



# Uniting technology and sustainability

How to get the full value from  
your sustainable tech strategy

As businesses set ever more ambitious environmental, social, and governance (ESG) goals, their sustainability and technology strategies need to become more tightly aligned. CIOs can play a critical role in supporting their company's transformation to a sustainable organization. An effective **sustainable technology strategy** helps drive business growth and ESG performance by delivering on three imperatives.

**01**

Using the power of technology to enable and accelerate sustainability efforts across the organization.

**02**

Protecting people and the planet by making technology itself progressively more sustainable.

**03**

Pursuing breakthrough innovation with ecosystem partners to develop radically different and more sustainable ways of doing business in the future.



# Sustainability is the new digital

**Sustainability has moved swiftly up the executive agenda in recent years. Even at the height of the COVID-19 pandemic, most CEOs interviewed for an Accenture study<sup>1</sup> said that “becoming a truly sustainable and responsible business” was a top priority. And with good reason. Beyond the great promise of protecting people and the planet, companies with a higher sustainability performance—across environmental, social, and governance (ESG) indicators—perform better financially than their peers.<sup>2</sup> Just as digital transformation required every company to become a technology company, with technology at its heart, now every business needs to become sustainable—and technology is again taking center stage.**

Technology is—and will continue to be—the fundamental driver of sustainability for organizations, and their supply chains, customers, and broader business ecosystems. Ninety-two percent of companies in our survey aim to achieve net-zero targets by 2030, which will require deployment of advanced technologies to measure, reduce, and remove an organization’s carbon footprint. Technology is essential to improving transparency and traceability in global supply chains. It helps companies uncover insights to spur action, whether that means transforming customer experiences or building a more sustainable organization.

And as recent events have shown, technology is also essential for organizations to adapt fast, whether that means protecting customers and employees during the COVID-19 pandemic or restructuring supply chains and rapidly transitioning to green energy in light of current geopolitical uncertainties. Every organization in our sustainable tech survey of 560 companies with revenues above US\$1 billion ranked technology as either “important” or “very important” for achieving their sustainability goals.

While technology is a fundamental driver of sustainability, the solution itself needs to be monitored so that it doesn’t become the problem. Technology can and does create sustainability issues. For example, training a single artificial intelligence (AI) model can emit as much CO<sub>2</sub> as five relatively ordinary cars do in their lifetimes.<sup>3</sup> And using a mobile phone for just one hour a day for one year produces some 1.4 tons of CO<sub>2</sub>—that’s more carbon emissions than two round-trip flights between London and Glasgow.<sup>4</sup> This brings technology within the ambit of the sustainability efforts of organizations. The priority? To design and deploy sustainable, green technology to harness the benefits of meeting the sustainability agenda.

Finally, no single organization can hope to address global sustainability challenges and create impact at scale on its own. To meet the United Nations Sustainable Development Goals (SDGs), ecosystems with interconnected systems that bring together businesses, startups, nonprofits, academia, and public-sector organizations are needed to drive urgent action beyond the boundaries of any individual organization. Technology will be a key enabler for solving these complex problems at scale.

## Developing a sustainable technology strategy to unlock business value

Many companies have begun to pilot and scale use cases that harness technology to drive sustainability. There are clear benefits from doing so. In fact, as our analysis shows, companies that adopt sustainable technology to a significant extent achieve 4% higher ESG scores on **Arabesque S-Ray dataset**—a global specialist in measuring ESG metrics—than those that do not.<sup>5</sup> This can translate into an 11% jump in their ESG ranking. And between 2013 and 2020, companies with consistently high ESG performance tended to generate 2.6x higher total shareholder returns, compared to those with mid-range ESG scores.<sup>6</sup>

So, what's holding back organizations? For many, the transformation is daunting (see Figure 1.) Nearly one-fifth of the organizations say their biggest challenge is that they are not aware of the unintended consequences of technology. Lack of ready solutions is a big concern, as is complexity associated with adopting these solutions. And then, there's what we call the intent-action gap—**only 7% of companies have fully integrated their business, technology, and sustainability strategies.**

The intent-action gap leads companies to make trade-offs between their business and sustainability goals—trade-offs that can be reduced or eliminated in organizations that have developed holistic sustainable

technology strategies. As sustainability strategies take shape, the CIO will be the common denominator as different members of the C-suite take “ownership” of specific aspects and become reliant on technology to achieve their objectives:

- CFOs looking for data and measurement tools to report progress toward sustainability goals to the investor community will need to turn to technology
- CMOs repositioning their brands as sustainable will need to use technology to help consumers choose sustainable products and services
- CHROs seeking to upskill and reskill their workforce while improving inclusion and diversity will gain major benefits from technology, and
- COOs and CSCOs looking to track and reduce carbon emissions in operations and supply chains will depend on technology to do so.

Given technology's pivotal role in sustainability transformation, the CIO should have a seat at the table on sustainability decisions. At the moment, however, most do not: only 49% are on the leadership team setting sustainability goals, and just 45% are assessed on achieving these goals.

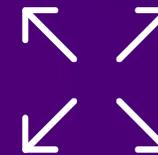
**Figure 1.**

The top barriers preventing companies from achieving their sustainable technology goals.



### Lack of solutions and standards

**40%** believe that the right solutions are not available or are yet to mature, including availability of the right talent to lead these initiatives.



### Complexity

Nearly **33%** are struggling with complexity of solutions or with making their legacy systems sustainable. Some (**12%**) are yet to migrate to cloud from their on-premises data centers, which is a perceived barrier.



### Lack of awareness

Around **20%** are not aware of the unintended consequences of technology or whether the technology they use is sustainable.

How can companies seize the opportunity to harness the full potential of an integrated sustainable technology strategy? Together, the C-suite, with the CIO as the catalyst for change, can accelerate transformation by formulating an effective sustainable technology strategy with these three integral elements (see Figure 2):

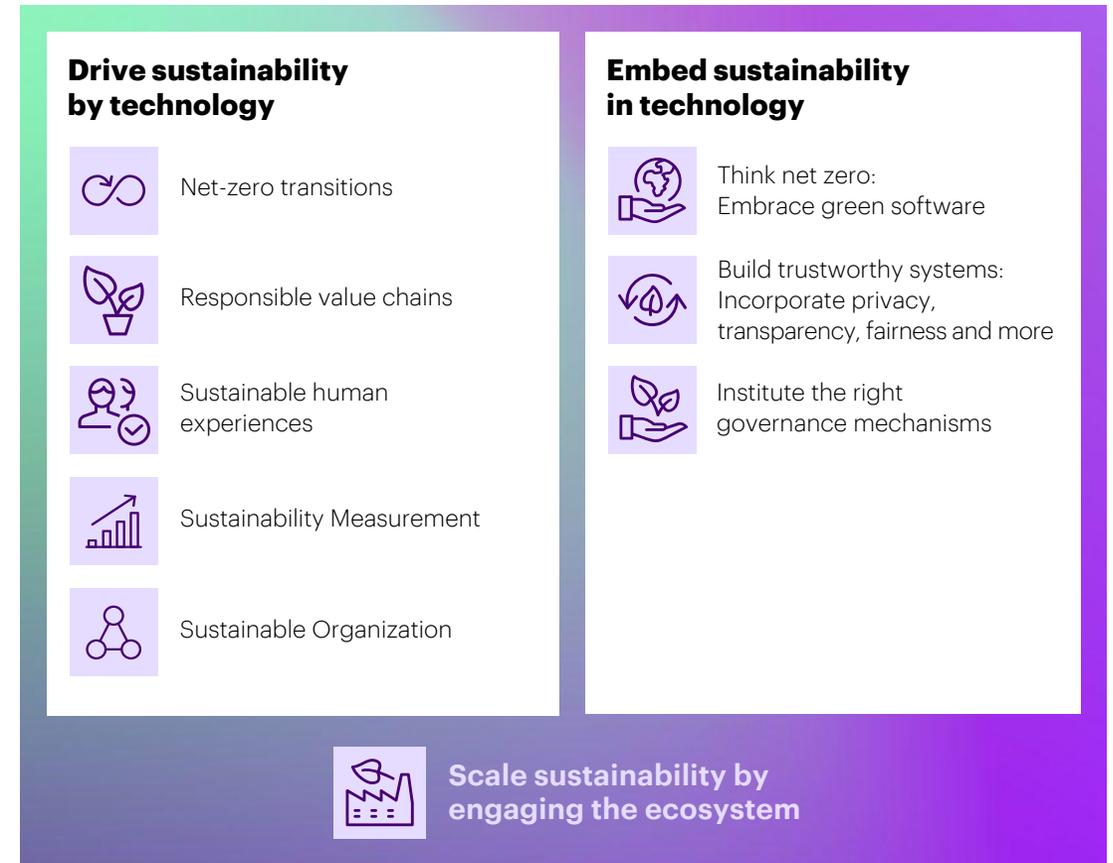
- **Sustainability by tech:** using technology innovation to drive sustainability initiatives and transform the business model.
- **Sustainability in tech:** measuring the ESG impacts of technology, and working to ensure it's designed, developed, and deployed sustainably.
- **Sustainability at scale:** orchestrating an ecosystem of businesses, technology companies, startups, non-profits and government organizations to harness technology in completely new ways to solve the “wicked problems” of this decade and deliver sustainable outcomes.

We used our survey findings to develop a Sustainable Technology Index that measures the extent to which companies have succeeded in combining these three elements. Our analysis revealed a “crowded middle” around the median score of 0.45, on a scale of 0 to 1. This suggests that most companies still have a long way to go in achieving all three elements of a sustainable technology strategy. Around 60% of the companies in our survey had scores within the range of 0.3 to 0.5.

Despite the challenges, around half of all respondents are seeing returns on their sustainable technology investments in the form of improved financial metrics, ESG goals, customer experience, innovation, software quality, or hiring ability (Figure 3).

**Figure 2.**

The three components of an effective sustainable technology strategy.





**Figure 3.**

How sustainable tech contributes value in various forms.

**Growth**

**48%**

of companies say technology-led sustainability initiatives lead to increased revenues from better products.

**Innovation**

**49%**

of companies say technology-led sustainability initiatives help create new businesses.

**Customer experience**

**49%**

of companies say sustainable technology is essential for enhanced customer experience.

**Talent**

**49%**

of companies say a commitment to sustainability is a big draw for software engineers and tech talent.

**Software**

**44%**

of companies say focus on sustainability principles helps build better quality software.

**ESG goals**

**53%**

of companies say investing in sustainable technology can play a big role in meeting ESG targets.

While this is a promising start, very few companies currently gain multiple business benefits across the spectrum—most report only one of these. In fact, the likelihood of a company achieving at least five business benefits is directly related to its score on our Sustainable Technology Index. Our regression analysis shows that if the average performers (which score around 0.45 on the Index) were to move into the group of top performers, they would be 21% more likely to realize at least five benefits. That presents a strong case for an integrated sustainable technology strategy.

In the following sections of this report, we'll take a closer look at the three key areas that companies need to consider as they shape robust sustainable technology strategies.

The image is a composite background. The left side shows an aerial view of a green tractor with a yellow implement working in a field of brown, harvested crops. The right side is a close-up of a green printed circuit board (PCB) with several silver electrolytic capacitors. One capacitor is clearly labeled '4e-9 096'. The overall lighting is a mix of natural and artificial, with a strong red and blue color cast over the right half.

# Sustainability by technology

Today, most organizations aim to achieve their net-zero ambitions by 2030. To meet this tight timeline, they want to embed sustainability throughout their supply chain, reducing carbon emissions while also addressing issues like human rights and ethical sourcing. They want to promote their brands' sustainability credentials. And they want to be able to report all of this to their stakeholders, especially the investor community. As they progress toward these goals, technology is a vital enabler across the five key areas that are most important to them:

- 01** | Accelerating net-zero transitions
- 02** | Moving toward sustainable value chains
- 03** | Promoting sustainable choices for customers
- 04** | Measurement, reporting and performance on ESG goals
- 05** | Building a sustainable organization

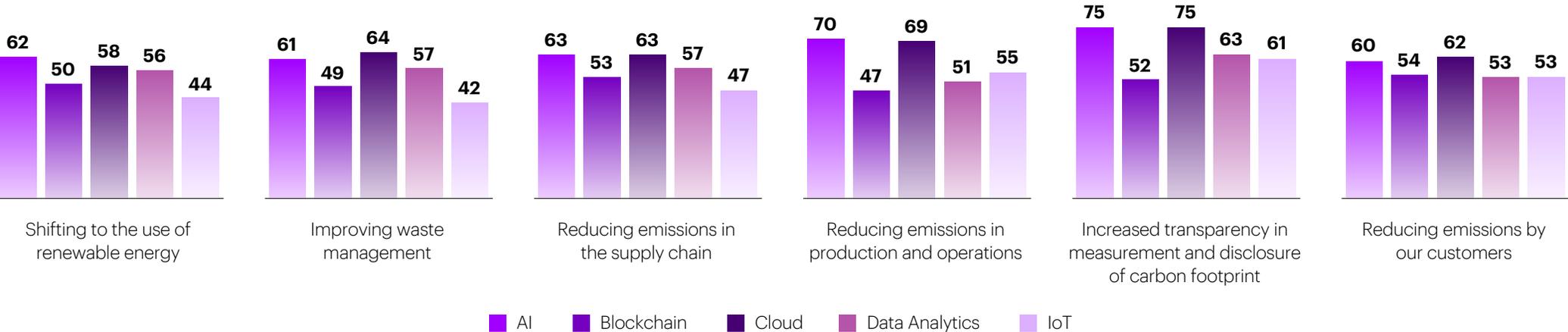
# 01

## Accelerating net-zero transitions

Various technologies—AI, cloud, blockchain, analytics, IoT, and more—can play a role in reducing carbon emissions. AI is a particularly powerful tool. For instance, of the companies in our sustainable tech survey that successfully reduced emissions in production and operations, 70% used AI to do it (see Figure 4.)

**Figure 4.** Use of various technologies to achieve emissions targets by companies focused on achieving a particular objective.

**How companies use various technologies to achieve their emission targets**  
% of companies





To take one example, we helped a global building materials company launch a groundbreaking application, powered by machine learning, to predict cement strength in real time during production. This enabled data-driven decision-making, providing the potential to deliver eco-friendly cement at no extra cost to consumers. It allowed for a possible reduction in CO<sub>2</sub> emissions of up to 13,000 tons per plant (3 million tons in total) and cost savings of up to US\$150 million across all plants.

While improving operational efficiency is a good place to start, a net-zero transition for climate leadership requires a well-rounded strategy that covers several approaches including carbon reduction, carbon offsets, policy engagement, and green financing linked to the target of limiting global warming to 1.5°C.

Consider Microsoft, which has been carbon neutral since 2012 and has set the target of becoming carbon-negative (removing more carbon than it emits each year) by 2030.<sup>7</sup> By 2050, it aims to have removed all of the historical carbon emissions it has produced since it was founded in 1975. Its strategy covers multiple areas. While offsets funded by an internal carbon tax are in part reinvested to drive energy efficiency gains, the focus is now shifting to the creation of carbon-intelligent solutions that are designed to help customers reduce their carbon footprints using data science, AI, and digital technology.

The Microsoft Sustainability Calculator, for example, helps customers understand and report the carbon footprint of their cloud workloads on Azure. Greater energy transparency is targeted for Teams, Edge and other Microsoft products. Partnerships and co-innovation with customers are driving new low-carbon solutions, such as sustainable smart building offerings that can reduce buildings' energy consumption by up to 40%. Microsoft also plans to engage with public policy issues, such as expanding applied research efforts on carbon and removing regulatory barriers for scaling technology solutions.<sup>8</sup>

Overall, carbon-intelligent technology solutions can help drive net-zero transitions in three important ways:

- assessing the carbon footprints of organizations, products, and supply chains
- reducing emissions in a transparent manner for proper certification and accreditation, and
- removing carbon through carbon sequestration and credits.

## 02

### Moving toward sustainable value chains

Supply chains account for 60% of all global emissions—and according to an Accenture study, interruptions in supply chains caused by extreme climate events are a major concern for 49% of CEOs.<sup>9</sup> However, the interconnectedness of modern supply chains makes gathering data challenging. Some 63% of CEOs say that the difficulty of measuring ESG data across their value chains is a barrier to sustainability in their industry.

**63%**

of CEOs say that the difficulty of measuring ESG data across their value chains is a barrier to sustainability in their industry.

A powerful enabler in building more sustainable supply chains is digital twin technology, which brings together data and intelligence at massive scale to create virtual, mirrored worlds of products and processes. Digital twins provide an opportunity to run massive simulations to help build responsible supply chains.<sup>10</sup>

According to a study conducted by Accenture, a mere five industry-specific use cases have the potential to save 7.5 billion tons of cumulative carbon emissions by 2030.<sup>11</sup>

For example, life sciences company Sanofi's Framingham production facility is using real-time data capture to optimize its manufacturing process with a digital twin. The result is an industrial process that's 80 times more productive than a traditional factory—thereby reducing energy consumption and carbon emissions by 80%, water footprint by 91%, and chemicals use by 94% annually.<sup>12</sup>

Meanwhile, automotive manufacturer Porsche is working with Circularise to create a digital twin of its entire supply chain for traceability of plastics and tracking sustainability metrics. This enables improved decision-making for future vehicles and end-of-life recycling approaches.<sup>13</sup>

Blockchain provides a way for organizations to improve transparency and traceability in global supply chains, and is increasingly being used in ESG reporting to help consumers verify companies' claims about being resource-positive and environmentally friendly. For example, Mastercard's Provenance Solution uses blockchain to provide real-time traceability, with a shared record that enhances accountability and trust between supply-chain parties.<sup>14</sup>

## 03

### Promoting sustainable choices for customers

While focusing on a company’s direct sustainability impact is a natural place to start, organizations in many industries have found that the biggest challenge—environmental or otherwise—is downstream, at the level of their customers. However, they can’t force customers to make the right choices. In fact, the sustainable consumer mass-market may never reach a tipping point because people so often exhibit an “intent–action gap” between their good intentions and the actual choices they make.<sup>15</sup>

Brands need to take the lead by closing their own intent–action gap to nudge customers toward making sustainable choices. They should also reduce the burden on their customers. How? By making buying decisions intuitive. By clearly showing why some products and services are more sustainable than others. And by providing context or points of reference to help people evaluate and compare different choices.

Here, once again, technology can make a difference. Consider Levi Strauss & Co., which launched its “Buy Better, Wear Longer” campaign, in the process shifting its approach from the traditional “sell-what-you-make” to “make-what-you-sell.”<sup>16</sup> As a part of this initiative, the company is encouraging customers to recycle their clothes via their recommerce platform called SecondHand. Customers receive a gift card in exchange for their old pair of jeans, which is resold as a unique product for others to buy. Levi Strauss

estimates that buying a used pair can reduce carbon emissions by 80%. If the garment is too worn out, it is recycled and the materials used for building insulation.

Furthermore, AI has helped Levi Strauss improve its forecasting of customer preferences, thus better aligning production with demand to reduce overproduction and inventory. A new digital sampling capability is helping to reduce the number of samples. Levi’s® has also joined the “Fashion for Good” initiative to help scale technology solutions for transforming the industry.<sup>17</sup> The current “take-make-waste” model has resulted in the apparel industry contributing some 7% of global greenhouse gas emissions.<sup>18</sup> It urgently needs to move toward a circular and regenerative approach, and Levi Strauss is helping to drive this shift.

In short, Levi’s® is closing its own intent–action gap rather than waiting for its customers to drive the transformation. In the process, it is easing the burden on its customers to make the right choices.

To bring greater clarity to its customers, Shell is developing and deploying edge intelligence algorithms through its ChargeWorks electric vehicle program to optimize the charging station experience. On top of managing energy consumption, the algorithms monitor input from the grid and give customers the option of purchasing power that has a lower carbon intensity.<sup>19</sup>



# 04

## Measurement, reporting and performance on ESG goals

Today, most companies recognize the importance of ESG metrics. Technologies such as AI can help: Our sustainable tech survey found that out of the 61% of companies that increased transparency in the measurement and disclosure of their carbon footprint, 75% did so using AI.

However, while progress is being made, there's clear room for improvement in the ESG metrics themselves. Nearly half of the companies in another recent **Accenture study** say they have neither defined the ESG KPIs they need, nor identified the right data source(s) to measure them.<sup>20</sup> Only 26% have the right data to underpin their ESG KPIs, and 70% still use manual or semi-automated processes for ESG management.<sup>21</sup>

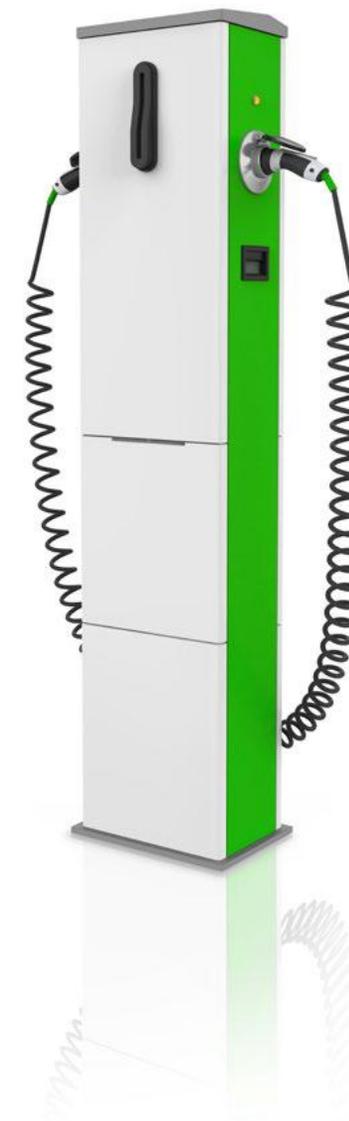
The first step? To define their ESG KPIs and report them effectively, companies need to gain insights into what matters to their stakeholders. Organizations must be able to make informed decisions based on data and insights. Take the case of a leading international automobile manufacturer, for instance. Despite setting ambitious decarbonization goals and introducing electric vehicles, the company found its ESG strategy wasn't gaining traction with investors and customers.

The key was to start with a clear understanding of investor perceptions, using databases that investors would trust, including Arabesque S-Ray's machine-learning platform that

analyzes 22 core ESG metrics daily. This helped provide a clear picture to identify areas for prioritization. As a result, 18 core ESG initiatives at the company were distilled into four concentrated initiatives: decarbonization, circular business models, workforce transformation, and human rights in the supply chain.

Based on these four key initiatives, the automobile manufacturer's ESG narrative was rewritten into easily understandable goals and KPIs for each area, providing the basis for the transformation of day-to-day processes. Between the start of the project and its completion, the company's market capitalization rose significantly.

The next step is for ESG measurement to provide granular insights that can drive action. This was the challenge that Alibaba faced: Alibaba wanted to implement a robust ESG strategy that would help them stay abreast of the increasing carbon neutrality regulations in China. The company needed to develop an intuitive ESG platform to successfully implement such a strategy. Alibaba partnered with Accenture to design a cloud-based, AI-enabled sustainability platform, that would auto-collect data and measure ESG performance across the value chain. The tool also provides recommendations on operation optimization to improve ESG scores. Furthermore, the ESG platform creates new revenue streams for the company, as Merchants, Suppliers and Consumers that use the platform have an opportunity to avail services, like "Green packaging" and "Renewable Sourcing" provided by Alibaba.<sup>22</sup>



# 05

## Building a sustainable organization

Sustainability practices need to be scaled across the entire company. This means embedding sustainability into the organization’s DNA, which in turn links closely to both its profitability and ESG performance.<sup>23</sup> An organization’s sustainability DNA is shaped and influenced by many actions, including championing inclusion, diversity, and equality within the business, creating a learning culture, and using emerging technologies for solving problems without creating harmful side-effects.

Employees want the power to create sustainable solutions. Democratizing access to technology empowers them to act, by using components such as natural language processing, no-code/low-code, and robotic process automation (RPA) to solve problems. All of this helps to weave sustainability into the organizational fabric.<sup>24</sup>

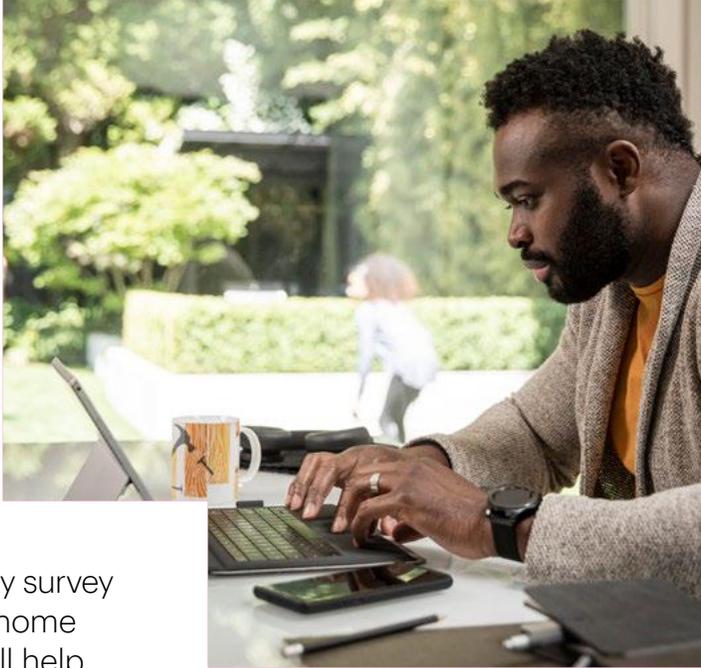
The shift to hybrid work, driven by the pandemic, has helped companies accelerate progress toward their sustainability goals by right-sizing their office spaces and cutting down on polluting and energy-consuming employee commutes. This large-scale workforce transformation is likely to stay. In fact, 51% of the companies in our sustainability survey plan to adopt hybrid or work-from-home models. Of those companies, 50% think it is better for the environment and 43% believe it will help them to achieve sustainability goals faster.

As companies learn more about the impact of this transformation on their culture, they will discover further opportunities to improve their sustainability DNA. Twitter, for example, has announced permanent remote working to increase diversity in hiring, unhindered by location.<sup>25</sup>

As part of strengthening their sustainability DNA, companies will also need to minimize the harmful side-effects of the technology they use. This is the topic we’ll look at next.



of the companies in our sustainability survey plan to adopt hybrid or work-from-home models. Of those, 43% believe it will help them to achieve sustainability goals faster.





# Sustainability in technology

Today, technology is embedded in every aspect of our lives, delivering huge benefits in terms of speed, convenience, and connectivity. However, a side-effect is that the global population is generating ever more data—and consuming ever more power.

As more people go online and the use of technology increases, the result is rising carbon emissions from IT. By one estimate, the information and communications technology (ICT) sector's share of the world's carbon footprint has expanded from just 1.5% in 2007 to 4% today, and is heading toward 14% by 2040.<sup>26</sup> While the precise figures are subject to debate, this overall upward trend is clear. And it's projected to accelerate further due to the rising adoption of power-intensive technologies like AI and blockchain.<sup>27</sup>

Left unchecked, this rising tide of data and power consumption could easily propel carbon emissions far beyond their current levels. And this risk is accompanied by concerns around technology's potential impacts on other aspects of ESG: For example, it could also have unintended negative consequences for society, such as widening inequality through AI making biased decisions.

Together, these factors mean CIOs need to play their part by making their technology more sustainable. We've identified three focus areas that organizations should prioritize:

- 01** | Think net zero:  
Embrace green software
- 02** | Build trustworthy systems: Incorporate privacy, fairness, transparency, robustness, and accessibility
- 03** | Institute the right governance mechanisms

# 01

## Think net zero: Embrace green software

While software drives intelligent solutions designed to tackle environmental challenges, companies also need to make their software itself an integral part of their sustainability strategy—a view we presented earlier in the Harvard Business Review article **“How Green Is Your Software?”**.<sup>28</sup>

The reality is that software is at the heart of all technology. And companies need to adapt how software is designed, developed, deployed, and used to minimize its carbon footprint. Software runs on hardware, and any uptick in software use increases the emissions of machines and devices on which it runs. Green software practices can reduce energy consumption in multiple ways. A few examples? A sustainable software development lifecycle. Making the user experience sustainable. Further enabling green AI and data practices. And sustainably managing the physical layer on which software runs.

We have identified seven priority areas related to green software (see Figure 5).

**Figure 5.**  
Green Software Framework.

	Impact area	Green software practices	Did you know?
1	Green <b>Software development lifecycle</b>	Adopting <b>energy efficient and green practices</b> across the software development lifecycle - from selecting platforms, programming languages, to designing software architecture and DevOps, to save energy, reduce emissions, and develop <b>carbon-efficient software</b>	Interpreted languages can consume 10x more energy than semi-compiled and 48x more energy than compiled
2	Green <b>UI/UX</b>	Driving <b>user friendly digital experience</b> with effective <b>accessibility</b> - easier navigation and therefore lower screen time reducing emissions; <b>optimizing performance</b> by selection of screen color, evaluating screen's processing power and compressing content and images	By modifying UI to support dark mode, an app can reduce the UI carbon emissions by -60%
3	Green <b>AI</b>	Evaluating the <b>trade-off</b> between energy efficiency and accuracy of the AI/ML models based on the criticality of the use case. Repurposing existing models for a different task called <b>transfer learning</b> can further cut down energy and time and in turn emissions	With a responsible target accuracy, the carbon emissions of your ML models can be reduced by -80%
4	Green <b>Cloud &amp; data centers</b>	Encouraging data center to <b>cloud migrations</b> , right hosting decisions and green application development on cloud for hardware and energy efficiency; further evaluate <b>implementation of edge computing</b> - inherently a low energy technology - storing and using data near the device or end-user	By migrating GCP cloud location from asia-east-1 to europe-north-1, the project can save -66% of emissions
5	Green <b>Data</b>	Focusing on efficient <b>data processing</b> throughout the data lifecycle by eliminating storage waste, data compression, effective utilization of networks and data transmission, improving efficiency in workload management can reduce dark data from the ecosystem reducing emissions	Green Data Mgmt, can reduce the costs incurred on transmission & storage of “dark data” which accounts for 70% -90% of all data
6	Green <b>Distributed ledger technology</b>	Using energy efficient <b>DLT algorithms and green blockchain design principles</b> including decisions on number of nodes in the network, size of transaction data, compression strategy, data storage, computing and network infrastructure	Consensus algorithm, network design, increased transaction frequency, etc. have a huge impact on emissions
7	Green <b>Infrastructure</b>	Driving reduction in environmental impact of IT infrastructure - <b>end-user devices, networking components and data center by considering both usage emissions and the lifecycle emissions</b> associated with manufacturing and end-of-life. Encouraging responsible procurement and end-of-life management amongst others	Currently, only about 17% of e-waste collected is recycled. And most organizations recycle less than 10% of their hardware

### Green software development lifecycle

Organizations need to put green software at the heart of their transformation. This means taking a proactive and strategic approach to sustainability from the very start of the software development lifecycle. And considering its potential for energy efficiency at all stages—from defining user requirements, to designing, implementing, testing, and maintaining software.

In our survey, we asked companies whether they incorporate sustainability principles at various stages of the software development lifecycle, such as establishing metrics or aligning developer KPIs with green software strategy. Only two of the 560 companies we interviewed said they always take all these actions. Most take just one or two (see Figure 6).



Uniting technology and sustainability

**Figure 6.**

Adoption of sustainability principles through the software development lifecycle.



These findings indicate huge room for improvement. Making the most of newer architectures demands a different approach to software development—one that prizes energy efficiency as much as traditional measures like functionality, security, and scalability. Yet only half of our respondents set separate goals for sustainability as part of their overall software agenda.

## Green user experience

User experience (UX) is a broad field, including UX design, visual design (VD), industrial design (ID), interaction design (IxD), and more. Growing numbers of companies are focused on reducing energy consumption associated with the UX, and rightly so. It's an opportunity to transform the UX into a value-added service by viewing customer interactions with a company's systems, products, and services through a sustainability lens.

For example, sustainably designing, developing, and hosting webpages might require more thoughtfulness at the planning stage. But these efficiencies will streamline the UX and drive down costs for businesses. An environmentally responsible website not only produces fewer carbon emissions, it's also faster, more intuitive and potentially more profitable than less efficient webpages.

The Google homepage is a great example of minimalist design. It focuses on delivering core functionality in the simplest package. Google has also reported that using

dark and less saturated colors on phones and other devices increases energy efficiency. For instance, running Google Maps in night mode reduces screen power consumption by 63%.<sup>29</sup> Companies can unlock even greater sustainability gains by reducing content sizes, compressing pictures, and using vector images that can scale without increasing file sizes or losing quality.

Another example? Streaming video content in high definition can be eight times more carbon intensive than streaming in standard definition, and the difference isn't always perceptible to users.<sup>30</sup> Allowing images to blur at the edges, referred to as "foveated rendering" in virtual reality, can significantly reduce workloads and energy consumption.

Ultimately, for users, a green digital experience comes down to balancing purposeful design and business goals: maximize functionality and minimize extraneous information for a streamlined user experience. It contributes to increased accessibility, easier navigation, and creating useful content.



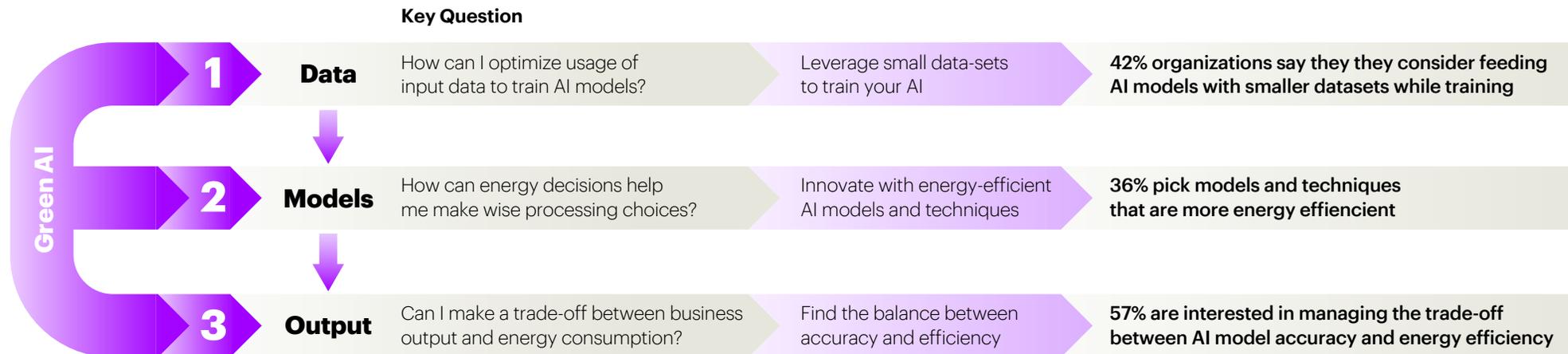
## Green AI

It's estimated that training a deep-learning AI model with 213 million parameters and a neural architecture search function generates more than 313 tons of CO<sub>2</sub> emissions. That's roughly the same as 315 return flights between New York and San Francisco.<sup>31</sup>

The amount of computing power needed to train large AI models has risen dramatically in recent years. From 2012 to 2018, it increased by a factor of more than 300,000.<sup>32</sup> Most of this power is used to create small, incremental gains in accuracy by throwing more compute at the AI models—a concept known as “Red AI.” Looking across the entire lifecycle of an AI application, we can see three main ways to turn “Red AI” green (see Figure 7).

**Figure 7.**

A three-dimensional approach to make AI green.



Fortunately, more energy-efficient approaches to AI don't require significant compromises to be made on the quality of AI models. In many cases, they can reach a sufficient level of accuracy using far smaller data volumes and much less energy. An example of what can be achieved? Our researchers at Accenture Labs found that training an AI model on 70% of the full dataset reduced its accuracy by less than 1%, but cut energy consumption by a staggering 47%.

A further opportunity to make AI greener lies in the fact that not all models need to be created and trained from scratch. Organizations can save energy and time by using "transfer learning," which involves repurposing an existing model that has already been trained for a different task.<sup>33</sup>

Another way to make AI greener is to use **neuromorphic computing architectures**, inspired by the brain, that can deliver increasingly sophisticated AI at the edge. Neuromorphic systems are several orders of magnitude more energy-efficient than general-purpose computing architectures. A spiking neural network, one type of neuromorphic computing model, is designed to avoid unnecessary computations by focusing on individual spikes in the network in the same way that neurons interact with synapses. Even the most energy-intensive AI models, however, can be made greener using other proven techniques, such as encoding, quantization and pruning. Applied together, they can shrink a deep neural network to around a fiftieth of its original size, greatly improving energy efficiency without a big hit to accuracy.<sup>34</sup>

Take one recent collaboration with an automotive client. We demonstrated that spiking neural networks running on a neuromorphic processor can recognize simple voice commands up to 0.2 seconds faster than a commonly used embedded graphics processing unit (GPU) accelerator. Even better: They use up to a thousand times less power. This brings truly intelligent, low-latency interactions into play, at the edge, even within the power-limited constraints of a parked vehicle.

Still, some trade-off between accuracy and energy efficiency may be unavoidable. To determine the appropriate trade-off, companies should clearly define their business goals when using AI. Sometimes, the marginal value of using vast datasets and energy-intensive models is worthwhile, but in many instances it is not.

### Managing the trade-off between AI accuracy and energy consumption

We recently conducted experiments using the publicly available Iris flower dataset developed by biologist Ronald Fisher. Our goal was to identify the various species of Iris flower included. We discovered that our model required 964 joules of energy to achieve an accuracy of 96.17%. Raising the model's accuracy just 2.5%—from 96.17% to 98.67%—required 15,077 joules. That's about 15 times more energy than was needed to increase the model's accuracy from 0% to 96.17%. The final 0.08% boost in accuracy was the most energy-intensive, requiring 4,705 joules. Is that level of accuracy always worth the extra energy? That is a case-by-case, company-by-company decision.

For scenarios where maximum accuracy is desirable, we have developed a load-shifting software asset, which automatically maximizes renewables sources in the energy mix. The system was successfully piloted in a client project for deep learning-based optical character recognition (OCR), where the use of renewables was maximized across cloud instances based in Singapore (solar), Ireland (wind), and California (solar).

## Green cloud and datacenters

Cloud's impact on carbon emissions can be substantial. It's estimated that migrating to public cloud could reduce the annual global CO<sub>2</sub> emissions from IT systems by 59 million tons. That's an impact equivalent to taking 22 million cars off the road.<sup>35</sup> But despite the clear environmental benefits, our research shows that only 41% of companies are migrating to The public cloud as part of their IT sustainability initiatives.

Far from being a static destination, cloud is a foundation for future operating models: The real benefits are realized by combining it with other technologies such as AI, platforms, edge, and 5G. In fact, 34% of CIOs in our survey said that failure to migrate to cloud from on-premises datacenters is a major barrier to sustainable technology. This tells us that cloud is a proven path to sustainability gains—and that it still has considerable room to grow.

While migrating to public cloud is key, improving server utilization is an important tool for reducing energy consumption at datacenters. Server virtualization, containerization, and serverless computing address this issue in different ways. These techniques have substantial room for growth, as fewer than a third of companies use them today (see Figure 8).

Companies running on-premises systems also have major opportunities to decarbonize their datacenters through initiatives like switching to renewable energy sources and optimizing cooling. For example, Google developed an algorithm with its subsidiary DeepMind that automates and optimizes cooling at its datacenters, thus reducing its datacenter energy requirements by 40%.<sup>36</sup> It's also now using a carbon-intelligent platform to shift workloads to times of day when there is no shortage of renewable energy.<sup>37</sup> Over time, the company seeks to develop solutions to shift non-urgent compute tasks across geographic locations, wherever energy is cheapest and least polluting.

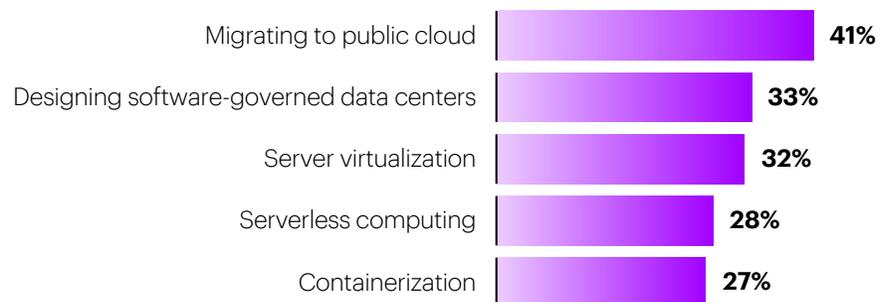


### Canada Mortgage and Housing Corporation: Realizing the sustainability benefits of cloud

Canada Mortgage and Housing Corporation was faced with the challenge of aging, insecure infrastructure, and lack of integration of its applications portfolio that acted as a barrier to achieving its ambitious goal of providing affordable housing to everyone by 2030. So it decided to migrate to Microsoft Azure Cloud to gain real-time insights into clients and the housing market. Accenture's MyNav Green Cloud assessment was able to quantify the sustainability impact of this transformation: over 80% reduction in IT-related CO<sub>2</sub> emissions and more than 50% reduction in travel-related CO<sub>2</sub> emissions.

**Figure 8.**

Steps organizations are taking to reduce energy consumption at datacenters.



While cloud can dramatically reduce carbon emissions, it sometimes creates another problem: Moving large quantities of data to and from the cloud requires a lot of energy. Edge computing significantly cuts energy consumption by shifting processing from the cloud to whatever device is being used, on demand.<sup>38</sup> To move data processing to the power- and thermal-constrained devices at the edge, organizations need energy-efficient software models, such as those designed for “edge AI.”

To realize the full green potential of edge computing, companies must pair it with other energy-saving measures. One of these is deploying more energy-efficient hardware at the edge, by replacing older CPUs with newer chip architectures, such as GPUs and field-programmable gate arrays (FPGAs). GPUs are more energy-efficient than CPUs because their memory architecture specializes in supporting high-speed data streaming for intensive applications (see box).

### From graphics processing units to intelligence processing units

Chip architecture is changing fast. The GPU market leader, Nvidia, has redesigned its chips to manage AI workloads. And Graphcore, a startup, has produced an “intelligence processing unit” (IPU) that is even more energy-efficient than GPUs. (The company has said that its IPU processes data 10 times to 50 times faster than GPUs, saving energy along the way.)<sup>39</sup>

How does the IPU work? To process data faster, it deploys built-in memory processing, which reduces the amount of data sent between chips. IPU also increase throughput (the amount of data delivered during any given period) by about 300% and decrease latency (the time it takes data to be delivered) by 20%, compared with GPUs.<sup>40</sup>

Further, IPU are designed to make computer brains more human-like. To do this, IPU forgo the slower, heavier, number-crunching typical of GPUs in favor of a speedier process that relies on less precise math. The upshot: Graphcore’s latest M2000 IPU were able to train Google’s natural language processing model, BERT-large, in just 12 hours and 6 minutes. That’s 2.6 times faster than a standard GPU,<sup>41</sup> and it saves energy.<sup>42</sup>

## Green data

With the growing popularity of AI, we expect to see an explosion in data volumes. This means companies will need to take steps to ensure that data is used in sustainable ways to maximize business value.

There is evidence that data-driven organizations average more than 30% growth a year. However, we also know that some **70–90% of the data that organizations collect is “dark data,”** which is not used for insights or decision-making. As a result, a lot of energy is being wasted on its transmission and storage.

To improve, companies need to better manage the data lifecycle from a sustainability perspective. Some examples? Eliminating unnecessary data collection and storage. Using smaller datasets. Utilizing networks and data transmission more effectively. And improving efficiency in workload management. (To learn more about “sustainable data,” check out our article in *The Economist*.<sup>43</sup>)

## Green distributed ledger technology

Bitcoin consumes more energy in a year than the entire nation of Switzerland.<sup>44</sup> However, innovations to make the technology less energy-hungry are already emerging. For example, the Ethereum Foundation (the creators of Ether—the second-largest cryptocurrency by market capitalization) is moving to a proof-of-stake algorithm instead of proof-of-work blockchains. The Foundation expects this change to cut energy consumption by 99.95%.<sup>45</sup>

Initiatives to adopt more energy-efficient consensus algorithms (such as those used in blockchain) will need to be combined with other ways of conserving energy. For example, validating data accuracy across all the network nodes of blockchain consumes a lot of bandwidth. It can be more energy-efficient to use approaches that reduce the amount of on-chain data, such as off-chain storage and data archives. Ethereum 2.0 is now using a different technique called “shard chain.” It splits the database horizontally, so that only one part (shard) is updated rather than the entire network. This reduces hardware requirements. Limiting the use of smart contracts—which are agreements executed using code—and simplifying them will also help.

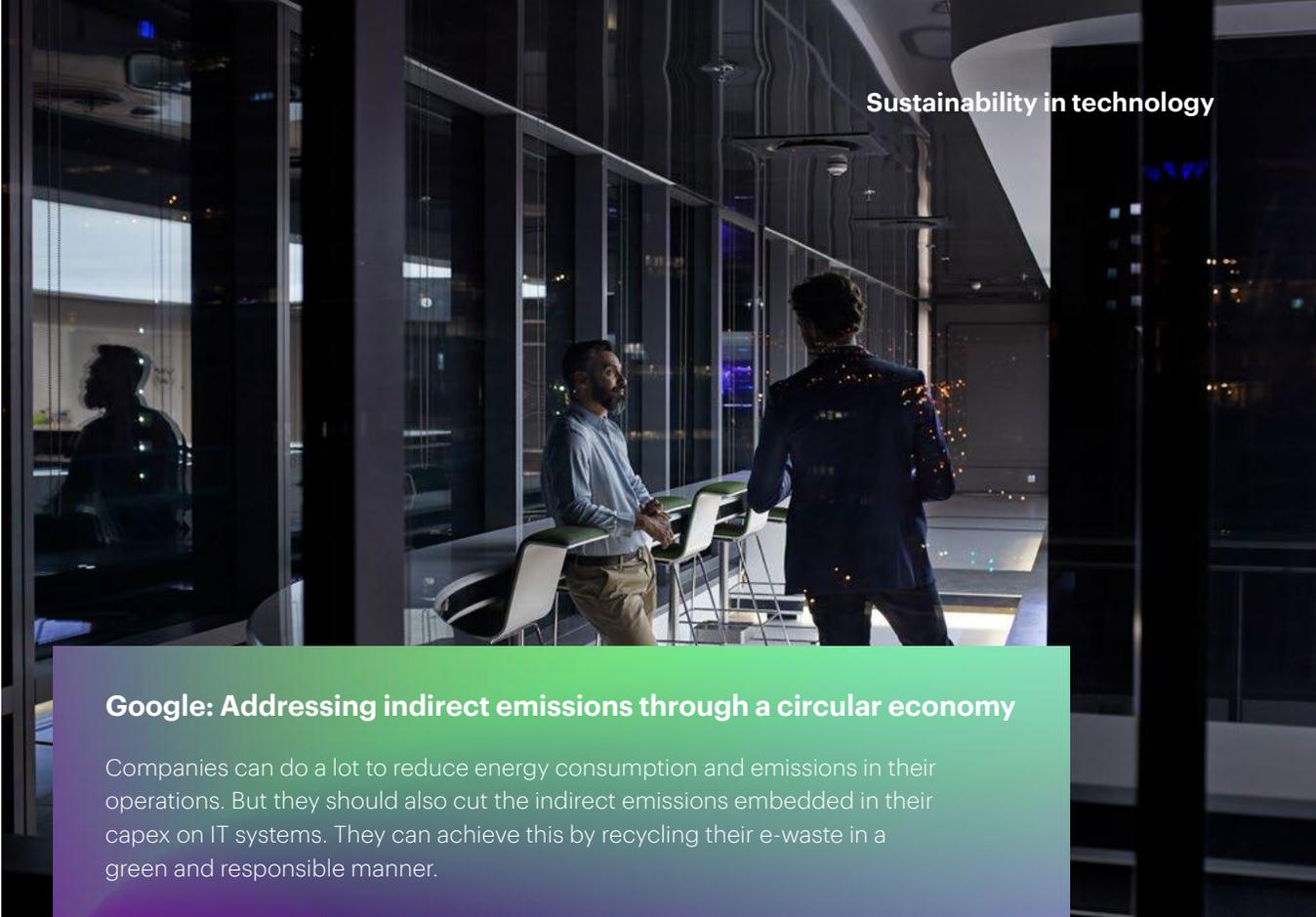
Another important consideration is the metaverse—which converges the physical and digital worlds through a combination of technologies ranging from cloud and AI to extended reality (XR) and blockchain. It will take a combination of these green software principles to ensure that the metaverse does not cause a surge in greenhouse gas emissions.



## Green infrastructure

The hardware layer generates both direct and indirect emissions. It includes end-user devices such as laptops and desktop computers as well as cloud, datacenters, and networks. It's vital to identify which devices have the biggest impact, and then develop a strategy to address them.

Creating leaner software can help reduce the need for more capex in hardware systems. This shrinks the carbon footprint of both manufacturing and operations. In fact, a large proportion of device-related emissions comes from manufacturing. For example, it's estimated that to counteract the carbon footprint from manufacturing, the current average lifetime use of smartphones would need to increase by up to three years.<sup>46</sup> It is imperative, therefore, that organizations shift the current "take-make-waste" model to a "take-make-take-make" model that keeps devices operational for as long as possible, then reuses and recycles the raw materials in zero-waste value chains. There's still huge room for improvement in this area. Currently, only about 17% of e-waste collected is recycled.<sup>47</sup> And most organizations recycle less than 10% of their hardware.



### Google: Addressing indirect emissions through a circular economy

Companies can do a lot to reduce energy consumption and emissions in their operations. But they should also cut the indirect emissions embedded in their capex on IT systems. They can achieve this by recycling their e-waste in a green and responsible manner.

For instance, think of Google, which declared a net-zero lifetime carbon footprint in 2020.<sup>48</sup> The company developed a circular value chain for its data centers by focusing on four strategies—Maintain, Refurbish, Reuse, and Recycle.<sup>49</sup> Google tries to get the most out of every component used in its data centers. In 2020, 23% of the hardware components used in server upgrades were refurbished. The company also announced that by 2022, it would incorporate recycled materials in all of its Made by Google products. Further, Google actively participates in "Drive Reuse" initiatives: It sold 8.2 million components in the secondary market in 2020.<sup>50</sup>

## 02

### Build trustworthy systems: Incorporate privacy, fairness, transparency, robustness, and accessibility

The environmental aspects of sustainability are important, but they're not the only issue that matters. Companies need to make trust a fundamental element of their business model and competitive edge.

Companies like Lemonade, a New York-based insurance company, bank on reciprocity of trust to create competitive edge. The company provides instantaneous claims settlement through a combination of machine learning, chatbot, and cloud. Lemonade simply takes a fixed percent of the premium and allows its customers to send the remaining amount to a charity of their choice. This means that the customers have little incentive to cheat. Sophisticated use of technology underpins this model of trust.

As the company explains: *"At Lemonade, we're playing a version of the trust game. We trust our customers, and therefore often pay their claims instantly. We're doing so in a fair and transparent way, hoping to effect a virtuous cycle of trust and reciprocity."* And they are witnessing this reciprocity in action. One of their policyholders received the claim for a stolen laptop from the AI chatbot. But a few days later he wrote to Lemonade's claims officers seeking to return the payout. He said that his laptop had been located and returned to him. The claims officer, who had been in the industry for decades, could not believe it. This had never happened to him. For Lemonade, this is not an isolated case: Nearly 5% of their customers returned the claim after their stolen item was found.<sup>51</sup> In essence, our evolutionary instincts program us for reciprocity, whether it is trust or distrust.

For a sustainable technology strategy to cover all the bases, it must also consider the human and social impacts of technology, and—in turn—its effect on company performance. Failure to tackle trust can not only undermine an organization's wider ESG strategy, but it can also entangle it in a reciprocity of distrust affecting its shareholder value.

There are five areas of trust that are particularly important for technology systems: privacy, fairness, transparency, robustness, and accessibility.



### Privacy

To build trust with their customers and stakeholders, organizations will increasingly rely on privacy-preserving techniques, such as multiparty systems like **blockchain**, distributed ledgers, and tokenization protocols.

In a multiparty system, data isn't just "information" anymore—it can act as instructions, authentication and even enforcement, with the power to declare which aspects of the data can be shared and how the data can be used, as well as revoking permissions when those terms are violated.<sup>52</sup> By being "trustless" in the sense that third parties are not needed, multiparty systems protect the privacy of users and build trust.

In many cases, it's possible to re-identify individuals—even in anonymized datasets—by using publicly available information. That's why companies like LinkedIn are adopting differential privacy by introducing random noise in data, while losing very little information in the overall dataset.<sup>53</sup> For example, you can see aggregated analytics and demographic information on people who viewed an article, but you can't see which specific users read it. The focus is on protecting private actions, such as clicking on an article, while still being able to share aggregated analytics and insights on how well a campaign performed across different demographic groups.

Accenture Labs has used another approach for some use cases. It generates synthetic data that retains the statistical properties of the original but retains none of the initial data to safeguard individuals' privacy. Organizations can also opt for "data cooperatives" that combine a number of privacy-preserving techniques to protect data at rest or in transit.

## Fairness

Whether they are employees or customers, people need the assurance that the decisions taken by the AI models built on top of the data-sharing platforms are fair and unbiased. As companies rely on increasing levels of automation for everything, from hiring to resource allocation, fairness is becoming increasingly important: Witness how HR departments now commonly use AI to source and evaluate candidates. However, a [study](#) by Harvard Business School and Accenture has revealed that these AI models screen out millions of “hidden workers”—such as people with disabilities, gaps in their employment history, care responsibilities, or few formal qualifications.<sup>54</sup>

There are various ways that companies can make their AI models fairer. [Many tools](#) exist that identify when certain groups of people are treated unfairly by an algorithm and model the impact of potential corrective measures. Together with Allied Irish Bank (AIB), we explored how theoretical approaches to tackling algorithmic bias could be applied to real-world retail-banking scenarios. We built a tool that assesses models for bias, enabling AIB to affirm confidence and a deeper understanding of their models, and to continue to deliver fair, trustworthy banking for their customers.

## Transparency

Trust, fairness and transparency are closely interlinked. Being able to explain AI-powered decisions—whether these involve turning down an employee’s request for promotion or rejecting a customer’s application for a bank loan—is important for building trust. But causality is often difficult to explain with AI systems that remain a “black box.” To enhance transparency, Accenture has helped clients use counterfactual explanations which show what it would take to flip a decision from “no” to “yes.” So, in the scenario of a customer applying for a bank loan, you might tell them by how much they would need to increase their salary to become eligible. Another approach is using knowledge graphs to discover new connections that might influence the decision. Organizations may sometimes need to remove some variables if they find these tend to cause bias in algorithms. AI models can also be designed to enable “causal analysis” such as whether a particular outcome is affected by who is making the decision or merely a correlation we see in our data.



## Robustness

Organizations today operate in a high-risk environment. Accenture’s State of Cybersecurity Resilience study revealed that the average number of cyberattacks had risen 31% in 2021 over the previous year. At the same time, nearly one-third of more than 4,700 CISOs said that security is not a part of cloud discussions, and they lack the internal skills to create a proper cloud security framework.<sup>55</sup>

C-suite executives also tend to underestimate the risks associated with emerging technologies: AI, 5G, extended reality, and quantum computing.<sup>56</sup> For example, cybercriminals can destabilize the behavior of out-of-the-box AI solutions by poisoning the data, carefully manipulating some part of the model, or “backdooring” into one common model that affects many others.<sup>57</sup>

Clearly, companies need to build robust systems that are secure from external manipulation. As a first step, the CXOs need to work in close partnership with the CISOs to drive down risks in alignment with business priorities. They must constantly assess and monitor the risks to business, including cyber culture and cybersecurity resilience. And given the current climate of accelerated movement to cloud, security has to be a key concern from the very start—rather than an afterthought.

Finally, CXOs need to recognize that emerging technologies can pose security risks too. They need to create a risk framework and implement mitigating mechanisms. For example, by subjecting AI models to adversarial attacks, companies can retrain these models to be more robust. They can prune their full-scale AI models to perform within the power- and storage-constrained edge environments without compromising their defense mechanisms. And they can add humans into the loop to handle sensitive data and processes, such as authorizing large transactions.

## Accessibility and inclusion

To support organizations’ ESG goals, technology must be inclusive. But this isn’t always the case. Despite growing awareness of the need for technology to be accessible to all, much more needs to be done **to create an inclusive work culture** where people with disabilities can thrive and enjoy the same ease of access as others (see Figure 9).

**Figure 9.**

Companies’ efforts to make their technology more accessible.



What should companies be doing about this? Three things. First, ensure that IT accessibility requirements and standards are clearly established at the start of the software development lifecycle. Second, train developers on accessible design. And third, audit all software and platforms to make sure that they meet the accessibility needs of all employees and customers, whatever their abilities.

Accenture has mapped out a multi-year plan to drive collaboration between the IT organization and other Accenture teams toward making all employee interaction with software, devices, and services fully accessible, all the time. Initiatives include defining global accessibility standards, creating a virtual Accessibility Center of Excellence, and formalizing a global IT Accessibility practice and program.

# 03

## Institute the right governance mechanisms

Sustainability practices are still too often an afterthought when companies assess how software works and how it's used. How should companies improve? By taking a proactive and strategic approach to embedding sustainability in technology. Each time companies develop or start using a new technology, they should work to identify any potential unintended negative consequences for sustainability.

The key to success? Recognizing that delivering on sustainability in tech will require clear governance structures that define principles, practices, and metrics to eliminate inertia and conflicting priorities, underpinned by enterprise-wide training, led from the top.

### Create transparent governance structures

As Salesforce's Einstein AI technology is made available across its products, the company has reinforced its commitment to ethical and responsible AI. It created an Office of Ethical and Humane Use, which defined and implemented an ethical AI framework across the organization based on the principles of human rights, privacy, safety, honesty, and inclusion. The framework clearly defines the steps to be taken to resolve concerns.<sup>58</sup>

- establish a committee consisting of diverse team members with clear authority to govern, and clarity of roles and responsibilities
- build an actionable playbook that translates principles into practice and defines stakeholders responsible for various actions
- provide personalized training to team members on ethical principles and how to mitigate unintended consequences
- establish channels to raise questions and to escalate and resolve concerns for shared responsibility.

Essentially, these steps include communicating with stakeholders and industry experts, encouraging counter-perspectives, and removing bias from training datasets using best practices established by the Data Science Review Board.<sup>59</sup>

## Draw on cross-domain expertise

There are no simple checklists for creating green software or responsible AI. Instead, companies will need to rely on a culture of responsibility, driven by a collaborative approach across different parts of the business. For example, strategy and marketing leaders should assess brand and reputational risks. Compliance and legal teams must define ethical and procedural principles. And human resources will need to reskill employees, as well as minimize risks.

Getting both business and IT experts involved is important, because most decisions will require buy-in from across the organization. For example, migrating to public cloud to reduce the carbon footprint of datacenters may seem like an easy win, but it's vital to ensure that the cloud meets business needs around latency, security, and regulatory compliance.

Cross-domain expertise becomes even more important in view of the revolution in immersive tech (eg virtual and augmented reality) happening around us.<sup>60</sup> The potential impact of these technologies on human behavior, mental health, and general wellbeing remains largely unexplored. What's more, there are other potential risks relating to technology, such as fake news, cyberbullying or dissociative disorders due to technology addiction. Addressing these issues will require the involvement of neuroscientists, mental health experts, and behavioral scientists.

For example, digitally created doubles of individuals, or "digital personas," are increasingly central to creating compelling brand experiences. However, companies must ensure that these digital personas are ethical by design as well as protected from abuse.<sup>61</sup> This issue raises tricky questions. How do you obtain consent from customers? How do you prevent racial and gender bias in creating these personas? How do you protect these digital twins of people from hacking? As more companies offer experiences via digital personas, these issues will become too big to ignore.

## Develop a culture of sustainability across the organization

The sustainable software movement is not the sole obligation of software engineers. It requires collaboration from all employees, irrespective of their job description. That's why Google's central accessibility team provides accessibility training courses to all employees, especially software engineers, product managers, and user-experience designers. Both internal and external developers are encouraged to test their products for accessibility across platforms like iOS, Android, and the web.

Further, Google's innovation is driven in close collaboration with people living with disabilities. For example, the new Accessibility menu in Android was developed based on the user experience of people living with muscular dystrophy or spinal cord injuries. It's designed to ease their everyday use of smartphones. And in September 2020, Google organized more than 200 global meetups of local guides to identify accessibility issues at over 12 million locations, such as restaurants and restrooms.

Google is also adopting AI tools, such as YouTube live captioning and Lookout (an app that uses computer vision to identify food labels and banknotes or read documents). These technologies are helping the company iterate products constantly for an ever-changing virtual and physical world.<sup>62</sup>

Trust in new technologies is paramount. For instance, the metaverse's success will depend on fostering trust in the underlying technology and experiences to drive adoption and user acceptance. That trust is contingent upon concepts that consumers and enterprises care about today: safety, privacy, security, sustainability, equity, inclusion, accessibility, wellbeing, and more.

### CIOs to the fore

Although technology is becoming core to executives’ sustainability agendas, the role of most CIOs has not evolved in line with this shift (see Figure 10.) Legacy business processes may continue to hamper this evolution.

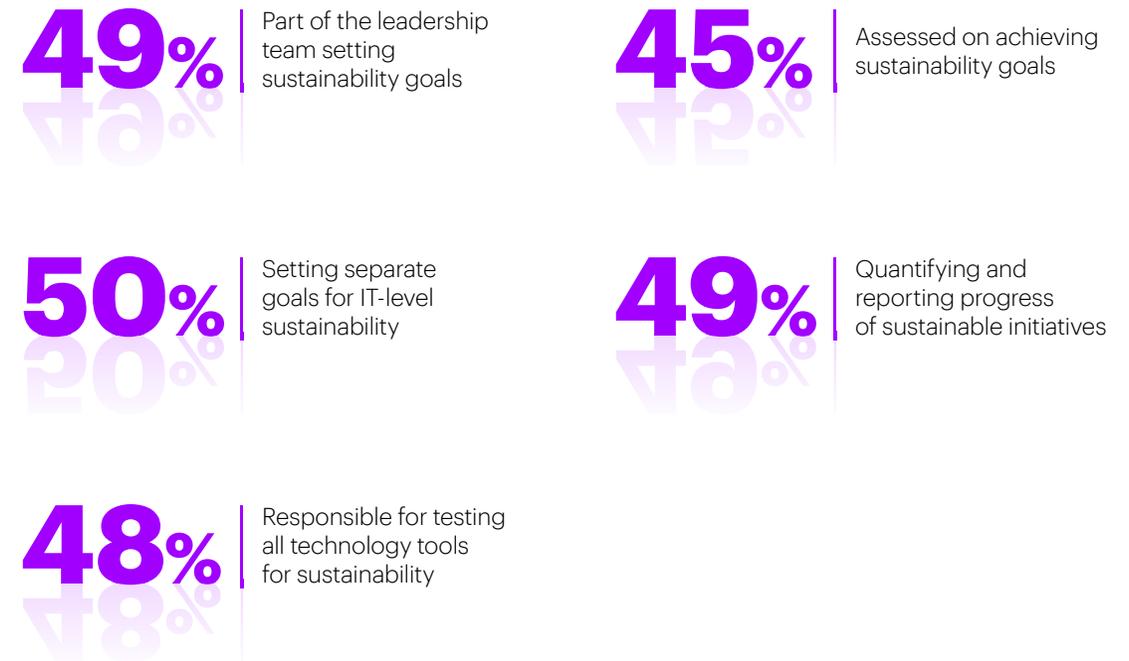
For example, when it comes to green software, many CIOs don’t know how much electricity their IT systems consume. Why? Because the electricity bill comes out of the facilities management team’s budget.

The same applies to cloud. Developers can make cloud workloads more efficient. But they are unlikely to do so unless they’re aware of the power consumption, monetary costs, and carbon emissions they incur by procuring cloud storage. There needs to be a mindset shift away from the current default of building excess capacity to promote traditional IT goals. Instead, the focus needs to be on green software. To help encourage this shift, Microsoft, for example, has built a sustainability calculator its customers can use to track carbon emissions and identify their causes.<sup>63</sup>

Delivering on the promise of sustainable technology will require CIOs to take a seat at the sustainability table. They must work in close collaboration with other executives to identify the technologies that will help the company achieve its sustainability goals. And, at the same time, they must address the environmental and social impacts of the technology itself.

**Figure 10:**

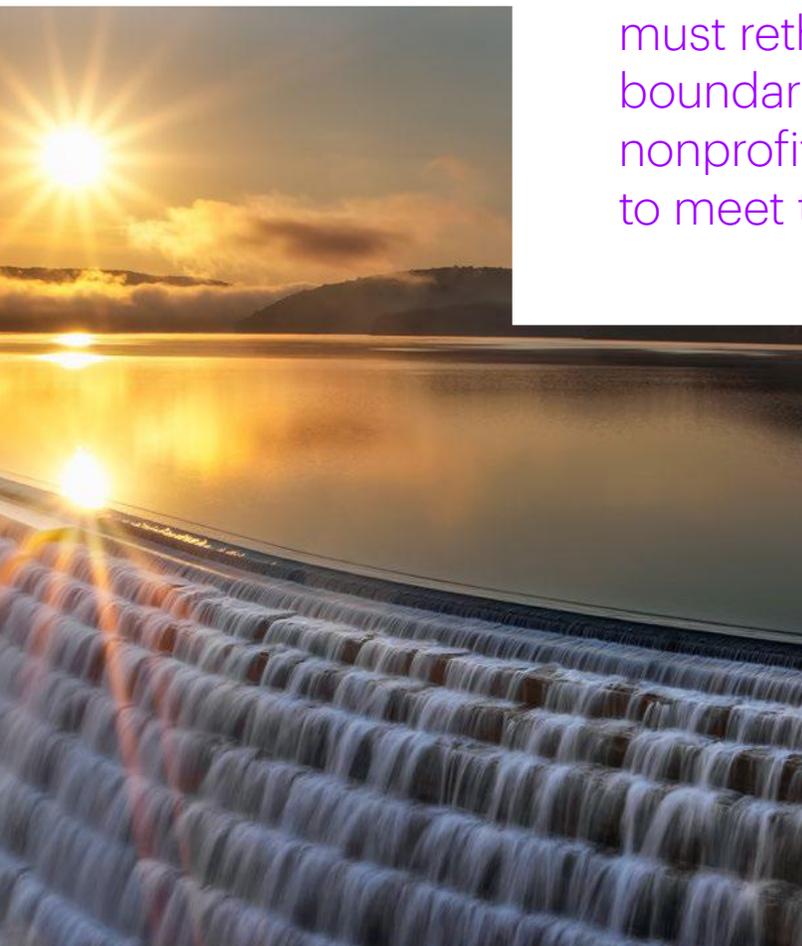
The role and responsibilities of CIOs for sustainability.





# Sustainability at scale

No single organization can hope to address global sustainability challenges and create impact at scale on its own. In this decade to deliver, companies must rethink their use of technology to drive urgent action beyond the boundaries of their own organizations. In other words, businesses, startups, nonprofits, academia and public-sector organizations must work together to meet the United Nations Sustainable Development Goals (SDGs).



Ecosystems, in their pure form of complex networks or interconnected systems, will help revolutionize the use of technology and drive sustainability at scale. The first step will be measuring and analyzing carbon footprints. Beyond that, accelerated innovation will be needed for solving complex problems—for example, cutting carbon emissions at scale by enabling reliable, high-quality data ingestion, integration, transparency, and auditability. All this means working beyond the boundaries of one company to decarbonize the entire value chain.

Continued coordinated action with government organizations, policymakers and market forums such as the International Sustainability Standards Board (ISSB) will be essential for fostering standardization, bringing in regulations, and building awareness. And companies will need to work with startups and nonprofits to collect data and create impact at the last mile, all the way from the farmer, miner or forester to the consumer—at scale.

Organizations are aware of the important role of ecosystems. In fact, 43% of companies in our survey are now joining industry

collaborations, alliances, and advocacy groups focused on eco-friendly technology. Take the MIT Climate and Sustainability Consortium (MCSC)—a cross-industry alliance that’s accelerating the development of solutions to address sustainability issues. Its core objectives? Drive down costs. Lower the barriers to adoption of sustainable technologies and processes. And hasten the retirement of carbon-intensive technologies.

These are all steps in the right direction. But delivering sustainability at scale will need more focused attention and technology standardization. Stakeholders also need to see how they’ll benefit from participating in these broader initiatives. We need to fundamentally reimagine how technology can help change human behavior, rethink how we produce and consume resources, and rebuild entire industry clusters for sustainability to ensure that the SDGs are met.

Let’s explore how we can use technology to address some of the most complex problems we face today.

## Breaking barriers with technology to solve the “30% problem”

We have identified some of the key problems that will need special attention and are likely to prove impossible to solve without the interplay of ecosystems and technology. We refer to them as the “30% problem” (see Figure 11.) This describes a range of key statistics that show how, in assessing progress toward the SDGs, the 30% figure comes up again and again. They represent the persistent and intractable “wicked” problems that have proved to be extremely difficult to address through the regular workings of the market mechanism. And they need urgent attention if we are to achieve the SDG ambition by 2030.

Digital technologies can align the entire ecosystem to find innovative and scalable solutions that address these problems by creating markets for sustainability. And we need these alternative solutions. We can’t hope to keep burning fossil fuels and still be sustainable. Or continue with current modes of education, which require a teacher per 40 students, to deliver quality education at scale. Innovations that rely on technology to do most of the heavy lifting—like Sugata Mitra’s US\$1 million TED prize winning “school in the cloud” experiment, where students cluster around a single computer to find answers to questions posed by a “granny” teacher in the cloud—can be more effective and affordable. They can also address a variety of constraints, such as lack of quality teachers or classrooms to provide education to millions of poor children.

Of course, the SDGs are bigger than these issues. But each one is still a complex challenge that must be solved to achieve the SDGs by 2030.

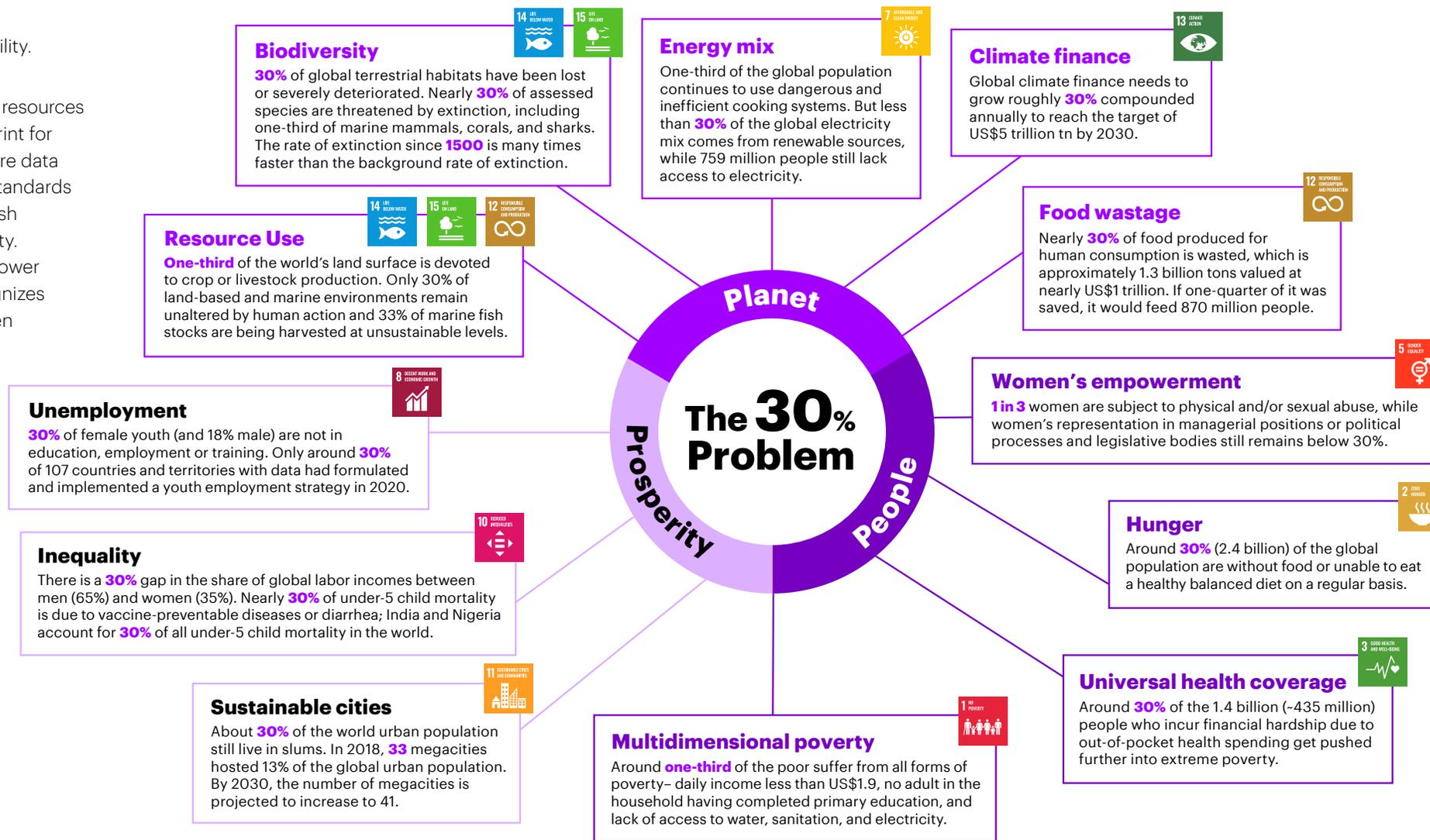
There are some important points to note about these challenges:

- In many ways, they’re interconnected. So solving one problem helps to solve the others. For example, 30% of all food produced is wasted. Reducing food waste can help meet the goal of zero hunger. Even better, it requires no increase in the land devoted to crop cultivation, which often causes deforestation and loss of biodiversity.
- These challenges will need a wider ecosystem play to solve them—no single organization can hope to do it alone. Big improvements will only be made when multiple organizations (eg government agencies, banks, agritech companies, biochemicals, farmers, agri-buyers, consumer packaged goods manufacturers, and retailers) come together, working across organizational boundaries. The importance of this ecosystem play is even greater when one considers that solving these challenges will require many of them to be addressed simultaneously. For example, efforts to alleviate poverty will be hampered if 30% of the low-income population keeps falling back deeper into poverty due to lack of affordable medical care.
- Technology can be a key enabler in overcoming these challenges. That might mean mapping and visualizing the issues across value chains, convening people to build solutions, or creating integrated platforms designed to serve a common purpose.

**Figure 11.**

The 30% problem of sustainability.

Organizations will need to pool resources and develop a common blueprint for action. They'll also need to share data and best practices, agree on standards and specifications, and establish transparency and accountability. It's all about tapping into the power of the ecosystem, which recognizes the interdependencies between organizations, stakeholders, and technology.





## Digital finance for changing human behavior

Human consumption is at the root of exponential carbon emissions, climate change, and loss of biodiversity. Behavioral change is needed to catalyze sustainable action and habits. But changing the behavior of billions of people is no easy task. And there's an acute shortage of finance for sustainability. The "Every Action Counts" coalition seeks to leverage technology and partnerships to enhance green awareness and spark action by one billion green digital champions around the globe by 2025. The coalition was created by the Green Digital Finance Alliance, which was launched by Ant Financial Services and the UN Environment Programme (UNEP). It's committed to using digital technology to reshape the current financial system around sustainability.

The coalition aims to promote knowledge-sharing to inspire innovative green technology solutions around the world. It's working to help each payment platform and consumer goods company focus on the green behaviors most important to its audience. Members include companies such as BBVA, Ant Group, Mastercard, Lazada, and Rabobank. They're promoting locally relevant tech-enabled approaches to drive sustainable consumer behaviors in the regions where they operate.

## Platform ecosystems to reduce Scope 3+ emissions

Currently, most companies are focused on reducing their:

- Scope 1 greenhouse gas emissions—direct emissions generated by their operations, and
- Scope 2 emissions—indirect emissions related to their purchase of electricity, steam, heat, and cooling.

Beyond that, organizations should focus on their Scope 3 emissions—the indirect emissions generated in their value chains, but not by activities that the companies own or control. Forward-thinking companies are now setting targets for the Scope 3 emissions within their downstream and upstream value chains. There's a big opportunity for an anchor player in each industry to set ambitious targets. This player can then encourage its suppliers and consumers to follow suit using incentives, brand exposure, or simply gamification.

One of the leaders on this front is Walmart, which launched Project Gigaton to engage suppliers in climate action. It's also working with NGOs and other stakeholders to avoid, sequester or cut one gigaton (one billion metric tons) of carbon emissions from its global value chain by 2030. Walmart's challenge is to collect data from its 100,000+ suppliers and encourage them to reduce their own carbon footprints. This, in turn, helps Walmart cut its Scope 3 emissions.

What else is Walmart doing? In 2020, it partnered with Schneider Electric to launch the Gigaton PPA program. In this initiative, Walmart will use Schneider Electric's global collaboration platform and community of 300 renewable energy purchasers and solution providers to educate its own suppliers on renewable energy transactions and purchase agreements.<sup>64</sup> As of April 2022, 2,300 suppliers have joined the program. And so far, Walmart has cut the carbon emissions from its global value chain by 416 million metric tons, or 42%.<sup>65</sup>

Alibaba has announced that it is reducing what it calls "Scope 3+ emissions," which are the emissions generated by all the participants in its platform's ecosystem. This is a powerful initiative, as Alibaba has grown to become the largest retail commerce business in the world in terms of gross merchandise value (GMV).

Alibaba has set a bold target of reducing its Scope 3+ greenhouse gas emissions by 1.5 gigatons by 2035. This will align it with broader efforts to limit global warming to 1.5°C. As part of this initiative, Alibaba intends to promote green consumption, recycle second-hand goods, embrace energy-efficient technologies and tools, and adopt more sustainable packaging practices. It's already making progress. For example, by using algorithms to optimize the size of boxes, Alibaba reduced the use of packaging materials by 15%.<sup>66</sup> It has also set a three-tier governance framework for meeting its objectives: a sustainable committee at the board level, a steering committee for strategic planning and goal-setting, and a cross-business action group with representatives from each business unit.

## Using technology to create impact at the last mile

Businesses weren't built for solving some of the problems they face today. Reducing carbon emissions or protecting human rights in their supply chains is complex enough. And it's even harder to meet goals like reducing inequality, providing clean water, and protecting wildlife. The fastest way for organizations to touch millions of lives? Partnering with startups and nonprofits to re-envision and amplify their impact at the last mile with technology.

What can this look like in practice? Take Project Amplify, for example, an initiative launched by Accenture and Microsoft Asia. This is supporting 47 startups with access to the latest technologies, expertise, and mentoring to scale their social impact and sustainability efforts. Participants in the program include:

- DIBIZ—a Singapore-based startup that seeks to help manufacturers, traders, and farmers collaborate on sustainability
- TapEffect—a social enterprise in Cambodia providing clean and safe tap-water to under-served towns and rural areas
- Docturnal—a company in India that leverages AI and machine learning for proactive, affordable, and non-invasive detection of diseases

- FluxGen—a sustainability startup in India that develops AI and IoT-based water management solutions to make industries water positive.

Another example? Look at charity: water. This nonprofit has provided clean, safe drinking water to nearly 15 million people in 29 countries. It's partnered with Accenture Labs' Tech4Good program to build an anomaly detection system that spots potential malfunctions with pump sensors, so repair mechanics can be dispatched as quickly as possible. The system uses data science, machine learning, advanced probabilistic models, and cloud-connected pump sensors. As a next step, the Accenture team is involved in delivering predictive maintenance solutions.

### Open data-sharing to advance sustainability

Ecopetrol, Accenture, and AWS have come together to build a groundbreaking industry platform. It enables ecosystem participants to share data and create a single source of truth to optimize water management and promote water reuse between and within industries. Ecopetrol is working hard to improve the environment for the communities where it operates. It's aiming to reduce freshwater capture by 66% and eliminate all discharges to surface water by 2045.<sup>67</sup>

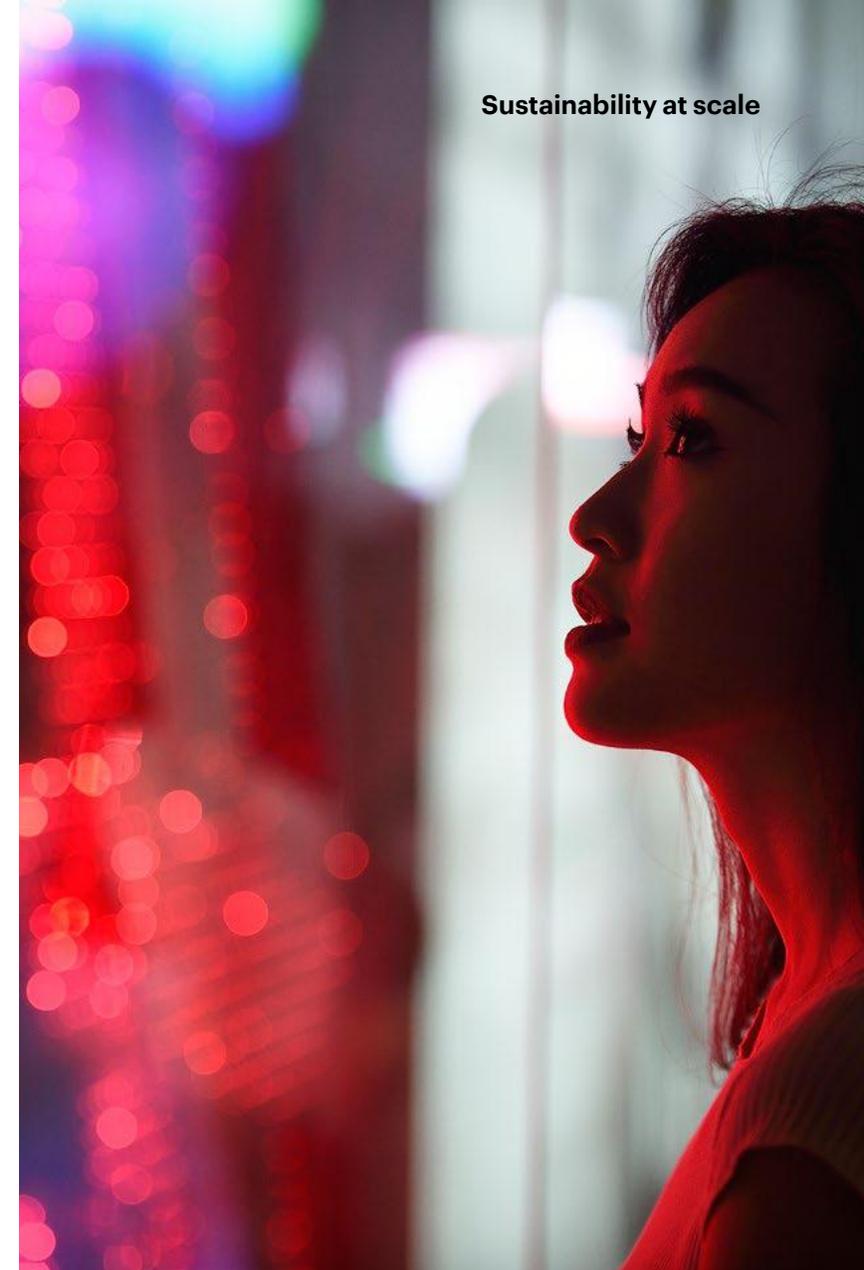
Or look at Mastercard, which has launched an Inclusive Growth Map that helps entrepreneurs, developers, urban planners, and economic development corporations to identify opportunities to invest in revitalizing neighborhoods. The system uses Mastercard's proprietary data from more than 37 million people across the United States. The map helped identify opportunities for retail in neighborhoods of City of New Orleans that were struggling to recover after Hurricane Katrina. Two years later, those neighborhoods had seen a 200% increase in economic activity and spending.<sup>68</sup>

### Empowering youth with digital technology and skills

Youth unemployment and low wages are major concerns in the developing world. But these topics are becoming even more important, given how intelligent technologies are set to reconfigure the nature of work and skills required for certain roles. Automation is likely to have the greatest impact on lower-skilled work, placing young workers at particular risk. And special attention should be paid to the impact on jobs done by women, many of whom are already adversely affected by the gender pay gap.

Technology can help solve these issues. For instance, personalized, accelerated, continuous, and experiential learning can accelerate reskilling. However, addressing the challenge at scale will require multi-stakeholder partnerships. One example of this is the One Million Arab Coders platform launched by the United Arab Emirates government. This is supported by various stakeholders including Facebook, Oracle, and Udacity. And it's also backed by a number of companies that provide employment to people graduating from the program.<sup>69</sup>

Addressing the gender pay gap will require support from businesses, governments, and academia. It's essential to help women get better-paid jobs and increase their digital fluency.<sup>70</sup> Business leaders must also focus on creating a culture of inclusion in the workplace. For example, here at Accenture, we aim to achieve a gender-balanced workforce by 2025. So we're creating flexible working arrangements to support women. And we're partnering with external organizations like everywoman and Catalyst that offer self-development platforms for the advancement of women in business.<sup>71</sup>



### Incentivizing change by opening markets for sustainability

Rabobank, a cooperative bank in the Netherlands with a significant focus on international business and rural activities, is opening carbon markets for farmers. Using remote sensing technology and AI, the bank is making carbon sequestering and monetization both affordable and scalable. And it's incentivizing farmers to adopt agroforestry by enabling them to profit from selling "carbon removal units" in carbon markets.

To scale the program, Rabobank is partnering with a number of NGOs, cooperatives, and governments.<sup>72</sup> It recently issued its first low-interest "SDG 12.3" loan, aimed at helping organizations meet the SDGs. The first customer? A large organic supermarket chain called Ekoplaza, which plans to use the money to help reduce food waste.

### Designing standards, specifications, and certifications for sustainable technology

Current sustainable technology initiatives are missing a few critical ingredients. For example, there's a distinct lack of design standards and specifications, as well as people trained in developing sustainable software. Accenture and Microsoft—along with GitHub and Thoughtworks—are founding members of the Green Software Foundation (GSF).<sup>73</sup> This aims to build an ecosystem of people, standards, tooling, and practices

to reduce carbon emissions generated by software development. It's the first such industry consortium born out of a desire to meet the ICT sector's goal of achieving a 45% reduction in greenhouse gas emissions by 2030. The ecosystem is continuing to expand, as the foundation welcomes new members such as BCG GAMMA, Goldman Sachs, Shell, Amadeus and NTT DATA, among many others.

Dedicated working groups at the GSF are focused on calculating and reporting on application-level carbon intensity, developing best practices on energy patterns for AI, and creating tools and training resources for green software engineering. For example, the Software Carbon Intensity technical specification aims to clearly articulate the methodology for calculating total carbon emissions.<sup>74</sup> The aim is to overcome the problems of opaque metrics and lack of standardization across industries.

Most organizations are currently constrained by the lack of tools and practices for sustainable technology. The World Economic Forum (WEF) has launched the Global AI Action Alliance, which brings together more than 100 companies, governments, civil society organizations, and academic institutions to accelerate the adoption of inclusive, transparent, and trusted AI.<sup>75</sup> As the Alliance notes, while there has been explosive growth in ethical AI guidelines, this has created an implementation and learning gap—both in designing and deploying ethical AI, as well as rapidly scaling proven tools and practices. The Alliance's goals include developing tools and practices for reducing bias and driving responsible product design, and developing a certification mark for responsible AI design.





Governments too are setting up independent advisory bodies to provide oversight and impartial expert advice on ethical and responsible use of data and AI. Examples include the Centre for Data Ethics and Innovation (CDEI) in the United Kingdom and Singapore's Advisory Council on Ethical Use of AI and Data. As a part of these ecosystems, technology companies can help provide concrete guidance, supported by metrics, to accelerate action.

### Benefiting from innovations in climate tech

Partnerships with academia and startups can help accelerate innovation in sustainability. The aim? To reinvent products and services and develop new lines of business with sustainability "built in."

Our research found that 51% of companies are working with academia and research labs to develop innovative sustainable technology solutions. And some 41% of companies are creating new tools and technologies for sustainability through collaborations with startups or niche partners. The startup ecosystem, in particular, is achieving astonishing growth. It received US\$37 billion of venture capital investment in climate tech in 2021 alone—2.5 times the pre-pandemic level.<sup>76</sup>

This new wave of innovation is powered by carbon-intelligent platforms, with plug-and-play sensors, data integration from multiple sources on cloud, and visualization and simulation of emissions for optimization. One example is Arabesque, which brings together AI, ESG data and financial technology to provide advisory and data solutions focused on performance

and sustainability. Another is Supercritical, a startup building software solutions based on the "footprint, reduce and remove" principle to help businesses achieve their net-zero goals.

Two considerations will be important for stitching together an ecosystem to scale sustainability with technology:

1. The material impact the sustainability initiative has on a company's stakeholders and broader society.
2. Identifying common goals that bring partners together. This will help companies overcome the most critical barriers they face in using technology to scale sustainability.

The process of navigating this complex maze can be further accelerated by support from technology companies. One example is SDG Ambition, a joint vision of the UN Global Compact, Accenture, and SAP, with 3M as patron sponsor. SDG Ambition has published concrete guidance to help more than 1,000 businesses across 40 countries accelerate action toward achieving the SDGs, especially around tracking their sustainability performance and enhancing their impacts in line with benchmarks.<sup>77</sup> SAP and Accenture also launched a global sustainability-focused accelerator program at SAP, iO Foundries.<sup>78</sup> This aims to help early-stage B2B startups incubate new technology solutions for sustainability and build startup innovation networks, all while minimizing their own IT carbon impact.

## Is your tech strategy reactive or ready?

Delivering on the sustainability agenda will be impossible without technology. However, companies must also look at the other side of the equation—one that's often been neglected: making the technology itself more sustainable. This will help organizations respond to customer, investor, and employee demands, while shaping a brighter future for people and the planet. And it'll become increasingly important at a time of compressed transformation, as technology becomes ever more deeply embedded in our lives and businesses.

CIOs must take a fresh look at their technology through the lens of sustainability. Creating and implementing a comprehensive sustainable technology strategy—one that makes technology more sustainable and uses that technology to drive sustainability at scale—is now the core mission of the purpose-driven CIO. The responsibility is huge. But the opportunity is even bigger. In seizing it, CIOs will drive new sources of value, while leading the way to a more sustainable future.

# Authors

## **Paul Daugherty**

*Group Chief Executive*

*Accenture Technology & Chief Technology Officer*

[paul.r.daugherty@accenture.com](mailto:paul.r.daugherty@accenture.com)

## **Peter Lacy**

*Accenture Global Sustainability Services*

*Lead & Chief Responsibility Officer*

[peter.lacy@accenture.com](mailto:peter.lacy@accenture.com)

## **Sanjay Podder**

*Accenture Global Lead –*

*Technology Sustainability*

[sanjay.podder@accenture.com](mailto:sanjay.podder@accenture.com)

## **Shalabh Kumar Singh**

*Thought Leadership Research Senior*

*Principal, Accenture Research*

[shalabh.kumar.singh@accenture.com](mailto:shalabh.kumar.singh@accenture.com)

# Contacts

## **Sanjay Podder**

Accenture Global Lead –  
Technology Sustainability

[sanjay.podder@accenture.com](mailto:sanjay.podder@accenture.com)

## **Julia Kusterer**

Europe Lead –  
Technology Sustainability

[julia.kusterer@accenture.com](mailto:julia.kusterer@accenture.com)

## **Anand Nataraj**

Asia Pacific, Middle East,  
Africa and LATAM Lead –  
Technology Sustainability

[a.nataraj@accenture.com](mailto:a.nataraj@accenture.com)

## **Pasha Ponomarev**

North America – Sustainability Strategy

[pavel.ponomarev@accenture.com](mailto:pavel.ponomarev@accenture.com)

## **Sophie Mayo**

Global Lead – Sustainability Ecosystem

[sophie.j.mayo@accenture.com](mailto:sophie.j.mayo@accenture.com)

# Contributors

## **Matthew Robinson**

Managing Director, Accenture Research

## **Vikrant Kaulgud**

Technology Lab Fellow, Accenture Labs

## **Ray Eitel-Porter**

Global Lead—Responsible AI, Accenture

## **Sophie Mayo**

Managing Director, Accenture Sustainability Partnerships

## **Giju Mathew**

Manager, Accenture Research

## **Medb Corcoran**

Managing Director, Accenture Labs

# Acknowledgement

We'd like to express our thanks for the valuable insights of the many external experts who contributed to the report's findings. We're also grateful to **Melina Viglino** (survey lead), **Rebecca Tan** (editor), **Jakub Wiatrak**, **Swathi Sivaraman**, **Katarzyna Furdzik** and **Regina F. Maruca**.

# About the research

## ESG performance regression analysis

We applied regression analysis to look at the relationship between sustainable technology adoption and companies' overall ESG performance. In this process, we used the Q4 2021 Arabesque S-Ray ESG scores for the 276 companies that overlap with our survey sample. Our analysis controls for a company's specific effects such as: industry, country, and size. We developed the following equation:

$$ESG_n = \alpha \cdot A_n + \sum_{j=1}^l \beta_j \cdot C_{j,n} + \varepsilon_n$$

where  $ESG_n$  – company's  $n$  ESG score,

$A_n$  – sustainable technology adoption variable,

$C_{j,n}$  – firm-specific controls such as industry, country, size.

## Sustainable Technology Index and 360° Value delivery

To measure companies' performance in sustainable technology, we created the Sustainable Technology Index.

**Figure 12:**

Sustainable Technology Index structure.



The Index is based on the sum of positive responses to multiple-choice survey questions and normalized on a scale of 0-1. We applied equal weights on each level of aggregation.

The Sustainable Technology Index (STI) was used in binary response regression analysis. In this approach, we analyzed the probability that a company is delivering value across 360° (ie the benefits include improvements in five or more KPIs related to various areas of an organization's operations). We developed the following equation:

$$Pr(V_n = 1) = \alpha \cdot STI_n + \sum_{j=1}^l \beta_j \cdot C_{j,n} + \varepsilon_n$$

where  $V_n$  – company's  $n$  meeting five or more of the 360° Value KPIs,

$STI_n$  – Sustainable Technology Index,

$C_{j,n}$  – firm-specific controls such as industry, country, size.

# Survey

The research was conducted in September and October 2021 via a web survey. The sample comprised of 560 CIOs, CTOs, Chief Sustainability Officers, and those directly reporting to them (Directors, VPs) from companies above US\$1 billion revenue. The research had a global scope, covering 12 countries and 11 industries.

## Survey Demographics–Full Data

Country	N=	%	Primary Industry	N=	%	CG&S Sector	N=	%	Job Function	N=	%
Argentina	21	4	Banking	51	9	Agricultural	17	31	CIO or equivalent	139	25
Australia	21	4	Communications/Media	50	9	Food	13	24	CTO or equivalent	138	25
Brazil	21	4	High Tech	52	9	Beverages/Alcoholic	8	15	CSO or equivalent	142	25
China	21	4	Chemicals	49	9	Home & Personal Care	5	9	Directly Reporting to	141	25
Germany	50	9	Consumer Goods	55	10	Beverages/Non-Alcoholic	4	7	CIO/CTO/CSO		
France	50	9	Retail	54	10	Tobacco	1	2			
United Kingdom	80	14	Health	48	9	Other	7	13	<b>Revenue</b>		
Japan	21	4	Natural Resources	51	9				\$1 to \$1.9 billion	194	35
Mexico	21	4	Automotive	50	9	<b>Banking Sector</b>			\$2 to \$4.9 billion	155	28
Malaysia	21	4	Industrial Manufacturing	50	9	Retail	9	18	\$5 to \$9.9 billion	85	15
Singapore	21	4	Life Sciences	50	9	Commercial	34	67	\$10 to \$14.9 billion	31	6
United States	212	38			Investment	7	14	\$15 to \$19.9 billion	20	4	
					Other	1	2	\$20 to \$24.9 billion	22	4	
								\$25 billion or more	53	9	
					<b>Health Sector</b>						
					Provider	32	67				
					Payor	16	33				

Source: Accenture Research Sustainable Tech Survey: October 2021, Sample: N = 560  
Copyright ©2022 Accenture. All rights reserved.

# References

1. Accenture (2021). Shaping the sustainable organization
2. United Nations Global Compact & Accenture (2021). Climate leadership in the eleventh hour
3. **Karen Hao**, MIT technology Review. *Training a single AI model can emit as much carbon as five cars in their lifetimes*. June 05, 2019
4. **Hannah Sparks**, New York Post. *A year of cell phone use emits as much CO2 as two round-trip flights*. May 01, 2019
5. This finding is based on an analysis of 276 companies in our research whose ESG impact has been scored by Arabesque S-Ray (a global data provider that specializes in measuring ESG metrics)
6. <https://www.accenture.com/us-en/insights/strategy/measuring-sustainability-creating-value>
7. [https://www.microsoft.com/en-us/corporate-responsibility/sustainability?activetab=pivot\\_1:primaryr3](https://www.microsoft.com/en-us/corporate-responsibility/sustainability?activetab=pivot_1:primaryr3)
8. <https://blogs.microsoft.com/blog/2020/01/16/microsoft-will-be-carbon-negative-by-2030/>
9. Kris Timmermans, "How supply chains can unlock net zero emissions," January 6, 2021, Accenture
10. Sanjay Podder and Shalabh Kumar Singh, "Tech + Sustainability = Leadership," April 12, 2021, Technology Innovation, Accenture
11. Accenture and Dassault Systems, "The critical role of virtual twins in accelerating sustainability," March 9, 2021
12. Sanofi, "Factory of the Future," April 8, 2020
13. Stephen Moore, "Porsche in Joint Effort for Plastics Traceability," Plastics Today, November 10, 2020
14. Mastercard Provenance Solution, "Building trust and transparency into modern supply chains"
15. Accenture, "Reality Check," 2021
16. Jeff Hogue, "We Need to Talk About Conscious Consumption," Levi Strauss & Co., June 2, 2021
17. <https://fashionforgood.com/about-us/>
18. <https://www.levistrauss.com/2020/10/08/making-levis-secondhand-second-nature-for-fans/>
19. Shell (2020). Three ways to thrive through the digital and energy transitions
20. <https://www.accenture.com/us-en/insights/strategy/measuring-sustainability-creating-value>
21. Peter Lacy et al, "Measuring sustainability. Creating Value," Accenture, 2022
22. <https://www.youtube.com/watch?v=BsLje6HW9pg>
23. Ellyn Shook, Peter Lacy, Adrian Monck, Jill Rademacher, "Shaping the sustainable organization," Accenture, 2021
24. For more, see Sanjay Podder and Shalabh Kumar Singh, "Tech + Sustainability = Leadership," Technology Innovation, Accenture, April 12, 2021
25. <https://www.bloomberg.com/news/articles/2022-01-12/twitter-leaned-on-work-from-anywhere-to-recruit-more-black-latinx-employees>
26. Belkhir, L. & Elmeligi, A. (2018). Assessing ICT global emissions footprint: Trends to 2040 & recommendations. *Journal of Cleaner Production*, 177, 448–463

27. <https://doi.org/10.1016/j.jclepro.2017.12.239>
28. Sanjay Podder, Adam Burden, Shalabh Kumar Singh, and Regina Maruca, "How Green is Your Software?", Harvard Business Review, September 18, 2020
29. <https://www.viget.com/articles/11-things-youre-already-doing-to-green-the-web-as-a-designer/>
30. Lizzy Rosenberg, "Even though it's virtual, the metaverse does actually impact the environment," World Economic Forum, 16 Feb 2022
31. **Karen Hao**, MIT technology Review. Training a single AI model can emit as much carbon as five cars in their lifetimes. June 05, 2019
32. Amodei, D. & Hernandez, D. (2018, May 16) AI and Compute. Open AI
33. Sanjay Podder and Shalabh Kumar Singh, "Sustainable Data: In pursuit of net zero," The Economist
34. **Yao, S., Xu, Y., Calzada, D.** Network Compression and Speedup
35. Accenture (2020). The green behind the cloud
36. Richard Evans, Jim Gao, "DeepMind AI Reduces Google Data Centre Cooling Bill by 40%," July 20, 2016
37. Ana Radovanovic, "Our data centers now work harder when the sun shines and wind blows," Google, April 22, 2021
38. Edge computing is being driven by developments on both the consumer and enterprise fronts. On the former, video streaming, gaming, and other data-intensive applications are creating huge amounts of data that must be stored and processed in real-time. On the latter, connected cars, robots, drones, enterprise mobile devices, cameras and sensors for IoT, and medical imaging devices all require agility (for processing) and security (for handling sensitive data)
39. The Economist, "The cost of training machines is becoming a problem," June 11, 2020
40. George Leopold, "Microsoft Azure Adds Graphcore's IPU," HPCWire, November 15, 2019
41. Chen Jin & Phil Brown, "BERT-Large Training on the IPU Explained," May 6, 2021
42. Nick Flaherty, "GraphCore details power figures for Mk2 chip and AI system," eeNews Europe, August 27, 2021
43. Sanjay Podder and Shalabh Kumar Singh, "Sustainable Data: In pursuit of net zero," The Economist
44. **James Vincent**, The Verge. Bitcoin consumes more energy than Switzerland, according to new estimate. July 04, 2019
45. <https://ethereum.org/en/energy-consumption/#:~:text=A%20recent%20estimate%20suggested%20that,each%20node%20on%20the%20network>
46. Carole-Jean Wu and Udit Gupta, "Most of computing's carbon emissions are coming from manufacturing and infrastructure," March 2, 2021
47. The Economic Times, "Reuse and recycle: Google, Microsoft & Dell join forces to tackle e-waste crisis by 2030," March 19, 2021
48. <https://www.climateaction.org/news/google-announces-its-lifetime-net-carbon-footprint-is-now-zero>
49. <https://sustainability.google/progress/projects/circular-economy/>
50. <https://www.datacenterdynamics.com/en/analysis/re-use-refurb-recycle-circular-economy-thinking-and-data-center-it-assets/>
51. <https://www.lemonade.com/blog/lemonade-proves-trust-pays-off-big-time/>
52. David Treat, "How to build trust in a new digital world," 2021, Accenture
53. Kenthapadi, K. (2019, April 10) Privacy-preserving analytics and reporting at LinkedIn

54. Accenture (2021) Uncover missed talent pools, improve diversity
55. Kelly Bissell, Jacky Fox, Ryan Lasalle, And Paolo Dal Cin, "The state of cybersecurity resilience 2021," November 3, 2021
56. [https://www.accenture.com/\\_acnmedia/PDF-136/Accenture-Security-Technology-Vision.pdf](https://www.accenture.com/_acnmedia/PDF-136/Accenture-Security-Technology-Vision.pdf)
57. [https://www.accenture.com/\\_acnmedia/PDF-129/Accenture-Financial-Services-AI-Good-Bots-PoV-Web.pdf](https://www.accenture.com/_acnmedia/PDF-129/Accenture-Financial-Services-AI-Good-Bots-PoV-Web.pdf)
58. <https://www.salesforce.com/news/stories/how-salesforce-infuses-ethics-into-its-ai/>
59. <https://becominghuman.ai/tackling-ethics-in-ai-algorithms-the-case-of-salesforce-1f9d7a178913>
60. Laurence Morvan, Armen Ovanessoff, Marc Carrel-Billiard, Francis Hinterman, "A responsible future for immersive technologies," May 15, 2019
61. Sanjay Podder, Shalabh Kumar Singh, Neville Dubash, and David Light, "Creating Valuable (and Trusted) Experiences With Digital Personas," MIT Sloan Management Review, April 27, 2021
62. Eve Andersson, "Technology that is accessible to everyone: Three ways we're building for people with disabilities," Google, May 17, 2018
63. [https://www.microsoft.com/en-us/sustainability/sustainability-guide/sustainability-calculator/?activetab=pivot\\_1%3aprimariyr2](https://www.microsoft.com/en-us/sustainability/sustainability-guide/sustainability-calculator/?activetab=pivot_1%3aprimariyr2)
64. <https://corporate.walmart.com/newsroom/2020/09/10/walmart-and-schneider-electric-announce-groundbreaking-collaboration-to-help-suppliers-access-renewable-energy>
65. <https://www.walmartsustainabilityhub.com/climate/project-gigaton>
66. <https://techwireasia.com/2021/12/alibaba-group-announces-carbon-neutrality-goal-by-2030/>
67. <https://www.watertechonline.com/industry/article/14235479/ecopetrol-accenture-and-aws-work-to-help-companies-advance-journey-to-water-neutrality-through-firstofitskind-open-platform>
68. Sanjay Podder and Shalabh Kumar Singh, "Data for Good," Accenture, September 23, 2020
69. <https://www.arabcoders.ae/news/2>
70. [https://www.accenture.com/t20170315t221422\\_w\\_/se-en/\\_acnmedia/accenture/conversion-assets/dotcom/documents/global/pdf/dualpub\\_23/accenture-iwd-getting-equal.pdf](https://www.accenture.com/t20170315t221422_w_/se-en/_acnmedia/accenture/conversion-assets/dotcom/documents/global/pdf/dualpub_23/accenture-iwd-getting-equal.pdf)
71. <https://www.accenture.com/us-en/blogs/blogs-careers/getting-to-equal-what-leaders-need-to-know>
72. <https://acorn.rabobank.com/>
73. <https://newsroom.accenture.com/news/accenture-github-microsoft-and-thoughtworks-launch-the-green-software-foundation-with-the-linux-foundation-to-put-sustainability-at-the-core-of-software-engineering.htm>
74. [https://github.com/Green-Software-Foundation/software\\_carbon\\_intensity/blob/dev/Software\\_Carbon\\_Intensity/Software\\_Carbon\\_Intensity\\_Specification.md](https://github.com/Green-Software-Foundation/software_carbon_intensity/blob/dev/Software_Carbon_Intensity/Software_Carbon_Intensity_Specification.md)
75. WEF, "World Economic Forum Launches New Global Initiative to Advance the Promise of Responsible Artificial Intelligence," News Release, Jan 28, 2021
76. <https://www.holoniq.com/notes/global-climatetech-vc-report-full-year-2021/>
77. "United Nations Global Compact launches 'SDG Ambition' impact initiative aiming to scale up business action at the national level," Accenture Newsroom, January 23, 2020
78. <https://newsroom.accenture.com/news/accenture-and-sap-extend-partnership-to-help-companies-accelerate-sustainability-transformation-drive-new-sources-of-value-and-lead-in-the-circular-economy.htm>

## About Accenture

Accenture is a global professional services company with leading capabilities in digital, cloud and security. Combining unmatched experience and specialized skills across more than 40 industries, we offer Strategy and Consulting, Interactive, Technology and Operations services—all powered by the world’s largest network of Advanced Technology and Intelligent Operations centers. Our 699,000 people deliver on the promise of technology and human ingenuity every day, serving clients in more than 120 countries. We embrace the power of change to create value and shared success for our clients, people, shareholders, partners and communities. Visit us at [www.accenture.com](http://www.accenture.com)

## About Accenture Research

Accenture Research shapes trends and creates data-driven insights about the most pressing issues global organizations face. Combining the power of innovative research techniques with a deep understanding of our clients’ industries, our team of 300 researchers and analysts spans 20 countries and publishes hundreds of reports, articles and points of view every year. Our thought-provoking research—supported by proprietary data and partnerships with leading organizations such as MIT and Harvard—guides our innovations and allows us to transform theories and fresh ideas into real-world solutions for our clients. Visit us at [www.accenture.com/research](http://www.accenture.com/research)

Copyright © 2022 Accenture.  
All rights reserved.

Accenture and its logo are  
registered trademarks of Accenture.

This document refers to marks owned by third parties. All such third-party marks are the property of their respective owners. No sponsorship, endorsement or approval of this content by the owners of such marks is intended, expressed or implied.

This content is provided for general information purposes and is not intended to be used in place of consultation with our professional advisors.