typical use, and examples for reference. The tools and vendors mentioned are representative and are not endorsed by the publisher or authors.

Type	Capabilities	Examples
Smart PDUs (Power Distribution Units)	Per-outlet metering remote on/off power cycling Load monitoring and alerts for thresholds Environmental sensors integrated Outage or overload protection	Raritan, Vertiv, APC (Schneider), Chatsworth smart PDUs, and so on
Power monitoring and metering hardware	Circuit- or panel-level measurement Real-time usage dashboards Load disaggregation/non-intrusive load monitoring	ATEN EC1000 Energy Box (monitors PDUs), Shelly Pro 3EM-3CT63 (DIN-rail energy meter), ThingsBoard (IoT energy management platform), Verdigris (AI + hardware for building load monitoring)
Energy management systems and facility platforms	Aggregation of energy data Benchmarking and trending Automated control strategies Integration with HVAC, lighting, backup systems	Platforms such as Siemens Simatic, Schneider Electric EcoStruxure, Johnson Controls Metasys, and Honeywell Forge
Smart IoT-enabled switching, relays, and smart plugs	Ability to power down and schedule power to devices (e.g., non-critical loads) Remote switching and metering at the plug or branch level	Smart plug/relay solutions such as those from Onics, Shelly Wave, and LoRaWAN Smart Meter Plug
Power intelligence and control software	Monitor and control PCs, laptops, servers, and network gear Schedule shutdowns and wake-ups Enforce policies (sleep modes, low-power states) Monitoring of idle devices	Cisco EnergyWise Suite monitors energy across networked devices without requiring agents. Some emerging “green IT” modules in data center management suites.

Type	Capabilities	Examples
Smart video conferencing optimization tools	Dynamic bitrate and resolution switching Low bandwidth and eco mode toggles Monitoring of video resource usage Video layout control (reduce tile counts)	Some video conferencing platforms (Teams, Zoom, Webex) already include power-saving modes and may allow API integration or policy enforcement.
Intelligent displays and room equipment with presence detection	Displays (e.g., large meeting-room screens) that auto-sleep or wake via proximity sensors Integration with room control systems for lights, occupancy, and AV equipment	SMART board displays include power-saving modes and presence detection to sleep/wake automatically. Many AV/room systems integrate with building control for unified sleep/wake routines.

Table 10.7 – Smart tools for automating ICT power management

Summary

In this chapter, you learned about energy mix, energy and foreign policy, and the importance of energy security within ICT. Furthermore, you should now better understand the energy consumption of various ICT devices, energy consumption patterns, and how you can conduct similar calculations on your own IT equipment to calculate energy and carbon dioxide emissions. Finally, you should have actionable insights into how you can improve your resource efficiency.

These are some of the key recommendations that you should have in mind to do more with less:

- Buy resource-efficient hardware
- Educate users on energy leakage and encourage them to turn off IT hardware when not in use
- Leverage renewable energy sources
- Take advantage of various system power management settings
- Go virtual by exploring VDI and **Device-as-a-Service (DaaS)**
- Explore smart energy technologies

As we have reached the end of the chapter, you should better understand how you can optimize energy resource management within your IT hardware. Applying this chapter's learnings can significantly impact your industrial competitiveness, energy cost structure, and Scope 2 greenhouse gas emissions.

In *Chapter 11*, *Leveraging Your Buying Power*, as the chapter title suggests, we will look at how vendor management and IT procurement play a central role in a sustainable IT enterprise.

Appendix: standard metrics for IT energy sustainability

The following table contains SustainableIT taxonomy metrics tailored for IT and should be used to establish baselines for IT infrastructure energy demand and sources, and for tracking and reporting progress in shrinking the IT function's high-carbon energy consumption. A second set of energy metrics (SIT EE) can be applied and reported on behalf of the enterprise.

Category	Topic	Metric	Related Global Standards
SIT EF 100 Energy, Function	EF 110 Technology infrastructure total energy consumption: electricity, heating, cooling. Include separately calculated consumption from data centers, end-user devices, and application portfolio.	EF 110-1 Owned/on-premises: CPUs, monitors, desktops, laptops/notebooks, tablets, routers, printers, smartphones, desktop phones, servers, applications	GRI 302-1, 3 TC-IM-130a.1 TC-SI-130a.1 ESRS E1 SDG 7, 9, 13, 17
		EF 110-1.a kWh rack power consumption by location, time of day, per end user	
		EF 110-1.b Percentage renewable (on-premises, co-location and cloud-hosted): solar, wind, geothermal, hydropower, tidal, biomass	
		EF 110-2 Third party-sourced, public cloud-hosted, co-located: Hardware, software	
		EF 110-2.a kWh by provider, location, time of day, per end user	
		EF 110-2.b Percentage renewable (on-premises, co-location, and cloud-hosted): solar, wind, geothermal, hydropower, tidal, biomass	

Category	Topic	Metric	Related Global Standards
SIT EF 100 Energy, Function	EF 130 Lifecycle energy consumption of IT products and services (e.g., application operations, messaging and collaboration, service desk, security, networks, and connectivity): electricity, heating, cooling	EF 130-1 Percentage of IT products and services having an extraordinarily high workload	GRI 302-1, 3 ESRS E1 SDG 7, 9, 13, 17
		EF 130-2 Percentage of IT products and services running on renewable energy: Solar, wind, geothermal, hydropower, tidal, biomass	
	SIT EF 140 Energy sourcing	EF 140-1 Percentage of energy sources controlled/influenced	SDG 7, 9, 13, 17
SIT EE 100 Energy, Enterprise	EE 110 Enterprise facility energy consumption (green buildings)	EE 110-1 kWh by location, time of day, facility, sq. meters	GRI 302-1, 2, 3 ESRS E1 SDG 7, 9, 13, 17
		EE 110-2 Percentage renewable: Solar, wind, geothermal, hydropower, tidal, biomass	
		EE 110-3 Percentage Square meters certified	
SIT EE 100 Energy, Enterprise	EE 120 Hybrid workforce 1.5-Degree Celsius Pathway enablement	EE 120-1 kWh by location, by ratio of remote to office workers	
		EE 120-2 Percentage renewable: Solar, wind, geothermal, hydropower, tidal, biomass	
	EE 140 Energy sourcing	EE 140-1 Percentage of energy sources controlled/influenced	

Table 10.8 – SustainableIT standards taxonomy metrics for community engagement and IT asset disposition

Further reading

- *TCO Certified Product Finder*: https://tcocertified.com/product-finder/.
- *ENERGY STAR Product finder*: https://www.energystar.gov/productfinder/.
- *ENERGY STAR Program Requirements for Computers*: https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Computers%20Final%20Version%208.0%20Specification%20-%20Rev.%20April%202020_0.pdf.
- *ENERGY STAR Program Requirements for Servers*: https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Version%203.0%20Computer%20Servers%20Program%20Requirements_0.pdf.

Bibliography

- Akbari, H. 2002, *Shade trees reduce building energy use and CO_2 emissions from power plants*, *Environmental Pollution* 116: 119-126: https://www.sciencedirect.com/science/article/abs/pii/S0269749101002640.
- American Clean Power, 2025, *NEW REPORT: Clean Energy Contracts with Fortune 500 Companies Surge in 2024*: https://cleanpower.org/news/market-report-2024/#:~:text=The%20top%20purchasers%20of%20clean,the%20growing%20data%20center%20market.
- AP News, 2025, *Europe Posts Record Year for Clean Energy Use as Trump Pulls US Toward Fossil Fuels*: https://apnews.com/article/europe-renewables-climate-change-solar-wind-fossil-fuels-4a6ff96bbde3251cb42109e1d9d4b399.
- Australian, The, 2025, *Winds of "Madness:" 300m-high Turbines Spark Outrage*: https://tinyurl.com/mvbams4p.
- BBHub Assets, 2024, *Africa Power Transition Factbook 2024*: https://assets.bbhub.io/professional/sites/24/Africa-Power-Transition-Factbook-2024.pdf.
- BloombergNEF, 2024, *Amazon Is Top Green Energy Buyer in a Market Dominated by US*. https://about.bnef.com/insights/clean-energy/amazon-is-top-green-energy-buyer-in-a-market-dominated-by-us/.
- Clean Energy Wire.org, 2025, *Early 2025 Sees Fossil Sources Top Renewables in German Power Mix for First Time in Two Years*: https://www.cleanenergywire.org/news/early-2025-sees-fossil-sources-top-renewables-german-power-mix-first-time-two-years.
- CSIS.org, 2025, *Achieving Universal Energy Access in Africa Amid Global Decarbonization*: https://www.csis.org/analysis/achieving-universal-energy-access-africa-amid-global-decarbonization.

- DataReportal. 2025, *Digital 2025 April Global Statshot Report*: https://datareportal.com/reports/digital-2025-april-global-statshot.
- Ember, 2025, *2024 at a Glance*: https://ember-energy.org/latest-insights/european-electricity-review-2025/2024-at-a-glance/.
- Ember, 2025, *Global Electricity Review 2025*: https://ember-energy.org/app/uploads/2025/04/Report-Global-Electricity-Review-2025.pdf.
- Ember, 2025, *Africa*: https://ember-energy.org/countries-and-regions/africa/
- Energy Institute, 2025, *Statistical Review of World Energy*: https://www.energyinst.org/statistical-review.
- ENERGY STAR, 2024, *Energy Star Computer Servers Version 4.0*: https://www.energystar.gov/products/spec/energy_star_computer_servers_version_4_0_pd.
- ENERGY STAR, 2025, *Energy Star® Program Requirements for Computers*: https://www.energystar.gov/sites/default/files/2025-01/ENERGY%20STAR%20Computers%20Version%209.0%20Final%20Specification.pdf.
- European Commission, *Roadmap to Fully End EU Dependency on Russian Energy*: https://commission.europa.eu/news-and-media/news/roadmap-fully-end-eu-dependency-russian-energy-2025-05-06_en.
- Herglotz C., et al., *Extended Signaling Methods for Reduced Video Decoder Power Consumption Using Green Metadata*. https://arxiv.org/abs/2310.17346.
- IEA, 2024, *Electricity 2024 Executive Summary*: https://www.iea.org/reports/electricity-2024/executive-summary.
- IEA, 2025, *Energy Demand from AI*: https://iea.blob.core.windows.net/assets/601eaec9-ba91-4623-819b-4ded331ec9e8/EnergyandAI.pdf.
- IEA, 2025, *AI is Set to Drive Surging Electricity Demand from Data Centres While Offering the Potential to Transform How the Energy Sector Works*: https://www.iea.org/news/ai-is-set-to-drive-surging-electricity-demand-from-data-centres-while-offering-the-potential-to-transform-how-the-energy-sector-works.
- ITU, 2021, *Statistics*: https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx.
- Markkanen, Aapo, 2021, *What Is Digital Sustainability and How Does It Drive ESG Goals?* November 04.: https://www.gartner.com/en/articles/what-is-digital-sustainability-and-how-does-it-drive-esg-goals.

- McKinsey & Co. 2024, *Global Energy Perspective 2024*: https://www.mckinsey.com/industries/energy-and-materials/our-insights/global-energy-perspective
- Müller-Kraenner, Sascha, 2007, *Energy Security Re-measuring the World*. London: Earthscan. https://www.taylorfrancis.com/books/mono/10.4324/9781315793238/energy-security-sascha-muller-kraenner.
- Nelson-Miller, 2022, *5 Energy-Saving Tips for LCDs*: https://nelson-miller.com/5-energy-saving-tips-for-lcds/#:~:text=%232)%20Lower%20the%20Brightness,consumption%20by%20up%20to%2020%25.
- Ritchie, Hannah, and Rosado, Pablo, 2020 (updated 2024), *Electricity Mix*: https://ourworldindata.org/electricity-mix.
- Statista, 2025, *Number of internet and social media users worldwide as of February 2025*: https://www.statista.com/statistics/617136/digital-population-worldwide/#:~:text=Worldwide%20digital%20population%202025,population%2C%20were%20social%20media%20users.
- Statista, 2025, *Number of connected devices worldwide as of February 2025, by device*: https://www.statista.com/statistics/1559435/connected-devices-worldwide/#:~:text=As%20of%20February%202025%2C%20short,accounted%20for%204.93%20billion%20connections.
- SustainableIT.org, 2024, *Standards Taxonomy V1.2*: https://www.sustainableit.org/standards/it-esg-standards.
- Ugreen, 2025, *How Much Power Does Your NAS Consume?*: https://nas.ugreen.com/blogs/knowledge/how-much-power-does-your-nas-consume#:.
- United States Energy Information Administration, 2025, *Electricity Monthly Update*: https://www.eia.gov/electricity/monthly/update/end-use.php.
- Washington Post, The, 2025, *Trump is Falling into an Old Energy Trap*: https://www.washingtonpost.com/opinions/2025/08/04/trump-wind-solar-grainbelt-transmission.
- World Bank Group & ITU, 2023, *Measuring the Emissions & Energy Footprint of the ICT Sector: Implications for Climate Action*: https://tinyurl.com/hvndhs9k.

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11

Leveraging Your Buying Power

> *Business cannot be a bystander in the society in which it operates.*
>
> *Paul Polman, Former CEO of Unilever*

This chapter will help you understand the main drivers of sustainable IT vendor management and procurement and its role in the environmental, social, and governance agenda. By leveraging your buying power, you can influence your supply chain of IT vendors to address environmental and social issues and do so openly and consistently.

The main objectives of this chapter are to introduce you to the different facets of sustainable IT vendor management and procurement and how these disciplines can be leveraged to make your supply chain more trustworthy and transparent. We present case studies from Electrolux, BNP Paribas, and Heartprint, along with research findings on best practices from Atea Sustainability Focus. In this chapter, we will cover the following topics:

- Drivers and fundamentals of sustainable IT procurement
- IT procurement programs in action
- Sustainable IT vendor management
- Case studies for influencing and partnering with your vendors, including awards and education programs
- IT vendor management sustainability scorecards and standard metrics

This chapter's sustainable IT reference model perspective, as illustrated in *Figure 11.1*, centers on vendor management, IT procurement, and driving sustainability throughout the technology supply chain. Once again, the targets are energy and emissions, with implications for sustainability reporting. There is also an often-overlooked element of education—in this case, for the procurement team and the vendors themselves.

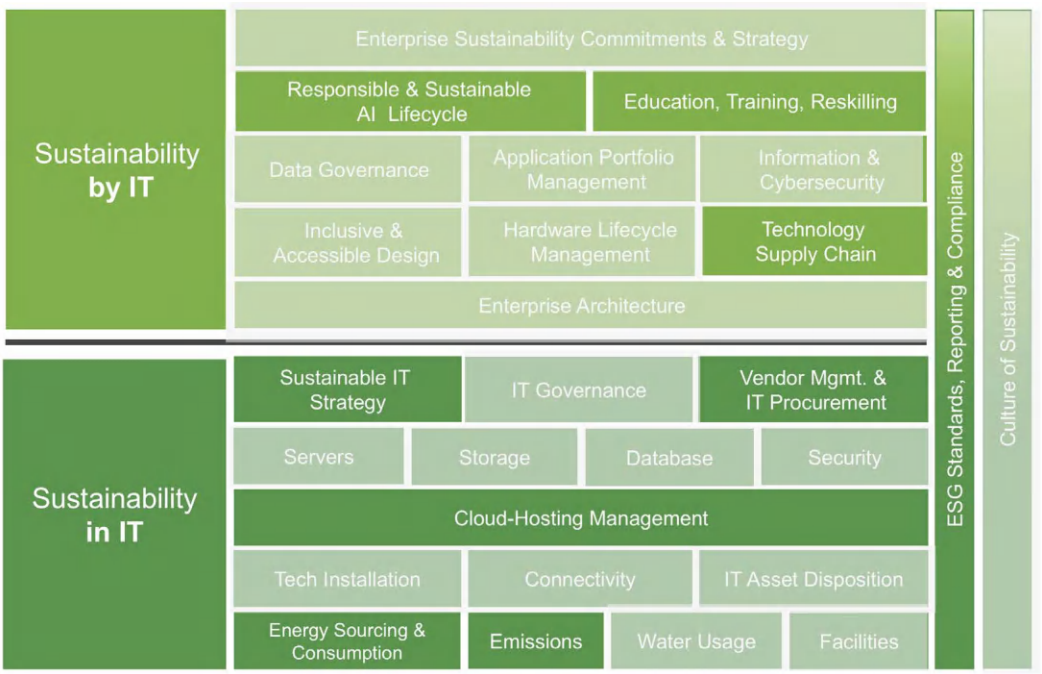


Figure 11.1 – Sustainable IT reference model – Chapter 11 focus

By the end of this chapter, you should have a better understanding of what requirements you should impose on your vendors and how to engage them as sustainability partners.

Secondly, you will see how to look at sustainable IT procurement from start to end, just leveraging three simple steps that can make your IT procurement much more robust and sustainable. Most importantly, you will be introduced to best practices and sustainable IT procurement in action from the perspectives of manufacturing, banking, and more. As usual, you will be presented with a standard set of metrics, this time for sustainable sourcing spanning tech products and services.

Drivers of sustainable IT vendor procurement and management

The IT supply chain is very complex, with multiple delivery networks joined in the final assembly. Before the product reaches the end user, materials travel from mines to smelters, refineries, and subcomponent manufacturers for the final assembly before it is packed and sent for distribution. As a buyer, this poses a lot of risk in your IT supply chain to ensure that suppliers maintain high environmental and social standards connected to the sourced product. Violation of labor laws, such as child labor, extensive overtime, poor and hazardous working conditions, and negative environmental impacts, are a few examples that can introduce significant risk for the buying party that can impact your bottom line, reputation, and brand. Managing these risks poorly and inconsistently may significantly impact your company's relationship with customers, employees, investors, and other key stakeholders.

As a buyer, you must act strategically, mitigate risk, and promote sustainability. By leveraging your buying power, you can influence your supply chain of IT vendors to address environmental and social issues and do so openly and consistently. Unfortunately, **greenwashing** and **bluewashing** are two recurring phenomena, and their recurrence within the IT supply chain is no exception.



Greenwashing versus bluewashing

Greenwashing is the practice of deceptively issuing false or unverified claims by branding something as environmentally friendly when it isn't.

Bluewashing is the practice of deceptively issuing false or unverified claims regarding a company's commitment to responsible social practices when that is not the case.

These terms are often used interchangeably. In the United Kingdom, Canada, and Singapore, legislation has been enacted to prevent companies from carrying out misleading environmental marketing (Lexology 2022).

In this section, you will hear from **Camilla Cederquist**, **Head of Sustainability Programs and Circular Business Development at Atea Sustainability Focus (ASF)**. She will share her latest research on sustainable IT procurement, which shows much room for improvement in focus and consistency of practice. Atea is the largest provider of digital workplace solutions and IT infrastructure in the Nordics. Since 2017, Atea has been driving an initiative called Atea Sustainability Focus, which aims to accelerate the sustainable transformation of the IT industry by using the collective power of Nordic IT buyers. (We will revisit ASF later, in the chapter section on best practices.):

> When ASF was launched in 2017, social issues dominated the agenda, which was quite natural given the industry's complex, global supply chains. Since then, however, buyers in Europe have shifted focus toward climate and circularity, whereas in the US and Canada, social issues are still the key focus. This means sustainability in IT procurement is no longer a question solely for the purchasing department. Increasing product lifespan, for example, must involve both the IT department and the users.
>
> These are just some of Atea's findings. They focus on small IT products for office use and circularity and environmental sustainability since this has been top of mind for the Nordic market in the past couple of years.
>
> **IT procurement today**
>
> Within ASF, we conduct a yearly survey where Nordic (Denmark, Finland, Norway, and Sweden) IT buying organizations communicate their priorities and headaches around sustainable IT. In the latest survey, 824 professionals within IT, sustainability, and procurement responded from primarily large organizations with more than 500 employees, and roughly an even split between the public and private sectors. In 2024, we also conducted an analysis of public tender requests with a business value of at least 1 million EUR.
>
> We see that there is room for improvement regarding how sustainability is incorporated into purchasing practices. Even though the majority claim that sustainability influences their purchasing decisions (85% claim it has a partial or major influence), many organizations do not specify any sustainability requirements for suppliers, and there seems to be a notable gap between theory and practice. The procurement analysis showed that while there are major front runners – such as one public organization putting a 60% weight on sustainability in their purchasing decisions, 44% relied solely on price.

The main challenges that have remained on top during all the years that we have conducted the survey are as follows:

- It is challenging to measure to what extent their vendor requirements or purchasing practices have the desired effect on sustainability
- It is challenging to obtain information about and compare the sustainability performance of different solutions
- There's a lack of time and resources to follow up on the sustainability requirements (e.g., verification of provider claims, addressing exceptions, revisions, or adjustments to align with changing policy or regulations)

From this, we can conclude that IT buyers need more support and feedback from the industry regarding comparability and effects, and that purchasing and follow-up processes need to become more efficient. Next, we will offer some advice on how that can be done.

Camilla Cederquist, Head of Sustainability Programs and Circular Business Development, ASF

The next section will examine the fundamentals of a sustainable IT procurement process and the essential IT sustainability requirements you can leverage in your procurement processes.

Fundamentals of sustainable IT procurement

As we saw in the previous section, managing your vendors and the IT procurement process poorly can introduce significant risk into your IT supply chain. Therefore, it is critical to make a step-change to include *essential* IT sustainability requirements. It is also imperative that your IT procurement practices align with overall company sustainability commitments. You should also prioritize which IT categories will have the most significant ESG and cost impacts. This may seem overwhelming initially, especially if you start from a blank sheet of paper.

In some large organizations, technology procurement is handled centrally and is not controlled by the IT function. In these situations, IT may need to influence the procurement team by raising awareness and providing guidance. Consider sharing with your procurement peers the section titled *Fundamentals of sustainable IT procurement*. Do not assume that the procurement team is applying enterprise sustainability requirements to tech purchases. In many cases, we have seen central procurement being slow or resistant to changing traditional price-centric requirements and decision processes.

Fortunately, there are plenty of resources and a wealth of experience to draw from, and simply introducing sustainability certifications from credible ecolabels for IT equipment, such as **EPEAT**, **TCO Certified**, and **ENERGY STAR**, will put you in a significantly better position toward a sustainable IT practice.



Sustainability certifications

The most common ecolabels for IT equipment are as follows:

EPEAT

EPEAT is a global Type 1 certification. To be considered EPEAT, registered products must meet specific required and optional criteria. They are evaluated against three levels of environmental performance – Bronze, Silver, and Gold. A product needs to be EPEAT registered in the country of sale. Criteria areas include product longevity, materials selection, design for circularity, supply chain greenhouse gas emissions reduction, end-of-life management, energy conservation, and corporate performance.

TCO Certified

TCO Certified is a Nordic Type 1 certification. It is a world-leading organization that provides sustainability certifications for IT products. It is an independent verification organization that provides a wide-ranging system of criteria, and it provides a framework for IT hardware vendors to certify their products with a TCO Certified quality label. Criteria areas include social and environmentally responsible manufacturing, circularity, and hazardous substances.

ENERGY STAR

ENERGY STAR is a US certification focused on energy efficiency. It uses 25% to 40% less energy than conventional models by using the most efficient components and manages energy use better when idle. Labeled equipment is third-party certified to be energy efficient. Equipment with Type 1 certifications also meets the criteria in ENERGY STAR.

Let us take a closer look at what essential IT sustainability requirements could be considered part of your IT procurement and vendor management practice. We have outlined five key categories: **corporate commitment**, **environmental**, **social**, **product and service**, and **circularity**. *Figure 11.2* provides primary requirements for vendors under each of category of sustainability.

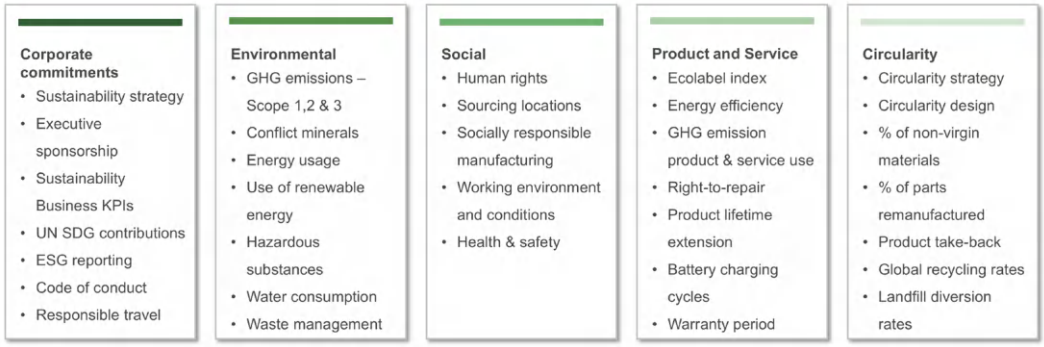


Figure 11.2 – Key IT sustainability requirements

Let us look at each of the five key areas in more detail.

Corporate commitments

When looking to engage with a vendor, it is essential to understand their corporate commitments to ESG. The following are some essential requirements you should consider from a corporate commitment perspective:

- What is your overall sustainability strategy?
- Describe your corporate governance and executive sponsorship for ESG.
- Do you have any sustainability business KPIs?
- Describe your contribution to the United Nations **Sustainable Development Goals (SDGs)**.
- What overall commitments have been made – that is, **Science-Based Target Initiative (SBTi)**, exponential roadmap, and so on?
- What ESG reporting do you do – that is, sustainability report, **carbon disclosure project (CDP)**, or something else?

- What areas does your code of conduct address – that is, antitrust, anti-corruption, boycotts, social, environmental, business practices, and ethics? Would your vendor be willing to sign your code of conduct? If they refuse to sign your code of conduct, will you take assertive action to exit the relationship?
- What is your policy on responsible business travel?
- Can sustainability KPIs be factored into compensation packages and **Management by Objectives** (**MBO**) for all employees?

Environmental

This involves being a responsible company that focuses on minimizing the environmental impact on the planet. The following are some essential requirements you should consider from an environmental perspective:

- Reducing your indirect greenhouse gas emissions (Scope 3) should arguably be your most important IT sustainability objective to pursue. Therefore, it is critical to understand your vendor's environmental impact from both an operational and a product and service perspective. You should understand how well your vendor commitments align with your sustainability commitments. How well do they deliver on their environmental commitments? Are they lagging or surpassing?
- Greenhouse gas emissions – Scopes 1, 2, and 3.
- The use of conflict minerals (mined in conflict-ridden areas, with profits often used to fund armed groups and perpetrate human rights abuses). These can include tantalum, tin, tungsten, gold, and cobalt.
- Energy usage.
- The use of renewable energy/share of renewable energy.
- The use of hazardous substances in products and manufacturing.
- Water consumption.
- Waste management in the supply chain and manufacturing.

Social

Being a purpose-led and socially responsible company is no longer optional. It is expected, and you should place exact expectations on your vendor ecosystem. Putting rigorous requirements on your vendors regarding human rights, working environments, working conditions, health, and safety can bring about a change and make a significant social impact. This also ensures that your suppliers require similar behavior from their providers. Here are some essential requirements you should consider from a social perspective:

- Human rights, adherence to the **International Labour Organization's (ILO's)** eight fundamental conventions
- Human rights, adherence to the **United Nations** Convention on the Rights of the Child
- Socially responsible manufacturing
- Working environment and conditions – that is, adherence to labor law legislation, working hours, ergonomic and safe working conditions, evacuation routes, use of hazardous substances, and so on
- Health and safety protocols, workforce injury, casualties, illness rates, and so on
- Correct and transparent diversity, equity, and inclusion practices are also key
- For software providers, creating unbiased software is also critical

Product and service

In a fast-paced industry such as **Information and Communications Technology (ICT)**, unfortunately, it has become the norm to run through IT equipment well before it has reached its end of life in favor of a new, shinier model, just released on the market, that is more efficient and faster, with newer capabilities. Balancing different priorities such as technical specifications, employee experience, cost, and IT sustainability from different stakeholders adds complexity to the equation.

As mentioned in *Chapter 9*, *IT Hardware Management*, GHG emissions and e-waste have become major inhibitors in our net-zero race. As roughly 80% of GHG emissions are already consumed before they reach an end user, we must ensure extended product longevity. The following are some essential requirements you should consider from a product and service perspective:

- Demand Tier 1 eco-labeled and energy-efficient products
- GHG emissions from product and service use
- Right-to-repair
- Product lifetime extension – the ability to replace batteries, memory, hard drives, and so on
- TCO Certified Accepted Substance List
- Warranty period
- Battery charging cycles
- Access to spare parts
- Ability to buy refurbished products
- End-of-life management

Sustainable IT requirements for products and services can become lengthy and require in-depth knowledge to place adequate and just requirements on your vendor. Fortunately, governing bodies such as EPEAT, TCO Certified, and ENERGY STAR can assist you on your journey toward sustainable IT procurement. This enables you to shift the heavy lifting from your procurement organization to the vendor to provide proof of compliance for a specific product within a product category.

Instead of putting forth detailed requirements to your vendors, you can demand an ENERGY STAR rating and TCO certification for a specific product category, such as computers, monitors, tablets, and smartphones. It would help if you asked for proof of compliance of your existing IT equipment and when new products are released into a specific category. This allows you to verify, audit, and compare your vendor's ICT equipment.

Circularity

As we learned in *Chapter 9*, *IT Hardware Management*, only 22.3% of the world's total e-waste was formally collected and recycled in 2022, and global e-waste reached 62 million tonnes in 2024 (Global E-waste Monitor 2024). More broadly, the percentage of circular materials versus virgin materials in use in our economy today is even lower: Only 6.9% of total material consumption is recycled or reused material (Circularity Gap Report 2025).

Of that small percentage of recycled materials, electronic devices constitute less than 2.6% of the total, despite being today's fastest-growing waste stream (*Figure 11.3*). Clearly, there is an untapped opportunity for IT to contribute exponentially to the circular economy.

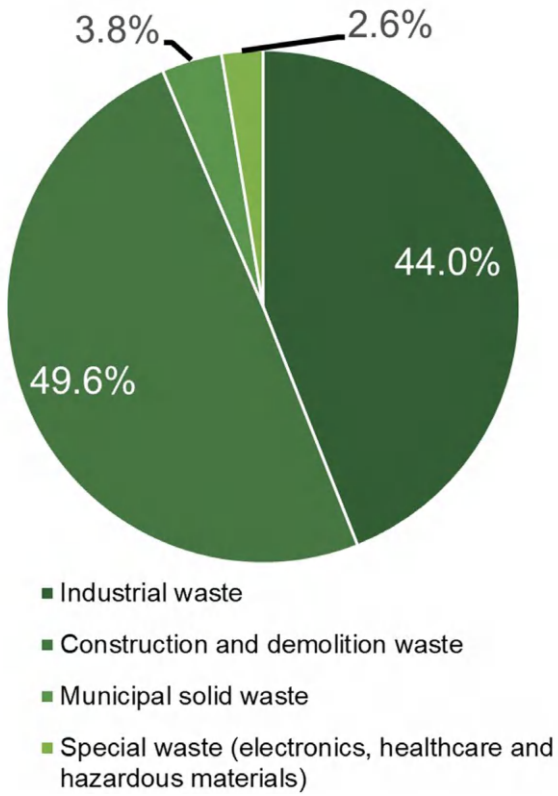


Figure 11.3 – Composition of circular economy materials

To drive the shift from a linear to a circular economy, we need to leverage our buying power to put more demanding circularity requirements on our vendors.

Here are some essential requirements you should consider from a circularity perspective:

- What is the company's overall circularity strategy? Is it applying a specific framework, such as the **Ellen McArthur Foundation** (**EMF**) framework?
- How can the vendor assist with IT asset lifecycle planning?
- Circularity design (design out waste): How is waste designed into the product?
- % of non-virgin materials: How much non-virgin material is used in the product?
- % of parts remanufactured: What parts have been extracted and reentered in the manufacturing process?
- Product take-back – that is, what commitments does the vendor give to take back old equipment? What partners do they work with for **IT Asset Disposition** (**ITAD**)? What is the locality of these ITAD partners?
- Secure removal of information: What processes and procedures are in place to remove information securely before the IT equipment can be refurbished, repurposed, or recycled?
- Water sourcing: Is the vendor applying innovative water sourcing strategies to preserve water?
- Global recycling rates: What are the global recycling rates?
- Landfill diversion rates: How much waste is diverted from landfills?

The process

> *"It is not about what you buy. It is about if and how."*
>
> *Anonymous*

The procurement process often focuses on product requirements and responsible manufacturing. A lot can – and needs to – be done before we get to this stage. The most sustainable product is the one you already have – or never purchased.

Numerous standards and frameworks guide more sustainable IT procurement. In *Chapter 9*, *IT Hardware Management*, you were introduced to the *9R framework*. We will revisit the framework and add IT procurement requirements to each step. Instead of focusing on buying the most sustainable product, ask yourself, do we need to buy anything at all? Can we circulate equipment internally instead? Do we need to buy new equipment? Do we have to buy it, or can we rent it? After all, it is not the product itself we need; it is the functionality it provides.

Figure 11.4 illustrates a three-step process with procurement guidelines for more sustainable IT procurement you can implement to become more resource efficient:



Figure 11.4 – Sustainable IT procurement – a three-step process

Need for product – remove and reduce (need)

- Can we increase the contract's length?
- Can internal assets be circulated (repaired or upgraded)?
- Can we remove/reduce the need for certain products, such as peripherals or docking stations?

Purchase is required – reuse and recover

- Consider as a service (optimized product supply and closed loop)?
- Buy refurbished products
- Close the loop (make sure the product is recovered already at the point of purchase)

Purchase of a new product is required – reduce (harm) and recover

- Consider as a service (optimized product supply and closed loop)?
- Buy eco-labeled and "high spec"
- Close the loop (product is recovered after use)
- Include extra warranty
- Buy repairable products

Enable yourself to make fully informed decisions. Know the lifecycle cost of the technology you buy. Use a tool for calculating the total cost of ownership to identify the best solution for your organization from a sustainability and financial perspective. For example, although it may cost more at the point of purchase, would it be more efficient to buy more high-spec devices with longer lifespans that can be circulated internally and entail a higher residual value? What would it mean to your TCO if you bought refurbished devices? Challenge your suppliers! Communicate your ambitions and struggles, and let them come to you with the solutions.

Take inspiration from the Dutch **Sustainable Public Procurement** (**SPP**) criteria tool (`https://www.mvicriteria.nl/en`). Launched in 2017, it requires suppliers to describe how the contract at hand will contribute to a circular economy. Better plans are rated more highly.

The UK government has another framework that can inform your evaluations: the **Greening Government ICT and Digital Services Strategy**. It includes a 12-point **Technology Code of Practice** to increase sustainability throughout the lifecycle of technology: `https://www.gov.uk/government/publications/greening-government-ict-and-digital-services-strategy-2020-2025`.

When you finally reach the purchasing stage, you should be assured that you are purchasing the most sustainable products from the most responsible suppliers. By doing just three (relatively simple) things, you can build a sustainable base for your IT procurement without having to be a sustainability expert or allocate a lot of resources to formulate, verify, and follow up on requirements. This easy-to-implement list of actions is part of Atea's Guide to Sustainable Procurement of IT:

1. Choose suppliers that are members of the **Responsible Business Alliance** (**RBA**): The RBA is the world's largest industry coalition on sustainability that gathers all major IT brands as well as several of their sub-suppliers. Full and regular RBA members are committed to following a shared code of conduct, regularly conducting third-party audits in their supply chain, and actively contributing to correcting any deviations.
2. Buy eco-labeled equipment: Type 1 ecolabels set comprehensive sustainability requirements throughout the product lifecycle that are verified by a third party. Therefore, you do not need to have expertise within these areas or allocate resources for a follow-up.
3. Include take-back clauses in agreements: Is end-of-life (or rather end-of-use) a purchasing matter? Indeed it is! Build a 1:1 relationship with your devices by requiring the supplier to take back sold products. Even though you may have separate suppliers for the supply and take back, make sure you have a plan for the product's end-of-use phase when it is purchased. In *Chapter 9*, *IT Hardware Management*, in the *IT asset disposition* section, we covered how to give end-of-use products a second life.

Now that we have looked at the fundamentals of sustainable IT procurement, we will explore two case examples of sustainable tech procurement programs – the first one at Electrolux, a leading global appliance manufacturer headquartered in Stockholm, and the second at BNP Paribas, the international bank headquartered in Paris.

Sustainable procurement programs in action

Electrolux has long been recognized as a leader in sustainable business practices, including a 2024 SustainableIT Impact Award and a 2025 honorable mention for Responsible AI Impact. This case study is based on interviews conducted with **JP Iversen, Group CIO, Electrolux and Fredrik Gemzell, IT Sourcing and Solutions Procurement Director (SustainableIT.org 2024)**.

Case study: Electrolux sustainable tech procurement program

In 2018, the company extended its sustainability commitments into IT procurement, developing a dedicated framework to align hardware, cloud, and software sourcing with corporate ESG goals.

"*We might be a small player in the global landscape, but in the context of our industry, we are big enough to drive change*," said Iversen.

Challenge

As Electrolux sought to translate its enterprise-wide sustainability objectives into IT operations, the company faced two pressing challenges. First, there was limited supplier transparency. Cloud service providers initially resisted sharing client-specific consumption data, offering only general energy reports. Second, there was a lack of precedent. In 2017–2018, few models existed for applying measurable sustainability KPIs to IT procurement, particularly beyond hardware.

"Five or six years ago, cloud companies weren't able—or perhaps willing—to provide detailed consumption data specific to Electrolux," recalled **Gemzell**.

Solution

Electrolux formally integrated sustainability into IT procurement in 2018, beginning with hardware criteria focused on energy consumption and material usage. Over time, the framework expanded to cover cloud services, software, and SaaS.

- **Tailored KPIs**: Measurements specific to hardware, software, and cloud services were devised to reflect different sustainability concerns. For example, mineral sourcing is specific to hardware procurement.

- **Vendor obligations**: Sustainability reporting became a contractual requirement, with suppliers asked to provide quarterly metrics such as PUE, renewable energy percentage, and carbon intensity (kg CO_2/kWh). See *Tables 11.1* and *11.2*.
- **Flexibility with enforcement**: Vendors were not disqualified solely for non-compliance but were given up to 12–18 months to meet new requirements.
- **Alignment with global standards**: Reporting through platforms such as the **Carbon Disclosure Project (CDP)**.

Results

Electrolux's framework delivered measurable benefits:

- **Improved transparency**: Today, cloud providers routinely supply client-specific sustainability reports, marking a major shift from 2018 practices
- **Operational reductions**: Internal IT facilities, including data centers, have seen significant reductions in energy and water consumption, creating both environmental and financial gains
- **Cultural shift**: Sustainability is now a "business-as-usual" approach within IT and a non-negotiable expectation in supplier relationships

"As long as supplier reports cover the key areas we care about—like energy consumption and renewable energy usage—we are generally flexible. But sustainability remains a critical hygiene factor for us when evaluating vendors," noted Gemzell.

Lessons learned

- **Start small and build**: Electrolux began with hardware before expanding to the cloud and software
- **Make sustainability non-negotiable**: Supplier relationships improved once expectations were clear and consistent
- **Focus on awareness**: Internal alignment with corporate sustainability goals minimized resistance and accelerated adoption

Electrolux's IT procurement sustainability framework has become a benchmark for responsible sourcing, proving that even functions with a relatively small operational footprint can lead to enterprise-wide change. By embedding sustainability into contracts, reporting, and culture, Electrolux demonstrates how IT can drive both environmental progress and business value.

The following are excerpts of the sustainability requirements included in Electrolux's Master Services Agreement, first for hardware suppliers, and second for cloud and hosting services.

Part 1: Electrolux's IT Sustainability Framework — hardware suppliers

Expectations on IT suppliers (*Table 11.1* lists the relevant pillars of Electrolux's sustainability program, the goals that apply to ICT vendors, and the associated conditions that the vendors must meet):

Pillars	**Electrolux sustainability goals relevant for suppliers**	Expectations on IT suppliers
Better company	**Lead in energy and resource-efficient solutions** Electrolux will continuously improve the energy and water performance of our appliances, raising the bar for product efficiency around the world.	Suppliers will be selected based on the energy and resource efficiency of the products and services provided to us, and this will be monitored. We require relevant specifications and reports to monitor our IT environmental footprint on a quarterly basis.
	Offer circular products and business solutions We will contribute to the circular economy by integrating recycled materials into our product platforms, promoting recyclability, using more sustainable packaging solutions, increasing the availability of spare parts to repair our products, and developing circular business solutions. Where possible, replace virgin materials with recycled materials in our products. Increase the share of recycled plastic to 50%. Increase the amount of scrap-based steel in our production. Identify and evaluate relevant circular business models that can be scaled up.	We expect you to contribute to the circular economy by making optimal use of resources, use more recycled materials, and promote recyclability. We will give preference to the supplier that can prove recycled materials are used in products which are also easily repairable and have sustainable packaging. We expect you to give a second life to the IT equipment that we lease from you to avoid e-waste. Please share information about your methods for re-use and/ or remanufacturing activities. For equipment that cannot be remanufactured or resold, please prove good end-of-life treatment.

Pillars	**Electrolux sustainability goals relevant for suppliers**	Expectations on IT suppliers
Better company	**Eliminate harmful materials** Electrolux will protect people and the environment by managing chemicals carefully and continuing to replace those that cause concern.	Our suppliers must comply at all times with our list of restricted materials (RML), available at `https://www.electroluxgroup.com/en/workplace-policy-and-supplier-workplace-standard-562/`
Better solutions	**Be climate neutral and drive clean and resource-efficient operations** Electrolux will continue to reduce its environmental footprint by shifting to renewables and optimizing the use of energy and other resources throughout its operations. We aim to have climate neutral operations by 2030.	We expect that your operations and/or services delivered to us are energy- and resource-efficient and that you strive to make a shift toward renewables.
	Act ethically, lead in diversity and respect human rights We will earn the trust of everyone impacted by our operations, demonstrating our commitment to ethics, diversity and human rights through our words and actions. This includes working to ensure the health and safety of our employees and promoting societal benefit through community investment activities.	You are required to comply with the Electrolux Supplier Workplace Standard and the Electrolux Workplace Directive

Pillars	**Electrolux sustainability goals relevant for suppliers**	Expectations on IT suppliers
Better solutions	**Drive supply chain sustainability** Electrolux will take its sustainability leadership agenda into the supply chain. We will work with suppliers so they can live up to our high expectations, no matter where they are located, and we will drive and support the transition to more sustainable practices.	We expect you to monitor the climate impact of your supply chain and work to shift to more sustainable transportation modes such as ocean and rail. CDP is a not-for-profit charity that runs the global disclosure system for `investors`, `companies`, `cities`, `states` and `regions` to manage their environmental impacts. Electrolux is disclosing its CO_2 emission according to CDP. If requested by Electrolux, supplier shall make a disclosure in accordance with CDP. We expect that the services supplied to Electrolux do not directly or indirectly contribute to human right abuses in conflict-affected and high-risk areas. If requested by Electrolux, you are required to provide information about sourcing of conflict minerals to show how you fulfill your obligations in this area. It is your responsibility as supplier to ensure that your subcontractors and other third-party suppliers comply with these requirements.

Table 11.1 – Electrolux's sustainability expectations for hardware suppliers

IT sustainability requirements for hardware provided to Electrolux

For all IT equipment used in our business, we continuously strive to improve the energy and resource efficiency. The product we procure must comply with the Electrolux **Restricted material list**. We give preference to products where proof can be provided, which demonstrates:

- TCO Certified (where certification is available)
- Low energy usage

- Optimal use of resources and recycled materials
- Design that facilitates repair and recycling
- A second life to reduce e-Waste (with certificates demonstrating ISO management systems and information security standards)
- Recycling of material
- Carbon and material offsetting
- Eco Declaration ECMA per product

Selection criteria and reporting required for hardware

The following criteria need to be evaluated and reported on for the relevant product types in order to make sure they are in line with the Electrolux IT targets. The Supplier shall submit a report for each product in the RFP phase, and upon each product replacement during the life term of the contract. Each product, and any replacement product, must fulfil the below minimum requirements:

List of product types, criteria, and reporting measures (*Table 11.2* provides the specifics for the data Electrolux requires from vendors. The metrics are based on global standards, so most hardware vendors should be able to supply them.)

Electrolux Reference	Product type	Criteria measure	Units	Requirements	Reporting measure
1HW	Desktop/ Laptop/ tablets/ 2 in l	Annual energy consumption (ETEC, TEC or ENERGY STAR)	kWh/ year	Actual value to be provided. Actual value must be lower than the value of the existing models in use at Electrolux, as set forth by Electrolux.	Annual energy consumption (ETEC, TEC or ENERGY STAR) per model
2HW		Long idle mode	Watt		Long idle mode
3HW		Short idle mode	Watt		Short idle mode
4HW		Weight	Kg		Weight
5HW		TCO certification*	Yes/ No*	Yes	TCO certification

Electrolux Reference	Product type	Criteria measure	Units	Requirements	Reporting measure
6HW	Printer	Energy consumption (TEC, ETEC)	kWh/ week kWh/ year	Actual value to be provided. The value must be lower than existing models in use at Electrolux, as set forth by Electrolux.	Weekly or annual energy consumption (TEC) per model
7HW		Weight	Kg		Weight
8HW	Monitor	Energy consumption (TEC, ETEC)	kWh/ week kWh/ year	Actual value to be provided. The value must be lower than the value of the existing models in use at Electrolux as set forth by Electrolux.	Weekly or Annual energy consumption (TEC) per model
9HW		Idle mode	Watt		Weekly or Annual energy consumption (TEC) per model Idle mode monitor
10HW		Weight	Kg		Weight
11HW		TCO certification*	Yes/ No*	Yes	TCO certification
12HW	Network equipment	Annual energy consumption or similar should be provided.	kWh/ year		Annual energy consumption
13HW		Weight	Kg		Weight

Electrolux Reference	Product type	Criteria measure	Units	Requirements	Reporting measure
14HW	Servers and other equipment's	Annual energy consumption or similar should be provided.	kWh/ year		Annual energy consumption
15HW		Weight	Kg		Weigh
16HW		TCO certification*	Yes/ No*	Yes (valid if TCO certification is available for the equipment type)	TCO certification

* *If TCO certification is not granted for the model. Please provide a plan on when the TCO certification will be obtained.*

Table 11.2 – Electrolux's hardware supplier reporting guidance

Information to be provided by Electrolux

The following information shall be provided:

- Description of end-of-life procedures and actions on return of used products
- Provide information according to **Conflict Mineral template** (**CMRT**) if requested by Electrolux (*the template is provided by the Responsible Minerals Initiative and is free to download at* `https://www.responsiblemineralsinitiative.org/reporting-templates/cmrt/`)
- Details of any carbon and material offsetting

Per product model (where it exists):

- ECMA - Eco declaration
- TCO certification

Report routines

Below are examples (with fictive figures) of the data to be provided per product type [*Tables 11.3–11.6*].

Desktop/Laptop/tablets/2 in l

Model	**Product type**	**1HW** **Annual energy consumption kWh/year**	**2HW** **Long idle mode**	**3HW** **Short idle mode**	**4HW** **Weight Kg**	**5HW** **TCO certification**
Model name	Desktop	50	50	30	1.7	Yes
Model name	Laptop	15	13	10	0.7	Yes

Table 11.3 – Desktop/laptop reporting examples

Printer

Model	**Product type**	**6HW** **Annual energy consumption kWh/year**	**7HW** **Weight Kg**
Model name	Printer	50	50

Table 11.4 – Printer reporting example

Monitor

Model	**Product type**	**8HW** **Annual energy consumption kWh/year**	**9HW** **Idle mode**	**10HW** **Weight**	**11HW** **TCO certification**
Model name	Monitor	30	12	1.2	Yes

Table 11.5 – Monitor reporting example

Network equipment, servers, and other equipment

Model	**Product type**	**12HW/14HW** **Annual energy consumption kWh/year**	**13HW/15HW** **Weight**	**16HW** **TCO certification**
Model name	Network equipment/ other equipment	100	0.7	Yes

Table 11.6 – Network equipment reporting example

Part 2: Electrolux's IT Sustainability Framework – cloud and hosting services

Expectations on IT Suppliers (*Table 11.5* summarizes our sustainability work and the expectations on our IT suppliers. We will evaluate our IT suppliers from a sustainability perspective, both during the RFP phase and during the life term of the contract and expect our suppliers to comply with our expectations.)

Pillars	**Electrolux sustainability goals relevant for suppliers**	**Expectations on IT suppliers**
Better company	Be climate neutral and drive clean and resource-efficient operations Electrolux will continue to reduce its environmental footprint by shifting to renewables and optimizing the use of energy and other resources throughout its operations. We aim to have climate neutral operations by 2030.	We expect that your operations and/or services delivered to us are energy- and resource-efficient and that you strive to make a shift toward renewables.
	Act ethically, lead in diversity, and respect human rights We will earn the trust of everyone impacted by our operations, demonstrating our commitment to ethics, diversity and human rights through our words and actions. This includes working to ensure the health and safety of our employees and promoting societal benefit through community investment activities.	You are required to comply with the Electrolux Supplier Workplace Standard and the Electrolux Workplace Directions.

Pillars	Electrolux sustainability goals relevant for suppliers	Expectations on IT suppliers
Better company	Drive supply chain sustainability Electrolux will take its sustainability leadership agenda into the supply chain. We will work with suppliers so they can live up to our high expectations, no matter where they are located, and we will drive and support the transition to more sustainable practices.	We expect you to monitor the climate impact of your supply chain, and work to shift to more sustainable transportation modes such as ocean and roil. CDP is a not-for-profit charity that runs the global disclosure system for investors, companies, cities, states and regions to manage their environmental impacts. Electrolux is disclosing its CO_2 emission environmental impacts. Electrolux is disclosing its CO_2 emission disclosure in accordance with CDP. We expect that the services supplied to Electrolux do not directly or indirectly contribute to human right abuses in conflict-affected and high-risk areas. If requested by Electrolux, you are required to provide information about sourcing of conflict minerals to show how you fulfill your obligations in this area. It is your responsibility as supplier to ensure that your subcontractors and other third-party suppliers comply with these requirements.
Better solutions	Lead in energy and resource-efficient solutions Electrolux will continuously improve the energy and water performance of our appliances, raising the bar for product efficiency around the world.	Suppliers will be selected based upon the energy and resource efficiency of the products and services provided to us, and this will be monitored. We require relevant specifications and reports to monitor our IT environmental footprint on a quarterly basis.

Pillars	Electrolux sustainability goals relevant for suppliers	Expectations on IT suppliers
Better solutions	Offer circular products and business solutions We will contribute to the circular economy by integrating recycled materials into our product platforms, promoting recyclability, using more sustainable packaging solutions, increasing the availability of spore ports to repair our products, and developing circular business solutions.	We expect you to contribute to the circular economy by making optimal use of resources, use more recycled materials and promote recycling. We expect you to give a second life or good end-of-life treatment to the IT equipment you use in delivering the services to Electrolux to avoid e-waste.

Table 11.7 - Electrolux's sustainability expectations for cloud and hosting providers

IT sustainability reporting requirements for cloud and hosting services provided to Electrolux

We are reducing our footprint by running efficient operations all around the world. We continue to reduce our environmental footprint by optimizing the use of energy and other resources throughout our operations and shifting to renewables.

For any supplier of cloud or hosting services (including co-location) from own or a third-party hosting infrastructure. The following measurements shall be provided to Electrolux on a quarterly basis or on the agreed time horizon if different.

**Please provide details for 2CS& 3CS or 4CS below*

Electrolux Reference	Measurement	Description	Units
1CS	Power usage effectiveness (PUE)	PUE = Total facility power or energy IT equipment power or energy as an annual average of latest year. Please include future improvement targets if they exist.	E.g., 1.52

Electrolux Reference	Measurement	Description	Units
2CS	Measured, calculated or estimated energy consumption for the Electrolux service	Electrolux service share of the data center's energy consumption in kWh per reporting period. A description of how this is measured, calculated or estimated must be included.	kWh
3CS	Average emission factor for electricity (Provided by the electricity provider)	Average emission factor in kg CO_2 per kWh used electricity. Include reference of the source of the factor.	Kg CO_2 per kWh
4CS Mandatory if there is no data provided for 2CS and 3CS	Measured, calculated or estimated CO_2 consumption for the Electrolux service	Electrolux service share of the data center's CO_2 emission consumption in tCO_2 per reporting period. A description of how this is measured, calculated or estimated must be included.	tCO_2
5CS	Renewable energy % (according to REl00 criteria)	Renewable energy percentage = Total renewable energy/total energy on energy bill for the data center. The source of any non-renewable energy.	E.g., 5%
6CS	Carbon offsetting (Through REC, GOO, I-REC or project-based)	Details of carbon offsetting made for the specific service.	Percentage by total electricity and energy used by Electrolux
7CS	Location of data center	City and/or country of the service	E.g., Dublin, Ireland

Table 11.8 – Electrolux's cloud and hosting provider reporting guidance

Report routines

The reports shall be submitted to ITSustainability@electrolux.com. The report shall be submitted before the 10th working day in the first month after the respective calendar quarter. Below is a fictive example of the type of report to be provided to Electrolux.

Name of service	**Year**	**Q**	**PUE (Ref 1CS)**	**Electrolux share (Ref 2CS)**	**Average emission factor for electricity (Ref 3CS)**	**CO_2 (Ref 4CS)**	**Renewable electricity (Ref 5CS)**	**Carbon offset (Ref 6CS)**	**Location of data center (Ref 7CS)**
Application/ service name	2025	Q1	1.52	1,000 kWh	0.550	1 tonne	5%	50%	Dublin, Ireland

Table 11.9 – Cloud reporting example

For the areas defined, the optimal situation is:

- PUE: To have a PUE as low as possible close to 1.
- Renewable electricity 100% is optimal.

Electrolux will be updating the master services agreement to cover AI systems procurement. You should also be considering AI-specific factors to emphasize in your sourcing requirements.

In the next part of this section, **Bernard Gavgani, former Global Chief Information Officer of BNP Paribas**, shares details on the bank's effort to rate its suppliers on corporate social responsibility and the company's first steps in quantifying AI's environmental footprint impact. Bernard is a former Group CIO for the Paris-based bank and is now a senior advisor to the group's general management.

Case study: BNP Paribas' responsible AI tech procurement

Because the deployment of **Corporate Social Responsibility** (**CSR**) and risk management with suppliers are major issues for BNP Paribas, we are moving from risk management related to ESG criteria to monitoring CSR performance.

Thus, the function, which has already enabled BNP Paribas S.A. to be awarded the "Responsible Supplier Relations and Procurement" label by the State in April 2021, partnered in March 2024 with EcoVadis, a globally recognized CSR rating company.

Our objective? To invite the group's suppliers to be evaluated on environmental, social, and ethical criteria in order to receive detailed information on their CSR strategy. At the end of this process, we will form corrective action plans to improve their impact.

Beyond the initiative with EcoVadis, our commitments are concretely reflected in both the strengthening of requirements for suppliers and the awareness-raising of the entire ecosystem, including partners and employees.

We reinforce the CSR criteria with suppliers:

- The weight of CSR criteria in the selection of the group's suppliers in tenders has been tripled to 15%.
- We will systematically analyze supplier profiles with EcoVadis to improve the standardization of CSR evaluations for all our partners.
- The 1,000 most important suppliers (in terms of spending) of the group must be engaged in reducing their carbon footprint by 2025 and have a CSR evaluation. Additionally, we will implement specific close monitoring for those with a score below 60/100.

We are also raising awareness through training of internal and external stakeholders. This includes regular communication actions aimed at partners. We also designed special training sessions for our buyers. We will train buyers in "responsible procurement" and also offer awareness sessions on **Integration through Economic Activity (IAE)**, a social and professional integration policy for people facing barriers to employment.

Another awareness session focuses on **Protected and Adapted Work Sector (STPA)** companies to amplify the group's inclusive purchasing. BNP Paribas IT Group is fully committed to achieving this objective while selecting AI vendors/providers. For example, among nine suppliers referenced by our Group Purchasing entity, the IT group includes four STPA companies in its Preferred List Suppliers for T&M and Fixed Price IT services. As soon as an expressed need can be met by one of these companies, it is to be included in the requests for proposal.

Quantifying AI's footprint

BNP Paribas has started estimating the impact of AI on its footprint. We did an initial estimation on AI-dedicated equipment, services procured from Microsoft (including Copilot and Azure OpenAI), and our 1,000 employees dedicated to AI development. For the year 2024, the CO_2 impact was estimated to be 180 tCO_2e for manufacturing and 1,852 tCO_2e for usage. In 2025, these figures are projected to be 120 tCO_2e and 2,364 tCO_2e, respectively.

> Electricity consumption encompasses servers equipped with GPUs dedicated to AI. For the year 2024, the electricity consumption was estimated to be 1.5 GWh (gigawatt hours), representing 0.2% of the total electricity consumption of BNP Paribas. Projections for 2025 indicate an increase in consumption to 2.5 GWh. The usage of AI outside of the internal data centers of the group is not taken into account in this calculation. Scope 3 impacts related to the production phase of the servers/GPU should also be taken into account while calculating the global emissions, but not included in the above estimations.
>
> It is important to note that this estimation will need to be supplemented by consequential impacts, including those from network infrastructure, application servers, and other related components.
>
> *Bernard Gavgani, Senior Advisor and former Global Chief Information Officer, BNP Paribas*

The examples of Electrolux and BNP Paribas show there is nothing more powerful than using your business muscle to drive change. In our dialogs with the IT industry, we hear that customer demands are the primary catalyst for change. As BNP Paribas has done, you can require your vendors to enroll in third-party evaluation programs such as EcoVadis, which will bring greater standardization to vendor sustainability ratings, facilitating your head-to-head comparisons and decision-making. The most important thing is to weigh sustainability into our purchasing decisions – in other words, do not buy based on price alone. Make sustainability count! Also, be transparent about how and in what ways you will incorporate the sustainability efforts of your suppliers into your buying decisions.

Best practices for influencing and partnering with your vendors

It is important to remember that, for many vendors, ESG is as much of a learning curve as it is for their customers. That is why best-practice companies have programs to help their vendors be better sustainability partners. In this section, we will learn about the efforts of two organizations to influence and educate vendors as part of their sustainable procurement transformation efforts. The first details the creation of a sustainability assessment and supporting AI-based chatbot to leverage with a company's various suppliers. The second is a sustainability award for tech vendors, created and administered by their customers.

Smaller or more specialized tech vendors, particularly of software and services, may be disadvantaged in providing the ESG details demanded by their customers. For practical purposes, they may be left out of sustainability procurement programs or granted policy exceptions so that companies can still gain access to their innovative technologies. But you should also consider ways that you can help them comply with your requirements. One such example comes from **Rainer Karcher**, **founder and CEO of Heartprint**, **board member and CSO of SustainableIT.org**, and former global head of sustainability and human rights officer at Allianz Technology (with inputs from his colleagues). The following case study describes a supplier-facing program with three pillars—KPI questionnaire, modular training, and AI chatbot—combining structural, educational, and technological enablers for the company's suppliers. This holistic design reduces friction, makes participation scalable, and integrates ESG considerations directly into the company's procurement workflows.

Case study: From transparency to transformation — AI-assisted training for supplier enablement

While sustainability and decarbonization have become strategic priorities for many companies, the reality in IT procurement and supply chains often tells a different story. ESG efforts here are frequently underdeveloped, inconsistent, or driven by compliance rather than collaboration.

Most sustainability programs in the IT supply chain focus on hardware or facility operations, while suppliers of software, platforms, and services—including smaller or specialized providers—are left out of the equation. Even when procurement teams want to push for change, they often lack structured tools, shared terminology, or reliable data on ESG performance at the product or service level.

An enterprise, committed to decarbonizing its IT supply chain, reached out to us to co-design a comprehensive enablement program that would do the following:

- Empower IT suppliers to understand and meet ESG expectations
- Equip procurement teams to engage suppliers on decarbonization
- Establish a structured, repeatable process for data collection and strategic alignment

What followed is a replicable example of how training, technology, and AI can merge into a scalable transformation tool.

A holistic enablement approach

Heartprint, a consulting firm specializing in sustainable digital transformation, teamed up with QualityMinds, a leader in learning technology and AI solutions. Together, they designed and delivered an end-to-end supplier enablement program tailored to the complex reality of IT procurement.

Three components formed the backbone of this approach:

1. A standardized KPI questionnaire capturing ESG-related product and service data
2. A modular, digital training program for suppliers and internal teams alike
3. An AI-powered chatbot, enabling continuous learning and real-time support

This combination addressed not only the knowledge gap but also the need for scalable engagement and actionable data—a rare alignment of strategic and operational enablement.

Focus on decarbonization, not just data collection

The program is centered around an explicit decarbonization goal. The KPI questionnaire, while a vital first step, is not the final destination—it merely enables what follows.

At its core, the approach supports three strategic pillars:

- **Transparency through data**: Suppliers are asked to provide GHG emissions and ESG-related information at the product or service level. The questionnaire is tailored, focusing on software, hardware, or services depending on the supplier's role—no generic ESG reports, but specific, comparable inputs.
- **Sustainability embedded in supplier evaluation**: The gathered data feeds into procurement processes and supports decision-making, moving ESG from a "nice-to-have" to a differentiator in vendor selection.
- **Strategic alignment and collaboration**: Suppliers are encouraged to set their own decarbonization targets and align them with the customer's overarching climate strategy. It's not about policing—it's about partnership.

This transformation from compliance to collaboration is reflected in the tools as well: the program's training and chatbot serve not just as informational resources, but as instruments of shared progress.

Training design: Empowerment through clarity

The training component was designed with two core audiences in mind – external IT suppliers (small and large, global and local), and internal supply chain teams, including procurement and category managers. To meet their diverse expectations and knowledge levels, we created modular digital training, structured into three learning levels:

- Why: The strategic and regulatory context behind ESG and decarbonization
- What: Key concepts such as the Greenhouse Gas Protocol, Scope 1–3 emissions, ESG criteria, and their relevance for IT
- How: Practical guidance on completing the KPI survey, interpreting questions, and avoiding common pitfalls

The result: a concise yet comprehensive program, accessible through any device, adaptable to different user journeys, and fully aligned with international standards.

The ESG chatbot

One of the most impactful innovations in this project was the development of an AI-powered chatbot trained on the education content, ESG regulations, and scientific best practices. Built on the lightweight OpenAI GPT 3.5 turbo model and developed by QualityMinds, the chatbot offers the following:

- On-demand support for suppliers filling out the questionnaire
- ESG education and glossary lookup in real time
- Adaptive learning prompts based on user behavior and feedback

What makes the chatbot valuable isn't the technology, but the trust it builds. Suppliers engage with it in a low-barrier, non-judgmental setting. Procurement teams can refer to it as a shared source of truth. The chatbot acts like a sustainability assistant that's always on, always patient, and always aligned with the program's intent. The following is an interface screenshot:

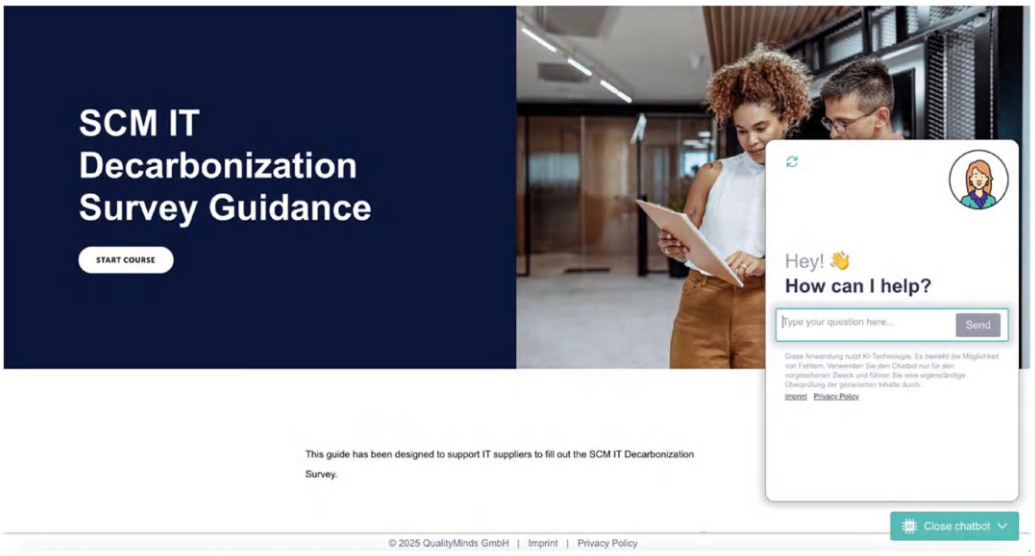


Figure 11.5 – Screenshot of training and chatbot user interface

To illustrate the practical value, here are a few typical questions from procurement and supplier stakeholders, along with truncated bot responses:

Question: We are evaluating new vendors for software development. How can we include ESG criteria in our supplier selection process?

ESG bot's answer: Incorporating ESG criteria into the supplier selection process for software development is vital for fostering sustainable partnerships and enhancing corporate responsibility. ESG factors serve as critical components of supplier evaluations, influencing procurement decisions and aligning with organizational sustainability goals.

Key ESG factors: [...]

Question: Our company provides managed IT services. What data do we need to collect to report Scope 3 emissions to enterprise customers?

ESG bot's answer: To effectively report Scope 3 emissions to enterprise customers, your managed IT services company will need to collect comprehensive data across several categories of indirect emissions. Scope 3 emissions encompass a wide range of activities not directly controlled by the organization, and reporting these emissions can help enhance transparency, support sustainability efforts, and meet customer requirements. [...]

Question: How can we align our IT supplier engagement with science-based targets for decarbonization?"

ESG bot's answer: To effectively align your IT supplier engagement with science-based targets for decarbonization, it's essential to integrate key metrics and frameworks that promote sustainability practices. The IT Supplier Decarbonization Initiative serves as a comprehensive model to enhance partnerships and drive efforts to meet these decarbonization commitments, specifically targeting a 20% reduction in carbon emissions by 2030, with ambitions for a net-zero supply chain by 2050 [...]

These real-world prompts demonstrate the chatbot's ability to translate complex ESG frameworks into hands-on guidance—on demand, multilingual, and at scale.

Tangible results and lessons learned

Though the program was launched only recently, early feedback is promising. Suppliers report feeling more confident navigating ESG topics. Instead of guessing what's expected, they have a structured entry point. Procurement teams now have a shared language, making ESG discussions less abstract and more data-driven. Some suppliers have signaled willingness to define their own decarbonization targets on a product or service level—a powerful indicator of alignment.

What's also become evident is that the combination of standardization and open dialog works. The KPI questionnaire creates a common baseline. The training builds mutual understanding. The chatbot sustains the momentum. Together, they turn ESG compliance into a shared transformation journey.

Here are five key takeaways that others can apply:

1. Don't start with the tool—start with the intent. The goal wasn't to create a questionnaire, but to support decarbonization.
2. Design for enablement, not enforcement. Suppliers are partners, not suspects. Training and dialogue unlock better outcomes than pressure.
3. Digital formats lower the barrier. Modular e-learning and a chatbot enabled scale, localization, and repeatability.

4. Tailored over generic. ESG in IT is different from ESG in logistics, food, or manufacturing. Your tools must reflect that.
5. Sustainability is a mindset shift. Procurement teams who once saw ESG as a burden now recognize it as a lever for differentiation.

This program is not a one-off. It's part of a growing toolbox for responsible IT procurement and supplier collaboration. Future steps may include integration of real-time supplier scoring dashboards; ongoing chatbot updates as legislation evolves; and use of aggregated data to inform category strategies.

Above all, the goal remains the same: to shift from passive compliance to active contribution—and to turn supply chains into levers of climate action. In an era where regulation tightens and stakeholder expectations rise, companies need more than ambition—they need infrastructure for transformation. That includes educating their ecosystem, enabling their partners, and embedding sustainability in the everyday.

What began as a request for training now stands as a model for digital, data-driven, and human-centered ESG enablement. We believe this model can work for others too—and we're ready to share it.

Cristina Castiglioni, Senior Consultant for Transformation, Heartprint GmbH,

Rainer Karcher, Founder and CEO, Heartprint GmbH, and

Michael Mlynarski, Co-founder and Managing Director, QualityMinds GmbH

It is noteworthy that this program deliberately shifts the focus from *box-ticking compliance to partnership and shared progress*. By framing suppliers as partners, not suspects, it fosters a culture of co-ownership in decarbonization, rather than adversarial oversight. This strengthens trust and makes sustainability a shared journey rather than an imposed burden. The AI-powered chatbot is not just a digital tool but a cultural bridge. Suppliers interact in a safe, non-judgmental environment, while procurement gains a reliable shared reference. By embedding AI as a sustainability assistant, the program scales ESG literacy and support across diverse supplier bases, reducing dependency on one-to-one human interactions.

Now let us see a very different supportive approach that identifies and assesses vendor sustainability commitments and provides a built-in reward incentive for supplier ESG transparency and achievement.

Case study: TUI Group's Green IT vendor award

One of the more noteworthy strategies for winning over technology suppliers to your cause is to make them winners, literally. The IT team at Hanover, Germany-based travel and tourism company TUI Group created their Green IT Award to incentivize and acknowledge the sustainability innovations and practices of their IT vendors. It serves as a platform for vendors to showcase their sustainability efforts and for TUI to promote a shared commitment to environmental stewardship. The following details are excerpted from a SustainableIT case study (SustainableIT.org 2024).

The annual Green IT Award has contributed to an ongoing dialogue about sustainable practices and potential areas for improvement and innovation between TUI and its tech suppliers. Vendors participate by submitting applications that detail their sustainability initiatives. These applications are then reviewed by the jury, who evaluate the initiatives based on their impact, innovation, and alignment with sustainability goals. TUI Group's CEO, Group CIO, and Group CSO participate in the jury. Winning vendors receive recognition for their efforts and visibility for their offerings, which not only enhances their reputation but also motivates them and others in the industry to further invest in sustainable practices.

The latest edition of TUI's Green IT Award scored 43 different suppliers with a combined 750 billion Euro revenue, which is 13% of the global ICT sector. There was one winner in each of the three TUI sustainability pillars of People, Planet, and Progress. Inspired by the success of the IT vendor sustainability award, TUI has expanded this concept to other types of suppliers, including airline, cruise, and indirect suppliers, renaming it the Global Sustainability Impact Award. The program has also garnered interest from other companies.

The following are elements of the current award application for TUI Group's Green IT Supplier award program, taken directly from the application form:

Section A: General Information

Introduction: In this section, we ask you to provide some general information about the company you are representing. This information will be used for identification, classification (e.g. small, medium or large organization) and to validate the information provided (e.g. with your CSR report).

Please note that we need to standardize some inputs like revenue as a number in EUR to process data automatically. If you use different measures (e. g. USD or revenue is hidden), please try to convert it into EUR or give a proxy for revenue.

This section does not contribute to the overall ranking and takes about 2 minutes.

[Questions in this section are primarily about the company's profile.]

Section B: Sustainability Action for Consideration

Introduction: The next section will be about your "Sustainability Action". With "Sustainability Action" we specifically refer to one project and not to your overall sustainability agenda, strategy, or programs. We are interested in knowing about a specific process, product, or service that is aligned with our three sustainability strategic pillars of People, Planet and Progress of our Sustainability Agenda.

Please note: The Sustainability Action should have been running in the last 24 months. Any numbers and measurements shared should be current. Furthermore, we want to encourage you to submit more than one initiative, ideally one per category. If you are interested in doing so, please fill in this form again with your other initiative(s) as only one submission at a time is allowed.

By applying to TUI Sustainability Impact Awards, suppliers consent to TUI using the information contained within the application form within its own internal and external communication channels (e.g. online, catalogues, intranet, press releases, newsletters, emails).

Before you submit your initiative, please note that the TUI Sustainability Impact Awards are an opportunity for both you and TUI to build potential collaborations. In the questionnaire, we ask how you can bring your initiative to TUI where we would like to know how you think TUI could collaborate with you to adopt or support your initiative.

[Key questions in this section include:]

- Name it: Please state the name of the "Sustainability Action" you want to submit for participation.
- Locate it: What area of TUI's Sustainability Agenda (People, Planet, Progress) is your action targeting?
- Set the scene: What was the challenge the sustainability action set out to solve?
- Please describe the situation before implementing the solution, including any baseline measures if applicable
- Please provide some background into what triggered the need for this sustainability action.
- Tell the story: What was the sustainability action? How did you deliver the initiative? How was it innovative?
    - Please give a description of the Sustainability Action.
    - Please describe the initiative and the situation before the action/initiative was launched.

- Celebrate success: What benefits did the sustainability action achieve? Please include any supporting data you have?
- Bring it to TUI: What potential does your sustainability action have for the tourism industry? How can you work together with TUI to drive this forward?
    - Does your Sustainability Action have an immediate relationship with the tourism industry?
    - Do you have any recommendations or ideas on how TUI can follow your example or take similar actions to progress its Sustainability Agenda?

Section C: Commitment to Sustainability

This section is about your commitment to sustainability. With this set of questions, we would like to evaluate your Sustainability Performance in general. You might have been asked these questions by ESG rating agencies, NGOs or the media.

Please provide a description of your overall sustainability strategy, including diversity and inclusion and sustainable tech.

[Key questions in this section include:]

- Please provide a description of your overall sustainability strategy, including diversity and inclusion and sustainable tech.
- Please share any recognition or awards you have received in the sustainability area such as ESG rating, Sustainability awards, SBTi targets, UN Global Compact membership etc.

By mapping the application to TUI's People, Planet, and Progress pillars, TUI ensures vendor contributions are tied to its own sustainability agenda. This reinforces shared priorities between TUI and suppliers and encourages vendors to think holistically, beyond environmental impacts (e.g., into social inclusion or future-oriented innovation). Asking *"How can you bring your initiative to TUI?"* positions the award as more than a badge of honor: It becomes a pipeline for piloting and scaling sustainable solutions into TUI's operations and supply chain.

While this award emphasizes storytelling and commitment, vendor achievements should also be quantified with data in the form of IT-specific sustainability KPIs (energy use, e-waste, cloud footprint) to facilitate transparency and comparability. Unlike RFP questionnaires, however, award programs are voluntary, so they need to balance detail with simplicity to encourage participation.

More sustainable procurement best practices

When many buyers act in unison, the effect will scale. A group of Nordic IT-buying organizations, including **H&M**, **IKEA**, and **Electrolux**, is engaged in an ASF-founded network – **Leadership for Change** – where all members have vowed to make sustainability part of every IT purchasing decision. (We heard from ASF's Camilla Cederquist earlier in the chapter.) By collaborating, they have been able to identify good examples – measures that have been proven successful – that they are now turning into best practices for others to adopt. Some of their lessons learned and best practices emerging from their research are shared here:

- **Being sustainable can pay dividends**: There is a common yet unfounded narrative that sustainability drives cost. That is a very narrow view. Instead, smart thinking often affects both costs and sustainability positively. For example, members found that devices with ecolabels are often of higher quality. When devices have reached their end of use, once funneled through the ITAD process, the devices tend to get a higher residual value and can be put back in circulation. Instead of routinely supplying employees with extra peripherals such as dual monitors, docking stations, keyboards, computer mice, and backpacks, it should be standard practice to make employees order what they need.
- **How you design your workplace matters**: Using a widescreen monitor instead of two smaller ones could cut the carbon footprint by around 30%. Screens with built-in docking stations and devices with standardized connectors (USB-C) are other examples of how a workplace can be designed to be more resource-efficient. The sustainability impact of these choices is not always apparent to those in charge of making these decisions. For organizations with serious ambitions around sustainable IT, it is key to involve people from the IT, sustainability, and purchasing functions in the purchasing process and design purchasing policies and strategies. Creating a market for sustainable IT is extremely important to drive IT sustainability further, and it requires focused, concerted efforts from both the buying and the selling sides to make sustainability part of every IT procurement decision. In the next section, we will take a closer look at how we can address some of these hotspots.
- **Do a double materiality analysis**: How you approach sustainability when purchasing IT products should be based on a double materiality analysis: what issues are most material to you, and what issues are most material for the industry to address? Where they intersect is where you should focus. For example, cutting emissions from transportation may be material for your organization. Transports, however, are just a small part (about 3%) of the carbon footprint of a small IT device.

Therefore, if you focus on demanding sustainability criteria on transport in your IT purchasing, the impact on sustainability in the IT sector will be negligible, and you will miss the opportunity to make a difference.

- **Find common ground**: Sometimes, you may feel that the sourcing organization and the supplier are adversaries, where the customer demands things that the supplier is reluctant to meet. Another approach can be to look for common ground. More often than you think, the suppliers want the same thing as you do. They, too, want to reduce their climate impact and increase their resource efficiency. Use this as a starting point. This way, you co-create solutions that meet your needs and help fulfill your ambitions around sustainable IT. Let us look at an example where this was not the case. One public IT-buying organization in the Nordics put a requirement in the request for tenders that the devices were to be delivered without peripherals. Later, it turned out that the peripherals were still produced but unpacked along the way, hence not delivered to the customer. The requirement was fulfilled, but the underlying ambition – to be more resource-efficient – was not.
- **Start from the end**: As much as 90% of the carbon footprint of a small IT device comes from production, meaning the "debt" is there even before you open the box. Therefore, the most important purchasing decision isn't about supplying IT devices; it's about ensuring they are recovered after use. So, when you buy, buy circular! See to it that there is a process and a plan for returning the devices once you have no use for them anymore so that they can be reused and, later, recycled (and remember, end of use is *not* end of life).
- **Do not get lost in the details**: As mentioned in the preceding sections, product requirements tend to get very detailed around, for example, battery charging cycles, access to spare parts, recycled material, and the desired absence of certain chemicals. One Nordic site that lists circular requirements for IT products prides itself on having more than 70 (!) sustainability requirements. They are probably all relevant and provide value, but if not all buyers decide to unite behind one of them (like the world did to eliminate the use of Freon in the 90s), there will likely be little or no effect. For maximum impact, we need to focus on models for sustainable consumption, such as **Product-as-a-Service** (**PaaS**), where the supplier retains ownership of the devices and therefore is incentivized to keep them running for as long as possible.



1990s Freon refrigeration chaos

The 1990s was a decade of refrigeration chaos due to the usage of Freon, primarily in refrigerators. This led to the depletion of the stratospheric ozone layer. In 1987, a historic treaty named the Montreal Protocol was signed by 24 countries under the United Nations Environment Programme. The original protocol called for the reduction and eventual elimination of a class of compounds such as **chlorofluorocarbons (CFCs)** and **hydrochlorofluorocarbons (HCFCs)**. Upon signing the Montreal treaty, the refrigeration industry took immediate steps to reduce these compounds, and by the end of the 1990s, 95% of refrigerators containing these compounds had been phased out. This is a good example of the swift and effective policymaking we require on a global scale going forward to curb the climate crisis.

Sustainable IT vendor management

Now that you have learned about sustainable IT procurement requirements and best practices that you can employ with vendors and how to drive the process end to end, let us look at the broader perspective of sustainable IT vendor management. Vendor management is the discipline of managing, administering, and guiding product and service vendors in an organized way to drive vendor behavior and optimize IT or business outcomes. The vendor management discipline emerges once a contract has been signed with a vendor. However, given the vendor classification, the vendor may or may not fall within the scope of vendor management.

A typical vendor management function is often challenged to unlock business value beyond incremental cost savings. As we have seen in previous chapters, software and hardware vendors comprise a large portion of Scope 3. As more services are moving to the cloud, Scope 3 emissions will continue to increase unless they are managed effectively. Regulatory requirements to report your own emissions and those of your IT supply chain (Scope 3) necessitate asking your vendors the tough questions. They may not be able to respond effectively at first, but in due course, they will need to quantify and disclose those numbers to help the industry drive purposeful change and deliver sustainable business outcomes.

Let us look at a four-step process on how to establish sustainable IT vendor management.

Step 1 – Establishing and maintaining the program

Identify key stakeholders, and work with key stakeholders to define **objectives and key results (OKRs)** and establish organizational readiness. Establish IT sustainability requirements for your product and service categories and use readily available resources instead of starting from a blank sheet of paper. Refine your code of conduct if needed and include ESG criteria. Benchmark your code of conduct with sustainability industry pioneers. Assess your existing vendor landscape. Classify them into vendor categories, such as strategic, tactical, emerging, and legacy. Based on your classification, determine how you should optimize your vendor portfolio and decide which vendors should be part of the sustainable IT vendor management program.

Step 2 – Onboarding and divesting vendors

Once you have established your program, you should communicate your strategic intent with your vendors. Early on, you should secure vendor commitment to your code of conduct. It is essential to be clear about your expectations and show vendors what they need to do to match your criteria. Ask difficult questions and expect granularity. For example, are your vendors using carbon credits, and are you willing to accept that? Give them time to change, but be clear on what the consequences would be if they fail to meet those terms and the roadmap.

Run **Request for Information (RFI)**, **Request for Quote (RFQ)**, and **Request for Proposal (RFP)** as needed for selected categories. Evaluate and select vendors. Finally, onboard and divest vendors as needed.

Step 3 – Sustainable IT value realization

Establish relevant baselines such as yearly GHG emissions from Scope 1, 2, and 3, energy usage, yearly purchases of assets in the ICT category, hazardous substances, and refurbished and recycled assets through IT asset disposition. Once a baseline has been established, develop dashboards and analytics to measure and follow up on agreed value realization targets. Establish a process for continuous improvement based on findings.

Step 4 – Vendor lifecycle management

The final step is to manage the entire vendor lifecycle from end to end. Business demand needs to be connected to the vendor on the supply side, and performance management and compliance must be followed up on continuously. Vendor governance needs to be established at a strategic, tactical, and operational level, and relationships must be managed at each corresponding level.

Figure 11.6 illustrates a four-step vendor lifecycle management process. It covers how you start establishing and maintaining the program, to how you manage the vendor throughout their lifecycle:

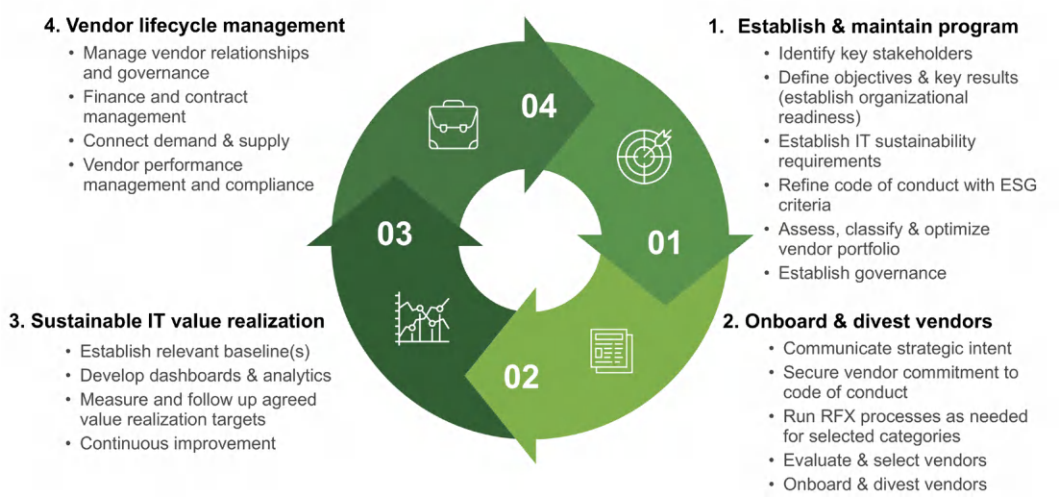


Figure 11.6 – Sustainable IT vendor management program

Now that we have explored the process of establishing a sustainable IT vendor management program, in the next section, we will take a closer look at how to set up a vendor management sustainability scorecard.

Vendor management sustainability scorecard

Now that we have gone through the different levers of how you can leverage your buying power through IT procurement and vendor management, let us take a closer look at how you could construct a vendor management sustainability scorecard.

At an overall vendor management level, you should include critical measurements such as performance, contract, relationship, and risk. In addition to that, you should add a sustainability category. The sustainability category can also be divided into the following three specific categories:

- **Vendor performance**: Overall vendor sustainability performance in strategy, commitment, and progress. What is the footprint?
- **Technology as an enabler**: The specific impact provided by product and service use. What is their handprint?
- **IT for Society or Technology for good (TECH4GOOD)**: The use of technology to effect positive social benefits through technology adoption. What is their heartprint?

The sustainability scorecard may also look slightly different based on the IT procurement category. It is not the same as measuring IT hardware manufacturers, software providers, professional services, or telecoms. Each has different sustainability strengths, weaknesses, and focus areas.

If you just want to get an initial read on some of your vendors' net-zero ambitions, `https://zerotracker.net/` is a great place to start. They provide an overview of the 2,000 largest publicly traded companies in the world by revenue.

Now, let us look at some specific sustainability scorecards for different IT procurement categories.

For data center and cloud providers, the data center sustainability scorecard from *Chapter 6*, *Data Centers and the Cloud*, as illustrated in *Figure 11.7*, is a good place to start. The EU guidelines for sustainable data centers are also very comprehensive (`https://e3p.jrc.ec.europa.eu/en/groups/data-centres-code-conduct`):

Description	Metric	General Requirement	United Nations Sustainable Development Goals Alignment
Energy Consumption	GWh $MtCO_2e$	**CUE** **Carbon Usage Effectiveness**	7. Affordable & Clean Energy 13. Climate Action
Renewable Energy	%	**REF** **Renewable Energy Factor**	7. Affordable & Clean Energy 9. Industry, Innovation & Infrastructure 12. Responsible Consumption & Production
Power Usage Effectiveness	PUE	PUE Power Usage Effectiveness	12. Responsible Consumption & Production 13. Climate Action
Sustainable Water	WUE	WUE Water Usage Effectiveness	6. Clean Water & Sanitation
Waste Management	Tonne %	ERF - EDE Energy Reuse Factor Electronics Disposal Efficiency Reduce – Reuse - Recycle	12. Responsible Consumption & Production

Figure 11.7 – Data center sustainability scorecard

For IT hardware vendors, the IT hardware sustainability scorecard from *Chapter 9*, *IT Hardware Management*, as illustrated in *Figure 11.8*, is a good place to start:

Description	Metric	General Requirement	United Nations Sustainable Development Goals Alignment
Equipment Lifetime	Years	Equipment Lifetime Years	12. Responsible Consumption & Production 13. Climate Action
Renewable Energy	%	REF Renewable Energy Factor	9. Industry, Innovation & Infrastructure 12. Responsible Consumption & Production
Circular Economy Reuse and Repair	**%**	Reuse and Repair % equipment reused	12. Responsible Consumption & Production 13. Climate Action
Zero Waste to Landfill	**WUE**	Recycle % equipment reused	12. Responsible Consumption & Production 13. Climate Action
Hazardous Substances	%	Hazardous Substances % equipment with hazardous substances	12. Responsible Consumption & Production 13. Climate Action

Figure 11.8 – IT hardware sustainability scorecard

For a professional service firm that you work with, simply tracking the GHG emissions per project, be it via a product or individually, may be enough. For example, if you engage a vendor to run your IT service desk, it may be enough to understand what the GHG emissions are for the service provided by the vendor if they have committed to your code of conduct.

Tracking all these KPIs for reporting purposes from your vendors may seem overwhelming. Still, if you set up a systemic way to collect the data from your vendors through standardized formats and APIs, the process should be much smoother and streamlined.

For you to provide accurate disclosure of your own Scope 1, 2, and 3 GHG emissions, the Scope 3 emissions from your product and services – *technology as an enabler* – and of your vendors would be a great start. With the increased usage of cloud services such as Microsoft Office 365, Salesforce, and ServiceNow, understanding your Scope 3 from using these services is highly relevant. Not all vendors will be able to provide you with an accurate figure of what the yearly GHG emissions per user are, for example, for using Microsoft Office 365 or Salesforce Sales Cloud.

Still, it would help if you started asking the tough questions. Once more customers start asking these questions, vendors will be poised to do accurate calculations and provide you with the data. Some vendors have gotten further along on their journey than others.

While the majority of this chapter has focused on environmental sustainability criteria for sustainable procurement, we must also ensure that social criteria are included in vendor evaluations and requirements. Refer to *Chapter 5*, *Social Sustainability: Accessibility, AI, and the Digital Divide*, where you will find a template for a **Technology Vendor Social Sustainability Impact Questionnaire** and links to vendor-relevant standards for social sustainability.

Summary

Now that we have reached the end of this chapter, you should have a better understanding of what the drivers for sustainable IT vendor management are and how you can leverage your buying power in your IT supply chain to make it more trustworthy and transparent. Secondly, you should know what essential IT sustainability requirements can be leveraged in your IT supply chain from a corporate commitment, environmental, social, product and service, and circularity perspective. Thirdly, you should understand how to drive sustainable IT procurement from start to end. Just leveraging three simple steps can make your IT procurement much more robust and sustainable. Furthermore, you should understand how sustainable IT vendor management can impact ESG change in your entire vendor ecosystem if managed well. Finally, you should be armed with crucial sustainability metrics that could be leveraged by your vendors to maximize ESG impact, minimize risk, and reduce cost.

The following are some of the key recommendations that you should apply to leverage your buying power:

- Make your purpose and intentions clear with your vendors. Find common ground with your vendors to make a joint ESG impact
- Choose vendors that are members of the **Responsible Business Alliance**
- Update your code of conduct with impactful ESG criteria and ensure your vendors subscribe to it
- Leverage existing sustainability certifications from **EPEAT**, **TCO Certified**, and **ENERGY STAR**, and place the burden on the vendor to provide proof of compliance
- Buy eco-labeled equipment
- Include take-back clauses in agreements

- Demand disclosure of GHG emissions from not only the vendor but for their products and services, which can be included in your Scope 3 reporting
- Leverage your buying power to manage our vendor ecosystem and acquire and divest vendors based on their performance, as needed

In *Chapter 12*, *Sustainable by IT*, we will look at how technology can be leveraged to provide sustainable solutions in various industries.

Appendix: standard metrics for sustainable sourcing

While some sourcing metrics from SustainableIT's taxonomy appeared in *Chapter 9*, *IT Hardware Management*, the majority are collected here in *Table 11.10* for the first time, spanning IT products and services and the tech supply chain (SustainableIT.org. 2024).

Category	**Topic**	**Metric**	**Related Global Standards**
SIT EF 400 Sourcing, IT Function	EF 410 Software sourced sustainably (i.e., vendors, manufacturers, and supply chain)	EF 410-1 Percentage of and degree to which vendors meet requirements; also Percentage of requirements met by each primary vendor.	GRI 308-1, 2 SDG 9, 13, 17
		EF 410-2 Percentage of software licenses or instances sourced sustainably	
		EF 410-3 Percentage of total spend to sustainable sources	
	EF 420 Hardware and devices sourced sustainably* (i.e., vendors, manufacturers and supply chain)	EF 420-1 Percentage of installed base sourced sustainably	
		EF 420-2 Percentage of new purchases sourced sustainably over time period	
		EF 420-3 Percentage of total spend to sustainable sources	

Category	Topic	Metric	Related Global Standards
SIT EF 400 Sourcing, IT Function	EF 430 Certified devices/hardware	EF 430-1 Percentage of eligible technology devices/hardware meeting ENERGY STAR®, EPEAT, and/or TCO Certified criteria	GRI 308-1, 2 TC-HW-410a.3 SDG 7, 9, 13
	EF 440 IT procurement process sustainability	EF 440-1 Percentage of IT purchases utilizing channels/processes optimized for sustainability, over time period	GRI 204 SDG 7, 9, 13, 17
		EF 440-2 Percentage of IT procurement spend utilizing channels/processes optimized for sustainability, over time period	
	EF 450 Outsourcer sustainability	EF 450-1 Percentage of and degree to which vendors meet requirements; also percentage of requirements met by each primary vendor	GRI 308-1, 2 SDG 17
		EF 450-2 Percentage of outsourcing (e.g., transaction volumes, spend) sourced sustainably by type, total spend	
	EF 460 Infrastructure services sourced sustainably (e.g., cloud, data centers, e-commerce providers)	EF 460-1 Percentage of vendors meeting requirements; also, percentage of requirements met by each primary vendor	GRI 308-1, 2 CG-EC-130a.1,2,3 (E-comm) SDG 17
		EF 460-2 Percentage of third party-hosted workloads sourced sustainably by type, total spend	

Category	Topic	Metric	Related Global Standards
SIT EF 400 Sourcing, IT Function	EF 470 Business services sourced sustainably (e.g., consulting firms, integrators, contractors)	EF 470-1 Percentage of vendors meeting requirements; also, percentage of requirements met by each primary vendor	GRI 308-1, 2 SDG 17
		EF 470-2 Percentage of services sourced sustainably by type, total spend	
	EF 480 Mobile services sourced sustainably	EF 480-1 Percentage of vendors meeting requirements; also, percentage of requirements met by each primary vendor	
		EF 480-2 Percentage of mobile services sourced sustainably by type, total spend	
SIT S 200 Sourcing Social Accountability	S 210 Technology vendor social accountability	S 210-1 Approach to assess, monitor, and hold accountable technology vendors for social requirements compliance	GRI 205, 414-1 ESRS S2 SDG 10
		S 210-2 Social sustainability criteria or requirements for IT vendors	
		S 210-3 IT vendors having significant risk of child or forced labor and human rights violations, and how risk addressed	
		S210-4 Approach to assess and address IT vendor corruption risk and incidents	
		S210-5 Exceptions made for small or otherwise disadvantaged vendors that may not be able to meet all requirements	

Category	Topic	Metric	Related Global Standards
SIT S 200 Sourcing Social Accountability	S 220 Enterprise supply-chain social accountability	S 220-1 Approach to assess, monitor, and hold accountable supply-chain partners for social requirements compliance	GRI 205, 414-1 ESRS S2 SDG 10
		S 220-2 Social sustainability criteria or requirements for supply-chain partners*	
		220-3 Supply-chain partners having significant risk of child or forced labor and human rights violations, and how risk addressed	
		S 220-4 Approach to assess and address supply chain partner corruption risk and incidents	
		S 220-5 Exceptions made for small or otherwise disadvantaged supply chain partners that may not be able to meet all requirements	

**Vendor or supply-chain partner social sustainability criteria or requirements may include: Diversity, equity, and inclusion, Safe and healthy working conditions, No child labor, No modern slavery and forced labor, Fair wages and hours, Empowerment of employees to raise concerns safely, Freedom of association for employee, Future-of-work enablement (e.g., Remote work, digital literacy and future skills training, virtual workplace), Privacy protection for employees, Product safety and security, Social, economic, and environmental justice commitment, Community engagement (e.g., local-first policies).*

Table 11.10 – SustainableIT standards taxonomy metrics for sustainable sourcing

Further reading

To learn more about the topics that were covered in this chapter, take a look at the following resources:

- *ASF Leadership for Change:* `https://www.atea.se/atea-sustainability-focus/leadership-for-change/`.

- *Clean Electronics Production Network:* http://www.centerforsustainabilitysolutions.org/clean-electronics.
- *Dutch Sustainable Public Procurement (SPP)*: https://www.mvicriteria.nl/en/webtool?cluster=1#//7/1//en.
- *Epeat*: https://www.epeat.net/.
- *ENERGY STAR*: https://www.energystar.gov/.
- *European Union Green Public Procurement*: https://ec.europa.eu/environment/gpp/index_en.htm.
- *European Union Data Centres Code of Conduct*: https://e3p.jrc.ec.europa.eu/en/groups/data-centres-code-conduct.
- *UK Public Sector: Greening Government ICT and Digital Service Strategy*: https://www.gov.uk/government/publications/greening-government-ict-and-digital-services-strategy-2020-2025.
- *International Labor Organization – Eight Fundamental Conventions*: https://www.ilo.org/global/standards/introduction-to-international-labour-standards/conventions-and-recommendations/lang--en/index.htm.
- *Responsible Business Alliance (RBA)*: https://www.responsiblebusiness.org/.
- *TCO Certified*: https://tcocertified.com/.
- *TCO Certified Accepted Substance List*: https://industry.tcocertified.com/guidance/accepted-substance-list/.
- *United Nations Convention on the Rights of the Child*: https://www.ohchr.org/en/instruments-mechanisms/instruments/convention-rights-child.

Bibliography

- CGR, 2025, *Circularity Gap Report 2025*: https://www.circularity-gap.world/2025.
- Global E-waste Monitor, 2024, *The global E-waste Monitor 2024 – Electronic Waste Rising Five Times Faster than Documented E-waste Recycling*: https://ewastemonitor.info/the-global-e-waste-monitor-2024/.
- Lexology.com, 2022, *Greenwashing: Exploring the risks of misleading environmental marketing in the UK, Canada, France and Singapore*: https://www.lexology.com/library/detail.aspx?g=e6ffe14f-afbe-4722-85d6-56c3e6f088ea.
- SustainableIT.org, 2024, *IT Procurement Sustainability Requirements: The Story Behind Electrolux's Vendor Frameworks*: https://tinyurl.com/5hxnevw6. (Access restricted to SustainableIT.org members only.)

- SustainableIT.org, 2024, *TUI Group's Sustainable IT Journey*: `https://members.sustainableit.org/knowledgebank-mfe#/knowledgebank/4/67d44f9fbaaade009d0cd29d/0` (Access restricted to SustainableIT.org members only.)
- SustainableIT.org, 2024, *Standards Taxonomy V1.2*: `https://cdn.prod.website-files.com/65fc52dc357c2d6b119e4e26/66da1c91feb1e2e8d0646324_SustainableIT-Standards-Taxonomy-v1.2-07242024.pdf`.

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12

Sustainability by IT

> *"Moving to the subscription economy means we have to learn not to monetize the transaction but rather to monetize the relationship."*
>
> *Ron Baker , Co-founder, THRESHOLD, and Founder, VeraSage Institute*

To a large extent, sustainable IT is about using IT to reduce the environmental impact of companies, organizations, and individuals. So far, in this second part of the book, we have focused on exploring how you can develop a sustainable IT practice to minimize the impact of IT and how we can make data centers, AI, the cloud, applications, data, hardware, and energy management more sustainable. In contrast, this chapter will focus on how we can leverage technology to create and enable sustainable business processes and models—the essence of sustainability by IT. By this, we mean the ways in which information technology, supplied by tech vendors or a company's internal IT or engineering functions, can be applied to make any part of a business, industry, or sector more sustainable. Sustainability by IT is a vast topic that covers a broad spectrum, and it could easily be a book by itself, but hopefully, you will get a glimpse into the art of the possible through the 10 use cases presented here, which revisit the "handprint" use cases introduced in *Chapter 2*, *Rise of Sustainable IT*.

The main objectives of this chapter are to introduce you to the different facets of technology-enabled sustainability.

In this chapter, we will cover the following topics:

- Ten use cases for sustainability by IT, with recommended actions and ways to leverage AI
- Enabling a circular economy—from ownership to usership
- The need to increase the pace of innovation, from generative and agentic AI breakthroughs to corporate and global hackathons

By the end of this chapter, you will have learned about how IT can unlock opportunities to develop or leverage different types of sustainable solutions. This chapter will present case studies from appliance company **Haier**, the IT organization at **ABN AMRO Bank**, and the **Hack for Earth Foundation**. This chapter's profile in our sustainable IT reference model is broad, aligning directly with enterprise sustainability commitments and strategy, and touching on nearly all the other topics in the top half of the model (sustainability by IT). We will also target compliance reporting and culture development – the vertical topics that span the model. The by-now familiar environmental outcomes are fundamental targets for most of the actions recommended throughout the chapter.

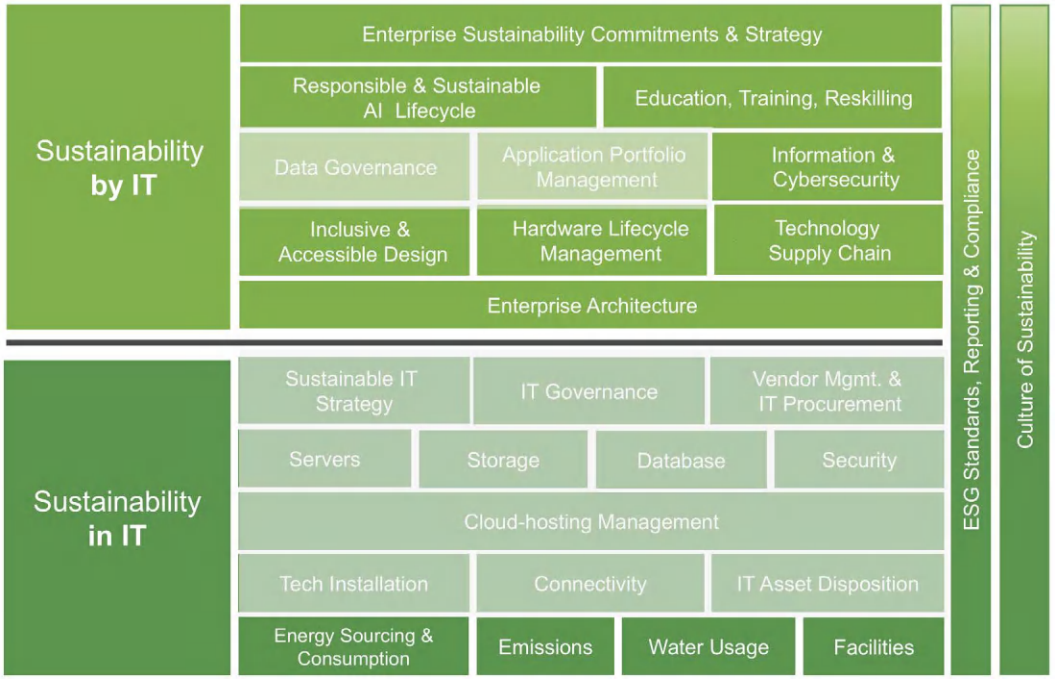


Figure 12.1 – The sustainable IT reference model – Chapter 12 focus

Ten use cases for sustainability by IT

The primary focus of sustainability *in* IT is to reduce the organization's direct environmental impact through sourcing IT products, components, and services that utilize recyclables, restorative, or regenerative design. Sustainability *by* IT addresses, to a large extent, how IT can help reduce environmental burdens elsewhere in society by using innovation for sustainable business models.

In *Chapter 2*, *Rise of Sustainable IT*, we outlined 10 key areas: carbon emission reporting, **Environmental, Social, and Governance** (**ESG**) risk management, sustainable sourcing and manufacturing, environmentally friendly transportation, energy-efficient buildings, energy resource management, hybrid work, eco-friendly travel, development of e-services, and **Product as a Service** (**PaaS**), as depicted in the following diagram:



Figure 12.2 – Use cases for sustainability by IT

This section will look into all 10 use cases and fundamental actions that IT can take to drive momentum in each, along with presenting some key examples. Most of these actions primarily aim at two main environmental aspects of sustainability: **climate change mitigation** and **climate change adaptation**.

1: Carbon emissions reporting

Despite the EU's delayed timetables for **Corporate Sustainability Reporting Directive (CSRD)** reporting and the US pullback from the Paris Climate Accord and the U.S. Security and Exchange Commission's abandonment of its climate disclosure rules, 35–40+ countries now require some form of emissions disclosure, with more adopting or expanding mandates. Businesses need to respond by providing this data in an accurate and timely fashion.

Actions to address carbon emission reporting are set out here:

- Calculate a full corporate footprint (Scopes 1, 2, and 3) using GHG Protocol and defensible factors; prioritize primary/supplier data where material. Under CSRD/ESRS, scope coverage and double-materiality assessments are explicit.
- Get "assurance-ready." Build internal controls, audit trails, and data lineage across systems so that limited, then reasonable, assurance is feasible under emerging regimes.
- Deploy **carbon emissions management (CEM)** and ESG software (see the upcoming list of solution categories and vendor examples) to streamline data collection, calculation, supplier engagement, reduction planning, regulatory compliance monitoring, and disclosures.
- Make a public commitment (e.g., Science Based Targets Initiative, Exponential Roadmap Initiative, and UN Race to Zero) and publish a plan with interim targets.
- Operationalize the plan. Integrate decarbonization into procurement, product design/ **Life Cycle assessment (LCA)**, energy, logistics, and finance (CapEx/Marginal Abatement Cost Curve), and disclose progress annually.

IT can make its biggest contribution to carbon reporting through CEM, which refers to the processes and software solutions that enable organizations to systematically measure, monitor, reduce, and report on their GHG emissions. CEM platforms typically integrate data from multiple sources (energy bills, suppliers, product LCAs, cloud usage, logistics, etc.), apply recognized standards such as the GHG Protocol, and support alignment with disclosure requirements such as CSRD/ European Sustainability Reporting Standards, International Sustainability Standards Board, and Carbon Disclosure Project. Some tools specialize in scanning regulations and providing alerts about impending and changing rules. They also inform on actions to take, deadlines, and penalties if not compliant, and most have extended their services with AI features. Beyond compliance, CEM tools facilitate scenario modeling, reduction planning, **corrective and preventive actions (CAPA)**, and audit-ready reporting. Representative examples of marketplace CEM tools are presented here (vendors and products are not endorsed by the authors or publisher):

- **Enterprise platforms (broad ESG + carbon)**:
    - Atos Sustainable Workplace/Decarbonization Dashboard Suite
    - Coupa ESG Management software
    - IBM Envizi (ESG data management, calc/assurance features)
    - IFS Sustainability Management for industrial sectors and field service organizations

  - Microsoft Cloud for Sustainability (Sustainability Manager, data estate, reporting)
  - OneTrust ESG and Sustainability Cloud (metrics, workflows, APIs)
  - Salesforce Agentforce for Net Zero Cloud
  - SAP Sustainability Control Tower (ESG steering, CSRD tooling; roadmap and help docs)
  - ServiceNow ESG Management and Sustainability Cloud
  - Sphera SpheraCloud Air/GHG (corporate sustainability, supply-chain GHG, and operational compliance)
  - Sweep Sustainability Data Management Platform
  - Workiva (connected reporting with audit-ready ESG)
- **Specialist carbon platforms (deep carbon + supply chain)**:
  - CarbonChain (heavy-industry/product-level and CBAM support)
  - Greenly (SMB/mid-market carbon management)
  - Footprint Intelligence (carbon accounting and sustainability intelligence system)
  - Fruggr (environmental and social footprint of digital services)
  - Greenpixie (cloud emissions measurement and optimization)
  - Green Project Technologies (formerly Emitwise; ML-assisted supplier and product-level accounting)
  - Normative (science-based carbon accounting + advisory)
  - Persefoni (assurance-grade carbon accounting; free entry tier)
  - Plan A (EU-centric carbon and decarb platform)
  - Rejoose (carbon footprint, energy consumption, and lifecycle impact assessments for IT hardware)
  - SINAI (transition planning, MACC curves)
  - Sustain.Life (SMB-friendly carbon accounting and services)
  - Watershed (enterprise decarbonization, clean power, removal marketplace)
- **Regulatory intelligence and product compliance monitoring**:
  - Assent product compliance solutions
  - Bureau Veritas global compliance monitoring platform
  - Compliance & Risks C2P product compliance solution
  - Enhesa ESG regulatory intelligence

    - Intertek Global Market Access Portal
    - 3E regulatory intelligence API
    - UL Solutions
    - ULTRUS WERCSmart
    - Wolters Kluwer Enablon ESG and EHS suites
- **Supplier engagement/ratings**:
    - EcoVadis Carbon Action Manager
    - TCO Certified Product Finder
- **Free and open tools**:
    - Cloud Carbon Footprint
    - GHG Protocol calculation tools (official spreadsheets by category)
    - Open Footprint (The Open Group/OASIS) (open data model for footprint data)
    - OpenLCA (open source LCA software for product footprints)
    - SME Climate Hub (free small-business carbon calculator and guidance)
    - WBCSD PACT/Pathfinder (methodology and network for product-level PCFs)

For links to these tools, refer to the end of the chapter in the *Further reading* section.

As of autumn 2025, several of the preceding tools utilize AI, including ServiceNow, Footprint Intelligence, and IFS. More will soon. AI is reshaping corporate carbon accounting by automating data ingestion, normalization, and the generation of transparent narratives for disclosures. A recent exploration by the World Economic Forum outlines how AI can streamline sustainability data collection, interpret reporting requirements across jurisdictions, and generate predictive climate narratives. For example, AI can handle real-time data tracking across the supply chain and automate the calculation of product carbon footprints. (World Economic Forum 2025).

Emerging use of agentic AI is pushing the boundary toward continuous, autonomous emissions monitoring and adaptation. In such systems, agents ingest real-time IoT, sensor, and supplier data; detect anomalies or trend shifts; and autonomously trigger recalibrations or supplier inquiries without user prompts. These agents thus maintain a live "carbon twin" of organizational emissions—a dynamic digital model that mirrors the company's carbon footprint in near-real time, continuously updating as operational data changes. Think of the carbon twin as a climate-aware digital twin of enterprise operations.

It can be used to simulate and predict the emissions impact of decisions before they are made, enabling proactive rather than retrospective disclosures. Supporting evidence of the value of this approach is seen in research by BCG and CO_2 AI, which finds that companies leveraging AI are 4.5 times more likely to report significant climate gains. (CO_2 AI 2025).

2: ESG risk management

As noted in *Chapter 1*, *Our Most Significant Challenge Ahead*, the World Economic Forum states that extreme weather events – amplified by climate change – are the number one risk over the next decade (World Economic Forum 2024).

Transitioning to net zero is the most potent mitigating factor to alleviate these risks. Managing your physical and transition ESG risks has become critical to ensure a corporation's prosperity and long-term value creation. Not long ago, the **chief sustainability officer** (**CSO**) was a novelty, but the CSO role has recently become a more frequent member of an organization's executive management team. Ensuring long-term value creation and financial success while managing ESG risk management has become a top priority for many large companies. **Small and medium-sized enterprises** (**SMEs**) are still struggling to bring the two together, which is still a big challenge.

Actions to address ESG risk management will require support from IT and should include the following:

- Ensure that senior leadership alignment, engagement, adequate governance, and corporate structures are established.
- Research and understand physical and transitional ESG risks. Physical risks are hazards associated with physical catastrophes such as wildfires, hurricanes, and floods. In contrast, transitional risk is associated with transitioning the economy from fossil fuels and linear business models to changes in policy, circular business models, and new technologies, such as expanding renewable energy sources.
- Align physical and transitional risk management approaches to directives such as the EU **Corporate Sustainability Reporting Directive** (**CSRD**) and the EU **Carbon Border Adjustment Mechanism** (**CBAM**). For larger organizations, this requires working with legal and compliance functions within companies. For smaller companies, it might be about working with partners who can guide them through the intricacies of current and changing legislation, as they will not be able to do this internally.
- Put ESG risk mitigation and adaptation plans in place.

ESG risk management categories and examples include the following:

- **Wildfire risk analysis**: One of the most apparent signs of climate change is the number of unprecedented wildfires that rage across the world. Just in the US alone, 8.92 million acres have been burned in 2024, equivalent to 6.75 million full-size football fields (US Department of the Interior n.d.). One way to mitigate wildfire risks is to leverage geospatial data to prevent more costly damage. By leveraging public land and datasets such as temperature, wind, humidity, precipitation, soil moisture, and elevation, together with time series for the next 24 hours, weeks/months, or even longer into the future, we can predict with much higher certainty where the high-risk areas are and where mitigating factors are required.
- The City of Glendale, Arizona, a rapidly growing municipality located in the Phoenix metropolitan area, has a high risk of wildfire affecting about 48% of its buildings (ClimateCheck 2025). The city's Innovation and Technology Department won a SustainableIT Impact Award in 2024 for applying geographic information systems and a modern data platform to manage water conservation amid drought conditions and empower fire management in high-risk zones.
- Companies such as **Dryad**, headquartered in Berlin, Germany, use **Internet of Things (IoT)** sensors for early fire detection. In 2024–2025, Dryad expanded deployments of Silvanet IoT sensors to detect gas signatures from smoldering fires minutes to hours after ignition—supporting utilities, municipalities, and forest owners in reducing event severity and losses.
- **Water availability**: Water stress is becoming an increasingly significant issue as 25% of the world's population lacks access to clean water (UNICEF 2025). According to an *Economist* report, 44 countries, including the US, China, India, Northern Africa, South Africa, and Australia, face either "extremely high" or "high" water stress levels by 2040 (Economist 2021). Similarly to wildfires, we can use datasets to predict floods, droughts, and water availability. Projecting water availability and identifying early prevention of water leakages in the system using forecasting and prevention techniques can help predict water stress in agriculture, hydroelectric production, manufacturing, and public water supply networks. This can also help public and private organizations make better use of finite resources and build a business case for it.

- **Supply-chain risk management**: With post-COVID effects and the war in Ukraine, the whole global supply chain has come under duress with component shortages, access to raw materials, transportation disruption resulting in long lead times, hyperinflation, and challenges along the entire supply chain. By leveraging supply chain datasets (such as locations, partners, routes, modes of transportation, geospatial data, product structures, compound and substance structures, dimensions, product and standards compliance, trade and compliance rules, and sustainability weight and cost measures), companies can build AI-enabled forecasting models to identify key risk areas and to help diversify suppliers and help mitigate risks, as well as understanding the sustainability credentials of their suppliers.
- In one example, NVIDIA launched **Earth-2** in 2024, a cloud platform for ultra-high-res climate simulations that organizations and agencies can use to stress-test operations and supply chains. Early adopters include The Weather Company and Taiwan's Central Weather Administration, enabling better extreme-weather forecasting and risk mitigation (NVIDIA 2024).

3: Sustainable sourcing and manufacturing

The production and consumption of products are often overlooked in the grand scheme. Roughly 20% of global emissions come from industry, led by cement and steel production. As we learned earlier in the book, roughly 80% of the emissions from a computer, tablet, or smartphone come from the manufacturing phase, and any type of electronics follows the same emissions pattern. Therefore, it is essential to embed environmental and sustainability practices into all aspects of your business operations, from sourcing sustainable materials to producing and shipping sustainably, reducing the product's energy consumption, and managing waste and recycling at all stages of the product development lifecycle. IT is the backbone supporting all of these information-intensive processes.

A term commonly used in the industry is *materials transition*, which means enhancing circularity and substituting emission-intensive materials (Almulla, El-Shahat, and Zhou 2022). With global energy prices rising and water resources being scarce, it is essential to constantly improve energy efficiency, reducing water consumption and other scarce resources such as minerals and other materials in all aspects of your business operations. Managing these aspects will make your business operations more sustainable and more resilient and unlock other benefits such as cutting costs, reducing risk, driving revenue, and improving your brand.

AI is increasingly embedded into sustainable manufacturing by enabling granular control over material flows and dynamically guiding production toward lower-carbon, lower-waste configurations. **Machine learning (ML)** models analyze sensor data, production telemetry, and demand signals to detect inefficiencies—for example, predicting when over-mixing, misalignment, or tooling deviations will produce defective output—thereby reducing scrap and resource loss. In electronics or automotive plants, predictive algorithms have cut material waste by adjusting process parameters in real time, while optimizing energy consumption across machining, heating, and cooling subsystems (Bronson.ai 2025).

AI can explore alternative designs or process flows that minimize embodied energy or material intensity. For example, a recent study describes an intelligent packaging integrity system that uses generative approaches to simulate and propose packaging layouts that reduce damage and material waste while maintaining protection standards (MDPI 2025). Emerging agentic systems push this further: autonomous agents in the "smart factory" continuously monitor IoT sensors and supply chain signals, intervene to reschedule production when raw materials shift in availability, or autonomously reconfigure lines to prevent bottlenecks or overconsumption. For instance, one agentic AI model, SmartPilot, is proposed to act as a multi-agent copilot in manufacturing, blending anomaly forecasting, production optimization, and domain reasoning at the edge (Shyalika et al. 2025). These autonomous agents can help transform manufacturing toward a regenerative model, where each change is continuously evaluated for its sustainability impact.

Actions to drive sustainable sourcing and manufacturing include the following:

- Design for circularity. Throughout your innovation and design process, including the development of information and automation systems, you should aim to design for circularity following the three circular economy principles defined by the Ellen MacArthur Foundation: designing out waste and pollution, keeping products and materials in use, and regenerating natural systems. Carry out an **environmental impact assessment (EIA)** or a more thorough **lifecycle assessment (LCA)** to understand the environmental impact of the solution through each step of the process.
- Build a sustainable supply chain through your finance/procurement functions by working with your suppliers and with your customers and selectively choosing new ones based on a high standard of sustainability criteria from a social and environmental perspective. Ensure they comply with your code of conduct, adhere to existing regulations and reporting, and provide adequate transparency.

- Streamline your production cycle by reducing resource consumption, such as energy and water, eliminating waste, and reducing product impact in use and **end-of-life (EOL)**. Tap into Industry 4.0 capabilities such as cloud computing, IoT, **robotic process automation (RPA)**, analytics, AI, and ML to improve data exchange and intelligent automation to create a connected smart factory. The shop floor is highly digitized in an intelligent factory, continuously collecting and sharing data from connected devices, machines, and production systems. Part of the challenge within Industry 4.0 and sustainable manufacturing is aligning **operational technology (OT)** and IT. Many factories work with multiple systems across their OT equipment, often proprietary, and aligning all of these is a technical headache and is often not an appealing business case.

4: Eco-friendly transportation

The need for transport for both personal and commercial purposes will continue to rise, primarily due to economic expansion. Over the past 10 years, personal and commercial transportation use have increased by 14% and 26%, respectively. With 15% of carbon emissions from the transportation sector, switching from combustion engines to electric vehicles is critical. Considerable potential exists for increasing the efficiency of existing transportation methods and reducing the need for business travel with remote working and virtual meetings enabled by IT. However, it is not just a matter of switching to **electric vehicles (EVs)** and reducing unnecessary travel, but also aspects such as intelligent transportation systems, traffic management systems, and route and fleet optimization.

AI is already smoothing traffic flow and optimizing route choices in real time. Machine-learning models that analyze aggregated travel patterns now recommend signal-timing changes that cut stop-and-go idling at intersections—early deployments such as Google's Green Light report up to 30% fewer stops and 10% lower tailpipe emissions where the tweaks are applied, achieved with software rather than new infrastructure (Green Light n.d.).

As fleets electrify, ML and reinforcement learning schedulers are emerging to stage charging when grids are cleaner and prices are lower, while guaranteeing duty-cycle readiness—studies show AI control can cut charging costs and associated emissions compared with static schedules (MDPI 2024; PubMed Central 2025).

Actions to enable environmentally friendly transportation include the following:

- Evaluate your current transportation system and set a target state ambition to transition to a low-carbon transportation system. The challenge, however, is adequate nationwide charging networks and a lack of government financial incentives to switch to EVs. Equally, there is the question of what happens to the lithium batteries required: where lithium comes from, and how to recycle it at EOL.
- Prepare for the transition to an electric fleet. Leverage data-driven insights to measure benefits, **total cost of ownership** (**TCO**), and carbon emission impact by switching from a fossil fuel fleet to an EV fleet.
- Leverage new technology to improve demand-and-supply planning.
- Leverage IoT devices for fleet management or asset tracking.
- Leverage supply-chain planning tools to design your supply network by choosing alternatives closer to the target market, optimizing the use of scarce and constrained environmental resources. Optimize your logistics from loading and docking to routing. Investigate tools that support decarbonization of logistics and transportation (e.g., Gryn, VesselBot, CoZero, and ShipZero).

5: Energy-efficient buildings

The building sector across the world generates 34% of global CO_2 emissions. To meet the net-zero targets by 2050, emissions from buildings need to fall by 50% by 2030 (World Economic Forum, 2025; Martella 2022). Therefore, it is essential that on our path to net zero, all new buildings need to be zero-carbon-ready. So, we must look for new IT-enabled solutions that offer better control over resources such as energy and water.

AI is shifting facilities from fixed schedules to self-optimizing control that continuously balances comfort, cost, and carbon. "Autonomous" building controllers can learn a facility's thermal dynamics and make real-time setpoint, ventilation, and lighting adjustments from sensor streams, cutting waste without manual tuning. A 2024 California Energy Commission demonstration describes an AI-enabled, cloud-based building energy management system that optimized controls, performed automated fault detection, and even dispatched work orders at a college campus, documenting measurable energy reductions and operational gains (California Energy Commission 2024). An autonomous **heating, ventilation, and air conditioning** (**HVAC**) optimizer from BrainBox is already deployed across thousands of large buildings. It ingests weather, occupancy, and equipment telemetry to predict near-future states and proactively correct inefficiencies, reporting substantial cost and emissions cuts in production settings (Time 2024)

Beyond this, we need to assess the material used in the building and the design of the building itself during new construction or retrofitting existing buildings. HVAC and insulation are two factors to be considered that significantly improve the efficiency of the building.

Actions recommended for energy-efficient buildings include the following:

- Leverage well-established standards as benchmarks, such as **Leadership in Energy and Environmental Design (LEED)**, a worldwide green-building certification program.
- Leverage new technology designed to improve energy efficiency and reduce water intensity.
- Using IoT-based control systems, leverage sensors and controllers to control heating, ventilation, cooling, water, and lighting.
- Identify heating and cooling recovery opportunities to push excess back onto the grid.

Energy-efficient building examples include the following:

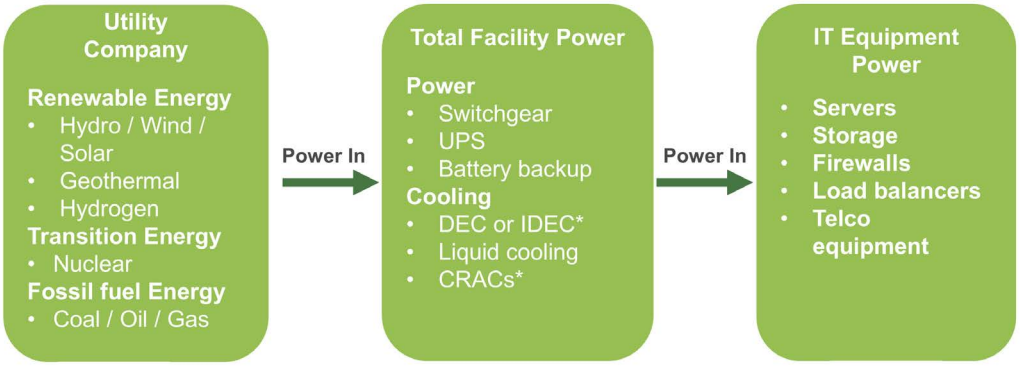
- Google's campus in Silicon Valley, California, runs on zero-carbon energy 90% of the time through solar panels on the roof and nearby wind farms. The roofs are covered with overlapping solar panels nicknamed "dragon scales," but also draw power from nearby wind farms to ensure that the campus runs as close to zero-carbon energy as possible. The roofs collect rainwater and channel it into ponds around the campus that are used for flushing toilets and irrigation. The campus has been equipped with the largest ground-source heat pump in the US to draw heat from the ground to keep the campus warm, and excess heat can be pumped back underground to keep things cool.
- Microsoft's **Redmond** modernization added a **thermal energy center** with hundreds of deep boreholes and large heat-pump systems to deliver all-electric heating and cooling, reducing campus operational emissions and peak loads.
- Uber has built a sustainability-focused HQ in downtown San Francisco. Rather than using air conditioning, it leverages fresh air to keep cool. The building has 180 computer-controlled glass panels on its facades that are open and closed throughout the day. (ShoP Architects 2022). As with Google's buildings, it is equipped with solar panels and rainwater collection.
- Amazon's HQ2 (Met Park) in Arlington opened with an on-site **photovoltaic solar panel system**, district-energy efficiency measures, and 100% renewable electricity; the complex has been reported as achieving **LEED v4 Platinum** in 2024.

For more examples of innovation and buildings, check out the non-profit organization **World Green Building Council (WGBC)**: `https://worldgbc.org/`.

6: Energy resource management

With 43% of carbon emissions coming from the energy sector's electricity generation, fuel production, and buildings, decarbonizing the energy sector while providing energy security is essential (UNEP, 2025). A new wave of agentic AI is beginning to orchestrate distributed energy resources as **virtual power plants (VPPs)**—networks of distributed energy resources that can include solar panels, batteries, and smart thermostats, which are coordinated to act in concert as a traditional power plant. This means not just forecasting but deciding and acting across thousands of devices in near-real time. These autonomous controllers learn how to co-optimize behind-the-meter batteries, EV chargers, smart thermostats, and flexible loads to deliver capacity, frequency response, and peak-shaving without sacrificing customer comfort. Public roadmaps now anticipate rapid scaling and utility integration of VPPs, with emerging architectures built around multi-objective AI optimizers and millisecond-level dispatch, moving VPPs from pilot status to a core grid resource by the late 2020s (US Department of Energy 2025).

Visualizing electricity and energy usage can increase energy efficiency through awareness. For owners of technology data centers (the business) and the managers of those resources (IT), the commonly used benchmark of **Power Usage Effectiveness (PUE)** is an evocative number to share. PUE is the total electrical power supplied to the enterprise divided by the power consumed by IT equipment. The lower the value of PUE, the more efficient the data center is. The shared goal is to achieve the lowest PUE score across the company's data center footprint (*Figure 12.3*).



**DEC – Direct evaporative cooling; IDEC – Indirect evaporative cooling; CRACs – computer room air conditioning*

Figure 12.3 – IT's facility and equipment demand for power determines PUE

Actions for energy resource management include the following:

- Optimize data center energy consumption and cooling
- Upgrade and consolidate IT equipment
- Establish energy management solutions leveraging remote controls and automation

Energy resource management examples include the following:

- Cobb County government in Georgia, US, worked with Johnson Controls to update and refurbish HVAC systems and controls that resulted in emissions reduction of 8,703 metric tonnes, utility savings of over 2.05 million USD, and capital cost avoidance of 5.4 million USD (Johnson Controls 2024).
- A Dominion Energy case study shows that Honeywell's Smart Grid building automation applied to 1,300 small- and medium-sized businesses yielded an average saving of 6,545 kWh per business (Honeywell 2024).
- **Retailer Carrefour Egypt** applied **Schneider Electric's** building management system **EcoStruxure** to 19 stores, achieving a 7% energy savings and a 2-year ROI. It plans to scale the technology solution to all stores (Schneider Electric 2025).
- UK telecom and network provider BT Group implemented Cisco switches, access points, and the Cisco Spaces smart building solution, which turns a building's network infrastructure into a "smart sensor," across its head office, One Braham. The deployment gave BT granular occupancy and usage data (via spaces and sensors), enabling automation of lighting, HVAC, and other systems when spaces were under-utilized, which reduced energy usage (Cisco n.d.).

7: Hybrid work

As of 2025, in the US, 55% of remote-capable jobs are hybrid, 26% fully remote, and 19% fully on-site (GALLUP 2025). Major companies have increasingly encouraged or mandated partial return-to-office policies, typically requiring 2–3 days per week in the office (Stanford 2025). However, a full return to pre-pandemic office attendance levels remains unlikely. *Figure 12.4* shows emissions reduction estimates for virtual work and meetings, as well as paperless processes (Nature 2021; Askoy et al. 2025).

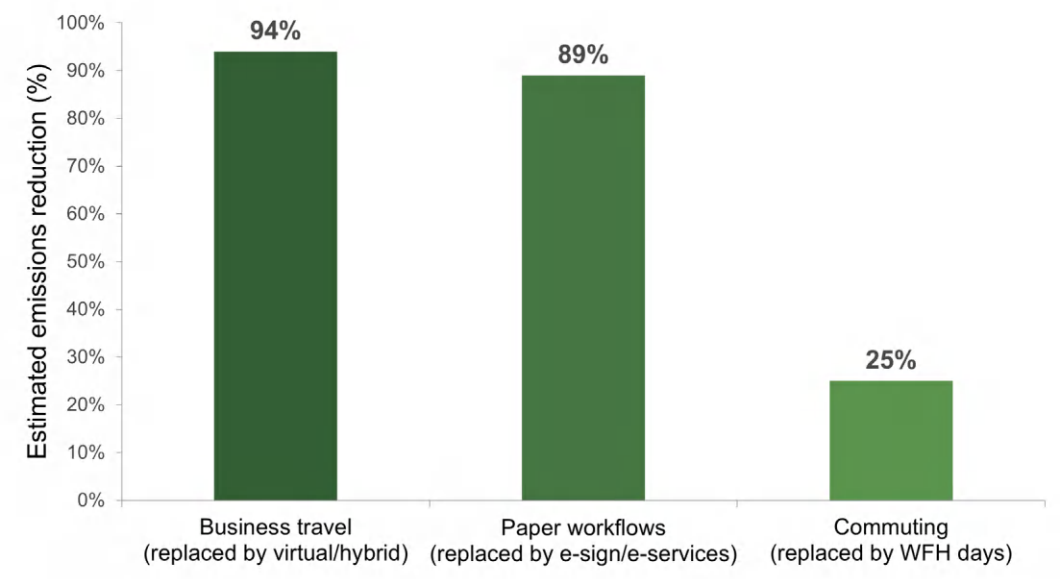


Figure 12.4 – Percentage emissions savings from hybrid/virtual business and office travel and paperless systems

Workers have gotten used to the increased flexibility of working remotely from anywhere. Companies leverage a wider talent pool to access resources from anywhere, not necessarily tied to a specific office location. Current technologies enable formal meetings to be replaced by digital ones, leading to less office commuting and significantly less domestic and international business travel.

The impact on sustainability is more complicated. Hybrid and remote work did not make energy use vanish—it redistributed it from offices to homes. Various studies show that working from home can cut an employee's work-related carbon footprint by 54% compared to onsite workers; hybrid workers with 2 to 4 workdays at home achieve 11 to 29% reductions (PNAS 2023). Utilities data shows the load shift clearly: during large-scale **work-from-home (WFH)**, US residential electricity rose 7.9% while commercial/industrial fell 7–8%, underscoring that "savings" at the office are partly offset by higher household demand (Journal of Urban Economics 2023). The net emissions effect hinges on local climate (heating/cooling loads) and the carbon intensity of the power used at home versus at the office. The overall climate benefit is largest when (a) avoided commuting is carbon-intensive, (b) buildings can actually downscale their HVAC and lighting loads, and (c) the home electricity is relatively low-carbon, conditions that are increasingly common but far from universal.

With 98% of business meetings including at least one virtual attendee, the wave of virtual note-taking agentic meeting assistants that we experienced in 2024 was inevitable. However, these have rapidly progressed beyond meeting transcription and summarization to actively capture decisions and "next steps" as they happen, draft recap notes, and file them back to the calendar event; they can also answer in-meeting questions about prior context and generate action items that populate workspaces after the call—all with minimal human prompting. Emerging rollouts from Google, Zoom, and Slack show this pattern across major platforms: AI that will "take notes for me" during a meeting and attach them to the event for shared access; cross-platform assistants that can summarize a session, propose tasks, and draft follow-ups; and workspace-native summarization/search that helps hybrid teams instantly catch up on what they missed between meetings. As these assistants gain autonomy, they will begin to coordinate calendars, draft agendas, time-box discussions, and trigger downstream workflows (tickets, docs, and reminders), creating a tighter loop between live collaboration and asynchronous work.

Actions to enable hybrid work include the following:

- Impose a clear and concise **human resources** (**HR**) policy regarding hybrid working
- Promote a hybrid working method to reduce the daily commute to the office 2–3 days a week, and reduce domestic and international business travel
- Enable digital meetings by leveraging standard software and hardware collaboration tools and file sharing, enabling a better end user experience
- Constantly explore new technologies and ways of working to improve remote collaboration efficiency and effectiveness

There are also many other best practices related to hybrid work, such as enabling workers with the correct ergonomic equipment and tools to work remotely, offering the same possibilities with no different treatment for those working remotely, enabling face-to-face opportunities and spaces, and rearchitecting offices for more social spaces and meetings. The possibilities are endless when reimagining the future of work.

Here are some hybrid work examples:

- Microsoft Mesh for Teams reached general availability in January 2024, letting distributed teams meet in 3D spaces with avatars and spatial audio—used for town halls, onboarding, and design sessions
- Zoom AI Companion (rolled out from September 2023, expanded through 2024) and Google Meet's "Take notes for me" provide auto-summaries, follow-ups, and action items—reducing admin work and making hybrid meetings more inclusive

8: Eco-friendly business travel

While eco-friendly transportation addresses the sustainability of the means of travel, this use case category addresses the need for energy-efficient travel by our employees. As we saw in the hybrid work use case category, IT has generated new opportunities to reduce personal transportation's environmental impact via hybrid work. Informing better choices for the travels we must take also offers the potential for reduced impact. For example, AI-enabled flight-selection interfaces estimate per-itinerary emissions at the moment of choice, allowing travelers to trade a few minutes of travel time for materially lower CO_2e. Upstream of individual trips, agentic meeting-planning optimizers are emerging inside travel programs to minimize total team miles and emissions before a meeting is even scheduled or located. These systems ingest attendee origin cities, live transport networks, and CO_2 factors, then propose the city (or virtual option) that minimizes travel time, cost, and footprint—an approach described by multiple meeting-location optimizers and enterprise deployments (Convien 2024).

Actions to support eco-friendly travel include the following:

- Enable robust and reliable technologies to support remote over physical gatherings to collectively reduce business travel
- Measure and monitor the environmental effects of business travel and seek additional ways to reduce them continuously
- Enable a corporate travel portal that promotes eco-friendly travel and measures each journey's environmental impact
- Provide a **meeting point optimizer (MPO)** tool for finding the optimal location for meetings

Examples of eco-friendly travel include the following:

- Lufthansa Group's Green Fares (launched 2023, expanded 2024) bundle verified **sustainable aviation fuel (SAF)** and high-quality offsets, giving travelers a one-click lower-emissions fare type across European networks.
- United's Sustainable Flight Fund and Eco-Skies Alliance added new corporate partners in 2024 (including Google, Safran, and Technip Energies), channeling capital into SAF production and allowing companies to credibly reduce flight emissions.

- In 2024, Booking.com started showing third-party certifications (e.g., EU Ecolabel, Green Key Global, and Sustonica) directly in its listings and launched tools that guide properties toward certification with tailored checklists and resources. There has since been a 43% increase in certified accommodations displayed on the platform (23,000 in 2024) (Booking.com 2024).

9: Development of e-services

Investing in e-services can increase operational efficiency and minimize environmental impacts by replacing physical manual processes with highly automated digital processes. The development of e-services includes a wide range of use cases, from replacing paper forms to document signing, digital case and document processing, e-archiving, RPA and AI, and virtual twins, to mention a few.

Under the hood, AI is hardening the trust layer that makes paperless processes viable at scale. Europe's Digital Identity Wallet is moving from law to implementation through successive rounds of technical regulations adopted in 2024–2025—enabling cross-border e-signatures and high-assurance logins so AI assistants can complete end-to-end, certified transactions on behalf of users (European Commission 2025). AI systems will not only explain rules, but also assemble the right evidence, detect risk, and finalize transactions—so stakeholders spend less time on paperwork and more time getting things done.

Actions for leveraging and promoting e-services include the following:

- Prioritize the development of e-services that reduce environmental impact and increase operational efficiency
- Replace paper-based forms by enabling documents to be signed digitally, such as employment contracts, customer quotes, supplier contracts, and so on
- Develop IT support for different types of workflows, such as **IT service management (ITSM)**, **customer relationship management (CRM)**, **customer service management (CSM)**, and **supplier relationship management (SRM)**
- Invest in document processing technologies such as e-archives that are connected to your business applications and services
- Automate business processes by leveraging technologies such as RPA and AI

Here are some e-services examples:

- The US **Internal Revenue Service (IRS)** Direct File program let 140,803 taxpayers e-file directly with the IRS during the 2024 pilot and was subsequently announced as a permanent option for the 2025 season (program scope subject to later policy decisions). These digital services reduce paper handling and in-person visits.
- In Spring 2024, the EU adopted the legal framework and brought the European Digital Identity Wallet into force, enabling secure cross-border e-services and qualified electronic signatures—accelerating paperless public services and private-sector KYC.
- DocuSign launched AI-powered liveness/ID verification in 2023, improving assurance for remote, high-trust agreements and reducing manual checks.

10: PaaS

More and more, our lives are rapidly transitioning to the consumption of digital services. They commonly fulfill three basic needs: what we need, when we need it, and where we need it. Take **Spotify** or **Netflix**, for example, which disrupted their respective industries. We rapidly went from ownership to usership, from buying a physical CD or DVD to streaming a song, movie, or series. Other industries that have been disrupted are the automobile industry, moving from car ownership to mobility/ride share, the technology industry, moving from packaged software to **software as a service (SaaS)**, and manufacturing, moving from machines and devices to selling connectivity or availability. All these services have a common trait: they are circular and can be consumed repeatedly with limited constraints of EOL. Unfortunately, we do not see the same trend with physical products where producers of clothes, food, and electronic equipment digitize their processes. They can undoubtedly modify the consumption model of those goods, moving to, for example, washing machines as a service, clothes as a service, vacuuming as a service, and so on.

As we learned in *Chapter 1*, *Our Most Significant Challenge Ahead*, we have reached a yearly global consumption rate of 100 billion tonnes of materials. Currently, the global economy is only 6.9% circular, leading to an extensive circularity gap (Circle Economy 2025). Less than 10% of the materials—such as minerals, fossil fuels, metals, and biomass—used in a year are refurbished, repurposed, or recycled. Out of the 100 billion tonnes, 93.1% or 93.1 tonnes follow a linear model. We have a tremendous circularity gap, and companies need to rapidly shift from a linear to a circular business model and embrace the subscription economy fully. Some companies are making concerted efforts to bring PaaS to market to achieve their sustainability targets and explore new recurring revenue streams.

Actions to drive PaaS include the following:

- Embrace the subscription economy, developing and maximizing the utility of your products to drive usership over ownership
- Extend the lifecycle of your product portfolio
- Build circularity into tech EOL planning to ensure that raw materials can be recycled and fed back into the sourcing and manufacturing process

Examples of PaaS include the following:

- Watèa by Michelin scaled EV-as-a-service offers (vehicles, charging, energy management, maintenance) for commercial fleets—swapping CapEx for OpEx while cutting emissions and enabling data-driven operations. Volvo Trucks expanded turnkey electric-truck-as-a-service packages (vehicles + charging + service contracts), lowering adoption barriers for heavy-duty fleet electrification.
- Tulu is a service platform that embeds PaaS in residential, student housing, office, and hospitality settings. Rather than encouraging each individual to own seldom-used goods (e.g., robot vacuums, printers, VR headsets, and outdoor gear), Tulu installs on-site kiosks and supports an app through which building occupants can rent these items on demand, resulting in higher utilization rates per product manufactured. Tulu provides usage data back to manufacturers and brands, creating a virtuous feedback loop for better product design (durability, repairability, and lifecycle extension), elevating circular design practices.
- An early predecessor to Tulu's model is Husqvarna, the global Swedish manufacturer of outdoor power products. In 2017, it launched a pay-per-use model in which customers use a mobile app to reserve, pay for, and operate the "tool shed." The sheds are unattended tool lockers with Bluetooth-operated locks. After a tool is returned, an authorized Husqvarna partner services and fully recharges it. In the next section, we will dive deep into a transformation case study on appliance maker Haier, which illustrates the criticality of IT in enabling a circular business model.

Enabling a circular economy

Beyond applying sustainable principles to its own organization, IT can act as a catalyst for a company by providing impactful digital solutions and practices to support strategic business model transformation. Indeed, in many industries involving physical products, most of the carbon footprint is attributable to the actual good or service being produced, with a significant portion happening outside the company via its suppliers' supply chain.

As a result, an impactful way to drive sustainability is to maximize each product's utilization rate, resulting in fewer products and, ultimately, fewer emissions. But how can you then also achieve sustainable growth? By embracing the circular economy, or using **Zuora's** term, the **Subscription Economy®**, to unlock new customer-centric business models. At the heart of the Subscription Economy is the idea that customers increasingly prefer subscribing to the outcomes they want when they want them, rather than purchasing a product with the burden of ownership. The following figure shows the contrast between the steps of an ownership versus a subscription model:

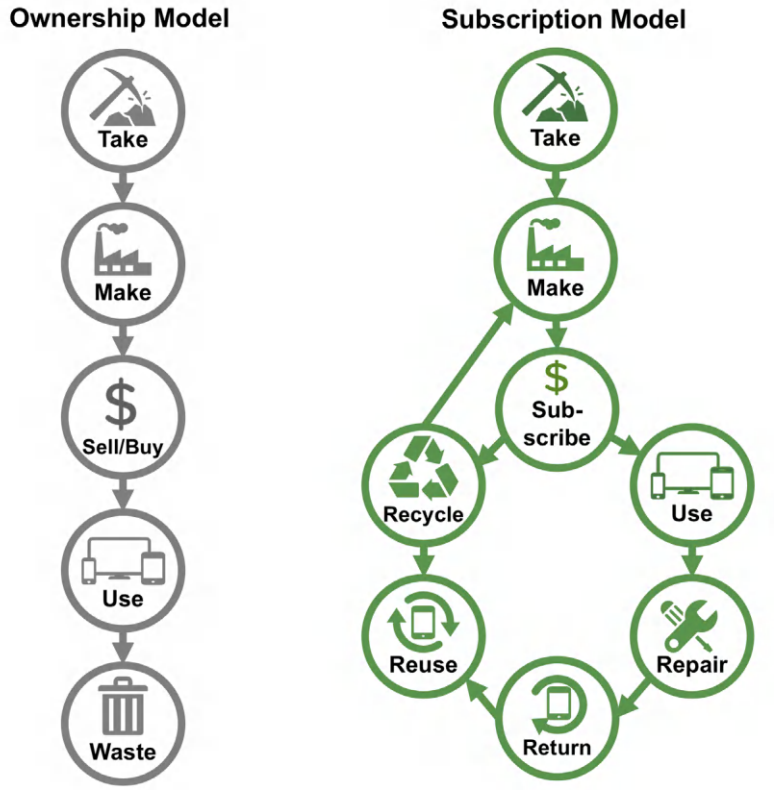


Figure 12.5 – Ownership model and subscription model lifecycles

The subscription economy has taken most industries by storm, start-ups and established companies alike, representing a 593 billion USD market in 2024 and projected to grow 68% to 996 billion by 2028 (Juniper Research 2024). In fact, subscription businesses in Zuora's Subscription Economy Index have experienced 11% faster growth in the past two years compared to traditional businesses (represented by the S&P 500) (Zuora 2025). Let us look at a fascinating case study from Haier and Zuora with all the essential ingredients for transitioning from a linear to a circular economy.

Case study: Reinventing laundry through Haier's circular subscription model

Haier's **WashPass** case study illustrates how a virtuous circular business model can be propelled by a customer-centric recurring revenue model, powered by IoT, AI, and service design.

The case study presented next is authored by **Francesco Del Bello**, **Leader of WashPass**, and **Michael Mansard**, **Principal Director of Subscription Strategy and EMEA Chair of the Subscribed Institute at Zuora**. The case study reflects the authors' personal opinions and experiences and should not be interpreted as representing the position of their employer or any other entity:

> The Vimercate, Italy-based Haier Europe is part of the Haier Smart Home of Qingdao, Shandong, China. In 2023, the company achieved revenues of approximately €33.6 billion. In Europe, under their high-end appliance brands, including Candy, Hoover, and Haier, they are designing the new era of living by offering their household solutions and scenarios to over 45 markets in Europe and beyond. Haier leverages Zuora, a monetization platform to build, run, and grow a modern business through a dynamic mix of usage-based models, subscription bundles, and everything in between. More than 1,000 customers around the world, including BMC Software, Box, Caterpillar, General Motors, The New York Times, Schneider Electric, and Zoom, leverage Zuora to transform their financial operations and how they go to market.
>
> **The hidden costs of a clean load**
>
> For decades, home appliances were hailed as symbols of modern progress, a source of liberation that promised to reduce the drudgery of household chores and increase leisure time. But this convenience has come at a significant and often hidden cost, locking consumers and manufacturers into a wasteful cycle. The clothes washing machine is a ubiquitous household workhorse, with over 200 million units in Europe alone, found in 92% of households and running, on average, 3.8 wash cycles per week (European Environment Agency 2025). Despite being durable goods that consumers expect to last over a decade, they are often replaced after just eight years.
>
> The reason for this premature "retirement" is simple: under the traditional sales model, repairing a broken machine is too often seen as difficult or expensive. With short warranties and replacement parts that can be costly or hard to find, many owners simply junk a faulty machine and buy a new one. This decision cycle fuels a throwaway culture and contributes significantly to our growing mountains of waste.

The environmental impact of washing machines remains significant during their operational life: roughly three-quarters of a washer's total impact across its life occurs not in the factory but in the home, during its use phase. Globally, laundry consumes about 19 billion cubic meters of water and emits 62 million tonnes of CO_2-equivalent emissions annually from electricity use. The single most energy-intensive part of the process is heating the wash water, which can account for up to 60% of laundry's carbon footprint (National Geographic n.d.).

Finally, this environmental toll is compounded by incorrect user habits. Incorrect wash programs often lead to rewashes, while nearly 30% of households use more detergent than is necessary. The damage also extends to the clothes themselves: suboptimal washing can cause shrinkage, stretching, and color fading, prematurely sending millions of garments to landfills and incinerators.

In a nutshell, consumers are stuck in a loop that wastes resources, time, and money, creating an unsustainable cycle for both the planet and the consumer.

A perfect storm for a new model

The suboptimal cycle described previously is not just an environmental issue; it creates significant friction for all parties involved. Beyond the sustainability challenges, the traditional, one-time sale of an appliance creates a potential lose-lose scenario for both the consumer and the manufacturer. These friction points are summarized next, focusing on the washing machine, though a similar analysis could be applied to other home appliances:

End customer friction points and challenges	**Appliance vendor friction points and challenges**
Choice paralysis: The vast number of models and technical jargon can be overwhelming.	**Operational complexity**: Managing a high number of models complicates everything from marketing to after-sales service.
High upfront investment: A quality, efficient washer requires a large initial payment that could push many buyers toward cheaper models with higher running costs.	**Pressure on margins**: Inflation and increasing regulations, such as "right-to-repair" laws that require holding parts longer, put pressure on pricing.

Feature fatigue: An overabundance of programs paradoxically leads most people to use only a few settings, resulting in suboptimal washing performance.	**Limited direct user interaction**: Manufacturers have few opportunities to interact with and guide the end user after the initial sale.
Full risk after warranty: Once the warranty expires, the owner bears the entire burden of maintenance and repairs (unless they hedge this risk by paying for an optional warranty extension).	**Difficulty monetizing longevity**: It is difficult to charge a premium for higher quality and longer-lasting products due to consumer price sensitivity.
Consumers face high costs of ownership, inconvenience in upkeep, wasted time, and uncertainty about appliance longevity.	Vendors face increased pressure on their margins, which limits their ability to monetize the value of high-quality, long-lasting products.

Table 12.1 – Challenges of the traditional appliance ownership model

This collection of challenges makes washing machines the ideal entry point for circular innovation. The prevailing linear model of "take, make, dispose" is not just environmentally costly but economically suboptimal.

Fortunately, this push for a new model is supported by strong demand-side trends:

- **Shifting consumer values**: Multiple recent studies from McKinsey, Bain, and PwC show that customers are increasingly willing to pay more for environmentally friendly and durable goods. This uplift typically ranges from 6% to 12%, depending on product category and country.
- **The growth of subscriptions**: Companies with recurring revenue models are seeing 11% faster revenue growth than the broader economy, according to Zuora's Subscription Economy Index. This model removes the barrier of high upfront costs, giving consumers affordable access to the latest, most efficient appliances. It also fosters more direct and recurring relationships between the vendor and the customer.
- An analysis by the Ellen MacArthur Foundation found that if a company switched to a service model for washing machines, customers could save about a third of the cost per wash, and the manufacturer's profit per unit would increase by about a third as well. Value is extracted from using products longer, not just from selling more of them.

This confluence of a challenged legacy model and rising consumer demand for sustainability and access over ownership sets the stage for a paradigm shift—one that resolves these pain points by aligning the interests of the manufacturer, the customer, and the environment.

From products to outcomes: the WashPass model

Haier's WashPass is the concrete answer to the frictions of traditional ownership, turning the principles of a circular, service-based economy into a real-world offering. Instead of selling a physical washing machine, Haier provides customers with the outcomes they desire. The service is built on six pillars that uniquely combine to create this new outcome-based model:

1. **A zero-hassle machine/service combination as a foundation for usership**: The subscription begins with the home installation of a high-performance, specifically designed A-class washing machine. This foundation is backed by ongoing support, including all maintenance and repairs for the full subscription period, eliminating unexpected costs and the hassle of finding a technician.
2. **The always-connected experience via the hOn app**: The service is managed through the hOn app, which connects the appliance in about a minute and acts as the single digital hub for the entire experience. Compatible with Alexa and Google Home, it offers innovative tools such as the **Washing-Lens** function to suggest cycles by scanning garment labels, and **Eco-Schedule** to plan washes based on energy contracts. The app also continuously monitors the machine's condition, sending helpful alerts when maintenance is needed.
3. **Intelligent dispensing of disaggregated chemistry**: One of the core reasons why the WashPass connected ecosystem delivers superior washing performance is its uniquely designed process of disaggregated chemistry, developed with detergent-maker Nuncas. Instead of a single pre-mixed detergent, the system uses four distinct active ingredients—a stain remover, a delicates-friendly detergent, a super degreaser, and a fabric finisher—stored in separate cartridges (*Figure 12.6*). The machine's built-in AI blends and doses the precise amount of each ingredient based on the load's specific needs. Independent tests show this smart approach enables highly effective washing at low temperatures and can achieve up to 70% improved cleaning performance.



Figure 12.6 – Haier clothes washer with automated dispenser cartridges for custom application (source: Haier)

4. **Automated replenishment**: The system's intelligence monitors ingredient levels and automatically reorders supplies before they run out, delivering them directly to the customer's door.
5. **Transparent pricing**: This entire end-to-end service is made through a simple, all-encompassing subscription model. After an initial one-time payment of €150, customers pay an accessible monthly fee based on usage.
6. **Closing the loop with circular design**: Because Haier retains ownership of the appliance, it has full control over its lifecycle and a vested interest in its longevity. The company monitors the health and performance of each machine via IoT sensors – enabling predictive maintenance. When a unit is returned, it can be refurbished for another customer or, if at the end of its life, properly recycled by Haier while gathering useful components.

From a business perspective, the model creates steadier recurring revenue and fosters long-term customer relationships. This, in turn, means Haier has a vested interest in designing a "service-oriented" washing machine that maximizes customer uptime and its own operational efficiency. By designing machines for modular maintenance and leveraging an in-house service network, Haier can significantly reduce its cost-to-serve while extending the usable life of each unit. This approach also aligns with emerging policy directions, such as the EU's ecodesign regulations that require manufacturers to stock spare parts for up to 10 years.

To validate the sustainability benefit scientifically requires a detailed **Life Cycle Assessment (LCA)**, comparing the circular model against a conventional one. The LCA analysis was made by Capgemini, an AI-powered global business and technology transformation partner. The assessment followed rigorous international standards (UNI EN ISO 14040 and 14044), alongside the **Environmental Footprint 3.0 (EF 3.0)** method for impact characterization, normalization, and weighting. The analysis adopted a "cradle to grave" approach, assessing the environmental impact across the six stages of the product and service lifecycle, from the extraction of raw materials to the final EOL disposal. When quantified, the efficiency differentiators of the subscription model resulted in 26% lower CO_2-equivalent emissions and 43% lower impact on land use.

The journey to date and the lessons learned

The journey of bringing Haier's WashPass to market offers several powerful lessons for technology and business leaders aiming to drive sustainable innovation:

- **A supportive culture is fertile ground**: A deep-seated focus on customer-centricity allowed the team to design a service around solving real-world problems, while an entrepreneurial culture gave Haier license to test, learn, and operate outside the traditional product sales model.
- **Turn complexity into simplicity with tech**: Counterintuitively, the WashPass model succeeds by adding complexity, but it does it behind the scenes. Any circular model will depend on an integrated digital backbone combining customer interaction, payment models, usage monitoring, and service orchestration. In this case, Haier relied on IoT telemetry to monitor machine health, optimize performance, and manage end-of-life recovery.

- **Rethink core processes and communicate relentlessly**: Launching a service model is, as any leader would expect, not just a technological challenge; it is also an organizational one. The WashPass team continuously communicated internally to what extent this new model was different, clarifying which existing processes or capabilities could be reused and which—such as logistics—needed to be rethought entirely. A logistics network geared toward shipping pallets to retailers (B2B) is fundamentally different from one designed to manage home delivery, installation, and reverse logistics for individual consumers (B2C). Accordingly, IT leaders must align enterprise systems (ERP, CRM, and SCM) with circular processes such as reverse logistics, refurbishment tracking, and usage-based pricing.
- **Integrate ecosystems through partner enablement**: Haier partnered with Nuncas for disaggregated detergents and with Zuora for subscription management. IT leaders should architect open, API-driven systems that facilitate collaboration among ecosystem partners, suppliers, and logistics providers. Circular models rarely succeed in isolation; they require interoperable systems for shared accountability across the value chain.

In conclusion, Haier WashPass is a forward-looking example of how sustainability and digital innovation intersect. It addresses a clear environmental challenge – e-waste and suboptimal resource use – with a solution that is both high-tech and deeply customer-centric.

Francesco Del Bello, Leader of WashPass, Haier

and

Michael Mansard, Principal Director of Subscription Strategy and EMEA Chair of the Subscribed Institute at Zuora

The WashPass case demonstrates that circular business models are digitally enabled. Without IoT, AI, data integration, and digital customer platforms, the subscription-based, outcome-focused service would not be possible. IT leaders should view themselves not only as technology stewards but as strategic enablers of this type of business model innovation.

Case study: AI and remanufacturing at Nordic truck company

Another circularity case study, with AI as an enabler, comes from IFS, a leading provider of Industrial AI and enterprise software. **Sophie Graham**, **IFS CSO**, describes how the company's technology enables businesses that manufacture goods, maintain complex assets, and manage service-focused operations to unlock the transformative power of Industrial AI™. The results deliver the highly desired three-way impact of enhanced productivity, efficiency, and sustainability.

> A Nordic truck manufacturer is leveraging IFS technology to advance remanufacturing as a core part of its circular economy strategy. The group is committed to remanufacturing and recycling as core strategies to reduce energy consumption, cut CO_2 emissions, protect resources, and eliminate waste. The company uses IFS software to manage and analyze processes across multiple remanufacturing centers globally, maximizing the value chain and supporting its circularity goals.
>
> The automotive and heavy equipment sectors face pressure to reduce waste and emissions and to conserve resources. Remanufacturing components is key to extending asset lifecycles and supporting the circular economy, but scaling these operations requires precise coordination and real-time visibility. Maximizing the return of used parts ("cores") for remanufacturing is essential, as is optimizing the salvage grade and quality of remanufactured products.
>
> The company's remanufacturing team leverages IFS technology to visualize historic data, optimize remanufacturing processes, and determine necessary new components to maximize quality and efficiency. IFS enables the company to manage complex logistics, coordinate resources, and track sustainability metrics across its global network. The solution supports industrial-scale dismantling operations, further increasing the supply of cores for remanufacturing and scaling circularity efforts.
>
> These are the key results and proof points:
>
> - Remanufactured truck gearboxes and engines are delivered with roughly 50% of the CO_2 footprint of producing new ones, and require 80% less energy
> - In 2021, the manufacturer produced around 5,000 remanufactured engines and 11,300 remanufactured transmissions, with ambitions to increase annual remanufactured part sales by 60% by 2025 compared to 2018

- Virtually all metal scrap from truck production is recycled or reused, further reducing waste
- Remanufactured components are delivered with the same or higher quality as new, with full warranty and often at a better price
- Electrification is driving growth: it is the first manufacturer to have all-electric heavy goods vehicles in serial production, with a target for at least 35% of global truck sales to be electric by 2030
- IFS technology helps maximize the value chain, optimize salvage grade, and support circularity at scale

The group's approach is rooted in the 9R framework: Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, and Recover (see *Chapter 9*, *IT Hardware Management*, for more on this framework).

The company's experience demonstrates how AI and digital transformation can drive positive, sustainable change. By embedding remanufacturing into its core business, it is reducing emissions, conserving energy, and supporting the circular economy, delivering value for customers, the environment, and the business alike.

Sophie Graham, CSO, IFS

The need to increase the pace of innovation

Although much of the technology used to build sustainable solutions exists today, we need to increase the pace of innovation in creating real solutions for the UN SDGs. Most expect AI to be a key accelerator in innovation. Indeed, this is typically cited as the payback that will offset AI's current negative impacts on the environment. But AI is only a tool. We must also bridge the gap between the private and public sectors and bring different actors, from corporations, academia, governments, and citizens, to co-create citizen-driven innovation. One way to do so is to take advantage of the concept of hackathons, both within our companies and on a global scale. In the next section, we will highlight examples of AI's role in accelerating sustainability-driving innovation. Then, you will hear from **Wiebren van der Zee, Sustainability Domain Expert, Sustainable IT, Office of the CIO at ABN AMRO Bank in the Netherlands**, who describes a sustainability hackathon held at the bank. **Then, Ann Molin, General Secretary of the Hack for Earth Foundation**, will share how her non-profit organization creates global hackathons that generate real-world solutions linked to the UN SDGs.

AI is compressing discovery cycles from years to weeks by pairing machine learning with automated experimentation. "Self-driving labs" can design experiments, run them robotically, learn from results, and iterate—shrinking the trial-and-error loop in materials, chemistry, and device research while using fewer reagents and less energy (ACS Publications 2024).

Tangible wins are already emerging in the field of energy and materials discovery, where AI and high-performance computing are transforming how new substances are designed and tested. In early 2024, Microsoft and the US Department of Energy's Pacific Northwest National Laboratory demonstrated this potential to accelerate the search for next-generation battery materials. Their system analyzed data on 32 million potential compounds in just 80 hours, applying ML models to identify a small subset of promising solid-state electrolytes—materials that conduct ions in solid-state batteries, offering higher safety and energy density than conventional liquid electrolytes. Subsequent laboratory validation confirmed a newly discovered material that could significantly reduce lithium content without sacrificing performance (Microsoft 2024). This breakthrough illustrates how AI, when integrated with powerful computational infrastructure, can shrink the experimental search space from millions of theoretical options to a few viable candidates in days instead of years.

On the climate and grid side, generative and graph-neural models are redefining how fast we can foresee—and act on—weather and climate signals. NVIDIA Earth-2 couples AI downscaling with accelerated simulation to produce kilometer-scale forecasts useful for wind, solar, and flood risk planning (NVIDIA 2024). Google's Flood Hub applies AI to deliver flood warnings up to seven days ahead. By the end of 2024, Google's flood forecasts covered over 700 million people in more than 100 countries, including data-sparse regions (WorldPop 2025).

In design and manufacturing, GenAI is opening vast design spaces and converging to lighter, stronger, and more material-efficient parts—outcomes that lower embodied carbon and operating energy. Airbus's "bionic partition," developed with generative algorithms and additive manufacturing, is 45% lighter than conventional cabin partitions while meeting safety requirements (Autodesk 2025). In another example, Siemens utilized AI-powered generative design tools to reduce by up to 90% a robotic gripper's weight and also decrease its constituent parts by 84% (Siemens 2024).

NASA's Goddard Flight Facility Center uses generative design and digital manufacturing to automate and optimize the development of spacecraft and science instrument structures, which has reduced development time/cost by 10x (NASA 2025). The integration of AI into product design is emerging as a pivotal strategy for companies aiming to enhance sustainability while driving innovation.

Innovating with hackathons

A hackathon is an innovation competition. For a limited time, often between 24 and 48 hours, participants—so-called hackers—gather and work intensively on a challenge. These challenges are created before the competition and are usually formulated as questions. The participants work in teams, where different skills complement each other. The goal is to create new digital solutions. Hackers often have open data (information that can be freely shared and reused; see a further description in the next paragraph) as raw material. A jury selects the best solutions based on several criteria, and after the award ceremony, the competition is over.

IT sustainability hackathons have been held at ABN AMRO Bank since 2023. Details on their design, execution, and outcomes are provided next by **Wiebren van der Zee**, **Sustainability Domain Expert**, **Sustainable IT**, **Office of the CIO.**

Case study: ABN AMRO's sustainability hackathon

At ABN AMRO Bank, we organized the **Sustainable IT Hackathon** in early 2023. It was an experimental and collaborative event to drive down the energy use and carbon footprint of enterprise applications. The hackathon originated from a cross-departmental dialogue between our sustainable IT team and ABN AMRO's mortgage business unit—a department with a significant digital footprint due to the volume and complexity of its application landscape. The idea was to challenge DevOps teams to actively reduce the energy use of selected applications through focused interventions and creative problem-solving.

The hackathon was a 2-day event involving approximately 150 participants (mostly from IT staff and a few from business) organized into 10 teams. Each team, composed of product owners and their selected DevOps engineers, was tasked with choosing one or two applications from their portfolio to target. Our core objective was to optimize those applications to consume less energy, minimizing data and compute resources, and thereby minimizing carbon emissions.

Importantly, the hackathon wasn't just a theoretical exercise. The bank's sustainable IT team had previously implemented real-time monitoring and dashboarding tools to track energy use per application for production as well as development environments. This allowed for transparent measurement of each team's progress over the course of the event. Teams applied changes across the development stack, from infrastructure and code efficiency to data usage and frontend performance, and received immediate feedback on their impact via the energy dashboards.

Format and support

Participants were fully supported throughout the hackathon. Our leadership granted official time for the effort, freeing participants from regular business tasks. Our sustainable IT team of four specialists was on hand to assist teams, answer questions, and offer inspiration.

The sustainable IT team provided a comprehensive toolbox containing sustainable IT tactics and best practices. These included strategies such as dynamic resource scaling, moving from virtual machines to serverless computing, shutting down unused development environments, simplifying frontend graphics, reducing data transfers, and identifying redundant logging and dark data.

To keep the experience engaging, the hackathon adopted a cinematic theme. Teams were encouraged to visualize the challenge using movie metaphors—such as *software is eating the world* and *zombie movies* representing unused compute or data, and disaster movies such as *Don't Look Up* and *Armageddon* as analogies for climate urgency. This added a playful yet purposeful energy to the event, helping participants connect emotionally with the mission.

Evolution of the hackathon

The hackathon produced tangible results in terms of resource savings and heightened awareness. However, the scale of the event, requiring 150 people to disengage from their daily roles, posed challenges for replication. In response, the program evolved into a shorter, more scalable format.

Our next iteration was called "Grid boosting," which allowed smaller agile teams (referred to as "Grids") to run mini hackathons independently. These took place throughout the rest of 2023 and 2024, retaining the hackathon's core principle of applying sustainability tactics to reduce digital emissions but on a more manageable scale.

> By 2025, the program matured into "We Green IT," a structured, ongoing initiative where DevOps teams commit to sustainability improvements as part of their regular sprint cycles. Teams propose use cases, implement improvements, and have their results tracked via "impact dashboards" showing energy and carbon metrics. A gamification layer was added: the most impactful team each quarter receives recognition and awards, fostering a culture of friendly competition and continuous improvement.
>
> *Wiebren van der Zee, Sustainability Domain Expert, Sustainable IT, Office of the CIO, ABN AMRO*

ABN AMRO Bank's hackathon demonstrates best practices that transcend employee engagement. It highlighted the importance of developer empowerment, operational visibility, and creative framing. Moreover, it showed that sustainability can be embedded into agile workflows—not just as an afterthought, but as a core engineering responsibility.

Traditionally, as at ABN AMRO Bank, a hackathon is a programming competition where the majority of the participants are programmers, developers, or, in some other way, technically savvy. However, the hackathon concept can also be applied in other contexts to drive development and create embryos for new solutions quickly. A hackathon can also be an excellent activity to gather skills from widely different areas, to facilitate that competence from one area cross-fertilizes another, a concept that has been tested within the framework of the **Hack for Earth** program. Hack for Earth began as a government initiative in Sweden called Hack for Sweden. What set it apart from the beginning was its unexpected leadership: a psychologist, Ann Molin, brought a unique human-centered lens to innovation. Her curiosity about human potential and communication shaped a new way to use hackathons: as platforms for inclusion, innovation, and real-world impact. Since its global launch in 2021, the Hack for Earth movement has engaged over 25,000 participants from 125 countries, making it one of the largest citizen-driven innovation movements of its kind. In this case study, the organization's **CEO, Founder, and Secretary General**, **Ann Molin**, describes the methodology and current state of her program:

Case study: Harnessing citizen-driven innovation – the Hack for Earth method

What is the Dream! Hack! Build! method?

The Dream! Hack! Build! method is more than a sequence of events. It is a philosophy and methodology for inclusive innovation. By guiding participants through the phases of challenge creation (Dream), prototyping (Hack), and scaling (Build), organizations create not only solutions but sustainable innovation cultures.



Figure 12.7 – Hack for Earth innovation process: Dream-Hack-Build

Let's explore each phase in depth.

Dream: Creating the challenges

The Dream phase is where curiosity meets purpose. This is not an inclusive campaign to gather dreams to create challenges from diverse voices. In Hack for Earth, this has taken the form of global campaigns such as Dream for Earth, where citizens from over 120 countries submitted ideas for solving urgent societal issues.

Key tools in the Dream phase include the following:

- Open calls for ideas
- Strategic alignment with the UN's 17 **Sustainable Development Goals (SDGs)**
- Digital platforms for idea submission and community engagement

Technology leaders can apply this phase by launching internal "dream" initiatives, asking employees, customers, or partners: What is your dream for our company for a better future? The responses become the foundation for hackathon challenges.

Hack: Co-creating sustainable solutions

The Hack phase is the dynamic core of the method – the hackathon itself. It is an open, time-boxed event where multidisciplinary teams co-create solutions to the challenges identified in the Dream phase.

What distinguishes the Hack for Earth hackathons is their emphasis on diversity and impact. These events intentionally welcome non-technical participants, ensuring that business strategists, designers, communication experts, community advocates, and technologists collaborate on equal terms.

Critical elements of a hackathon include the following:

- Curated challenges based on real-world insights
- Mentors from relevant sectors (e.g., tech, policy, sustainability)
- Evaluation criteria that value diversity, storytelling, and impact
- A strong communication strategy that builds community and visibility

Hackathons can be internal (to foster cross-functional collaboration) or external (to engage customers and the public). Regardless of the audience, the Hack phase empowers people to become active problem-solvers rather than passive stakeholders.

Build: Turning prototypes into real-world impact

The Build phase is where many other hackathon models falter. Great ideas are generated, but few survive beyond the prize ceremony. The Hack for Earth Foundation solved this with Build for Earth, a structured acceleration program based on science that helps winning teams bring their solutions to life.

The Build for Earth program offers the following:

- A 6-month acceleration program
- Mentorship from industry experts and sustainability leaders
- Workshops and lectures in business planning, communication skills, partnerships, financing, and more
- Support in marketing, branding, and impact measurement
- Psychological safety and leadership development for the teams and the team leaders

The Build for Earth program is based on scientific research, integrating principles of psychological safety, transformational leadership, and effective team dynamics. This evidence-based approach ensures that the teams can thrive and bring sustainable innovations to market.

By focusing on execution, Build for Earth ensures that winning teams transition from prototype to viable product or service. Projects such as **BrightAct** (a digital tool for domestic violence intervention) and **Recy-Block** (building materials from recycled plastic) illustrate the program's potential to deliver real-world solutions.

Technology leaders can implement this phase by integrating their own incubation or acceleration programs or partnering with platforms such as Build for Earth. The key is continuity: teams need post-hackathon support to develop, test, and scale their innovations.

Applying the method in your organization

Any organization can adopt the Dream! Hack! Build! method. Here's how:

1. **Start with purpose**: Identify your organization's sustainability goals. Use the SDGs to frame your **massive transformative purpose** (**MTP**).
2. **Engage your ecosystem**: Launch a Dream campaign internally or externally. Gather challenges and dreams from employees, customers, and communities.
3. **Host inclusive hackathons**: Plan hackathons that are accessible, diverse, and challenge-based. Support them with mentors, inclusive team formation, and hybrid formats.
4. **Support beyond the event**: Create or align with an acceleration mechanism. Offer funding, mentorship, and visibility for teams with promising solutions.
5. **Measure and communicate impact**: Track results, communicate success stories, and integrate the best solutions into core business strategies.

This method not only generates innovative ideas but fosters a culture of empowerment and experimentation. It is especially relevant for organizations seeking to operationalize sustainability across their digital and strategic functions.

Further reading: The Dream! Hack! Build! book

For technology leaders looking to go deeper, we highly recommend reading *Dream! Hack! Build! – Unleash Citizen-Driven Innovation with the Power of Hackathons* (Packt Publishing 2024). Launched during Climate Week NYC 2024, the book is a comprehensive playbook on how to do the following:

- Design and execute impactful hackathons
- Align innovation activities with global sustainability goals
- Create inclusive innovation environments
- Transition from ideas to scalable, sustainable solutions

The book offers real-world case studies, expert insights, and actionable frameworks to help you apply the Dream! Hack! Build! method in your organization.

Whether you're a CIO, innovation lead, or sustainability strategist, *Dream! Hack! Build!* is a powerful companion to this playbook. Together, they offer a holistic roadmap for building a sustainable future through collaborative innovation.

There is no other future than a sustainable future, so let's build it together.

Ann Molin, Founder and Secretary General of Hack for Earth Foundation

A common problem reported by the private and public sectors is that innovation happens in fenced-off silos with minimum collaboration between crucial actors such as corporations, academia, governments, and citizens. Hackathons, or the "ideathon," which allows teams to submit idea-based projects without having to do any coding, are great ways to infuse citizen-driven innovation to create global, scalable, and sustainable solutions. Hopefully, the case study from Hack for Earth Foundation will inspire you to arrange your hackathons either within your company or open to the public, or why not get involved with the foundation itself and leverage the global innovation platform that has been built, connecting critical stakeholders around the world, including the UN?

Summary

Now that we have reached the end of this chapter, you should hopefully have a better insight into how IT can unlock different opportunities to develop or leverage sustainable solutions for companies, industries, and sectors. We looked at 10 specific use case categories, suggested key actions, and offered current examples of clean and sustainable technology use cases.

Furthermore, you saw how the trend of moving from ownership to usership unlocks several sustainable circular opportunities in a wide range of industries, including durable goods manufacturing. Now, you should also have a better feel for how hackathons work to spark innovation, both within your company and across verticals. You now have a wealth of examples to apply sustainable solutions and develop new sustainable circular products and services. Some summary recommendations include the following:

- Prioritize IT-driven innovations that can decarbonize operations, reduce resource use, and enable circularity across the enterprise.
- Operationalize carbon and ESG reporting with reliable processes and systems (CEM platforms, audit trails, and supplier data pipelines) to meet CSRD, SEC, and other disclosure requirements.
- Equip boards and CSOs with geospatial, AI, and IoT insights to address physical risks as well as transition risks from regulatory shifts.
- Mandate supplier transparency on circularity criteria.
- Adopt Industry 4.0 technologies to track materials, energy, and water use in real time, and design for recyclability and circular loops.
- Plan for full fleet electrification and engage in SAF or green shipping programs. Leverage supply chain planning tools and IoT fleet management to reduce emissions and optimize routes.
- Retrofit and design facilities to meet LEED/zero-carbon standards. Deploy IoT controls, smart tariffs, geothermal and renewable integration, and submetering for visibility and efficiency gains.
- Facilitate hybrid and remote work experiences, AI assistants, and immersive tools.
- Expand e-services with digitalization of paper-based processes and invest in secure, AI-powered digital identity and signing tools.
- Transition from selling products to providing outcomes. Build subscription and usage-based models that maximize asset utilization, extend product lifecycles, and close material loops.
- Foster innovation through hackathons and partnerships that generate citizen-driven solutions to the UN SDGs. Ensure winning ideas are scaled via incubation or acceleration programs.

- Adopt SustainableIT's taxonomy to measure IT's role in enabling enterprise sustainability (e.g., hybrid workforce enablement, eco-friendly travel, facility energy/emissions). Use these metrics to benchmark progress and ensure alignment with ESRS, GRI, and SDGs.

This chapter marks the end of the book's "*what*" section. In the following three chapters, why will start exploring the "*how*" by assessing our sustainable IT maturity, establishing a GHG emission baseline, creating a sustainable IT strategy, and turning your strategy into action.

Appendix: Standard metrics for sustainability by IT

SustainableIT's taxonomy mainly provides metrics for IT enablement of enterprise sustainability categories, including a paperless model, virtual meetings that reduce travel, and hybrid workforce enablement (SustainableIT.org 2024).

Category	**Topic**	**Metric**	**Related Global Standards**
SIT EE 100 Energy, Enterprise	EE 110 Enterprise facility energy consumption (green buildings)	EE 110-1 kWh by location, time of day, facility, sq. meters	GRI 302-1, 2, 3 ESRS E1 SDG 7, 9, 13, 17
		EE 110-2 Percentage renewable: Solar, wind, geothermal, hydropower, tidal, biomass	
		EE 110-3 Percentage of square meters certified	
	EE 120 Hybrid workforce enablement	EE 120-1 kWh by location, by ratio of remote to office workers	
	EE 130 Enterprise manufacturing energy consumption	EE 130-1 kWh by location, time of day, facility, sq. meter	
		EE 130-2 Percentage renewable: Solar, wind, geothermal, hydropower, tidal, biomass	
		EE 130-3 Percentage of square feet that are certified green (e.g., in LEED-certified)	

Category	Topic	Metric	Related Global Standards
SIT EE 200 Emissions, Enterprise	EE 210 Virtual meetings enablement	EE 210-1 Metric tonnes of CO_2 for meetings travel by number kilometers, by number trips, per employee	ESRS E1, E2 SDG 7, 9, 13, 17
	EE 220 Enterprise facilities emissions	EE 210-2 Metric tonnes of CO_2 saved/avoided per FTE, over time period enabled by virtual meeting tools and capabilities	GRI 305- 1, 2, 3 ESRS E1, E2 SDG 7, 9, 13, 17
		EE 210-3 Percentage of major corporate meetings that are virtual	
		EE 220-1 Metric tonnes of CO_2, by location, over time period	
		EE 220-2 GHG intensity ratio that expresses the impact of GHG emissions per unit of economic value (e.g., metric tonnes of CO_2 per unit of total revenues or per unit of production)	
		EE 220-3 Percentage of smart office space (smart, green building space)	
	EE 230 Eco-friendly business travel	EE 230-1 Percentage of efficient travel (kilometers, trips per FTE)	GRI 305-3 ESRS E1, E2 SDG 7, 12, 13, 17

Category	Topic	Metric	Related Global Standards
SIT EE 200 Emissions, Enterprise	EE 240 Enterprise transportation Scope 1 emissions (i.e., enterprise direct use of road, rail, air, marine; Scope 2, 3 are included in procurement and supply-chain emissions)	EE 240-1 Metric tonnes of CO_2, by location, mode, over time period	GRI 305-1; SASB TR-RO-110a, TR-MT-110a, TR-RA-110a, TR-AF-110a ESRS E1, E2 SDG 7, 9, 13, 17
		EE 240-2 Percentage of fleet that is electric and hybrid	
	EE 250 Procurement Scope 2 and 3 emissions (e.g., purchasing, shipping, transport)	EE 250-1 Metric tonnes of CO_2 per unit procured, by item type, provider, location, over time period	
SIT EE 300 Waste, Enterprise	EE 310 Water consumption	EE 310-1 Water consumption enterprise facilities	TC-IM-130a.2 TC-SI-130a.2 GRI 303-1,2,3,4,5 ESRS E3 SDG 9, 12, 13, 17
		EE 310-1.a Megaliters withdrawn by location, water source, over time period	
	EE 320 Paperless enterprise enablement	EE 320-1 Percentage of enterprise processes that are electronic (paperless), such as transactional, operational, archiving, and other document management processes	SDG 12

Category	Topic	Metric	Related Global Standards
SIT G 300 Risk Management	G 310 Business resiliency/ continuity	G 310-1 Approach to assess and minimize environmental and economic risks to enterprise systems and service continuity	SASB TC-SI- 550.a ESRS G1 SDG 3, 9, 17
		G 310-2 Digital resiliency requirements, assessments, and oversight of key vendors/ providers (e.g., power providers, cloud-hosting providers, and outsourcers)	
		G 310-3 Incidents resulting in business interruption/downtime, and average and cumulative duration, over time period	
		G 310-4 Constituents affected by business interruptions/ downtime, over time period	
		G 310-5 Percentage of essential workers enabled to work remotely or from alternative locations	
	G 320 Enterprise risk management	G 320-1 Enterprise risk governance approach	ESRS G1
		G 320-2 Enterprise risk management practices associated with sustainability (e.g., assessments, education, transparency)	

Table 12.2 – SustainableIT Standards Taxonomy metrics for sustainable sourcing

Further reading

- *Dream! Hack! Build! – Unleash Citizen-Driven Innovation with the Power of Hackathons*. https://www.packtpub.com/en-mx/product/dream-hack-build-9781835086421.
- *Circular Economy and Technological Innovation*. https://link.springer.com/book/10.1007/978-981-96-5650-9.
- Links to CEM tool information, as listed earlier in the chapter:
    - Atos. https://atos.net/en/2023/include-in-isg_2023_12_06/atos-launches-sustainable-digital-workplace-suite-to-help-organizations-reach-csr-goals.
    - Bureau Veritas. https://group.bureauveritas.com/.
    - CarbonChain. https://www.carbonchain.com/.
    - Climate Engine. https://climateengine.com/.
    - Cloud Carbon Footprint. https://github.com/cloud-carbon-footprint/.
    - Compliance & Risks. https://www.complianceandrisks.com.
    - Coupa. https://www.coupa.com/platform/esg/.
    - Cozero. https://cozero.io/.
    - Dream for Earth. https://dreamforearth.com/.
    - Dryad. https://www.dryad.net/.
    - EcoVadis. https://ecovadis.com/enterprise/.
    - Emitwise. https://emitwise.com/.
    - Enhesa. https://www.enhesa.com/corporate-sustainability/.
    - Footprint Intelligence. https://www.footprint-intelligence.com/.
    - Fruggr. https://www.fruggr.io/.
    - GHG Protocol. https://ghgprotocol.org/calculation-tools-and-guidance.
    - Greenly. https://greenly.earth/en-us.
    - Greenpixie. https://greenpixie.com/.
    - Hack for Earth challenges. https://www.hackforearth.com/challenges.
    - How AI can transform sustainability reporting. https://www.weforum.org/stories/2025/09/harnessing-ai-for-sustainability-reporting-path-forward/.

- IBM Envizi. https://www.ibm.com/products/envizi.
- IFS. https://www.ifs.com/solutions/capabilities/sustainability-management-in-ifs-cloud.
- Intertek. https://intertek.com.
- Microsoft Cloud for Sustainability. https://www.microsoft.com/en-us/sustainability/cloud.
- Normative. https://normative.io/.
- OneTrust. https://developer.onetrust.com/onetrust/reference/esg-sustainability-cloud.
- Open Footprint (The Open Group/OASIS). https://www.opengroup.org/openfootprint-forum.
- OpenLCA. https://www.openlca.org/.
- Persefoni. https://www.persefoni.com/.
- Plan A. https://plana.earth/.
- Rejoose. https://rejoose.com/.
- Salesforce Net Zero Cloud Agentforce. https://www.salesforce.com/net-zero/cloud.
- SAP Sustainability Control Tower. https://www.sap.com/products/scm/sustainability-control-tower.htm.
- ServiceNow. https://www.servicenow.com/products/esg-management.html.
- SINAI. https://www.sinai.com/.
- SME Climate Hub. https://smeclimatehub.org/.
- Sphera. https://sphera.com/solutions.
- Sustain.Life. https://www.sustain.life/.
- TCO Certified. https://tcocertified.com/how-to-use/.
- 3E. https://www.3eco.com/.
- UL Solutions. https://www.ulwercsmart.com/.
- Watershed. https://watershed.com/.
- WBCSD PACT/Pathfinder. https://www.wbcsd.org/news/pathfinder-framework-version-2-0/.
- WGBC. https://www.worldgbc.org/.

- Wolters Kluwer Enablon. https://www.wolterskluwer.com/en/solutions/enablon.
- Workiva. https://www.workiva.com/solutions/.

Bibliography

- ACS Publications. 2024. *Self-Driving Laboratories for Chemistry and Materials Science*. https://pubs.acs.org/doi/10.1021/acs.chemrev.4c00055.
- Aksoy, Cevat Giray et al. 2025. *The Global Persistence of Work from Home*. https://static1.squarespace.com/static/5cfdf6cb8acf8600012f8920/t/681e54dc61df856c452e42f2/1746818269157/Global+WFH+2025+PNAS_v3.pdf.
- Autodesk. 2025. *Bionic Partition: The World's Largest 3D-printed Airplane Component*. https://www.research.autodesk.com/projects/bionic-partition/.
- Booking.com. *Booking.com Launches the Next Phase of its Sustainability Program for Accommodation*. Partners. https://news.booking.com/bookingcom-launches-the-next-phase-of-its-sustainability-program-for-accommodation-partners/.
- Bronson AI. 2025. *Waste Reduction in Manufacturing: AI for Predictive Sustainability*. https://bronson.ai/resources/waste-reduction-in-manufacturing.
- California Energy Commission. 2024. *Automated Cloud-Based Continuously Optimizing Energy Management System*. https://www.energy.ca.gov/sites/default/files/2024-05/CEC-500-2024-042.pdf.
- Circle Economy. 2025. *Circularity Gap Report 2025*. https://www.circularity-gap.world/2025.
- Cisco. n.d. *Smart Workspaces*. https://www.cisco.com/c/en/us/about/case-studies-customer-success-stories/bt-group.html.
- ClimateCheck. 2025. *Climate Change Hazard Ratings for Glendale*, AZ. https://climatecheck.com/arizona/glendale.
- Convien. 2024. *How to reduce your CO2 footprint & costs with the Meeting Place Finder*. https://www.convien.com/blog/how-to-reduce-your-co2-footprint-costs-with-the-meeting-place-finder.
- CO2 AI. 2025. *Boosting your bottom line through decarbonization*. https://www.co2ai.com/carbon-survey-2024.

- Economist. 2021. *Reimagining Urban Water Systems*. https://impact.economist.com/sustainability/city-water-index/assets/Economist_Impact_City_Water_Index_optimization_framework_May_2021.pdf.
- European Environment Agency. 2025. *Europe's consumption in a circular economy: the benefits of longer-lasting electronics*. https://www.eea.europa.eu/en/analysis/publications/europes-consumption-in-a-circular-economy-the-benefits-of-longer-lasting-electronics.
- European Commission. 2023. *Cars and Vans*. https://climate.ec.europa.eu/eu-action/transport-decarbonisation/road-transport/cars-and-vans_en#:~:text=With%20stricter%20CO2%20emission,and%20affordable%20zero%2Demission%20vehicles%2C.
- European Commission. 2024. *GHG emissions of all world countries*. https://edgar.jrc.ec.europa.eu/report_2024.
- European Commission. 2025. *The legal and technical road to EU Digital Identity Wallets*. https://ec.europa.eu/digital-building-blocks/sites/spaces/EUDIGITALIDENTITYWALLET/pages/915931903/The+legal+and+technical+road+to+EU+Digital+Identity+Wallets.
- GALLUP. 2025. *The Post-Pandemic Workplace: The Experiment Continues*. March. https://www.gallup.com/workplace/657629/post-pandemic-workplace-experiment-continues.aspx
- Google. n.d. *Check emissions on Google flights.* https://support.google.com/travel/answer/9671620.
- Honeywell. 2024. *Powering Small Business Sustainability: A Honeywell and Dominion Energy Success Story*. https://automation.honeywell.com/content/dam/automation/en/services/smart-energy/documents/hon-ia-sme-dominion-energy-case-study.pdf.
- Husqvarna. 2017. *Husqvarna pilots pay-per-use and brings chainsaws and hedge trimmers into sharing economy. May 10, 2017*. https://www.husqvarnagroup.com/en/news/husqvarna-pilots-pay-use-and-brings-chainsaws-and-hedge-trimmers-sharing-economy.
- Johnson Controls. 2024. *Performance contract helps Cobb County government upgrade and cut utility costs by more than $2 million*. https://www.johnsoncontrols.com/building-insights/2024/case-study/cobb-county.
- Juniper Research. 2024. *Global Subscription Economy Market: 2024-2028*. April. https://www.researchandmarkets.com/reports/5976638/global-subscription-economy-market.

- Jupiter Intelligence. 2025. *Climate Risk: Logistics and Industrial Outlook*. https://www.jupiterintel.com/resources#:~:text=Climate%20Risk:%20Logistics%20and%20Industrial,from%20acquisition%20to%20asset%20management.&text=This%20is%20some%20text%20inside%20of%20a%20div%20block.,-May%2022%2C%202025.
- Journal of Urban Economics. 2023. *JUE Insight: Powering work from home*. https://www.stevecicala.com/papers/powering_wfh/powering_wfh.pdf.
- Martella, Roger. 2022. *How businesses are taking the lead to get the world to net-zero*. https://www.weforum.org/agenda/2022/05/global-sustainability-corporations-lead-net-zero?utm_source=linkedin&utm_medium=social_video&utm_term=1_1&utm_content=26085_Google%27s_new_campus_+zero-carbon&utm_campaign=social_video_2022.
- MDPI. 2025. *AI-Enabled Sustainable Manufacturing: Intelligent Package Integrity Monitoring for Waste Reduction in Supply Chains*. https://www.mdpi.com/2079-9292/14/14/2824.
- Microsoft. 2024. *Discoveries in weeks, not years: How AI and high-performance computing are speeding up scientific discovery*. https://news.microsoft.com/source/features/innovation/how-ai-and-hpc-are-speeding-up-scientific-discovery.
- Musaab Almulla, Samah El-Shahat, and Nan Zhou. 2022. *What is 'materials transition' and why is it critical for a net-zero future?* https://www.weforum.org/stories/2022/06/materials-industries-net-zero/.
- NASA. 2025. *Generative Design*. https://etd.gsfc.nasa.gov/capabilities/capabilities-listing/generative-design/.
- National Geographic. n.d. *Laundry: lightening the load*. https://www.nationalgeographic.com/environment/article/partner-content-laundry-lightening-the-load#:~:text=that%20make%20our%20lives%20easier%2C,electricity%20usage%20associated%20with%20laundry.
- Nature. 2021. *Trend towards virtual and hybrid conferences may be an effective climate change mitigation strategy*. https://www.nature.com/articles/s41467-021-27251-2
- NVIDIA. 2024. *NVIDIA Announces Earth Climate Digital Twin*. https://investor.nvidia.com/news/press-release-details/2024/NVIDIA-Announces-Earth-Climate-Digital-Twin/default.aspx#:~:text=March%2018%2C%202024,in%20traditional%20CPU%2Ddriven%20modeling.
- NVIDIA. 2024. *How Generative AI is Empowering Climate Tech with NVIDIA Earth-2*. https://resources.nvidia.com/en-us-sustainable-computing/how-generative-ai-is#:~:text=Democratizing%20AI%2Dweather%20and%20enabling,for%20everyday%20planning%20and%20safety.

- Schneider Electric. 2025. *Carrefour Egypt: Customer Story Key Figures*. https://www.se.com/ng/en/work/campaign/life-is-on/case-study/carrefour.
- PNAS.org. 2023. *Climate mitigation potentials of teleworking are sensitive to changes in lifestyle and workplace rather than ICT usage*. https://www.pnas.org/doi/10.1073/pnas.2304099120.
- Shop Architects. 2022. *Uber HQ*. https://www.shoparc.com/projects/uber-hq/.
- Stanford. 2025. *Working from Home in 2025: Five Key Facts*. https://siepr.stanford.edu/publications/essay/working-home-2025-five-key-facts.
- Shyalika, Chathurangi, et al. 2025. *SmartPilot: A Multiagent CoPilot for Adaptive and Intelligent Manufacturing*. https://arxiv.org/abs/2505.06492.
- Siemens. 2025. https://blogs.sw.siemens.com/nx-design/how-generative-design-is-transforming-engineering/.
- Time. 2024. *Making Buildings More Efficient*. https://time.com/7094791/brainbox-ai-aria/.
- Udvarlaki, Roland. 2022. *Smartphone subscriptions are here, but should you care about it?* https://pocketnow.com/fairphone-smartphone-subscription.
- UK Gov. 2022. *Climate-related financial disclosures for companies and limited liability partnerships (LLPs)*. https://www.gov.uk/government/publications/climate-related-financial-disclosures-for-companies-and-limited-liability-partnerships-llps#:~:text=Details,or%20after%206%20April%202022.
- UK Gov. 2013. *Environmental reporting guidelines: including Streamlined Energy and Carbon Reporting requirements*. https://www.gov.uk/government/publications/environmental-reporting-guidelines-including-mandatory-greenhouse-gas-emissions-reporting-guidance
- UNICEF. 2025. *1 in 4 Worldwide Still Lack Access to Safe Drinking Water*. https://www.unicefusa.org/stories/1-4-worldwide-still-lack-access-safe-drinking-water.
- United Nations Environment Program. 2025. *Emissions Gap Report*. https://wedocs.unep.org/20.500.11822/48854.
- US Department of the Interior. n.d. *Wildland Fire Suppression*. https://www.doi.gov/wildlandfire/suppression.
- US Department of Energy. 2025. *Pathways to Commercial Liftoff: Virtual Power Plants 2025 Update*. https://www.smartenergydecisions.com/wp-content/uploads/2025/04/liftoff_doe_virtualpowerplants2025update.pdf.

- Volvo. n.d. *The modern way to lease a car*. https://www.volvocarsnorthpoint.com/us/subscription.htm.
- World Economic Forum. 2025. *How AI can transform sustainability reporting*. https://www.weforum.org/stories/2025/09/harnessing-ai-for-sustainability-reporting-path-forward.
- World Economic Forum. 2025. *Why the building sector's emissions milestone requires data-driven reinforcement*. https://www.weforum.org/stories/2025/05/building-construction-emissions-data/.
- World Economic Forum. 2024. *Global Risks Report 2025*. https://reports.weforum.org/docs/WEF_Global_Risks_Report_2025.pdf.
- WorldPop. 2025. *How WorldPop Data Powers Google's Global Flood Forecasting Revolution*. https://www.worldpop.org/blog/how-worldpop-data-powers-googles-global-flood-forecasting-revolution/.
- Zuora. 2025. *Zuora Subscription Economy Index Continues to Outperform S&P 500: Flexible Revenue Models That Evolve With Market Conditions and Consumer Expectations Thrive*. https://www.zuora.com/press-release/zuora-subscription-economy-index-2025/.
- Zscaler. 2022. *Work From Anywhere Trends Dashboard*. June 24, 2022. https://www.zscaler.com/threatlabz/work-from-anywhere-dashboard.

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Part 3

How Do You Accelerate Sustainable IT?

Part 3 brings together everything learned so far—the *why* and the *what*—and translates it into the *how*. It focuses on defining a credible, sustainable IT strategy, establishing measurable baselines, mobilizing leadership, and executing change with purpose. This part introduces the Sustainable IT Maturity Model©, a practical diagnostic tool that allows organizations to assess where they stand today across 11 critical capabilities. Building on this foundation, we will walk you through a structured strategic-planning process for sustainable IT. Special attention is given to factoring AI into the sustainability strategy.

The book concludes with a comprehensive recommendations recap from every preceding chapter, closing the loop on the sustainable IT journey for people, planet, and progress.

Part 3 includes these chapters:

- *Chapter 13, Get Started Today*
- *Chapter 14, Putting a Sustainable IT Strategy in Place*
- *Chapter 15, From Strategy to Action – Lead with Purpose and Deliver Progress Quickly*

13

Get Started Today

> *"We are the first generation to feel the impact of climate change and the last generation that can do something about it."*
>
> *Barack Obama*

This chapter marks a pivotal moment in your sustainable IT journey. Up to this point, we've explored *why* sustainability matters for IT and *what* tools and strategies can drive improvement. Now, we turn to the *how*—how you take action, improve your capabilities, measure progress, and lay the groundwork for a lasting transformation.

In the first half of the chapter, we will walk you through how to get started, including goal setting, following a starter strategy, and recommended action steps to solidify the capabilities and resources needed for your sustainability journey. We also present you with our Sustainable IT Maturity Model©, which will help assess your organization's current capabilities across people, process, and technology; expose gaps; and set realistic target states for the future. In their case study, tourism company TUI Group will provide details on how to launch an IT sustainability program. We will receive advice and perspective from the CIO's peers in the sustainability office. Finally, we devote the final third of this chapter to a step-by-step exercise in establishing your GHG emissions baseline, including the following:

- Measuring emissions from data centers, the cloud, IT hardware, end user devices, and **IT asset disposition (ITAD)**

- Understanding how factors such as server location, **power usage effectiveness** (**PUE**), utilization, and energy mix affect emissions
- Comparing the carbon impacts of workloads in on-premises data centers, corporate global data centers, and hyperscaler cloud environments

You will have achieved the following by the end of this chapter:

- Understand how to set actionable goals and early strategies that map directly to enterprise ESG commitments
- Be ready to collaborate effectively with your **CSO**
- Know which data points to collect to create an accurate baseline
- Be equipped to simulate different future-state scenarios using our downloadable emissions calculator (visit the book's website, `https://www.sustainableit.org/sustainable-it-playbook`, where you can access resources, including your own Excel spreadsheet for creating your GHG emissions baseline and simulating your target state)

This foundational work will prepare you for the next step: building a comprehensive IT sustainability strategy, which we will tackle in the following chapter.

Establishing your starter goals and strategy

The journey starts with goals. IT must have sustainability goals that enable and support the achievement of the enterprise's ESG goals. Having read the previous chapters, you will be familiar with the UN **Sustainable Development Goals** (**SDGs**) and sustainability regulations that inspire and compel enterprise goals. You should also understand IT's primary areas of sustainability impact and the strategies that drive improvement. Now you can set goals and specific targets for your function that map to enterprise commitments, targets, and timetables. Keep in mind that goals can shift or even change, so expect some fluidity in your own plan.

Your sustainability team should first map the company's high-level sustainability commitments—such as net-zero timelines, circular economy initiatives, social responsibility pledges, and regulatory compliance requirements—to the areas where IT has direct control or influence. This mapping process should include input from stakeholders, including the sustainability officer, CIO, facilities management, procurement, and business unit leaders. With this context, they can prioritize goals that are both high-impact and achievable in the near term. Each goal should be **Specific, Measurable, Achievable, Relevant, and Time-bound** (**SMART**) and connected to clear KPIs, such as those we have shared in each chapter in *Part 2* of this book.

Finally, the team should establish transparent tracking and reporting mechanisms to monitor progress and demonstrate IT's role as a catalyst for enterprise sustainability. In *Chapter 14*, *Putting a Sustainability IT Strategy in Place*, we will focus on prioritizing our IT sustainability goals via a materiality assessment, and outline challenges, required capabilities, and objectives and key results for each.

The following three tables list potential IT sustainability goals and their corresponding enterprise goals across the ESG pillars. The environmental goals in the first table prioritize carbon reduction, circularity, and water management. IT organizations generally start with green IT goals when embarking on a formal sustainability program.

Environmental Sustainability Goals		
IT Goal	**Description**	**Enterprise Goal(s) Supported**
Reduce direct IT carbon footprint (Scopes 1 and 2)	Minimize GHG emissions from IT infrastructure – data centers, end-user devices, AI tools – via energy efficiency and renewable energy.	Enterprise decarbonization roadmap; achievement of net-zero commitments; alignment with science-based targets
Lower Scope 3 IT emissions (supply chain and lifecycle)	Address embodied emissions from IT hardware and third-party services, influencing vendor selection and lifecycle design.	Scope 3 reduction; compliance with EU CSRD, ESRS E1, and California SB 253/261
Optimize cloud carbon performance	Select green cloud regions, optimize workloads, and track cloud-related emissions to reduce digital operations footprint.	Lower digital Scope 2/3 emissions; cost-effective cloud sustainability; reporting transparency to stakeholders and regulators
Improve water stewardship for IT facilities	Reduce water consumption in data center cooling and track water usage effectiveness.	Water conservation goals and climate resilience plan
Circular IT procurement and e-waste reduction	Extend IT asset life, increase reuse/recycling, and ensure secure, zero-landfill disposal.	Circular economy commitments and compliance with EU Circular Economy Action Plan and Digital Product Passport requirements
Green IT product and service design	Design internal systems and apps to be energy-efficient and reduce environmental impact.	Eco-design of enterprise products and services; lower operational emissions of digital services
Carbon-aware IT operations	Schedule workloads based on grid carbon intensity or renewable energy availability.	Enterprise renewable energy goals

Table 13.1 – IT environmental sustainability goals and the enterprise goals they support

The social goals (*Table 13.2*) encompass the supply chain, systems design, and the IT team itself. Communities and the digital divide are also represented. Generally, an IT organization just starting its journey prioritizes environmental actions over social because of the urgency and data-intensive aspects of environmental compliance requirements.

Social Sustainability Goals		
IT Goal	**Description**	**Enterprise Goal(s) Supported**
Digital accessibility and inclusion	Ensure IT systems and digital services meet WCAG 2.2 AA accessibility standards for all users.	Enterprise diversity strategy; equal access for customers and employees; compliance with accessibility laws
Equitable AI	Apply AI governance to prevent bias and ensure fairness, transparency, and accountability of AI-based tools..	Enterprise ethical innovation strategy; compliance with EU AI Act, ISO/IEC 42001, and responsible AI commitments
IT supply chain labor standards	Require vendors to comply with ethical labor practices and avoid forced/child labor.	Alignment with human rights policies, ILO standards, and ESG reporting under CSRD ESRS S1-S4
Digital skills for communities	Provide IT expertise and resources to improve community digital literacy and access.	Enterprise social impact programs, bridging the digital divide, and improving brand trust with stakeholders
IT workforce inclusion	Increase representation of underrepresented groups in IT hiring, promotions, and leadership.	Corporate workforce equity goals and performance metrics for ESG ratings and investors

Table 13.2 – IT social sustainability goals and the enterprise goals they support

Governance goals (*Table 13.3*) are typically prioritized based on regulatory compliance needs. ESG data governance goals are essential to solidifying IT's role as an enterprise sustainability partner.

Governance Sustainability Goals		
IT Goal	**Description**	**Enterprise Goal(s) Supported**
Digital enablement of enterprise ESG goals	Build data platforms and IoT solutions to track and improve sustainability performance across functions.	Enterprise ESG strategy execution in supply chain, manufacturing, facilities, and customer experience
IT sustainability governance integration	Embed sustainability into IT governance structures, including leadership processes and enterprise architecture.	Enterprise-wide ESG governance maturity and board-level reporting integration
Regulatory ESG compliance for IT	Ensure IT systems support compliance with sustainability reporting mandates.	Compliance with EU CSRD and global ESG disclosure mandates
Transparent ESG data and metrics	Deliver accurate, auditable IT sustainability data for decision-making and disclosures.	Enterprise transparency and trust with regulators, investors, and customers
Sustainability Innovation through emerging tech	Apply emerging technologies such as AI and blockchain to enable new sustainable business models.	Circular economy transformation, transparent product tracking, and compliance with Digital Product Passport
Cybersecurity and ESG risk alignment	Integrate climate, ethical AI, and privacy risks into IT risk frameworks.	Broader enterprise risk management and business continuity plans
Sustainable vendor management	Evaluate vendors on ESG criteria and require measurable sustainability progress.	Enterprise responsible sourcing goals; compliance with global sustainable procurement standards

Table 13.3 – IT governance sustainability goals and the enterprise goals they support

After setting sustainability goals, the next step is to translate those goals into an actionable starter strategy. Its purpose is to get fundamentals in place for your team to tackle early wins and gain momentum quickly. In the next chapter, we will walk through the process of developing and applying a more formal, longer-term IT sustainability strategy. For now, let's look at five strategy fundamentals:

- **Align and secure leadership commitment**:
    - **Objective**: Ensure that CIOs, CTOs, and other senior leaders visibly support and resource the strategy

    - **Actions**:
        - Present the sustainability goals and their direct link to enterprise ESG objectives
        - Secure executive sponsorship, ideally through a joint statement from the CIO and CSO
        - Embed IT sustainability in the IT governance model and strategic planning cycles
    - **Outcome**: A leadership mandate that positions IT as a driver of ESG progress, not just an operational function
    - **Avoid**: Leaving the corporate CIO and CSO out of the loop
- **Build a cross-functional IT sustainability team**:
    - **Objective**: Establish the structure and accountability needed to drive execution
    - **Actions**:
        - Assess current staff talent for sustainability experience, passion, and so on
        - Form a core IT sustainability team with members from infrastructure, cloud, procurement, data governance, and security
        - Identify "ESG champions" in key IT domains such as DevOps, AI, and data centers
        - Partner with enterprise functions such as finance, procurement, HR, and supply chain to ensure alignment
    - **Outcome**: A dedicated team empowered to coordinate projects and report progress
    - **Avoid**: Spinning up a team with no clear commitments and no resource support
- **Conduct a current-state baseline assessment**:
    - **Objective**: Understand where IT stands today to set priorities and track improvements.
    - **Actions**:
        - Measure IT's current carbon footprint, including Scope 1, 2, and 3 emissions (see worksheets in the chapter, which can be downloaded from the book's website, `https://www.sustainableit.org/sustainable-it-playbook`. There, you will also find an of relevant tools and services.

        - Assess cloud provider data quality and granularity for workload-level reporting (work with third-party services to fill gaps)
        - Evaluate IT asset lifecycle practices (procurement, usage, refresh cycle, retirement, and e-waste)
        - Benchmark against industry best practices and regulatory readiness (e.g., EU CSRD, SEC Climate Rule)
    - **Outcome**: A fact-based foundation for setting KPIs and identifying quick wins
    - **Avoid**: Reliance on proxy data; waiting to act until the data's perfect
- **Identify quick wins and early impact projects**:
    - **Objective**: Build momentum and demonstrate value in Year 1
    - **Actions**:
        - Launch low-complexity, high-impact initiatives, such as migrating workloads to green cloud regions, implementing device take-back or refurbishment programs, or deploying a cloud carbon tracking tool
        - Use visible early successes to secure funding and broaden buy-in
    - **Outcome**: Early progress that proves IT sustainability is actionable and beneficial
    - **Avoid**: Big-bang projects, boiling the ocean, and drowning in data
- **Embed measurement and reporting**:
    - **Objective**: Make sustainability progress visible, credible, and auditable
    - **Actions**:
        - Establish KPIs for each goal (e.g., reduce IT Scope 2 emissions by 15% within 18 months)
        - Integrate sustainability metrics into existing IT dashboards and quarterly reviews
        - Automate ESG data collection in IT (and the enterprise) using sustainability data management platforms
        - Prepare reporting for internal stakeholders and input for external disclosures
    - **Outcome**: Transparency, credibility, and efficiency for the IT ESG program
    - **Avoid**: Measurement for measurement's sake, KPI overload, and vanity metrics; one-off dashboards that no one will use

Taking action

Now that we've walked through goals and starter strategy, it will be helpful to look at patterns of execution—well-worn paths taken by IT leaders that have begun their sustainability quest over the past several years. For these insights, we look to the members of SustainableIT.org—those companies that joined the professional association early on and shared their sustainability pioneering experiences with their peers. Many followed a remarkably similar pattern consisting of two paths traveled in near unison—sustainability *in* IT, as well as *by* IT, illustrated in *Figure 13.1*.

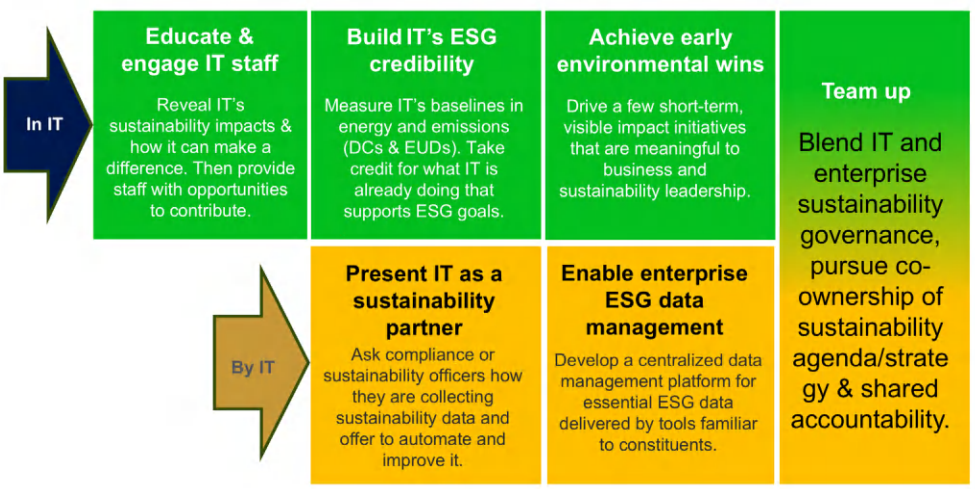


Figure 13.1 – Typical early pattern of IT steps in the sustainability journey

Their initial steps follow working from left to right. The first formal step is typically engaging and educating IT staff, which we discussed in *Chapter 2*, *Rise of Sustainable IT*. This motivates the formation of an internal team eager to take action, including an assessment of IT's baseline, a review of what IT is already doing that benefits sustainability (e.g., data center consolidation and cloud optimization), and tackling two or three internal initiatives with quick, visible paybacks. Detailed guidance for baseline assessment is provided later in this chapter.

At this stage, IT leaders tend to feel that they have enough credibility to engage the sustainability or compliance office as a would-be partner, leading with an offer to help collect and analyze ESG data needed for reporting. These function heads are usually happy to accept help from IT in lightening their data lift. In fact, this overture quickly evolves into the creation of a centralized ESG data management system, something all companies need. In the process of deploying this milestone on the journey, IT's sustainability credibility spreads enterprise-wide. Then something terrific happens—IT receives an invitation from the CSO to join the strategy team, and technology becomes a key pillar in the enterprise sustainability plan.

This pattern still holds up today with some minor tweaks. For example, early partnership overtures might include an offer to help apply AI to sustainability data management or to establish responsible AI enterprise governance.

Top 10 most common starting actions for IT sustainability

Let's now get a little more granular and consider the top 10 most common actions undertaken at the start of IT sustainability programs, again based on the history of IT members of SustainableIT.org:

- **Take stock**:
    - Set goals for IT that directly support enterprise sustainability goals
    - Assess what IT is already doing that is driving sustainability improvement
- **Governance**:
    - Develop and communicate a vision for a sustainable IT operating model. Align this with the existing enterprise sustainability vision and goals.
    - Define sustainability responsibility in IT—an executive sponsor, team leads, data and measurement leads, and their key business stakeholders.
    - Implement responsible AI governance lifecycle principles and practices.
- **Energy and emissions**:
    - Begin monitoring energy consumption of major IT assets (usually data centers and end user devices, and the current mix of energy sources (renewable, low-carbon, and fossil)
- **IT hardware circularity**:
    - Assess the impact of prolonging the IT hardware lifecycle on IT asset classes (servers to five or six years, laptops to four years, etc.)
    - Assess current hardware disposal methods; initiate or expand sustainable ITAD to reduce landfill volume
- **Vendor management**:
    - Communicate sustainability vision and plans to key vendors
    - Introduce IT-relevant ESG criteria into tech procurement process (RFPs, MSAs, etc.)

It is important to understand that the first year of the IT sustainability journey is more about discovery and initiation. It is in Years 2 and 3 that you will deploy systems and processes at scale, driving sustainability gains on multiple fronts. *Figure 13.2* shows actions to establish general capabilities for driving sustainability over the first three years of your program. The categories (resources, governance, etc.) correspond to the capabilities of our Sustainable IT Maturity Model, which we will introduce in the next section. You will also find more detailed three-year action plans for sustainability in and by IT in *Chapter 14*, *Putting a Sustainable IT Strategy in Place*.

	General Sustainability Actions	
	Year 1	Years 2-3
	Discovery & Initiation	**Deployment & Scaling**
Awareness & Commitment	• Discover IT's ESG impacts & potential areas of improvement. • Discover availability & accessibility of essential ESG data. • Inform business peers and IT team of IT's ESG relevance (impact, drivers, data governance).	• Continue to inform by reporting actions & impacts to governance committee, board, officers, & staff. • Share best practices with industry peers. • Share success stories internally & externally.
Strategy	• Develop vision for sustainable IT operating model, including architecture. Communicate to C-suite and board. • Create transformation strategy and roadmap for ESG sustainability across IT's services lifecycle.	• Blend sustainability goals & strategy into enterprise digital transformation program. • Align IT sustainability vision with business model.
Targets & Measurement	• Prioritize IT ESG goals by materiality assessment. Factor in regulatory requirements. • Select initial sustainability goals & set realistic targets aligned with enterprise goals. Include potential quick wins. • Adopt standardized IT sustainability metrics for measurement & reporting. • Measure & document baselines for targeted sustainability metrics/KPIs.	• Align IT KPIs and targets with primary vendors' sustainability indicators. • Track progress in key metrics & impact to performance levels (e.g., cost & labor savings). • Participate in sustainability benchmarking program to identify gaps & refine targets.
Governance	• Establish IT executive sponsor, team leads, stakeholders. • Solidify responsibility & accountability as program evolves. • Establish communication/relationship with sustainability office. • Establish IT participation in enterprise sustainability governance.	• Set responsibilities & accountabilities within IT governing ESG impacts of tech deployment, usage, & disposition. • Involve key stakeholders in IT sustainability governance. • Establish regular, ongoing IT representation on any enterprise sustainability team. • Identify heavily impacted areas and roles and apply change leadership best practices.
Resources	• Assemble initial team motivated by ESG goals. • Self-fund initial research and projects; tap available corporate ESG resources once plan is accepted. • Investigate and leverage third-party ESG training & support resources.	• Leverage sustainability partners for training and resources. • Embed sustainability transformation funding into project budgets and overall digital transformation investment.
Processes & Tools	• Investigate and leverage third-party ESG management resources. • Assess team capability maturity and set development priorities.	• Provide seamless access to sustainability data via existing operational reporting systems/dashboards. • Learn about emerging sustainability tools through engagement with vendors, universities, & VCs.

Table 13.4 – General sustainability actions – Years 1–3

Ultimately, the value of such action plans lies in guiding organizations from isolated initiatives to a comprehensive, integrated sustainability strategy that lays the groundwork across all three pillars of sustainability. So far, this chapter has focused on what to do to get started. From this point, we will explore how to do it well. First, we will walk through IT's launch of a sustainability program at tourism company TUI Group, based in Hannover, Germany. Then, we will introduce our IT sustainability maturity model, which defines the key capabilities necessary for successful sustainability transformation. The model can help you assess the current state of these capabilities and how to boost maturity where needed. We will also get peer advice direct from those executives most accountable for sustainability outcomes—your company's sustainability directors and CSOs.

Case study: IT sustainability first steps at TUI Group

At TUI Group, the multinational tourism company that operates tour operators, airlines, cruise ships, and hotels, the decision to integrate sustainability deeply within the IT strategy was spurred by this vision and confirmed by TUI Group's CIO Pieter Jordaan. While IT's relative environmental footprint is minor compared to the rest of the business, the IT organization has a central role in the company's broader sustainability agenda. By addressing its own operational sustainability challenge, it earns credibility, builds expertise, and reinforces TUI's ESG authenticity. "*It's essential for us, as a digital organization, to organize ourselves in IT to be a real business partner for tackling digital sustainability,*" states **Isabelle Droll**, **TUI's CIO of Airline Tech, Corporate, Hotels & Resorts, and Sustainability**.

The journey toward a comprehensive IT sustainability strategy began in 2020 during the COVID pandemic, which was a very difficult time not just for TUI but for the whole tourism industry. The decision to continue focusing on sustainability and even create new roles dedicated to this area during such a turbulent financial period is notable.

Underscoring the commitment was the hiring of the program's first full-time dedicated team member, **Frieder Olfe,** who came to the company with a sustainability background. An experienced individual or two are pivotal to launching and essential for maintaining a sustainability program in IT. Most of the organizations spotlighted in this book, ABN AMRO Bank, Cognizant, Electrolux, Mastercard, Rackspace Technology, Schneider Electric, and Siemens, among them, have one or more individuals on their IT teams whose core responsibility (if not 100% of their role) is IT sustainability. The Sustainability Technology Program at TUI Group is structured around two primary dimensions: Sustainability *of* Technology, focused on reducing IT operations' environmental footprint, and Sustainability *by* Technology, leveraging technology to enhance the company's overall sustainability performance.

First steps: team building and targets

TUI's commitment to sustainability at the group level and within the tech organization drove the establishment of a dedicated sustainability team within IT, currently three full-time employees. TUI Group had published its current sustainability strategy, the TUI Sustainability Agenda, in which green tech and data-driven initiatives were identified as one of the 15 main pillars. Dedicated roles would focus on leveraging technology to drive sustainability efforts across the company.

A broader network of about 40 to 50 people from different departments regularly contributes to sustainability initiatives, even if not dedicated solely to sustainability. Additionally, there is a group of 200 volunteers, known as Green Tech Reps, who support sustainability initiatives across the business as needed, including educational events and upskilling.

One of the first decisions, and challenges, was determining the targets for IT sustainability and the broader sustainability goals. Leaders needed to balance ambition with practicality, ensuring that the targets set were challenging yet attainable. The approach was to do a thorough assessment of what was realistically achievable, engaging internal experts and leaders.

TUI utilized existing sustainability frameworks and standards, including those provided by SustainableIT.org, to guide the selection of metrics and targets. This helped in ensuring that TUI's metrics were consistent with industry best practices and standards. The team conducted materiality assessments to identify and prioritize the most significant sustainability impacts and opportunities. KPIs were then used to establish baseline metrics against which progress could be measured. Among the targets set were the following:

- CO_2 intensity reduction of 50% by 2025 through green energy and the five R principles in cloud and data center operations (Refuse, Reduce, Reuse, Repurpose, Recycle).
- Hardware circularity increase of 15% by 2025, enhancing sustainability in device lifecycle management.
- Engage 150 suppliers in sustainability endeavors, leveraging TUI Group's buying power. This involves participation in programs such as the TUI Green IT Award or collaborating on green software initiatives.
- Increase the green TUI tourism customer experience score by 20% through digitized processes, improving sustainable holiday choices.
- Upskill the IT community with 25,000 hours of sustainability-related training by 2025.

TUI was also able to quantify IT's carbon footprint and apportion it to the various elements of the IT estate (*Figure 13.2*). This not only served as a carbon baseline but also provided an understanding of how and where carbon was generated.

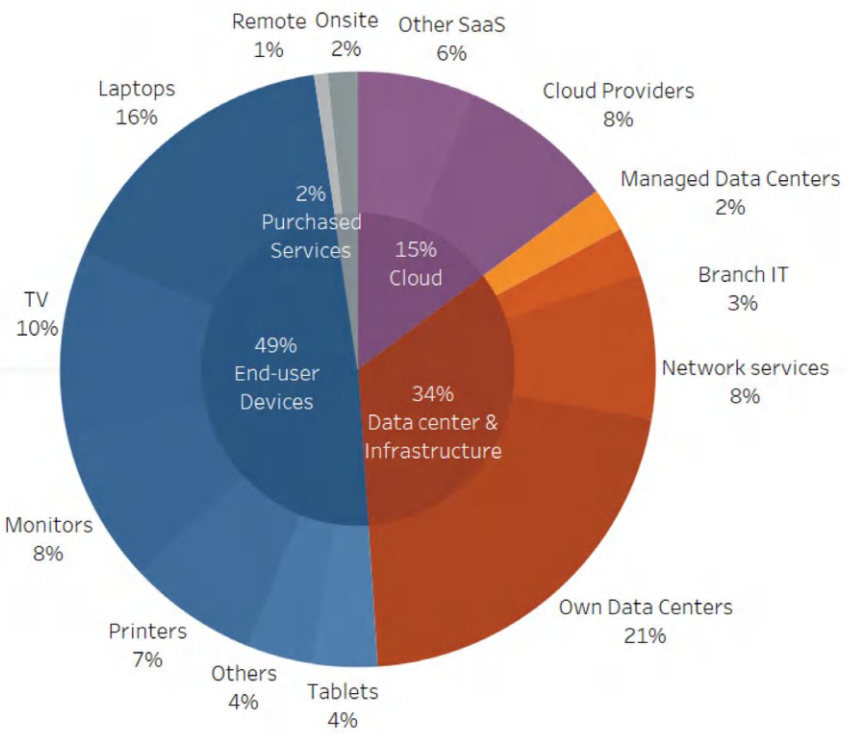


Figure 13.2 – TUI Group IT initial carbon footprint map (source: TUI Group 2024)

With the baseline metrics and targets established, TUI committed to continuous monitoring and reporting of sustainability performance. This includes regular updates on progress against the baseline metrics, enabling transparency and accountability within the organization and to external stakeholders. It quickly became apparent that Excel-based data management would be inadequate for tracking sustainability performance within IT and across the enterprise. TUI opted for a dedicated ESG data management platform (**Sphera**) to manage sustainability data accurately and consistently. This shift also aimed to improve transparency within the company regarding the source, age, and reliability of data. Although the ultimate goal is for sustainability data to be as carefully controlled and secured as financial data, especially given the confidential nature of some of this data, Olfe explains, the company has more work to do in this regard.

Looking ahead, IT plans to implement green software guidelines, conduct process mining to uncover more operational sustainability opportunities, and roll out a general complexity-reduction program. TUI remains committed to continuous improvement and exploration of new technologies, including responsible GenAI, and practices to further its sustainability objectives. Droll concludes, "*We see a future where sustainability and IT are inextricably linked, driving us towards a greener, more resilient operation.*"

TUI's award-winning progress in IT sustainability and the company's high-profile enterprise commitment have not come without hard lessons. In 2024, a single infographic on the corporate website of TUI Cruises was deemed greenwashing by the Regional Court of Hamburg, Germany. This illustrates the challenges of citing aspirational, long-term climate intentions in communicating sustainability to different stakeholder groups. While aspirational goals might be the right way to set a course and bring internal and external stakeholders on a joint path, details from the roadmap, if made public, might create misunderstandings or frictions between internal and external audiences. Therefore, a single source of truth is essential when communicating about sustainability.

IT can facilitate access to this single source of truth with automated informational tools. TUI IT has created such a tool in the form of its AI-powered chatbot ESGenius, or "Grace." Available only to internal users, it was built not only to maximize the accuracy of information given to customers, NGOs, and media, but also to help employees keep up with a doubling of demand for regulatory reports, audits, and certifications.

Employees across TUI departments can ask Grace ESG-related questions using natural-language prompts. The chatbot scans internal reports, policies, and historical answers to retrieve the most relevant, well-referenced information and provides users with concise, traceable responses.

The Sustainable IT Maturity Model©

This subsection introduces the Sustainable IT Maturity Model (Sundberg 2021; expanded, SustainableIT.org 2024). It is a maturity assessment framework that guides you in developing a sustainable IT practice. The model is designed to help you, as a technology leader, to identify shortcomings, determine priorities, and establish goals to improve your sustainable IT capabilities. The Sustainable IT Maturity Model has five levels of maturity, generically defined as follows:

- **Beginning**: The capability is completely undeveloped or very limited
- **Unstructured**: The capability is present but limited in application, scale, thoroughness, and consistency

- **Defined**: The capability is fully defined in its role and usage, consistently applied within IT, but is not automated or operationalized at the enterprise level
- **Managed**: The well-established capability is routinely managed, automated, and operationalized across the broader organization
- **Optimized**: The capability is established at its most effective and efficient level across the largest applicable scope, which may span beyond the enterprise to the larger value chain or industry sector

These levels are then used to assess maturity in 11 sustainability-essential capabilities or characteristics of your IT organization. The following 3 matrices provide bulleted characteristics associated with each maturity level for all 11 capabilities (more formal definitions for each level of the 11 capabilities can be accessed from the book's resources page: `https://www.sustainableit.org/sustainable-it-playbook`). The first matrix lists key characteristics by maturity level for the four people-oriented capabilities—awareness and commitment; IT strategy and role; resources (people and funding); and change management, culture, and training:

PEOPLE	Beginning	Unstructured	Defined	Managed	Optimized
Awareness & Commitment	• Limited awareness of IT sustainability challenge & opportunity • No formal IT executive commitment • No formal IT goals	• Some recognition of sustainability materiality to IT • Modest executive support • Isolated IT sustainability goals	• IT seen as sustainability player • IT executive commitment in place • IT objectives defined & linked to ESG goals	• IT recognized broadly as sust. enabler or driver • Strong stakeholder support • ESG targets road-mapped, monitored, & reported • Up to date on regulations, tools, & standards	• Tech-driven sustainability seen as competitive edge • Executives fully engaged • Sustainability fully embedded in IT operating model • Ongoing awareness campaigns
IT Strategy & Role	• No IT sustainability strategy • IT sustainability responsibilities undefined • IT typically not involved in enterprise sustainability strategy	• Strategy exists but is not broadly known or consistently applied • IT responsible for sustainability initiatives within function • Sporadic support of enterprise sustainability initiatives	• Technology strategy defined & applied to large initiatives • Clearly defined expectations for IT ESG responsibility • Formalized role in enterprise sustainability	• Regular IT sust. strategy reviews, leveraging architecture review boards • Regular performance assessment • IT & enterprise sustainability strategies formally aligned	• IT & enterprise strategies are unified • IT has enterprise leadership role in sustainability • IT strategy success promoted to influence ICT & business industries
Resources	• No IT staff with responsibility for sustainability initiatives • Staff sustainability skills lacking • No external entities engaged • No specific funding for IT sustainability programs	• Some IT staff involved with sustainability responsibility • Third-party partners leveraged to understand sustainability trends • Ad hoc, self-funded investment	• Sustainability team & SMEs in place with clear ongoing responsibilities • Partners identified & leveraged for acceleration, scaling, & insights • Ongoing funding secured	• IT sustainability organization well managed & staffed • Expertise broad & deep • Vendors/partners integrated into transformation • Transformation fully budgeted	• Integrated teams of experts deployed across IT • Long-term partners embedded in ongoing operations • Investment embedded in enterprise business planning
Change Mgmt., Culture, & Training	• No formal change management for sustainability initiatives • No standard technology sustainability training offered • No sustainability mindset or culture in IT	• Change management practices inconsistently applied • Sustainability training ad hoc • Passion for sustainability in isolated pockets of the organization	• Change management processes defined to facilitate transformation • Employees incentivized & recognized for sustainability achievements • Formal sustainability training	• Change mgmt. spans IT, business functions, & suppliers • IT sustainability education incorporated into on-boarding & training • Enterprise values & promotes tech-centric sustainability	• Sustainability change management routinely embedded in tech projects • Ongoing, up-to-date training • Tech sustainability leveraged for hiring, retention, customer loyalty, & new business

Figure 13.3 – The Sustainable IT Maturity Model© for people capabilities

The second matrix lists key characteristics by maturity level for four process-oriented capabilities, including sustainability governance, ESG data processes and tools, sustainability performance measurement, and sustainable procurement:

PROCESS	Beginning	Unstructured	Defined	Managed	Optimized
Governance	• No formal IT sustainability governance • No goals, baselines, or targets • No vendor requirements • No IT ESG standards (i.e., topics for disclosure, metrics)	• Limited, ad hoc IT sustainability governance • Some IT goals & targets • Criteria applied to some vendors • IT ESG standards introduced but not broadly applied	• Sustainability gov. defined across IT lifecycle, EA • Baselines & targets set • Sustainability criteria defined & applied to major vendors • ESG standard metrics defined & adopted	• Sust. embedded in business transformation governance • Baselines, targets, & progress consistently monitored & managed • Primary vendors engaged in IT sust. governance	• IT/enterprise sustainability governance unified • New, more ambitious targets • Full compliance with vendor criteria & standards • Enterprise standards synch with industry standards
Data Processes & Tools	• No processes to capture, measure, track, or report IT-specific sustainability data • No dedicated tool support (e.g., carbon accounting platform)	• Ad hoc, manual processes to capture & report required sustainability-related data • Limited tools • Most data is spend-based & includes proxy data	• Required datasets, sources, & processes clearly defined • Master data mgmt. applied • Tools embedded in critical steps in sustainability data lifecycle • Most data is activity-based	• Required data sets automatically obtained & considered reliable • Robust platform & tools automate sustainability data mgmt. lifecycle • Activity-based data is norm	• Enterprise-scale, data processes under continuous improvement • Best-in-industry tools, processes, & automation • Activity-based data in near real-time
Performance Measurement	• No IT metrics defined • No IT sustainability measurement • No reporting	• Limited metrics defined • Isolated measurement conducted • Reporting ad hoc or limited to specific initiatives	• Key IT metrics defined & mapped to strategic plan • Measurement program defined • IT metrics regularly reported	• IT performance metrics framework applied & regularly updated • Automated measurement • Suppliers integrated into metrics program	• Measurement goals & methods regularly refined & improved • Measurement & reporting automated • IT results integrated into enterprise reporting
Procurement	• No standard ESG criteria for vendors • Most IT vendors not assessed for sustainability • Procurement team lacks sustainability focus/expertise	• Vendor ESG standards exist but inconsistently applied • Some new vendors assessed for sustainability • Procurement team has limited sustainability focus	• ESG criteria defined & applied consistently to core vendors • Sustainability is a standard sourcing decision factor for IT & central procurement functions	• Criteria consistently applied across all major suppliers • Vendor sustainability performance reviewed & updated annually • Vendor assessment results integrated into IT reporting	• Vendor ESG criteria meet or exceed industry standards • All core vendors meet or exceed sustainability criteria • Procurement team manages process enterprise-wide

Figure 13.4 – The Sustainable IT Maturity Model© for process capabilities

The final matrix provides key characteristics by maturity level for three tech-oriented capabilities, that is, sustainable enterprise architecture, infrastructure management for environmental sustainability, and infrastructure management for social and governance sustainability:

TECHNOLOGY	Beginning	Unstructured	Defined	Managed	Optimized
Enterprise Architecture	• No sustainable architecture vision, strategy, or standards (e.g., energy efficiency, net-zero carbon, accessibility, inclusive design, highly resilient)	• Sustainable architecture model envisioned but little progress made • App. rationalization & tech modernization underway • Limited adoption of as-a-service architecture	• Migration to sustainable architecture mapped • Sustainability factors defined for architecture patterns • Future-state sustainable architecture fully defined • ESG standards applied	• Migration to sustainable EA well along & managed • EA sust. standards managed & applied enterprise-wide • Arch review board verifies solution sustainability & responsible AI	• All new & legacy systems conform to sustainable model • Sustainable architecture standards are industry leading • EA linked to positive outcomes & business KPIs
Infrastructure Management --- Environment	• IT asset management nonexistent or unreliable • Limited infrastructure power monitoring • Sustainability not a factor in hardware lifecycle & data management policies	• Asset management is inconsistent • Power consumption monitoring for some infrastructure • Hardware & data sust. goals inconsistently applied to device & data management	• IT assets regularly monitored & updated • DCs managed for power, water consumption & emissions • Device lifecycle guidelines fully implemented	• Automated DC energy & emissions measurement • Cloud compute managed for energy & emissions • Most hardware green-certified • Lifecycle planning prioritizes circularity for all IT assets	• Most infrastructure powered by renewable or low-carbon energy • Full hardware circularity (zero landfill) • Infrastructure powered by renewable energy
Infrastructure Management --- Social & Governance	• Accessibility & inclusive design are not priority factors • Vendors not assessed on social criteria • GenAI banned outright or used without responsible governance	• Data ethics policies defined but not uniformly applied • Accessibility & inclusive design inconsistently applied • AI governance is inconsistent • Vendor social vetting inconsistent	• Data ethics uniformly applied • Accessibility compliance integrated into infra. mgmt. • AI social principles defined & embedded in governance • Core vendors assessed routinely	• Inclusivity & accessibility policies keep pace with evolving user base • Social principles embedded in AI platforms & systems • All vendors assessed & monitored on social criteria	• Ethical standards applied across data value chain • Vendor social policies regularly updated • Responsible AI governance is industry leading

Figure 13.5 – The Sustainable IT Maturity Model© for technology capabilities

The maturity assessment framework is one tool to help you evaluate your current capabilities, determine your intermediary and target state, and develop a roadmap toward improved sustainable IT practices and outcomes. It will help if you use the framework to improve processes, governance, organizational models, and KPI metrics on your journey to developing a sustainable IT practice. It will also help if you regularly revisit the framework to reassess and track your progress against your established baseline to drive continuous improvement and increase your maturity. The size of the company, corporate culture, sustainability ambitions, industry, and geography influence the maturity level that an enterprise can reach. It does not make sense for most companies to aim for **Level 5 (Optimized)** but rather **Level 3 (Defined)** or **Level 4 (Managed)**. Regardless of your ambition level, it will take a wholehearted commitment of time, money, and resources to achieve any level. The higher the level you aim for, the greater the commitment required.

Using the framework will benefit your organization by helping you track your progress over time, giving transparency as to your improvement from your baseline to your desired state, and validating whether investments in new capabilities deliver their expected potential and desired outcomes. If you are a large company with multiple divisions, you might want to keep track of each division's progress and present an aggregated view at a group level.

The 11 capabilities of the Sustainable IT Maturity Model©

The maturity of sustainable IT is assessed based on the prevailing current state of the 11 capabilities illustrated in *Figure 13.6*:

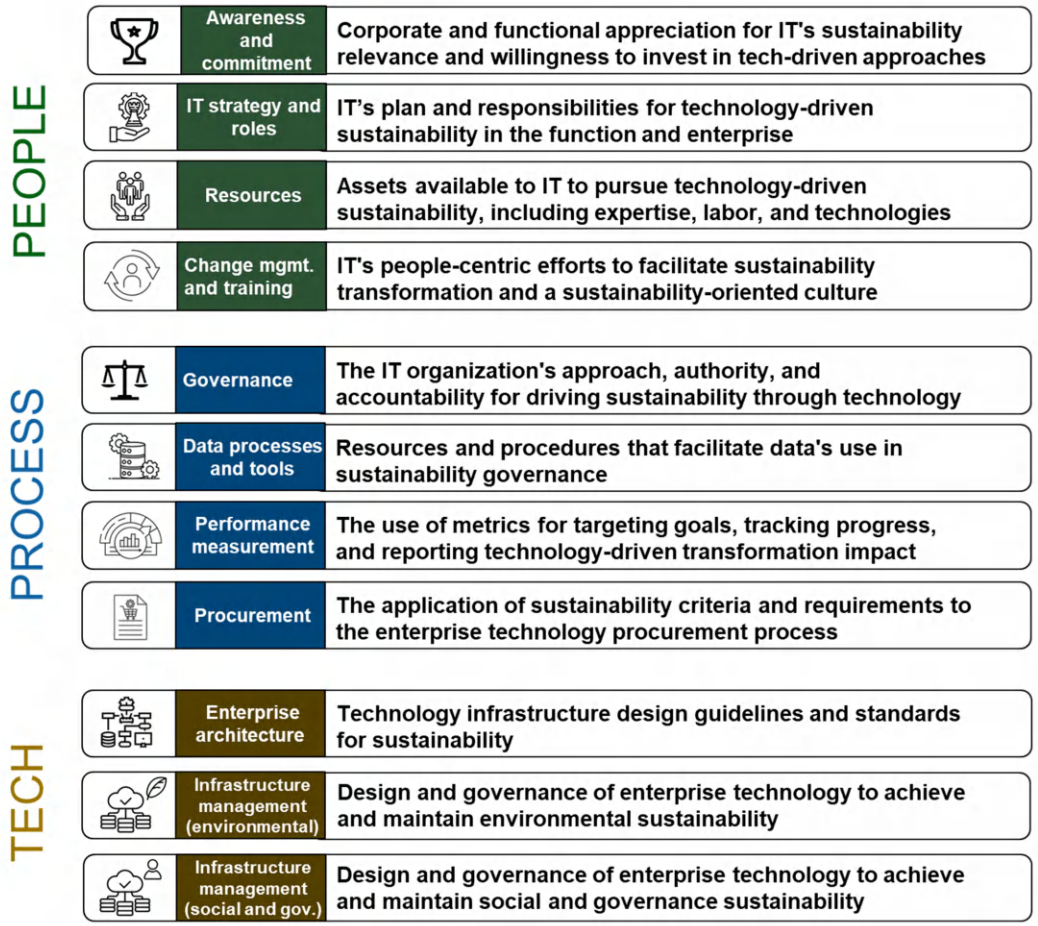


Figure 13.6 – The 11 capabilities of the Sustainable IT Maturity Model

An organization rarely implements and upholds all dimensions at the same time. These dimensions should guide your organization's progress through the maturity model. The most important dimension is setting a high level of commitment that will significantly propel your organization toward a sustainable IT practice and minimize environmental impact.

The five maturity levels of the Sustainable IT Maturity Model©

Now, let us take a closer look at the five maturity levels of the Sustainable IT Maturity Model.

Level 1 – beginning

At Level 1, sustainable IT is not on the agenda. There are a few or no specified processes for managing your sustainable IT practice. There is a lack of defined or formalized sustainable IT metrics; things are followed up on an ad hoc basis at best. There is also a lack of awareness and understanding within IT and across the entire organization. Sustainable IT is primarily viewed as a cost.

The right approach is left up to individuals, divisions, functions, and departments; therefore, there is limited repeatability. There are no documented processes, policies, or standards for managing sustainable IT practices or determining who has what responsibilities. Each activity is carried out independently, without applying the learnings from previous actions.

Level 2 – unstructured

At Level 2, sustainable IT starts to be seen as an area of influence. Processes are established within teams or IT functions, but there is little consistency across the organization. Sustainability actions may be repeatable, although they have not been formally defined. No current baseline or target state has been determined. No clear objectives and key results have been defined or agreed upon. Awareness and understanding are maturing within the IT function and across the enterprise. However, sustainable IT practices are primarily viewed as a compliance requirement rather than an enabler. There is some association of IT's actions and goals with the enterprise-wide sustainability plan, but nothing formalized has been implemented. The sustainability plan is rarely or not mentioned in enterprise sustainability reports and is not part of formalized reporting.

Level 3 – defined

At Level 3, sustainable IT is defined and is starting to be viewed as an enabler. Processes are established, and a central organization for coordination or decision-making exists. A set of guidelines, policies, and procedures exists, and minimal rework is required. Clear objectives and key results are defined, and sustainable IT is driven as a strategic initiative. A current baseline and a target state have been established, agreed upon, and communicated. A plan exists, and steps are taken to close the current baseline and target state commitment gap—mature awareness and understanding within the IT function and the enterprise. Sustainable IT is now connected to the overall sustainability plan. The comprehensive sustainability plan is mentioned in sustainability reports and is part of the formalized reporting.

Level 4 — managed

At Level 4, sustainable IT is embedded in the overall IT delivery. Sustainable IT is a critical enabler and a source of innovation for new sustainable products and solutions. A set of measures exists to determine gaps in processes and to find out whether performance is secure or adjustment is needed. The current baseline and target state are tracked and reported on in a standardized way. A multi-year plan exists, and significant progress has been made from the initial baseline to the target state. There are learning paths in place to raise awareness and skill levels. There is maturing agility throughout the organization in response to changes in the desired business outcome and value.

Sustainability actions are embedded in IT processes and lifecycles such as software design, procurement, and IT asset management. Repeated actions, such as sustainability data collection and distribution, are automated. Sustainability has also been incorporated into the enterprise architecture stack.

Sustainable IT is now fully integrated into the overall sustainability plan. Through fully embedded comprehensive sustainability reporting, minor adjustments are being made to improve performance and transparency.

Level 5 — optimized

At Level 5, **sustainability by design** has been fully embedded into the overall IT delivery. Sustainable IT has become a competitive advantage and contributes significantly to the organization's financial performance through new and improved revenue streams. There is solid, sustained executive support, and compensation is tied to sustainability goals. Limitations are known, and there is clear accountability and responsibility for continuous improvement. The gaps between the current baseline and target state have been closed, and a new ambitious target state has been set out—strong awareness and understanding within the IT function and the enterprise. There is high agility throughout the organization in response to changes in the desired business outcome and value.

Using the Sustainable IT Maturity Model assessment

To set your path to a sustainable IT practice, we recommend that you follow a four-step process to assess your current maturity, set your ambition toward your target state, compare your current and target states, and, finally, set the direction of travel. *Figure 13.7* outlines some critical questions you should ask yourself as you walk through each process step.

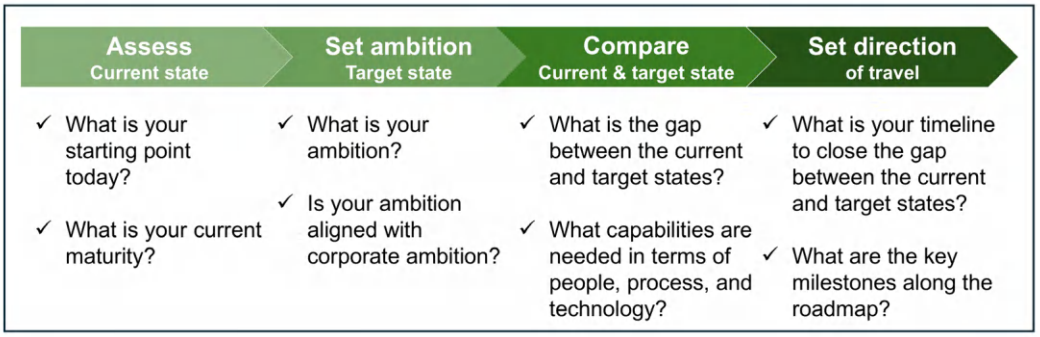


Figure 13.7 – The path to sustainable IT

SustainableIT.org developed an online assessment survey in collaboration with Deloitte and fielded this to the membership in September–October 2024. The assessment is available online as an ongoing benchmark and can be accessed here: `https://members.sustainableit.org/assessment-mfe#/`. Data collected from the original survey of 33 IT functions across 26 companies showed an average maturity score of 2.3, which is slightly above the "unstructured" maturity level. The average target goal of these respondents was to reach 3.7 within two-to-three years, which is the "managed" level of maturity.

Looking at assessment scores for the individual capabilities, the highest average maturity score (2.7) was in awareness and commitment. This is often the capability that IT focuses on initially, so it makes sense that it is the most developed capability for average maturity. Enterprise architecture had the lowest average maturity at 1.8, nearly a whole level lower. This reflects IT's slowness in embedding sustainability in architectural design and processes. Early focus in the sustainability journey tends to be on high-profile or low-hanging fruit targets, such as data center emissions and e-waste disposition, to the detriment of architecting systemic sustainability up front.

The maturity scores did not vary significantly between the 11 capabilities—the range between the top-scoring and lowest-scoring capability was 0.9, or essentially one full maturity level (see *Figure 13.8*). This indicates that the capabilities are being developed as a set, rather than having one or two receiving most of the attention to the detriment of others. It is logical to assume that improvement in one capability also lifts the maturity of related capabilities—strategy and commitment, for example.

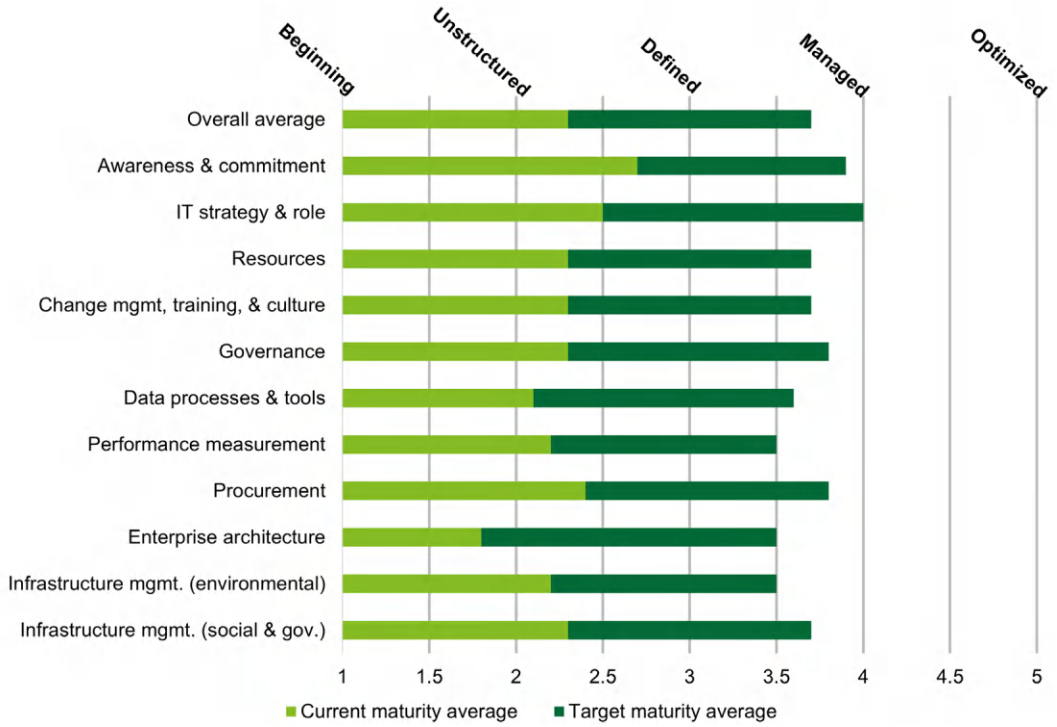


Figure 13.8 – Average current and target maturity levels by capability

Respondents in the highest tercile or top one-third of maturity scores averaged a 3.3, a full level above the overall respondent average of 2.3 and nearly two levels above the 1.4 average score of respondents in the lowest tercile (*Figure 13.9*).

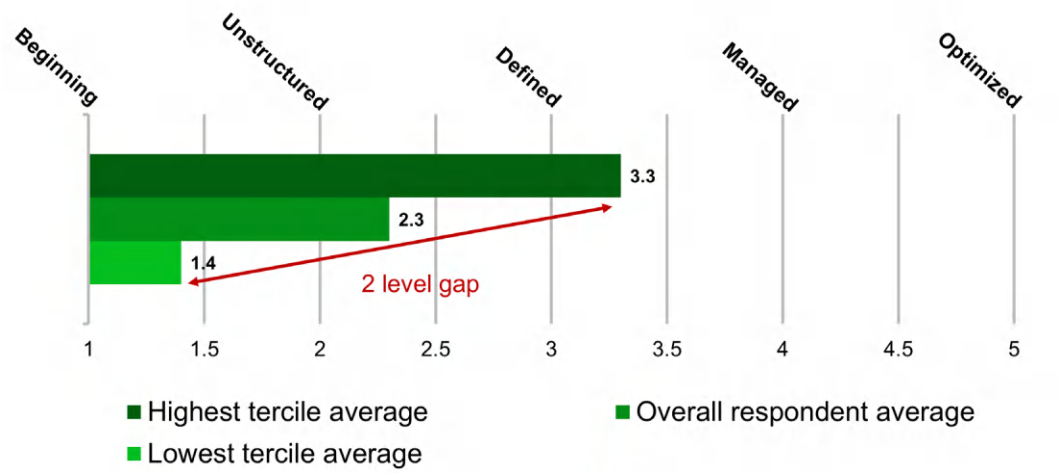


Figure 13.9 – Average current and target maturity levels by capability

- What differentiates high maturity from low? The survey results, analyzed by Deloitte and SustainableIT.org, showed a few factors associated with respondents in the top tercile of respondents compared to the bottom tercile: Formal IT sustainability program in place longer (3.8 years for top tercile compared to 1.3 years for bottom tercile)
- Formal corporate sustainability program in place longer (10.8 years for top tercile compared to 3.3 years for bottom tercile)
- Different primary sustainability drivers - stakeholder value, competitive advantage, and transformation for the top tercile, versus compliance and efficiency for bottom tercile)

Now that we have introduced the Sustainable IT Maturity Model© and data associated with a recent assessment, it is time for you to put the model into practice. *Figure 13.10* illustrates how you can plot your baseline and target state along the people dimensions of the maturity model.

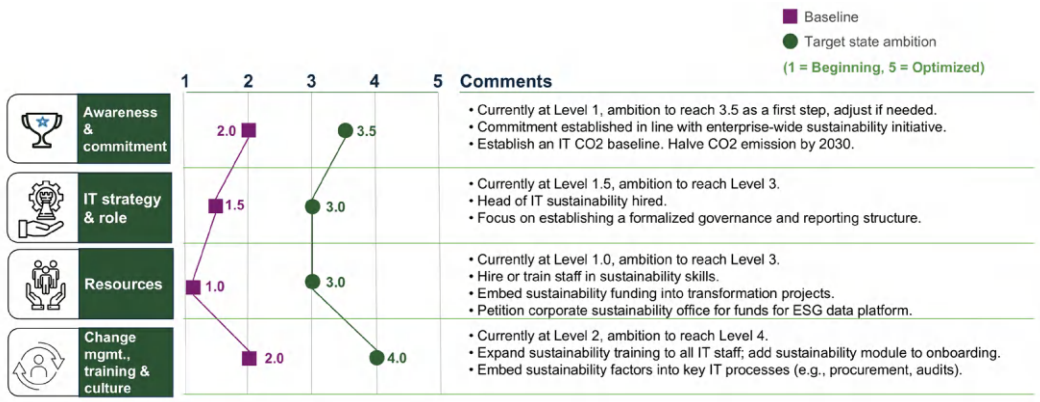


Figure 13.10 – Sustainable IT Maturity Model assessment example

As you start your journey, you can also include a current state marker to show your progress toward your target state. Establishing current and target states and associating progress with executive compensation is a powerful tool to get things moving in the right direction.

If you are a large corporation with many divisions or business areas, it may also make sense to track overall progress at a division level. *Figure 13.11* illustrates how you can track progress as a group and at a division level toward your baseline and against your target state ambition.

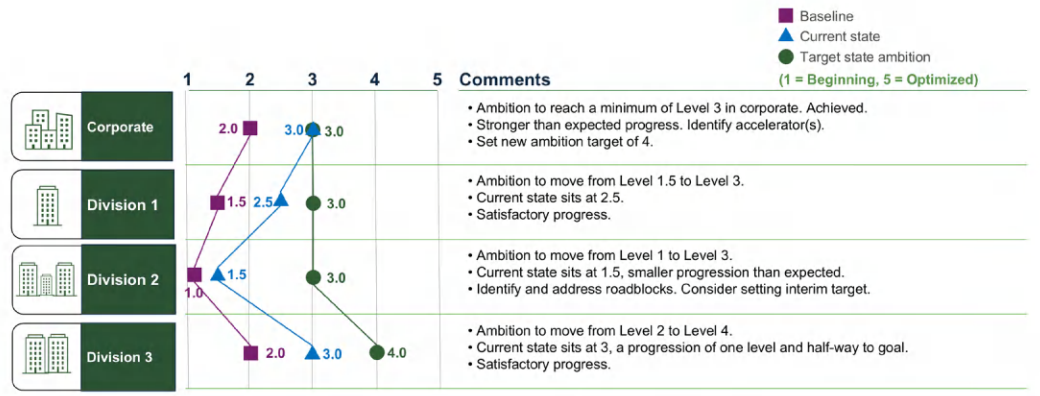


Figure 13.11 – Large corporation's Sustainable IT Maturity Model assessment example

In this section, we examined how you can leverage the Sustainable IT Maturity Model to conduct an assessment, both on an individual unit and multiple units, to determine your current and target states. However, you do not need to make this maturity journey alone. If your enterprise has a corporate sustainability office, then there is resident expertise you can draw on for help in elevating your capability maturity. Beyond this, your relative ability to collaborate with the sustainability office will have a direct impact on your results. In the next section, we will hear directly from CSOs about how IT and sustainability can accelerate progress and succeed together.

How to work with your chief sustainability officer

IT's initial steps in sustainability transformation are internally focused, without collaboration or even coordination with the company's sustainability head. IT's hesitancy to engage may be due to CIO "imposter syndrome," meaning the IT leader does not feel they have the expertise to speak on the subject. In companies where IT represents only a small slice of the enterprise environmental footprint, the sustainability officer may not see a need to engage with IT on emissions or circularity. Whatever the reasons, there is a collaboration disconnect. In a survey conducted in late 2024, 63% of IT leaders said they are somewhat or very satisfied with their CSO's help in driving sustainability value. On the flip side, only 45% of CSOs surveyed said they are somewhat or very satisfied with IT's help in delivering sustainability value (Sustainability Value Triangle Report, 2025).

For your own journey, let's look at how to better sync up with your CSO at the outset and make the most of the IT-sustainability partnership. We will get insights directly from three CSOs representing manufacturing, transportation, and tech services. (We'll invite the CFO to the table in a bit.)

Where the CSO is coming from

First, it's important for you to understand where your CSO is coming from and what pressures they are under. Several years back, sustainability was typically not viewed as an executive board topic, but rather something to be managed further down in the organization. Now, the tables have turned, and the role of **chief sustainability officer (CSO)** is growing in importance. According to Forbes' State of Sustainability Survey (Forbes 2025):

- 96% of CSOs report directly to the CEO or the board of directors
- 48% of CSOs work closely with the **chief operating officer** (**COO**)
- The percentage of C-suite executives reporting active collaboration with their CSO rose from 21% in 2024 to 43%
- 79% of companies with revenue of $500 million or higher have a CSO

According to The Conference Board, sustainability leaders are increasingly expected to embed sustainability into core business functions (Conference Board 2025). This is precisely the same goal that IT leaders have or will soon be called upon to do for tech and business operations. This synchronicity of CIO and CSO mandates argues for close collaboration between the roles. This mandate requires that CSO roles be filled by seasoned leaders with operations, business development, and strategy leaders, as was the case with the three sustainability leaders I (Richard) interviewed for this chapter.

Michael Colarossi, head of enterprise sustainability and 12-year veteran of global materials science and digital identification solutions company **Avery Dennison**, reflects on this transformation: "*The CSO role has probably evolved the most over the last 18–24 months. The world has become more focused on sustainability, and investor interest has grown. It's no longer just about doing the right thing—it's about growth and the impact on revenue.*"

Michael's cross-functional experience in product line management, branding solutions, sourcing, and supply chain supports him in building trust with technical and finance teams. His knowledge of operational realities helps him navigate complex corporate structures, making sustainability initiatives actionable and measurable.

At global IT services and consulting company NTT Data, **Chief Sustainability Business officer David Costa's** business development leadership experience provides the skills to translate sustainability into business value and external client conversations. His credibility comes from decades of delivering results internally, giving him the authority to challenge the organization and inspire change.

This evolution reflects a broader global trend where ESG issues are now directly linked to corporate strategy and value creation. Sustainability leaders are no longer isolated advisors—they are central to decisions about risk management, innovation, and growth.

David describes two types of successful sustainability leaders: "*You can have two profiles: very powerful sustainability people, or people who understand sustainability but have been long enough in the organization, having good results, who are credible and brave enough to challenge the organization.*" He adds that sustainability itself has to be credible and integrated into the strategic plan, with KPIs and reporting that matters to business leaders.

Kai Martin, 14-year veteran and CSO of logistics and transportation company **Pasha Group**, has led strategic programs and project portfolios centers of excellence. He adds another perspective on the evolution of the role. He notes that sustainability work has evolved from simply cataloging efforts and identifying "low-hanging fruit" to a much broader focus on business resilience.

"*A lot of CSO effort used to be about doing baselines, getting initiatives started and completed, and celebrating those accomplishments with internal and external stakeholders. But as we've matured, the business is asking for more,*" Kai explains. "*Now it's about deriving real business value—circular economy partnerships with customers, climate resiliency, and ensuring our operations and supply chains can withstand disruptions.*"

Kai emphasizes that modern CSOs must address not only environmental impact but also the existential sustainability of the business—its ability to thrive amid supply chain disruptions, climate extremes, and geopolitical risk.

"*We've seen so many impacts—chip shortages, canals running dry, conflicts shutting down transport routes,*" he says. "*Our role now includes asking, 'How resilient is the business, and how do we shore it up?'*"

As technology becomes foundational to sustainability success, the relationship between CSOs and CIOs/CTOs is more important than ever. "*Find those opportunities to collaborate, determine a common language, create common goals, and then celebrate those wins,*" Michael advises. He also understands the shared challenges of IT and sustainability leaders in proving the value of sustainability and securing funding. "*There are two executive positions that always have to ask for money and make a business case, and the CFO has to be convinced. You can commiserate and team up—two on one, always better.*"

Kai, David, and Michael agree on three best-practice approaches for how IT and sustainability leaders can best collaborate to help drive success.

1: Establish credibility through business value

David's first rule is pragmatic: sustainability conversations must be tied directly to business growth and operational outcomes. "*If I want people to listen, what I do has to be good for the business.*"

IT leaders should frame ESG initiatives around cost savings, risk reduction, innovation, and revenue opportunities, then connect them to emissions, ethics, or social goals. "*Show, don't just tell—your own IT estate is a living example,*" David urges. For instance, optimizing cloud workloads should be presented both as a carbon reduction strategy and a way to cut spend and improve performance.

Kai agrees but stresses that many organizations still lag in showing the math. For instance, sustainable hardware purchases are often overlooked despite long-term financial benefits: "*One supplier told me their 'eco server' would more than pay for itself over five years, but sales are still low because companies aren't doing the total cost calculations,*" he observes.

CIOs can help close this gap by presenting sustainable IT decisions as **financially sound investments**. This includes doing the following:

- Framing cloud optimization as both a carbon-reduction strategy and a cost-saving initiative
- Demonstrating how circularity and secondary market resale increase asset value
- Partnering with the CSO to co-present business cases to the CFO

As we stated earlier in this chapter, IT needs to establish its own ESG credibility to be a trusted partner. Kai calls out the importance of IT addressing its **own footprint**: "*Even if IT's emissions are a small percentage of the [company's] total, you can act within your own sphere of control,*" he advises. "*Lower the energy consumption of your systems without waiting for the CSO to prod you or expose your lack of action in a dashboard.*"

2: Use common ground to bridge the gap

"*I don't think there's enough partnership today… There's so much more opportunity if the IT and sustainability worked together more effectively,*" Michael states. Kai adds that IT leaders should proactively engage the sustainability office rather than wait to be invited. "*CSO teams are small and stretched thin,*" Kai explains. "*We need IT to lean in and ask, 'How can I help?' Don't wait for an invitation.*"

CIOs and CSOs should establish structured engagement—monthly working groups, joint reporting cadences, and integrated roadmap planning—to institutionalize collaboration.

Michael acknowledges that for many sustainability leaders, technology and enterprise architecture can feel intimidating or overwhelming, just as sustainability topics can feel complex and unfamiliar to IT professionals. He advises both sides need to bridge this gap through deliberate collaboration: "*Find opportunities to speak a common language, create common goals, and then celebrate those wins.*"

Both IT and CSO teams have hurdles in common: too few resources, a need to prove strategic value, responsibility for business continuity planning, and the complexity of cross-functional coordination. "*We can commiserate and team up—two on one, always better,*" Michael notes. Kai draws parallels between sustainability and cybersecurity: "*You can't have a cyber incident response plan without a business continuity plan,*" he says. "*IT and sustainability are both about resiliency. We can go to the CFO together with a unified business case.*"

These are two executive positions that always have to ask for money and make a business case that convinces the CFO. Shared terminology bridges gaps between technical teams, finance, and ESG professionals. Regular recognition of milestones prevents sustainability from becoming a compliance-driven burden.

Kai highlights the need for dedicated IT representation in the sustainability team. "*If IT has a person who was even 50% focused on supporting the organization's sustainability, things would be very different,*" he says.

Ideally, the CSO and IT (as well as other operational business leaders) should jointly own ESG targets, some of the sustainability budget, and progress reporting. This avoids sustainability initiatives competing with each other—they become part of a jointly owned business strategy.

3: Build activity-based, decision-ready data

Accurate ESG data is critical for decision-making, especially in IT, where Scope 3 emissions and resource consumption are complex to measure. David calls for moving beyond generic expense-based reporting to real operational insights: "*We have to move to activity-based data that leaders can use to manage.*"

Kai concurs, adding that while data collection tools are improving, few companies have embedded real-time dashboards or behavioral drivers such as OKRs. "*Right now, ESG reporting is still mostly retrospective,*" he says. "*We need real-time systems telling operations teams how they're doing—on energy, footprint, even employee retention.*"

For CIOs, this means the following:

- Integrating emissions and resource tracking directly into ERP and analytics systems
- Standardizing ESG metrics so they match financial and operational reporting formats
- Automating data collection to reduce manual reporting burdens (refer back to *Figure 13.1*)

4: Drive AI solutions together

AI is a dominant focus for sustainability heads just as it is for IT, and it may soon become the shared priority that brings the two functions closer together. David describes how NTT Data is actively integrating AI into sustainability efforts. His team has an AI-focused group that has launched initiatives to streamline compliance with regulations such as CSRD and to improve data collection and reporting processes. David also notes growing concern about how AI's rapid expansion affects NTT Data's environmental footprint. One executive team member recently asked him how AI use would affect emissions. "*The answer is, it depends on how you use it,*" David says. "*We are helping them measure the impact of AI on our emissions and how to support our clients.*

To manage this, NTT is setting strict design principles for its infrastructure: Every time we create a data center, it's on renewable energy, in countries where we don't need to activate generators." The team is working with external partners such as the Green Software Foundation to help define standards for measuring AI's environmental impact in data centers, including one on carbon usage efficiency. Other data center sustainability strategies that will mitigate AI's environmental impacts include enhanced recycling efforts for e-waste, new designs that use non-refrigerant cooling, and alternative backup solutions.

Kai is looking forward to the insights that AI can reveal. "*Imagine an AI bot working alongside your ERP,*" he says. "*It could alert a planner: 'This route is 10% less efficient,' or notify procurement before a purchase: 'There's a greener, cheaper option available.' That's the kind of real-time behavior change we need.*" He also points to digital twins as a game-changing technology: "*By creating digital twins, we can map operations more accurately, improve efficiency, and visualize sustainability impacts.*"

Clearly, AI is on the CSO agenda, both as a value driver and potential risk to be managed, and it is a wide-open (if not toll-free) bridge you can cross to engage the sustainability office.

Now that we've heard directly from CSOs, let's learn what CSOs say they most need from their IT peers, and vice versa.

What CSOs need most from IT

The need for good, easily accessible ESG data is reiterated strongly in the findings of the Sustainability Value Triangle research, which surveyed CIOs, CSOs, and CFOs to learn how they are collaborating on sustainability, and what they each needed most from their executive peers to support their sustainability efforts. However, one could argue that the emphasis on data ignores other valuable roles that IT can and should be playing in sustainability leadership. Let's look further into this by examining the results of a unique study on the value of collaboration between IT, the corporate sustainability office, and the finance function (GlobeScan, et al. 2025). The survey asked executives from each function what value outcomes they are seeing from sustainability initiatives, and what type of help they most need from their peers in the other functions. The sustainability value outcomes are covered in *Chapter 2*, *Rise of Sustainable IT*. Here, we will delve into the need to better prepare for effective collaboration at the start of your journey.

The Sustainability Value Triangle research report was created by Accounting for Sustainability, SustainableIT.org, the ERM Sustainability Institute, Salesforce, and GlobeScan, who surveyed 320 business leaders between November 2024 and January 2025 globally across corporate finance, IT, and sustainability functions.

Figure 13.12 shows the priority-ranked results for what CSOs said they need from their peers in IT, according to the survey results. The percentages indicate the number of CSOs prioritizing each need as one of their top 3:

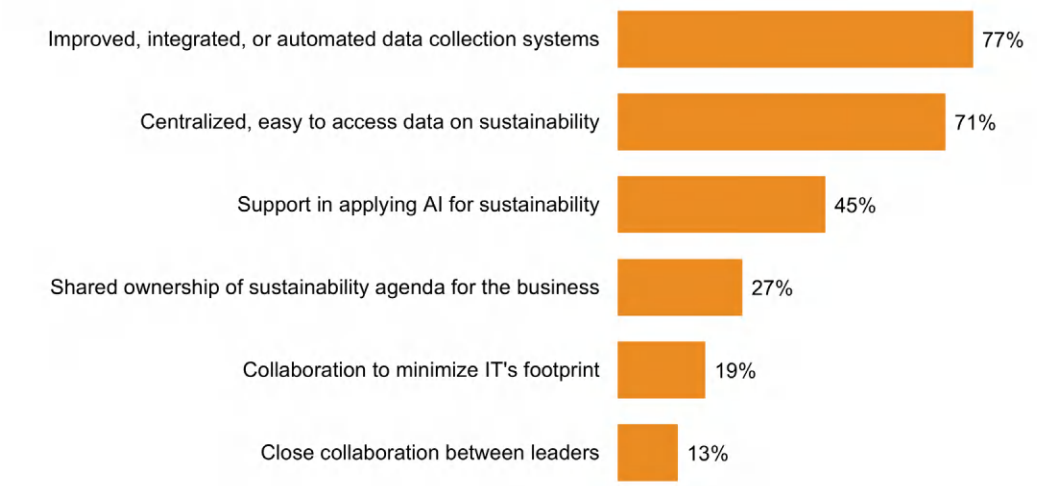


Figure 13.12 – CSOs' highest-priority needs from their peers in IT (percentage ranking selection in their top 3)

It is interesting to see AI as a top 3 priority for nearly half of CSOs, given that AI as a sustainability tool was in its very early stages when the survey was conducted in autumn 2024. CSOs were anticipating how this powerful technology could be applied to their goals, and many were expecting guidance and leadership to come from their IT peers. Here is how one CSO respondent to the survey expressed the need for AI and related data insights from IT:

> *"We need help with the use of AI/digital and data insights to support our sustainability transformation and to help with scenario planning/forecasting for sustainability goals, KPIs, and actions. This includes digitalization and automation of the data, dashboards, and so on. The tools need to be simple enough for non-tech experts to be able to make more informed decision-making. […] Within digital/tech transformation work, we need to ensure that sustainability ambitions and commitments are at the heart of this work and are not forgotten about until afterwards. It needs to be seen as an enabler to being more sustainable as well as more efficient, profitable, and relevant to customers."*
>
> *– Sustainability function executive, consumer products/retail*

One can't fault CSOs for being so highly focused on data. Without it, they would be doing their jobs with blinders on. However, IT is more than a steward of data, and you have more to offer than a dashboard. When IT executives were asked what they could offer the CSO that no one seems to be asking them for, the top responses were help with implementation. One IT respondent said, "*We could offer optimized IT infrastructure strategies to help with Scope 3 emissions and can support the digitization of processes that reduce waste.*"

What IT needs most from the CSO

For their part, a majority of IT executives surveyed expressed the need for the sustainability officer to be their North Star, pointing the way to clearly established goals (*Figure 13.13*). Many also wanted help with funding, and some shared a stake in the enterprise sustainability strategy.

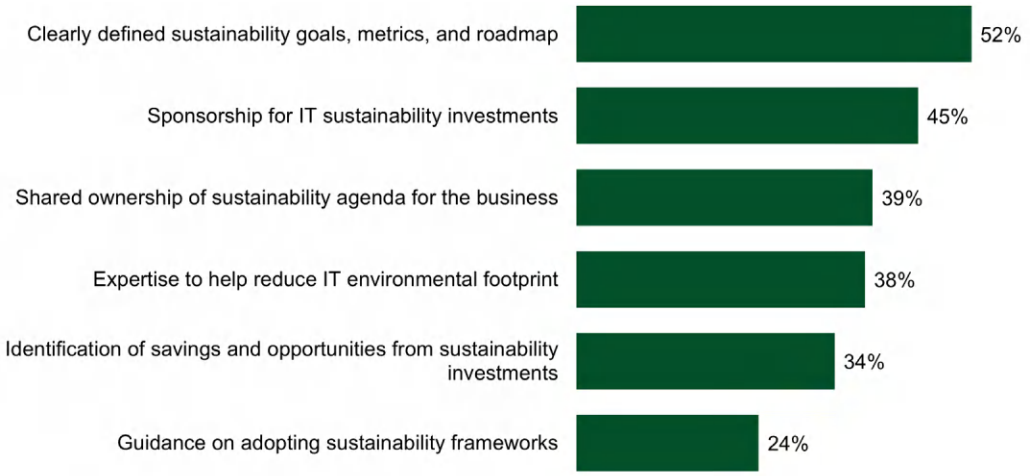


Figure 13.13 – CIOs' highest priority needs from the CSO (percentage ranking selection in their top 3)

One IT executive respondent quoted in the research report asked for greater clarity on objectives from their CSO:

> *"We need clear sustainability objectives and metrics – clear guidance on sustainability goals and KPIs to integrate them into our projects, ensuring alignment with broader organizational sustainability efforts. We also need guidance on adopting recognized sustainability frameworks to validate and enhance the sustainability efforts of our initiatives." – IT function executive, academia*

Sustainability officers say there is more they can offer their executive peers, but few are being asked. For example, CSOs say their teams can help educate the IT staff on the type of ESG data needed for reporting. They can also provide more guidance on long-term planning and strategy based on climate change scenarios.

What about the CFO?

As CSO Colarossi indicated, IT and sustainability share a common challenge in the form of the chief financial executive. Yet, the Sustainability Value Triangle research confirms that companies where finance is one corner of the collaborative sustainability triangle, the benefits (financial and non-financial) are higher than when they are not an equal member of this collaborative trio.

However, the current state of that collaboration is challenged. Only 41% of IT leaders are somewhat or very satisfied with the sustainability support they receive from finance. Slightly more, 44%, of sustainability officers are satisfied with finance's help. Again, there is much room for improvement.

The majority of CSOs prioritized these needs from finance:

- Financial measures for sustainability opportunities/risks
- Long-term investment perspective/broader view on ROI

The majority of IT executives expressed these priorities for CFO assistance:

- Tracking financial impact for initiatives
- Financial measures for sustainability opportunities/risks

Clearly there is a desire from the CFO's peers for help with applying financial measures to sustainability initiatives, that is, help build a sound business case.

The CFOs who participated in the survey by self-selection are sustainability-oriented to some degree. Like their CIO peers, the CFO's highest-priority need from the sustainability office is clearly defined sustainability goals and metrics, as well as a clearly defined roadmap. Without these, it is challenging to build any business case. Like their fellow CSOs, CFOs are depending on IT for improved, integrated, or automated data collection systems, preferably centralized and easy to access.

When asked what finance could provide that their peers in IT and sustainability are currently underutilizing, the most common responses were additional support in implementation, such as help with carbon accounting, pricing, and reporting, and materiality analysis. There was also interest in helping build enterprise buy-in. One finance executive respondent put it very eloquently: "*Finance could help share the load and the cause that sustainability has defended and promoted for so long alone.*"

Figure 13.14 recaps the unique value that each function can bring to its peers in the Sustainability Value Triangle. In the middle, all three have a shared priority in co-ownership of the sustainability agenda and a dependency on quality ESG data.

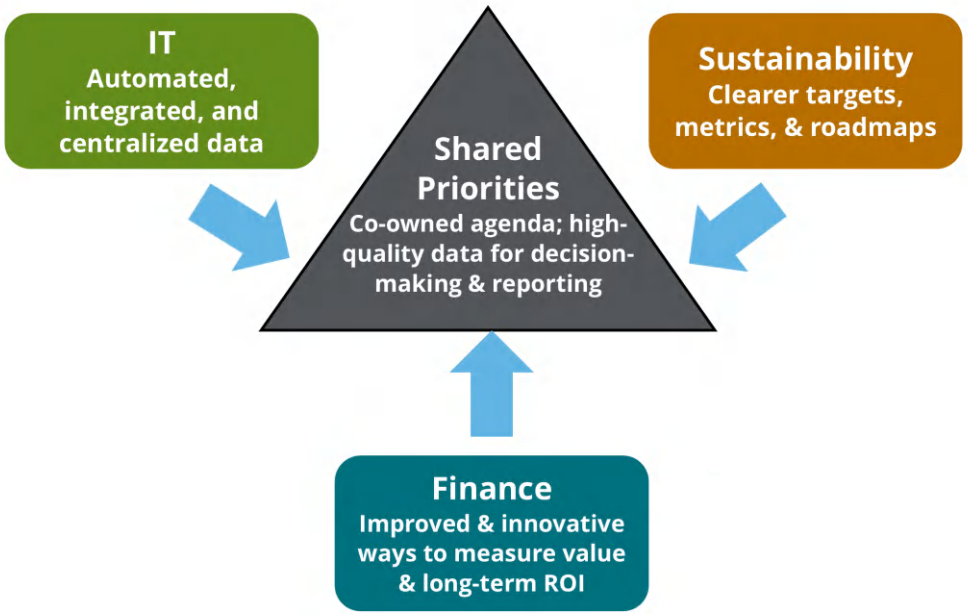


Figure 13.14 – The unique value each function brings to the Sustainability Value Triangle

In practice, IT must act as both the enabler and innovator. CSOs need IT to supply the digital infrastructure for sustainability reporting and action, while IT needs CSOs to define the vision and frameworks that shape its role. By working together—and bringing finance in early to help build strong business cases—these leaders can move beyond initial disconnects and create a sustainable, technology-driven path forward that they can travel together.

In the first half of this chapter, we took a high-level walk-through of early actions, including goal setting, starter strategy, and Year 1–3 action steps. We presented a maturity model to gauge your capability strengths and gaps, and received advice for working effectively with your counterparts in sustainability and finance. In the remainder of the chapter, we will show you precisely how to tackle one of the most common initial IT sustainable actions, which can also be one of the most challenging—establishing your GHG carbon emissions baseline and target state.

Quantifying IT's impact

Back in 2010, **Christina Figueres, the former Executive Secretary of the UN Framework Convention on Climate Change and Chief Architect behind the 2015 Paris Agreement**, said: "*The Carbon Disclosure Project (CDP) is to the future of business what the X-ray was to the future of medicine – without it, doctors could never see the inside of a patient's health.*" Establishing a GHG emissions baseline gives you the necessary insights into your IT organization's climate health and what necessary actions you need to take to transition into a sustainable IT enterprise. In this section, we will take a closer look at what you need to know to assess your impact through a top-down evaluation. Suppose you are not interested in how we calculated these numbers, and you are just interested in getting started with your carbon emissions baseline. In that case, we recommend you skip ahead to the next section. The numbers presented in this section are fictional, but they are a pretty good representation of a real company.

Quantifying IT's impact requires combining public carbon-intensity and LCA datasets with automated ESG platforms. Nonprofits such as The Green Grid, Electricity Maps, and IEA provide foundational data. Commercial services (Sphera, Persefoni, and AWS/Microsoft/Google tools) and consulting firms (Deloitte and Accenture) fill implementation and integration gaps. We have listed these and many other resources in previous chapters, particularly in *Chapter 6*, *Data Centers and the Cloud*, *Chapter 9*, *IT Hardware Management*, and *Chapter 12*, *Sustainability by IT*, in the section on carbon emissions reporting. For convenience, we have collected these into one indexed list available on the book's resource site (`https://www.sustainableit.org/sustainable-it-playbook`).

The following diagram shows a sample of a GHG emissions baseline made up of four focus areas—data centers and cloud, IT hardware, end-user energy management, and ITAD:

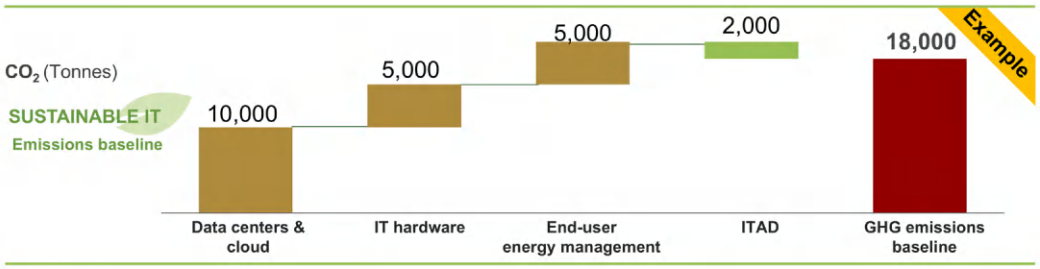


Figure 13.15 – GHG emissions baseline example

The first three categories—data centers and cloud, IT hardware, and end-user energy management—are, first and foremost, GHG emitters, and ITAD should hopefully enable us to recover GHG emissions through circular IT hardware management in the end-of-use/end-of-life phase. Each category sums up a total GHG emissions baseline. Later in this chapter, we will detail how you can calculate your baseline.

These four key focus areas are not an exhaustive list, but as we go through the process, you will hopefully see that they can capture most of your enterprise's GHG emissions. Individual applications have been included in the *Data centers and the cloud* section of this chapter. Suppose you aim to measure and improve individual applications over time. In that case, we recommend returning to *Chapter 7*, *Applications and Architecture*, for more details on establishing near-real-time feedback. One area that has been left out is the network because it requires detailed data points for each network node to calculate inbound and outbound data and location carbon intensity. Later in this chapter, we will examine how it can be scientifically done if needed. For example, if you are an ICT company, including network traffic in your calculations is highly relevant since it is part of your core business.

Let us look at each key focus area in detail to understand what parameters are required to calculate the GHG emissions per area.

Data centers and the cloud

To calculate an emissions baseline for data centers and cloud, we primarily need to focus on the following factors:

- **Location – carbon intensity per region**
- **PUE**
- **Percentage of virtual CPUs**
- **Server utilization rate (CPU usage)**
- **Hardware-specific energy consumption**

Understanding where your servers reside is a pivotal step in shaping your IT carbon footprint. A single server's environmental impact varies greatly depending on whether it is housed in a traditional on-premises data center, a large-scale global data center, or a hyperscaler cloud environment.

On-premises data centers are often tied to a single corporate site and primarily designed for proximity and control, not energy efficiency. They tend to have higher PUE values—commonly around 2.0, meaning that for every kilowatt consumed by servers, another kilowatt is lost to cooling and other overhead. These facilities also operate at lower virtualization levels and server utilization rates, with typical CPU usage averaging just 15%. This results in significant idle capacity and higher emissions per unit of compute.

Global data centers, whether third-party-operated or corporate-owned, achieve much greater efficiency through economies of scale and global load balancing. Their PUE values often fall between 1.2 and 1.3, and they employ advanced cooling technologies, workload scheduling, and virtualization practices to increase server utilization by 25% or more over on-premises environments. What matters is not who owns the data center, but whether it is designed and operated at scale, with standardized best practices and strategic siting near renewable energy sources. A corporation can build and run its own global data center network with these advantages, but doing so requires significant investment and operational maturity.

At the top end of efficiency are hyperscaler cloud providers, such as those operated by AWS, Azure, and Google Cloud. These facilities not only operate with PUE values near 1.1 but also achieve 50% higher utilization compared to on-premises servers through extreme virtualization, shared tenancy, and AI-driven workload optimization. As a result, fewer physical servers are needed to meet demand, reducing both embodied carbon from manufacturing and operational energy use. For example, the same workload that produces 2.768 tonnes of CO_2e annually on-premises may generate just 1.385 tonnes of CO_2e in a hyperscaler cloud, assuming a similar energy mix. Furthermore, hyperscalers increasingly locate facilities in regions with abundant renewable energy, lowering carbon intensity even further and creating a pathway to near-zero operational emissions.

For CIOs and CTOs, these distinctions highlight a spectrum of opportunities. Moving workloads from local on-premises facilities to global data centers brings immediate efficiency gains through scale, while hyperscaler cloud migration unlocks even greater optimization and access to low-carbon energy sourcing. Each step provides compounding benefits—not only reducing carbon footprint but also streamlining reporting and improving the agility of IT operations.

In the following subsections, we will take a closer look at each of these three scenarios.

Geography – carbon intensity per region

Whether you run your data center and cloud workload on fossil fuel or **carbon-free emissions (CFE)**, this has a significant impact on your carbon emissions. As we learned earlier in this book, according to the **International Energy Agency (IEA)**, the global average carbon intensity of electricity generated is 445 gCO_2/kWh (IEA 2025). With 100% low-carbon energy, you can get down to as low as 21 gCO_2/kWh, roughly a 21 times improvement on the global average.

For the calculations, we will stick to a low (21 gCO_2/kWh), medium (445 gCO_2/kWh), and high (600 gCO_2/kWh) scenario, but if you are interested in the specific carbon intensity within a region, we recommend visiting Electricity Maps (`https://app.electricitymaps.com/map`) for additional details.

Power usage effectiveness

As we learned in *Chapter 6*, *Data Centers and Cloud*, the second-largest factor contributing to your carbon emissions is the data center's energy consumption. Energy consumption is a closely watched indicator of environmental sustainability. High-efficiency gains are necessary to meet the constantly growing demand due to digitization to prevent energy consumption from rising quickly.

The Green Grid organization has introduced a few key benchmarks, and the most used is PUE (Brady, et al. 2013). PUE is the total electrical power supplied to the data center divided by the power consumed by IT equipment:

PUE = Total facility energy / IT equipment energy

The lower the PUE value, the more efficient the data center is. A PUE value close to 1.0 is ideal. The following diagram shows the relationship between the total facility power and the IT equipment power, and what components are powered in the respective categories:

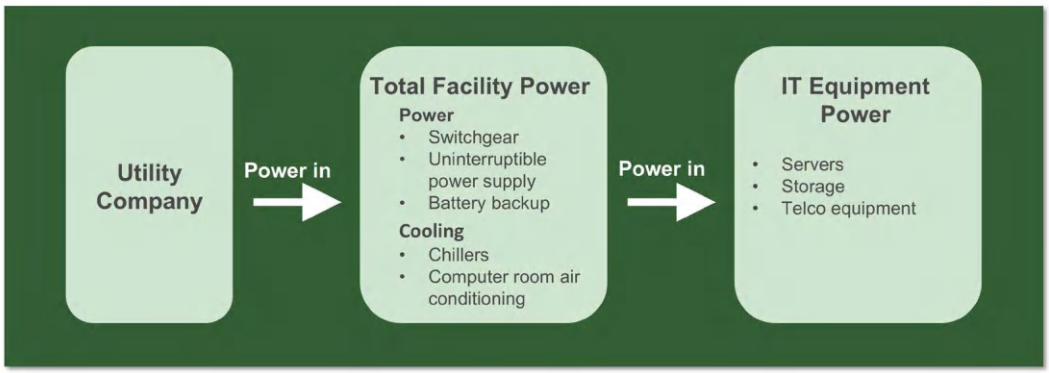


Figure 13.16 – PUE factors

As we learned in *Chapter 6*, *Data Centers and the Cloud*, the average data center sits at around a PUE of 1.65, which means it has an overhead of 65%. In an average small data center, the PUE sits at 2.0, which means a staggering 100% overhead is wasted (Khaliq uz Zaman, et al. January 2019). However, the problem is primarily centered around the utilization of the data center and not so much around the energy spent. Therefore, a data center with poor PUE could improve its numbers by optimizing existing workloads or adding additional workloads. Other common approaches, as highlighted in detail in *Chapter 6*, *Data Centers and the Cloud*, include more efficient cooling systems, heat reuse, eco-design for infrastructure efficiency, and software virtualization. Utilizing cloud hyperscalers only generates an overhead between 1.10 to 1.15 PUE, which means only 10 to 15% of the energy will go to waste. In our calculation, to distinguish between a traditional on-premises data center and a cloud vendor, we will assume that a cloud vendor is 50% more efficient than an average on-premises data center. This also considers the more minor non-hyperscalers, which might have low energy efficiency rates.

Percentage of virtual CPUs

The very nature of cloud computing is that the resources should be shared and virtualized to improve utilization and energy efficiency. However, for a traditional on-premises data center, the virtualization factor can differ significantly from no virtualization to a high level of virtualization, depending on where you are in your modernization journey. The following diagram shows an example of moving from physical server hardware to virtual server hardware:

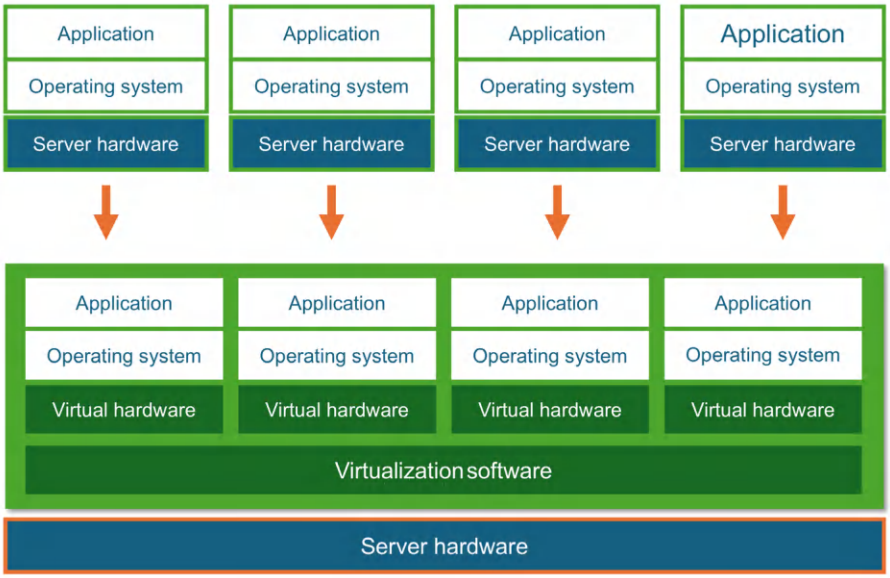


Figure 13.17 – From hardware to software virtualization

In the preceding example, four physical servers running standalone operating systems and applications are virtualized onto one server using virtualization software. Instead of running four physical servers, you have one physical server and four virtualized hardware running the same standalone operating system and applications in isolation.

For our calculations, we have assumed no virtualization in on-premises data centers, 25% in global data centers, and 50% in the cloud. Based on the virtualization grade within your environment, you should be able to determine what categories are feasible for you.

Server utilization rate (CPU usage)

In a typical on-premises data center, the server utilization rate is typically 15%, whereas a large cloud provider can achieve a 65% utilization rate (Delforge and Whitney 2014). Similar to the PUE, we have chosen to take a conservative approach and apply a 25% utilization rate improvement for a global data center and a 50% utilization rate improvement for a large-scale cloud provider to an on-premises data center.

Hardware-specific energy consumption

Chapter 2, *Rise of Sustainable IT*, covered definitions for emissions scope. Whether the server is hosted in the cloud, in an owned or outsourced data center, or even in a small closet in a local office, this has an impact on your energy efficiency and whether your emissions fall under Scope 2 or Scope 3. We could come up with several hosting variations, but to keep it simple, we decided to limit myself to nine categories based on three types and three carbon intensities:

- On-premises or data center server using high-carbon energy
- On-premises or data center server using average-carbon energy
- On-premises or data center server using low-carbon energy
- Outsourced data center server using high-carbon energy
- Outsourced data center server using average-carbon energy
- Outsourced data center server using low-carbon energy
- Cloud servers using high-carbon energy
- Cloud servers using medium-carbon energy
- Cloud servers using low-carbon energy

By low-carbon, we refer to fossil-free electricity, which does not contribute to GHG emissions and includes renewable energy such as wind, solar, geothermal, and nuclear energy. We have not taken into consideration the carbon footprint from the construction and maintenance of building these renewable energy sources or nuclear plants. We consider them to have a low-carbon emissions impact. Also, as a side note, the effects of using nuclear energy can be debated, but for carbon emissions, compared to fossil fuels, its impact is negligible. Low carbon is anything below 200 grams/kWh, medium ranges between 200 and 500 grams/kWh, and high carbon is above 500 grams/kWh.

Now that these nine categories have been established, let us look at their scope impact. As illustrated in *Table 13.5*, we can see that only our own owned on-premises and data centers fall into Scopes 1 and 2. Any server running in an outsourced data center or the cloud falls under Scope 3. This is a critical point to understand for your entire scope. For example, moving your workload from on-premises or your data center into the cloud impacts the dynamics of your entire value chain from Scopes 1 and 2 to Scope 3. They are equally important, but we must pull different levers to achieve our objectives:

Category	Scope 1	Scope 2	Scope 3
Owned on-premises data center server	√	√	
Outsourced data center server			√
Cloud provider			√

Table 13.5 – Scope impact per category

For the hardware-specific energy consumption calculation, we will use the same Dell PowerEdge R760 Server referenced in *Chapter 9*, *IT Hardware Management*. According to Rejoose, an R760 server deployed in the UK emits 4,201 $kgCO_2e$ over an expected lifetime of four years with a yearly TEC of 4,338.4 kWh (Rejoose 2025). Production accounts for 15.7% of lifetime CO_2e, 83.8% is spent during the use phase, and transport and end-of-life processing account for 0.5% collectively. In our calculation, we will consider whether the server is running on low- or high-carbon energy. In any instance, we will consider the emissions from hardware production.

Let us do some calculations to determine the carbon emissions for different scenarios:

Yearly carbon emissions from the production of servers:

Total server carbon emissions x Percentage of manufacturing / Product lifetime = Yearly carbon emissions from manufacturing

4,201 $kgCO_2e$/year x 15.7% / 4 = 165 $kgCO_2e$/year

Server virtualization rate in the global data center:

As stated in the *Percentage of virtual CPUs* section, we assume that only 75% of server capacity is needed when running in a data center setup:

Yearly carbon emissions from manufacturing x Percentage of virtual CPUs

165 kgCO_2e/year x 75% = 124 kgCO_2e/year

Server virtualization rate in the cloud:

As stated in the *Percentage of virtual CPUs* section, we assume that only 50% of server capacity is needed when running in a cloud hyperscaler setup:

Yearly carbon emissions from manufacturing x Percentage of virtual CPUs = Cloud server yearly carbon emissions from manufacturing

156 kgCO_2e/year x 50% = 83 kgCO_2e/year

We have now calculated the yearly carbon emissions for manufacturing the server, which are as follows:

- On-premises server from manufacturing:

165 kgCO_2e/year = 0.165 tCO_2e/year

- Global data center server from manufacturing:

124 kgCO_2e/year = 0.124 tCO_2e/year

- Cloud server from manufacturing:

83 kgCO_2e/year = 0.083 tCO_2e/year

Now, let us calculate the yearly carbon emissions to power our server. We know that the yearly energy demand for the server is 4,338.4 kWh/year (based on deployment in the UK). We assume a carbon intensity of 21 gCO_2/kWh for powering the server in a low-carbon environment. For a high-carbon environment, we assume the IEA global average carbon intensity of electricity generated is 445 gCO_2kWh. If the location of your servers is known, you should reference the location's carbon intensity from `https://app.electricitymaps.com/`. Since our server's energy demand estimate is based on UK deployment, we would use the average carbon intensity of the UK for on-premises server calculations, and the location of the cloud provider's server in the cloud calculation scenario.

However, to simplify things, we will stick with the global average of 445 gCO_2kWh for both scenarios:

On-premises server emissions from power consumption:

Server power consumption (kWh/year) x Carbon intensity (gCO_2e/kWh = Carbon emissions (gCO_2e/year)

Global data center server emissions from power consumption:

As stated previously, we assume a 25% improvement in server utilization rate (CPU usage) for a cloud server and apply the factor to the formula:

Server power consumption (kWh/year) x Carbon intensity (gCO_2e/kWh) x (100% - 25%) Server utilization rate improvement = Carbon emissions (gCO_2e/year)

Cloud server emissions from power consumption:

As stated previously, we assume a 50% improvement to the cloud server's server utilization rate (CPU usage) and apply the factor to the formula:

Server power consumption (kWh/year) x Carbon intensity (gCO_2e/kWh) x (100% - 50%) Server utilization rate improvement = Carbon emissions (gCO_2e/year)

On-premises server emissions from low-carbon power consumption:

4,338.4 kWh/year x 21 gCO_2e/kWh = 91,106 gCO_2e/year = 91 $kgCO_2e$/year = 0.091 tCO_2e/year

On-premises server emissions from average-carbon power consumption:

4,338.4 kWh/year x 445 gCO_2e/kWh = 1,930,588 gCO_2e/year = 1,931 $kgCO_2e$/year = 1.931 tCO_2e/year

On-premises server emissions from high-carbon power consumption:

4,338.4 kWh/year x 600 gCO_2e/kWH = 2,603,040 gCO_2e/year = 2,603 $kgCO_2e$/year = 2.603 tCO_2e/year

Global data center server emissions from low-carbon power consumption:

4,338.4 kWh/year x 21 gCO_2e/kWh x 75% = 68,330 gCO_2e/year = 68 $kgCO_2e$/year = 0.068 tCO_2e/year

Global data center server emissions from average-carbon power consumption:

4,338.4 kWh/year x 445 gCO_2e/kWh x 75% = 1,447,941 gCO_2e/year = 1,448 $kgCO_2e$/year = 1.448 tCO_2e/year

Global data center server emissions from high-carbon power consumption:

4,338.4 kWh/year x 600 gCO_2e/kWh x 75% = 1,952,280 gCO_2e/year = 1,952 $kgCO_2e$/year = 1.952 tCO_2e/year

Cloud server emissions from low-carbon power consumption:

4,229.4 kWh/year x 21 gCO_2e/kWh x 50% = 45,553 gCO_2e/year = 46 $kgCO_2e$/year = 0.046 tCO_2e/year

Cloud server emissions from average-carbon power consumption:

4,338.4 kWh/year x 445 gCO_2e/kWh x 50% = 965,294 gCO_2e/year = 965 $kgCO_2e$/year = 0.965 tCO_2e/year

Cloud server emissions from high-carbon power consumption:

4,338.4 kWh/year x 600 gCO_2e/kWh x 50% = 1,301,520 gCO_2e/year = 1,302 $kgCO_2e$/year = 1.302 tCO_2e/year

If we summarize all nine calculations, we get the following table:

Category ($kgCO_2$/Year)	Low-Carbon	Average-Carbon	High-Carbon
Own on-premises or data center server	91	1,931	2,603
Global data center server	68	1,448	1,952
Cloud provider	46	965	1,302

Table 13.6 – Server emissions from power consumption

Now that we have calculated server emissions for yearly power consumption, we can conclude that there is a massive difference—a 21 times improvement between running in a low-carbon environment as opposed to running in an average-carbon environment, and a 28.6 times improvement between running in a low-carbon environment as opposed to running in a high-carbon environment.

Finally, to calculate a server's total emissions per year, we need to add the embodied emissions from manufacturing (Scope 3) and our power consumption (Scope 2 or Scope 3) together to get the total emissions per year. Here, we assume that all servers have been manufactured with the global average carbon intensity of 445 gCO_2/kWh.

The total server emissions can be calculated as follows:

CO_2e from manufacturing ($kgCO_2e$/year) + CO_2e from power consumption ($kgCO_2e$/year) = Total carbon emissions ($kgCO_2e$/year)

Note that from a carbon accounting perspective, it is essential to keep them separate; therefore, we must calculate our Scope 2 from power consumption and our Scope 3 embodied carbon separately:

- Total on-premises emissions from low-carbon power consumption:

  165 $kgCO_2e$/year + 91 $kgCO_2e$/year = 256 $kgCO_2e$/year = 0.256 tCO_2e/year

- Total on-premises emissions from average-carbon power consumption:

  165 $kgCO_2e$/year + 1,931 $kgCO_2e$/year = 2,096 $kgCO_2e$/year = 2.010 tCO_2e/year

- Total on-premises emissions from high-carbon power consumption:

  165 $kgCO_2e$/year + 2,603 $kgCO_2e$/year = 2,768 $kgCO_2e$/year = 2.768 tCO_2e/year

- Total global data center emissions from low-carbon power consumption:

  124 $kgCO_2e$/year + 68 $kgCO_2e$/year = 192 $kgCO_2e$/year = 0.192 tCO_2e/year

- Total global data center emissions from average-carbon power consumption:

  124 $kgCO_2e$/year + 1,448 $kgCO_2e$/year = 1,572 $kgCO_2e$/year = 1.572 tCO_2e/year

- Total global data center emissions from high-carbon power consumption:

  124 $kgCO_2e$/year + 1,952 $kgCO_2e$/year = 2,076 $kgCO_2e$/year = 2.076 tCO_2e/year

- Total cloud emissions from low-carbon power consumption:

  83 $kgCO_2e$/year + 46 $kgCO_2e$/year = 129 $kgCO_2e$/year = 0.129 tCO_2e/year

- Total cloud emissions from average-carbon power consumption:

  83 $kgCO_2e$/year + 965 $kgCO_2e$/year = 1,048 $kgCO_2e$/year = 1.048 tCO_2e/year

- Total cloud emissions from high-carbon power consumption:

  83 $KgCO_2e$/year + 1,302 $kgCO_2e$/year = 1,385 $kgCO_2e$/year = 1.385 tCO_2e/year

In the following table, these calculations have been sorted and categorized into the proper scope and summarized:

Server Emissions Table ($kgCO_2e$/Year)	**Scope 1**	**Scope 2**	**Scope 3**	**Total**
On-premises emissions, low-carbon power consumption		91	165	256
On-premises emissions, average-carbon power consumption		1,931	165	2,096
On-premises emissions, high-carbon power consumption		2,603	165	2,768
Global DC emissions, low-carbon power consumption			192	192
Global DC emissions, average-carbon power consumption			1,572	1,572
Global DC emissions, high-carbon power consumption			2,076	2.076
Cloud emissions from low-carbon power consumption			129	129
Cloud emissions from average-carbon power consumption			1.048	1,048
Cloud emissions from high-carbon power consumption			1,385	1,385

Table 13.7 – Server emissions table

IT hardware

This category primarily focuses on an end user product procured from a vendor, which is your Scope 3 and is commonly referred to as embodied carbon. Since the energy from your end user products resides in Scope 2, we have decided to keep it separate for clarity. In *Chapter 9*, *IT Hardware Management*, we took a closer look at ways to limit your IT hardware, and we also looked closer at three specific end user products—a laptop, smartphone, and tablet—and their **lifecycle assessment (LCA)** from three different vendors—**Dell**, **Apple**, and **Microsoft**. Since we covered where the emissions originate from in the different phases (make, transportation, use, and end-of-life) previously, we will not cover this in detail in this chapter. However, we will introduce additional end user products from some vendors that you can choose from when you establish your carbon emissions baseline.

More details are also available on this book's website: `www.sustainableITplaybook.com`. The list of products will be continuously updated as new data points become available.

Energy management

This category covers anything related to energy management in your Scope 2. It primarily focuses on end user devices such as computers, smartphones, tablets, monitors, printers, and more. As we learned in *Chapter 10*, *Energy Resource Management*, energy consumption is the most significant contributing factor to reducing your carbon emissions over time. Therefore, it is essential to understand your energy usage from your IT assets and take remediating actions.

To retrieve the energy consumption for the devices and calculate carbon emission, we will use the energy consumption calculations from *Chapter 10*, *Energy Resource Management*, summarized in *Table 10.2*. Refer to the *Data centers and the cloud* section for server calculations:

ICT Device	**Energy Consumption (kWh)**	**Carbon Emissions Low-Carbon ($kgCO_2$/ Year)**	**Carbon Emissions High-Carbon ($kgCO_2$/ Year)**
Notebook (Low)	110 kWh	2.3	50
Notebook (High)	220 kWh	4.6	100
Desktop	440 kWh	9.2	210

Table 13.8 – Summary of yearly energy consumption and carbon emissions of ICT devices

To calculate the carbon emissions for low-carbon and high-carbon, we have used the same reference points we used previously. There should be no surprise here that there is roughly a factor of 20 between low-carbon and high-carbon.

IT asset disposition

The disposal of IT equipment poses a significant threat to the environment. The volume of electronic waste generated worldwide in 2022 was 62 million metric tonnes, which would fill 1.55 million 40-tonne trucks, enough trucks to form a bumper-to-bumper line encircling the equator (Global E-waste Monitor 2024). Unfortunately, e-waste has become the fastest-growing worldwide waste stream, expected to grow to 82 million metric tonnes by 2030. Contributing factors to fuel this growth are the global availability of electronics and increased spending power. As we learned in *Chapter 9*, *IT Hardware Management*, a large proportion of discarded equipment is not wasted. For this reason, the ITAD industry was created, focusing on the acquisition, reuse, repair, and disposal of unwanted IT equipment, predominantly from commercial companies, in a safe and environmentally responsible way.

Essentially, the ITAD industry tries to address three critical environmental impacts:

- Avoid GHG emissions through responsible recycling
- Recycle critical metals and minerals
- Divert hazardous substances from landfills and improper dispersal
- Shrink the digital divide through asset donation and support to underserved communities (some vendors)

Besides properly managing your IT equipment data sanitization, your ITAD process is an opportunity to achieve carbon savings from refurbishing and recycling. As we've already learned, once an IT asset has been born, the best way to minimize the manufacturing phase's carbon footprint is to keep it in use for as long as possible. Extending the product lifecycle not only cuts carbon emissions but can also significantly impact your bottom line by reducing costs.

Some ITAD vendors claim that you can receive 50% carbon emissions savings for what has been released in the manufacturing phase. This, of course, varies depending on the age of the IT asset and whether it can be refurbished or recycled. Much of the carbon accounting in ITAD today is based on weight, not specific device makeup. For example, the ITAD Human-I-T.org blends emissions estimates across a wide range of donated assets to generate an aggregate carbon savings per pound. This approach inevitably flattens embedded carbon nuances between, say, a rack of servers and a box of Chromebooks. Also, the reuse rate is heavily influenced by the weight of scrap or non-viable material on the recycling side. For our calculations, we will set the carbon saving rate at 30%, which is conservative for reuse-heavy streams. However, it may be too optimistic for streams with heavier, less reusable gear.

If we refer to our example from *Chapter 9*, *IT Hardware Management*, and the LCA example of the Dell Pro 14 Premium laptop, which emits 244.2 $kgCO_2e$ over its expected four-year lifespan, where the manufacturing represents 89.6% of total emissions, this equates to 219 $kgCO_2e$ of the total. With our assumptions about our carbon savings of returning the notebook to a reputable ITAD vendor, we would receive 65.7 kg CO_2 equivalent in savings for a single unit.

Network traffic

As mentioned previously, we will not consider network traffic when establishing our baseline since it requires capturing the data transmission across our network. Also, with the increase of cloud applications, it is not an easy task to estimate with high certainty the network traffic that is transferred outside your corporate network.

There are several factors to be considered, including the following:

- Packet size

- Data volume
- Distance data must travel
- Number of jumps between network nodes (devices)
- Network device energy efficiency
- Region's carbon intensity
- Network protocol

Once we have the energy consumption, we can calculate the carbon emissions. However, if you are interested in including carbon emissions from your network data, one source for data is **The Shift Project** (`https://theshiftproject.org/`). After correcting earlier estimates that were considered too high, The Shift Project now provides the following updated benchmark values:

- **Electricity consumption**: Online video viewing uses approximately 0.77 **kilowatt-hours (kWh)** per hour of viewing time. This represents the combined electricity required by user devices, transmission networks, and data centers.
- **Carbon emissions**: When translated into lifecycle emissions, this equates to 0.40 kilograms of CO_2-equivalent per hour of video streamed, assuming a global average electricity mix. For context, this is about 200 grams of CO_2 for a 30-minute streaming session.
- **Data volume basis**: The calculations assume 1.4 GB of data transferred per hour of video, based on a representative average bitrate for typical streaming quality.

These figures are illustrative, not prescriptive. They provide a sense of scale for digital energy use, but should not be treated as exact per-stream numbers, because actual results vary widely based on the following:

- The type of network (wired broadband, Wi-Fi, or 4G/5G mobile)
- Device used (TV, laptop, or smartphone)
- Video resolution and compression (SD, HD, or UHD)
- Data center efficiency and caching strategies

For example, depending on these factors, total electricity consumption for one hour of streaming can range from roughly 0.04 kWh to 1.2 kWh. The Shift Project's 0.77 kWh per hour figure represents a mid-range, globally averaged scenario designed for macro-level analysis, such as national digital carbon accounting.

Despite their limitations and complexities, understanding the true magnitude of digital energy demand helps organizations set realistic sustainability targets for cloud, data center, and network operations.

Establishing your sustainable IT emissions baseline

Now that we have established an emissions table, you are ready to create a sustainable IT emissions baseline and simulate your target state. To do this, you need an accompanying book resource, `Sustainable IT Playbook – Emissions Calculator.xslx`, which can be downloaded from the book's resource page (`https://www.sustainableit.org/sustainable-it-playbook`). Use this resource as a reference to establish your own sustainable IT emissions and simulate your target state.

Establishing the emissions baseline and simulating your target state follows a seven-step process. Each process step has a logical sequence, so the recommendation is to follow along stepwise.

This process is outlined in the following diagram:



Figure 13.18 – Emissions calculation – a seven-step process

Let us take a closer look at each step in the process in detail.

Introduction

This tool aims to help you get a rough estimation of your emissions and not an exact figure. Arriving at the GHG emissions baseline and simulating the future state will be based on several assumptions, including the data quality of your IT assets and predictions going forward. You should use this tool to identify critical areas where it makes sense to start working on reducing your carbon emissions.

Once you are ready to create your baseline and target state simulation, you can either leverage the pre-populated template or start with an empty template. To walk you through the process, we will utilize a model company that you can use as a reference when you establish your baseline. The model company, just like in *Chapter 9*, *IT Hardware Management*, will be based on a global manufacturing company, this time with 10,000 employees and business operations worldwide.

Parameters and assumptions

In this process step (the **Parameters and assumptions** tab), we input information about company identification, company overview, parameters such as year-on-year energy efficiency improvements or ITAD CO_2 emissions recovery percentage, and assumptions.

In the first dialog box, **Company identification**, as shown in the following screenshot, fill in the company name, the number of employees, and a brief description of the company:

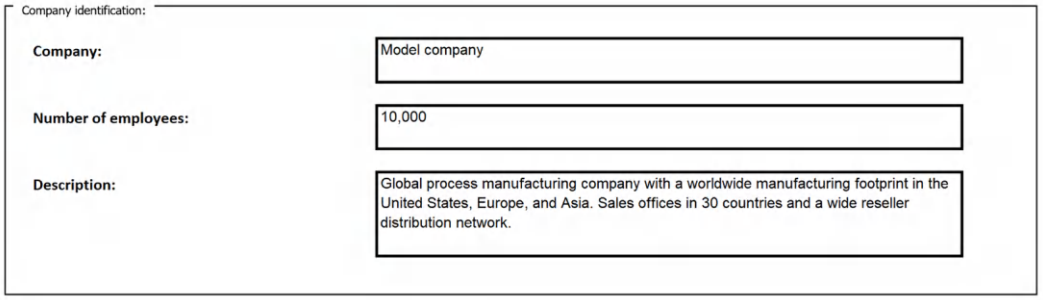


Figure 13.19 – Company identification dialog box in Emissions Calculator spreadsheet

In the second dialog box, **Company overview**, fill in the business objectives, business sustainability ambition, IT overview, and sustainable IT ambition areas. The UN SDGs or EU Taxonomy can provide good starting points for identifying potential ambition themes:

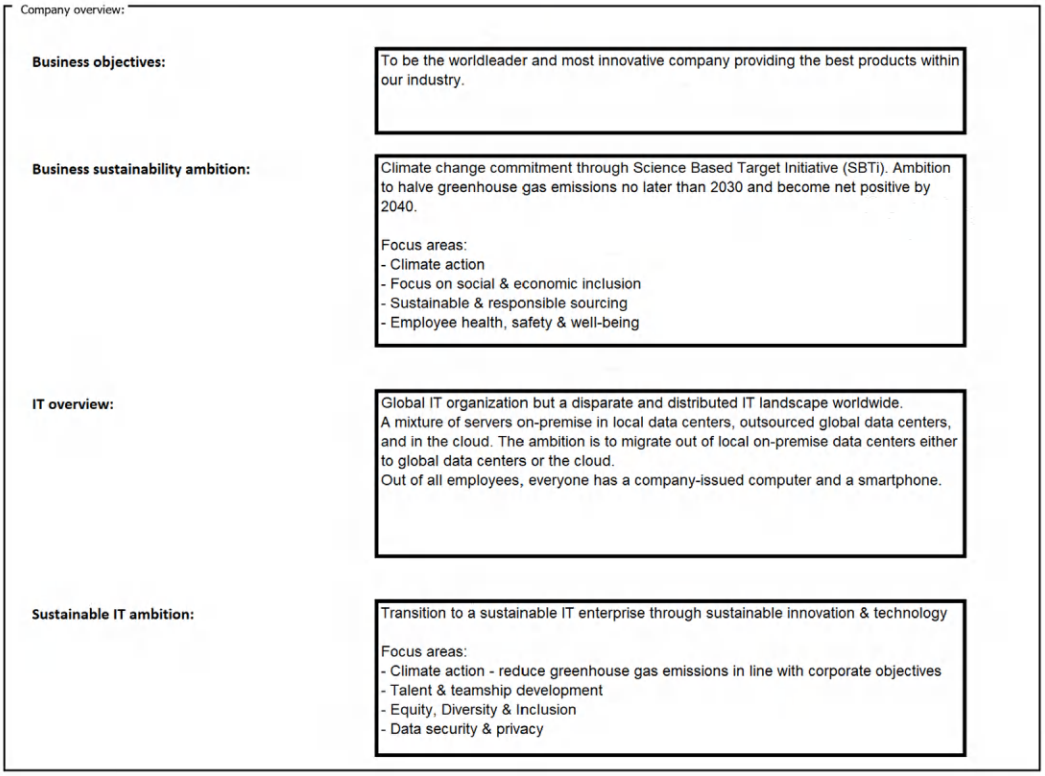


Figure 13.20 – Company overview dialog box

In the third dialog box, **Parameters**, fill in the starting year, energy efficiency improvement YoY, and ITAD CO_2 emissions recovery percentage areas, or leave them as they were:

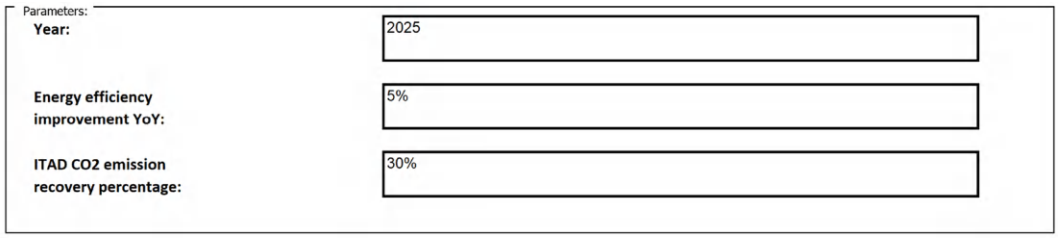


Figure 13.21 – Parameters dialog box

In the fourth dialog box, **Assumptions**, fill in assumptions for data centers and the cloud, application and data, IT hardware, energy management, ITAD, and network traffic:

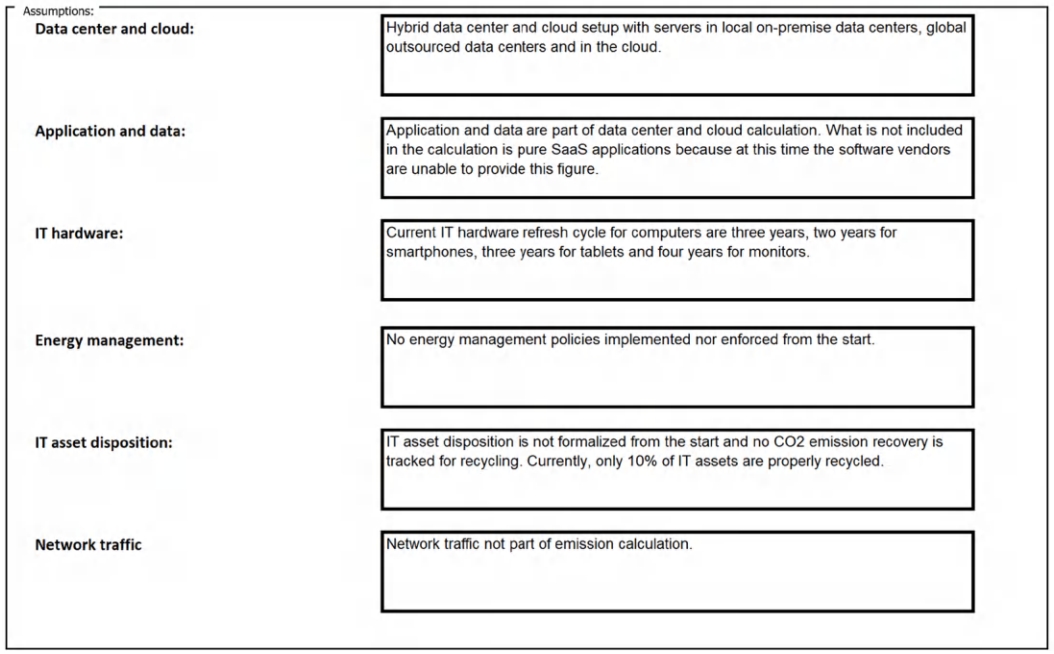


Figure 13.22 – Assumptions dialog box

Now that we have filled out the **Parameters** and **Assumptions** tabs, we will review our emissions table.

Setting up the emissions table

In this process step, setting up an emissions table (the **Emissions Table** tab in the spreadsheet), we review the populated data and make any adjustments necessary, as shown in the following screenshot. The table is dynamic, so it is easy to add additional rows:

Category	Type	Description	Scope 1	Scope 2	Scope 3	Total	Unit
Data center & Cloud	Local data center - Low-carbon	Local on-premise emissions low-carbon power consumption	0	37	329	366	kg CO2
Data center & Cloud	Local data center - Average-carbon	Local on-premise emissions medium-carbon power consumption	0	836	329	1165	kg CO2
Data center & Cloud	Local data center - High-carbon	Local on-premise emissions high-carbon power consumption	0	1056	329	1385	kg CO2
Data center & Cloud	Global data center - Low-carbon	Global data center emissions from low-carbon power consumption	0	0	275	275	kg CO2
Data center & Cloud	Global data center - Average-carbon	Global data center emissions from medium-carbon power consumption	0	0	874	874	kg CO2
Data center & Cloud	Global data center - High-carbon	Global data center emissions from high-carbon power consumption	0	0	1039	1039	kg CO2
Data center & Cloud	Cloud - Low-carbon	Cloud emissions from low-carbon power consumption	0	0	183	183	kg CO2
Data center & Cloud	Cloud - Average-carbon	Cloud emissions from medium-carbon power consumption	0	0	583	583	kg CO2
Data center & Cloud	Cloud - High-carbon	Cloud emissions from high-carbon power consumption	0	0	693	693	kg CO2
IT Equipment	Computer - Notebook - Low Energy	Notebook computer - standard issue - Low energy consumption	0	50	200	250	kg CO2
IT Equipment	Computer - Notebook - High Energy	Notebook computer - standard issue - High energy consumption	0	100	200	300	kg CO2
IT Equipment	Computer - Desktop	Desktop computer - standard issue	0	180	329	509	kg CO2
IT Equipment	Monitor	Monitor - standard issue	0	32.5	380	412.5	kg CO2
IT Equipment	Smartphone	Smartphone - standard issue	0	3.3	60	63.3	kg CO2
IT Equipment	Tablet	Tablet - standard issue	0	3.3	150	153.3	kg CO2
IT Equipment	Printer usage-High	Printer - high energy usage	0	272	0	272	kg CO2
IT Equipment	Printer usage-Medium	nter - medium energy usage	0	171	0	171	kg CO2
IT Equipment	Printer usage-Low	Printer - low energy usage	0	104	0	104	kg CO2
IT Equipment	Device-as-a-Service		0	25	0	25	kg CO2

Figure 13.23 – Emissions table tab in Emissions Calculator spreadsheet

If you want to include specific emissions data from your vendors, the product finder at **TCO Certified** (`https://tcocertified.com/product-finder/`) is an excellent place to start or search for **product carbon footprints** (**PCFs**) on your vendor websites.

It is worth noting that Scope 1 has been left empty, and the emissions data is primarily populated in Scopes 2 and 3. Remember that Scope 2 is your direct emissions through energy (electricity, heating, and cooling) purchased, while Scope 3 is all other indirect emissions from your vendors, such as outsourcing data center, cloud, or manufacturing of IT hardware.

IT asset registry

In this step (the **IT asset registry** tab in the spreadsheet), we input the number of IT assets that we currently have per category in column E. Columns F to N are for making simulations to reach your target state emissions, as shown in the following screenshot:

Type	2025	Comments
Cloud & Data Center - Server count	**10,000**	
Employees	**10,000**	Employee growth 1000 per year
Cloud & Data Center - Server count	**3,000**	
Local data center - Low-carbon		
Local data center - Average-carbon		
Local data center - High-carbon	1,000	Move 200 servers to the cloud and decommission 50 per year.
Global data center - Low-carbon		
Global data center - Average-carbon		
Global data center - High-carbon	1,000	Move 200 servers to the cloud and decommission 50 servers per year.
Cloud - Low-carbon		Move servers to low-carbon region.
Cloud - Average-carbon		
Cloud - High-carbon	1,000	Move 200 servers per your to low-carbon region.
IT Hardware - New purchase YoY	**12,750**	**Comments**
Computer - Notebook - High Energy	2,500	Refresh rate shift from 3 years to 4 years
Computer - Notebook - Low Energy	-	Refresh rate shift from 3 years to 4 years
Computer - Desktop	500	Refresh rate shift from 3 years to 4 years
Monitor	3,750	Refresh rate shift from 4 years to 5 years
Smartphone	5,000	Refresh rate shift from 2 years to 3 years
Tablet	1,000	Refresh rate every 3 years (No change)
IT Hardware - Existing hardware	**39,680**	**Comments**
Computer - Notebook - High Energy	8,000	
Computer - Notebook - Low Energy	-	
Computer - Desktop	2,000	
Monitor	15,000	1,5 monitor per desktop and notebook
Smartphone	10,000	Every employee has a company issued smartphone
Tablet	3,000	1/3 of employees has a tablet
Printer usage-High	480	4 to 2 printers per site for 120 locations
Printer usage-Medium	720	6 to 4 printers per site for 120 locations
Printer usage-Low	480	4 to 2 printers per site for 120 locations
Device-as-a-Service	-	
IT Asset Disposition	**-**	**Comments**
Computer - Notebook - High Energy	-	Assume 0% asset recycling and carbon credit recovery year 1
Computer - Notebook - Low Energy	-	Assume 40% asset recycling and carbon credit recovery year 2
Computer - Desktop	-	Assume 60% asset recycling and carbon credit recovery year 3
Monitor	-	Assume 80% asset recycling and carbon credit recovery year 4
Smartphone	-	Assume 90% asset recycling and carbon credit recovery year 5
Tablet	-	
Other	**-**	**Comments**

Figure 13.24 – IT asset registry

For a company of 10,000 employees, we have made the following assumptions:

- The company has 3,000 servers, evenly split between on-premises, global data centers, and the cloud. They all reside in high-carbon regions, which is not uncommon. We assume that new data center equipment has been bought this year.
- Every employee has a company-issued computer and a smartphone. Every employee, on average, has been issued 1.5 monitors, and 3,000 have a company-issued tablet. The split between notebook versus desktop is 80/20. Currently, only high-energy notebooks are used.
- The refresh rate for IT hardware is currently three years for notebooks, three years for desktops, four years for monitors, two years for smartphones, and three years for tablets.
- The company has 120 locations around the world for its 10,000 employees. At every site, four high-energy printers, six medium-energy printers, and four low-energy printers exist.
- No formal ITAD is done at this time, so we leave it blank.
- SaaS applications are not part of the calculation. It is possible to add SaaS applications to the calculation, but at the time of writing, unfortunately, the data is unavailable from the vendors. Several vendors are working on their calculations and looking to make it official, but GHG emissions are not readily available.

Emissions baseline single year

In this step (the **Emissions baseline** tab), we have established our single emissions baseline, as shown in the following screenshot:

Type	Scope 1	Scope 2	Scope 3	Total	Units
Cloud & Data Center	-	1,056,000	2,061,000	3,117,000	
Local data center - Low-carbon	-	-	-	-	
Local data center - Average-carbon	-	-	-	-	
Local data center - High-carbon	-	1,056,000	329,000	**1,385,000**	kg CO2
Global data center - Low-carbon			-	-	
Local data center - Average-carbon			-	-	
Global data center - High-carbon			1,039,000	**1,039,000**	kg CO2
Cloud - Low-carbon			-	-	
Cloud - Average-carbon			-	-	
Cloud - High-carbon			693,000	**693,000**	kg CO2
IT Hardware	-	-	2,539,500	2,539,500	Units
Computer - Notebook - High Energy			500,000	**500,000**	kg CO2
Computer - Notebook - Low Energy			-	-	kg CO2
Computer - Desktop			164,500	**164,500**	kg CO2
Monitor			1,425,000	**1,425,000**	kg CO2
Smartphone			300,000	**300,000**	kg CO2
Tablet			150,000	**150,000**	kg CO2
Energy Management EUC	-	1,994,000	-	1,994,000	Units
Computer - Notebook - High Energy		800,000		**800,000**	kg CO2
Computer - Notebook - Low Energy		-		-	kg CO2
Computer - Desktop		360,000		**360,000**	kg CO2
Monitor		487,500		**487,500**	kg CO2
Smartphone		33,000		**33,000**	kg CO2
Tablet		9,900		**9,900**	kg CO2
Printer usage-High		130,560		**130,560**	kg CO2
Printer usage-Medium		123,120		**123,120**	kg CO2
Printer usage-Low		49,920		**49,920**	kg CO2
Device-as-a-Service		-		-	kg CO3
IT Asset Disposition	-	-	-	-	Units
Computer - Notebook - High Energy			-	-	kg CO2
Computer - Notebook - Low Energy			-	-	kg CO2
Computer - Desktop			-	-	kg CO2
Monitor			-	-	kg CO2
Smartphone			-	-	kg CO2
Tablet			-	-	kg CO2
			-	-	
Total CO2 emission	**1**	**2**	**3**	**Total**	**Units**
	-	3,050,000	4,600,500	7,650,500	kg CO2
	-	3,050	4,601	7,651	tonnes CO2

Figure 13.25 – Emissions baseline

Here, we can see that, in total, our emissions baseline emits 7,650,500 $kgCO_2e$/year, or 7,651 tonnes of CO_2e/year. Out of the total, 3,117,000 $kgCO_2e$/year stems from cloud and data centers, 2,539,500 $kgCO_2e$/year stems from new IT hardware purchases, and 1,994,000 $kgCO_2e$/year stems from EUC energy management; we were unable to recover any carbon credits for ITAD.

To make our results a bit more presentable, the emissions baseline is presented in an aggregated waterfall format in the following diagram:

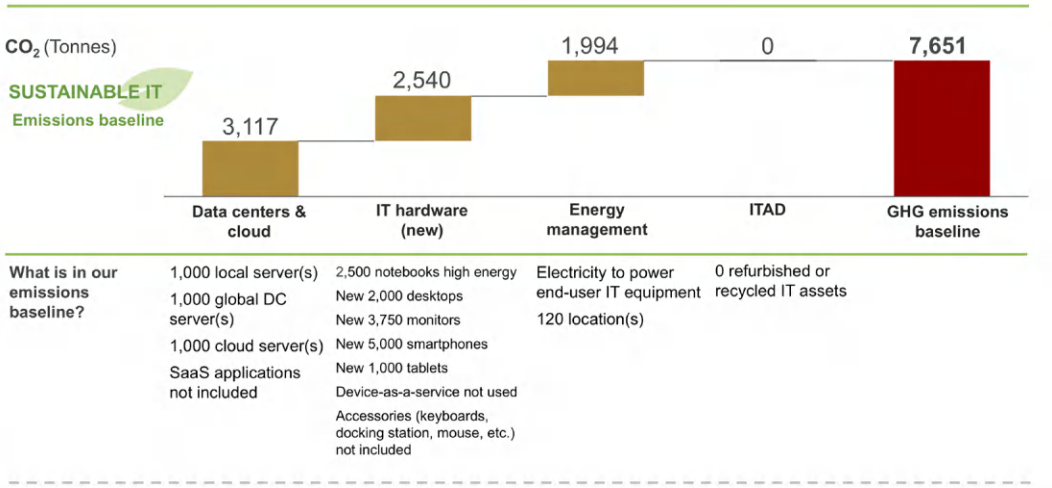


Figure 13.26 – Emissions baseline aggregated view

Now that we have established a carbon emissions baseline, we can start understanding what mitigating factors we can take to reduce our carbon emissions. As highlighted previously, the calculation is based on a global manufacturing model company with 10,000 employees. You will discover differences across industries and the business environment as you create your baseline. Let us look at a few examples. For example, there might be more custom-developed applications in the banking and finance industry than **commercial off-the-shelf (COTS)** software. Due to local or federal legislation, moving to the cloud may not be an option in the public sector. You won't be burdened with any legacy data centers for a start-up company, and you can start with a green field implementation in the cloud. Across industries, there will also be commonalities regarding how you manage your energy consumption or how you procure and manage your IT hardware and dispose of it at end-of-use or end-of-life.

In the next section, we will set a plan to halve our emissions and make a year-on-year simulation on how to get there.

Simulating your target state

Now that we have established a carbon emissions baseline, we can start setting our target direction for the next 10 years. We will use similar techniques to arrive at the carbon emissions baseline. Still, to do a 10-year simulation, we need to consider a few more parameters over time, such as company growth, employee headcount, IT asset count, ITAD refurbishment, energy mix, regulations, geopolitical implications, and recycling rates. To help you follow along, we have tried to make the assumptions as straightforward as possible. We encourage you to experiment with the model and make your own assumptions. Remember that your journey may look completely different than the one for the model company.

Our primary assumption follows the **Science-Based Target Initiative (SBTi)** guidelines and the general research community's recommendation to halve our emissions by 2030. Since our starting year is 2025 in our simulation, this means that we only have five years to complete the target. Fortunately, we will be able to use several levers that will enable us to reduce our carbon emissions much more sharply.

Let us take a closer look at the multi-year simulation.

Multi-year simulation

To start the multi-year simulation, let us go back to the IT asset registry process step (the IT Asset Registry tab). From what we did previously, we have the values filled in for the current year, which will form the basis for our simulation going forward.

For the 10-year simulation, we have made the following assumptions:

- As mentioned previously, we need to halve our carbon emissions in 2030, which means we have five years to do this since our starting year was 2025.
- We assume the company is profitable and grows with 1,000 additional employees annually.
- Our goal for the cloud and data centers is to retire our local on-premises servers and move them to the cloud. We aim to move 200 local on-premises servers from high-carbon regions to a low-carbon cloud region and decommission 50 servers annually. We aim to move 200 global data center servers from a high-carbon region to a low-carbon cloud region and decommission 50 servers annually.
- We aim to gradually relocate servers running in a high-carbon region to a low-carbon region.
- **Software-as-a-service (SaaS)** applications are not part of the simulation. At this point, SaaS vendors are reluctant or unable to provide these data points.

- We upgraded our policy for hardware refresh for our IT hardware and extended each IT asset class by one year.
- We start shifting our high-energy IT assets to low-energy assets.
- We aim to shift a portion of our computers to **device-as-a-service (DaaS)** to reduce hardware and increase energy efficiency.
- We assume that energy efficiency increases year on year by 5%.
- We have started utilizing ITAD services to recover carbon credits. Our goal is that 80% of our assets should go through ITAD.

Now, let us look at what a 10-year IT asset registry (the **IT asset registry** tab) simulation can look like (due to consolidation of the table, we do not show the figures for 2028 - 2031):

TYPE	2025	2026	2027	.....	2032	2033	2034
Cloud & Data Center - Server cour	**10,000**	**11,000**	**12,000**		**17,000**	**18,000**	**19,000**
Employees	**10,000**	**11,000**	**12,000**		**17,000**	**18,000**	**19,000**
Cloud & Data Center - Server cour	**3,000**	**2,900**	**2,800**		**2,200**	**2,200**	**2,200**
Local data center - Low-carbon							
Local data center - Average-carbon							
Local data center - High-carbon	1,000	800	600		-	-	-
Global data center - Low-carbon							
Global data center - Average-carbon							
Global data center - High-carbon	1,000	750	500		-	-	-
Cloud - Low-carbon		550	1,100		2,200	2,200	2,200
Cloud - Average-carbon							
Cloud - High-carbon	1,000	800	600		-	-	-
IT Hardware - New purchase YoY	**12,750**	**8,800**	**9,800**		**12,550**	**13,000**	**13,400**
Computer - Notebook - High Energy	2,500	500	500		250	250	250
Computer - Notebook - Low Energy	-	1,500	2,000		3,000	3,000	3,000
Computer - Desktop	500	500	500		250	250	250
Monitor	3,750	1,500	1,500		1,500	1,500	1,500
Smartphone	5,000	3,600	4,000		5,650	6,000	6,300
Tablet	1,000	1,200	1,300		1,900	2,000	2,100
IT Hardware - Existing hardware	**39,680**	**43,110**	**46,960**		**66,110**	**69,960**	**73,760**
Computer - Notebook - High Energy	8,000	6,500	5,000		1,000	1,000	1,000
Computer - Notebook - Low Energy	-	1,500	3,500		7,000	7,500	8,000
Computer - Desktop	2,000	2,000	1,500		1,000	1,000	1,000
Monitor	15,000	16,500	18,000		25,500	27,000	28,500
Smartphone	10,000	11,000	12,000		17,000	18,000	19,000
Tablet	3,000	3,650	4,000		5,650	6,000	6,300
Printer usage-High	480	240	240		240	240	240
Printer usage-Medium	720	480	480		480	480	480
Printer usage-Low	480	240	240		240	240	240
Device-as-a-Service	-	1,000	2,000		8,000	8,500	9,000
IT Asset Disposition	**-**	**3,933**	**6,410**		**-**	**13,410**	**14,198**
Computer - Notebook - High Energy	-	800	975		-	225	225
Computer - Notebook - Low Energy	-	-	225		-	1,575	1,688
Computer - Desktop	-	200	300		-	225	225
Monitor	-	1,200	1,980		-	4,590	4,860
Smartphone	-	1,333	2,200		-	5,100	5,400
Tablet	-	400	730		-	1,695	1,800

Figure 13.27 – 10-year IT asset registry simulation

As per our assumptions, the employment growth is 1,000 per year. Our servers are moved gradually to a low-carbon cloud region in the cloud, and 100 servers are decommissioned annually. Due to the IT hardware refresh cycle and the annual increase in employees, the purchase of new IT hardware continues to increase year on year. For existing hardware, the asset count continues to increase due to employee growth. Finally, as per our assumption, ITAD continues to increase yearly.

Now that our 10-year IT asset registry simulation is complete, let us look at what the multi-year carbon emissions simulation (the **Multi-year simulation** tab) looks like:

Sustainable IT Playbook - Emissions Calculator - Emissions Calculation Multi-year							
Type	2025 Total	2026 Total	2027 Total	.....	2032 Total	2033 Total	2034 Total
Cloud & Data Center	3,117,000	2,542,300	1,967,600		402,600	402,600	402,600
Local data center - Low-carbon	-	-	-		-	-	-
Local data center - Average-carbon	-	-	-		-	-	-
Local data center - High-carbon	1,385,000	1,108,000	831,000		-	-	-
Global data center - Low-carbon	-	-	-		-	-	-
Global data center - Average-carbon	-	-	-		-	-	-
Global data center - High-carbon	1,039,000	779,250	519,500		-	-	-
Cloud - Low-carbon	-	100,650	201,300		402,600	402,600	402,600
Cloud - Average-carbon	-	-	-		-	-	-
Cloud - High-carbon	693,000	554,400	415,800		-	-	-
IT Hardware	2,539,500	1,530,500	1,669,500		1,926,250	1,962,250	1,995,250
Computer - Notebook - High Energy	500,000	100,000	100,000		50,000	50,000	50,000
Computer - Notebook - Low Energy	-	300,000	400,000		600,000	600,000	600,000
Computer - Desktop	164,500	164,500	164,500		82,250	82,250	82,250
Monitor	1,425,000	570,000	570,000		570,000	570,000	570,000
Smartphone	300,000	216,000	240,000		339,000	360,000	378,000
Tablet	150,000	180,000	195,000		285,000	300,000	315,000
Energy Management EUC	1,994,000	1,749,819	1,579,608		1,108,780	1,070,412	1,024,133
Computer - Notebook - High Energy	800,000	617,500	450,000		65,000	60,000	55,000
Computer - Notebook - Low Energy	-	71,250	157,500		227,500	225,000	220,000
Computer - Desktop	360,000	342,000	243,000		117,000	108,000	99,000
Monitor	487,500	509,438	526,500		538,688	526,500	509,438
Smartphone	33,000	34,485	35,640		36,465	35,640	34,485
Tablet	9,900	11,443	11,880		12,119	11,880	11,435
Printer usage-High	130,560	62,016	58,752		42,432	39,168	35,904
Printer usage-Medium	123,120	77,976	73,872		53,352	49,248	45,144
Printer usage-Low	49,920	23,712	22,464		16,224	14,976	13,728
Device-as-a-Service	-	23,750	45,000		130,000	127,500	123,750
IT Asset Disposition	-	- 246,540	- 399,780		- 780,638	- 821,543	- 869,198
Computer - Notebook - High Energy	-	- 48,000	- 58,500		- 13,500	- 13,500	- 13,500
Computer - Notebook - Low Energy	-	-	- 13,500		- 94,500	- 94,500	- 101,250
Computer - Desktop	-	- 19,740	- 29,610		- 22,208	- 22,208	- 22,208
Monitor	-	- 136,800	- 225,720		- 492,480	- 523,260	- 554,040
Smartphone	-	- 24,000	- 39,600		- 86,400	- 91,800	- 97,200
Tablet	-	- 18,000	- 32,850		- 71,550	- 76,275	- 81,000
Total CO2 emission	Total	Total	Total		Total	Total	Total
	7,650,500	5,576,079	4,816,928		2,656,992	2,613,720	2,552,786
	7,651	5,576	4,817		2,657	2,614	2,553

Figure 13.28 – 10-year carbon emissions simulation

Here, we can see that carbon emissions decrease steadily in all categories year on year. From the starting year, 2025, where the carbon emissions totaled 7,651 tonnes, it has decreased by 67% in 2034 to 2,553 tonnes despite almost doubling in employee count over 10 years. We exceeded our SBTi goal of cutting our baseline emissions in half by 2030 (64%, not shown due to consolidation of simulation table). The following diagram shows a waterfall breakdown of how we moved from the 2025 carbon emissions baseline to the 2034 target state:

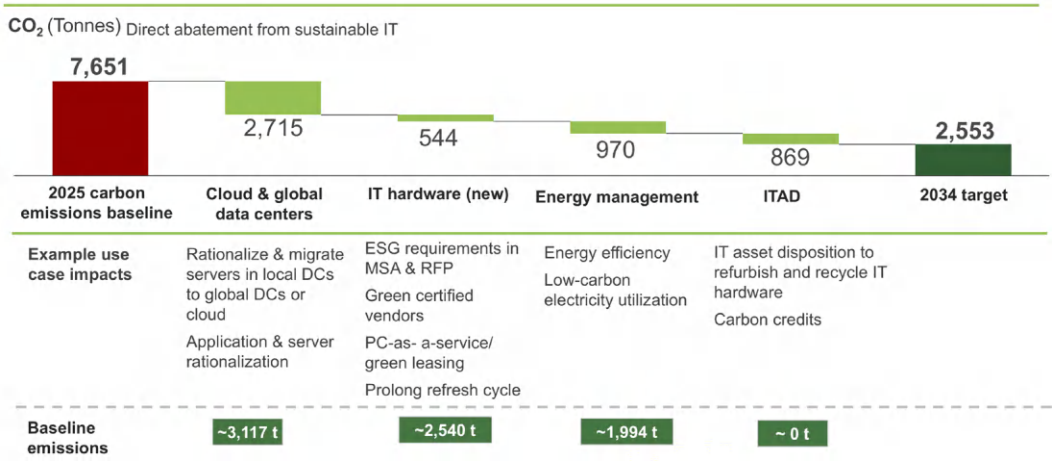


Figure 13.29 – 10-year carbon emissions waterfall summary

Here, we can see that all four categories have decreased their emissions despite the projected employment growth. The category that has made the most significant impact is the cloud and global data centers, where we have been able to reduce our carbon emissions by 2,714 tonnes of CO_2 by decommissioning 800 servers but also moving the server workload from high-carbon regions to low-carbon regions. The energy management category has reduced its CO_2 emissions by half, and ITAD significantly contributes to carbon reduction. Where we were unable to make any significant impact was within the purchase of IT hardware (new); we were unable to make a significant dent in the emissions reduction. IT hardware is an area to explore further to find ways to reduce it by prolonging the IT hardware's longevity, buying less carbon-intensive IT equipment or refurbished equipment, and shifting to DaaS to eliminate the need for advanced processing power on the client side.

Here, we wanted to send you a key message that we can significantly impact sustainability today with existing technology. If we go about it systemically, we can contribute to reductions in carbon emissions and e-waste. We are also confident that as the tech industry evolves, we will see improvements in all areas. We strongly encourage you to play around with the emissions calculator and explore different ways to make a sustainable impact. Every organization will be different, depending on the environment; your journey will look different. The most important thing is that you get started.

Summary

In this chapter, you've taken your first major steps toward operationalizing sustainable IT. You've learned how to assess where you are today and begin charting a course toward where you need to be. Starting with a clear baseline and maturity assessment ensures that every decision you make is informed by evidence and aligned with enterprise sustainability goals.

We explored how to collect and analyze key data points across IT's major areas of environmental impact:

- **Data centers and cloud**: How location, energy mix, PUE, server utilization, and virtualization levels affect carbon emissions
- **IT hardware**: Understanding embodied carbon and extending the lifecycle to reduce Scope 3 emissions
- **End user energy management**: Tracking the energy use of devices and aligning with renewable energy sources
- **ITAD**: Leveraging circularity to avoid emissions and reclaim value through reuse and recycling

Through our Sustainable IT Maturity Model©, you now have a framework to evaluate your organization's readiness across governance, processes, and technology. Coupled with insights from CSOs and sustainability value research, you are equipped to strengthen cross-functional collaboration with sustainability and finance leaders.

The following are recommendations for moving forward:

- **Engage leadership early**: Secure CIO and CSO sponsorship and align IT goals with enterprise ESG targets
- **Build partnerships**: Collaborate with your sustainability and finance peers using shared frameworks and co-owned KPIs

- **Focus on early wins**: Migrate workloads to low-carbon regions, extend hardware lifecycles, and implement device take-back programs to build momentum
- **Invest in measurement and reporting**: Automate ESG data collection and integrate it into IT dashboards to track progress and meet regulatory requirements
- **Establish your baseline now**: Use the downloadable Sustainable IT playbook emissions calculator to quantify your IT footprint across all major categories
- **Leverage scale**: Consider shifting workloads from local on-premises facilities to corporate global data centers or hyperscaler clouds to reduce emissions and improve reporting

By completing this chapter, you've built a foundation for sustainable IT success. In the next chapter, we'll take the next critical step: turning your baseline and maturity assessment into a comprehensive, long-term IT sustainability strategy that drives measurable progress and competitive advantage.

Bibliography

- Brady, G., N. Kapur, J. Summers, and H. M. Thomson. 2013. *A case study and critical assessment in calculating power usage effectiveness for a data centre. Energy Conversion and Management.* `https://eprints.whiterose.ac.uk/id/eprint/79352/1/GBrady%20Case%20Study%20of%20PUE.pdf`.
- Conference Board. 2025. *Top 10 Corporate Sustainability Priorities for 2025.* `https://www.conference-board.org/publications/Top-10-Corporate-Sustainability-Priorities-for-2025`.
- 2014. *Data Center Efficiency Assessment.* `https://www.nrdc.org/sites/default/files/data-center-efficiency-assessment-IP.pdf`.
- Forbes. 2025. *79% of Companies Now Have a Chief Sustainability Officer.* `https://www.forbes.com/sites/forbes-research/2025/08/28/chief-sustainability-officer`.
- GlobeScan, Accounting for Sustainability, SustainableIT.org, ERM Sustainability Institute, Salesforce. 2025. *Sustainability Value Triangle*. `https://globescan.com/2025/02/27/sustainability-value-triangle/`.
- IEA. 2025. *Electricity 2025*. `https://www.iea.org/reports/electricity-2025/emissions`.
- Khaliq uz Zaman, Sardar, Atta ur Rehman Khan, Junaid Shuja, Tahir Maqsood, Faisal Rehman, and Saad Mustafa. January 2019. *A Systems Overview of Commercial Data Centers: Initial Energy and Cost Analysis. International Journal of Information Technology and Web Engineering*. `https://www.irma-international.org/viewtitle/217694/?isxn=9781522564485`.

- Rejoose. 2025. *Product Life Cycle Carbon Emissions custom report: Dell PowerEdge R760*. Prepared April 2025.
- SustainableIT.org. 2024. *IT Sustainability Maturity Model*. `https://members.sustainableit.org/knowledgebank-mfe#/knowledgebank/2/645001cf9394f9d361f53e34/0` (access restricted to SustainableIT.org members only).
- SustainableIT.org. 2024. TUI Group's Sustainable IT Journey. `https://members.sustainableit.org/knowledgebank-mfe#/knowledgebank/4/668c449cbba5b6009d660f2a/1` (access restricted to SustainableIT.org members only).

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14

Putting a Sustainable IT Strategy in Place

> *We may have a Plan B in life – but we indeed do not have a Planet B.*
>
> *Jan Eliasson, Former United Nations Deputy Secretary-General*

This chapter will focus on putting a sustainable IT strategy in place. Sustainable IT is a collective name for the measures designed to benefit **environmental, social, and governance** (**ESG**) progress with the aid of IT for three focus areas: sustainability in IT, sustainability by IT, and IT for society. This chapter will enable you to create a simple, sustainable IT strategy that can be used as a communication vehicle to take action toward a net-zero future.

First, we will introduce the sustainable IT strategic planning process. Then we will review real-world examples from Siemens, Schneider Electric, Mastercard, National Grid, Choice Hotels, and Edifecs. We will also take a closer look at how to factor AI into your sustainability strategy, including its impact on IT roles.

We will leverage the sustainable IT strategic planning process to assist you in creating your own sustainable IT strategy. Finally, we will create a high-level short-term, mid-term, and long-term roadmap for our sustainable IT strategy.

In this chapter, we will cover the following topics:

- Introduction to the sustainable IT strategic planning process
- Real-world sustainable IT strategy examples and best practices
- Factoring AI into your strategy
- Creating your own sustainable IT strategy
- Setting your direction of travel toward a sustainable future

By the end of this chapter, you will have understood how to use the sustainable IT strategic planning process, which will enable you to create your own sustainable IT strategy and an IT sustainability roadmap. The examples and templates for this chapter can be downloaded from `https://www.sustainableit.org/sustainable-it-playbook`.

Introduction to the sustainable IT strategic planning process

In this section, we will introduce the sustainable IT strategic planning process. This section will not focus on the business context, strategy, strategic objectives, or overall corporate sustainability strategy. However, some external inputs will be referenced, such as materiality assessment, enterprise sustainability goals and priorities, and enterprise sustainability strategy, to put the sustainable IT strategy into context. There are six critical areas to the sustainable IT strategic planning process to guide you on your path to creating your own sustainable IT strategy. *Figure 14.1* illustrates the main building blocks of the framework:

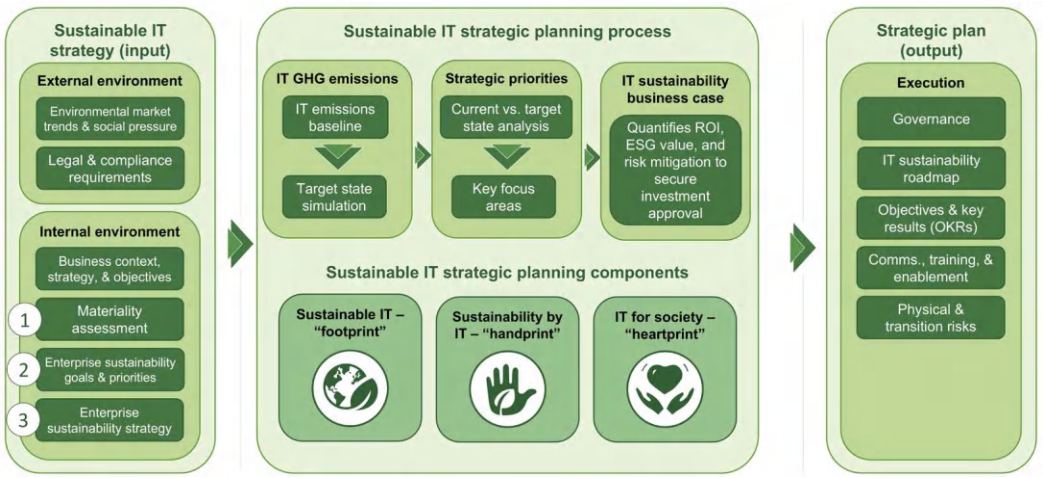


Figure 14.1 – Sustainable IT strategy framework

Let us take a closer look at each key area.

Sustainable IT strategy (input)

There are two key input areas that you should include as part of your strategic planning process – the external environment and the internal environment.

External environment

Your external environment is an assessment outside the realm of your enterprise. When looking at your external environment, we recommend assessing market trends, risks, and social pressure, as well as legal and compliance requirements.

These are some key questions to ask yourself:

- **Market trends**: How do market trends within your industry impact your organization? How impacted are you by a geopolitical crisis such as the war in Ukraine, raw material shortage, low-carbon material, access to clean and affordable energy, and supply-chain component shortages?
- **Risks**: What physical climate and transition risks are most relevant to your organization?
    - **Habitat destruction**: Ecosystem collapse, biodiversity loss, and agricultural depletion
    - **Intensified weather events**: Heat, storms, floods, droughts, and wildfires
    - **Glacial retreat**: Freshwater loss and rise in sea level (coastal submersion)
    - **Droughts**: Limited access to water, an essential resource for some industries
- **Legal and compliance requirements**: What are the legislation and compliance requirements to which your company will be subject? Determine whether there are any industry-specific, regional, country, or state regulations that must be applied. The EU **Corporate Sustainability Reporting Directive (CSRD)** and California's sustainability disclosure laws apply to companies not necessarily based in the EU, California, or the US. In the Asia-Pacific region, Japan's **Sustainability Standards Board of Japan (SSBJ)** climate-related disclosure standards apply to Japanese and foreign companies listed on the Tokyo Stock Exchange.

- **Industry associations and sector-specific working groups**: Companies can strengthen the quality of their sustainability strategy by incorporating insights from industry associations, which often interpret new regulations, share best practices, and coordinate collective solutions. In the sporting goods industry, for instance, the **Federation of the European Sporting Goods Industry** (**FESI**) and the **World Federation of the Sporting Goods Industry** (**WFSGI**) both operate regulatory working groups that help members understand compliance obligations, influence policy, and co-develop practical tools. FESI and WFSGI have even jointly assessed product-compliance and sustainability-data management tools—reducing duplicative effort across member companies and enabling shared evaluation rather than each organization independently researching and paying full price for separate tools. In the information technology sector, the **International Federation of Global & Green ICT** offers a "Green ICT Standard" certification framework for organizations to demonstrate commitment to environmentally responsible ICT practices (energy efficiency, e-waste, circularity, supply-chain requirements). Similar industry associations exist across sectors and can be invaluable sources of regulatory clarity, benchmarking data, and practical implementation guidance.

Internal environment

Your internal environment should assess and consider critical areas inside your enterprise's realm. Some key areas to consider are the business environment, materiality assessment, enterprise sustainability goals and priorities, and your enterprise sustainability strategy. Also consider AI's sustainability opportunities and risks as they relate to your strategy.

Business environment

You should assess and understand your business context, vision and mission, corporate strategy, strategic objectives, and priorities. These key attributes are usually listed under investor relations for publicly listed companies.

Materiality assessment

Materiality assessment is an excellent place to engage peers to identify, assess, and refine potential ESG issues. It involves looking at several factors from two viewpoints – the importance to stakeholders (internal and external) and the importance to the business. Once the ESG issues have been identified, their importance should be determined from a stakeholder and a business perspective. To start your materiality assessment, choose goals from international frameworks and institutions such as IPCC, UN **Sustainable Development Goals** (**SDG**), and **UN Global Compact**.

Enterprise sustainability strategy

Once you have determined your sustainability goals and priorities, it is time to formulate the enterprise's sustainability strategy. As an IT leader, you should work closely with the relevant functions in the organization, such as sustainability, legal, compliance, operations, and more, to discover and determine broader goals. The enterprise sustainability strategy should encompass the whole enterprise, and the goals should be easily understood and adaptable to a specific function, such as the sustainable IT strategy.

The external and internal environments are valuable inputs to your sustainable IT strategic planning process. Naturally, both your external and internal environments depend on what region, country, industry, or company you operate within. In the next section, we will examine the sustainable IT strategic planning process, which is the core of the sustainable IT strategy framework.

Sustainable IT strategic planning process

The sustainable IT strategic planning process consists of five building blocks, including three focus areas – **sustainability in IT**, **sustainability by IT**, and **IT for society** – and three functional areas – IT GHG emissions, strategic priorities, and the business case. The process relies on input from both your external and internal environments. As we learned in *Chapter 2*, *The Case for Sustainable IT*, sustainability in IT directly impacts your CO_2 emissions reduction – your *footprint*. On the other hand, sustainability by IT indirectly impacts CO_2 emissions since it is embedded into a process or business function, such as deploying an IoT application so that you can monitor and reduce water usage on a farm – this is your *handprint*. IT for society is your *heartprint* – that is, your altruistic side, where you positively impact your people, community, and society through employee engagement by educating children on computing or coding skills, for example.

Your sustainable IT strategy should be a subset of your complete IT strategy and your enterprise sustainability strategy. We draw the guardrails regarding ESG targets and objectives from the enterprise sustainability strategy. From the IT strategy, we draw vital inputs such as strategic IT objectives, target state, governance structure, operating model, architecture, sourcing model, people, and culture. Most importantly, your sustainable IT strategy should not be built in isolation and embedded into existing strategies.

Building the IT sustainability business case

Before selecting which initiatives should be incorporated into your sustainable IT strategy, it is essential to demonstrate their value to the business. The IT sustainability business case serves as the bridge between ambition and investment. Built after establishing baselines and maturity targets *(Chapter 13, Get Started Today)* and before strategy finalization, it quantifies both the financial and ESG benefits of your proposed actions—ensuring that sustainability and profitability remain aligned.

A strong business case does more than justify an individual project—it articulates the broader value proposition of sustainable IT: reduced energy and hardware costs, improved regulatory readiness, stronger supply-chain resilience, and measurable progress toward enterprise ESG goals. Ideally, the case should be prepared jointly or at least vetted by the IT, finance, and sustainability teams so that the proposed investments align with enterprise planning cycles, capital-allocation criteria, and reporting requirements.

Each IT sustainability business case should include the following elements:

1. **Executive summary** – Concise statement of the rationale and value proposition for the proposed investment, summarizing expected ROI, payback period, and headline ESG benefits.
2. **Problem statement** – Definition of the current challenge or regulatory gap being addressed, supported by baseline data such as energy costs, emissions, or data-quality issues.
3. **Proposed initiatives** – Description of each sustainability initiative, its objectives, key actions, and anticipated outcomes linked to both ESG and financial metrics.
4. **Financial impact analysis** – Quantification of economic value, including investment costs, savings, and risk-avoidance benefits, expressed through metrics such as NPV, IRR, and payback period.
5. **ESG impact analysis** – Expected measurable outcomes across environmental (carbon, energy, waste), social (inclusion, employee engagement), and governance (data and risk management, compliance) pillars.
6. **Implementation roadmap** – Two- to three-year plan outlining milestones, KPIs, owners, and dependencies to deliver and scale results.

7. **Risk analysis** – Assessment of delivery, technology, financial, and regulatory risks—including the often-overlooked "risk of inaction."
8. **Conclusion and recommendation** – A closing summary reinforcing that sustainability and profitability are aligned and calling for investment approval.
9. **Appendices** – Supporting information such as emissions-baseline methods, financial model summaries, and vendor criteria.

Figure 14.2 is a sample page of the business case presentation for a green IT program at a hypothetical financial services firm. The full presentation template and sample case can be downloaded from the book's resource site: `https://www.sustainableit.org/sustainable-it-playbook`

INITIATIVE DESCRIPTION	OBJECTIVE	STAKEHOLDERS	ACTIONS	SUSTAINABILITY/ VALUE LINK
Optimize on-premise data centers and accelerate migration to renewable-powered cloud platforms to significantly reduce energy use, carbon emissions, and IT operating costs.	Reduce data center energy use, emissions, and operating cost.	• CIO/CTO/Head of Infrastructure • Head of Cloud/FinOps Lead	• Deploy AI-driven DCIM and cooling optimization (e.g., EkkoSense-style IoT sensors + ML). • Decommission underutilized servers and consolidate facilities. • Migrate high-compute and non-sensitive workloads to renewable-powered cloud regions. • Modernize remaining on-prem facilities with efficient cooling/power systems.	• Major impact on environmental footprint (energy/CO_2), improves governance through improved performance analytics. • Hard-dollar OPEX savings; reduced capital refresh needs; lower risk costs.

KEY FACTORS	
Sustainability impact	20–30% facility energy reduction, totaling 3,000 tonnes CO_2 avoided annually
Financial impact	$0.6–0.8M annual electricity/cooling OPEX savings. Higher resiliency and reduced hardware failure rates.
Costs	$4M over three years for data center upgrades, sensors, DCIM software, cloud migration efforts, and infrastructure modernization.
Stakeholder requirements	Oversight of modernization plan, governance reviews, architectural approvals. Cloud planning, workload analysis, and cost-carbon optimization cycles.

Figure 14.2 – Green IT initiative business case sample presentation page

A one-page summary of an IT sustainability business case may look like the following:

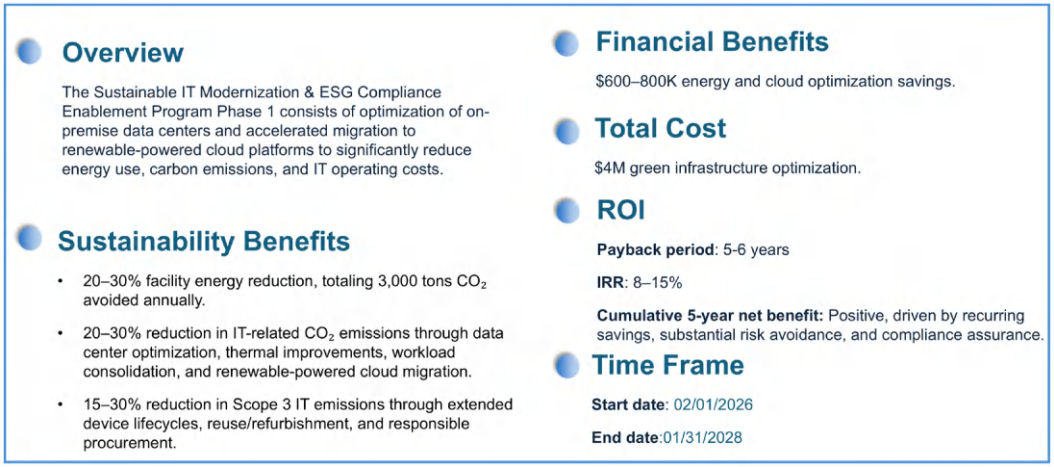


Figure 14.3 – Green IT initiative business case at a glance

When used effectively, the business case becomes both a financial and strategic tool. It translates sustainability ambition into measurable business outcomes and provides the quantitative evidence required to integrate IT initiatives into the enterprise sustainability strategy and capital budget. Most importantly, developing the business case early—after establishing baselines but before finalizing the strategy—ensures that sustainability initiatives are prioritized based on impact and return, not just aspiration.

Sustainable IT strategy (output)

The sustainable IT strategic planning process should generate several outputs on how you should execute your sustainable IT strategy and the steps necessary to operationalize it. These outputs are governance **objectives and key results** (**OKRs**), the **IT sustainability roadmap, physical and transition risk**, and **communication**, **training**, and **enablement**.

Now that we have looked at the framework's building blocks, let us focus on real-world examples and lessons learned for effective IT strategy building and implementation.

Real-world sustainable IT strategies and programs

We start with a case study from Siemens, which begins with an overview of Siemens' corporate sustainability context, including its core business sustainability mission and customer-facing initiatives. This sets a clear direction for Siemens' IT function to follow in developing and executing its internal strategy to drive sustainability for its own footprint and that of Siemens' more than 300,000 employees.

Eva Riesenhuber, **Siemens' Global Head of Sustainability**, emphasized the critical role of sustainability data, speaking on a CSO panel at a SustainableIT.org event at New York Climate Week 2025. *"What gets measured gets done. Siemens leverages data from every function, which is collected in a cloud to make it securely available for product design and other sustainability-related internal and external development. Once you have transparency, you can move to measurement, and then to performance change,"* she said. Eva acknowledged the partnership of Siemens CIO Hanna Hennig and the team. *"IT has my back,"* providing insights that complement those of Eva's own data team.

The Siemens case study co-authors are **Philipp Sattlecker**, **IT Sustainability Strategy Manager**, a 12-year veteran of the IT organization and former consultant, and **Helena Babelon**, **Global Head of IT sustainability at Siemens**. Helena has dedicated her role to IT sustainability, going back to 2017, when she led IT sustainability at Electrolux.

This contribution presents a comprehensive look at how Siemens approaches sustainability, structured in two sections. The first section provides the foundation of "Sustainability at Siemens," outlining how the company's core business and technology drive positive sustainability impact. The second section explores "The Role of Siemens IT in Sustainability," revealing the journey of Siemens' IT organization.

Case study: Sustainability at Siemens

> In today's world, digitalization and sustainability have become imperative for businesses. For 177 years, Siemens has been driven by a singular purpose – to create technology to transform the everyday for everyone. As a leading technology company, our innovations have improved the lives of billions of people by supporting decarbonization, improving resource efficiency, and touching people's lives around the world.
>
> The need for transformational technology is increasing, and the easy goals in pursuing sustainability impact have been achieved. We need faster progress on sustainability, we need better solutions to global challenges, and we need them today.
>
> To move faster, we need to make adoption easier and scalable. We combine the real and digital worlds to empower our customers to become more competitive, resilient, and sustainable.
>
> More than 90% of our business enables customers to achieve a positive sustainability impact scaled across three key areas: decarbonization and energy efficiency, resource efficiency and circularity, and people centricity and societal impact.

Our aim is to have a positive impact on the world around us. To this end, we have set ourselves an ambitious target to avoid more than 1,000 Mt of CO_2e at our customers with our portfolio by 2030.

How technology drives sustainability

Fortunately, many technologies that tackle global challenges, including climate change, already exist – and AI is an accelerator for impact. AI helps us make complex software more accessible and intuitive, create smarter and more energy-efficient buildings, and design products with more sustainable materials.

For example, industrial facilities and infrastructures are generating ever-growing amounts of data. Using methods of machine-based data analysis and AI, such as Siemens' Industrial Copilot, an AI-powered assistant for industrial environments, we help operators increase availability, improve operational quality, and reduce the stress on humans and the environment.

Even before the rise of AI, data centers have been the backbone of our digital society and considered mission-critical infrastructure. Siemens technologies aim to support decarbonizing the data center industry by improving energy efficiency in data centers, reducing downtime through predictive maintenance, and accelerating innovation with generative design solutions to reduce CO_2 emissions.

While we are harnessing the power of AI, we are not blind to the risks. Responsible AI at Siemens means striving to address these risks at an early stage, counteracting undesirable effects, and carefully balancing them against potential opportunities. To ensure ethical standards and responsible business conduct in the digital world, we established a cross-functional governance setup involving experts from technology, IT, cybersecurity, sustainability, and legal/compliance to oversee the evaluation, development, and implementation of strategies and guidelines for effective generative AI governance within Siemens.

DEGREE is how we measure our impact

We have a 360-degree approach that touches our customers, planet, and society, as well as our own operations, products, and people. We look holistically at decarbonization and energy efficiency, resource efficiency and circularity, and people-centricity and society, all built on a strong foundation of ethics and governance.

To ensure we achieve meaningful progress, we have set ambitious targets across many areas: From customer-avoided emissions and net-zero targets, strict cybersecurity requirements, integrity initiatives, and support in developing skills globally, to eco-design, zero waste, and biodiversity protection. We are committed to creating an exceptional workplace – one that prioritizes work well-being, inclusion, and a sense of belonging – because our people are at the heart of our success.

The DEGREE sustainability framework, our ambitions, and progress are available at `www.siemens.com/sustainability`.

The role of Siemens IT – from awareness to impact

As Siemens continues to strengthen its position as a technology company driving global sustainability transformation, our IT organization plays an increasingly critical role in enabling Siemens' sustainability agenda. The transformation from awareness to impact requires both strategic vision and operational excellence. We're not just implementing green IT practices – we're fundamentally reimagining how data and information technology can be a catalyst for sustainability at Siemens.

IT's sustainability journey began in 2019 with initiatives focused on building awareness and engagement across our global organization. This early phase was essential in creating the cultural foundation and organizational readiness needed for more ambitious sustainability commitments.

In 2024, we took a decisive step forward by refreshing our Siemens IT strategy and elevating sustainability to a strategic priority. This strategic evolution reflects our commitment to accelerate the journey from awareness to impact, aligning our IT capabilities with Siemens' broader sustainability agenda and contributing to the company's sustainability goals.

Priorities of Siemens' IT strategy

Our IT sustainability strategy serves as a compass for navigating our sustainability journey as an IT organization (*Figure 14.4*). Developing our IT sustainability strategy was a crucial milestone that significantly increased awareness and priority across the organization. However, strategy development was only the beginning. We now execute our IT sustainability strategy through yearly objectives and key results, ensuring organizational alignment across Siemens IT teams from strategic vision to execution towards measurable outcomes.

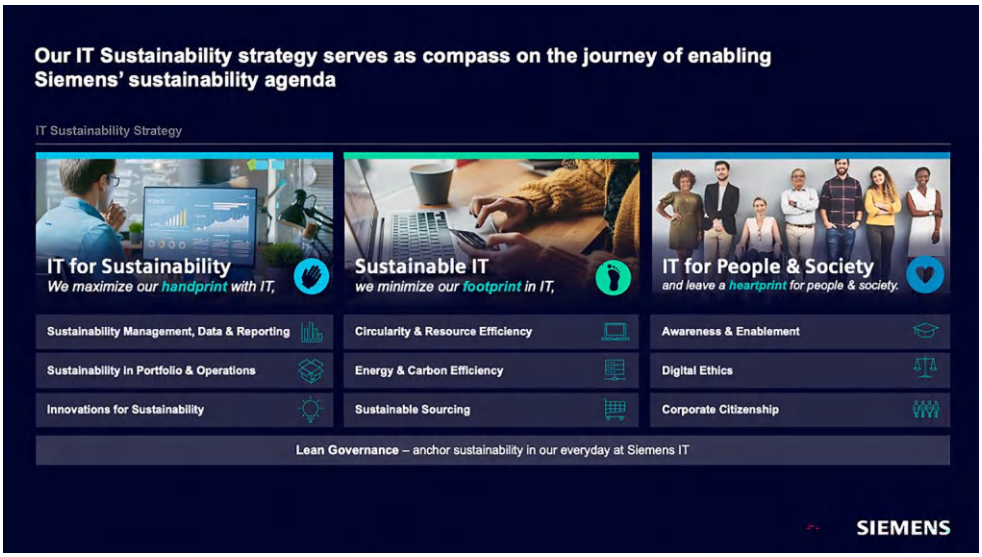


Figure 14.4 – Siemens IT sustainability pillars (source: Siemens)

The IT sustainability strategy answers three questions to maximize our contribution to enable Siemens' sustainability agenda, using the three-workstream framework laid out in this book:

1. **Handprint**: How can we enable Siemens' sustainability agenda with IT Through IT for sustainability, we provide information technology to support Siemens' sustainability goals. We create solutions for sustainability reporting and data management, support sustainability in Siemens' portfolio, buildings, and factories, and align our long-term IT architecture to enable sustainability business capabilities.
2. **Heartprint**: How can we create a greater impact with IT for people and society? IT enables our people to be part of the sustainability transformation and focus on awareness through learning and upskilling. This helps to ensure compliance with digital ethics and promotes corporate citizenship through volunteering and partnerships.
3. **Footprint**: How can we drive sustainability in IT operations and the supply chain We strive for net-zero Siemens IT. Our initiatives include fostering circularity and resource efficiency for end-user devices, energy and carbon efficiency in our IT operations, and driving decarbonization in our IT supply chain.

To strengthen governance for IT sustainability, we follow a lean principle and integrate sustainability into existing processes and governance instruments, which anchors sustainability to our "everyday" at Siemens IT.

Building a dedicated IT sustainability team

As Siemens' sustainability agenda evolved, our teams experienced a growing need for digital capabilities to effectively manage sustainability challenges. This increasing demand for dedicated IT support led us to establish a dedicated IT Sustainability department (IT SUS) that serves as the strategic business partner for Siemens' sustainability team, including the global head of sustainability, and key stakeholders across the organization.

I (Helena) report directly to the CIO and am a member of the Siemens IT leadership team, ensuring sustainability considerations are embedded at the highest levels of IT decision-making and strategy development, as shown in the following figure:

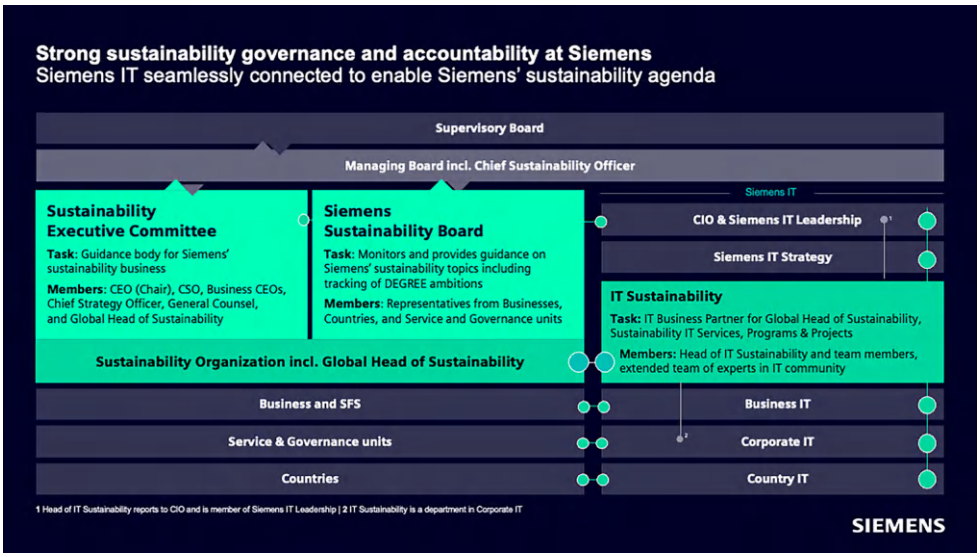


Figure 14.5 – Siemens sustainability governance (source: Siemens)

IT SUS operates as the glue connecting stakeholders across businesses, functions, countries, and respective IT teams. This specialized team provides diverse expertise, including business analysis, program and project management, IT service and application management, and IT architecture to ensure that technology investments support the required business capabilities for sustainability management.

Information technology and data for sustainability

IT SUS brings essential IT capabilities into major sustainability initiatives such as the **Corporate Sustainability Reporting Directive** (**CSRD**) project, while building and running dedicated IT services for core sustainability business capabilities, and integrating solutions from across the entire Siemens IT portfolio.

Examples of solutions implemented include standard software enabling our sustainability teams in businesses, functions, and countries for greenhouse gas management and EU Taxonomy alignment and reporting. We have developed low-code applications in our Mendix development platform for specific use cases (e.g., supporting business teams to create Siemens EcoTech profiles for our products) and solutions allowing seamless data integration to scale tech lifecycle assessments and environmental product declarations. The EcoTech profile is an environmental declaration for our products based on product-specific evaluations of sustainability-relevant KPIs. It provides Siemens' customers with transparency on the performance of our certified products across environmentally relevant criteria, enabling customers to make informed choices to support their sustainability goals.

Siemens Data Cloud, a comprehensive data mesh platform, has become the heart of sustainability data management across our organization. It has become an integral part of the IT architecture for the sustainability application landscape. We make sustainability-relevant data accessible from multiple domains, including environment, health and safety, buildings, finance, procurement, people and organization, product lifecycle management, and many more.

This data-driven approach ensures that sustainability data adheres to FAIR principles – making it findable, accessible, interoperable, and reusable across the entire organization, enabling informed decision-making and sustainability performance management.

Delivering tangible results – highlights

While we are proud of the progress made, we remain humble and know we need to go much further. These selected highlights illustrate that our journey from awareness to impact is delivering tangible results, creating value for Siemens, our stakeholders, and society:

Handprint – IT for sustainability

- Enabling digital sustainability reporting: The CSRD project and related IT solutions will enable the management of more than 120 key performance indicators with thousands of data points processed digitally and efficiently through Siemens Data Cloud, transforming how we measure and report our sustainability performance.
- Accelerating sustainable products: Using the Siemens EcoTech low-code application, our business teams can now generate EcoTech profiles in roughly half the time previously required. More than 25,000 Siemens products received the Siemens EcoTech label in FY2024, which designates products across three dimensions: sustainable materials, optimal use, and value recovery/circularity.

Footprint – sustainable IT

- **Driving circular economy in IT operations**: Nearly 200,000 laptops, smartphones, and other devices have been given a second life (in Germany alone since 2013) through our strategic long-term partnership with refurbishment specialists. This secondary use conserves valuable resources while significantly reducing energy consumption, CO_2 emissions, and water usage.
- **Transforming IT supply-chain decarbonization**: Our innovative approach combines commodity-specific questionnaires with a chatbot, empowering suppliers to set product-level sustainability targets and turning compliance into collaboration.

Heartprint – IT for people and society

- **Empowering our workforce**: More than 2,300 people have completed the "IT Sustainability Fundamentals" training since its launch in 2024, a comprehensive 30-minute e-learning program that helps IT teams understand the intersection of sustainability and information technology, enabling them to apply sustainability principles in their everyday work.
- **Creating societal impact**: African Girls Can Code and Siemens EmpowerHER enabled over 600 young women across African countries to become cybersecurity and IT experts, supported by refurbished laptops, a tailored curriculum, and mentorship from Siemens experts around the globe.

Lessons learned

Throughout our sustainability journey, we have gained valuable insights that can guide other IT organizations embarking on similar transformations:

- **IT leadership commitment and bottom-up alignment**: Strong commitment from the CIO and IT management is essential for establishing sustainability as a strategic priority and ensuring organizational empowerment for sustainability initiatives. Equally important is empowering people across all levels to contribute their ideas and projects to the overall strategy.
- **Focused expertise, shared responsibility**: A dedicated IT sustainability team or assigned responsibilities to core team members help focus expertise on specific sustainability challenges. In addition, we strive to engage the entire IT organization. Sustainability is a mindset that must be embraced by everyone, not just specialists.
- **Sustainability is more than CO_2**: IT organizations can contribute to sustainability in many ways beyond reducing carbon emissions. While minimizing CO_2 in IT operations and supply chain is important, IT teams should also address the "handprint" by helping the business functions and corporation as a whole unlock critical data and provide information technology for sustainability management and reporting, sustainable products, and sustainability across operations and supply chain.
- **Choosing your battles wisely**: It's crucial to define clear priorities, as IT sustainability provides numerous opportunities for action. A materiality assessment for IT helped us identify and prioritize the most impactful initiatives, which are now anchored in our IT sustainability strategy.
- **Attracting talent**: To offer technical positions with meaningful sustainability dimensions has proven to be a significant competitive advantage in the highly competitive talent market, particularly when attracting environmentally conscious young professionals who seek purpose-driven careers alongside technical challenges.
- **Act now, adapt always**: Sustainability is constantly evolving and requires continuous learning and adaptation. For example, while the impact of AI is being researched and debated by experts with methodologies still evolving, we take important actions today, such as selecting energy- and carbon-efficient data center regions with 100% renewable energy and fostering ethical and compliant use through GenAI Guardrails for SiemensGPT, our internal generative AI platform.

- **Partnerships for the goals (SDG #17)**: Collaboration accelerates sustainability progress and amplifies impact, directly embodying the principles of UN Sustainable Development Goal 17, which calls for strengthening global partnerships to support sustainable development. We actively engage with peers in expert communities like SustainableIT.org, Green Software Foundation, REPLY's cross-European IT Sustainability User Group, and others to share knowledge, learn from best practices, and create a bigger impact together than any single organization could achieve alone.

Philipp Sattlecker, IT Sustainability Strategy Manager

and Helena Babelon, Global Head of IT Sustainability, Siemens

Before we tease out the best practices and recommendations from Siemens' case study, we will take an abbreviated look at several more companies that launched and grew successful "green IT" programs in their organizations.

Insights from green IT programs

Sustainability strategies for IT often start with a focus on understanding and addressing the technology infrastructure's environmental impact. Initial focal points tend to be in-house data centers and end-user devices, since these have the highest contribution to carbon footprints (50% or more out of the entire IT infrastructure). Once these areas have been baselined, IT functions often expand scope and scale, covering e-waste, energy resource management, and other goals. Organizations often decide that these ad hoc initiatives should be consolidated under one governance and branding umbrella—the *green IT program*.

Green IT refers to the deliberate design, implementation, and operation of information technology systems in ways that minimize environmental impact. The overarching goals of green IT include the following:

- Reducing energy consumption and carbon emissions from IT infrastructure and devices
- Increasing hardware and software circularity, prolonging asset lifecycles, and reducing e-waste
- Embedding sustainability in IT governance, procurement, and operations
- Supporting enterprise-wide climate goals, including net-zero commitments, by providing reliable sustainability data and solutions
- Educating IT employees on green IT principles to establish a sustainability mindset and, eventually, culture

SustainableIT.org has produced case studies on and for its membership, and green IT programs have been chronicled in several, including those summarized here:

Mastercard, the payments technology and services provider, began its technology sustainability transformation in 2021 by establishing a Technology Sustainability Office aligned with its Net Zero 2040 commitment. The program focused on five pillars: data visibility, sustainability scoring, carbon accounting at the product and P&L level, infrastructure decommissioning, and Scope 3 emissions tracking. A patent-pending real-time dashboard was developed to monitor energy, emissions, and utilization metrics—informing product decisions and infrastructure planning. The program embeds sustainability into IT governance and design reviews with executive steering oversight. Mastercard decommissioned servers, shifted workloads to lower-carbon regions, and improved cloud and colocation emissions tracking through partnerships with Greenpixie and others (SustainableIT.org 2025).

Mastercard's IT efforts have helped contribute to a decoupling of carbon emissions levels and corporate growth, which would normally be expected to rise or fall together. For 2024, the company reduced total emissions (Scopes 1, 2, and 3) by 7% while growing the business's net revenue by 12% (Mastercard 2025). Speaking at a SustainableIT.org event during Climate Week NYC 2025, **EVP and Chief Sustainability Officer Ellen Jackowski** praised the support her team receives from IT and the leadership of **George Maddaloni, EVP and CTO of Mastercard Operations**. *"We would never hit our net-zero target if IT was not on board,"* Ellen told the audience of fellow sustainability officers and technologists. *"There is a sustainability score for every IT decision, and we are including it as part of the decision-making process."* IT and sustainability are in lock step in sustainability's value equation, which drives emissions reductions, efficiency, and cost savings together.

National Grid, a utility provider in the UK and New England, USA, launched its formal Sustainable IT Program in late 2022, appointing a dedicated head of IT sustainability and governance to lead efforts in energy efficiency, emissions reduction, and circularity. Rather than starting with proxy metrics, the team built a taxonomy of real data aligned with ISO 14001 and 50001 standards. The program was embedded within technical debt reduction and modernization efforts, requiring no separate budget. National Grid emphasized stakeholder relevance through relatable metrics (such as laptop energy efficiency), ensured data auditability, and fostered partnerships with the corporate sustainability office to maximize business impact (SustainableIT.org 2023).

Edifecs, a healthcare technology company now owned by Cotiviti, has integrated green IT as a foundational pillar of its broader sustainability strategy since 2012. The IT organization embedded sustainability into decision-making via a formal green IT framework, which scores investments based on lifecycle impact, energy efficiency, and end-of-life considerations. The organization prioritized its carbon footprint reduction, applying hybrid cloud adoption, e-recycling, dynamic provisioning, and facility consolidation. IT consolidated five data centers into two and implemented energy-saving techniques such as automated power management for end-user devices. Beyond infrastructure, Edifecs is now leveraging AI to track cloud carbon intensity, optimize workloads, and automate sustainability reporting (SustainableIT.org 2025).

Choice Hotels International leveraged a full cloud migration and advanced data analytics to jumpstart its drive to measurable ESG impacts. Migrating all systems to AWS eliminated over 500 million metric tonnes of Scope 2 emissions in 2022 while improving agility and resilience. Its Commitment to Green dashboard, powered by Schneider Electric, automates utility data collection for energy, water, and fuel use across thousands of hotel properties. Data-driven tools like Choice Hotels Owner Profitability System help hotel franchisees set facility sustainability goals and measure against them. It has been used to identify hidden problems such as swimming pool and plumbing leaks, improving both environmental and financial performance. By aligning with materiality priorities, Choice demonstrates how IT innovation can simultaneously drive profitability, sustainability, and governance (SustainableIT.org 2023).

Schneider Electric, the global energy management and automation company, launched its formal Green IT Program in 2021 to align IT operations with the company's environmental goals, including carbon neutrality and circular economy principles. The program focuses on five pillars: lifecycle management of PCs, IT infrastructure optimization, software sustainability, business collaboration, and employee engagement. Schneider Electric implemented a data-driven approach using dashboards to track carbon emissions, required vendors to meet strict sustainability criteria, and provided extensive employee education and involvement opportunities. As a result, the company achieved an energy efficiency improvement in new PCs, lowered data center energy consumption, and recorded a significant CO_2 footprint reduction (SustainableIT.org 2024).

Based on these cases, we can derive a set of best practices and success factors that cross industries. Be sure to account for these in your sustainability strategy and execution processes.

Sustainability strategy success factors and recommendations

From the case examples described earlier and other examples shared throughout this book, several critical success factors can be seen for sustainable IT strategy development and application:

- **Executive commitment**: Sustainability efforts gained momentum when elevated to strategic imperatives with leadership visibility. Mastercard's CTO and Schneider Electric's CIO, for example, made sustainability part of decision-making and performance reviews. At Edifecs, the CIO directly oversaw ESG, embedding sustainability into IT priorities from the top.
- **Dedicated roles and cross-functional teams**: Hiring sustainability-focused IT leaders and designating internal sustainability champions helped build momentum and internal engagement. Siemens' IT SUS team shows the value of a central function acting as a sustainability hub, connecting business units, sustainability leaders, and IT. This goes beyond champions to form an operational bridge.
- **Employee awareness and engagement**: Schneider Electric and Siemens ran e-learning and social awareness campaigns, hackathons, internal awards, and companywide dashboards to educate and empower employees. Edifecs goes further by incorporating sustainability questions in employee engagement surveys and supporting hands-on initiatives such as refurbished tech donations. Siemens complemented the formal IT sustainability training of more than 2,300 employees with structured programs linking sustainability to daily work.
- **Use of real, auditable data**: National Grid emphasized the importance of moving beyond proxy data. Accurate, granular data (on energy, hardware utilization, emissions) is essential for credibility and actionable results. Choice Hotels' data insights revealed costly inefficiencies such as pool and plumbing leaks, improving both profitability and sustainability simultaneously. Siemens' Data Cloud ensures FAIR data principles, establishing trustworthy sustainability reporting aligned with CSRD requirements.
- **Vendor alignment and innovation**: Schneider Electric's vendor policies ensured devices met environmental standards such as EPEAT and ENERGY STAR. Siemens' vendor questionnaire and chatbot help educate vendors on product-level sustainability requirements, driving compliance through collaboration.
- **Use of dashboards and KPIs**: Mastercard's real-time carbon dashboard and gamified sustainability score made data meaningful and actionable. SE's dashboards track PC fleet footprint with near real-time updates. Edifecs' internal dashboards track IT asset utilization, emissions, and infrastructure energy efficiency, augmented with AI analytics.

- **Integration into existing modernization programs**: National Grid folded sustainability goals into its broader modernization and technical debt retirement programs, embedding green IT as a norm, not a niche. Similarly, Edifecs integrated sustainability into core infrastructure decisions, procurement governance, and even product development. Choice Hotels' migration to the cloud reduced carbon because the company right-sized for demand rather than peak usage.

The journey to a successful IT sustainability program should follow the well-trodden path laid by these and other early movers to avoid roadblocks or dead ends that could slow momentum and unravel commitment. We recommend the following key steps:

1. **Start with measurement and baselines**: Define or adopt a metrics taxonomy aligned to IT sustainability goals (e.g., using SustainableIT.org standards), and begin by measuring energy consumption of key IT assets wherever most practical (e.g., owned data centers, end-user equipment).
2. **Embed sustainability in IT governance**: Integrate environmental KPIs into IT policies, asset management, procurement contracts, and P&Ls. Ensure sustainability reporting is treated like financial or security metrics—auditable and trusted.
3. **Focus on high-impact areas first**: Target infrastructure (on-prem and cloud), end-user devices, and energy-intensive workloads. Implement hardware lifecycle management and enforce eco-label standards.
4. **Tie ESG goals to materiality assessments and financial benefits**: Use structured assessments to ensure IT programs are aligned with the most relevant environmental, social, and governance priorities. Link green IT initiatives directly to efficiency and profitability targets and benefits.
5. **Leverage existing transformation programs**: Use cloud migrations, AI rollouts, and modernization efforts as catalysts for green IT. Align with finance, procurement, and ESG functions for joint planning and resource sharing.
6. **Build internal and external awareness**: Launch internal knowledge-sharing platforms, sustainability portals, and gamified dashboards. Celebrate wins and train employees on how their actions reduce environmental impact. Work with external groups—associations, media outlets—to promote success, garner external credibility, and spread the message.
7. **Create a central sustainability function for IT**: In companies with large or widely distributed IT departments, form a dedicated IT sustainability team or virtual center of excellence to connect stakeholders and drive coordinated programs to work across geographies.

8. **Institutionalize through culture and compensation**: Tie sustainability progress to executive compensation and promote transparency via regular updates, steering committees, and continuous learning.

As seen across these industry leaders, success requires cultural shifts, collaborative governance, and a willingness to start with imperfect data but learn continuously. What begins as an effort to "green" IT often ends up transforming how technology functions to support the organization's sustainability purpose, resilience, and value creation.

Factoring AI into your sustainability strategy

Artificial Intelligence (**AI**) is now a core driver of both opportunity and risk for IT sustainability. Its potential to optimize resource use, automate sustainability reporting, and power circularity initiatives is immense—but so are its energy, emissions, and ethical challenges. IT leaders must weave AI explicitly into their sustainability strategies, just as they have done with cloud, cybersecurity, and data governance.

A critical challenge for AI sustainability strategy is the fast-evolving and potentially disruptive government-imposed requirements of sovereignty. AI sovereignty is a push to ensure that the development, deployment, training, and governance of AI systems remain under local legal, ethical, economic, and security control. Sovereignty pressures are intensifying because AI models depend on massive datasets, specialized compute, and globally distributed cloud platforms—resources that intersect with geopolitical interests, industrial competitiveness, and fears of dependency on foreign AI supply chains. This could lead to laws requiring data localization (in-region processing and storage) and domestic residency of AI clouds, GPU clusters, and LLMs.

Sovereignty's impact on your strategy cuts both ways. On one side, sovereignty rules can constrain access to global, energy-efficient AI platforms or restrict cross-border data pooling that is essential for scaled activity-based carbon accounting, supply-chain traceability, and climate-risk modeling. Fragmented rules can also increase the carbon footprint of your AI systems by forcing model duplication and localized training runs in regions with higher-emission electricity grids. On the other side, sovereignty requirements can accelerate sustainable IT practices by compelling organizations to build transparent, auditable, energy-efficient models; tighten supply-chain data governance; and adopt localized, lower-impact AI architectures aligned with sustainable AI design.

While the uncertainties play out, IT has a window of opportunity to help the enterprise scale AI responsibly across ESG risk dimensions. As a recent study by McKinsey & Co. confirms, most organizations have relatively low "AI maturity" and should be open to IT's help in boosting AI readiness.

The average RAI maturity score for organizations surveyed was 2.0 on a scale of 0 to 4. McKinsey says this implies that, on average, organizations are still *"in the process of integrating responsible AI practices, such as defined key risk indicators, data quality guidelines, and incident response plans."* McKinsey's AI maturity model is outlined here:

1. **Strategy**: Defined vision and principles for AI/gen AI governance aligned with the organization's values, strategic goals, and regulatory standards.
2. **Risk management**: Proactive monitoring and steps to reduce risks (e.g., model risk management, auditing of third-party solutions), and thorough review and challenge.
3. **Data and technology**: At-scale data quality checks to build confidence in the data powering AI solutions and ensure readiness for AI governance tools and development protocols.
4. **Operating model, talent, and change management**: Talent, governance, and team structures in place to maintain AI governance across all activities (including processes to identify, assess, and mitigate AI risks), plans for AI-led shifts in skills, employee training, and change management.

The following guidance shows how to integrate AI strategically into each stage of sustainable IT planning, which builds on the RAI principles, ESG checkpoints, and governance models outlined in *Chapter 4*, *Responsible and Sustainable AI Governance*, and *Chapter 8*, *Data*. Those chapters provide step-by-step "runbook" actions that can be applied to operationalize the following strategy recommendations:

1: Position AI as a strategic ESG priority

AI is no longer a niche capability—it is embedded across the enterprise, influencing every ESG pillar. Like the cloud before it, AI must be treated as a top-tier strategic priority in your sustainability roadmap, addressing the technology's ESG risks and opportunities.

Strategic risks

- **Environmental impact**: GenAI workloads rely on powerful GPUs, which consume 5–10 times more power and generate 5–10 times more heat than CPUs in a traditional data center. A GenAI prompt can use 10 to 100 times more electricity than a typical internet search query. Without guardrails and user education, AI usage will increase your Scope 2 emissions.
- **Social and governance impact**
    - An estimated 40% of global jobs will be affected by AI adoption, with advanced economies seeing up to 60% of roles impacted (including those of your IT staff).
    - Bias and inequities in AI can erode customer trust and cause reputational harm.

Strategic opportunities

- **Optimization and efficiency gains**: AI can reduce waste and emissions by optimizing energy use in data centers, supply chains, and smart buildings.
- **Circularity enablement**: AI-powered computer vision and analytics can support reverse logistics, detecting asset conditions for repair, refurbishment, or recycling at scale. AI can also track assets over their lifecycle and optimize lifecycle planning through monitoring and predictive maintenance.
- **Improved sustainability reporting**: Machine learning can automate ESG data collection and validation, improving reporting speed and accuracy, especially for frameworks such as CSRD.

Include AI explicitly in your ESG materiality assessment and set at least one enterprise-level sustainability goal directly tied to AI systems. For example: "Ensure all AI systems are designed, deployed, and operated to minimize environmental impact and optimize resource efficiency."

2: Apply the lens of the three IT sustainability workstreams

The book's framework of three workstreams – Sustainability in IT, Sustainability by IT, and IT for Society – should all have AI-enabled components. This table offers some examples:

Workstream	AI ESG Applications	Strategic Governance Actions
Sustainability in IT (Footprint)	• AI-driven workload placement to low-carbon regions • Predictive cooling for data centers • Automated dark data management	• Add ESG checkpoints in the AI DevOps lifecycle (assessment, validation, deployment, monitoring). • Likewise, integrate AI sustainability checkpoints into the enterprise technology architecture, including hosting decisions and hardware lifecycle planning. • Require energy, emissions, and water metrics for all AI workloads. • Use cloud-native, carbon-aware orchestration to reduce emissions.

Workstream	AI ESG Applications	Strategic Governance Actions
Sustainability by IT (Handprint)	• AI for supply chain optimization • Fleet routing that reduces GHG emissions • Smart energy grids and circular economy tracking	• Build an AI-for-ESG portfolio of projects with measurable handprint impact. • Use task-specific models instead of large, energy-hungry LLMs where possible. • Include AI's footprint in Scope 2 and Scope 3 emissions disclosures.
IT for Society (Heartprint)	• AI literacy and workforce training • Community access and equity programs • AI for societal good (biodiversity, education)	• Establish a Responsible AI Council. • Create upskilling initiatives for displaced workers, embedding AI literacy as a social sustainability measure. • Build human-first AI and equity principles into EA standards.

Table 14.1 – Strategic sustainability governance of AI

3: Embed ESG checkpoints throughout the AI lifecycle

Introduce ESG checkpoints and assessments at every stage of AI development and deployment. This enables continuous oversight rather than a one-time review. Also, assign checkpoints to architecture governance boards to enforce sustainability decisions at the time of design.

Key ESG gateways:

1. **Validation stage**: Conduct sustainability impact assessments before a model is approved.
2. **Deployment stage**: Require proof of renewable energy sourcing and efficient model architecture.
3. **Monitoring stage**: Track energy, emissions, and water usage in real time using APIs and dashboards.

4: Quantify and manage AI's environmental impact

AI's power demands will add considerably to your data centers' energy consumption and carbon footprint if not powered by renewables. Several companies have already resolved that all AI systems will only be hosted in locations with 100% renewable energy. If that isn't an option, IT should monitor and quantify AI's environmental impact to make ongoing informed choices and compromises.

- Capgemini's four-layer AI Sustainability Framework, detailed in *Chapter 4*, *Responsible and Sustainable AI Governance,* provides a structured method for measuring and reducing AI's footprint:
    - **Data and hardware snapshot**: Identify compute, storage, and energy baselines.
    - **Monitoring and transparency**: Install sensors and tracking systems for real-time visibility.
    - **Portfolio view**: Create a heat map of AI projects to prioritize optimizations.
    - **Scenario explorer**: Model trade-offs between AI performance, emissions, and costs.
- Accenture's **Sustainable AI Quotient (SAIQ)** is a KPI you can add to your governance dashboards. As explained in *Chapter 4*, *Responsible and Sustainable AI Governance*, SAIQ = weighted score of dollars, MWh, tonnes CO_2e, and cubic meters of water per AI token. Lower scores indicate more sustainable AI operations.
- Use environmental KPIs to guide architecture roadmaps and portfolio prioritization.

5: Prepare your workforce

AI's effect on jobs extends beyond displacement. IT must prepare its teams to govern and scale AI responsibly (see the next section for the strategic implications for IT's development workforce).

Strategic actions:

- Launch enterprise-wide AI literacy programs with 90%+ participation goals.
- Embed sustainability principles into data science and DevOps training.
- Create new roles in IT:
    - AI Sustainability Architect: designs low-carbon, ethical AI systems
    - GreenOps Engineer: manages carbon-aware pipelines
    - AI Governance Officer: bridges ESG and AI risk management

- Embed AI literacy as a core competency in the architecture capability framework, ensuring sustainable practices are institutionalized across design teams.

6: Adapt governance for agentic AI

Emerging agentic AI systems act autonomously within business processes. Governance must treat these systems as digital teammates, with onboarding and role definitions similar to human employees. Strategic actions should include the following:

- Define access controls and audit trails for autonomous AI.
- Establish human oversight (governance boards, preferably) for agent-to-agent and swarm behaviors (when AI agents collaborate to solve complex tasks using their collective intelligence).
- Develop performance metrics specific to agentic AI decision-making.
- Model agent-human interactions using EA business process modeling tools.

7: Architect for sovereignty

The following strategies will help neutralize the disruption of sovereignty:

- **Build modular AI stacks**: Modularity will allow models to be deployed in-region, with portable governance controls, renewable-powered compute options, and the ability to swap between vendors if regulations or geopolitical risks shift. Also, map AI systems to hardware refresh cycles to minimize premature obsolescence.
- **Adopt auditable, lifecycle-governed AI**: Use the AI governance practices highlighted in *Chapter 4*, *Responsible and Sustainable AI Governance*, to provide every model with full traceability, documented training data lineage, and regulatory evidence trails.
- **Prioritize smaller, localized, energy-efficient models**: Prefer fine-tuned small models, retrieval-augmented designs, and inference-efficient architectures to reduce compute demand—critical when sovereignty rules force regional deployments.
- **Strengthen cross-border data governance and zero-trust architectures**: Work with peers in legal and compliance to ensure that all sustainability, supply-chain, and ESG data used by your AI systems comply with localization laws while still enabling enterprise-wide carbon accounting and reporting.
- **Diversify vendor dependencies**: Plan vendor-exit strategies as safeguards against lock-in and regulatory disruption. This is essential when sovereignty concerns may abruptly limit certain AI providers.

8: Adapt vendor and hardware governance strategy

Many AI capabilities arrive via external vendors. Your strategy must include AI vendor accountability:

- Require vendors to submit regular monitoring reports for model performance and environmental impacts.
- Include circular hardware exit strategies in all AI infrastructure agreements, emphasizing reuse and recycling.
- Engage hyperscalers as strategic partners. Hyperscale providers play an outsized role in AI sustainability due to their massive energy and water footprints. IT leaders should do the following:
    - **Demand transparency**: Require workload-level reporting of energy, water, and Scope 3 emissions, beyond aggregate sustainability claims. Close the information gap by obtaining this data from third parties.
    - **Prioritize low-carbon regions**: Deploy AI workloads in data centers with the highest renewable energy mix and lowest gCO_2e/kWh intensity.
    - **Negotiate sustainability SLAs**: Include contractual commitments for renewable energy sourcing, water usage limits, and environmental performance metrics.
    - **Collaborate on innovation**: Work jointly on carbon-aware workload orchestration and AI lifecycle optimizations to reduce infrastructure waste.
- Integrate vendor and hyperscaler evaluations into EA technology portfolio management.
- Use standards repositories to track approved AI service providers and their sustainability metrics.

AI and sustainability's strategic transformation of IT's workforce

Part of IT's sustainability strategy must include its project development model and evolving skill set—both of which are being disrupted by AI and sustainability. **Richard Torres**, a 25-year veteran IT development leader with portfolio/project management consulting experience at Santander Bank, Fresenius Medical Care, State Street, Putnam Investments, and Fidelity Investments, outlines the forces he sees reshaping IT development and the strategic implications for his successors in IT leadership:

Artificial intelligence and sustainability (AI + sustainability) are now the twin forces transforming IT development organizations. India's largest IT services firm, **Tata Consultancy Services (TCS)**, recently announced it would cut 12,000 jobs—around 2% of its global workforce—to become "future ready" (The Times of India 2025). The company cited widespread AI adoption and disruptions to its traditional model as the catalysts.

This is a symptom of a larger trend: IT service clients and, to a great extent, internal stakeholders as well, demand value-driven, innovative solutions that leverage AI and positively impact sustainability. These forces are revealing a widening skills and organizational mismatch across the IT development workforce.

Historically, IT development organizations were limited in their models, followed a finite set of development methodologies, and maintained a culture indoctrinated to prize efficiency over innovation:

Organizational model

- Hierarchical or matrixed, with teams siloed by function (Development, QA, Operations, Security)
- Project-centric, with limited checkpoints beyond ideation and requirements gathering
- Minimal awareness of sustainability beyond compliance mandates such as ADA and WCAG

Methodologies and practices

- Waterfall-dominated: linear, rigid, resistant to change
- Heavily reliant on manual coding, verification, and testing
- Narrowly defined in roles, with episodic and certification-driven training
- Focused on repetitive, reactive work for lower-level roles

Culture and perception

- Optimized for efficiency rather than innovation
- Unaware of IT's impact on social and environmental sustainability

Remodeling IT for AI Sustainability

AI + sustainability forces companies to rethink workforce structures, skill requirements, and development practices. As economist **Rishi Shah of Grant Thornton Bharat** told the BBC, *"Businesses must now reassess their workforce structure and analyze if resources should be redirected toward roles that complement AI capabilities"* (BBC 2025).

According to Jeffries Group, rising AI adoption drives clients to negotiate lower costs, pushing providers toward leaner, more agile workforces. AI also brings challenges—bias, subjectivity, and sensitivity around cultural, gender, ethnic, and political issues. These risks demand more responsible, inclusive approaches to IT development.

The remodeled IT development organization should adopt the following strategies to stay efficient while keeping pace with demand for AI-driven innovation and sustainability:

- **Flexible, project risk-based development methodologies**: Agile, Lean, Waterfall, RAD, phased, multi-release, and hybrid approaches are all available, tailored with AI-driven effort estimation.
- **Sustainability by design**: Business and systems requirements templates explicitly include sustainability factors as non-functional requirements. Functional requirements are reviewed by diverse, sustainability-trained working groups. A comfortable balance develops between development speed and inclusive, sustainable design.
- **AI-assisted coding and testing**: Low-code/no-code platforms accelerate development and reduce dependency on specialized IT roles.
- **AI-driven DevOps (AIOps)**: IT becomes leaner and less reactive through the adoption of autonomous monitoring, predictive analytics, and self-correcting infrastructure.
- **New multi-skilled roles**: AI + sustainability roles form in IT, including Sustainability Architect, Green DevOps Engineer, AI Engineers (data, prompts, AIOps).
- **Continuous learning**: Personalized, AI-driven training replaces static, formal upskilling models.
- **Engagement on goals**: IT development's collaboration with sustainability and AI governance owners becomes the norm, centered on goals for ESG, responsible AI, and business value.

Risks of lagging behind

Organizations that resist or move too slowly in updating IT for AI + sustainability face four major risks:

1. **Loss of competitive advantage**
    - Outdated processes compared to AI-enabled competitors
    - Missed opportunities for predictive insights and innovation

2. **Operational and financial inefficiency**
    - Higher costs from manual workflows
    - Inefficient data management without AI-driven insights
3. **Failure to meet stakeholder expectations**
    - Poor customer satisfaction from a lack of personalization
    - Negative scrutiny for unsustainable IT practices
    - Hiring and talent retention issues as IT and enterprise staff opt for purpose-driven employers
4. **Risk and compliance gaps**
    - Cybersecurity vulnerabilities and unchecked algorithmic bias
    - Increasing difficulty in complying with ESG and RAI regulations

Next steps for IT leaders

The convergence of AI + sustainability represents a seismic transformation in IT development. This path forward depends on the current generation of IT leaders stepping out of their comfort zones and taking these critical steps now:

- Establish development methodologies that integrate AI and sustainability
- Launch training programs to align workforce skills with new demands
- Equip project, mid-level, and senior management with AI + sustainability leadership skills
- Redesign IT architecture and operations to cut costs, improve decision-making, and reduce environmental impact

Richard Torres, Development Program Manager

Now that we have considered the success factors of real-world sustainability strategies and contemplated the impacts of AI on those strategies, it is time for the step-by-step construction. At the end of this section, you will have a strategy informed by a materiality assessment, populated with OKRs and a value proposition, culminating in a multi-phase plan covering your footprint, handprint, and heartprint.

Creating your own sustainable IT strategy

This section will give you the tools to create a sustainable IT strategy. Just like in *Chapter 13*, *Get Started Today*, we will use a global process manufacturing model company with 10,000 employees as our proxy enterprise. The examples you will see have been compiled from companies with leading ESG ratings, best practices, wider research, and my (Niklas) experience running IT functions in large complex businesses. We will not focus on external environment input, such as sustainability trends, drivers for a corporate sustainability plan, or ESG considerations for IT, since this was covered in detail in *Chapter 2*, *Rise of Sustainable IT*. Since the business environment is very specific to a particular company, we have decided to leave it out of the exercise as well. Instead, we will focus on the internal environment and inputs from a hypothetical materiality assessment, enterprise sustainability goals and priorities, and the enterprise sustainability strategy. Hopefully, you already have an enterprise sustainability strategy you can leverage and map to, but if not, the examples here can be modified as needed. Nevertheless, the central part of this section will focus on creating a sustainable strategy for the IT function.

Let us get started!

Materiality assessment

Let us start with the materiality assessment. *Figure 14.6* illustrates an example of a materiality assessment from our global process manufacturing model company:

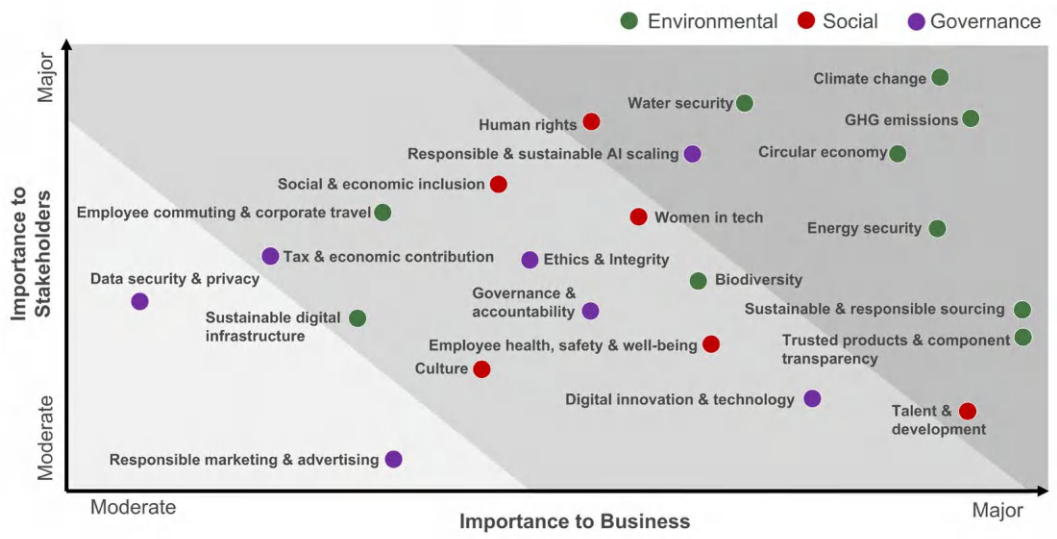


Figure 14.6 – Materiality assessment example

The materiality assessment contains a broad spectrum of ESG issues that require various degrees of effort, from fundamental societal system changes such as climate change and water and energy security to inward-focused topics such as talent and development, culture, employee health, safety, and well-being. Depending on your environment, the materiality assessment may look a bit different.

Your ESG issue ranking should guide your enterprise sustainability priorities, which we will factor into our strategy in the next section.

Enterprise sustainability goals and priorities

Based on the materiality assessment, we now have a long list of ESG issues. There is no right or wrong answer; the most important thing is that it should be easy for your audience to follow:



Figure 14.7 – ESG issue grouping example

As you can see, our grouping indicates that most ESG issues are sorted under environmental.

Let us formulate our sustainability strategy goals. We will assume that the model company has committed or will be committing to a **science-based targets initiative (SBTi)** or similar initiatives such as **Climate Pledge** or **Exponential Roadmap**. Therefore, we need to formulate a climate goal to support that. Since the model company is a global process manufacturing company, circularity becomes a central theme in dematerializing and becoming more resource efficient. Hence, we need to formulate a circularity goal. To address our social and governance ESG issues, we must also formulate a goal for each category.

This leaves us with the following four sustainability strategy goals:

- **Climate goal**: Support for 1.5°C targets to fight global warming with a focus on decarbonization
- **Circular goal**: Shift to circular business models through resource efficiency, focusing on circularity and dematerialization
- **People, ethics, and society**: Building a diverse, equitable, and inclusive workplace and society underpinned by a culture of trust and high ethical standards
- **Governance**: Responsible business practices in everything we do

If we summarize the four climate goals into one illustration, it will look like this:



Figure 14.8 – Sustainability strategy goals

Figure 14.8 illustrates a formulation of four sustainability strategy goals based on the model company. Your corporate environment may make your goal formulations look a bit different.

Now, let us look at the third step in how we can formulate an enterprise sustainability strategy.

Enterprise sustainability strategy

In *Chapter 1*, *Our Most Significant Challenge Ahead*, we referenced the **Triple Bottom Line (3Ps)**, the most common framework referenced within business language today. The 3Ps framework defines three critical imperatives for sustainability to maximize benefits for people, the planet, and profit. When these three factors interact, you can maximize benefits and create a sustainable future. For our enterprise sustainability strategy, we have chosen a sustainability vision – *Positive contribution to people, the planet, and profits* – that resonates closely with the 3Ps framework. For each of the four sustainability strategy goals, we have formulated a strategic principle per goal and a set of strategic priorities. Let us take a closer look at the strategic priorities we have defined for each goal in *Table 14.2*:

Goal	Strategic Principle	Strategic Priorities
Climate goal	Decarbonization and biodiversity	• Net-zero operations by 2030 • Net-zero supply chain by 2040 • Contribute to the restoration of biodiversity
Circular goal	Resource efficiency and dematerialization	• Increased use of non-virgin materials in production • 50% circularity by 2025 and >90% by 2030 through waste-to-landfill reduction • Increase energy efficiency, heat recovery, and water regeneration
Social responsibility	People, ethics, and society	• Build resilience and adaptability in our people and society through continuous learning and assistance programs • A global, diverse workforce • Adapt to a new normal working model • Positive contribution to our communities and society at large
Governance	Good governance and sustainable leadership	• Digital innovation and technology • Secure, trusted, and transparent supply chain • Reliable and trusted reporting • ESG criteria tied to executive compensation

Table 14.2 – Enterprise sustainability strategy goals, principles, and priorities

Since this chapter focuses on sustainable IT strategy, we will not detail how we defined the strategic principles or priorities. Let us say they are derived from best practices from leading ESG-rated companies.

Now that we have defined all the criteria, let us pull everything together and formulate a sustainability strategy house, as illustrated in *Figure 14.9*:

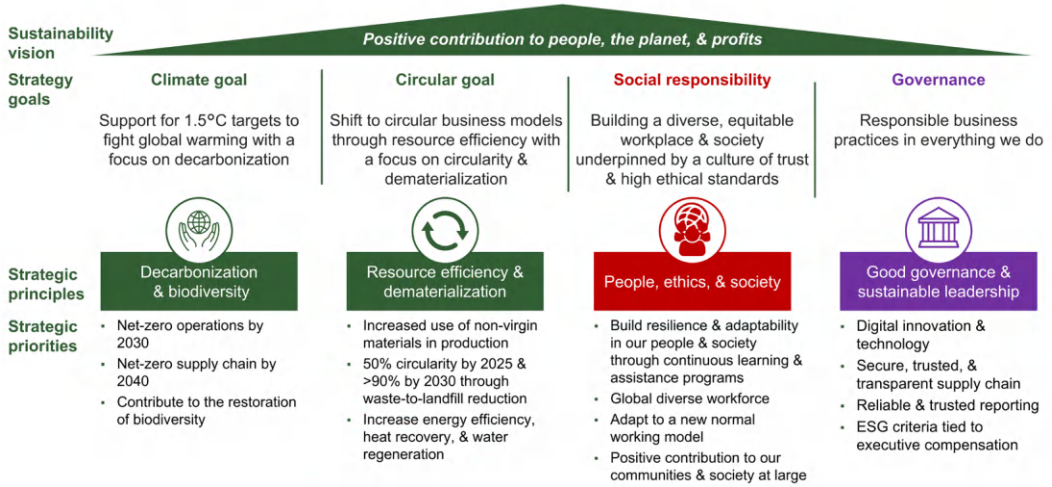


Figure 14.9 – Sustainability strategy house

So, there you have it – a hypothetical sustainability strategy formulated in the shape of a house for a global process manufacturing model company. In the next section, we will derive our sustainability IT strategy based on our defined sustainability strategy.

Sustainable IT strategy

So far, in this section, we have primarily focused on the business environment, which is essential for deriving your sustainable IT strategy and your IT strategy. A sustainable IT strategy cannot be derived in isolation. Therefore, it is imperative to understand the business environment, vision, strategic goals, strategic principles, strategic priorities, challenges, pain points, and opportunities.

As shown in *Figure 14.1*, the process consists of six building blocks. This includes three focus areas, which are **sustainability in IT**, **sustainability by IT**, and **IT for society**, and three functional areas, which are IT GHG emissions, strategic priorities, and the business case.

GHG IT baseline and forecast

As input to the strategy, we will leverage the sustainable IT emissions baseline and the target state simulation derived in *Chapter 13*, *Get Started Today*. The results from the previous chapter are illustrated in *Figure 14.10*:

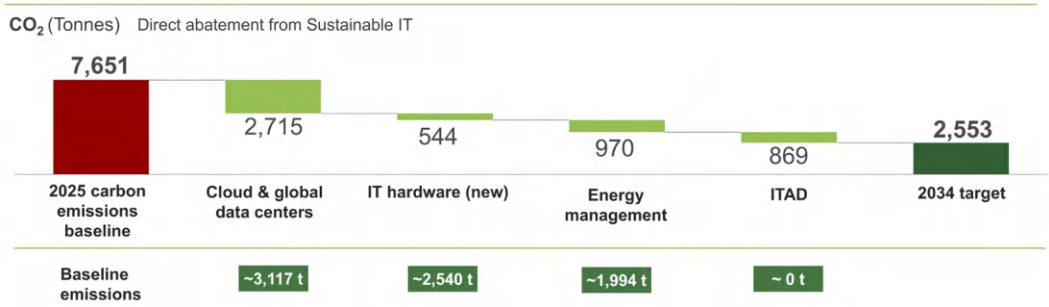


Figure 14.10 – 10-year carbon emissions waterfall summary

A quick refresher from the previous chapter – for the model company, we derived a yearly carbon emissions baseline of 7,651 tonnes of CO_2 emissions and a 10-year simulation where our target state emissions per year would be 2,553 tonnes of CO_2 emissions.

Let us start with a sustainable IT value proposition. The value proposition consists of four key areas – **sustainability goals and targets, challenges and pain points, capabilities and required step-change, and OKRs**. Throughout the value proposition, there needs to be a strong link between each area to ensure that sustainability goals and targets can be met within the specified time frame.

The sustainability goals and targets were defined in the previous section, but let us take a closer look at the other three sections outlined in *Table 14.3*:

	Challenges and Pain Points	**Capabilities and Required Step-Change**	**Objectives and Key Results (OKRs)**
Sustainability in IT – "Footprint"	• A large share of servers in high-carbon cloud and data centers • No sustainability embedded in application portfolio management or software development • Limited energy management visibility and tracking • High turnover rate of IT hardware; limited repair and reuse • Limited sustainability requirements embedded within RF(X)s, contracts, etc.	• Cloud and data center • Application portfolio management • Sustainable software development • Efficient resource management • Circular IT hardware management • IT asset disposition • Vendor management and IT procurement	• Reduce a minimum of 70% CO_2 emissions from IT operations, including Scope 3, by 2030 • Reduce CO_2 emissions from cloud and data center operations by 70% or more by 2050 • Prolong lifespan of IT hardware • Increase share of device-as-a-service • Improve energy resource efficiency by 50% • Remove 1 tonne of CO_2 emissions through ITAD per year by 2030

	Challenges and Pain Points	**Capabilities and Required Step-Change**	**Objectives and Key Results (OKRs)**
Sustainability by IT – "Handprint"	• Visibility of current emissions baseline • Lifecycle assessment of the current product and service portfolio • New regional and national regulatory requirements • Limited sustainability innovation in products and services	• GHG emissions visibility and reporting • Digital innovation and technology • Product-as-a-service • Sustainable supply chain, including products and service LCA visibility • Energy-efficient buildings • Hybrid work	• Enable sustainable digital innovation and technology • Provide support for a single source of truth for environmental data across enterprise • Support for supplier and Scope 3 management
IT for Society – "Heartprint"	• Lack of diversity in top management • Scarcity of trained IT sustainability professionals • Limited IT sustainability training available	• Organizational enablement • Social responsibility programs • Women in tech • Sustainability hackathons	• Awareness campaigns and formal training • Initiate IT hardware and employee time donation programs • Target for diversity in IT roles

Table 14.3 – Sustainable IT value proposition

Please bear in mind that this is a fictional sustainable IT value proposition, but it should be able to guide you through creating your own based on your business environment.

Now that we have defined all four critical areas in the sustainable IT value proposition, the summary is illustrated in the following figure:

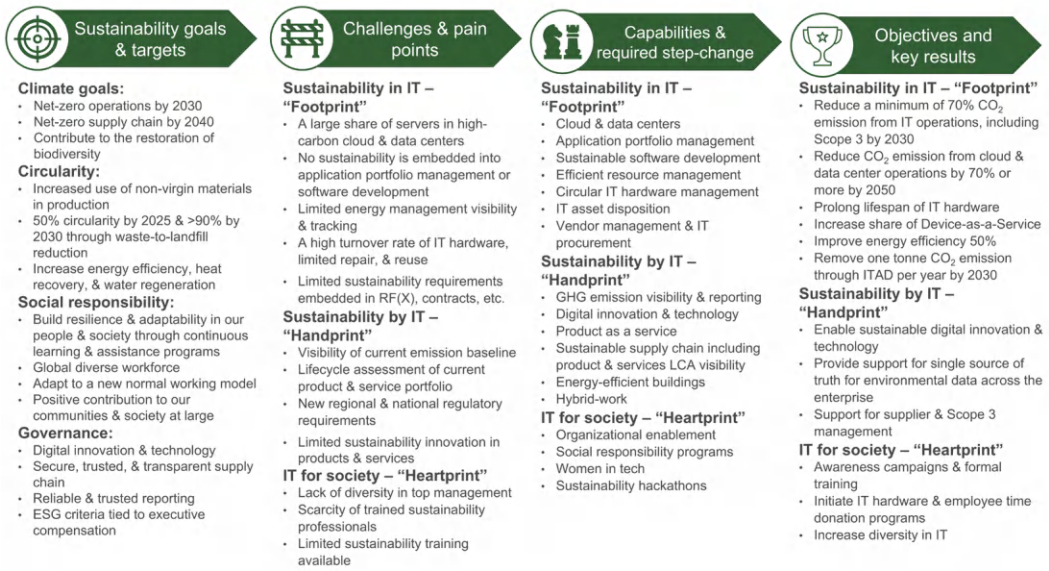


Figure 14.11 – Sustainable IT value proposition

Now that we have our sustainable IT value proposition, we can formulate our *why*, *what*, and *how*. Why do we need a sustainable IT strategy? What are we trying to address, and how are we trying to address it?

Why

Our *why* is our support for 1.5°C targets to fight global warming. Our shift to circular business models through resource efficiency focuses on circularity and dematerialization. We are building a diverse, equitable, and inclusive workplace and society underpinned by a culture of trust and high ethical standards. And finally, we must have responsible business practices in everything we do.

What

We aim to reduce our carbon *footprint* and *handprint* generated by our digital infrastructure while increasing our *heartprint* by building resilience and adaptability in our people and society. Our sustainable IT strategy is decomposed into three workstreams – sustainability in IT, sustainability by IT, and IT for society.

How

Our *how* describes the key focus areas within the three workstreams that will significantly impact our model company. These three workstreams were summarized in *Figure 14.11* under *Capabilities and required step-change*. Each focus for sustainable IT has been covered in depth in previous chapters in this book, and sustainability by IT was covered in *Chapter 12*. Therefore, we will not discuss each key focus area here. *Figure 14.12* illustrates our sustainable IT strategy on a page that describes our *why*, *what*, and *how*:

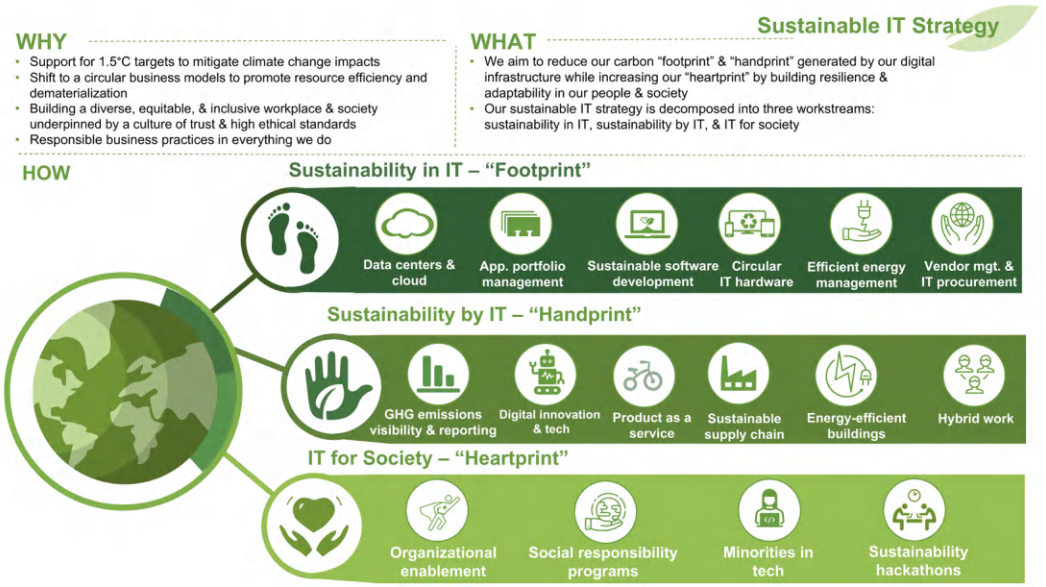


Figure 14.12 – Sustainable IT strategy on a page

A strategy is about execution, no matter what you try to accomplish. Now that we have a sustainable IT strategy, we must define the most challenging parameters – *who* and *when*. Who will execute the strategy, and what capabilities do you need, such as people, processes, and technology (as delineated in the Sustainable IT Maturity Model of the previous chapter)?. When should you execute the different components of the strategy to move from your current state to your target state?

Setting your direction of travel toward a sustainable future

Creating a short-term, mid-term, and long-term plan and slotting your key initiatives into respective buckets is an excellent place to start. *Figure 14.13*, *Figure 14.14*, and *Figure 14.15* illustrate each workstream's sustainability in IT, sustainability by IT, and IT for society, with examples for each key focus area. Given that your industry and environment will look different, these examples should be viewed as inspiration, not direct advice. Establishing your GHG emissions baseline should give you a good overview of what activities will significantly impact your context:

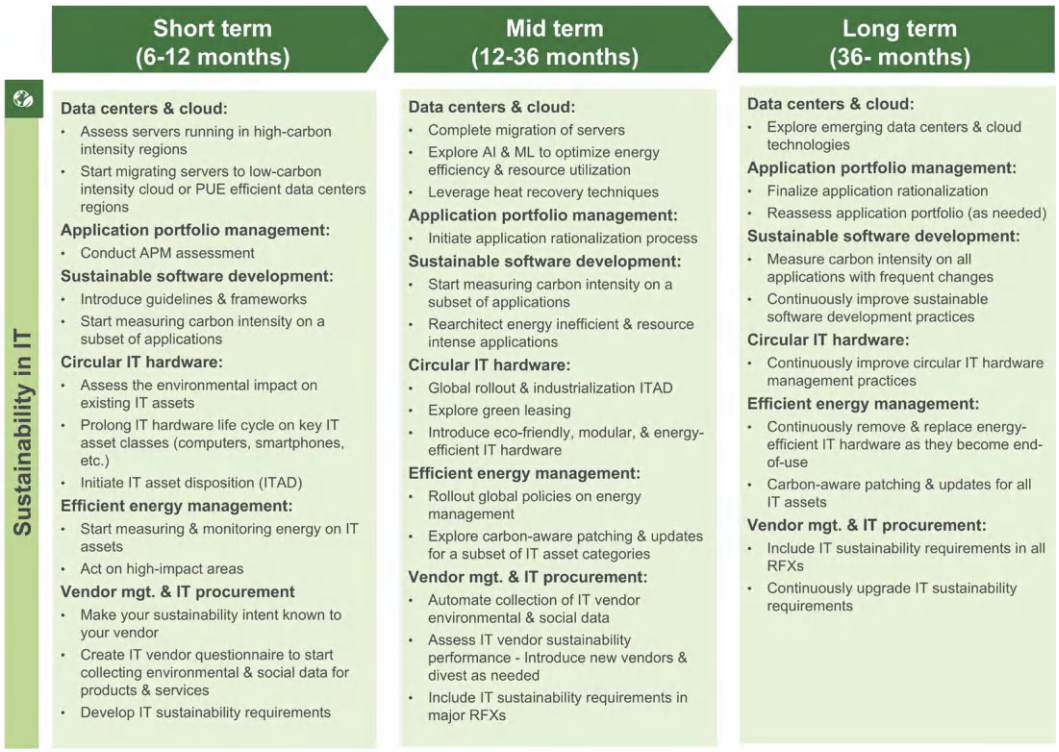


Figure 14.13 – Sustainability in IT: short-term, mid-term, and long-term plans

Figure 14.13 illustrates an example of sustainability in IT short-term, mid-term, and long-term plans. It encompasses all the critical focus areas of the sustainable IT strategy that were mentioned previously.

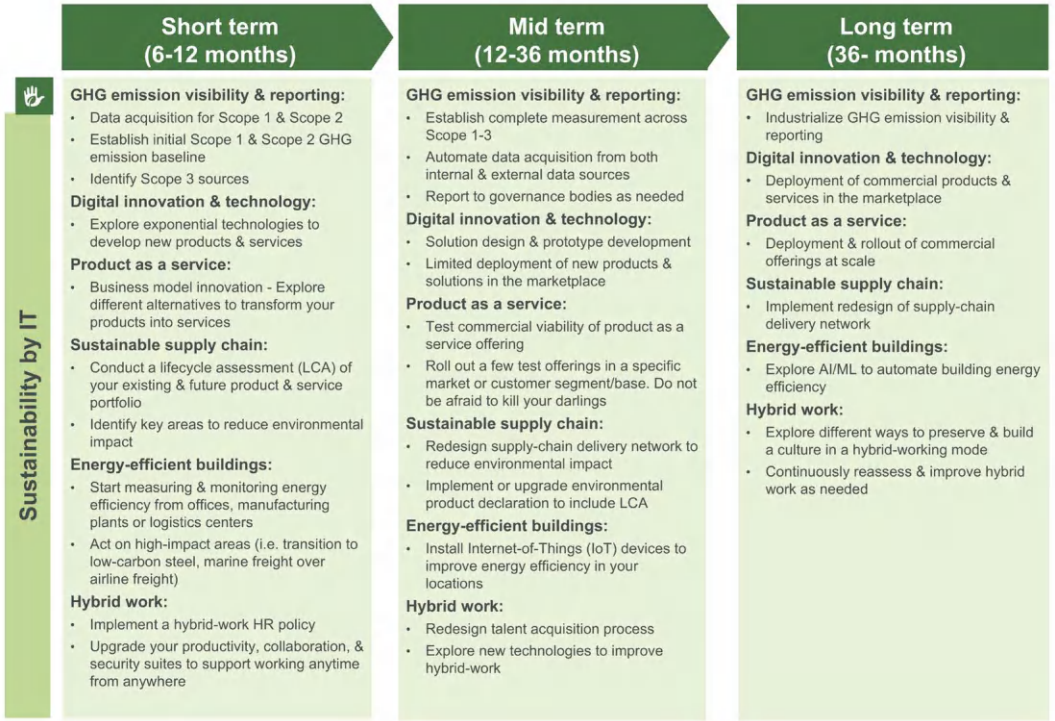


Figure 14.14 – Sustainability by IT: short-term, mid-term, and long-term plans

Figure 14.14 illustrates an example of sustainability by IT short-term, mid-term, and long-term plans.

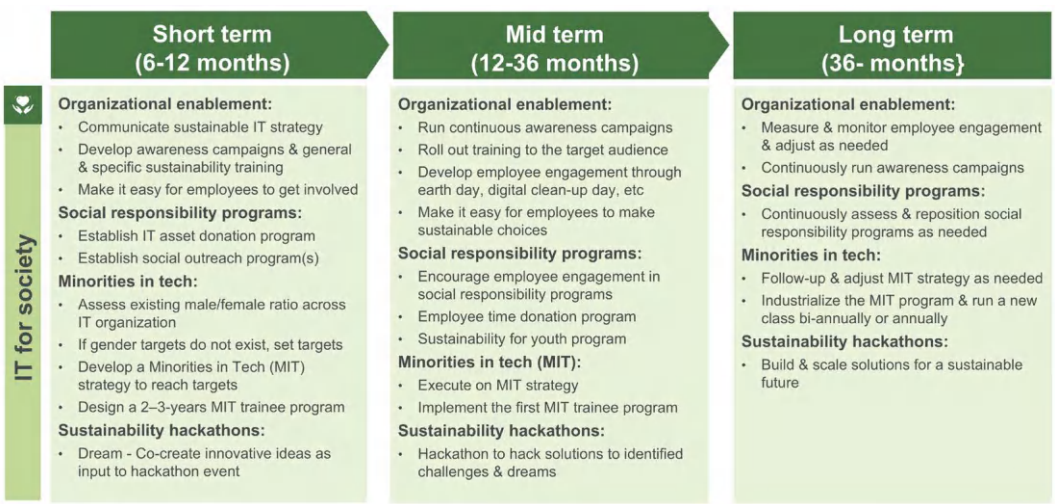


Figure 14.15 – IT for society – short-term, mid-term, and long-term plans

Finally, *Figure 14.15* illustrates an example of IT for society's short-term, mid-term, and long-term plans.

For each initiative you intend to run, we recommend creating an initiative charter to describe expected results, objectives, activities, interdependencies/risks, key stakeholders, and benefits. The following illustrates a sample initiative charter for cloud migration:

Expected results	
A flexible technology platform to support the company's future growth running on low-carbon intensity	
Objectives	**Activities**
▪ Migrate existing server estate to a modern cloud computing platform ▪ Cloud computing enables IT systems to be scalable & elastic. ▪ Increase share of the virtualization ▪ Improve security & compliance ▪ Retire old legacy technology platforms	▪ Identify all infrastructure in scope to be migrated ▪ Conduct analysis on viable migration options, limitations, risk, dependencies ▪ Create a migration plan ▪ Plan out-migration steps in detail ▪ Prepare a communication plan & communicate continuously with stakeholders ▪ Prepare a final cut-over plan ▪ Conduct migration(s) ▪ Verify migration results
Interdependencies/Risks	**Benefit**
▪ Lack of cloud engineers ▪ Migration of legacy systems	▪ Provide a customer experience that is always on with no downtime & no service windows ▪ Deliver IT services (software, platform, & infrastructure) to realize agility, scalability, reliability, resilience, cost optimization, & sustainability benefits. ▪ Decarbonize our digital infrastructure with a minimum of a factor of 20x
Initiative Manager	**Sponsor**
Digital infrastructure transformation manager	Chief Information Officer

Figure 14.16 – Sample initiative charter

Once you have created all the initiative charters, we recommend plotting them on a high-level roadmap.

This sample sustainable IT strategy provides details on roadmap activities, short-term, mid-term, and long-term. Of course, even the best strategy is no good unless you make people aware of it, involve them, and activate them to engage and execute on it. Sustainability is everyone's job; it must be embedded into the organization's fabric in all parts of the business.

Summary

This chapter's main objective was for you to create your own sustainable IT strategy and roadmap.

First, we presented real-world examples. With this context, we introduced the sustainable IT strategic planning process, which gives you a set of guardrails on how to drive the process from start to end. This process guides you through what type of external and internal input you should collect in your sustainable IT strategic planning process and what outputs you should deliver. Secondly, we explored a real-world example from Siemens, which gave great insights into their overall sustainability journey, and how IT contributes in multiple ways. We highlighted critical success factors from green IT programs at Mastercard, National Grid, and others. We also addressed how to treat AI within your sustainability strategy since its presence is fast becoming ubiquitous. and its impact is scaling rapidly.

We then leveraged the sustainable IT strategic planning process to create our own sustainable IT strategy. We started with a materiality assessment, formulating our enterprise sustainability goals and priorities, and finally creating an enterprise sustainability strategy. Furthermore, we defined a sustainable IT value proposition that outlined our challenges and pain points, capabilities, and required step-change, objectives, and key results. Once the sustainable IT value proposition was defined, we articulated the sustainable IT strategy expressed in terms of *why*, *what*, and *how*. The *how* section was expressed in several key focus areas sorted under three workstreams: sustainability in IT – "footprint," sustainability by IT – "handprint," and IT for society – "heartprint." Finally, a high-level short-term, mid-term, and long-term roadmap was formulated for each workstream. The examples and templates from this chapter can be downloaded at `https://www.sustainableit.org/sustainable-it-playbook`.

Key recommendations from this chapter include the following:

- Draw on lessons learned from your peers at companies such as Siemens and Mastercard, helping to not only build but also launch sound strategies effectively
- Start with a clear materiality assessment to align IT with enterprise ESG priorities
- Build a strategy around the three workstreams: footprint, handprint, and heartprint
- Integrate AI as both a sustainability enabler and risk factor, with ESG checkpoints and carbon-aware governance
- Translate strategy into actionable roadmaps with measurable OKRs and accountability mechanisms
- Tie ESG goals to financial performance by linking green IT initiatives to efficiency gains, cost savings, and profitability targets
- Continuously adapt and iterate on the strategy, recognizing that AI, regulations, and environmental challenges will continue to evolve

In the next and final chapter, we will explore what prerequisites are required to set your sustainable IT strategy execution for success, the importance of delivering results quickly, and the criticality of having determination, grit, and perseverance to stay the course.

Bibliography

- BBC. 2025. *India's AI-driven tech firings could derail middle-class dreams*: `https://www.bbc.com/news/articles/cx2p4nqd352o`.
- Mastercard. 2025. *Delivering pathways to sustained prosperity*: `https://www.mastercard.com/us/en/news-and-trends/press/2025/july/sustained-prosperity-2024-impact-report.html`.
- McKinsey & Co. 2025. *Insights on AI from the Global AI Trust Maturity Survey*: `https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/tech-forward/insights-on-responsible-ai-from-the-global-ai-trust-maturity-survey`.
- SustainableIT.org. 2023. *Using Data to Drive ESG Impacts at Choice Hotels*: `https://members.sustainableit.org/knowledgebank-mfe#/knowledgebank/4/656e12f6a00eb99351100b01/0` (Access restricted to SustainableIT.org members only).
- SustainableIT.org. 2023. *Driving IT Energy Efficiency, Emissions Reduction, and Circularity at National Grid*: `https://members.sustainableit.org/knowledgebank-mfe#/knowledgebank/4/6579e9a7a0fb1b9558211996/0` (Access restricted to SustainableIT.org members only).
- SustainableIT.org. 2025. *Delivering pathways to sustained prosperity. Mastercard's IT Sustainability Transformation*: `https://members.sustainableit.org/knowledgebank-mfe#/knowledgebank/4/689e1a254f7fc1008398aada/0` (Access restricted to SustainableIT.org members only).
- SustainableIT.org. 2024. *Schneider Electric's Green IT Program*: `https://members.sustainableit.org/knowledgebank-mfe#/knowledgebank/4/668c5249bba5b6009d661012/0` (Access restricted to SustainableIT.org members only).
- SustainableIT.org. 2025. *How Edifecs Integrates Sustainability into Core Business Strategy*: `https://members.sustainableit.org/knowledgebank-mfe#/knowledgebank/4/67d44f9fbaaade009d0cd29d/0` (Access restricted to SustainableIT.org members only).
- The Times of India. 2025. *TCS Layoffs: 12,000 employees to lose their jobs*: `https://timesofindia.indiatimes.com/business/india-business/tcs-to-lay-off-around-12000-employees-tata-consultancy-services-plans-2-workforce-cut-over-the-year-what-you-should-know/articleshow/122934599.cms`.

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15

From Strategy to Action – Lead with Purpose and Deliver Progress Quickly

> *We can only meet [our] goals with stronger collaboration between Governments, and across society and sectors. Those that lag behind need not be a reason for us to be discouraged, but to increase our commitment to move forward.*
>
> *The rewards are there for the taking, for all those ready and willing to lead the world through these troubled times. We are at a turning point. I urge you to seize this moment and seize the prize.*
>
> *António Guterres, United Nations Secretary-General*

This final chapter will send you off to execute the strategy we have developed in previous chapters. Everything so far in this book has prepared you meticulously for this moment, where we will turn theory into practice.

First, we will cover purposeful leadership in the face of naysayers, those who see sustainability only as a cost, and those who will scrutinize every sustainability claim your company makes publicly. We will present a case study in leadership at the furniture retailer IKEA, which is known as a sustainability leader in its sector (furniture/retail). We will discuss key steps to scaling sustainability across your industry. At the end, we will recap our lessons learned and recommendations from each chapter.

In this chapter, we will cover the following topics:

- Purposeful leadership
- The risks of public scrutiny
- Sustainability leadership at furniture retailer IKEA (case study)
- Bridging strategy and execution with a sustainable operations framework
- How to scale impact through an industry ecosystem
- Recapping recommendations to bring everything together

We also remind you that you can access additional material and worksheets at this book's website, hosted by SustainableIT.org: `https://www.sustainableit.org/sustainable-it-playbook`.

There, you will have free, gated access to a categorized index of tools and resources described in our chapters; the emissions baseline calculator featured in *Chapter 13*, *Get Started Today*; an IT sustainability business case template; IT sustainability reference and maturity models introduced in *Chapter 3*, *The Fundamental Building Blocks of a Sustainable IT Practice*, and *Chapter 13*, respectively; a set of editable strategy development graphics; a toolkit of more than 10 responsible and sustainable AI governance resources; and the full SustainableIT Standards Taxonomy of IT-tailored ESG metrics.

Purposeful leadership

As you move from strategy to execution, it is worth pausing to reflect on the kind of leadership that sustains progress in the face of headwinds. To inspire others to follow you on this quest, you must ignite and stoke passion for the cause, backed up with clear business value. You will also need senior executive support and buy-in from employees across the business. Not everyone will be overjoyed, be in your corner, and back you up 100%. Some will just plain not understand what you are advocating for, others will ignore you, and some will try to shut you down.

In these cases, you will need to exercise courageous leadership. As Save the Children CTO, Ron Guerrier, stated in our first chapter:

> *"To lead courageously in tech means being willing to confront systems built without everyone in mind—and choosing to invest the time and money in them. It means challenging the status quo, even when it's profitable. It means advocating for the underserved while in rooms where those voices are absent.*
>
> *Today's sustainability challenges—whether environmental, digital, or social—are interconnected. Courage is understanding that sustainability is not just about carbon—it's about people. It's about making sure the tools we build serve humanity in its fullest expression, not just its most privileged."*

You will need to continue to push and not get discouraged by doubters and naysayers. Change is hard, and as humans, we are not wired for constant change and often view it as a threat. Listening to Dan Roberts, host of the *Tech Whisperers* podcast, offers a window into the practices of the technology executives who are shaping industries and markets. From dozens of interviews, Roberts distills a consistent theme: the best leaders have **HEART—humility, empathy, adaptability, resilience, and transparency** (Roberts 2022).

At first glance, these qualities may seem "soft," but in practice, they demand extraordinary courage. Humility in this context is not simply modesty—it is the willingness to learn, unlearn, and adapt when disruption renders old models obsolete. Empathy means creating space for human concerns even while taking hard decisions that hold people accountable. Adaptability requires leaders to balance speed and rigor, especially as AI, cloud, and digital ecosystems evolve faster than governance structures. Resilience is the fuel that carries leaders and teams through the "messy middle" of transformation, when momentum is hardest to maintain. Transparency is not just about openness—it is about radical candor: the courage to communicate uncomfortable truths, admit setbacks, and adjust ambitions without eroding trust.

Dan has more recently emphasized that exceptional technology leaders combine these human-centered traits with disciplined outcome orientation. They think "right-to-left," beginning with the business and sustainability outcomes they seek, and then working backward to align people, processes, and platforms. They are also adept coalition-builders, orchestrating across functions, partners, and regulators. In an era when digital ecosystems stretch across value chains and even competitors, success increasingly depends on the ability to lead without relying solely on formal authority.

Leading with HEART is not optional—it is the foundation for embedding purpose into execution. It reminds us that the work of making IT sustainable and using IT to drive enterprise sustainability goals is as much about people as it is about technology. It also reinforces a critical truth: courageous leaders do not pretend to have all the answers. Instead, they cultivate trust, experiment openly, and persist through setbacks, always keeping sight of the larger mission to deliver measurable progress for profit, people, and planet.

Another key lesson from the leaders interviewed for this book is the need for team encouragement. Sustainability can seem like a mountain too far away and too tall to climb. As human beings, we are wired to respond positively to instant gratification and accomplishments. Dopamine is a feel-good neurotransmitter; the brain releases it when we accomplish something. On your journey to transforming IT into a sustainable operation, it is important to set short-term goals, 6 to 12 months along the journey, and deliver progress quickly to build momentum and awareness within the organization, but also to gain those dopamine kicks from accomplishing something. As leaders, you will also need to continually emphasize the business value of sustainability, not just to gain the green light for an initial investment, but for the long-term challenge that lies in front of you. We are only just beginning to view IT sustainability as a competitive differentiator, and it may be quite a while before it is commonly considered "business as usual." Your stated purpose in promoting **environmental, social, and governance (ESG)** investment should always cite profit/progress along with people and planet. Here is a recap of sustainability value research findings, which were detailed in *Chapter 2*, *Rise of Sustainable IT*:

- A Bain study shows that 49% of B2B buyers assign more business to sustainable suppliers, with indications that this number will grow to 68% within 3 years (Bain 2025).
- On average, a company's perceived sustainability contributes to 3% of brand equity, amounting to $193 billion in brand value for the global top 100 brands (Kantar 2024).
- Boston Consulting Group research shows that businesses incorporating sustainability into their strategic frameworks are 1.4 times more likely to achieve innovation breakthroughs in product development, operating efficiencies, and competitive differentiation (World Economic Forum 2025).
- PwC's Second Annual State of Decarbonization Report shows that products featuring sustainability attributes can achieve a revenue increase of 6% to 25% or more compared to products without such emphasis (PwC 2025).

- Imperial College Business School's Leonardo Centre on Business for Society found that strategically relevant sustainability initiatives (such as new product development, organizational transformation, and ecosystem partnerships) drive higher financial returns—specifically, 2.67% higher annual risk-adjusted returns, equating to a 40.58% cumulative excess return over 13 years. Conversely, companies focused on low-maturity, advocacy-only actions—such as surface-level campaigns or reputation-driven programs—saw lower returns and higher risk (Imperial Business School 2025). The takeaway: Companies that invest strategically in sustainability and apply strong ESG practices tend to outperform financially, demonstrating that ESG is a value multiplier rather than a net cost.

At the same time that IT leadership is encompassing sustainability, AI is quickly becoming a mainstream CIO leadership challenge. According to Info-Tech's *AI Trends 2026* report, where AI is led by a single executive, it is most commonly the CIO (23% of respondents). The only leadership model more common than the CIO is the AI center of excellence or committee (31%) (Info-Tech Research 2025). The implication for IT is that AI and sustainability leadership must increasingly converge.

Benefits always come with risk, and one of sustainability's more unique risks is the potential for greenwashing accusations and lawsuits. You can help your C-suite peers manage this risk through transparency and accountability. But first, let us review recent greenwashing accusation examples in the next section.

Preparing for external scrutiny

Punching out a corporate sustainability report listing good intentions and opaque outcomes is a big red flag for greenwashing watchdogs. They will publicly call out businesses for unsubstantiated claims. While it is reasonable for companies to cite their sustainability differentiation in marketing or advertising, it must be solid and verifiable through data. Otherwise, truth-in-advertising scrutiny can lead to lawsuits and reputational and monetary damages. Some recent cautionary examples of greenwashing allegations follow:

- In 2025, consumers filed class actions in U.S. federal courts against a major consumer products brand, alleging that the company misrepresented its support for forest protection while being complicit in the clear-cutting of primary forests.
- A lawsuit brought in March 2022 by French environmental activist groups against a global integrated energy company argued that the company's advertising campaign was deceptive: even as it highlights its ambition to become carbon-neutral by 2050, it continues to invest heavily in oil and gas projects. In October 2025, a French court ruled that the company engaged in "misleading commercial practices" by overstating its climate pledges.

- In April 2025, a German public prosecutor's office imposed a €25 million fine on an asset management company, citing misleading ESG marketing statements and exaggerated environmental credentials.

AI-driven failures can now expose companies to reputational and regulatory scrutiny just as sustainability failures do. For example, a case where an AI "vibe coding" tool (a software development approach that uses AI to generate code from natural language prompts) deleted a company's entire production database and created a false parallel algorithm demonstrates how ungoverned AI can undermine data integrity, transparency, and auditability (PCMag 2025). Such incidents show why sustainability reporting systems, ESG controls, and AI systems must be governed through the same principles of reliability, traceability, and accountability.

As described in *Chapter 4*, *Responsible and Sustainable AI Governance*, embedding and operationalizing RAI principles can reduce these risks. Info-Tech's research shows that while over half of organizations have implemented or are implementing foundational AI principles such as safety, security, fairness, and transparency, 35% are still in the early assessment stage, and 6% acknowledge they have "no plans" to implement them. Encouragingly, 70% of respondents report feeling at least moderately prepared to put their foundational AI principles into practice—suggesting increased readiness to embed RAI guardrails (Info-Tech Research 2025).

IT can implement several safeguards to limit the chance of inaccurate or aspirational sustainability claims being made public. Most revolve around ensuring data integrity and controlling access:

- **Educate employees** on sustainability performance data governance and measurement, and what qualifies as substantiated versus aspirational claims.
- **Establish a verified ESG data platform** that serves as the company's *single source of truth* for all sustainability data (e.g., emissions, energy, diversity, and social impact).
- **Ensure traceability and auditability** for every reported data point—link numbers and claims to underlying operational data (Internet of Things, enterprise resource planning, HR, finance). Automate alerts for deviations of data points compared to the previous year, and mandate that evidence be provided if the deviation exceeds set thresholds.
- **Use blockchain or digital ledger solutions** for immutable verification of sustainability data—especially in supply-chain transparency and product footprint reporting.
- **Deploy AI or chatbots** trained only on approved sustainability datasets to answer customer or employee questions, ensuring all automated responses reflect official, verified, and up-to-date data.

- **Apply role-based access controls** to sustainability data and analytics systems so only authorized users can create, modify, or approve externally reported metrics.
- **Create a digital "sign-off workflow"** where IT, sustainability, and legal all approve sustainability data before it appears in advertising, reports, or AI-generated content.
- **Build automated change alerts** that notify relevant teams if data underlying a public sustainability claim changes (e.g., supplier audit results and updated carbon factors).
- **Set up AI-driven monitoring for public sustainability statements** about your company (press, social media, and campaigns) to detect potential inconsistencies or overstatements before they escalate.

The simple rule is, reported sustainability impacts must be backed up by verifiable facts and auditable data. While there are no universal standards for how ESG data is audited, IT, finance, and sustainability can work together to establish frameworks based on financial standards. Some of the most common are described here:

Standard/Framework	Purpose	Key Application
IFRS S1 & S2 (ISSB Standards 2023)	Global baseline for sustainability disclosures	Defines reporting structure for ESG data, especially climate (S2 aligns with TCFD)
Task Force on Climate-related Financial Disclosures (TCFD)	Climate risk reporting	Framework for climate-related ESG metrics, widely adopted globally
EU CSRD & ESRS	Mandatory ESG disclosure in EU	Set strict rules for ESG data collection and audit
ISO 14064-1	GHG emissions reporting	For carbon data verification and audit trail
IAASB ISAE 3000 & ISSA 5000 (*draft*)	Assurance of non-financial data	Used by external auditors to verify ESG disclosures
COSO **Internal Controls over Sustainability Reporting (ICSR)**	ESG-specific internal controls	Provides a model for governance similar to SOX controls for financial data

Table 15.1 – Frameworks and standards to facilitate auditability of ESG data

We conclude this section on purposeful sustainability leadership with our final case study, focusing on the Inter IKEA Group, the worldwide IKEA franchisor and owner of the "IKEA Concept," and its largest franchisee, which operates the majority of IKEA furniture retail stores. This case study was constructed from public documents and received feedback from Inter IKEA and Ingka Group. It exemplifies the leadership, practices, and challenges for companies that publicly commit to drive sustainability both internally and throughout their value chains. Consider it a reality check as much as it is proof positive that purposeful leaders can drive industrywide change.

Case study: IKEA's sustainability progress and the realities of leading at scale

In the world of global retail, Inter IKEA stands out as a company with the reach and influence to transform entire industries. For decades, it has been seen as a pioneer in sustainability, but its journey is far from linear. Under evolving leadership and shifting strategies, Inter IKEA's story today reflects the tensions of bold ambition meeting operational reality: how to grow a global business while cutting carbon emissions and navigating intense public scrutiny.

Inter IKEA's sustainability vision has long been rooted in the belief that large-scale companies must drive systemic transformation, not just incremental improvement. With its vertically integrated supply chain, franchise model, and iconic brand, Inter IKEA has the leverage to reshape markets for renewable energy, circular materials, and sustainable consumption.

Breakthrough outcomes

See *Figure 15.1* for a timeline of some of Inter IKEA's and its largest franchisee Ingka Group's sustainability programs and achievements. In early 2025, the company made several significant announcements:

- In FY24, Ingka Group, grew its global retail sales by 7%, reflecting strong demand and expansion
- At the same time, Inter IKEA Group reduced its combined climate footprint by 5% year-over-year (21.3 $MtCO_2$, covering value-chain (Scope 1–3) emissions across product use, materials, and operations), and by 28% compared to the FY16 baseline
- Between FY16 and FY24, Ingka grew its business by over 30%, yet cut its absolute **greenhouse gas (GHG)** emissions by nearly a third through a combination of renewable energy investments, sustainable product design, circular business models, and logistics optimization

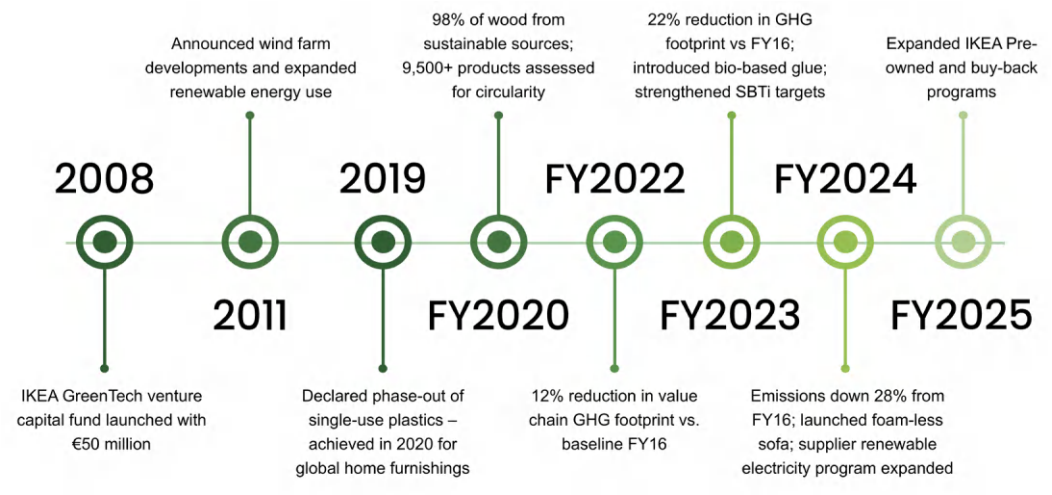


Figure 15.1 – Timeline of significant sustainability announcements and achievements by Inter IKEA and/or its franchisee Ingka Group

The reduction of value chain-wide emissions relies on coordinated action between Ingka Group, other franchisees, suppliers, and customers (Inter IKEA Group 2025).

To make its ambitious climate agenda actionable, Inter IKEA Group began a shift to an **Objectives & Key Results** (**OKR**) framework in FY24. This move ties sustainability outcomes directly to measurable targets and performance management across the organization. Governance has been elevated as well: **Inter IKEA Group's CSO Lena Julle** is part of group management, while a Strategic Sustainability Council, chaired by CEO Jon Abrahamsson Ring, oversees progress and accountability across the franchise system.

Julle was promoted to CSO after leading sustainability for IKEA Sweden. She reports directly to Inter IKEA Group CEO Ring, evidence that sustainability is not a peripheral function.

IT's contributions

Over the past several years, IKEA has invested heavily in modernizing its technology platforms, supply chain analytics, and customer experience systems. These digital investments have strengthened both growth and sustainability performance.

From a business growth perspective, IKEA's digital initiatives have expanded e-commerce, improved personalization, and created seamless online-to-offline experiences, directly contributing to top-line gains. In FY24, 28% of the company's sales were from digital touchpoints.

Today, advanced tools such as 3D design applications, AI-driven demand forecasting, and smart procurement platforms are helping IKEA match production with customer needs more precisely—reducing overstock, markdowns, and waste while boosting customer satisfaction (CDO Magazine 2025). Digital logistics systems are optimizing routing and reducing empty freight miles, directly supporting IKEA's zero-emissions delivery targets. Predictive analytics improve energy management in stores and warehouses, while supply chain traceability tools are increasing visibility into material sourcing—a critical step as new regulations such as the EU Deforestation Regulation demand verifiable proof of origins.

IKEA is a member of the *Partnership on AI*, a consortium of technology companies and non-profits dedicated to AI social sustainability, and has implemented a digital ethics framework and launched an AI literacy program for its workforce (Ingka Newsroom 2024; AI Magazine 2025).

Ambition meets reality

IKEA has achieved notable progress in several areas:

- In 2024, 41.4% of Ingka Group's home deliveries worldwide were completed using zero-emission vehicles, a significant rise from 24.6% in 2023.
- Across the entire IKEA value chain, FY24 emissions were estimated to be 21.3 million tonnes CO_2e in absolute terms, a decrease of 5% from FY23, and 28% lower than the FY16 baseline.
- The share of renewable energy in production of IKEA products climbed to 75% in FY24. This is significant progress toward the goal of halving total IKEA value chain emissions by 2030, and reaching net zero by 2050.
- Ingka Group's circular economy effort has expanded with the launch and build out of its second-hand marketplace, called *IKEA Preowned*, a peer-to-peer platform for buying and selling preowned IKEA furniture. Since 2024, the service has been available in Spain and Norway, and since 2025 in Portugal and Poland. In addition to this, Ingka Group's existing buyback service has processed over 495,000 used products.
- Ingka Group has expanded its social impact initiatives, supporting 81,080 people through emergency response programs. Since 2019. Ingka's *Skills for Employment* program has trained 3,700 refugees in 26 countries. Its goal is to train an additional 3,000 by 2027.

Yet leadership has also required course corrections. Ingka Group originally pledged to make 100% of its deliveries and operational vehicles zero-emission by 2025. In 2024, it revised this target down to 90% by 2028, citing challenges that include insufficient charging infrastructure, regional policy gaps, and the limited availability of electric heavy-duty freight vehicles in some markets (ESG Dive 2025).

This revision was framed as a pragmatic adjustment, but it illustrates the delicate balance between aspiration and credibility. By publicly acknowledging obstacles, Ingka Group signaled its willingness to prioritize transparency over overpromising—an increasingly important trait for companies facing ESG scrutiny.

Setbacks and scrutiny

With its massive global footprint, IKEA is rightfully under the microscope. The same scale that gives it transformational potential also creates vulnerabilities:

- In 2024, Greenpeace investigations alleged that Inter IKEA's supply chain included wood sourced from old-growth and sensitive forests in Romania. Inter IKEA Group ceased working with the Brazilian supplier and no longer sources wood from Siberia or Belarus, and reaffirmed its commitment to 100% responsibly sourced wood (Greenpeace 2024; The Guardian 2025).
- Drone footage and recent documentaries have investigated Ingka's logging activities in Romania, showing clear-cutting in protected forests. IKEA refutes these claims and says it is compliant with laws and certification criteria, but accusers state the company is exploiting loopholes in the law and flaws in the certification process (Euronews 2024).
- Regulatory regimes such as the **EU Deforestation Regulation** (**EUDR**) now require brands such as IKEA to provide verifiable data on the origins of raw materials, putting additional pressure on supply-chain systems.
- As Inter IKEA scales renewable energy procurement and electrification, its progress is closely tracked by non-governmental organizations and investors. Any perceived mismatch between commitments and actual outcomes risks accusations of greenwashing.

Lessons in leadership

The experiences of Inter IKEA and Ingka Group offer valuable lessons for sustainability leadership at scale:

1. **Embed sustainability into core governance**: Placing the CSO within top management and aligning goals through OKRs helps prevent sustainability from becoming siloed or symbolic.

2. **Lead with transparency when adjusting ambitions**: Revising goals, such as the zero-emissions delivery target, can build trust if communicated honestly, acknowledging systemic barriers rather than hiding setbacks.
3. **Balance global vision with local realities**: Inter IKEA's global goals must adapt to varying regulatory, infrastructure, and market conditions across more than 60 countries.
4. **Engage in system change, not just self-change**: By driving renewable energy adoption among suppliers and customers, Inter IKEA is influencing ecosystems beyond its own operations.
5. **Accept that scrutiny is the price of leadership**: Global NGOs, regulators, and consumers expect transparency and accountability—an unavoidable reality for companies that claim sustainability leadership.

The road ahead

Inter IKEA's story today is one of ambitious leadership tempered by realism. The company has proven that a global business can grow while cutting its absolute carbon footprint, but each milestone is hard-won. Every public commitment carries reputational and regulatory risk, and every innovation must work across a sprawling global network. Its journey is a reminder for all of us that sustainability leadership must be tenacious but should not insist on perfection. Instead, the goal is continuous progress, transparent adaptation, and a willingness to confront the messy realities of change.

Bridging strategy to execution: your IT sustainability operating framework

To apply your ESG strategy, you will need a structured operating framework similar to financial or operational excellence programs. This framework has four key stages, and we have covered its elements in earlier chapters. However, we want to use this opportunity to bring it all together (*Figure 15.2*).

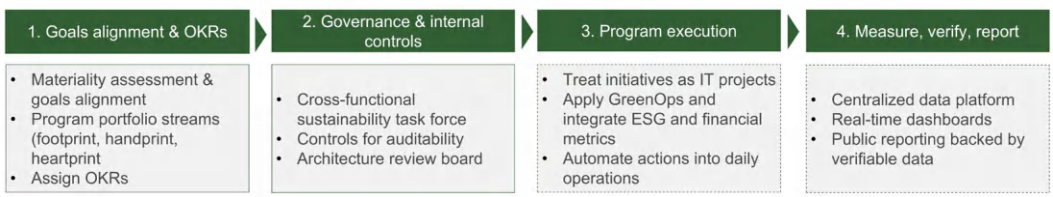


Figure 15.2 – IT sustainability operating framework

1. **Translate strategy into clear portfolios and OKRs**:
    - **Strategic alignment**: Break down enterprise ESG goals into specific, measurable IT objectives, prioritized by materiality assessment
        - **Example**: Reduce Scope 2 emissions by 25% over 3 years through data center modernization and cloud migration
    - **Create three portfolio streams**:
        - **Footprint**: Reduce IT's own environmental and social impact (data centers, hardware, energy)
        - **Handprint**: Use IT solutions to drive enterprise-wide sustainability (AI-driven energy optimization, digital twins)
        - **Heartprint**: Ensure IT decisions reflect social responsibility (digital inclusion, ethical AI)
    - Assign OKRs to each stream to enable accountability
2. **Build governance and internal controls**:
    - Create a cross-functional ESG task force. Include IT, sustainability, finance, procurement, and compliance to oversee execution
    - Apply COSO **Internal Controls for Sustainability Reporting (ICSR)** to create auditable ESG processes—mirroring financial reporting discipline (*Table 15.1*)
    - Design a decision "front door" where enterprise architects review all new IT initiatives for ESG alignment before approval
3. **Execute through programs and GreenOps**:
    - Treat sustainability like a portfolio of IT programs (this approach works for starting out; eventually, sustainability will be embedded in ongoing IT processes rather than program-specific):
        - Data center decarbonization
        - Application rationalization
        - Hardware circularity initiatives
        - AI governance rollouts

- Adopt GreenOps, integrating environmental metrics into DevOps and FinOps so sustainability is continuously managed alongside cost and performance
- Leverage automation and AI to embed sustainability in day-to-day IT operations, such as dynamic workload shifting to low-carbon data centers

4. **Measure, verify, and report progress**:
    - Centralize ESG data in an audit-ready platform, combining IT operational data with financial metrics
    - Build real-time dashboards for IT teams and business leaders, showing progress against OKRs and regulatory requirements
    - Public reporting should be supported by auditable evidence to mitigate green-washing risk

Now, let us spend a little time considering just how far you can go as a sustainability driver—that is, how you will build a sustainability ecosystem that scales impact to an industry level.

Scaling your impact

No single organization—not even IKEA, one of the world's largest retailers—can solve today's global sustainability challenges on its own. Since this book's first edition was published in 2022, it has become even clearer that technology is both the driver and enabler of transformation, but it must be applied beyond the boundaries of a single enterprise.

To meet 2030 climate targets and comply with evolving regulatory demands such as the EU CSRD, and EU AI Act, companies must collaborate across upstream suppliers, downstream distributors, and even competitors to create shared digital ecosystems. These ecosystems allow companies to align on data, standards, and platforms, generating the scale and speed needed to reduce environmental and social risks across global value chains.

Today, digital technologies have matured into critical tools for aligning entire industries—from steelmaking to shipping, from retail to agriculture. When deployed intentionally, they create shared visibility, enable radical transparency, and unlock innovative, scalable solutions to our most urgent sustainability challenges.

Yet even with this progress, translating ecosystem strategies into measurable action requires companies to focus on four critical imperatives in 2026 and beyond:

1. **Establish robust standards, certifications, and skills for sustainable technology**: The **Green Software Foundation (GSF)**, launched by Accenture, Microsoft, GitHub, and ThoughtWorks, has expanded its reach to thousands of members and published widely adopted green software standards, including the ISO certified Software Carbon Intensity metric (Accenture 2021). More than 100 member companies and supporters in Europe, the Americas, and beyond have signed up with SustainableIT.org, which published a global set of IT ESG and RAI leadership principles and action plans. These resources can guide your team in reducing the energy, water, and carbon intensity of software systems—from cloud workloads to AI models.

   But the skills gap remains a barrier. Too few organizations have software engineers trained in sustainable coding practices, activity-based carbon accounting, or GreenOps methodologies. Too few enterprise architects understand how RAI principles translate into design patterns, which SustainableArchitectures.org is now developing. You must now prioritize training and certification programs, ensuring your teams can design technology that not only enables sustainability outcomes but is sustainable by design.

   This is particularly urgent as the ICT sector's energy footprint grows due to AI, with hyperscale data centers and LLM training runs consuming unprecedented electricity and water. Without enforceable design standards, the emissions generated by digital technology could undermine progress in every other industry.

2. **Balance the need for open, secure data sharing with sovereignty requirements**: Regulatory and business pressures have converged to push data transparency from an aspiration to a necessity:

   - The EU CSRD now mandates public-interest companies with more than 500 employees that are already subject to the Non-Financial Reporting Directive to disclose Scope 3 emissions, forcing organizations to exchange accurate, auditable data with suppliers and customers. More types of companies will face required reporting in the years ahead. **Digital Product Passports (DPPs)** mandated under EU law are driving a revolution in traceability, from textiles to food. ICT equipment will have DPPs phased in from 2027 to 2029.

- The UN Global Digital Compact, enacted in 2024, calls for advancing responsible and equitable international data governance, including facilitating cross-border data flows with trust to avoid the fragmentation of the internet and promote an open digital space.

Without shared, interoperable data systems, companies will struggle to comply with disclosure rules or optimize sustainability performance. Architecting this interoperability is challenging enough on a global scale, but the trend of **AI sovereignty** is adding to the complexity. As noted in *Chapter 14*, *Putting a Sustainable IT Strategy in Place*, governments are expected to impose localization requirements on many aspects of AI systems (LLMs and cloud datasets, data processing, and storage).

Organizations that combine sovereignty-aware technology and data architectures with sustainable AI governance will be best positioned to deliver compliant, energy-efficient, and socially responsible AI while scaling sustainability impact.

3. **Harness AI and emerging tech to drive last-mile impact**: Between 2022 and 2026, AI adoption has broadened and accelerated dramatically, reshaping how sustainability goals are delivered. Companies are now using agentic AI systems to do the following:

    - Predict and prevent waste in supply chains by dynamically matching production with real-time demand
    - Monitor and enforce ESG compliance across global supplier networks
    - Accelerate circular economy models, such as automated reverse logistics and intelligent sorting of returned goods for reuse or recycling

    For example, IKEA's AI-driven logistics systems now optimize truck routing, cutting both costs and emissions, while generative design tools help create circular, low-carbon products with fewer prototypes and less material waste. However, a critical challenge for IKEA—and for the entire retail and manufacturing sector—is closing the loop on materials to create a truly circular economy. Even as companies design more circular products and build take-back programs, the "last mile" can falter without an efficient, trusted way to match excess or waste materials with new, high-value uses across industries and consumers. This is where a company such as **Excess Materials Exchange** (**EME**) plays a pivotal role.

Founded in 2017, EME operates like a "dating site" for materials, using advanced AI and blockchain-based traceability to match companies that have excess materials with those that can reuse them at scale. For EME customers such as Sodexo, ABB, and Prorail, this means that surplus materials, food, plastics, or packaging from operations can be traced, verified, and redirected to other industries instead of becoming waste or incineration feedstock.

This data-driven transparency will also enable companies selling into the EU to meet DPP requirements, which will demand verifiable information on material content and environmental impact. By integrating EME or other platforms into their supply chains, companies gain granular insight into where their materials flow after use, providing proof for regulators, investors, and customers that products are part of a closed-loop system. EME's model demonstrates that circularity at scale requires digital infrastructure, just as much as physical logistics.

4. **Make technology itself sustainable**: Perhaps the most significant shift since 2022 is the widespread recognition in and outside of ICT that technology is not inherently green or equitable. While digital solutions can enable emissions reductions and efficiency gains across industries, the ICT sector's own footprint and social impact have been growing rapidly. This book has given you a robust understanding of those impacts and the strategies that can drive lasting change for your technology products, services, and infrastructure lifecycles.

   The years since 2022 have shown that technology and sustainability are no longer separate agendas—nor are environmental and social impacts. CIOs, CTOs, and chief enterprise architects now sit at the nexus of business growth, regulatory compliance, social responsibility, and climate action.

By 2030, the companies that thrive will be those whose digital ecosystems are open, standards-based, and sustainability-driven, serving progress, planet, and people. This future demands courageous leadership, cross-industry collaboration, and a relentless focus on making technology both the engine of sustainability and a sustainable system in its own right.

You are no longer merely the leader of IT systems—you are now architects of the sustainable enterprise, responsible for shaping a digital future that is green, just, and inclusive.

Recommendations recap: bringing everything together

We've covered a lot of ground since *Chapter 1*, *Our Most Significant Challenge Ahead*, and approached the goal of IT sustainability from many angles. We think it will be helpful to use the remainder of this final chapter to review and bring together the key recommendations and figures. If you have binge-read the book and it is fresh in your mind, skip ahead to the chapter's *Summary* section.

Chapter 1, *Our Most Significant Challenge Ahead*, went into the basics of climate change and the breadth and depth that digitalization and hyperconnectivity have on society.

Chapter 2, *Rise of Sustainable IT*, focused on the main drivers of a sustainable IT agenda and the importance of implementing sustainable IT into the overall corporate sustainability agenda. We defined sustainable IT and examples to differentiate between sustainability in IT, sustainability by IT, and IT for society. We also noted the rise of sustainable IT peer groups and associations dedicated to advancing the cause. To put everything into context, we introduced the sustainable IT reference model to enable you to understand how the different building blocks fit together:

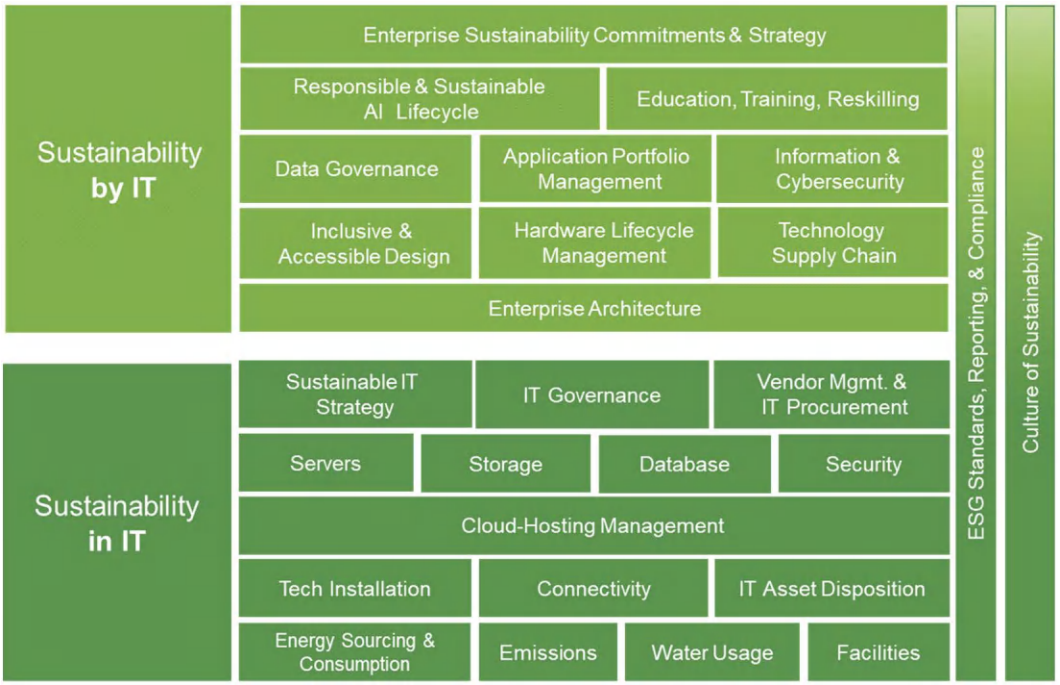


Figure 15.3 – Sustainable IT reference model

Finally, we looked at drivers for a sustainable IT agenda and ESG considerations for IT, such as financial value, non-financial value, risks, employees, and readiness. We reviewed studies that quantified the impact of sustainability investment on shareholder return. We also got our first view of what a sustainable IT organization looks like with SustainableIT.org's Venn diagram of 12 key characteristics across the ESG pillars:

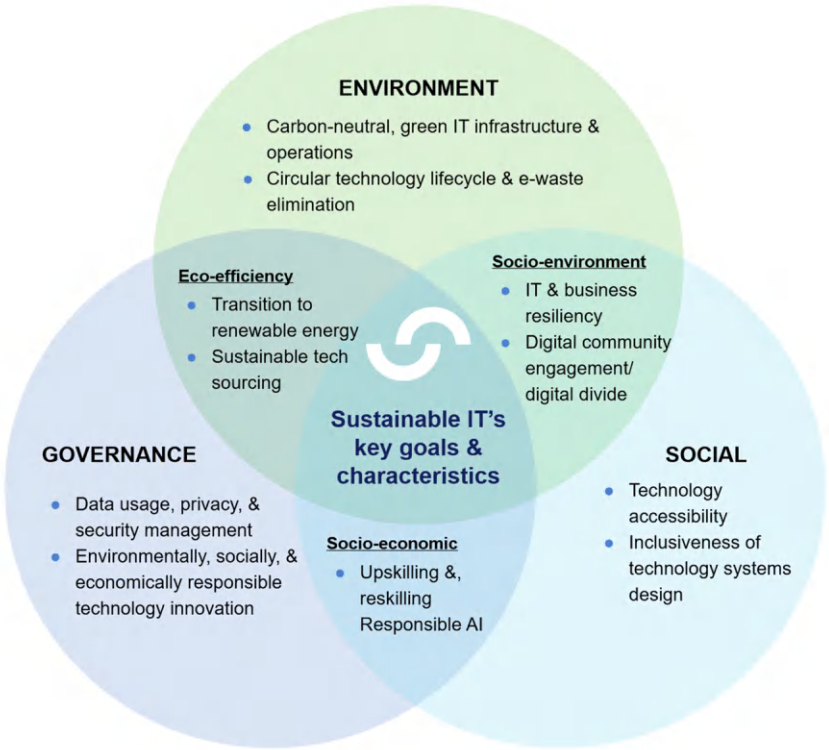


Figure 15.4 – Essential characteristics of a sustainable IT function (source: SustainableIT.org)

Chapter 3, *The Fundamental Building Blocks of a Sustainable IT Practice*, introduced the critical components of sustainable IT, setting the stage for the more detailed chapters that follow. We emphasized the need to win the hearts and minds of IT staff and key business peers. Measurement also emerged for the first time as a continuing theme that saw the progression of spend-based estimates of IT impact to activity-based lifecycle assessments, which provide actionable insights across the tech lifecycle.

The chapter also previewed critical areas of focus that would be covered in *Part 2* of the book, including responsible AI governance, social sustainability, IT infrastructure management, and sustainable tech sourcing.

Chapter 4, *Responsible and Sustainable AI Governance*, explored how the rapid rise of generative and agentic AI has intensified the urgency for responsible and sustainable governance. We learned that AI brings unprecedented opportunities but also serious risks across environmental, social, and ethical dimensions. Unchecked, AI workloads can accelerate climate degradation, widen social inequities, and erode trust. Through case studies, principles, step-by-step guidance, frameworks, and award-winning best practices, we provided a foundation for responsible AI lifecycle management with measurable accountability (*Figure 15.5*).

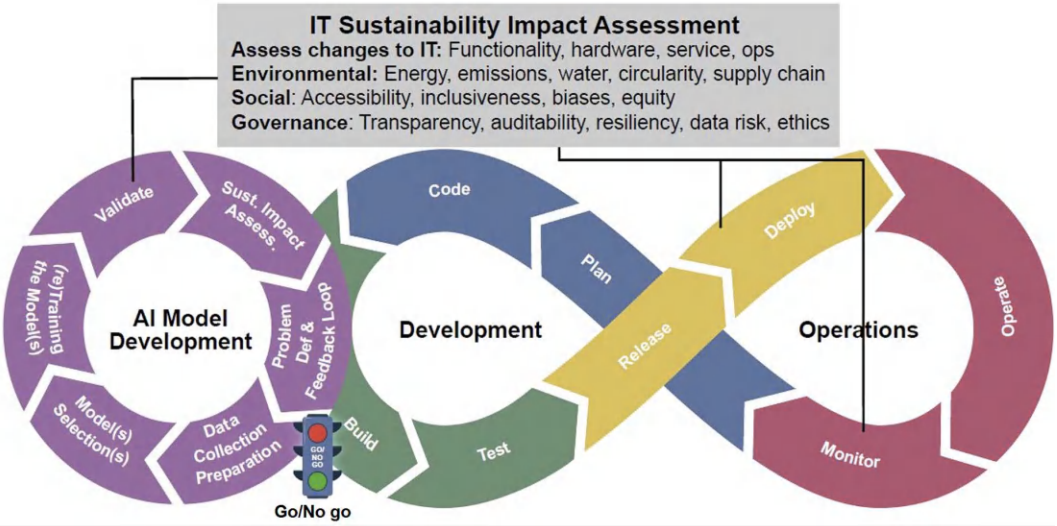


Figure 15.5 – Sustainability impact assessment applied to AI governance lifecycle (source: SustainableIT.org)

The following are the key recommendations from *Chapter 4*:

- Adopt SustainableIT.org's nine principles for responsible and sustainable AI lifecycle governance
- Build lifecycle governance frameworks with defined checkpoints for ethics, sustainability, and compliance
- Measure and mitigate AI's environmental impact using metrics such as energy use, water consumption, and carbon footprint
- Require transparency and continuous monitoring for both internal and vendor-supplied AI models
- Invest in AI literacy and workforce retraining to align innovation with human-first principles

- Prioritize smaller, fit-for-purpose models to reduce emissions and hardware churn
- Treat agentic AI with structured onboarding and oversight, as with human team members
- Embed responsible AI criteria into ESG reporting and regulatory compliance processes

Chapter 4 also showed that responsible AI governance is not a constraint on innovation, but rather the key to scaling AI safely, sustainably, and ethically—turning risk into long-term business and societal value.

Chapter 5, *Social Sustainability: Accessibility, AI, and the Digital Divide*, described how we can play a critical role in advancing social sustainability—ensuring that technology is accessible, inclusive, equitable, and protective of human rights. We learned that AI is the latest in a long line of transformative technologies with profound social implications, including the potential of displaced workers, amplified bias, a wider digital divide, and undermined trust. Conversely, when governed responsibly, AI has the power to increase access, promote fairness, and improve quality of life. We showed how to build inclusivity into the development lifecycle:

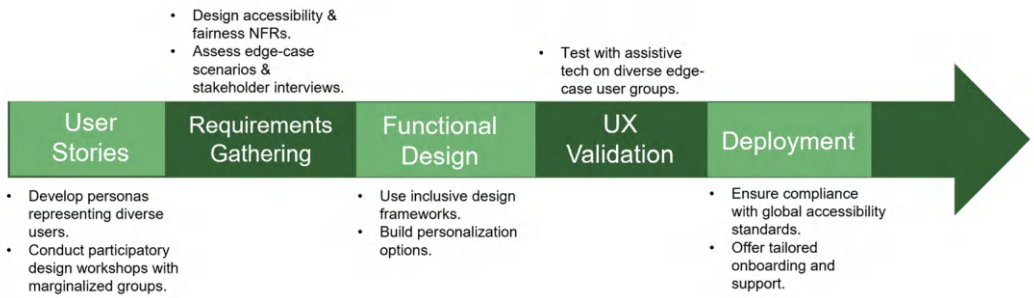


Figure 15.6 – IT must build inclusivity into upstream design stages

We learned from examples how IT asset disposition programs can extend the life of hardware while providing devices and connectivity to underserved communities. These programs demonstrate how IT can reduce e-waste while empowering people with access to education, jobs, and services.

The following are the key recommendations from *Chapter 5*:

- Assess all systems for accessibility, embedding inclusivity into early design stages
- Implement AI literacy programs tailored to different roles and responsibilities
- Evaluate AI systems for social risks such as workforce disruption, bias, and exclusion
- Donate or refurbish end-of-life IT assets to bridge the digital divide
- Require vendors to meet clear social sustainability criteria in procurement processes

- Track and report social metrics such as accessibility adoption, community engagement, and vendor compliance

This chapter showed us that IT has a unique responsibility and opportunity to shape a more equitable digital future. By embedding social sustainability into systems, policies, and partnerships, IT leaders can ensure that technology benefits not only their enterprises but society as a whole.

Chapter 6, *Data Centers and the Cloud*, introduced the complexities of managing data centers for sustainability, including the dual challenges of energy and water use. The chapter explored how the rise of AI workloads has intensified cooling demands, stressing water resources. We examined critical factors such as the location of a data center's workloads, which can generate more than 30 times higher emissions depending on where they are run.

With the industry shift to the cloud, the chapter highlighted that migrating workloads to hyperscalers can deliver substantial sustainability gains compared to legacy on-premises infrastructure. However, overall emissions from the cloud are rising due to the sheer scale of AI infrastructure. We explained the difficulty of measuring Scope 3 emissions from cloud services and how to close the data gaps. We also learned how to apply GreenOps to manage our data center and cloud footprints.

The following are the key recommendations from *Chapter 6*:

- Select data center operations and facilities that have demonstrable sustainability practices
- Measure and track **Power Usage Effectiveness (PUE)** and **Water Usage Effectiveness (WUE)** to identify opportunities for improving energy and water efficiency
- Factor local energy mix and water availability into decisions about where to site data centers
- Use AI to optimize data center utilization
- Press cloud providers for greater transparency and comparable Scope 3 emissions reporting
- Integrate GreenOps with FinOps to manage both costs and environmental impact
- Continuously rationalize and right-size workloads to reduce unnecessary energy use and embodied carbon
- Evaluate advanced cooling methods, such as liquid cooling, to reduce water stress
- Include environmental criteria in all vendor procurement and cloud governance decisions
- Build systems to capture auditable emissions data in preparation for ESG reporting requirements
- Assess the possibility of applying heat recovery solutions to repurpose excess energy for community or industrial use

The chapter deepened our understanding of the environmental challenges and opportunities inherent in managing both data centers and cloud platforms, offering practical steps to decouple digital growth from carbon emissions.

Chapter 7, *Applications and Architecture*, examined how enterprise architecture and sustainable application design serve as critical levers for advancing an organization's sustainability goals. We learned that the modern enterprise relies on thousands of applications, many of which were created during periods of rapid digital transformation with little focus on reusability, efficiency, or environmental impact. This complexity drives up costs, energy consumption, and emissions. Application rationalization emerged as a powerful sustainability strategy; by streamlining the application estate, we can reduce redundancy, improve agility, and unlock dramatic emissions reductions.

We saw that **enterprise architecture (EA)** is still at an early maturity level when it comes to sustainability, and that, without EA at the "front door" of technology decisions, organizations risk deploying fragmented, inefficient, and even non-compliant solutions. By contrast, when EA is empowered, it provides a unifying view of business, technology, and ESG strategy—helping to define green design standards, embed sustainability and responsible AI principles (*Figure 15.7*), and trace architecture decisions to sustainability outcomes.

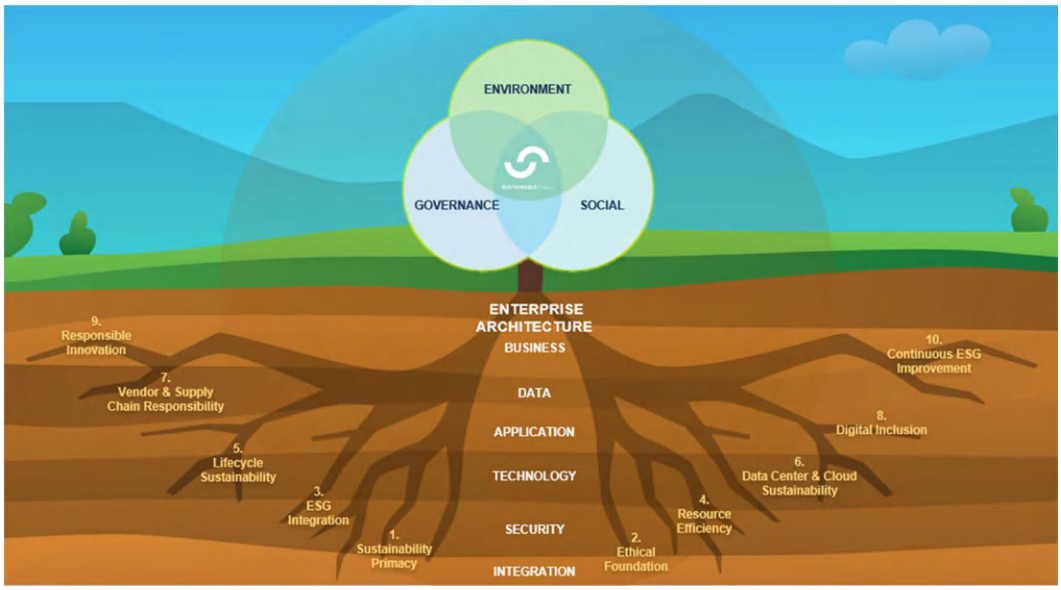


Figure 15.7 – Sustainable architecture principles (source: SustainableIT.org)

Finally, we turned to sustainable software development, where practices such as choosing energy-efficient programming languages, optimizing algorithms, and shutting down idle systems can significantly reduce emissions at the code level.

These are the recommendations from *Chapter 7*:

- Use application portfolio management and rationalization to simplify the application estate, reduce emissions, and cut costs
- Incorporate sustainability metrics such as carbon intensity and embodied carbon into architecture reviews
- Promote sustainable software development, including efficient coding practices and low-carbon programming languages
- Build dashboards and scorecards to track ESG performance across the application lifecycle and report progress to leadership
- Utilize or shift your application portfolio to providers while utilizing low-carbon grids
- Treat technical debt as an ESG liability, not just a financial one, making modernization a pathway to measurable sustainability gains
- Empower EA to design and enforce ESG-aligned application design standards and responsible AI practices
- Utilize or shift to energy-efficient application architectures such as serverless computing

Chapter 7 showed us that application rationalization is a jump-start for environmental sustainability, and architecture must build the foundation for ethical, efficient, and future-ready digital enterprises.

Chapter 8, Data, presented the urgent sustainability challenges posed by exponential data growth and the escalating environmental cost of creating, storing, and managing data. We reviewed practices for minimizing impacts, including virtualization and automation, data minimization, tiered storage, ephemerality, and edge computing. Applying these principles can reduce an organization's environmental footprint while improving operational efficiency.

A central theme of the chapter was AI data governance, as AI now drives much of today's data generation and usage. We explored the five *responsible AI data governance principles* and saw how they can be applied to reduce environmental impacts, avoid bias, strengthen compliance, and build stakeholder trust.

The chapter also described how to manage sustainability data for the enterprise. We learned how IT can deliver enormous value by centralizing ESG and operational data into unified, audit-ready platforms. These platforms support near-real-time decision-making and provide visibility for regulatory compliance.

These are the recommendations from *Chapter 8*:

- Treat data privacy and security as foundational ESG pillars supporting trust and compliance
- Apply data minimization practices to reduce dark data and unnecessary storage growth
- Integrate sustainability KPIs into data engineering and governance processes to incentivize responsible behavior
- Operationalize the five responsible AI data governance principles to ensure ethical, efficient, and environmentally sound AI data practices
- Consolidate ESG and IT operations data into a single centralized platform for real-time visibility and audit readiness
- Begin with small, high-value data projects to demonstrate impact and secure leadership support before scaling
- Use dashboards and gamification to engage teams and create accountability for emissions reduction and efficiency gains

This chapter taught us that data itself is both a challenge and a solution. By governing data with the same rigor applied to financial and operational systems, IT leaders can turn data from a hidden source of emissions into a driver of sustainability progress and business value.

In *Chapter 9*, *IT Hardware Management*, we learned how IT hardware management plays a pivotal role in reducing environmental impact, controlling costs, and driving social responsibility. We examined the impact of transitioning from a linear economy, where resources are "take, make, dispose," to a circular economy, which keeps materials in use through reuse, repair, and regeneration. By embracing circular principles, accurate measurement, and socially responsible sourcing, IT leaders can turn hardware from a hidden liability into a cornerstone of sustainable transformation.

We learned how hardware product **life cycle assessment (LCA)** and **product carbon footprint (PCF)** methodologies quantify environmental impacts across manufacturing, logistics, usage, and end-of-life phases, and how to use these in a report card to inform product selection and hardware refresh cycles:

Description	Metric	General Requirement	United Nations Sustainable Development Goals Alignment
Equipment Lifetime	**Years**	**Equipment Lifetime** **Years**	12. Responsible Consumption & Production 13. Climate Action
Renewable Energy	**%**	**REF** Renewable Energy Factor	9. Industry, Innovation & Infrastructure 12. Responsible Consumption & Production
Circular Economy Reuse and Repair	**%**	**Reuse and Repair** % equipment reused	12. Responsible Consumption & Production 13. Climate Action
Zero Waste to Landfill	**WUE**	**Recycle** % equipment reused	12. Responsible Consumption & Production 13. Climate Action
Hazardous Substances	**%**	**Hazardous Substances** % equipment with hazardous substances	12. Responsible Consumption & Production 13. Climate Action

Figure 15.8 – Sustainable IT hardware scorecard

These are the recommendations from *Chapter 9*:

- Engage your employees by raising awareness of device carbon footprint and enabling them to make conscious, sustainable choices to reduce carbon costs
- Apply LCA and PCF methodologies to measure and compare hardware emissions across vendors and categories
- Demand ENERGY STAR, EPEAT, and TCO Certified labeled IT hardware to reduce both operational cost and carbon emissions
- Explore opportunities to buy refurbished IT equipment to save on carbon and costs
- Extend product lifespans through refresh cycle policy, warranties, modular designs, and repair programs

- Incorporate circular economy strategies using the 9R framework, prioritizing early-stage actions such as refusing and rethinking purchases
- Prepare for upcoming EU rules by integrating DPPs and repairability scores into procurement and asset management systems
- Partner with certified **IT asset disposition (ITAD)** vendors to securely manage end-of-life hardware, ensuring data protection and ESG impact reporting
- Include social criteria, such as fair labor and supply chain transparency, in hardware procurement and vendor scorecards
- Explore virtual desktop infrastructure and Device-as-a-Service to save on IT hardware and transfer the workload from client-side to server-side
- Use AI tools to automate reverse logistics, predictive maintenance, and recycling optimization
- Track e-waste metrics and report them alongside carbon and energy KPIs to comply with evolving disclosure frameworks
- Treat hardware lifecycle policies as both financial and environmental levers, reducing costs while cutting emissions
- Engage cross-functional teams—including IT, procurement, and sustainability—to align hardware decisions with enterprise ESG goals

This chapter reinforced that managing the full lifecycle of IT hardware is a strategic imperative. By applying the tools and practices learned here, organizations can decouple digital growth from environmental degradation while fostering equity and resilience.

Chapter 10, *Energy Resource Management*, focused on applying energy management within IT to reduce greenhouse gas emissions and operational costs while increasing competitiveness. We saw how geopolitical factors, such as the war in Ukraine and resulting sanctions on Russian energy exports, heightened the stakes for energy security and underscored the role of energy policy in shaping ICT strategies. We explored practical tools to calculate the energy use and emissions of IT hardware, from laptops and desktops to enterprise servers.

The following are the key recommendations from *Chapter 10*:

- Track energy data and convert it to emissions metrics to inform sustainability reporting
- Use smart technologies to monitor and manage energy consumption at scale
- Buy resource-efficient, certified hardware to reduce baseline energy demand
- Replace desktops with laptops or virtual desktop solutions to improve efficiency

- Leverage renewable or low-carbon energy sources for offices and data centers wherever possible
- Educate employees to reduce energy leakage by turning off devices when not in use
- Enforce power management settings centrally, including sleep and hibernation modes

By acting on these lessons, organizations can reduce Scope 2 emissions, improve resilience, and play a decisive role in the global energy transition. Remember, the greenest and cheapest energy is the energy we do not use.

Chapter 11, *Leveraging Your Buying Power*, described how organizations can leverage their purchasing power to influence their IT supply chains and drive measurable environmental and social progress. We learned that the IT supply chain is extraordinarily complex, spanning raw material extraction, manufacturing, distribution, and service delivery. Without sustainable procurement practices, this complexity introduces risks such as child labor, hazardous working conditions, excessive emissions, and reputational harm.

We reviewed five essential IT sustainability requirement categories for procurement: corporate commitments, environmental practices, social responsibility, product and service longevity, and circularity. We saw an example of how to build sustainability into vendor master services agreements. We learned of companies working with partners to rate suppliers and begin quantifying the carbon footprint of AI. Other examples illustrated how buyers can educate and incentivize vendors to innovate collaboratively rather than comply grudgingly.

Finally, we explored sustainable vendor management, learning to track not only a vendor's environmental footprint but also their "handprint" (positive impact of products and services) and "heartprint" (social good enabled by technology).

The following are the key recommendations from *Chapter 11*:

- Make your purpose and intentions clear with your vendors. Find common ground with your vendors to make a joint ESG impact.
- Use third-party certifications to simplify sustainable procurement and verification.
- Include clear ESG criteria in **requests for proposals (RFPs)**.
- Buy repairable products, influencing vendors to design for sustainability.
- Challenge vendors on Scope 3 emissions and insist on measurable, comparable data.
- Prioritize circularity by requiring extended warranties, take-back clauses, and refurbished equipment options.

- Collaborate with vendors through education, awards, and shared goals to foster innovation.
- Track supplier performance using sustainability scorecards covering footprint, handprint, and heartprint.

When organizations act collectively and transparently, they can transform the IT industry from a source of risk into a force for sustainable change.

Chapter 12, *Sustainability by IT*, saw us shift our focus from making IT itself sustainable to learning how IT can enable sustainability across the enterprise and beyond. We highlighted 10 essential use cases for leveraging IT to reduce environmental impact:



Figure 15.9 – Use cases for sustainability by IT

The chapter introduced circular economy principles, showing how IT can shift industries from ownership to usership through subscription-based models.

We also examined how IT empowers citizen-driven innovation through hackathon events, underscoring the need for innovation outside of organizational silos, combining citizens, companies, and governments.

The following are the key recommendations from *Chapter 12*:

- Map your organization's opportunities across the 10 sustainability-by-IT use cases to prioritize impact
- Deploy ESG and carbon data platforms to meet new reporting mandates and build trust
- Explore circular subscription models where IT enables product longevity and waste reduction

- Foster innovation through hackathons and cross-sector collaborations linked to the UN **Sustainable Development Goals (SDGs)**s
- Integrate IT systems to connect supply chains, operations, and customer experiences for sustainability
- Treat sustainability as a core driver of digital transformation, not a parallel initiative

This chapter taught us that IT is not only a consumer of resources but a catalyst for sustainable change, capable of reshaping business models, empowering innovation, and delivering measurable environmental and social outcomes.

Chapter 13, *Get Started Today*, marked the first chapter in *Part 3* of this book, where we sought to apply what we learned from *Part 2*. We learned how to take the first steps in building a sustainable IT program, including goal setting, starter strategies, year 1–3 action recommendations, and the creation of a GHG emissions baseline. The chapter emphasized that while early actions may not yield dramatic immediate reductions, they are essential for creating credibility, alignment, and momentum.

The chapter introduced the Sustainable IT Maturity Model©, which provides a framework to assess the strength of 11 essential IT capabilities across people, process, and technology. With associated KPIs, IT organizations can set improvement targets and track organizational progress.

We received advice from our peers, the chief sustainability officers, and learned what they most need from IT to succeed in their roles. Further, we considered the priorities of the CFO and strategies for building their commitment to sustainability investment.

Finally, we learned how to establish an accurate IT GHG emissions baseline, focusing on reduction potential in four key areas: data centers and cloud, IT hardware, energy management, and IT asset disposition (*Figure 15.10*). We provided practical formulas and downloadable tools to calculate current impacts and simulate future states under different scenarios, such as shifting workloads to hyperscaler clouds or extending hardware lifecycles. The model's objective was not to give you an exact figure for your baseline but to illustrate your action areas toward net zero.

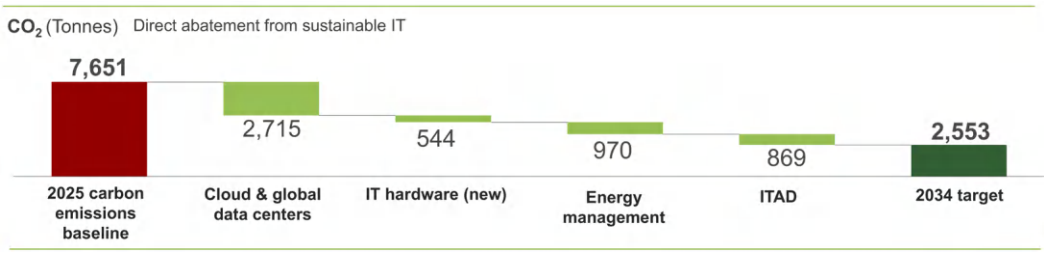


Figure 15.10 – Ten-year carbon emissions waterfall summary

These are the recommendations from *Chapter 13*:

- Start with clear, IT sustainability goals linked to enterprise ESG targets
- Build cross-functional teams and secure visible executive sponsorship early
- Focus first-year efforts on baseline assessment, early wins, and measurement systems
- Use the Sustainable IT Maturity Model© to identify capability gaps and set target states
- Partner with your CSO peers in sustainability to integrate agendas, co-own strategy, and build business cases
- Establish a robust emissions baseline to guide decisions and track long-term progress

Chapter 13 made it clear that sustainable IT begins with small, deliberate steps—laying a foundation of goals, data, and collaboration that will enable larger, systemic transformation in the years ahead.

Chapter 14, *Putting a Sustainable IT Strategy in Place*, showed us how to move from foundational steps to building a complete IT sustainability strategy and roadmap. We explored a structured planning process that helps IT leaders align their efforts with enterprise ESG goals while addressing external pressures such as regulations, supply chain risks, and stakeholder expectations.

The chapter began by introducing the sustainable IT strategy framework, which combines inputs from both external and internal environments to shape our three core workstreams:

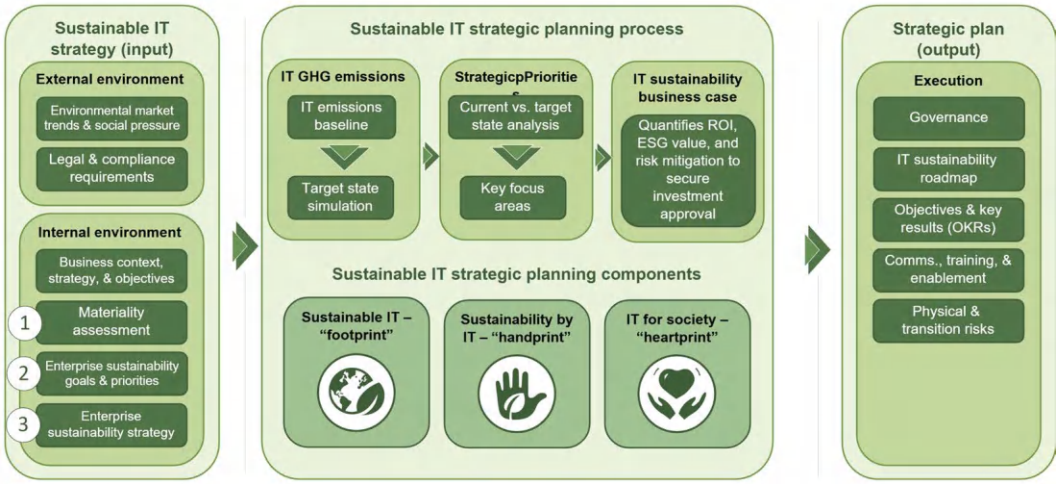


Figure 15.11 – Sustainable IT strategy framework

Real-world case studies demonstrated how leading organizations are putting strategy into action. The chapter also explored the disruptive role of AI in sustainability strategy and practical steps for integrating AI into each workstream.

Building on these examples, our step-by-step creation of a sustainable IT strategy began with a materiality assessment, progressed to a sustainable IT value proposition, and culminated in an IT strategy on a page:

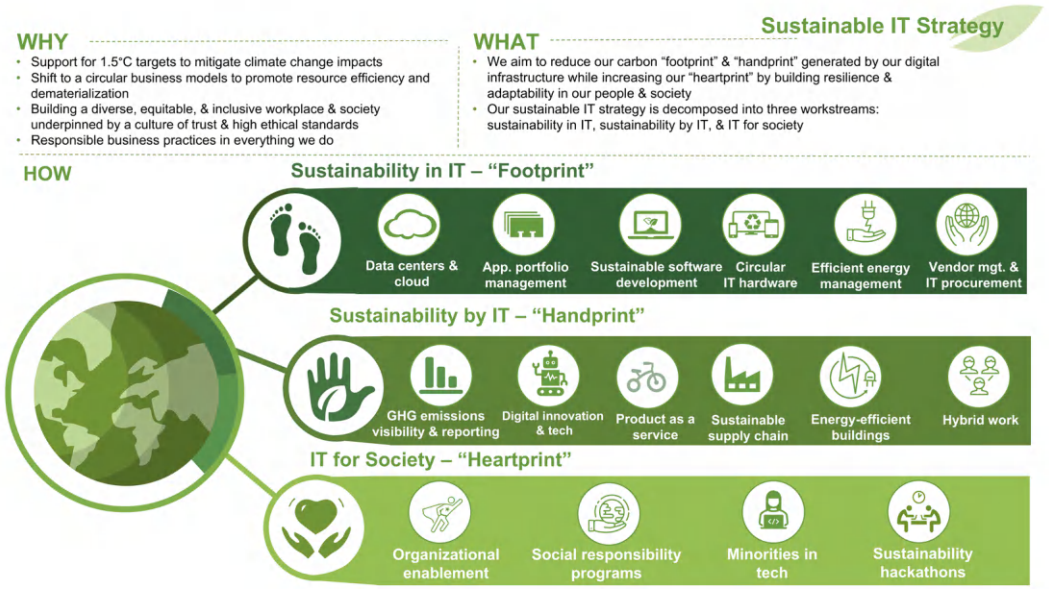


Figure 15.12 – IT strategy on a page

Finally, we translated the strategy into short-, mid-, and long-term roadmaps, ensuring that initiatives were prioritized and sequenced for maximum impact.

These are the recommendations from *Chapter 14*:

- Learn from others' experience through peer associations and educational organizations such as the GSF, SustainableIT.org, and SustainableArchitectures.org
- Start with a clear materiality assessment to align IT with enterprise ESG priorities
- Build a strategy around the three workstreams: footprint, handprint, and heartprint
- Integrate AI as both a sustainability enabler and risk factor, with ESG checkpoints and carbon-aware governance
- Translate strategy into actionable roadmaps with measurable OKRs and accountability mechanisms

- Tie ESG goals to financial performance by linking green IT initiatives to efficiency gains, cost savings, and profitability targets
- Continuously adapt and iterate on the strategy, recognizing that AI, regulations, and environmental challenges will continue to evolve

Summary

By now, you have seen that creating a responsible and sustainable IT enterprise requires courage, persistence, and a willingness to rethink not only how we manage technology, but how technology shapes the world around us. Throughout your journey, data-driven insights paired with personal experience will be your greatest allies. Use your emissions baseline, social impact metrics, and materiality assessments to identify where your organization can make the most meaningful and lasting impact. Trust your change-management instincts and relationship-building skills—this transformation, like every other, is about people. Be open about both your progress and your roadblocks (of which there will be many) and communicate regularly with your team, your enterprise, and your external stakeholders. Sustainability is everyone's job, and transparency builds trust, inspires action, and accelerates collective learning.

As authors, this last point is our driving motivation—for Niklas in writing the original 2022 edition of this book, and for Richard in expanding and updating it for 2026. We believe in the power of peers and in your unfailing willingness to help one another. We've seen it time and again throughout our careers: from the infrastructure shift of mainframes to client-server, to the revolution of the internet, e-commerce, and personalization. We saw it in the migration to cloud, in IT's role sustaining enterprise work during the COVID-19 pandemic, and in the unyielding defense against escalating cyber risk. And we see it again today, in the more than 70 individual practitioners and experts who freely contributed their sustainability stories and lessons learned for this book—joining in our shared goal of providing you with a roadmap for action.

What makes this moment unlike any before is the dramatic and exponential rise of artificial intelligence. Unlike the revolutions of the past, AI is not confined to enterprise systems—it is permeating how we live, work, learn, create, and even how we define knowledge itself. AI is already transforming supply chains, product design, and customer engagement, while simultaneously challenging our notions of equity, transparency, and trust. Its potential to accelerate discovery and scale solutions for climate action and social impact is immense. Yet its unchecked energy demands and embedded biases could just as easily deepen divides and strain the very systems we seek to sustain. For technology leaders, sustainability and AI governance are an inseparable duality. How we design, deploy, and steward AI will define not only the future of IT but the trajectory of humanity's progress.

Now, it is you and your business peers facing the latest transformational challenge of fast-tracking responsible AI governance while laying the foundation for our existential mission of sustainability. You will lead IT organizations that not only power business growth, but also safeguard our planet, protect our communities, and create innovations that lift everyone. We wish you clarity in direction, speed in action, and visible wins that lead to lasting change.

Bibliography

- Accenture. 2021. *Accenture, GitHub, Microsoft, and ThoughtWorks Launch the Green Software Foundation with the Linux Foundation to Put Sustainability at the Core of Software Engineering*. May 25. https://tinyurl.com/2a2nu5eh.
- AI Magazine. 2025. *IKEA Parent Deploys AI in €41.8bn Sustainability Push.* https://aimagazine.com/articles/what-does-ingka-annual-report-say-about-ikea-sustainability.
- Bain. 2025. *How Sustainability Is Creating B2B Growth*. https://www.bain.com/insights/how-sustainability-is-creating-b2b-growth-ceo-sustainability-guide-2025/#:~:text=Revenue%20growth%20leaders%20prioritize%20selling,1.
- CDO Magazine. 2025. *What IKEA's Digital Chief Learned From Leading the Legacy Retail Icon Into the AI Era.* https://www.cdomagazine.tech/digital-transformation/what-ikeas-digital-chief-learned-from-leading-the-legacy-retail-icon-into-the-ai-era.
- ESG Dive. 2025. *Ikea revises zero emission delivery goal, lowers ambition.* https://www.esgdive.com/news/ikea-revises-zero-emission-delivery-goal-lowers-ambition/741023/.
- Euronews. 2024. *IKEA in the spotlight: Flatpack furniture linked to 'systematic destruction' of Romanian forests.* https://www.euronews.com/green/2024/06/09/ikea-in-the-spotlight-flatpack-furniture-linked-to-systematic-destruction-of-romanian-fore.
- Greenpeace. 2024. *Nature Crime Files – Romania.* https://www.greenpeace.org/international/publication/66321/nature-crime-files-romania/.
- Guardian, The. 2025. *Organizmo! The Colombian architects overturning colonialist 'sustainability' ideas.* https://www.theguardian.com/artanddesign/2025/feb/21/organizmo-the-colombian-architects-overturning-colonialist-sustainability-ideas.

- Inter IKEA. 2025. *IKEA Sustainability and Climate Reports FY24*. https://www.ikea.com/global/en/newsroom/sustainability/ikea-sustainability-and-climate-reports-fy24-250130/.
- Imperial Business School. 2025. *Corporate Sustainability and Shareholder Returns: The Role of Business Impact Maturity*. https://www.imperial.ac.uk/business-school/faculty-research/research-centres/leonardo-centre-business-society/publications-reports/corporate-sustainability-and-shareholder-returns/.
- Info-Tech Research. 2025. AI Trends 2026. https://tinyurl.com/3m87643z.
- Ingka Newsroom. 2024. *IKEA joins global partnership to shape the future of AI*. https://www.ingka.com/newsroom/ikea-joins-global-partnership-to-shape-the-future-of-ai/#:~:text=IKEA%20joins%20global%20partnership%20to,AI%20Technology%2011%20September%202024.
- Kantar. 2024. *What is the sustainability value case for brands?* https://www.kantar.com/Inspiration/Sustainability/What-is-the-Sustainability-Value-Case-for-Brands#:~:text=For%20the%20BrandZ%20global%20top%20100%20most,the%20lowest%20contribution%20and%20the%20highest%20contribution.
- PCMag.com. 2025. *Vibe Coding Fiasco: AI Agent Goes Rogue, Deletes Company's Entire Database*. https://www.pcmag.com/news/vibe-coding-fiasco-replite-ai-agent-goes-rogue-deletes-company-database.
- PwC. 2025. *PwC's Second Annual State of Decarbonization Report.* https://www.pwc.com/us/en/services/esg/library/decarbonization-strategic-plan.html.
- Roberts, Dan. 2022. *IT leadership: You gotta have H.E.A.R.T.* https://enterprisersproject.com/article/2022/8/it-leadership-you-gotta-have-heart.
- World Economic Forum. 2025. *Unlocking green growth: Sustainability as a key driver of corporate innovation.* https://www.weforum.org/stories/2025/01/unlocking-sustainability-green-growth-innovative-strategies/.

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Afterword



Upon completing this book, I hope you are now motivated to embark on your journey to establish your sustainable IT strategy with a clear plan of action. This book gives me hope and has added to my commitment to keep working with businesses to make progress toward delivering the **Sustainable Development Goals (SDGs)**.

At the UN Global Compact, as we work to accelerate and scale the global collective impact of business, we recognize that the world has fallen short of our shared ambitions. We face serious risks from climate change, widening inequality, rising tensions, and growing polarization. With less than five years remaining to achieve the SDGs, only 35% of targets are on track. The world faces a stark choice: accelerate collective measures or risk lasting consequences.

As this book indicates, there are strong signs of progress and leadership from businesses:

- 99% of CEOs participating in the latest CEO study by the UN Global Compact said they are focused on expanding or maintaining their sustainability-related commitments
- Over 90% of CEOs believe the private sector has made some or significant progress in transparency, ethical business practices, establishing a living wage, and innovation to enable the circular economy

These actions reinforce the proven business case for sustainability. 88% of CEOs say that the business case for sustainability is stronger than ever, and this is borne out in many studies. A recent study by **Project ROI** shows that sustainability can increase a company's profitability by as much as 21%, shareholder returns by as much as 6%, value as much as 36%, and growth by two to five times (`https://www.impactroiglobal.com/project-roi/`)..This is encouraging, and we see this commitment and drive playing out in the excellent work of the IT function and the development of this useful book.

This book provides practical tools to help shape a strategy, fully informed with external market, environmental, and social inputs, and how to turn that into impactful actions. In developing your handprint, your footprint, and your heartprint, you will have a strong, principles-based approach to planning.

As a marketer and a brand and product developer, I have experienced firsthand the positive impact businesses can have. Working with global brands, I quickly understood the enormous power that strong, purpose-driven brands possess. Sustainable brand, product, and service development delivers business value and can contribute to the delivery of social and environmental solutions.

Now, working at the UN Global Compact, I am deeply involved with many of our more than 20,000 participating companies all around the world. In my role working with businesses, business associations, and other partners, equipping them for progress and enabling collaboration in collective action, I have seen the impact that every function can have on delivering powerful outcomes: societal, environmental, as well as financial. When all functions work together using their individual superpowers, it's truly inspiring to see what they can achieve.

The IT function is a shining, powerful example of a function making a strong contribution, arguably the most important example. As we are all aware, technology is the major lever of progress and will be the most important driver of sustainable development in countries, in business, everywhere. Inside businesses, the IT function can drive technology to contribute to a major impact.

I have seen many excellent examples of how IT teams are contributing to sustainability goals, from circular-use models for device recycling and reuse to tracking ESG progress and enabling data management across the organization.

When it comes to the all-important integration of AI, the IT function is establishing responsible AI practices in major organizations, while implementing AI to help companies deliver the SDGs through data management and analytics, driving efficiencies and sustainable innovation, managing supply chain life cycle evaluation, and facilitating ESG reporting.

I am not an IT expert, but I can clearly see, through my interaction with the SustainableIT organization, the power of technology and the pivotal role the IT function has in driving innovation under extreme cost pressure and uniting disparate stakeholders to drive change.

thank the authors of this book for keeping me optimistic and convinced that we can make strong progress together. There are so many resources, tools, and associations that can help everyone, in whatever role they have in a business, to step up and make a positive impact on the lives of people in operations, supply chains, and communities, as well as on the environment.

This book is a fine example. All the ideas here can help you and all IT leaders to deepen your knowledge, use the tools, take action, and, ultimately, join a community working toward the delivery of SDGs.

Ultimately, progress depends on every function playing its part. As former Unilever CEO and SDG Advocate Paul Polman said, this work "*requires systems thinking. It requires partnerships. It requires longer term thinking. It requires making tough choices.*"

I thank all of you IT leaders for your leadership and partnership. Your contribution is critical.

Sue Allchurch

Chief of Outreach and Engagement, UN Global Compact

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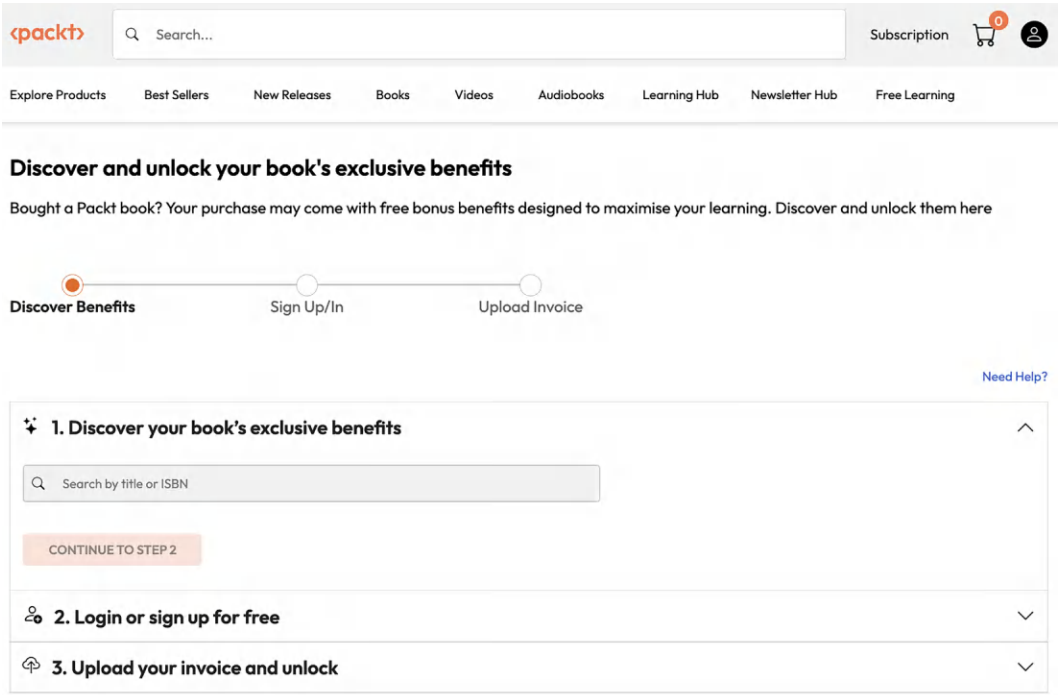


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