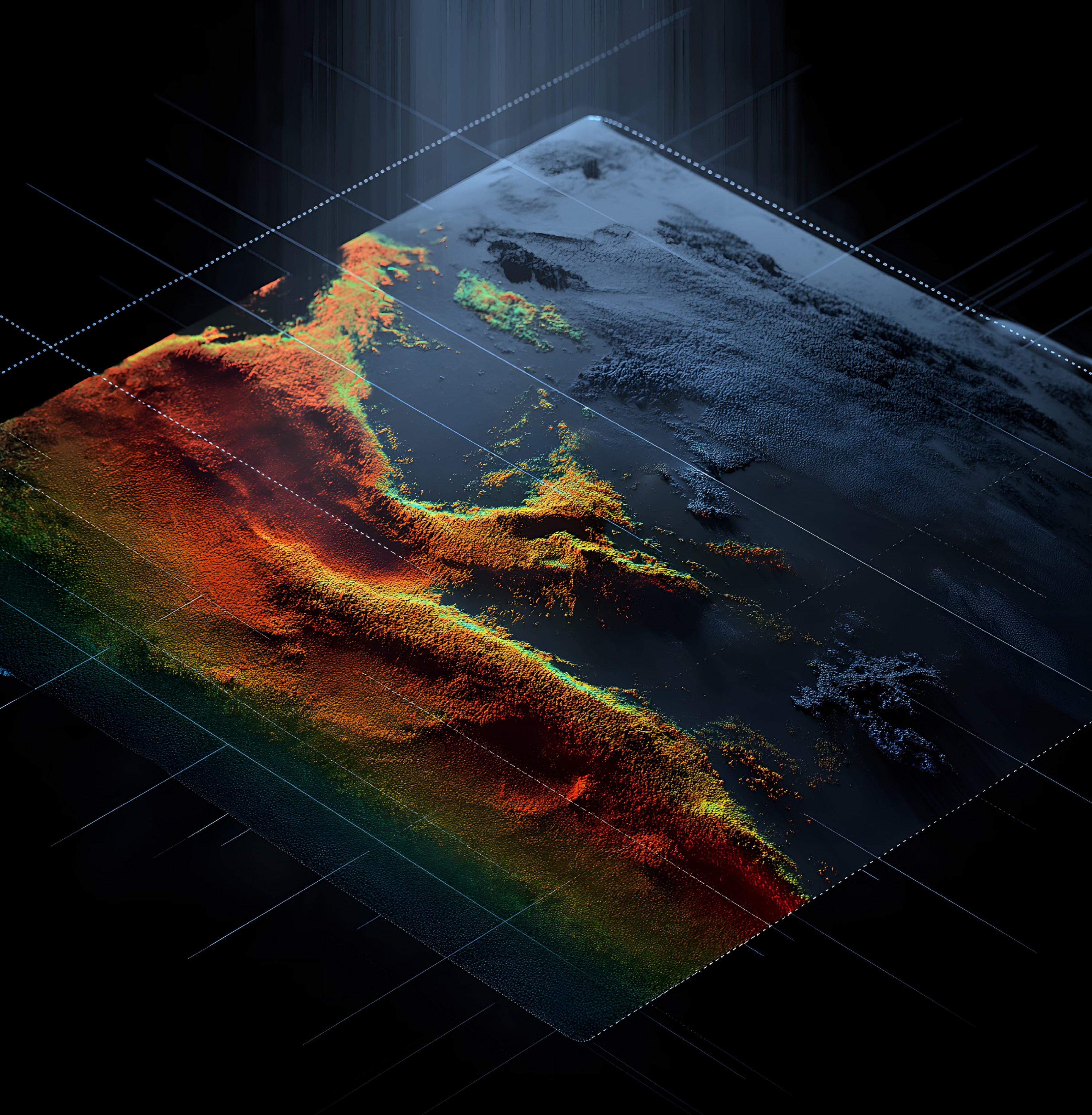
In collaboration with Oliver Wyman

# Nature Positive: Role of the Technology Sector

INSIGHT REPORT

DECEMBER 2025



**Images:** Adobe Stock, Midjourney, Unsplash

# Contents

# Foreword

**Melanie Nakagawa**
Corporate Vice President &
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Microsoft

Digital technologies have transformed the way we live and work, creating new opportunities, driving economic growth, and helping us tackle some of the planet's most pressing challenges. As digital infrastructure expands, accelerated by the rise of AI, responsible stewardship of ecosystems and natural resources like water, land, minerals and energy will be essential. This creates both a responsibility and an opportunity for the tech sector to show that innovation can advance while protecting the natural systems we all rely on.

Across the tech sector, companies are innovating to accelerate a nature-positive future, helping industries manage water with precision, monitor ecosystems and conservation efforts, scale circular markets for critical minerals and direct investment towards measurable environmental outcomes. These efforts show what is possible when technology and sustainability move forward together.

At Microsoft, we believe those who can do more, should. That is why we've woven sustainability into how we design, build and operate the physical infrastructure that supports our cloud business and AI. When nature is overlooked, the consequences ripple across communities and economies. Taking steps to use resources responsibly helps to reduce those impacts, lower costs and drive innovation for sustainable operations and energy.

The priority actions in this report help to turn that responsibility into practical steps across site selection, operations, procurement and product design that protect natural resources while creating business value. At Microsoft, we have seen this firsthand. In Mount Pleasant, Wisconsin, USA our AI data centre is expected to set a new benchmark for sustainable design, by using a closed-loop cooling system that allows more than 90% of the facility to recirculate water continuously. We plan to balance our energy use by matching fossil-fuel consumption with carbon-free energy on the grid, including power from a nearby solar project that's now under construction. We are also conscious of our impact beyond our immediate footprint. This is why we are partnering with local organizations to restore important prairie and wetland habitats.

Achieving impact at scale will require collaboration between companies, governments, investors and communities. We need to plan together, invest together and innovate together. The challenges ahead are substantial, but we remain optimistic. If we work collectively, technology can help us not only grow and innovate but restore and protect the planet for generations to come.

# Foreword

**Pim Valdre**
Head, Climate and Nature Economy; Member of the Executive Committee, World Economic Forum

**Nick Studer**
President and Chief Executive Officer, Oliver Wyman

Research from the World Economic Forum estimates that more than half of the world's gross domestic product (GDP) is moderately or highly dependent on nature and its services.[1] Given this scale of dependency and continued global records in heat, sea level rise and biodiversity loss, companies and investors face an imperative to act.

As the challenge of nature loss has grown more pronounced in recent years, the international conversation has continued to shift towards action. The 2015 Paris Agreement, the 2022 Kunming-Montreal Global Biodiversity Framework and the 2024 Conference of Parties to the United Nations Convention on Biological Diversity (CBD COP16) have provided governments and businesses with goals, targets and frameworks on how to create and implement nature plans. Sectoral guidance can further bridge the gap to action and highlight practical steps that are good for both nature and business.

The World Economic Forum, in collaboration with Oliver Wyman, has published extensive sectoral guidance over the last three years, based on data and insights from research, expert consultation and industry interviews. The result is the Forum's Nature Positive Transitions report series, which covers a range of industries, including chemicals, cement and concrete, mining and metals, automotive and now, with this latest overview, technology.

The technology sector presented a clear next area of focus, given its rapid growth and centrality to the ongoing transformation of the way we live, communicate and work. But tech companies are facing mounting constraints on that rapid expansion. The sector remains dependent on limited natural resources and faces increasing physical threats from storms, rising sea levels and wildfires, which climate change and nature loss are exacerbating.

As ever, halting climate change, reversing nature loss and preserving economic and social progress are interwoven goals. Companies that invest in nature and transition towards net-zero, nature-positive aligned business models will become better at managing these risks and enjoy competitive advantages. These include enabling further development and growth, building more resilient and sustainable supply chains, enhancing their public image and securing greater support from the financial sector.

The tech sector has an opportunity to lead in both economic growth and the nature-positive transition – but there is no time for delay.

# About the Nature Positive Transitions report series

*Nature Positive: Role of the Technology Sector* is published by the World Economic Forum in collaboration with Oliver Wyman. It is part of the World Economic Forum's Nature Positive Transitions report series, which outlines the different pathways to halt and reverse nature loss by 2030 – the mission at the heart of the Global Biodiversity Framework.

The series consists of three transitions: business sectors, cities and financial institutions. These reports highlight the relevance of nature-related risks, identify the impacts and dependencies of the economy and society on nature, and provide guidelines for business, city and financial institution leaders on key actions to accelerate the nature-positive transition.

The Nature Positive Transitions report series builds on the New Nature Economy Report Series. For more information, please visit Nature Positive Transitions.

## Sector reports:

- Nature Positive: Role of the Cement and Concrete Sector ↗
- Nature Positive: Role of the Household and Personal Care Products Sector ↗
- Nature Positive: Role of the Chemical Sector ↗
- Nature Positive: Role of the Automotive Sector ↗
- Nature Positive: Role of the Offshore Wind Sector ↗
- Nature Positive: Role of the Port Sector ↗
- Nature Positive: Role of the Automotive Sector China Deep-dive ↗
- Nature Positive: Role of the Mining and Metals Sector ↗

## Cities reports:

- Nature Positive: Guidelines for the Transition in Cities ↗
- Nature Positive: Leaders' Insights for the Transition in Cities ↗
- Nature Positive: Financing the Transition in Cities ↗
- Nature Positive: Cities' Efforts to Advance the Transition – Durban ↗
- Nature Positive: Cities' Efforts to Advance the Transition – Barranquilla ↗

## Finance reports:

- Nature Positive: Corporate Assessment Guide for Financial Institutions ↗
- Financing the Nature-Positive Transition: Understanding the Role of Banks, Investors and Insurers ↗

# Executive summary

## To ensure growth, tech companies must act decisively to address their substantial dependency and impacts on nature.

Technology permeates every facet of daily life. More than 1 trillion semiconductors are sold annually and used in smartphones, cars and most modern equipment.[2] Over 11,000 data centres are operational[3] with more opened every month, handling everything from streaming to 2 billion+ prompts sent daily to AI models.[4] The sector will continue growing strongly, driven by AI, cloud computing, high-performance electronics and innovations like quantum computing.

But this growth has a substantial nature footprint, driven by water and land use, pollution, waste and emissions. Semiconductor manufacturing consumes over 1 trillion litres of freshwater annually,[5] plus metals and critical minerals. Data centres draw 60+ GW of energy,[6] enough to power California's peak needs.[7] Discarded hardware dumps 60 billion kg of e-waste annually, with less than a quarter recycled.[8]

To ensure future success, tech companies must act swiftly to address their *impacts* on natural systems and their *dependencies* on natural resources. Failure would threaten tech's near-term licence to operate and long-term resilience. Since May 2024, $64 billion of data centre projects in the US have been blocked or delayed due to local concerns,[9] mostly about demands on natural resources and power. Nature-positive strategies can also present financial opportunities – from recovered metals for new products to cost savings from reduced power and water consumption.

This report summarizes tech's key impacts and dependencies on nature, and recommends seven priority actions for leaders in semiconductor manufacturing, data centres and hardware.

1. **Advance resilient and restorative water use**: Assess supply scarcity before site development, design for efficiency, adopt closed-loop systems to cool servers and facilities and invest in watershed restoration.

2. **Mitigate pollution and pursue circularity**: Avoid pollution through cleaner processes, reduce reliance on virgin inputs, design products for longevity and recyclability, support programmes that recover value from e-waste and restore affected ecosystems.

3. **Tackle non-power operational and embodied emissions**: Prevent emission leaks, deploy abatement technologies and invest in credible offset and removal schemes that deliver co-benefits.

4. **Promote land stewardship and restoration**: Prioritize brownfield development, conduct biodiversity risk assessments, integrate native landscaping and green infrastructure and invest in habitat restoration.

5. **Power operations sustainably**: Increase low- and zero-carbon power, energy-efficient computing and cooling, dynamic energy management and efficient building design to minimize upstream impacts from electricity supply.

6. **Engage with the supply chain**: Favour suppliers with robust sustainability certifications, prioritize low-impact materials and resource-efficient processes and establish clear biodiversity and water stewardship expectations across the value chain.

7. **Engage externally and support policy-making**: Report nature-related impacts and dependencies transparently through credible frameworks, support policy development and engage with customers.

Tech is a consistently innovative sector – now it has an opportunity to lead on nature too. This report details how the sector can embrace the nature-positive transition across its operations and value chain.

# Introduction

## Most top companies across sectors have climate targets, yet only 12% have one for biodiversity, despite the global economy's dependency on nature.

**Today, humanity uses the resources equivalent to that of 1.8 Earths.**

The challenge of nature loss grows steeper each year. Today, humanity uses the resources equivalent to that of 1.8 Earths. This means that the ecological footprint, which sums up the demands for biologically productive areas such as food, timber, fibre, carbon sequestration and infrastructure, exceeds the Earth's capacity by 80%.[10] This strain on natural resources has direct consequences on biodiversity and ecosystems, with an alarming 73% decline of the average size of monitored wildlife populations observed between 1970 and 2020 globally.[11] To maintain economic growth and prosperity will require working better within the boundaries that nature provides.

Addressing climate change and halting nature loss are interdependent priorities for both society and business. Climate change is one of the five key drivers of nature loss, alongside land-use change, pollution, natural resource use and exploitation, and invasive species.[12,13] In turn, land-use change contributes at least 12-20% of global greenhouse gas emissions (GHGs).[14] Addressing climate change relies on protecting nature[15].

BOX 1

### Defining nature positive

"Nature Positive is a global societal goal defined as 'Halt and Reverse Nature Loss by 2030 on a 2020 baseline, and achieve full recovery by 2050'. To put this more simply, it means ensuring more nature in the world in 2030 than in 2020 and continued recovery after that."

**Source:** Nature Positive Initiative.[16]

> Unless tech companies address their natural resource dependencies, they risk losing public support, facing costly delays or cancellations of critical projects.

## Why nature matters for tech

Recognition of nature's role in the success of businesses and financial institutions continues to grow. Companies – especially those in the tech sector – that address the nature impacts and dependencies in their operations and value chains can reap a range of benefits (see Figure 1). These include the following, explored in greater detail below:

- Securing social and regulatory licence to grow and operate.
- Developing resilience and adaptability to nature-related risks.
- Meeting growing stakeholder expectations.
- Delivering opportunities for financial growth and cost savings.

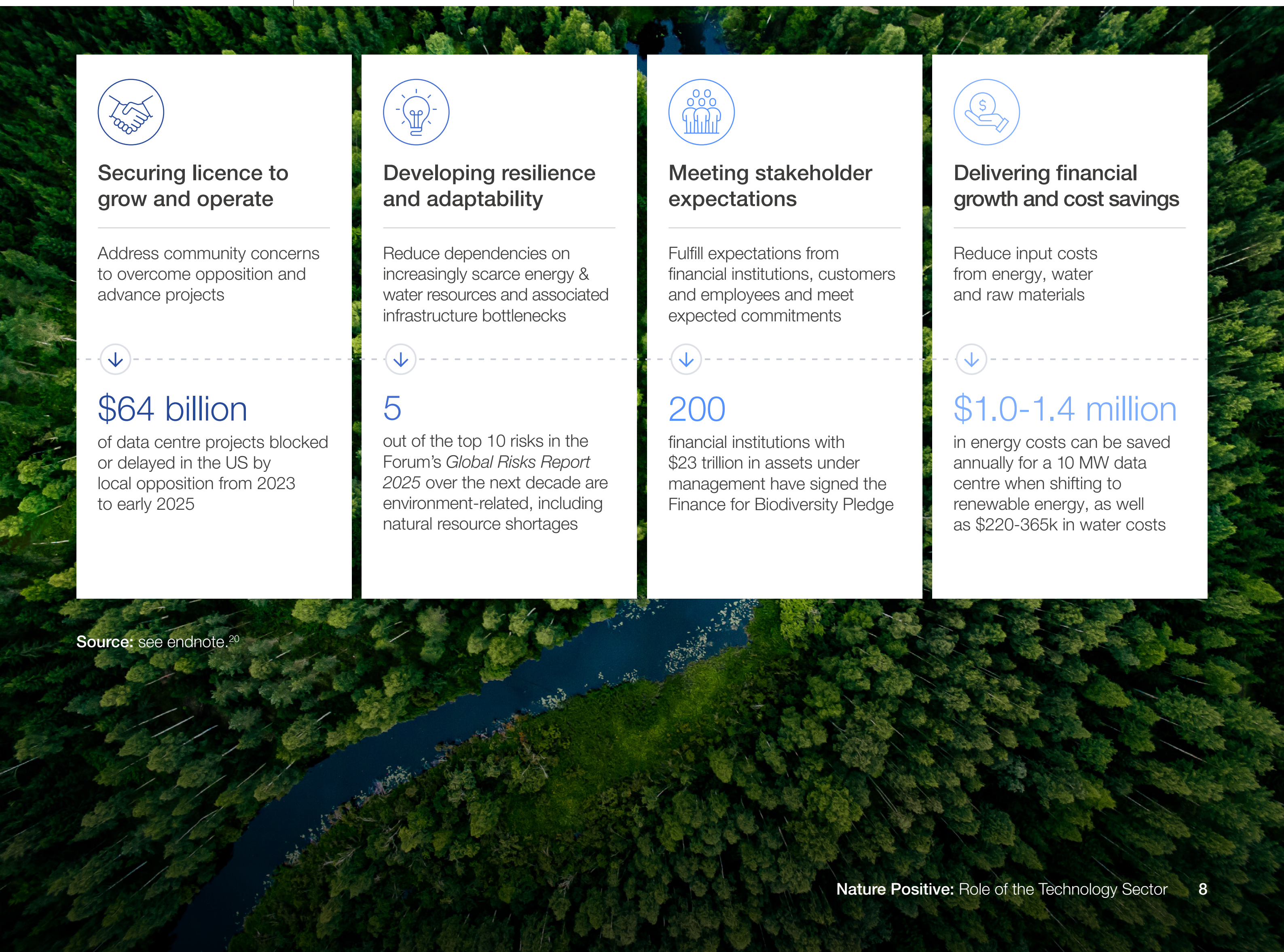
Companies that anticipate the risks of nature loss can minimize disruption from incoming policy and regulatory requirements, proactively manage nature-related physical, transition and systemic risks,[17] including dependencies on ecosystem services and assets, and benefit from early nature-related opportunities.

## Securing licence to grow and operate

Tech's rapid growth has led to a surge in infrastructure development, especially data centres, prompting increasing scrutiny from local communities and regulators. In the United States (US) alone over the past two years, $64 billion of data centre projects have been blocked or delayed due to local opposition.[18] This resistance often stems from concerns about competition for energy, water and other natural resources, as well as ecosystem disruption and increased pollution associated with some of these facilities. Recent US Energy Information Administration (EIA) analysis shows a 6.5% increase in retail electricity prices in the US from 2024 to 2025 after relatively stable prices in the decade prior and data centre electricity usage is among important factors blamed for this.[19]

Policy-makers and regulators are now caught between balancing national ambitions to attract tech investments with local and regional concerns. Unless tech companies address their natural resource dependencies and engage early, transparently and inclusively with communities and governments, they risk losing public support, facing costly delays or cancellations of critical projects.

FIGURE 1 **Why nature matters for tech companies**




**Source:** see endnote.[20]

Reliance by the tech sector on energy, water and other natural inputs can act as a bottleneck and slow sector growth.

## Developing resilience and adaptability

In the World Economic Forum's *Global Risks Report 2025*[21] five out of the top 10 risks over the next decade are environment-related: extreme weather events, critical change to Earth systems, biodiversity loss and ecosystem collapse, natural resource shortages and pollution. These risk areas apply to tech as they do to other sectors.

Reliance by the tech sector on energy, water and other natural inputs can act as a bottleneck and slow sector growth. "A new data centre can be built in 18 months," said Fatih Birol, Executive Director of the International Energy Agency (IEA), "but building new [power] transmission lines can take four to eight years".[22]

At worst, dependence on these inputs – especially power – can prevent growth altogether. For example, data centre hubs in places such as Northern Virginia and Ireland face limits on new builds due to insufficient power capacity and ageing infrastructure.[23] Beyond resource constraints, increasing climate hazards in the form of extreme heat, droughts, water stress and flooding threaten facility operations, while operational pauses decrease productivity and commercial performance.

By designing for and investing in natural resource efficiency, onsite renewable power generation and sustainable supply chains, to name a few areas, tech companies can build resilience and mitigate the risk of stranded or underperforming assets.

## Meeting stakeholder expectations

Business action on nature is increasingly required to meet stakeholder expectations. Calls for businesses to transparently manage and reduce their nature impacts remain strong and frequent, coming from policy-makers, regulators, investors, other companies, consumers and citizens (see Figure 2).

FIGURE 2 **Key nature-related stakeholder dynamics impacting businesses**

### Global agreements

- 196 parties agreed on the landmark Kunming-Montreal **Global Biodiversity Framework (GBF)** in December 2022
- GBF Target 15 calls for **mandatory assessment and disclosure** and for businesses to reduce their negative impacts on nature

### Guidance and standards

- **Taskforce on Nature-related Financial Disclosures (TNFD)** issued sector-specific guidance for 8 sectors and financial institutions
- **International Sustainability Standards Board (ISSB)** incorporated nature and biodiversity requirements
- **EU's European Sustainability Reporting Standards (ESRS)** started in 2024, including E4 on biodiversity and ecosystems
- **Science Based Targets for Nature (SBTN)** released updated target-setting guidance

Businesses

### Stakeholders and communities

- **85% of consumers** said they shifted their purchasing behaviour to become more sustainable in the past five years
- Union for Ethical BioTrade (UEBT) **Biodiversity Barometer** has shown consistent growth in biodiversity awareness among consumers over the past decade
- Nearly **75% of employees** find fulfillment through positive environmental impact
- **$64 billion** of data centre projects blocked/delayed in the US from 2023 to early 2025 because of local community opposition

### Financial institutions

- 200 financial institutions with €23 trillion in assets under management signed the **Finance for Biodiversity Pledge**
- **Nature Action 100** harnesses investor influence on businesses
- Network for Greening the Financial System (NGFS) established **Task force on Nature-related Risks** in 2022

**Source:** see endnote.[24]

## Delivering financial growth and cost savings

Aligning operations and value chains with a nature-positive pathway often unlocks significant economic opportunities and cost savings. Efficiency improvements in water, energy and land use directly reduce operational costs. Circular design and e-waste collection and recycling schemes reduce material costs and waste liabilities. The Forum's *New Nature Economy Report II: The Future of Nature and Business* estimated that a full nature-positive transition in the global economy could create $10.1 trillion of annual business opportunities by 2030. Of this amount, estimates show that undertaking priority actions for the technology sector could unlock about $800 billion in cost savings and revenue upside by 2030 for businesses operating across the sector's value chain. In particular, energy and water efficiency in operations, a move towards circularity through resource recovery, and engaging with the sector's mining and minerals supply chain present significant business opportunities. See Figure 3 and Table 1 for more information.

The nature-positive opportunities summarized in Figure 3 are derived from the Forum's *New Nature Economy Report II: The Future of Nature and Business* and are further analysed in Table 1. More information on the calculation methodology can be found in Appendix B: Methodologies.

FIGURE 3 **Nature-positive business opportunities for the tech sector, by 2030 ($ billion)**

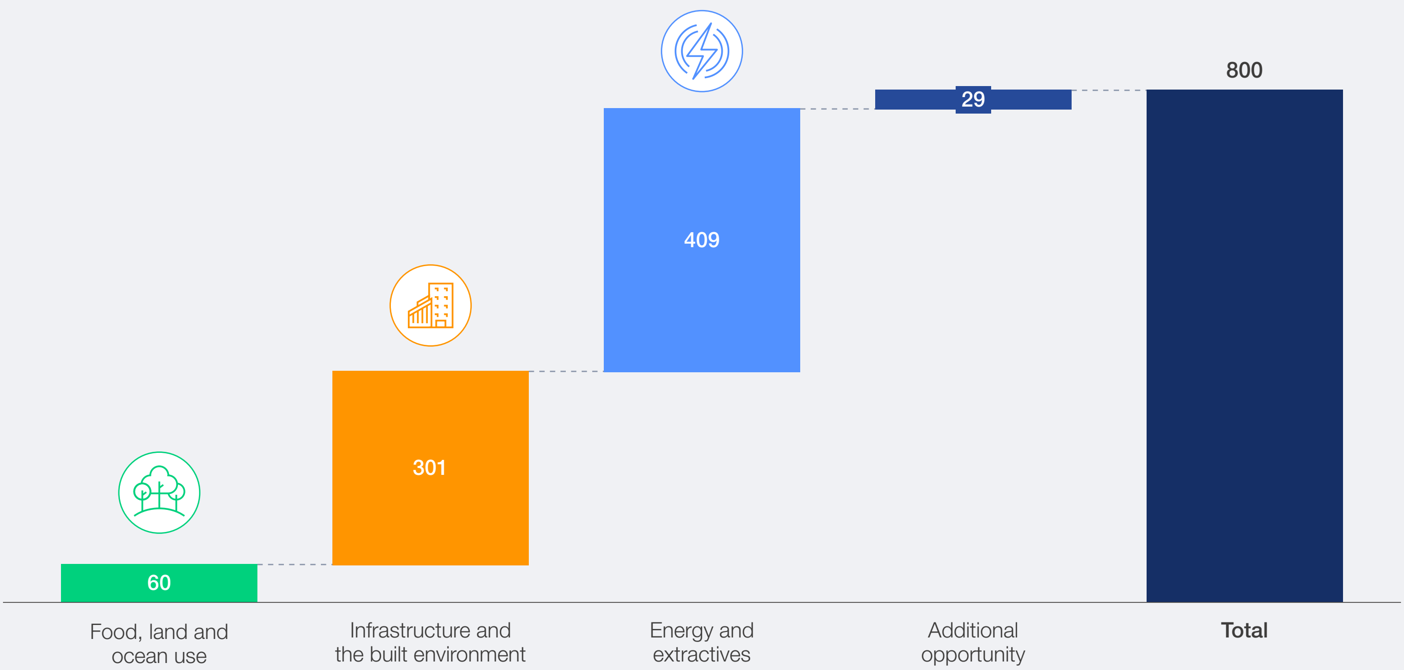


TABLE 1 | **Deep dive on nature-positive business opportunities for the tech sector**

| Socio-economic system | Business opportunity from *Future of Nature and Business* report | Original size in *Future of Nature and Business* report ($ billion) | Adjustment factor to size share of technology sector | Opportunity size for technology sector ($ billion) |
|---|---|---|---|---|
| **Food, land and ocean use** | Nature climate solutions | 85 | Technology sector share of global GDP: **15.5%** | 13.2 |
| | Restoring degraded land | 75 | | 11.6 |
| | Sustainable forestry management | 165 | | 25.6 |
| | Non-timber forest products | 65 | | 10.1 |
| **Infrastructure and the built environment** | Energy efficiency (buildings) | 825 | | 127.9 |
| | Smart metering | 95 | | 14.7 |
| | Urban green roofs | 15 | | 2.3 |
| | Waste management | 305 | | 47.3 |
| | Waste and sanitation infrastructure | 155 | | 24.0 |
| | Wastewater reuse | 50 | | 7.8 |
| | Energy access | 45 | | 7.0 |
| | Natural systems for water supply | 140 | | 21.7 |
| | Building resilience to climate shocks | 20 | | 3.1 |
| | Sustainable infrastructure financing | 295 | | 45.7 |
| **Energy and extractives** | Circular economy (appliances) | 565 | | 87.6 |
| | Circular economy (electronics) | 390 | | 60.5 |
| | End-use steel efficiency | 210 | | 32.6 |
| | Additive manufacturing | 135 | | 20.9 |
| | Circular models (construction) | 70 | | 10.9 |
| | Reducing packaging waste | 70 | | 10.9 |
| | Resource recovery | 225 | | 34.9 |
| | Shared infrastructure | 130 | | 20.2 |
| | Water efficiency in mining | 75 | | 11.6 |
| | Mine rehabilitation | 70 | | 10.9 |
| | Sustainable substances in extraction | 20 | | 3.1 |
| | Technology in energy and extractives supply chains | 30 | | 4.7 |
| | Expansion of renewables | 650 | | 100.8 |
| **Additional opportunity** | Energy efficiency (energy-intensive sectors) | 187 | | 29.0 |

**Source:** Technology sector share of global GDP is based on World Economic Forum and World Bank data.[25]

## Setting credible nature strategies and taking action

Despite these drivers and the increased momentum on nature over recent years, more can be done – both within the tech sector and across sectors. While 78% of Fortune Global 500 companies had climate change targets in 2024, only 26% had freshwater consumption targets and just 12% had targets for biodiversity loss.[26] Only 5% of companies have assessed their impacts on nature, with less than 1% understanding their dependencies.[27]

Nature is understandably a complex topic for company management teams – there is no single metric and impacts are highly context-dependent. However, by establishing and implementing credible nature strategies, individual companies, financial institutions and investors can contribute to the global nature-positive goal of reversing nature loss by 2030. These strategies should apply across organizations' spheres of control and influence, including at sites of high-biodiversity importance, in their direct operations as well as across their value chains.

BOX 2 **Fortune Global 500 companies' position on climate and nature**

| | | | | |
|---|---|---|---|---|
| 78% | 26% | 12% | 5% | < 1% |
| have climate change targets | have freshwater consumption targets | have targets for biodiversity loss | have assessed their impacts on nature | understand their dependencies on nature |

## Need for a sectoral approach

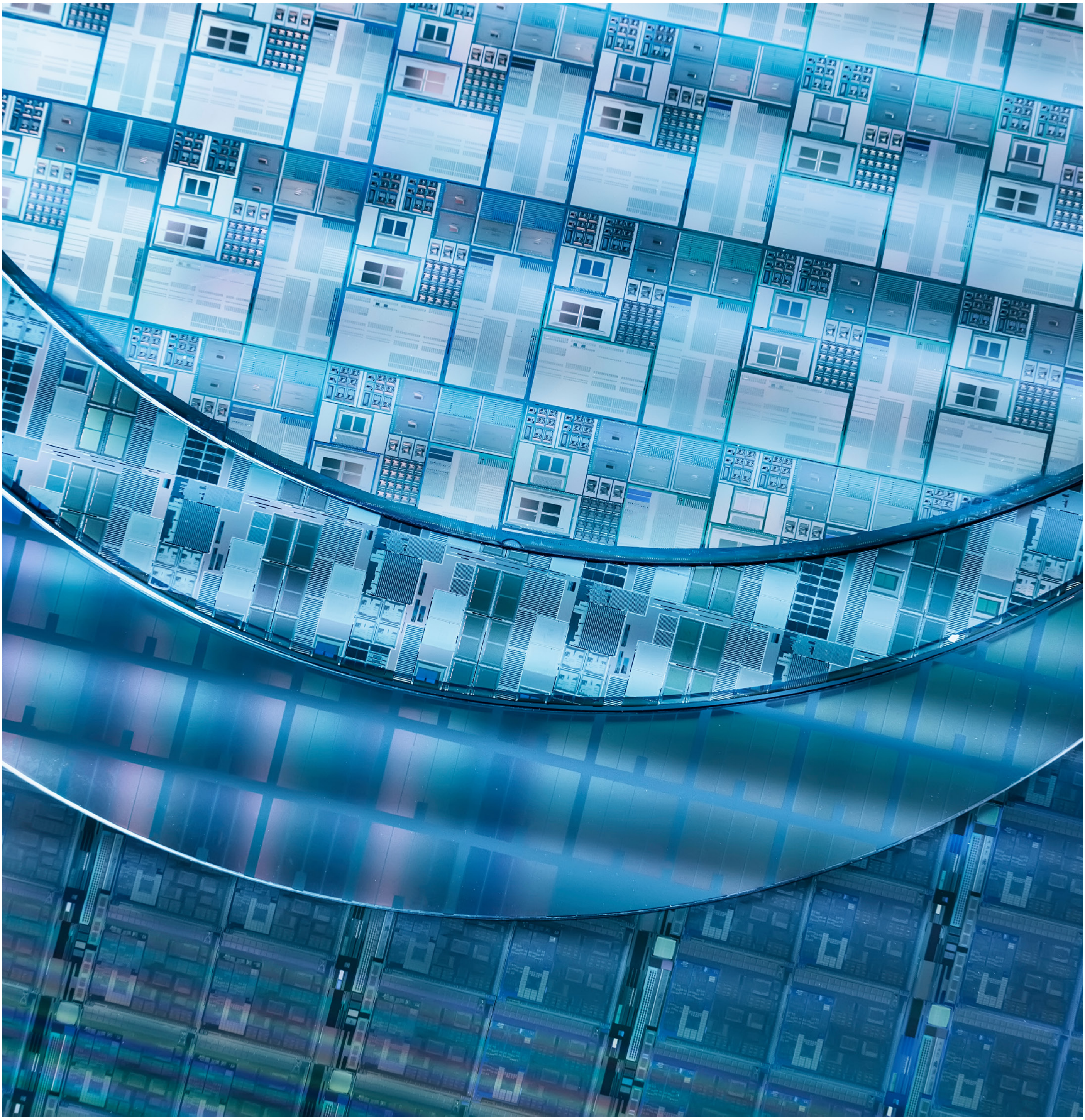
As nature impacts and dependencies differ significantly across sectors, analyses and guidance that are sector-specific can help companies understand their relationship with nature and the actions they can take to accelerate the transition to a nature-positive future.

To inform sectoral approaches, the World Economic Forum, alongside Business for Nature and the World Business Council for Sustainable Development (WBCSD), have produced guidance on 15 global sectors as part of the Sector Actions Towards a Nature-Positive Future initiative. For each sector, the guidance outlines priority actions for companies to take to transform their operations and value chains to make a meaningful contribution towards the Global Biodiversity Framework and help halt and reverse nature loss by 2030.

In this report, the World Economic Forum, in collaboration with Oliver Wyman, makes the business case for sector-specific priority actions in the technology sector. Future work will detail the sector's opportunities to enable and influence the nature-positive transition beyond its own value chain, both with other companies and with everyday consumers who rely on tech products.

# 1 Current state of the tech sector

Semiconductors, data centres and electronics consume huge quantities of water, power and critical minerals. Government and business both have a key role to play in mitigating their impact on nature.



## 1.1 Tech sector overview

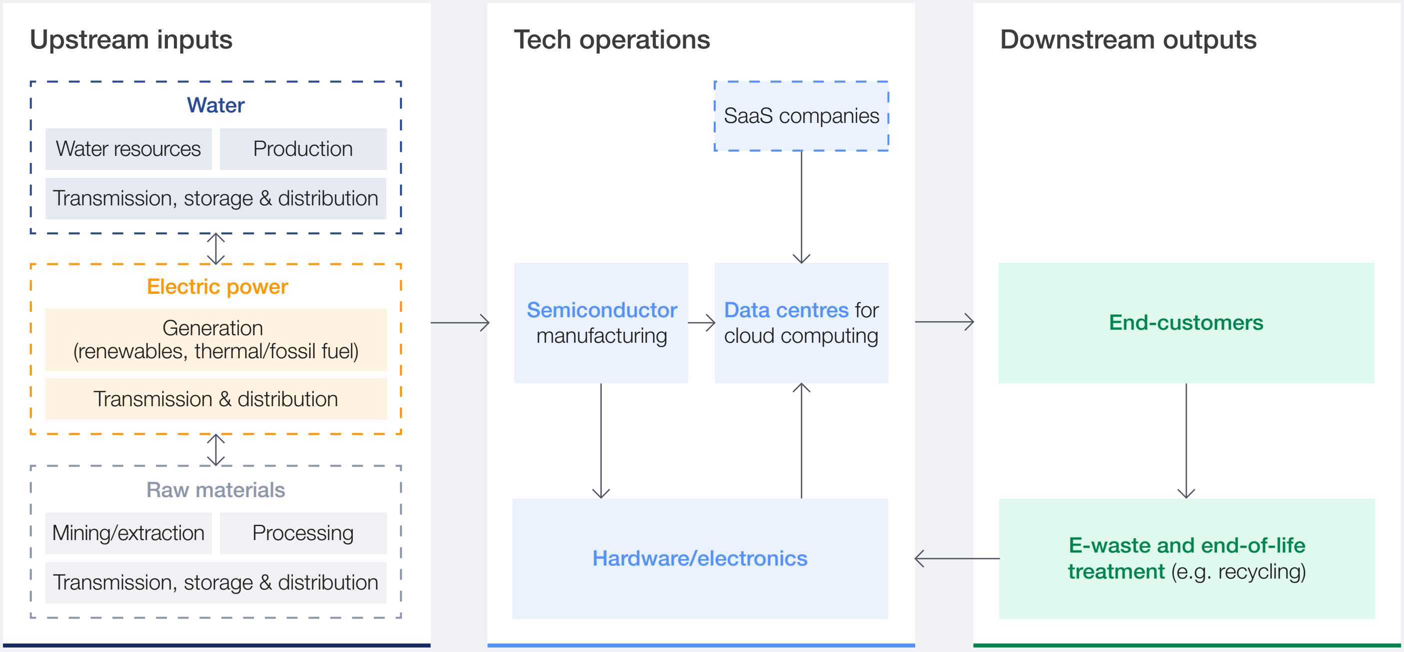
The tech sector has experienced strong growth in recent years and is poised to continue growing as demand for tech products, data centres and AI increases. The sector urgently needs to contribute to the nature-positive transition to reduce its impacts and dependencies on nature and to unlock new opportunities.

This report focuses on three core sub-sectors of tech – semiconductors, data centres and hardware/electronics – and much of their upstream and downstream value chain (see Figure 4). From AI to smartphones to the advanced microchips now found in everything from electric vehicles to home appliances, these sub-sectors are critical to modern life. Telecommunications infrastructure, while material, is not a key focus for this report, but has been reviewed by others including GSMA Intelligence.[28]

### Semiconductor manufacturing

The semiconductor industry provides critical components for chips used in electronic devices including computers, mobile phones, medical devices, cars and more. The industry's thirst for energy and water is enormous and growing, so the sub-sector's nature impact will continue to grow without mitigating action (see Figure 5).

FIGURE 4 **Simplified value chain of the tech sector**




**Note:** SaaS = software-as-a-service.

FIGURE 5 **Semiconductor industry in numbers**

- **6-8%** annual growth expected to 2030
- **400+** operational facilities
- **18** more plants under construction in 2025

- Average plant uses **~38 million litres** of water per day
- Global industry consumes **>1 trillion litres** of water per year

- **60-70%** of recent production located in **Taiwan** and **South Korea**
- 1 company accounts for **6%** of Taiwan's total energy consumption

**Sources:** see endnote.[29]

The latest data centres can require ~1 GW of power or more, 500-800 acres of land and up to 7 million litres of water per day for cooling.

An additional challenge for the sub-sector is its reliance on critical minerals and the impact of this on supply chain resilience. The concentration of 60-70% of recent semiconductor production in Taiwan and South Korea creates substantial supply chain risk and potential for geopolitical impact. The European Union (EU) and the US have both passed legislation to support domestic production of critical semiconductor chips.[30] The European Chips Act is expected to drive over $43 billion in investment up to 2030,[31] while the US CHIPS Act allocated ~$53 billion in federal subsidies.[32] These acts reinforce the importance of this sector and the ambition of governments to lead.

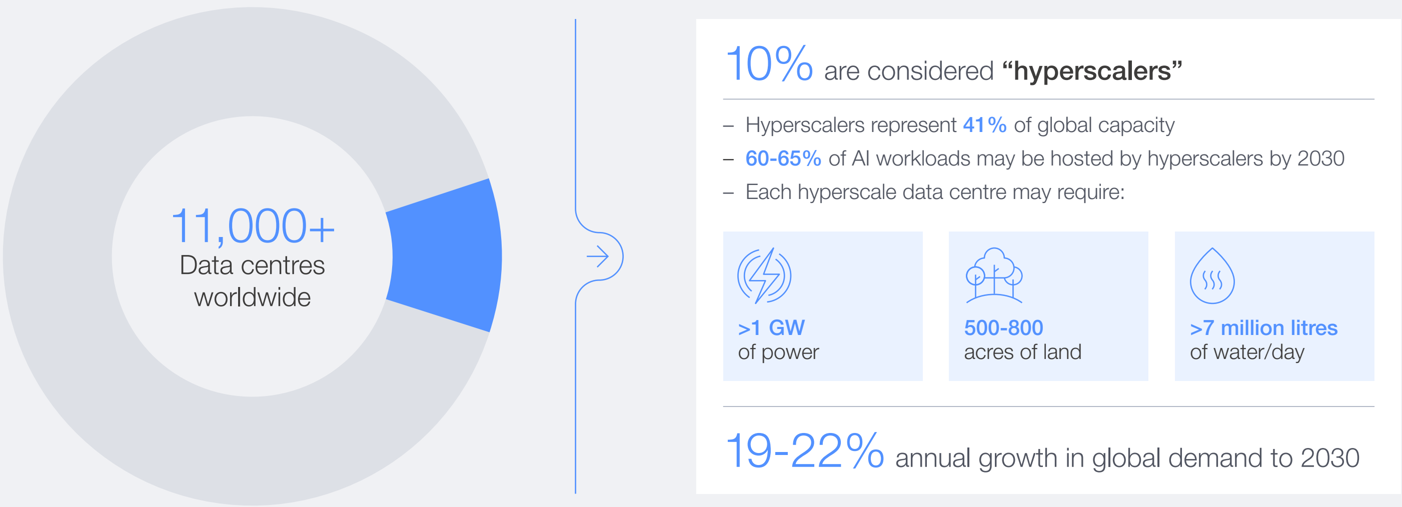
## Data centres for cloud computing

There are currently over 11,000 data centres operating worldwide. They require massive amounts of energy, land and water – a trend that is likely to accelerate, given demand is expected to rise by ~20% per year until 2030 (see Figure 6).

Before becoming operational, simply building data centres carries nature impacts through the steel, concrete and other materials required for construction. During 2024-25, the sector accounted for 70% of the increase in private non-residential construction in the US.[33]

Governments in some data centre hubs are limiting developments as power grids become strained and concerns mount over data centres monopolizing natural resources and limiting other industries' access to power, water and land. In Ireland, for example, data centres use ~10% of available electricity, resulting in limits on new builds.[34] Renewable power capacity cannot be built fast enough to enable growth while fulfilling a commitment to decarbonize 80% of electricity production by 2030. Insufficient infrastructure can also have secondary effects beyond limiting sector growth. One of the largest data hubs globally is in Northern Virginia, where developments are limited by insufficient power capacity and ageing infrastructure. Upgrades are not rapid enough to keep power reliable. Being persistent and innovative in mitigating their nature dependencies will allow data centre operators to better enable growth.[35]

FIGURE 6 **Data centre industry in numbers**




**Sources:** see endnote.[36]

## Hardware/electronics

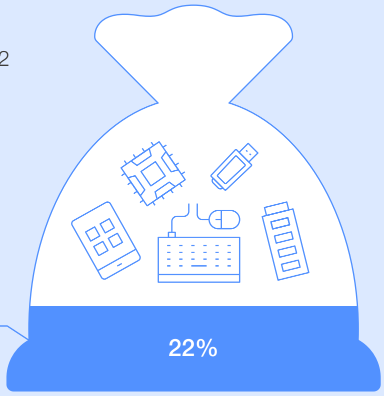
Manufacturing of hardware and electronics, such as personal computers (PCs), mobile phones and televisions, is expected to grow by ~8% per year to 2030 (see Figure 7). The industry not only consumes considerable resources during manufacture, but also generates over 62 billion kg of waste every year, much of it toxic. Only about one-fifth of this e-waste is recycled, with around 3.3 billion tonnes sent via uncontrolled transboundary movements to middle- and low-income countries, where it is often processed in unsafe conditions. Companies have a clear role to play in reducing the impact on nature from this industry.

FIGURE 7 **Hardware and e-waste industry in numbers**

**7-8%** annual growth in manufacturing to 2030

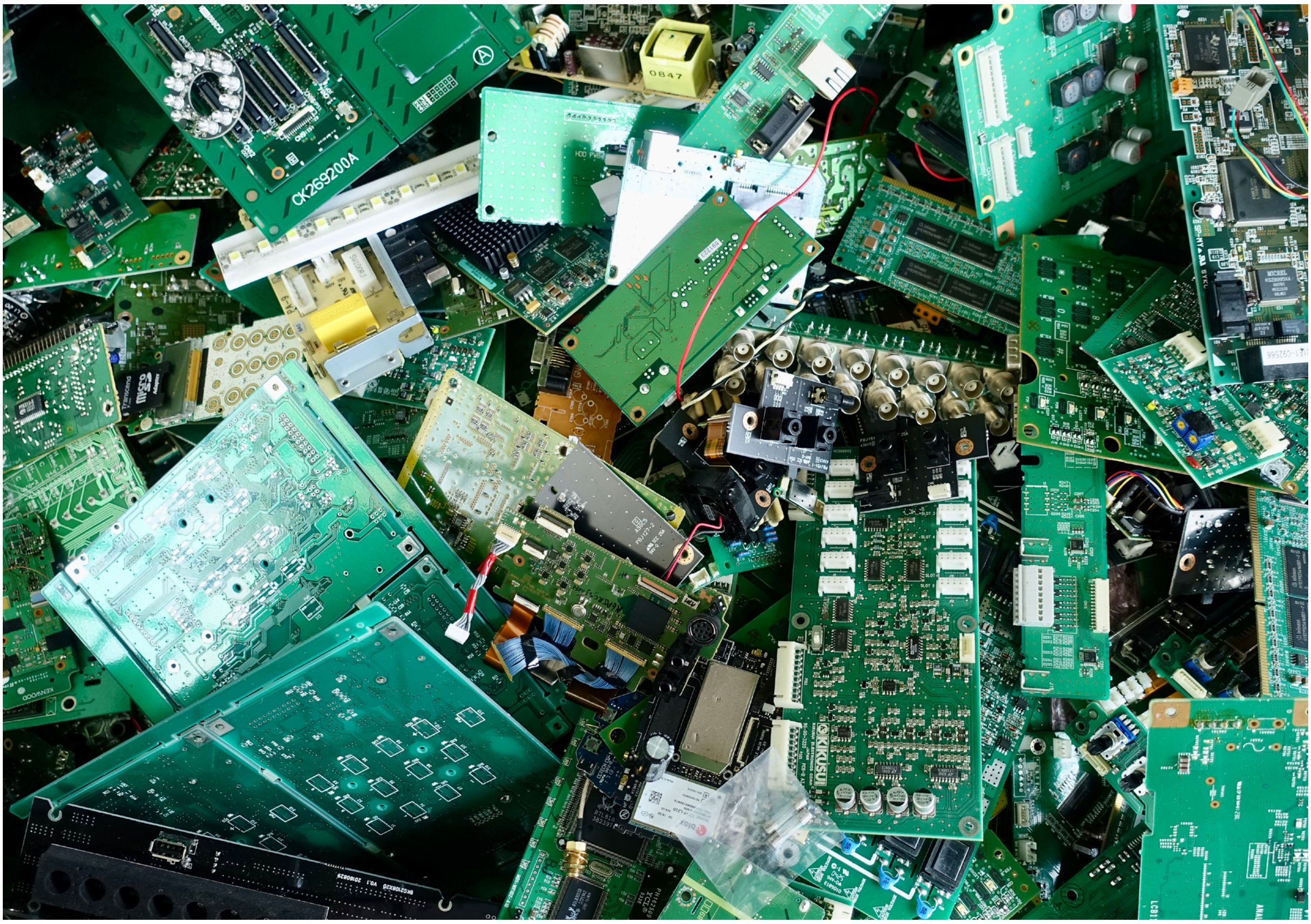
- US alone disposes of **300-400 million electronic** items each year
- e-waste accounts for **70% of US toxic waste** for only ~2% of landfill waste
- **Volumes expected to grow 5x faster** than concurrent growth in recycling
- High-income countries send **3.3 billion kg** of e-waste to middle- and low-income countries

**>62** billion kg
e-waste produced in 2022




Only **22%** of global e-waste is **recycled**

**Sources:** see endnote.[37]



## 1.2 Efforts to mitigate impacts and dependencies

Company commitments to lower impacts and restore nature are a critical starting point and many of the largest tech players have already begun taking action. Microsoft and Google both plan to replenish more water than they consume by 2030. With 47% of the world's population expected to be living in areas with strained water supplies by 2030, water-related commitments are essential.[38]

Three of the largest data centre companies – Google Cloud, Microsoft Azure and Amazon Web Services (AWS) – have commitments to purchase renewable power for 100% of their data centre operations by no later than 2030.[39] Energy demand and associated generation create nature impacts across water, greenhouse gas (GHG) emissions and land, so a shift to low- and zero-carbon sources brings material nature benefits.

While corporate commitments are voluntary and therefore variable, governments are beginning to pass regulations intended to limit or mitigate environmental impact from tech, at least for energy. The EU passed a revised Energy Efficiency Directive in 2023 that included an obligation for "the monitoring and reporting of the energy performance of data centres". The directive allows the European Commission to collect and publish data on the energy and water use of data centres, with the goal of a ~12% reduction in EU energy consumption by 2030. Since 2019, the EU has also required that servers and data storage products sold in the region meet requirements for minimum energy efficiency and maximum energy consumption when idle.

In China, the 2023 Action Plan for the High-Quality Development of Computing Power Infrastructure prioritized core principles including "green, low-carbon, secure and reliable". The Chinese government also released a green development plan in 2023 for data centres, which set targets on energy efficiency and renewable energy use. Similar restrictions and goals have been set elsewhere – in the UK, Ireland, Japan, Singapore and the US, to name a few.[40]

The UN Environment Programme has issued recommendations along these lines, encouraging governments to establish regulations regarding the environmental impacts of AI.[41] Where national policies misalign with community needs, local pushback against new tech development is growing. Communities are increasingly aware of and concerned by potential nature impacts from data centres and tech manufacturing.

Policies are not limited to restrictions or targets – there have also been major government investments in tech in recent years. Between the CHIPS Act taking effect in 2022 and mid-2024, the US semiconductor industry invested over $200 billion in manufacturing.[42] The CHIPS Act Notice of Funding Opportunity for Commercial Fabrication Facilities emphasized the importance of energy efficiency and sustainability and encouraged applicants to utilize clean energy sources to the maximum extent possible.[43] While the nature-related benefits of the CHIPS Act and other policy incentives may not be immediate, these policies fuel research that ultimately supports sector transition to nature positive.

## 1.3 The time to act is now

**Semiconductors and data centres consume a combined 1.5 trillion litres of water a year – more than the entire country of Denmark.**

The tech sector plays a key role in the transition to a nature-positive economy. Its products can enable progress and innovation across many industries, but the sector is also a contributor to natural resource consumption and nature impact. Semiconductors and data centres consume a combined 1.5 trillion litres of water a year,[44] more than the entire country of Denmark.[45] The sector accounts for ~4% of global energy use,[46] with growth expected to drastically increase energy consumption in future. The International Energy Agency (IEA) projects that in 2026, data centres' global energy consumption could be on par with that of Japan.[47] Mining for critical inputs, such as silicon, copper and gallium, will grow to support expected sector growth, creating additional pressures on nature.

Tech companies can transform business models and practices to minimize nature impacts and dependencies. To avoid nature-related risk, companies can invest in reducing dependencies, making supply chains more resilient and protecting and restoring nature. Wherever possible, it is best for tech companies to avoid, then reduce, drivers of nature loss in their operations and value chains to enable growth in light of increasing demand for their products.

# 2 Tech's nature impacts and dependencies

Semiconductors, data centres and tech hardware demand huge quantities of water, power and increasingly, land – generating significant impacts on nature. Addressing these factors is critical both for the tech industry and for the planet.

This chapter presents a high-level analysis of the tech industry's impacts and dependencies on nature, analysed by sub-sector. The analysis is based on global sector averages, but company-specific impacts and dependencies will vary according to their activities, supply chains and operational locations.

The semiconductor, data centre and hardware sub-sectors all have extensive nature-related impacts and dependencies. Understanding and addressing these is critical, both for improving nature outcomes and for preserving the overall tech industry's financial strength, given the principle of "double materiality" (see Figure 8).

These tech industries are highly dependent on natural resources and ecosystem services, such as minerals and metals, energy, freshwater and natural regulation of climate, soil and floods (see Box 3).

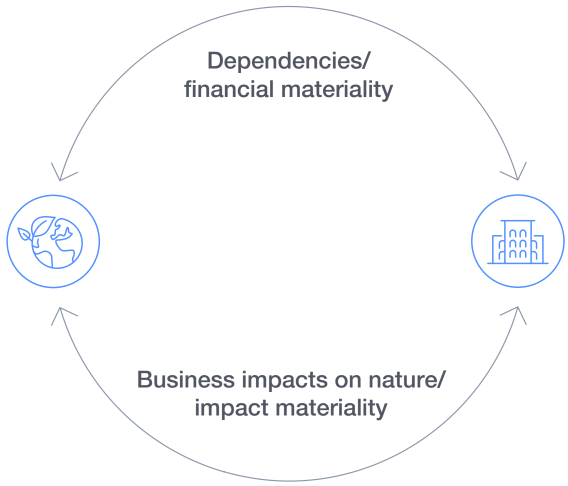
FIGURE 8 **Double materiality**

## Traditional materiality


### Examples of financial materiality

- Pressure on water availability and decline in quality affect company profitability
- Soil erosion and degradation lead to decreases in agricultural yields for agricultural food companies
- Dirty beaches and coastal areas cause drop in tourism traffic and revenues

## Double materiality




### Examples of impact materiality

- Company activities affect water supply and quality
- Unsustainable agricultural practices lead to decrease in soil quality
- Irresponsible travel and tourism cause pollution and over-exploitation of natural resources

**Source:** World Economic Forum.[48]

## BOX 3 Tech industry dependencies on natural resources and ecosystem services

### Mineral and metal inputs

Tech is highly dependent on mineral and metal inputs for manufacturing and operations, from silicon for chips to copper for wiring, and iron and steel for buildings. While many associate the tech sector with an abstract "cloud," it requires very real physical infrastructure.

### Energy generation

Tech manufacturing and data centre operations require significant quantities of energy, with projections indicating continued increase over coming years. Energy is currently provided from both renewable and non-renewable sources.

### Freshwater

Semiconductor manufacturing and data centre operations are both dependent on water, especially for cooling. Impacts on local water supplies can be substantial if not properly mitigated. In the US even a few years ago, one-fifth of data centres were located in moderately to highly stressed watersheds and nearly half were fully or partly powered by generation plants in water stressed areas.[49]

### Climate regulation, soil stability and flood protection

Tech relies on ecosystem services such as climate regulation to maintain stable temperatures and healthy soils and landscapes to mitigate floods and provide the physical stability required to ensure effective operating conditions. These natural systems protect critical tech infrastructure from climate-related risks and natural hazards.

### Regeneration of natural resources and waste absorption

The sector relies on the natural environment to re-absorb waste and regenerate the natural resources required for tech construction and operations. But rapidly rising e-waste volumes also present an opportunity for circularity and sustainable sourcing. Recycling and recovering metals from discarded hardware can reduce tech's reliance on new extraction and alleviate pressure on natural resources.

A materiality matrix summarizes impacts and dependencies for tech across nature-loss drivers, with electricity use included as a fifth area given its multiplying effect on nature impacts upstream of tech operations (see Figure 9).

## FIGURE 9 Materiality matrix

Materiality rating: Low, Medium, High, Not in focus

| Nature-loss drivers | Upstream inputs: Mining for the tech industry | Upstream inputs: Electricity | Tech value chain operations: Semiconductor manufacturing | Tech value chain operations: Data centres for cloud computing | Tech value chain operations: Hardware/ electronics |
|---|---|---|---|---|---|
| Water use | Medium | Medium | High | High | Low |
| Pollution and waste | High | Medium | Medium | Low | High |
| GHGs | Medium | High | Medium | Low | Medium |
| Land use | High | Medium | Low | Low | Low |
| Electricity use | Not in focus | Not in focus | High | High | Medium |

**Note:** See methodology in Appendix B; ratings reflect materiality across both dependencies and impacts.

Several frameworks exist to guide companies in locating their interface with nature and evaluating their impacts and dependencies, using their own specific operational and supply chain information (see Box 4). For more details and data points on tech impacts and dependencies presented in this chapter, visit Appendix A – Nature-related impacts and dependencies.

BOX 4

**Frameworks to guide companies in assessing their nature impacts and dependencies**

The following frameworks can help guide companies through their own assessments.

**Taskforce on Nature-related Financial Disclosures (TNFD)** – LEAP approach:[50]

– Locate your interface with nature.

– Evaluate your dependencies and impacts on nature.

– Assess your nature-related risks and opportunities.

– Prepare to respond to nature-related risks and opportunities and to report on your material nature-related issues.

**Science Based Targets for Nature (SBTN):**

– Step 1 (Assess)[51]

– Step 2 (Prioritize)[52]

## 2.1 Semiconductors

An average semiconductor manufacturing plant may use 18-38 million litres of water daily.

Semiconductor chip manufacturing is a complex multi-step process requiring extensive natural inputs – over one trillion litres of water globally each year, for example.[53] Core impacts and dependencies, as summarized in Figure 10, include the following:

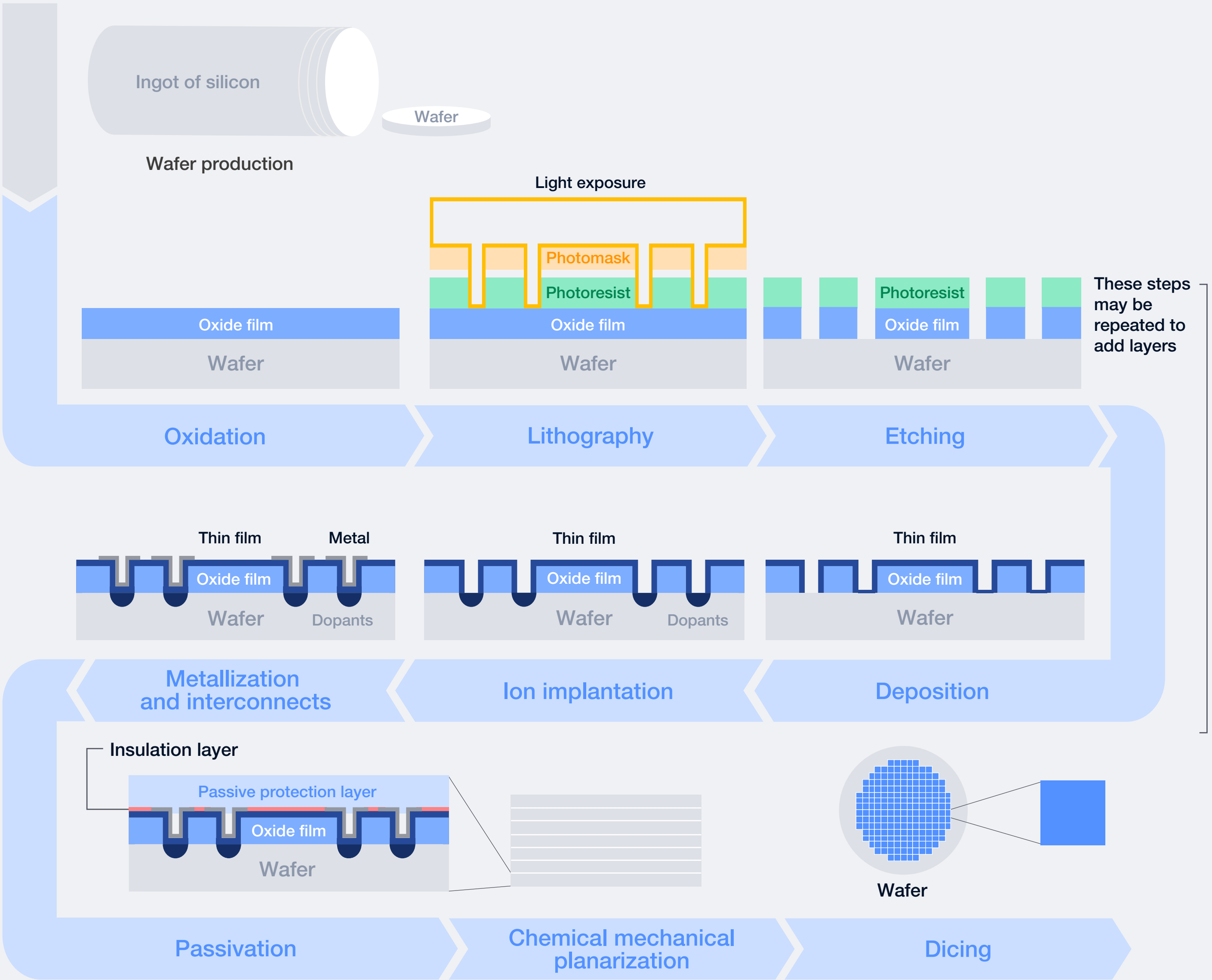
- **Water use**: Process requires high amounts of water to rinse and clean wafers, as well as for cooling.

- **Pollution and waste**: Process produces solid waste and wastewater, both with the potential to contain per- and polyfluoroalkyl substances (PFASs), also known as “forever chemicals” given their persistence in the natural environment.

- **Greenhouse gas emissions and electricity use**: Directly – several high-global warming potential (GWP) gases and compounds are required and currently have few alternatives. Indirectly – energy generation to support manufacturing releases additional GHG emissions.

- **Impacts from mining for critical inputs**: Minerals and metals used in manufacturing have high impacts across nature-loss drivers due to the methods used for extraction and refinement.

## FIGURE 10 | Semiconductor manufacturing – summary of key nature impacts and dependencies




### Water use

- Average plant may use 18-38 million litres daily
- Average facility utilizes ~45% recycled water

### Pollution and waste

- Manufacturing a 12-inch wafer can produce ~30 kg of waste
- Solid waste recycling rates range from 30-96%, with average ~70%
- Wastewater recycling rates range from 30-85%

### Mining for critial inputs

Required metals and minerals such as silicon, copper, germanium, gallium and arsenic create impacts when mined and processed

### Electricity use (primarily in lithography)

Energy use per wafer increased 3.5x (2010-2024)

### Greenhouse gas emissions

Emissions ($CO_2$e) per wafer increased nearly 3x (2010-2024)

**Sources:** see endnote.[54]

# 2.2 Data centres

Hyperscale data centre facility energy loads are upwards of 100 MW and growing.

Data centres' energy requirements have received significant public attention – by 2028, some estimate a power load as high as 140 GW,[55] a growth of nearly 2.5x from current demand. This power load is equivalent to India's estimated entire cooling energy demand by 2030.[56]

Data centre operations are varied, and energy is one of several broader impacts and dependencies on nature (see also Figure 11):

- **Electricity use:** Data centres often have substantial energy loads for day-to-day operations, which serve as an indirect driver of nature loss linked to land-use change, GHGs and climate change, and pollution. For more information on data centres' power use and the energy impact of AI, please refer to the Forum's Net Positive AI Energy Framework.

- **Water use:** Water is used extensively in many modern data centre designs for cooling; even with more closed-loop server cooling, some facilities still lose water to evaporation for facility-level heat rejection.

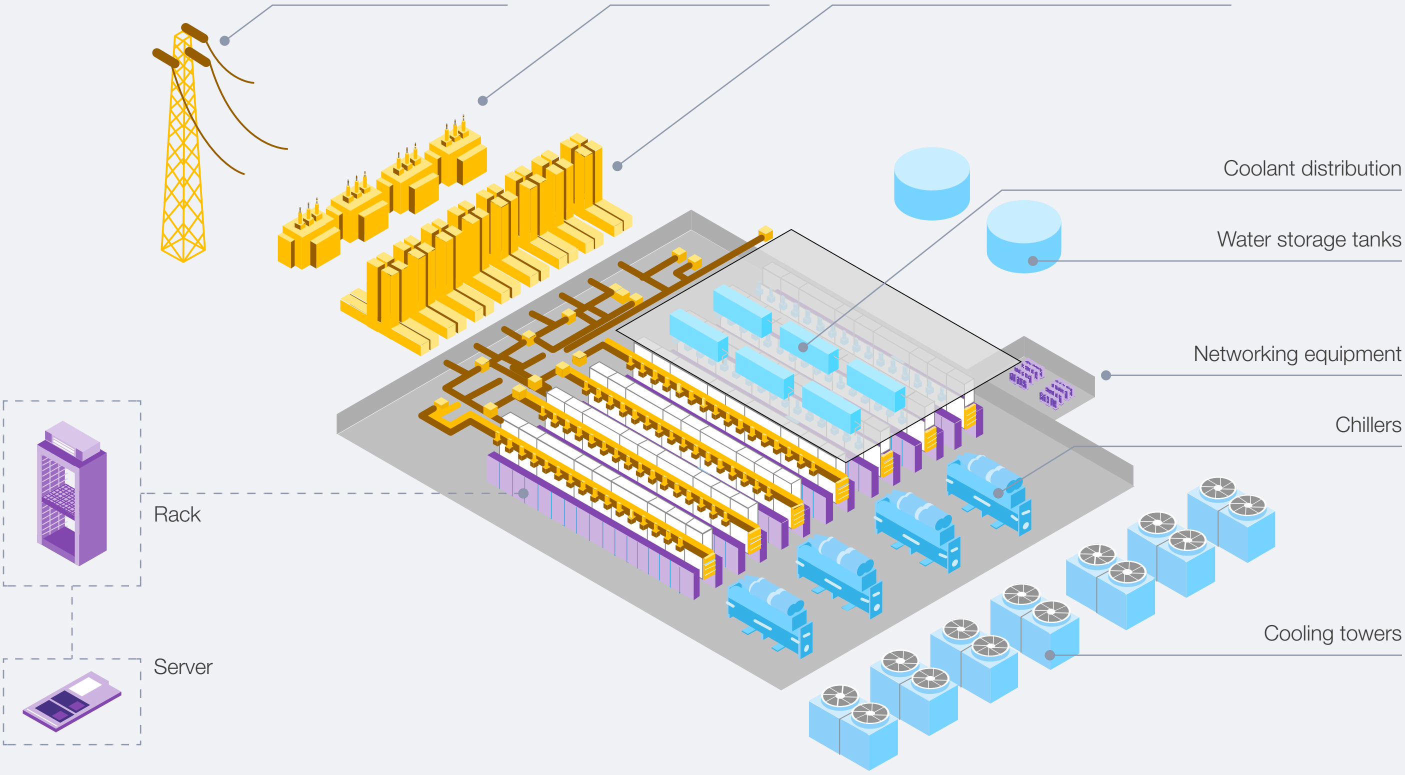
- **Material inputs and land use:** Data centres' global footprint is growing due to AI-driven demand, creating impact both from land use and from the construction materials required to build them.

- **Waste:** Heat in wastewater can degrade local ecosystems if not properly cooled. Beyond physical waste, data waste or "dark data" that is rarely or never used can consume vast resources for storage and back-ups.

Considerations related to cooling data centres merit special attention. AI growth is driving an increase in computing need, power density and therefore cooling need. Evaporative water cooling decreases power requirements, but results in increased water use. Conversely, avoiding evaporative water cooling can eliminate water consumption, but results in higher energy use. Depending on electricity source, this higher energy use can also result in increased water consumption along the value chain.

Data centre operators must thoroughly assess their sites for nature impacts and dependencies around water and electricity use. Using tailored assessments to determine the trade-offs between cooling designs, then working with local regulators and communities can support development of long-term, mutually supportive approaches. The analysis in Figure 12 provides sample implications when assessing global data centre hubs based on cooling, power and water trade-offs; but the specific nuance for developers will vary site by site.

FIGURE 11 | **Data centres – summary of key nature impacts and dependencies**




### Electricity use

- Hyperscale facility energy loads are upwards of 100 MW and growing.
- Facility PUE* ranges from 1.02 (immersion cooling) to 2.90 (air cooling), based on cooling type and efficiency measures but 1.4-1.6 is most typical

### Water use

- Hyperscale facility annual water usage may exceed 2 billion litres
- A typical facility will expel ~40% of its water use as wastewater
- Facility WUE** ranges from 0 (free air cooling, immersion cooling) to 2.91 (evaporation cooling), based on both server-level and facility-level cooling strategies

### Facility land use

Hyperscale facility footprint can exceed 1,900 sq. metres

### Core building materials

Concrete, steel, copper, aluminium, wood, plastics, composites, insulation, glass, tar

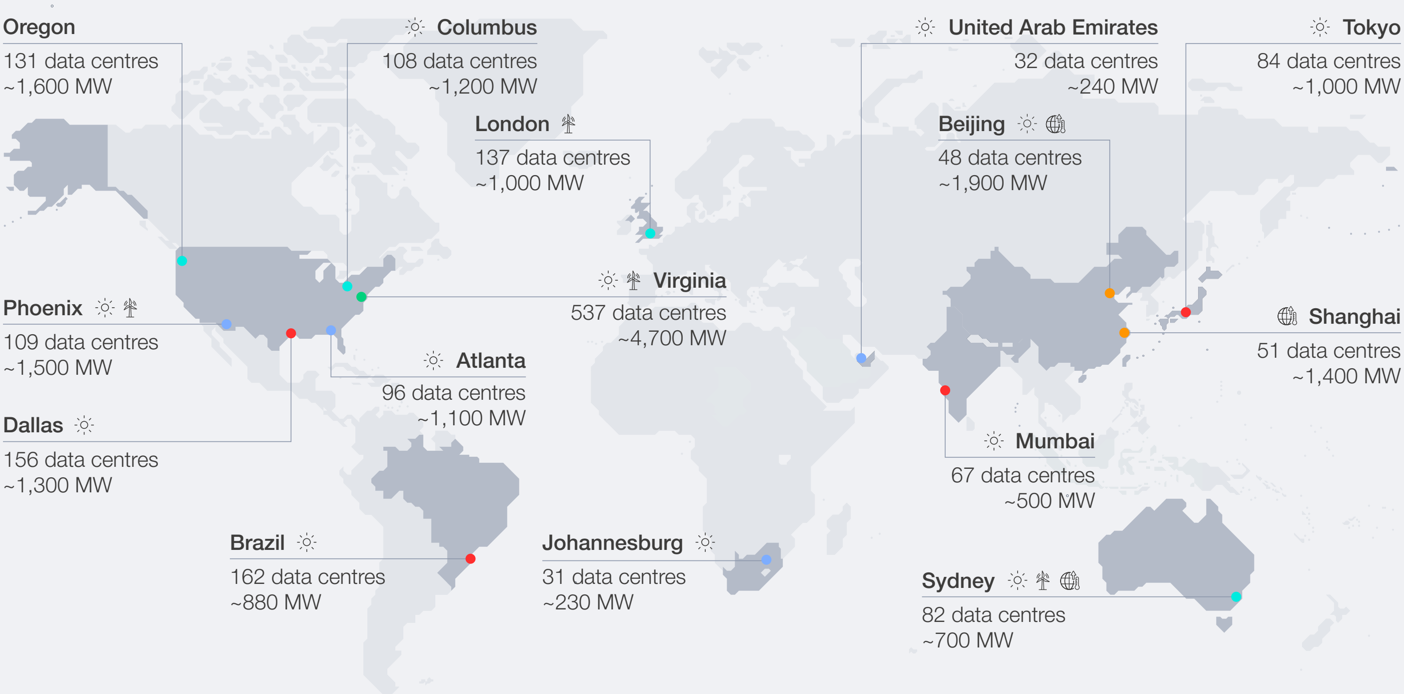
**Notes:** *PUE: power use effectiveness = total energy required by facility over total energy required for computing; **WUE: water use effectiveness = annual litres of water used for humidification and cooling over total annual kWh used to power IT equipment.

**Sources:** see endnote.[57]

FIGURE 12 | **Data centres (DCs) – summary of archetypes and sample implications**[58]

| Archetype | Cooling degree days* | Water stress level | Renewable energy share | Description | Implication |
|---|---|---|---|---|---|
| High cooling need, versatile cooling options | High/very high | Low/medium | High/very high | Regions with material cooling needs that have access to renewable power and low water stress | DCs can optimize efficiency through a variety of energy sources and cooling methods |
| High cooling need, prioritize renewable power | High/very high | High/very high | High/very high | Regions with material cooling needs that have access to renewable power but are water stressed | DCs may look to renewable power to maximize efficiency and reduce water use |
| High cooling need, incorporate water cooling | High/very high | Low/medium | Low/medium | Regions with material cooling needs that have limited access to renewable power but low water stress | DCs focus on energy efficiency, focusing less on water usage in the near term |
| High cooling need, constrained on cooling options | High/very high | High/very high | Low/medium | Regions with material cooling needs that have limited access to renewable power and high water stress | DCs may require innovative solutions (e.g. onsite water recycling, SMRs for power)** to optimize |
| Low cooling need, optionality in cooling | Low/medium | Low/medium or High/very high | Low/medium or High/very high | Regions with low cooling needs that have access to renewable power or have low water stress or both | DCs optimize operations based on the available resources with limited impact |
| Low cooling need, constrained on cooling options | Low/medium | High/very high | Low/medium | Regions with low cooling needs that have limited access to renewable power and high water stress | DCs may look to low-impact cooling methods (e.g. free air cooling) when possible |

Low/medium High/very high




SAMPLE IMPLICATION

**Dallas**

Dallas has significant cooling needs, but optionality given moderate water stress and high renewable energy share.

SAMPLE IMPLICATION

**United Arab Emirates**

DCs in the United Arab Emirates may seek innovative solutions (e.g. recycle water) to manage cooling requirements.

- High cooling need, but versatile
- High cooling need, renewable power
- High cooling need, water cooling
- High cooling need, constrained
- Low cooling need, optionality
- Low cooling need, constrained
- Very high/high solar potential
- Very high/high wind potential
- Very high/high geothermal potential

**Notes:** *Cooling degree days are used to indicate cooling requirements. The metric reflects how far above 15.5°C the daily average temperature is over the course of two years. See additional methodology in Appendix B. **SMR = small modular reactor.

## 2.3 Hardware and e-waste

**82**
billion kg

e-waste expected globally by 2030 – a 32% increase from 2022.

Hardware has a host of nature-related impacts and dependencies, from manufacturing, packaging and transportation to e-waste and end-of-life treatment. E-waste receives particular focus in this report – 62 billion kg was produced in 2022 and this number is expected to grow to 82 billion kg by 2030.

Figure 13 indicates how much of this total is recycled versus landfilled and compares nature impacts across pathways.[59] Broadly, hardware and e-waste impacts and dependencies on nature include:

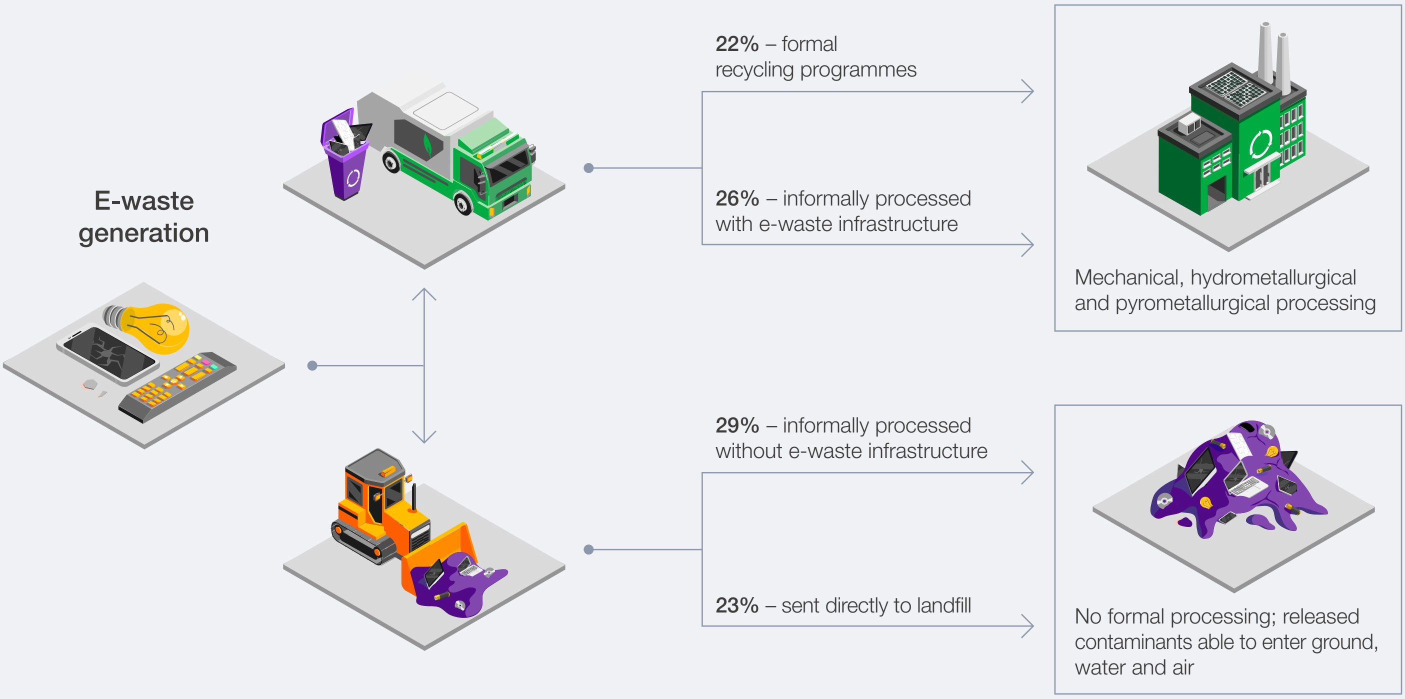
– **Hardware value chain impacts**: Although covered in less detail in this report, hardware manufacturing has a material nature impact given its raw material requirements, the energy needed for production, and the packaging and transportation to get products to market.

– **E-waste and pollution**: At least a quarter of e-waste goes directly to landfill, generating land-use impacts. This waste can release toxic heavy metals such as mercury, arsenic and lead that pollute water and soil surrounding disposal sites.

– **E-waste and end-of-life greenhouse gas emissions**: Emissions from burning waste and the release of hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs) from refrigerants are two potent sources of GHG emissions.

– **Water and electricity use in e-waste recycling**: Hydrometallurgical processing can require large water volumes, while the alternative pyrometallurgical processing can have high power requirements.

FIGURE 13 **E-waste – summary of key nature impacts and dependencies**




**Greenhouse gas emissions**
E-waste leads to **580 million** tonnes of $CO_2$e annually

**Land use**
**54 million** cubic metres of e-waste goes to landfill annually

| | Water use | Pollution and waste | GHG emissions | Electricity use |
|---|---|---|---|---|
| **Pyrometallurgy** | Minimal | 16-55 kg solid waste | 145 kg $CO_2$e | 7,500 kWh |
| **Hydrometallurgy** | 800 litres | 16 kg solid waste | 82 kg $CO_2$e | 150 kWh |
| | *All per 100 kg e-waste* | | | |

**Sources:** see endnote.[60]

# 3 Priority actions for tech companies towards nature positive

Tech companies can greatly reduce their impacts and dependencies on nature and cut costs, through reducing energy and water use, pursuing circularity, promoting land stewardship and engaging suppliers and policy-makers.

# 3.1 Seven priority action areas for the tech sector

Tech companies can transition to a nature-positive future by taking action across seven key areas, as outlined in Figure 14. Taking action will enable companies to better manage their nature impacts and dependencies, while also supporting positive commercial outcomes through enhanced resource management. While many companies have begun implementing listed actions, this report calls for a wider and more accelerated effort.

FIGURE 14 **Seven priority actions towards a nature-positive tech sector**

**Priority action areas for specific drivers of nature loss**

**1 Advance resilient and restorative water use**

Embed water-use efficiency and resilience into operations through proactive planning, onsite purification and reuse, and local replenishment

**2 Mitigate pollution and pursue circularity**

Advance a circular, low-impact approach through thoughtful design, extending equipment lifecycles, responsible waste processing and restoration projects

**3 Tackle non-power operational and embodied GHG emissions**

Pursue low-carbon operations for operational and embodied GHG emissions through prevention, emission scrubbing and accountability for residual emissions

**4 Promote land stewardship and restoration**

Minimize ecological impact by directing development away from sensitive areas and integrating biodiversity into site planning and design

**Priority action areas that apply across all drivers of nature loss**

**5 Power operations sustainably**

Support clean, efficient energy use by integrating low-carbon sources and smart systems into operations

**6 Engage with your supply chain**

Engage with suppliers to develop a lower-impact supply chain through utilizing sustainability certifications, prioritizing low-impact materials and innovating on processes

**7 Engage externally and support policy-making**

Shape science-based policy through proactive engagement, transparent reporting and responsible value chain practices

The first part of this chapter analyses these seven nature-positive priority action areas in more detail. Actions are ordered by their place in the mitigation hierarchy:[61,62]

- **Avoid** negative impacts
- **Reduce** negative impacts
- **Restore** nature after negative impacts
- **Compensate** for impacts that cannot be avoided or restored[63]

All actions strive to achieve at least No Net Loss (NNL) and ideally Biodiversity Net Gain (BNG), in line with nature-positive ambitions.[64,65] The Nature Conservancy has identified six principles to guide the application of the mitigation hierarchy (see Figure 15).

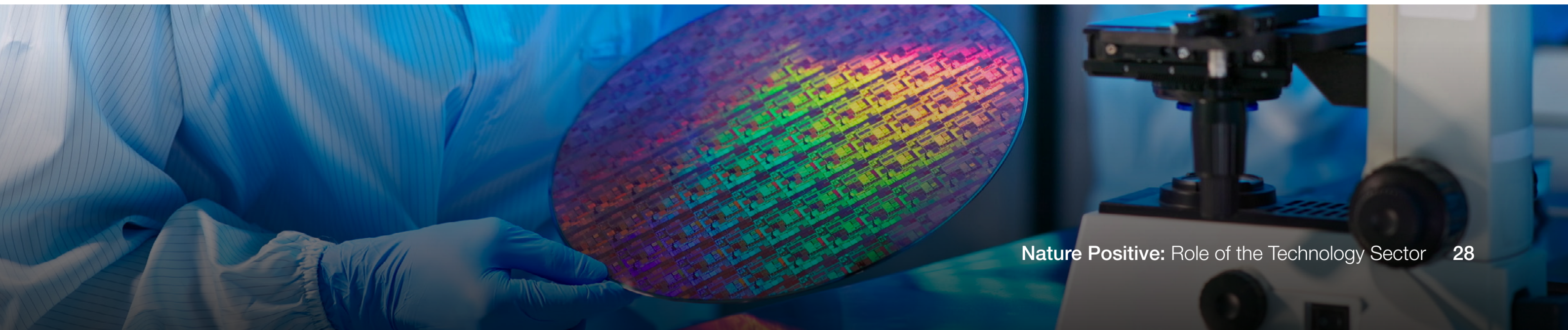


FIGURE 15 | **Principles for applying the mitigation hierarchy**

### Mitigation hierarchy steps

The steps are followed sequentially in order of priority:

- **Avoid** impacts
- **Reduce** impacts
- **Restore** after impacts
- **Compensate** for impacts

### Landscape context

Apply the mitigation hierarchy in a landscape context, taking into consideration direct, indirect and cumulative impacts

### Goal

Mitigation policy goals at the national, regional and local level ensure the mitigation hierarchy is applied to support conservation objectives and drive accountability for application. Over 100 countries have developed or are developing national mitigation policies that require offsets or enable the use of offsets

### Limits to offsets

There are limits to what can be offset and it is best to avoid impacts that cannot be offset as this may be the only means to prevent irreplaceable loss

### Sustainable outcomes

Mitigation seeks to support long-term, durable outcomes

### Stakeholder engagement

Mitigation follows best practice for stakeholder engagement, guided by the following principles:

- Inclusiveness
- Transparency
- Rights-based approach
- Respecting both science and traditional knowledge

**Source:** The Nature Conservancy.[66]

In addition to its place in the mitigation hierarchy, each action includes a qualitative assessment of two metrics:

- **Leadership**: What actions achieve transformational vs. incremental benefit? What is common practice vs. what will require time to achieve?
- **Feasibility**: Which actions provide financial benefit vs. which are a cost driver? Which have technical/implementation challenges?

The second part of this chapter compares all actions across these metrics, presenting a starting position for companies beginning their journey, as well as case studies on selected actions. Additional notes on these metrics and how they are applied are available in Appendix B: Methodologies.

ACTION 1

# Advance resilient and restorative water use

**Priority actions for water use**

| Action | | Leadership | Feasibility | Mitigation hierarchy | Sub-sector |
|---|---|---|---|---|---|
| 1.1 | Review site locations for water stress levels and work with local and regional officials to ensure availability. | Foundational | High | Avoid/reduce | Semiconductors, Data centres, Hardware |
| 1.2 | Pre-construction, design buildings and processes for water efficiency. During operations, update existing processes to improve inefficiencies and reduce water use. | Foundational | High | Avoid/reduce | Semiconductors, Data centres, Hardware |
| 1.3 | Implement a standard (e.g. ISO 46001) to conduct a full accounting of water use in operations and key supply chain components. | Leading | High | Avoid/reduce | Semiconductors, Data centres, Hardware |
| 1.4 | Prioritize using non-potable water, where feasible, and utilize closed-loop water systems for both server and facility cooling, with onsite water purification to minimize net freshwater withdrawals. | Leading | High | Avoid/reduce | Semiconductors, Data centres, Hardware |
| 1.5 | Champion and support projects to monitor and restore local aquifers and watersheds. | Aspirational | High | Restore/compensate | Semiconductors, Data centres, Hardware |

Semiconductors Data centres Hardware

### 1.1 Review sites for water stress

– Review site locations for water stress levels (current and future) and work with local and regional officials to assess competition across the entire water supply to ensure availability.

– Before new developments, water stress levels can be assessed using public sources such as the World Resources Institute Water Risk Atlas or by working with government environmental bodies. This process ensures that new developments limit undue added stress on local water infrastructure.

*Example:*

When Google assessed a potential build in Arizona in 2023, they adjusted the design to use air cooling to reduce impact on the local water supply.[67] The company has developed a Water Risk Framework to guide some of these decisions.

### 1.2 Design and operate for efficiency

– Pre-construction, companies can design buildings and processes for water efficiency.

– During operation, they can update existing processes identified as priority areas to improve inefficiencies and reduce water use.

– For energy-intensive processes such as cooling, companies can consider the trade-offs with water, as discussed in Chapter 2.2.

### 1.3 Assess complete water footprint

– Implement a standard, such as ISO 46001, to conduct a full accounting of water use in operations and key supply chain components, such as embedded water in energy generation, to identify priority areas.

– The World Resources Institute has a guide available to assist in calculating water use from purchased electricity. Fewer than one-third of data centre operators actively track their water usage metrics today.[68]

– For direct operations, implementing a monitoring system will allow companies to identify issues such as leaks or poorly optimized processes and rectify them. The solution can be as simple as replacing a component or sealing a leak.

*Example:*

HCLTech has developed a system called AquaSphere to monitor facility water usage and provide insights on where and how water is used.[69]

Fewer than one-third of data centre operators actively track their water usage metrics today.

Chip manufacturers in Taiwan reported an average wastewater recycling rate of 85% from 2016-2020.

## 1.4 Closed-loop and water reuse

- Prioritize using non-potable water, where feasible.
- Utilize closed-loop water systems for both server and facility cooling with onsite water purification to minimize net freshwater withdrawals.
- Doing so enhances water recycling rates to cut overall consumption, addressing both operator costs and community concerns around water availability.[70]
- This is especially important for semiconductor manufacturers due to requirements for ultrapure water and resulting high rates of water use. Some manufacturers already demonstrate high rates of water recycling.

***Example:***

Intel returns over 80% of its water for manufacturing reuse; while chip manufacturers in Taiwan reported an average wastewater recycling rate of 85% from 2016-2020.[71] Microsoft and others are piloting closed-loop, chip-level cooling to avoid water evaporation.[72]

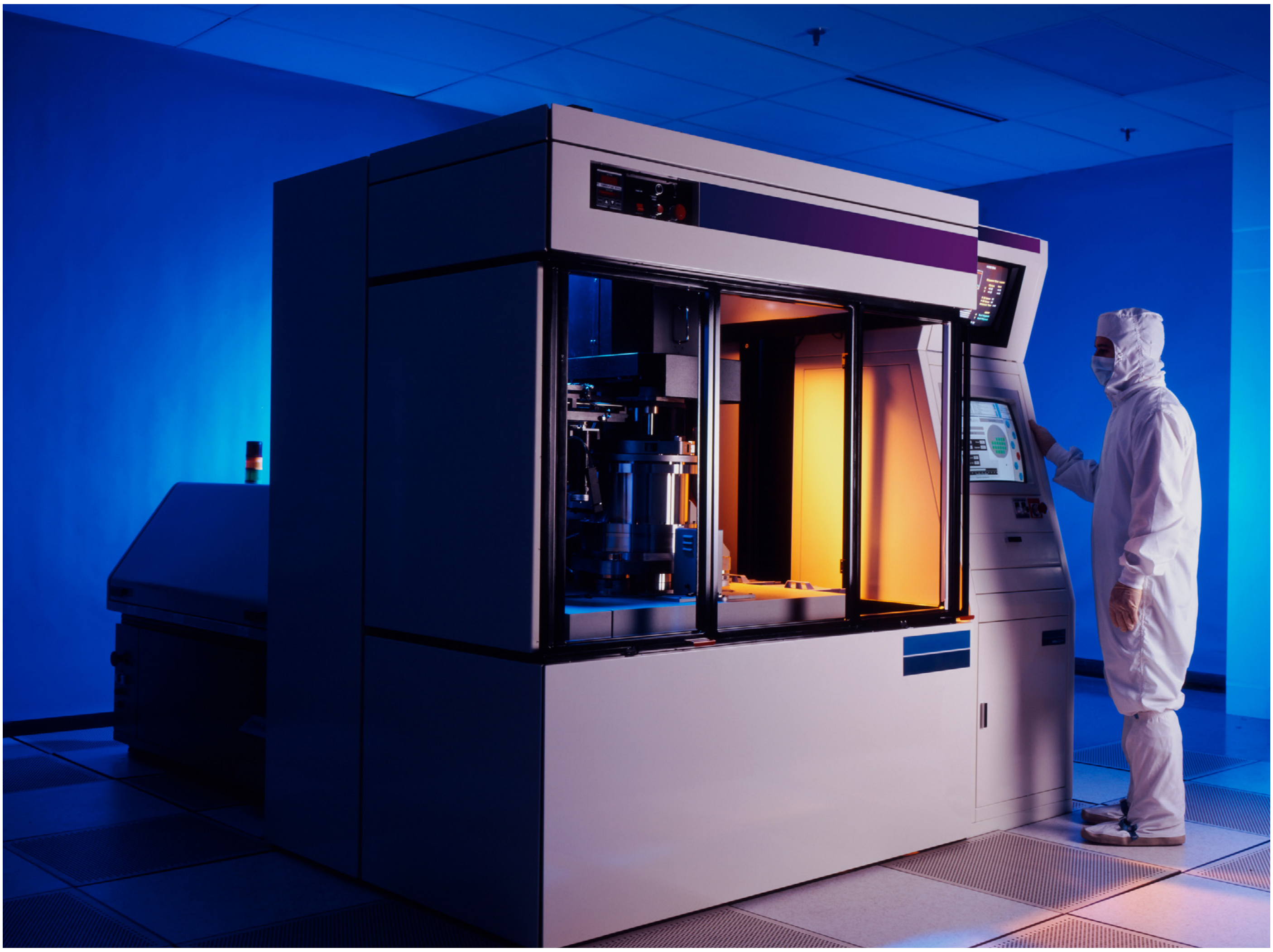
## 1.5 Restore local watersheds

- Champion and support projects to monitor and restore local aquifers and watersheds.
- This action often requires partnering with local and global organizations.

***Examples:***

AWS takes a multi-pronged approach in its goal to be water positive by 2030. The company works with water charities to bring clean water to areas in need and partners with nature groups for restoration projects, such as restoring watersheds in Brazil and South Africa, and building wetlands to recharge and improve the quality of groundwater in the UK.[73]

Through the Aquapreneur Innovation Initiative – a five-year partnership between HCL Group and UpLink (the early stage innovation ecosystem of the World Economic Forum) – AWS partnered with the start-up Kilimo to promote sustainable water management practices. The initiative as a whole aims to source and scale up high-potential solutions to conserve and restore freshwater ecosystems through innovation challenges. Through similar efforts, tech companies can contribute to collective efforts to address low rates of water replenishment globally, especially tied to priority water basins.



ACTION 2

# Mitigate pollution and pursue circularity

**Priority actions for pollution and waste**

| Action | | Leadership | Feasibility | Mitigation hierarchy | Sub-sector |
|---|---|---|---|---|---|
| 2.1 | Optimize hardware and process design with circularity in mind, e.g. utilize recycled materials and design with a modular focus to support repairability. | Leading | Low | Avoid/reduce | Semiconductors, Data centres, Hardware |
| 2.2 | Prioritize maintenance and replacement of individual components to extend product lifespan. | Foundational | High | Avoid/reduce | Semiconductors, Data centres, Hardware |
| 2.3 | Embed digital circularity practices to minimize data waste and associated resource needs. | Aspirational | High | Avoid/reduce | Data centres |
| 2.4 | Develop the infrastructure (e.g. collection systems, repair facilities, consumer awareness) to enable and encourage repair and reuse of consumer electronics. | Aspirational | Low | Avoid/reduce | Hardware |
| 2.5 | Develop collection programmes to streamline recycling processes, encourage proper disposal at authorized end destinations and harvest working components of unusable devices for reuse. | Leading | Low | Avoid/reduce | Data centres, Hardware |
| 2.6 | Invest in e-waste recycling infrastructure to expand recovery of valuable metals. | Aspirational | Low | Avoid/reduce | Semiconductors, Data centres, Hardware |
| 2.7 | Avoid pollution and contaminants (e.g. wastewater, waste heat, solid waste) impacting the environment by using advanced waste control systems and setting zero-waste-to-landfill standards (e.g. UL2799). | Foundational | High | Avoid/reduce | Semiconductors, Data centres, Hardware |
| 2.8 | Rehabilitate areas damaged by pollutants and waste by investing in and supporting land and water restoration efforts. | Aspirational | High | Restore/compensate | Semiconductors, Data centres, Hardware |

Semiconductors  Data centres  Hardware

### 2.1 Design for circularity and repairability

- Optimize hardware and process design with circularity in mind, e.g. utilize recycled materials and design with a modular focus to support repairability.
- This action begins at the design stage. Recycled metals can be 2-10 times more energy efficient than metals smelted from virgin ore,[74] decreasing the nature footprint of a new product.

### 2.2 Extend equipment lifespan

- Prioritize maintenance and replacement of individual components to extend product lifespan.[75]
- To support end-of-life, companies can also design products to make dismantling, refurbishment and recycling as simple as possible.
- Planning for each stage of a process or product lifecycle ensures that resources are used efficiently throughout. This especially means avoiding planned or inadvertent obsolescence through design to minimize earlier replacement.

Out of 31 billion kg of metal found in e-waste in 2022, only 60% was recovered, leaving over $60 billion in value in landfills.

### 2.3 Embed digital circularity practices

- Embed digital circularity practices to minimize data waste and associated resource needs.

- Circularity principles extend beyond physical hardware to encompass digital resources. Reducing the generation and retention of unnecessary data minimizes the associated storage, computing and network resources required over a product's lifetime, delaying hardware refresh cycles and reducing associated e-waste.

- Proactive "digital housekeeping", such as setting retention policies, de-duplicating files, optimizing data formats and removing unused or redundant datasets, can cut the nature footprint.

### 2.4 Develop repair infrastructure

- Develop the infrastructure to enable and encourage repair and reuse of consumer electronics.

- Following design, the focus shifts to reuse. Hardware refreshes contribute to massive volumes of e-waste, so replacing individual components or performing maintenance/refurbishment, rather than replacing the entire item, is key.[76]

- This includes developing a collection system, creating repair facilities and building consumer awareness.

***Example:***

Apple has a network of over 5,000 certified repair locations to support consumers in extending their product lifespan.[77]

### 2.5 Establish collection programmes

- Develop collection programmes to streamline recycling processes, encourage proper disposal at authorized end destinations and harvest working components of unusable devices for reuse.

- When a product reaches end-of-life, recycling and otherwise refurbishment are the best options and can be demonstrated in various ways.

- Having easy, widespread access points for consumers to drop off their end-of-life electronics avoids additional waste sent to landfills. Through these programmes, manufacturers ensure a steady supply of still valuable materials to channel into new products.

- Data centres can develop similar partnerships through zero waste initiatives to ensure that old hardware cycled out is safely disposed.

***Examples:***

Microsoft has implemented policies around managing waste, utilizing regional Circular Centers focused on e-waste from its data centres. These sites centralize collection and contribute to Microsoft recycling or reusing over 90% of its decommissioned computer servers and other technologies within data centres in 2024.[78]

A broader industry coalition is Australia's MobileMuster programme. It collects phones and accessories for recycling and is managed by the Australian Mobile Telecommunications Association (including companies such as Apple, Google, Samsung, TCL) and supported by recycling and government partners.[79]

### 2.6 E-waste recycling infrastructure

- Invest in e-waste recycling infrastructure to expand recovery of valuable metals.

- One barrier today is a lack of adequate e-waste processing infrastructure. Out of 31 billion kg of metal found in e-waste in 2022, only 60% was recovered, leaving over $60 billion in value in landfills.[80]

- Tech companies can be both the consumer, purchasing recycled materials (potentially at a discount) and the producer, sending electronics at end-of-life to be processed.

***Example:***

Western Digital has partnered with Microsoft, Critical Materials Recycling and PedalPoint Recycling to collect obsolete drives from Microsoft data centres and extract rare earth metals, as well as gold, copper, aluminium and steel. Still in its first year, the partnership has showed promising results, processing over 20,000 kg of drives.

### 2.7 Adopt pollution and waste controls

- Avoid pollution and contaminants impacting the environment by using advanced waste control systems and setting zero-waste-to-landfill standards (e.g. UL2799).

- This work begins with monitoring systems for individual processes, to ensure that each process is optimized to reduce input materials and to shut down leaks as soon as they occur.[81]

- By monitoring outputs, a comprehensive plan for managing waste can be developed, including tracking waste output, determining in-house separation and collection procedures and identifying alternative options for utilizing waste.

- For wastewater from semiconductor manufacturing, for example, water can be filtered and a portion of removed chemicals processed for reuse.

- For solid waste from manufacturing or e-waste processing, chemicals can be stripped out and the remaining by-product used in industrial processes, such as construction.

- Where operations generate substantial quantities of waste heat, which can be harmful when discharged into natural environments, that heat can be captured and repurposed for use in the facility or other nearby locations.[82, 83] At a minimum, establishing discharge temperature standards can protect the safety of local ecosystems.

*Examples:*

Incorporating these actions often offers commercial opportunities. In 2023, TSMC derived ~$40 million in benefit from resource circulation, achieved through a 96% waste recycling rate.[84] Meanwhile in Denmark, Microsoft is leveraging surplus data centre heat for district heating.[85]

### 2.8 Invest in pollution rehabilitation

- Rehabilitate areas damaged by pollutants and waste by investing in and supporting land and water restoration efforts.

- Even with best controls, pollution and waste may still occur; companies can go beyond impact mitigation to true nature positivity.

*Example:*

Samsung has launched a partnership with Seatrees, which focuses on restoring marine ecosystems using its own technology in support.[86]

Utilizing alternative chemicals or gases that are less impactful is an important part of pollution control and is discussed under Action 6.

ACTION 3

## Tackle non-power operational and embodied GHG emissions

**Priority actions for greenhouse gas emissions**

| Action | | Leadership | Feasibility | Mitigation hierarchy | Sub-sector |
|---|---|---|---|---|---|
| 3.1 | Monitor processes to identify and prevent potential for greenhouse gas leaks (e.g. CFCs, HFCs). | Foundational | High | Avoid/reduce | Semiconductors, Hardware |
| 3.2 | Utilize gas scrubbers to capture waste gases and prevent emissions. | Leading | High | Avoid/reduce | Semiconductors, Hardware |
| 3.3 | Design products with the goal of reducing embodied carbon through minimizing material inputs. | Aspirational | High | Avoid/reduce | Hardware |
| 3.4 | Invest in high-quality, verified carbon offset and removal credits to account for any remaining emissions, considering biodiversity and other co-benefits. | Leading | High | Restore/compensate | Semiconductors, Data centres, Hardware |

Semiconductors Data centres Hardware

Microsoft has committed to purchasing additional credits to account for past emissions and work towards becoming a 'carbon negative' company since inception, by 2030.

### 3.1 Monitor for direct GHG leaks

- Monitor processes to identify and prevent potential for greenhouse gas leaks (e.g. CFCs, HFCs etc.).
- When addressing direct, non-power GHG emissions, companies can first assess existing operations. Monitoring ensures that action can be targeted.
- Processes that use high-GWP (global warming potential) refrigerants or gases (e.g. CF4, NF3)[87] deserve extra consideration.
- For identified leaks or inefficiencies, immediate action limits the risk of contamination and improves operations, whether sealing a leak, optimizing a process to more efficiently use a gas, or upgrading to more efficient equipment.
- Energy and associated emissions are covered in more detail under Action 5.

### 3.2 Utilize gas scrubbers

- Utilize gas scrubbers to capture waste gases and prevent emissions. Once operations are optimized to avoid as many emissions as possible, facilities can then look to reduction through scrubbers.
- Other actions typically require more significant overhauls of processes, which require longer timelines to implement.
- There are several options for abatement, including point-of-use (applied to a targeted point in a process), point-of-area (applied to a section or across a process) and central abatement systems (applied across the entire facility). Which system to use depends on company- and facility-specific factors, with each having trade-offs on cost, operational impact and efficiency.[88]

***Example:***

Samsung uses its Regenerative Catalytic System (RCS) to handle process gases. The RCS can use less fuel and still lower emissions because it operates at a lower temperature than many, enabling up to 95% processing efficiency.[89]

### 3.3 Design to lower embodied carbon

- Design products with the goal of reducing embodied carbon through minimizing material inputs, such as reducing the quantity of plastic used. This action addresses indirect, embodied GHG emissions.
- Companies can seek to reduce the volume of material used and/or to use inputs with lower nature impacts, such as reusable packaging or recycled material. They can also request product carbon footprints.

***Example:***

IBM established a Design for the Environment programme that guides its business organizations and includes an objective to minimize resource use and select environmentally preferred materials.[90]

### 3.4 Invest in carbon credits

- Invest in high-quality, verified carbon offset and removal credits to account for any remaining emissions, considering biodiversity and other co-benefits.
- Carbon credits are typically divided between *offsets*, which compensate for emissions by preventing them elsewhere, and *removals*, which compensate for emissions by removing a set amount from the atmosphere. Carbon removals are often more highly regarded as a direct, traceable solution that physically reduces GHGs in the atmosphere.
- Critical concepts when assessing carbon credits include *additionality*, where emission reductions/removals tied to the project would not have occurred without the revenue generated from selling the credit, and *permanence* – the timeframe for the durability of the emissions reduction or removal.

***Example:***

Some companies may even consider purchasing additional credits to account for past emissions and work towards becoming a "carbon negative" company since inception, as Microsoft has committed to do by 2030.[91]

Action 6 on supply chain engagement includes additional relevant priority actions, emphasizing the importance of working with suppliers to utilize gases with lower GWP where possible.

ACTION 4

# Promote land stewardship and restoration

**Priority actions for land use**

| Action | | Leadership | Feasibility | Mitigation hierarchy | Sub-sector |
|---|---|---|---|---|---|
| 4.1 | Prioritize new developments in brownfield areas to avoid net new impact. | Leading | High | Avoid/reduce | Semiconductors, Data centres, Hardware |
| 4.2 | Utilize biodiversity risk assessments when conducting site selection to avoid construction on any high-value ecosystems, such as critical habitats or protected areas. | Aspirational | High | Avoid/reduce | Semiconductors, Data centres, Hardware |
| 4.3 | For new sites, conduct land assessments to identify any existing harm and establish a baseline to compare against when decommissioning a site to ensure any impact is remediated. | Aspirational | High | Restore/compensate | Semiconductors, Data centres, Hardware |
| 4.4 | Consider green roofs and utilize native landscaping that promotes local biodiversity, is pollinator friendly and eliminates or reduces irrigation requirements. | Leading | High | Restore/compensate | Semiconductors, Data centres, Hardware |
| 4.5 | Use biodiversity offsetting to account for any unavoidable habitat conversion, ensuring no net biodiversity loss. | Aspirational | High | Restore/compensate | Semiconductors, Data centres, Hardware |
| 4.6 | Engage community stakeholders to ensure those stakeholders recognize and benefit from project value. | Foundational | High | Restore/compensate | Semiconductors, Data centres, Hardware |

Semiconductors Data centres Hardware

### 4.1 Prioritize brownfield development

– Prioritize new developments in brownfield, or previously developed, areas to avoid net new impact. This action avoids direct impacts on intact natural ecosystems.

### 4.2 Assess biodiversity risk in sites

– Utilize biodiversity risk assessments to avoid construction on any high-value ecosystems, such as critical habitats or protected areas.

– When selecting sites, brownfield or otherwise, companies can avoid developing on the following categories of land:

  – IUCN categories Ia and Ib Protected Areas.[92]

  – Alliance for Zero Extinction sites.[93]

  – World Heritage Sites[94] and other critical habitats.

– In some other categories of land, companies may seek to avoid development unless specifically promoting positive climate, environmental or social outcomes at a local level, for example:

  – Areas defined as critical habitats by IFC PS6[95].

  – IUCN categories II-IV Protected Areas.[96]

  – Other key biodiversity areas (KBAs)[97] and areas of high ecological, cultural or community significance.

### 4.3 Establish biodiversity baseline

– For new sites, conduct land assessments to identify any existing harm and establish a baseline to compare against when decommissioning a site to ensure any impact is remediated.

– This action ensures that companies track the impacts of their own operations on land and ecosystems over time.

Nature is highly localized and no two areas of land offer exactly the same biodiversity, so offsets and restoration funding are not perfect compensation for land use.

### 4.4 Green roofs, native vegetation

- Consider green roofs and native landscaping to promote local biodiversity (e.g. pollinator friendly) and eliminate or reduce irrigation requirements.

- For new and existing facilities, this can include incorporating vegetation that reduces cooling and heating needs; using native plants that provide habitats for animals, require less maintenance and are pollinator friendly; minimizing the use of irrigation systems and conserving water through rain harvesting (where legal) and drought-tolerant landscaping; and implementing natural pest control methods instead of harmful chemicals.

***Example:***

Microsoft designed a data centre in the Netherlands where it planted native trees and vegetation, converted turf areas into pollinator friendly habitats and introducing green space for employees, leading to stronger erosion control, improved soil quality, enhanced biodiversity and more natural aesthetics.[98]

### 4.5 Invest in biodiversity offsets

- Use biodiversity offsetting to account for any unavoidable habitat conversion and to ensure no net biodiversity loss.

- These restoration efforts can be through investment in high-quality, high-integrity biodiversity offsets or other landscape-scale restoration funds (e.g. through the World Economic Forum's trillion trees community).

- Nature is highly localized and no two areas of land offer exactly the same biodiversity, so offsets and restoration funding are not perfect compensation for land use. Ensuring that biodiversity offsets seek to achieve No Net Loss (NNL) of biodiversity and ideally a Biodiversity Net Gain (BNG) improves outcomes.

- To assess this, results must be monitored and analysed to ensure the offset is achieved. IUCN has developed a framework for guiding the design, implementation and governance of biodiversity offset schemes, which companies can use to support their efforts.[99] IUCN also provides a helpful public introduction to biodiversity offsets.

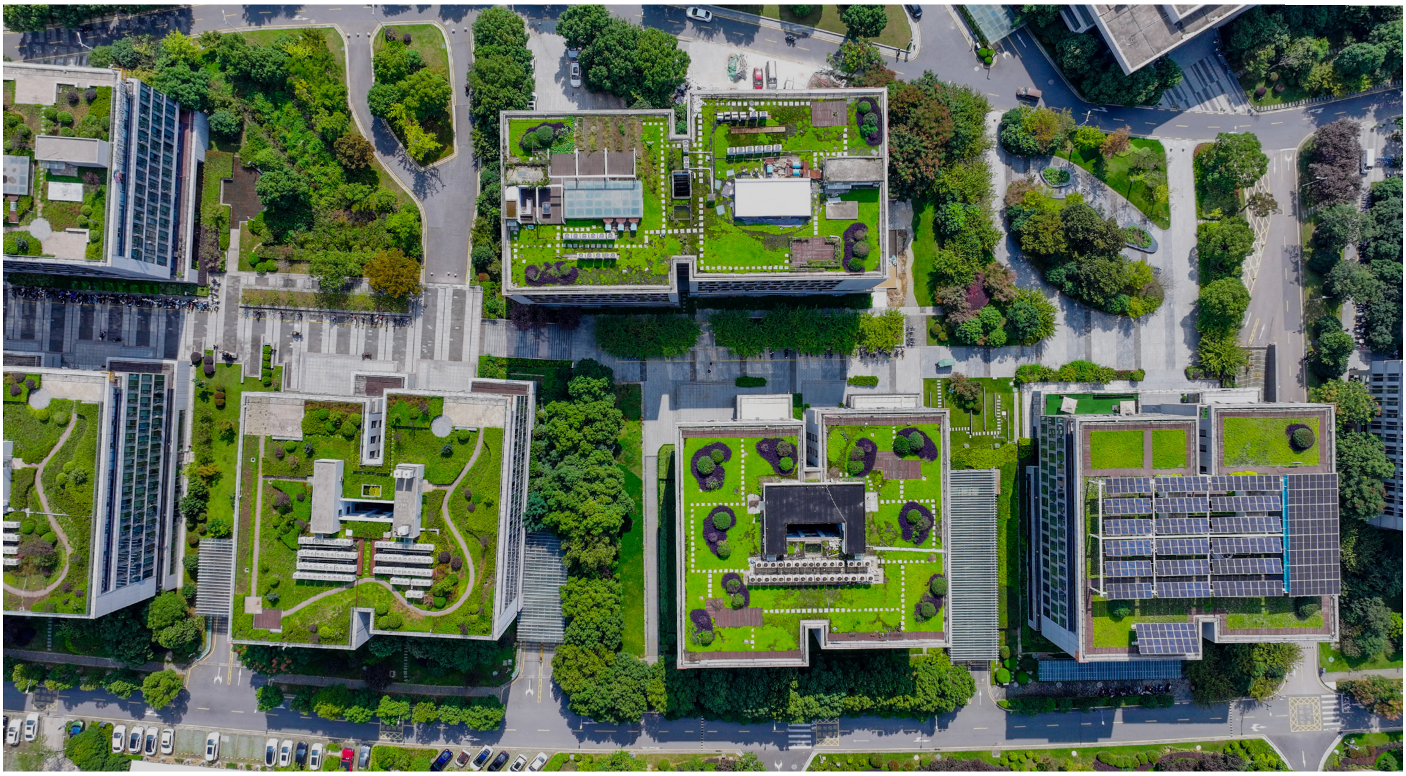
***Examples:***

Several tech companies are supporting land and biodiversity conservation. NEC coordinates with the Teganuma Aquatic Life Study Group to promote conservation efforts, such as managing invasive species and conducting annual check-ins with biodiversity experts and city officials, for an endangered species of dragonfly that has a habitat located on premises.[100]

HP has demonstrated the value of partnerships in these efforts, partnering with the Arbor Day Foundation, the World Wildlife Fund and Conservation International across restoration projects with substantial nature and human benefits.[101]

### 4.6 Engage community stakeholders

Beyond considering land and biodiversity impacts when siting facilities, companies can also better engage community stakeholders to ensure those stakeholders recognize and benefit from project value.



ACTION 5

# Power operations sustainably

| Priority actions for electricity use | | | | | |
|---|---|---|---|---|---|
| Action | | Leadership | Feasibility | Mitigation hierarchy | Sub-sector |
| 5.1 | Minimize nature impacts (e.g. water use, pollution, emissions) from electricity generation, by utilizing onsite low-carbon power sources and PPAs. | Foundational | High | Avoid/reduce | Semiconductors, Data centres, Hardware |
| 5.2 | Sponsor development of additional generation capacity, storage, and transmission and distribution infrastructure to enable additional renewable energy. | Leading | High | Avoid/reduce | Semiconductors, Data centres, Hardware |
| 5.3 | Design buildings for efficiency in power use (considering building envelope, HVAC, lighting etc.). | Foundational | High | Avoid/reduce | Semiconductors, Data centres, Hardware |
| 5.4 | Monitor and optimize cooling systems for efficiency and conditions (e.g. updating technology, climate monitoring to switch to free air cooling when conditions allow, raising operating temperatures). | Leading | Low | Avoid/reduce | Semiconductors, Data centres, Hardware |
| 5.5 | Install dynamic process management systems, in alignment with ISO 50001, to avoid idle energy use. | Leading | High | Avoid/reduce | Semiconductors, Data centres, Hardware |

Semiconductors Data centres Hardware

"Google signed a $20 billion deal in 2024 with a renewable developer for multiple GWs of power, along with infrastructure for energy storage and grid upgrades.

### 5.1 Low-carbon onsite energy or PPAs

- Minimize nature impacts from electricity generation by utilizing onsite low-carbon power sources and power purchase agreements (PPAs).

*Examples:*

Lenovo has 17 MW of solar power currently operational at its facilities and plans to add more.[102] As an alternative to onsite generation, companies may contract for existing or new low-carbon sources, such as solar or wind farms, through a PPA.

Qualcomm signed a PPA with Recurrent Energy in 2025 to supply 50,000 MWh annually, equivalent to 8,000 tonnes of $CO_2$.[103]

### 5.2 Sponsor low-carbon capacity

- Sponsor development of additional generation capacity, storage, and transmission and distribution infrastructure to enable additional renewable energy.

- As digital infrastructure grows and faces power constraints, companies can more directly support the development of low-carbon, low-impact power infrastructure.

*Example:*

Google signed a $20 billion deal in 2024 with a renewable developer for multiple GWs of power, along with infrastructure for energy storage and grid upgrades.[104]

### 5.3 Design power-efficient buildings

- In tandem with considering low-carbon power sources, companies should seek efficiencies in power use. Efficient building design includes consideration of building envelopes, advanced heating, ventilation and air conditioning (HVAC) systems and improved lighting choices.

- Certain power optimization measures, such as the adoption of high-voltage direct current (HVDC) power supply, can further benefit efficiency.

*Example:*

STMicroelectronics upgraded part of the HVAC at one site to use adiabatic cooling towers, saving 0.9 GWh in 2023.[105] STTelemedia in Singapore deployed hydrotreated vegetable oil (HVO) to reduce the impact relative to diesel fuel in backup generators.[106]

AWS uses temperature sensors in its data centres to track conditions and shift the type of cooling to optimize for energy and water.

## 5.4 Optimize cooling systems

- Monitor and optimize cooling systems for efficiency and conditions. Addressing electricity use for cooling is critical for lowering energy draw, especially for data centres.

- Cooling systems are best if designed for the local climate, while keeping in mind the trade-offs between energy and water use, as discussed in Chapter 2.2.

- For variable climates, companies can utilize multiple types of cooling with monitoring systems to switch to whatever type is most optimal at any given time. Where feasible, free cooling can be considered.

***Examples:***

AWS uses temperature sensors in its data centres to track conditions and shift the type of cooling to optimize for energy and water.[107]

Companies can consider other efficiency measures, optimizing hardware energy performance and raising indoor operating temperatures to decrease cooling requirements. Meta and Microsoft have both pledged to operate their data centres at higher temperatures to decrease energy consumption.[108]

## 5.5 Dynamic process management

- Install dynamic process management systems to avoid idle energy use. These systems will further enhance efficiency. Energy management systems ideally follow an accredited standard, such as ISO 50001.

- While most applicable for data centres, this can improve efficiency across tech manufacturing and other sub-sectors of the value chain.

***Examples:***

Google uses an AI system to query sensors across the data centre to optimize cooling technology, reducing energy use by 30%. Meta uses machine learning to manage the amount of air circulated for cooling.[109]

An additional resource companies can reference is the ZEROgrid initiative, which has produced a corporate actions playbook addressing key challenges to reliable grid decarbonization, types of corporate actions and an implementation guide. While fostering additional zero- and low-carbon renewable power capacity has clear benefits, companies must still consider the potential impacts of these power sources and infrastructure on nature and biodiversity. The Organisation for Economic Co-operation and Development (OECD) offers constructive considerations for integrating biodiversity into renewable power planning.[110]

ACTION 6

# Engage with your supply chain

**Priority actions for supply chain engagement**

| Action | | Leadership | Feasibility | Mitigation hierarchy | Sub-sector |
|---|---|---|---|---|---|
| 6.1 | Identify and work with suppliers who hold sustainability certifications (e.g. ISO 14001, Forest Stewardship Council, Rainforest Alliance) and have conducted impact assessments of their operations. | Foundational | High | Avoid/reduce | Semiconductors, Data centres, Hardware |
| 6.2 | Engage with metal and mineral suppliers for recycled materials and mining companies for lower impact materials (e.g. through book and claim transactions). | Aspirational | High | Avoid/reduce | Semiconductors, Data centres, Hardware |
| 6.3 | Collaborate with suppliers to identify and replace high-impact chemicals and gases (e.g. containing PFASs or high GWP) with less impactful versions where possible. | Leading | Low | Avoid/reduce | Semiconductors, Hardware |
| 6.4 | Seek out zero- or low-carbon alternatives for building materials and other material inputs. | Leading | High | Avoid/reduce | Semiconductors, Data centres, Hardware |
| 6.5 | For high-impact chemicals and gases that do not have existing alternatives, work with suppliers to develop new processes and inputs to phase out high-impact materials over time. | Aspirational | Low | Avoid/reduce | Semiconductors, Hardware |
| 6.6 | Set commitments related to building a responsible supply chain across nature-loss drivers (e.g. water, land, pollution and waste, GHG emissions) and ensuring broader regulatory guidance is followed throughout the value chain. | Leading | High | Avoid/reduce | Semiconductors, Data centres, Hardware |

Semiconductors  Data centres  Hardware

### 6.1 Suppliers with sustainability certificates

- Tech companies across the value chain should identify and work with suppliers who hold sustainability certifications and have conducted impact assessments of their operations.
- Certifications, especially when through reputable bodies and verified through independent auditors, provide a foundational level of assurance that suppliers are managing operations with regard for the environment. A non-exhaustive list of certifications is listed in Box 5.
- Companies can go further by requesting product-level environmental pressure data across nature-loss drivers and prioritizing suppliers that report on their nature-related impacts, enabling more informed procurement decisions and targeted improvement efforts.

*Examples:*

Delta Electronics has developed a supplier code of conduct focused on collaborating with suppliers to develop sustainable development targets for various areas, including energy conservation and carbon reduction, sustainable raw material procurement and waste reduction.[111]

ASUS has adopted a nuanced supplier grading management system. ISO 14001 certification is mandatory for all qualified suppliers, with additional requirements for specific issues. On water, motherboard suppliers must submit annual wastewater discharge testing reports. Suppliers who use substantive amounts of freshwater must identify mitigation measures if located near biodiversity-sensitive areas. In most cases, adopting a tiered approach to identify and manage factors with the highest environmental impacts, along with their corresponding suppliers, can improve the effectiveness of collaboration.

BOX 5 | **Example certifications to look for in suppliers**

- **ISO 14001**: International Standard for environmental management systems that provides a framework for companies to identify, manage and improve their environmental performance.[112]
- **Forest Stewardship Council (FSC)**: Certification ensuring products come from responsibly managed forests.[113]
- **Initiative for Responsible Mining Assurance (IRMA)**: Verification of mine sites indicating environmental and social performance has been measured by independent audit teams.[114]
- **R2v3**: Global standard for responsible electronics recycling and refurbishing.[115]
- **Sustainability certifications for construction of new buildings** or major renovations (e.g. LEED and WELL), especially for construction suppliers or property managers.
- ISO 50001: International standard onenergy management, especially for energy-intensive suppliers.

Embodied carbon in building materials accounts for 11% of global greenhouse gases.

### 6.2 Lower-impact metals, minerals

- Engage with metal and mineral suppliers for recycled materials and mining companies for lower impact materials. Metal and mineral inputs are a critical focus in the tech supply chain. By seeking suppliers that invest in biodiversity management, support local community stewardship and implement restoration commitments, tech companies can continue to grow while supporting the nature-positive transition.
- Book and claim transactions can serve as a mechanism to facilitate reaching deeper in the value chain, allowing tech companies to financially support and claim the environmental attributes of lower-impact or recycled materials even when physical traceability is not feasible.
- Participation in sustainable industry coalitions and traceability initiatives can further amplify these efforts.

*Example:*

Apple prioritizes recycled inputs: in 2024, the company avoided 6.2 million tonnes of emissions by sourcing recycled and other low-carbon materials, as per ISO 14021 specifications.[116]

### 6.3 Lower-impact chemicals, gases

- Collaborate with suppliers to identify and replace high-impact chemicals and gases with less impactful versions. Substances such as PFASs, industrial solvents and potent GHGs are critical to replace, given downstream effects on air, soil and water ecosystems.
- By collaborating with suppliers to find less harmful alternatives, tech companies can reduce their ecological footprint without compromising performance.

*Example:*

Tokyo Electron Limited developed a new etch process for semiconductor manufacturing that reduces the $CO_2$ footprint by using an alternative chemistry to the current process and operating at cryogenic temperatures, reducing GHG emissions by 83%.[117]

### 6.4 Lower-carbon building materials

- Seek out zero- or low-carbon alternatives for building materials and other material inputs. As highlighted by RMI's primer on the topic, embodied carbon in building materials accounts for 11% of global GHGs.[118]
- One data centre company conducted a 30-year life cycle assessment and identified the largest carbon impact as their cooling equipment, due to the lifecycle only being 5-7 years and equipment requiring frequent replacement. When designing, building or updating facilities, accounting for these impacts and targeting more sustainable approaches is critical.

*Example:*

Microsoft signed a deal with a low-carbon cement startup, Sublime Systems, enabling it to claim 622,500 tonnes of emission reductions over a 6-9 year period.[119]

### 6.5 Research and develop low-impact chemicals and gases

- For high-impact chemicals and gases that do not have existing alternatives, tech companies can work with suppliers to develop new processes and inputs to start phasing out high-impact materials.
- Given that many critical materials still lack scalable, sustainable alternatives, joint R&D programmes and supplier incentive schemes can accelerate the transition to nature positive.

Embedding nature into early-stage R&D will ensure a next generation of products that is better both for the industry and for nature.

– Companies can invest in co-development with suppliers, research institutions and startups to pioneer breakthroughs in sustainable materials. Embedding nature into early-stage R&D will ensure a next generation of products that is better both for the industry and for nature.

*Example:*

Semiconductor firm Micron has partnered with Merck KGaA to develop lower-GWP gases for use in semiconductor manufacturing.[120]

### 6.6 Set supply chain commitments

– Set commitments related to building a responsible supply chain across nature-loss drivers (e.g. water, land, pollution and waste, GHG emissions) and ensuring broader regulatory guidance is followed throughout the value chain.

– This practice must permeate across companies, otherwise efforts across the value chain may break down. By setting clear expectations for suppliers and engaging them on mitigating nature impacts, companies reinforce responsible practices, ensure progress is tracked and can highlight success stories.

*Example:*

Acer calls on suppliers and partners to assess the biodiversity-related risks of their operating sites and to adopt necessary measures to minimize negative impacts.[121]

Tech companies with co-located data centres may have less direct influence on data centre building construction or operations, but they can still drive the industry forward meaningfully by prioritizing co-location partners that adopt leading practices in the transition to nature positive.

ACTION 7

## Engage externally and support policy-making

**Priority actions for external engagement and policy-making**

| Action | | Leadership | Feasibility | Mitigation hierarchy | Sub-sector |
|---|---|---|---|---|---|
| 7.1 | Proactively engage in policy development to help shape balanced, science-based policies around areas concerning nature impacts and dependencies that are feasible for implementation. | Leading | High | Avoid/reduce | Semiconductors, Data centres, Hardware |
| 7.2 | Report using science-based frameworks (e.g. TNFD) across key nature-loss drivers (e.g. water use, GHG emissions, soil and water pollution) and consider setting external commitments (e.g. SBTN). | Foundational | High | Avoid/reduce | Semiconductors, Data centres, Hardware |
| 7.3 | Collaborate with regulators to track and publish nature impact metrics to develop reliable sector data and benchmarks. | Aspirational | High | Avoid/reduce | Semiconductors, Data centres, Hardware |

Semiconductors Data centres Hardware

Early engagement builds trust and credibility, both with regulators and with the public.

### 7.1 Proactively engage policy-makers

- Proactively engage in policy development to help shape balanced, science-based policies around areas concerning nature impacts and dependencies that are feasible for implementation.

- Early engagement builds trust and credibility, both with regulators and with the public.

***Examples:***

In the US, a joint board between the Department of Homeland Security and industry executives from companies including OpenAI, Anthropic, Nvidia, IBM, Microsoft, Alphabet, Adobe, AWS, AMD and more was established to advise on various AI topics, including discussions on critical infrastructure for its development and advancement.[122]

Another type of policy becoming more common is Extended Producer Responsibility (EPR) programmes. These programmes typically mandate some recycling and reuse of materials for certain products, with producers holding responsibility for the infrastructure. The EU for example has EPR legislation for packaging, e-waste and batteries.[123]

### 7.2 Report nature impacts

- Report using science-based frameworks across key nature-loss drivers and consider setting external commitments.

- In tandem with comprehensive regulation, voluntary reporting allows companies to lead the conversation on nature positive. Frameworks such as TNFD and SBTN provide structured approaches for assessing, disclosing and reducing nature-related risks and impacts.

- By aligning with them ahead of potential mandates, companies highlight their accountability and establish themselves as leaders in responsible governance.

***Examples:***

NEC registered as a TNFD Adopter in late 2023, in alignment with TNFD's corporate reporting guidance.[124] Companies can take these frameworks further by creating business units to analyse proposed measures for feasibility and benefit, and developing action plans for implementation.

Taiwan Mobile has a dedicated business unit responsible for determining how to achieve its net-zero emissions target that reviews all proposals for benefit before bringing the plan to the board of directors for implementation.

### 7.3 Sector-level nature benchmarks

- Collaborate with regulators to track and publish nature impact metrics to develop reliable sector data and benchmarks.

- Current company nature data is often incomplete, either due to a lack of reporting or inconsistent reporting standards. By working with public agencies, industry groups and research bodies, companies can contribute to the development of standardized metrics and sector benchmarks.

- This will enable stronger policy-making and allow companies to better compare performance and identify gaps in their current operations.

***Example:***

The European Green Digital Coalition, founded in 2021 by 26 members of the tech sector and supported by the European Commission and the European Parliament, developed science-based methods for their pilot phase to estimate the reduction and avoidance of GHG emissions for solutions targeting transport, agriculture, smart cities, energy and manufacturing.[125] Joining sector-wide efforts on these topics, whether some of those previously listed or others such as the Circular Electronics Partnership, brings a benefit to individual companies, the sector and society.

## 3.2 Comparison of nature action leadership and feasibility

FIGURE 16 **Tiering actions based on nature leadership**

| Foundational | Leading | Aspirational |
| --- | --- | --- |
| Foundational, often incremental actions that are or are becoming common practice | Actions adopted by several leaders that expand nature benefits and competitive advantage | Ambitious, often transformative and less common practices that shape the value chain |
| **1.1** Review sites for water stress | **1.3** Assess complete water footprint | **1.5** Restore local watersheds |
| **1.2** Design & operate for efficiency | **1.4** Closed-loop & water reuse | **2.3** Embed digital circularity practices |
| **2.2** Extend equipment lifespan | **2.1** Design for circularity/repairability | **2.4** Develop repair infrastructure |
| **2.7** Adopt pollution & waste controls | **2.5** Establish collection programmes | **2.6** E-waste recycling infrastructure |
| **3.1** Monitor for direct GHG leaks | **3.2** Utilize gas scrubbers | **2.8** Invest in pollution rehabilitation |
| **4.6** Engage community stakeholders | **3.4** Invest in carbon credits | **3.3** Design to lower embodied carbon |
| **5.1** Low-carbon onsite energy or PPAs | **4.1** Prioritize brownfield development | **4.2** Assess biodiversity risk in sites |
| **5.3** Design power-efficient buildings | **4.4** Green roofs, native vegetation | **4.3** Establish biodiversity baseline |
| **6.1** Suppliers with sustainability certificates | **5.2** Sponsor low-carbon capacity | **4.5** Invest in biodiversity offsets |
| **7.2** Report nature impacts | **5.4** Optimize cooling systems | **6.2** Lower-impact metals, minerals |
| | **5.5** Dynamic process management | **6.5** R&D low-impact chemicals, gases |
| | **6.3** Lower-impact chemicals, gases | **7.3** Sector-level nature benchmarks |
| | **6.4** Lower-carbon building materials | |
| | **6.6** Set supply chain commitments | |
| | **7.1** Proactively engage policy-makers | |

Water use | Pollution and waste | Greenhouse gas emissions | Land use | Electricity use | Supply chain engagement | Policy and external engagement

**Sources:** See methodology in Appendix B.

We can assess and compare actions based on the nature leadership they reflect from tech sector players. While each company should assess actions within the context of their operations and identify those most relevant for their nature-positive journey, the following tiering can help with planning the nature-positive transition:

– ***Foundational*** actions are table stakes and, as the name suggests, increasingly common and even expected among sector players.

– ***Leading*** actions are those where companies can begin to differentiate themselves; these actions offer more significant nature benefits and associated commercial, resilience and competitive advantages.

– ***Aspirational*** actions are among the most transformative, but as a result are often the most challenging to implement and will likely require the most time to gain traction.

The three case studies of selected priority actions below provide deeper insights into how companies have addressed some of these actions. The case studies highlight both nature and commercial benefits to emphasize how actions on the nature-positive journey can make sense for both a business and the environment.

CASE STUDY 1

## Using life-cycle assessments to drive innovation in data centre cooling – Microsoft and Schneider Electric.[126]

PRIORITY ACTIONS: WATER USE ELECTRICITY USE

Microsoft conducted an in-depth life-cycle assessment of data centre cooling technologies that demonstrated how shifting from air-cooling to advanced liquid-cooling methods (direct-to-chip and immersion cooling) can substantially reduce nature impacts.

The study identified reductions in GHG emissions (15-21%), energy demand (15-20%) and blue water consumption (31-48%) when moving from air-cooling to liquid-cooling in a 100% grid electricity scenario.

In a 100% renewable energy scenario, the study found similar reductions in GHG emissions (13-20%) and energy demand (15-20%), but a considerably greater reduction in blue water consumption of 50-82%, when moving from air-cooling to liquid-cooling.

When modelling a fully renewable energy scenario, a 10 MW data centre could see annual savings of $1.0-1.4 million in energy costs and $220,000-365,000 in water costs. While not directly experienced by the data centre, this would also save an additional $3.4-5.6 million in water costs from energy generation.

When comparing capital considerations between air-cooling versus liquid-cooling, Schneider Electric published a white paper that calculated capex costs are almost identical for 10 kW racks, at $7.02 for air-cooling and $6.98 for liquid-cooling.

As rack density increases, liquid-cooling sees additional cost savings as it enables more compact racks without requiring equivalent increases in equipment. Microsoft's cooling assessment, supported by Schneider Electric's capital review, highlights that liquid-cooling is a feasible way to reduce nature impacts and reduce costs for data centre operators.

**Shift from air-cooling to liquid-cooling reduces data centre impacts and costs**

| Reductions in | GHG emissions | Energy demand | Blue water consumption |
|---|---|---|---|
| 100% grid electricity scenario | 15-21% | 15-20% | 31-48% |
| 100% renewables scenario | 13-20% | 15-20% | 50-82% |
| Cost savings/year for 10 MW data centre | | $1.0 – 1.4 million | $220,000 – 365,000 |

CASE STUDY 2

## **Reusing rare earths through hard disk drive recycling –**
## Western Digital, Microsoft, Critical Materials Recycling and PedalPoint Recycling[127]

PRIORITY ACTIONS: POLLUTION AND WASTE SUPPLY CHAIN ENGAGEMENT

Western Digital, in collaboration with Microsoft, Critical Materials Recycling and PedalPoint Recycling, has developed a recycling initiative that transforms end-of-life hard disk drives (HDDs) into a valuable source of critical materials.

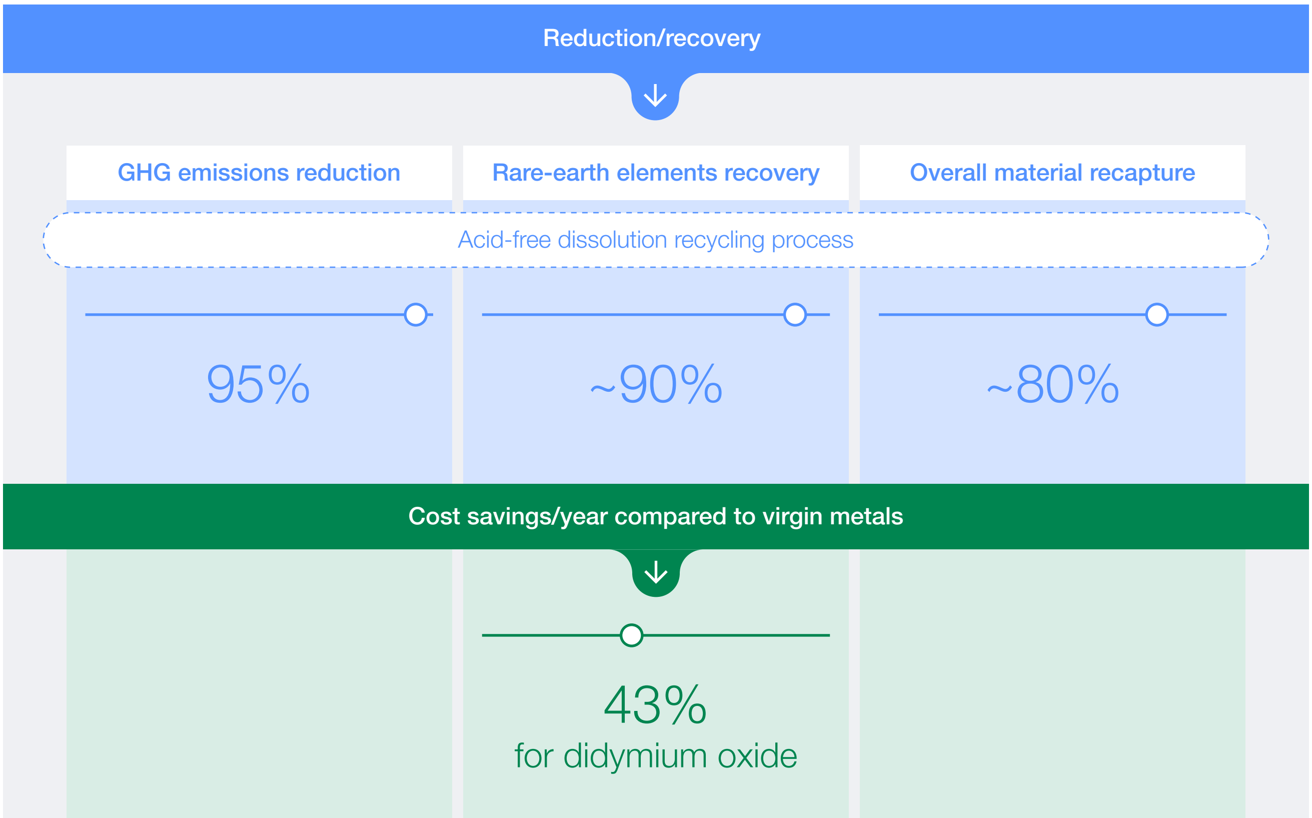
The pilot processed ~50,000 lbs of drives and achieved a ~90% recovery of rare-earth elements (e.g. neodymium, praseodymium, dysprosium) and ~80% overall material recapture (including other metals such as gold, copper, aluminium, steel).

Using an acid-free dissolution process, the programme not only avoids the hazards of traditional acid-based methods but also delivers a 95% reduction in greenhouse gas emissions compared to virgin mining.

By diverting ~50,000 lbs of HDD waste from landfills and directing high-quality materials back into supply chains, the initiative improves supply resilience, minimizes biodiversity impacts and reduces water and land use associated with mining.

Financially, recycled metals can reduce costs compared to procuring virgin metals. For example, didymium oxide is a mixture of praseodymium and neodymium that can see a reduction in cost of 43%, from $130/kg to $73/kg, when using recycled metals rather than virgin metals. With its scalable, economically viable approach supported by a reduced climate footprint and lower raw material costs, this pilot highlights a replicable, nature-positive model for global tech value chains.

**Reusing rare earths through hard disk drive recycling cuts waste and cost**



CASE STUDY 3

## Establishing a national collection scheme for recycling phones and accessories – Australian Mobile Telecommunications Association and members (Apple, Google, Samsung, TCL and more)[128]

**PRIORITY ACTIONS:** POLLUTION AND WASTE

Australia's MobileMuster programme, managed by the Australian Mobile Telecommunications Association – with members such as Apple, Google, Samsung, TCL and more – was initially established in 1998 and has been accredited since 2014.

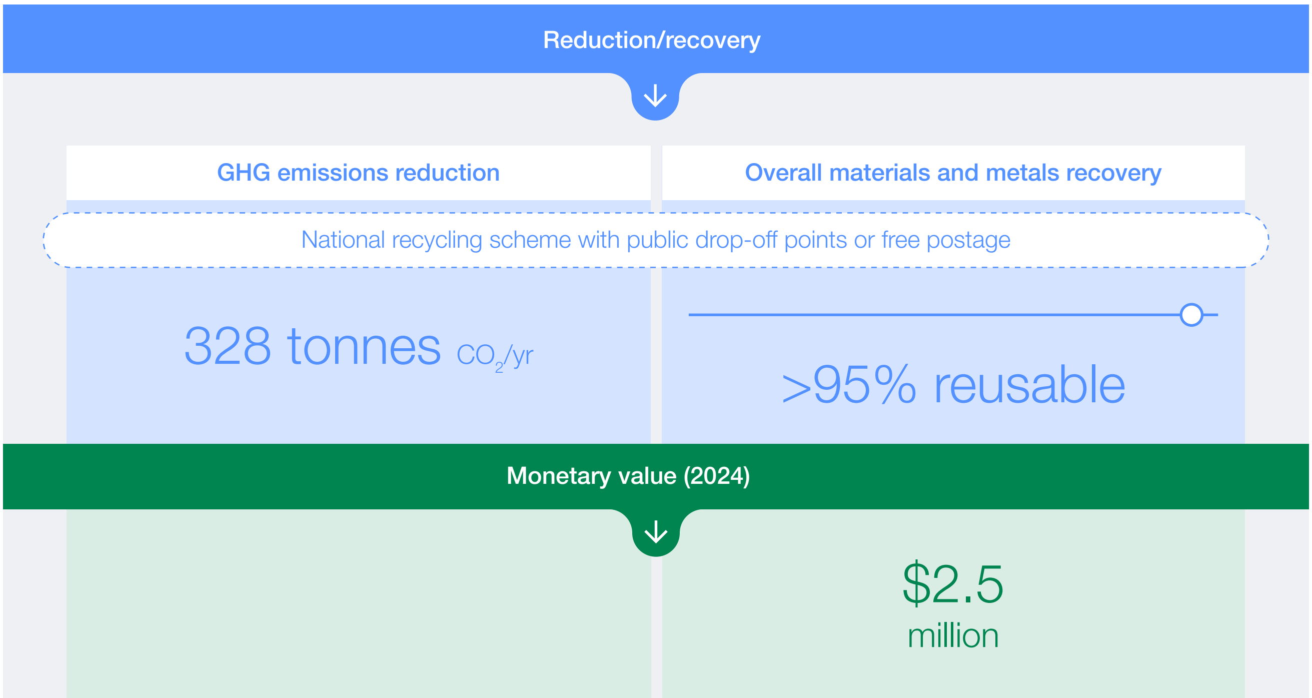
It has evolved into a best-in-class collection and recycling ecosystem, streamlining access through collaboration with local governments to create thousands of public drop-off points, ensuring that 96% of Australia's population has a drop-off within 10 km, in addition to free options to send items through the mail.

The initiative ensures that end-of-life phones, chargers and accessories are securely directed to authorized processing facilities where 100% of materials are recycled and over 95% of materials recovered can be reused.

MobileMuster also works with accredited partners and conducts audits to ensure that collected material is being responsibly recycled at authorized end destinations. In 2024, MobileMuster collected 109 tonnes of mobile phones for recycling that had the equivalent benefit of reducing $CO_2$ emissions by 328 tonnes, with the monetary value of the recovered metals equal to $2.5 million.

This recycling process helps eliminate hazardous materials leakage, conserve resources and reduce nature impacts from producing virgin metal. MobileMuster demonstrates how industry-led, government-supported efforts can deliver nature-positive outcomes and promote circular value in tech.

**Australia's national mobile phone recycling scheme cuts emissions and recovers materials**



# 4 Integrating nature-positive and net-zero strategies

The imperatives to tackle carbon emissions and nature loss are interdependent. Companies can integrate their nature-positive and net-zero strategies.

While many companies in the tech sector have already begun some of the recommended priority actions highlighted in Chapter 3, making transformative changes to business models demands significant investments of time and resources.

## 4.1 Assess, commit, transform and disclose

Tech corporate leaders can start to assess, commit, transform and disclose nature-related dependencies, impacts, risks and opportunities (DIROs) – as per the ACT-D framework – in a more systematic way, as follows:

- **Assess**: Identify, measure, value and prioritize nature-related impacts and dependencies across value chains to ensure companies act on the most material ones.
- **Commit**: Set transparent, time-bound, specific, science-based targets when material.
- **Transform**: Take actions to transform business models.
- **Disclose**: Track performance to publicly disclose material nature-related information.

Pursuing actions that contribute to nature positive alongside existing climate action can allow businesses to mitigate risks, capture nature-related opportunities and build long-term resilience. For more information on tools and guidance available for the ACT-D set of high-level actions, see Table 2.

The stages of ACT-D will require support from a range of other activities, including agreeing on definitions, determining materiality thresholds, mapping assets and operations, gathering information on existing nature-related activities, making the case for nature action internally within organizations (beyond disclosure) and establishing a vision of success.

TABLE 2 **ACT-D high-level framework – selected tools and guidance**

| | |
|---|---|
| **Assess** | – Consult the **Locate-Evaluate-Assess-Prepare (LEAP)** approach from TNFD.<br>– Follow the technical guidance to **assess**[129] and **prioritize**[130] from SBTN. |
| **Commit** | – Set **No Net Loss** (NNL) or **Biodiversity Net Gain** (BNG) targets for all sites, leveraging the International Finance Corporation's (IFC) *Performance Standard 6* for guidance.[131]<br>– Follow the approach that the International Union for Conservation of Nature (IUCN) is developing to **measure nature positive**[132] and **set targets**.<br>– Set science-based targets and consider site-specific commitments, taking inspiration from the technical guidance provided for **freshwater** and **land** by SBTN.[133]<br>– For climate, refer to the guidance from the Science Based Targets initiative (SBTi). |
| **Transform** | – Take inspiration from the World Economic Forum's Nature Positive Transitions report series.[134]<br>– Draw on the *Every Job is a Nature Job* brief from UNEP-WCMC.[135]<br>– Invest resources and commit management to deliver against **clear targets**.[136]<br>– Follow the **mitigation hierarchy** at a site-level for direct operations[137] and consider broader community and value chain engagement. |
| **Disclose** | – Consult TNFD's final recommendations for **nature-related disclosures**.[138]<br>– For climate, refer to the ISSB guidance on disclosure of sustainability-related financial information and **climate-related disclosures**.[139]<br>– Use CDP's disclosure platform, which includes guidance on climate change, forests, water security, biodiversity and plastics.[140] |

**Note:** This table is non-exhaustive. For more tools and guidance, see Business for Nature's *High-level Business Actions on Nature* and It's Now for Nature's *Nature Strategy Handbook*.

Climate change is a main driver of biodiversity loss and efforts to tackle climate change cannot succeed without safeguarding nature.

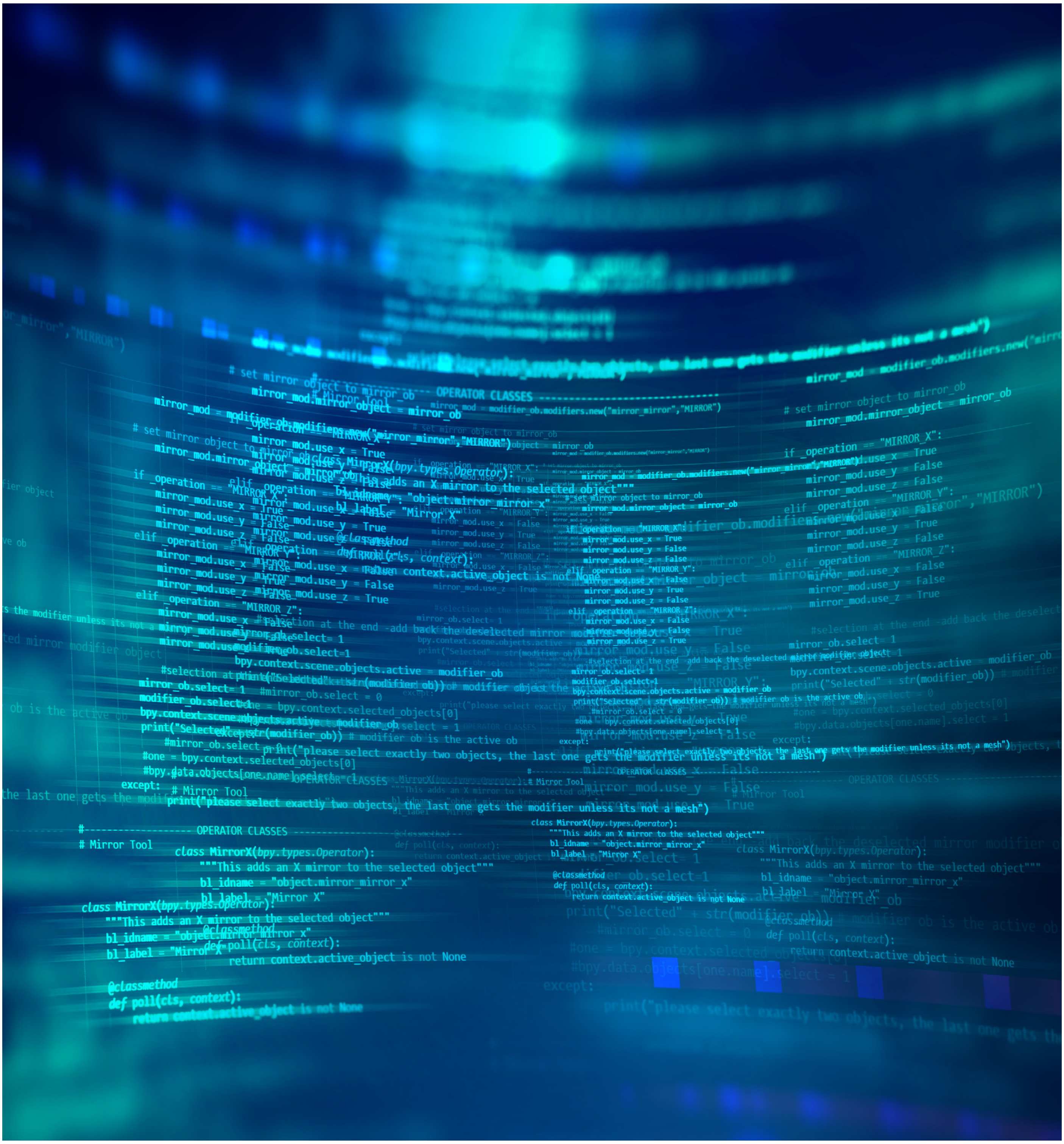
Delivering net-zero emissions and tackling nature loss are highly interdependent goals. Climate change is a main driver of biodiversity loss and efforts to tackle climate change cannot succeed without safeguarding nature. Therefore, the nature-positive transition aligns closely with companies' net-zero commitments and can be integrated into their climate transition plans. Likewise, companies can ensure that social objectives are integrated for a just and equitable nature-positive transition.

Additional guidance is emerging from the Forum and others on how to develop nature transition plans or adapt net-zero transition plans to include nature and biodiversity commitments and objectives, supported by several institutions. For example:

- The World Economic Forum's *Nature Positive: Get Started* provides guidance on aligning nature strategies with organizational maturity, identifying relevant metrics to track and mapping the nature-positive transition on to business functions.
- It's Now for Nature's *Nature Strategy Handbook* is a practical guide to support businesses across sectors in developing a nature strategy.
- Capitals Coalition has published the *Integrated Decision-Making Framework* that provides guidance on how to include value into financial-economic decision-making in a consistent way, trusted by decision-makers and investors.
- TNFD has published its *Discussion paper on Nature transition plans* with recommendations for real-economy companies and financial institutions.
- CDP and WWF are developing transition planning recommendations, including practical guidance on tools and methodology.

# 5 Priority actions for other stakeholders

Policy-makers, communities, tech customers, financial institutions and NGOs all have essential enabling roles to play in the tech sector's transition to nature positive.



While the tech sector is ultimately responsible for managing its own nature impacts and dependencies and driving progress towards nature-positive outcomes, it cannot achieve this transition in isolation. A broader ecosystem of stakeholders – including policy-makers, regulators, communities, tech customers, financial institutions and NGOs – can support and accelerate nature-positive action across the sector. By coordinating with these external stakeholders, the sector can more effectively and credibly deliver against ambitious nature commitments. This chapter is written for both companies in the tech sector and these relevant stakeholders.

## 5.1 Policy-makers, regulators and communities

**Across the US, $64 billion of data centre projects have been blocked or delayed over the last two years because of community opposition.**

As the tech sector continues to grow rapidly, policy-makers, regulators and local communities each have an important role in aligning growth towards nature-positive outcomes. Policy-makers are responsible for creating frameworks for incentivizing and developing the tech sector, while regulators are responsible for ensuring that development meets established guidelines and standards.

Proactive regulatory frameworks are essential, not only to mitigate the sector's nature impacts and dependencies but also to integrate nature-positive mandates into business operations. However, this process is rarely straightforward. Tension can occur between national or state goals to attract tech investment and local efforts – often driven by community input and resistance – to protect ecosystems, community health and access to natural resources.

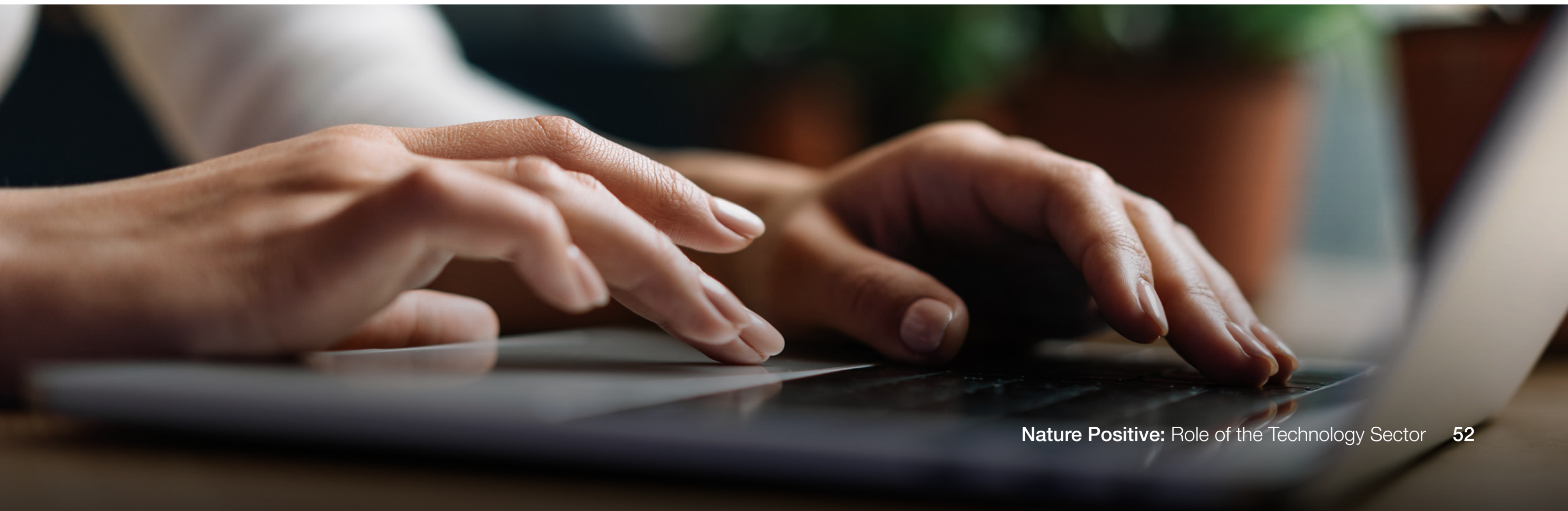
Recent cases, such as local opposition to data centres in West Virginia, supported by state level legislation,[141] and a data centre in Villamayor de Gállego, Spain, supported by regional policy,[142] illustrate the challenges of balancing these competing priorities. Across the US, $64 billion of data centre projects have been blocked or delayed over just the last two years because of community opposition.[143] Some geographies such as Singapore and Amsterdam lifted moratoriums on data centre construction, but under the condition of high energy-efficiency standards.[144]

These examples highlight the importance of inclusive decision-making, where policy-makers and regulators work closely with the tech sector and affected communities to ensure that development aligns with local nature values and social and economic priorities, otherwise licence to operate may be at risk for tech companies.

In addition to comprehensive policy design, community engagement and transparency are critical to achieving nature-positive outcomes. Ensuring that local communities are informed and empowered to participate in and shape planning processes can prevent nature harm and build public trust. Regulators play a critical role here by enforcing disclosure requirements, facilitating open dialogue and aligning corporate practices with nature commitments.

For example, Meta has plans to build its largest data centre to-date in Louisiana. This facility would require additional energy infrastructure to power operations and one proposal to meet this requirement involves building three new gas power plants with a total capacity of 2,260 MW. Government officials have reached out to Meta to open dialogue on the necessary energy infrastructure and the potential GHG emissions that could come from it, along with raising questions on how Meta would account for this new facility with respect to its ongoing climate commitments.[145]

National and regional planning must account for growing data centre energy and water demand, to ensure there is sufficient supply for both these and other priorities without inordinately raising prices for communities. By institutionalizing accountability and community participation, policy-makers, regulators and local communities can drive the tech sector to become not only more nature friendly, but also more equitable and resilient in the face of growing nature challenges.



## 5.2 Tech customers

While regulators and communities play a key role in guiding nature-positive outcomes, customers of the tech sector – especially large-scale users such as SaaS providers, financial institutions and public sector agencies – also hold significant leverage to drive change. Corporate buyers can increase their inclusion of nature considerations in their procurement strategies and recognize that their nature footprint extends beyond emissions tracked in scopes 1-3 to include broader impacts on land, water and biodiversity.

Prioritizing suppliers that demonstrate nature-positive practices enables customers to create strong market signals that reward positive nature actions, but this is only possible if the suppliers are transparent about their actions. A study by Economist Impact found a gap between AI users and suppliers, with AI users increasingly expecting suppliers to prioritize sustainability – this expectation adds to the pressure tech suppliers face to manage their growth sustainably.[146]

Active engagement begins with informed questioning and clear expectations. For both ongoing and new relationships with tech vendors, customers can use the ACT-D framework to assess progress to date, by asking questions such as those in Box 6.

BOX 6 **Questions tech customers can ask vendors, based on the ACT-D framework**

### Assess

- What percent of your data centres do you own versus co-locate?
  - Do you know where they are located? If so, where?
- Are you assessing your nature impacts, dependencies, risks and opportunities?
  - Have you screened your sites for water and other nature dependency risks?
- Which direct, indirect, regional and operational impacts and dependencies related to nature have you identified?
  - What is your current land use footprint?
  - What share of your operations and value chain are in ecologically-/biodiversity-sensitive or water-stressed areas?
  - What is your current energy mix by percent (renewables, fossil fuels, coal etc.)?
  - How much water do you withdraw? How much water is recycled, discharged or lost to evaporation?
  - How do you expect climate change to shift these metrics over time?
- What data points do you track?

### Commit

- What nature-related targets does your company have?
  - Do you have a clean energy target?
  - Do you have circularity programmes? What percent of your hardware is recycled?
  - Do you have a biodiversity commitment or target?
  - Have you installed biodiversity monitoring technology?
  - Do you have a water target?
  - Do you have a water neutrality or stewardship target and what is the timeframe?
  - How do you consider water commitments at specific sites?
  - Do you have an eco-design strategy for your devices?
- What is your target achievement level?
- What is the underlying target baseline or metrics?
- Do you have any certifications?
- How does your ambition compare with your peers?

### Transform

- Do you have a biodiversity or nature policy/action plan? What is it?
- What actions, including impact reduction measures and conservation and restoration initiatives, do you do that are related to nature?
- Do you have any actions/projects in water-stressed or sensitive ecosystems?
- Do you have a long-term transition plan to nature positive?

### Disclose

- What disclosure frameworks, standards or voluntary schemes are you reporting into?
- Do you have a system to manage risk?

These questions are not exhaustive, but they provide a starting point for tech customers to begin discussions with suppliers and vendors.

Additionally, tech customers may seek out partners aligned with recognized frameworks and standards, such as those highlighted under Action 6. Encouraging or requiring compliance with these standards in procurement contracts helps accelerate adoption across the sector. Companies can also magnify their impact through collective action, such as joining industry alliances, sharing best practices and aligning on common criteria for what constitutes nature-positive technology. As more organizations take this approach, sustainability becomes not just a differentiator but a foundational expectation in tech procurement.

## 5.3 Financial institutions

**Less than 3% of the $1.2 trillion needed annually for nature-positive business is being met, with major barriers including limited data, disclosure and incentives.**

Financial institutions play a key enabling role in the tech sector's transition to nature positive. As stewards of global capital, banks, insurers and investors have the capacity to channel significant capital to nature-positive transformation across value chains. By embedding nature metrics into assessment frameworks and client engagement, they can support credible transition plans.

However, less than 3% of the $1.2 trillion needed annually for nature-positive business is being met, with major barriers including limited data, disclosure and incentives. The Cambridge Institute for Sustainability Leadership has identified further barriers in its *Scaling Finance for Nature* report.[147] Regulatory changes such as the EU Corporate Sustainability Reporting Directive (CSRD) and improved corporate disclosures are accelerating progress, but further sector alignment is essential.

Despite these challenges, leading financial institutions are shifting from a compliance focus to viewing nature as an opportunity for value creation. Many are now linking financing to nature-positive outcomes, supporting technology sector projects such as sustainable data centres and digital infrastructure. With the rising adoption of frameworks such as TNFD and growing client engagement, the financial sector's power to shift tech towards nature-positive outcomes continues to build.

Additional details on the role of financial institutions in the nature-positive transition can be found in the World Economic Forum's *Nature Positive: Corporate Assessment Guide for Financial Institutions*.

## 5.4 Non-governmental organizations

Non-governmental organizations (NGOs) and multilateral initiatives play an essential role in enabling tech's transition to nature positive. By developing shared frameworks, convening cross-sector stakeholders and supporting regulatory alignment, these organizations help translate global nature goals into actionable guidance for companies. Frameworks such as TNFD provide a standardized approach for identifying and disclosing nature-related risks and dependencies. While voluntary, TNFD is quickly becoming a reference point for companies and regulators alike. Similarly, SBTN offers guidance for setting credible, science-aligned nature targets, while disclosure frameworks such as CDP and the Global Reporting Initiative support transparency and comparability across industries.

Institutions such as the World Economic Forum, the UN Environment Programme and Business for Nature play a critical role in bringing together leaders across sectors to align on shared priorities and accelerate the adoption of nature-positive solutions. These organizations build collaboration, support the development of emerging tools and inform future policy design. As nature standards continue to evolve, active engagement with these efforts will be critical for tech companies seeking to lead and shape the transition.

# Conclusion

A nature-positive tech sector is both a necessity and a strategic opportunity. This report has presented practical, commercially viable solutions that now need broader adoption to ensure long-term success for the sector and for nature.

The technology sector's operational resilience, access to resources and social licence to grow increasingly depend on natural ecosystems and responsible supply chains. At the same time, tech companies possess powerful levers – including innovation, capital, data and influence – to lead the shift towards sustainable growth models.

The seven action areas presented in this report offer practical, high-benefit interventions that are already being implemented by first movers across the industry. Solutions proposed here – including closed-loop water systems, low-GWP process gases, renewable energy integration and circular design – are both technically feasible and commercially viable. However, broader adoption will require leadership, investment and collaboration at scale.

Companies embedding nature into core strategy, product design, site development and procurement are more likely to ensure long-term success. Financial institutions and investors can accelerate progress by integrating nature risk into capital decisions. Policy-makers and regulators have a critical role in setting clear disclosure standards, incentivizing circularity and enabling nature restoration.

Through early leadership, the technology sector can not just mitigate risk, but help build the nature-positive systems on which a thriving digital economy depends. It can also play a key role in influencing and enabling the nature-positive transition beyond its own value chain – the focus of an upcoming body of work in 2026.

# Appendix A: Nature-related impacts and dependencies

This Appendix provides additional details and data points to support Chapter 2: Tech's nature impacts and dependencies. It is organized by tech sub-sector and associated impact/dependency categories in the main report.

## Semiconductors

### Water use

FIGURE A1

**Semiconductor plants – how much water is used?**

**Globally,** the semiconductor industry consumes:

**>1 billion m$^3$** of water/year → **15+ million** EU residents

**Average facility** manufacturing 40,000 wafers per month can use:

**18,000-38,000 m$^3$** of water/day → **up to 16** Olympic-sized swimming pools

**Sources:** see endnote.[148]

Semiconductor manufacturing is notoriously water-dependent. Water is used extensively to clean and rinse wafers at each step, as well as to operate equipment to handle waste and cooling. The requirement for ultrapure water (UPW) further increases water use. UPW has been treated to remove all impurities and it typically requires 1,400 to 1,600 litres of potable water to make 1,000 litres of UPW.[149]

Given high rates of water use, wastewater recycling is a major area of focus. In a survey of 19 manufacturers, 45% of water use was from recycled water. However, recycling rates varied widely among these manufacturers, from ~13% to 69%,[150] indicating there is continued opportunity for improvement across the sector.

Even with wastewater recycling rates improving, plants continue to face issues with local governments and communities as they seek to balance growth and water sustainability. Taiwan, home to 60% of global semiconductor manufacturing, faced its worst drought in half a century in 2021. Many plants were required to reduce water consumption up to 15%, resulting in companies buying truckloads of water to maintain operations. Droughts are expected to continue creating challenges for manufacturers, potentially cutting 2030 output projections by 10%.[151]

Beyond drought, semiconductor manufacturers face water-related challenges based on regulations and public pushback. In Arizona, home to at least eight semiconductor facilities,[152] plans for a TSMC plant were temporarily delayed in 2023 due to regulation requiring an assured water supply of at least 100 years.[153] Plans ultimately moved forward because TSMC planned to reuse 74% of its water. In Grenoble, France, in 2023, protesters opposed the extension of local semiconductor manufacturing capacity, chanting "water, not chips!"[154]

## Pollution and waste

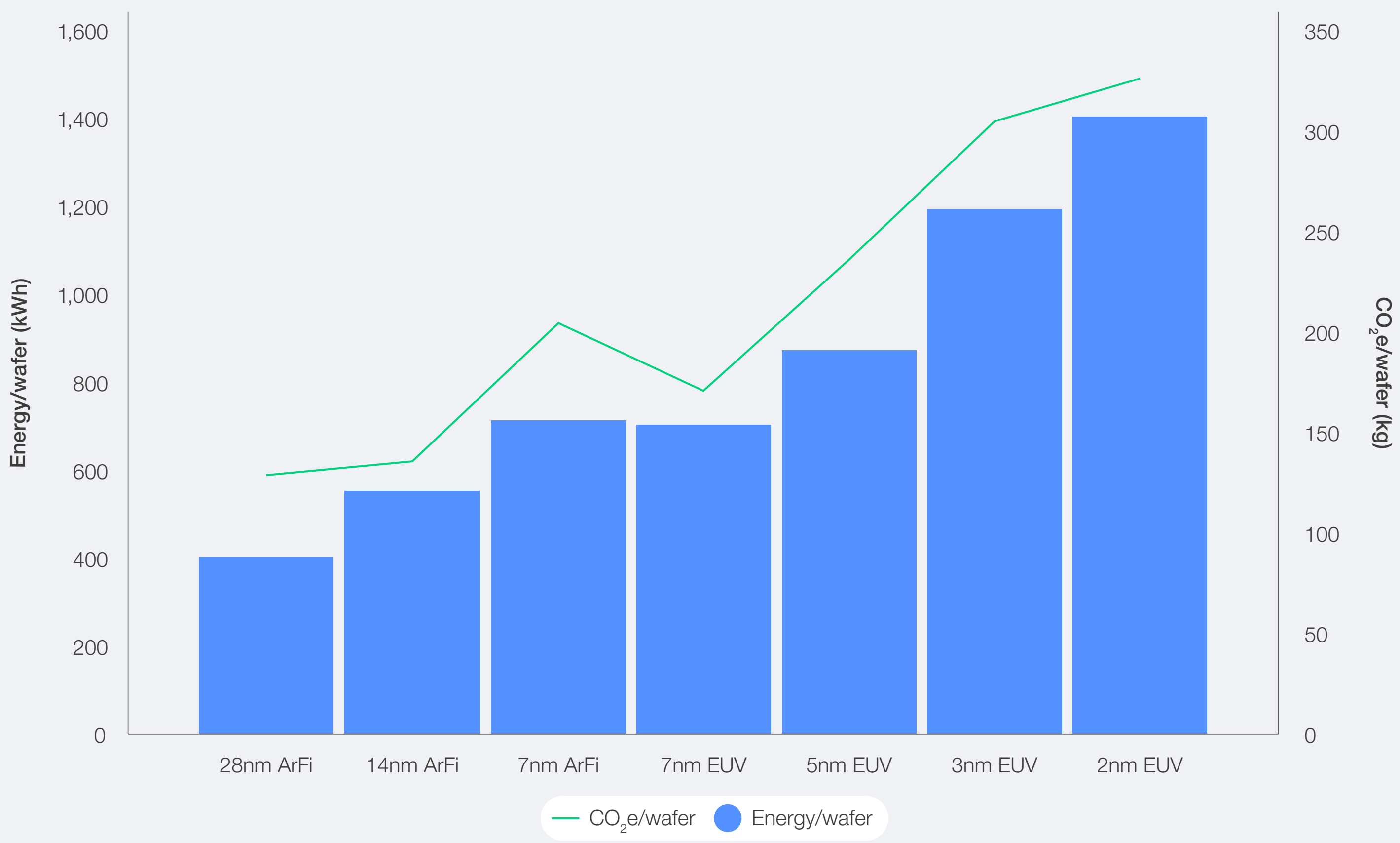
Semiconductor manufacturing is highly reliant on a diverse set of chemicals, resulting in pollution and waste. Half of the chemicals in manufacturing are in liquid form, creating wastewater pollution. A critical process to convert a wafer of silicon into a semiconductor involves several steps of layering chemical films (deposition) and projecting light (lithography) to create precise patterns. These chemicals often contain PFASs, with up to 163 different PFASs in use at any time across the industry. PFASs are known for their temperature resistance and being repellents of foreign material – these qualities make them ideal for semiconductor manufacturing; but the same qualities contribute to their status as "forever chemicals", given their tendency to accumulate rather than naturally break down. Up to 5% of PFASs used during semiconductor manufacturing may enter the environment, with the remainder found in hazardous wastewater.[155]

In 2023, the 12 largest semiconductor manufacturers generated ~2.7 million tonnes of waste, equivalent to that of 5 million EU citizens.[156] Half of this waste is classified as hazardous due to the waste metals and acids involved in manufacturing.[157] While the majority of non-hazardous waste is combusted for energy or recycled for other industrial use, such as metallurgy or automotive manufacturing,[158] recycling rates for hazardous waste vary substantially between companies, from ~20% to ~95%.[159]

## Greenhouse gas emissions and electricity use

Semiconductor manufacturing also produces direct GHG emissions. One concerning trend, shown in Figure A2 and covering 15+ years, is the ~160% rise in emissions per wafer as chips have got smaller and more powerful. The decrease in node size also drives a corresponding increase in energy use. This increase is primarily driven by lithography, a highly energy-intensive process that must often be repeated multiple times to create the layering needed for advanced chip design. Some manufacturers offset the impact of energy use by using renewable power, but this practice varies. Top performers use up to 90% renewable energy, while others use less than 10%.[160] In some cases, renewable energy use comes through the use of credits and may not always be clearly reported. Power purchase agreements (PPAs) or on-site renewable generation more directly ties energy supply to demand.

FIGURE A2 **Semiconductor plants – emissions and energy use**




**Note:** Plant emissions are for manufacturing only.

**Source:** Coles, S. et al. (2024). *Putting a price on ESG risks*. Barclays.

Roughly 65% of emissions from semiconductor manufacturing are due to energy use, with the remaining 35% direct emissions from the manufacturing process itself;[161] 70%+ of direct emissions are fluorinated gases, with half of that driven by PFASs. The impact of fluorinated gases is substantial because of their high GWP, which can be as much as 25,200 times that of $CO_2$ in the case of SF6. A lack of alternatives presents a significant challenge to avoiding PFASs, with the sector predicting that reasonable alternatives are potentially a decade or more away and require extensive research and development.[162] At the same time, ongoing considerations in several regulatory jurisdictions about phasing out PFAS will further exacerbate this challenge.

## Impacts from mining for critical inputs

A final and critical area for consideration with semiconductor manufacturing, which permeates across the tech sector value chain, is the extraction of metals and minerals used as inputs. While many metals and metalloids are required, the five most common are silicon, copper, germanium, gallium and arsenic.[163]

Silicon is by far most utilized, serving as the base material for over 95% of wafers today. This trend is expected to continue until at least 2030.[164] While only ~4% of global silicon supply is used for semiconductors,[165] silicon is highly material for the industry. Silica mining is typically done through open pit mining, which has various nature impacts. To create space for the mine, vegetation and soil must be cleared, which can lead to habitat destruction, biodiversity loss and erosion. Silica mining also generates silica dust, which has been known to cause respiratory issues if not managed. Water use, both to control the dust and to clean and process the ore, can lead to wastewater contamination that impacts local communities and ecosystems.[166]

Copper is used for wiring. As with silicon, copper is usually mined through open pit mining and has similar impacts. However, its impacts are typically greater for two reasons. First, one kilogram of silicon requires ~15 kg of feedstock,[167] but one kilogram of copper requires 99 kg of feedstock, so substantially more material must be mined per unit of output. Second, the chemical makeup of copper ore is more likely to lead to acid runoff, creating higher potential for pollution.[168]

TABLE A1 **Semiconductors – mining for materials**

| Material | Applications | Mining Method | Environmental Impact Considerations |
|---|---|---|---|
| **Silicon** | Most utilized base material for >95% of wafers | Open pit mining | – **Land:** Vegetation and soil must be cleared: habitat and biodiversity loss, erosion<br>– **Air:** Silica dust, causing respiratory issues if not managed<br>– **Water:** Risk of contamination impacting local communities and ecosystems |
| **Copper** | Used for electrical wiring, circuit boards | Vast majority is open pit mining | *Similar to silicon, plus some specific concerns –*<br>– **Water:** Potential acid runoff and pollution<br>– **Air:** Sulphur dioxide from blasting and smelting<br>– **GHG:** Energy intensive<br>– **Waste:** Volumes of waste rock and tailings pose contamination risk |
| **Germanium, Gallium, Arsenic** | Alternatives/ supplements to silicon for specific use cases | By-products from zinc, bauxite and copper respectively | *Similar to copper* |
| **Bauxite** | By-products supply (Aluminium) | Open pit mining | *Similar to copper* |
| **Zinc, Lead** | By-products supply (Germanium, Gallium, Arsenic) | Underground mining | – **Land and air:** Lower need for land rehabilitation and airborne dust due to confined impact<br>– **Water:** Potential formation of mine water reservoirs containing toxic contaminants<br>– **Air:** Can release trapped gasses from the ore such as methane<br>– **Social:** Risk for underground miners |
| **Gold** | By-products supply (Germanium, Gallium, Arsenic) | Open pit mining (except deep gold) | – **Pollution:** Chemical pollution from cyanide and mercury use<br>– **Land:** Deforestation (especially in tropical regions) |

Germanium, gallium and arsenic can be used as alternatives to silicon for specific use cases. Germanium is produced as a by-product of zinc smelting and coal burning, with electronics and photovoltaics comprising ~25% of the global market.[169] Gallium is a by-product of aluminium and zinc smelting, with semiconductors making up 40-45% of the global market.[170] Arsenic is a by-product of copper, lead and gold smelting, and electronics and technology account for ~8% of the global market.[171]

Bauxite (aluminium) is primarily surface mined and therefore has similar nature impacts as silicon and copper.[172] Zinc, coal, lead and gold are primarily mined underground.[173,174,175,176] Underground mining still impacts biodiversity and ecosystems through land use but tends to have more confined impact compared to surface mining, reducing the need for land rehabilitation. Water management is required to avoid the formation of mine water reservoirs that can contain toxic minerals and chemicals. Underground mining creates less airborne dust at the surface level but can release trapped gasses from the ore such as methane, a potent GHG.[177] Of course, the process creates different risks from surface mining for the workers involved, which must also be considered.

For more details on the impacts and dependencies of metals and mining, please refer to the World Economic Forum's report: [Nature Positive: Role of the Mining and Metals Sector].

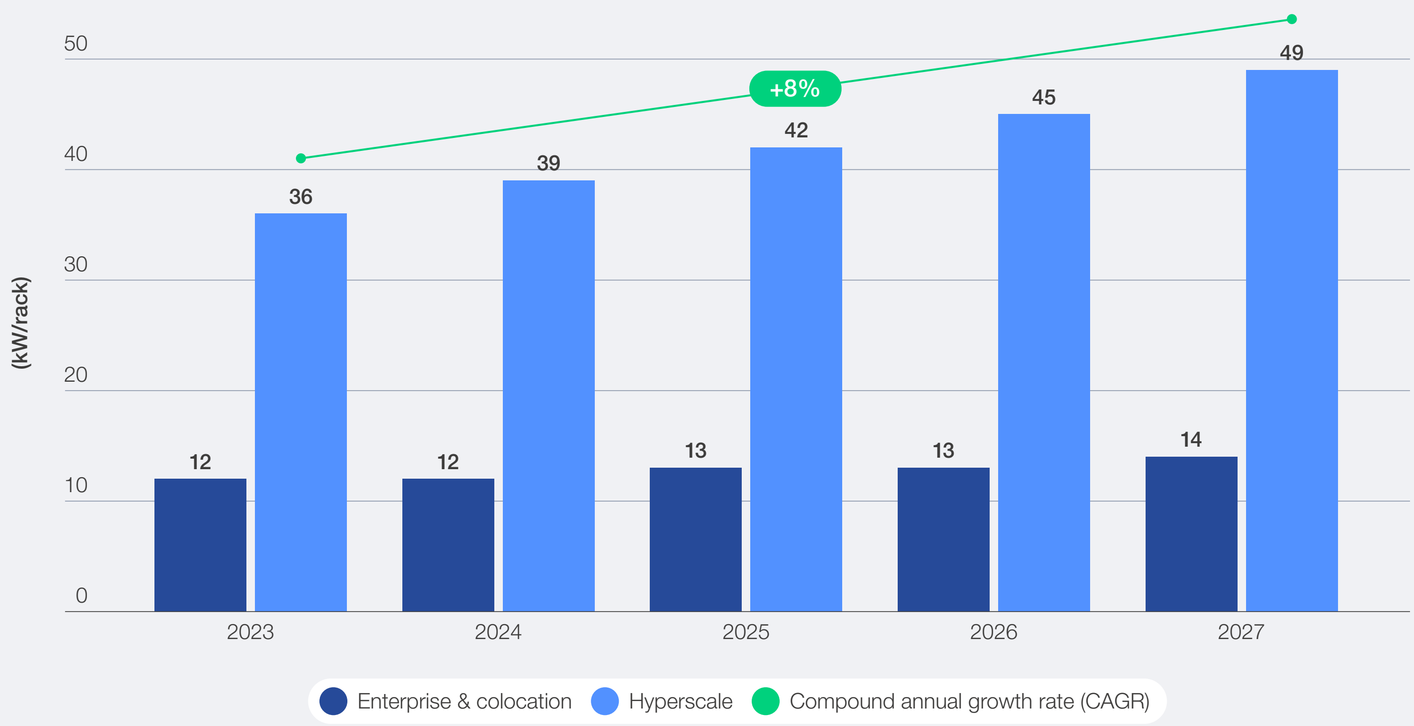
# Data centres

## Electricity use

Data centres require substantial energy to power their servers 24/7 and that requirement is growing rapidly. In 2023, global data centre energy loads totalled ~50-55 GW.[178,179] By 2028, predictions suggest global data centre energy loads of ~95-140 GW,[180] equivalent to the total power load of Japan in 2023. Variability in the forecast is driven by supply bottlenecks, potential operational efficiency improvements and a range of potential scenarios for the advancement and rate of adoption of AI.

Much of the projected increase is driven by AI. While average server rack power densities increased from 3 kW in 2011 to 12 kW in 2022, rack densities exceeding 20 kW were uncommon.[181] Following the widescale introduction of capable generative AI models in 2022, server rack densities have seen increases at the hyperscale level where AI models are trained and operated. Hyperscale server rack densities rarely fall below 30 kW and can be as high as 100 kW or even higher.[182] The impact of AI is visible in Figure A3, as hyperscale rack server densities are expected to continue increasing while enterprise/co-location rack densities remain largely constant.

FIGURE A3 **Data centres – server rack density, 2023-2027**

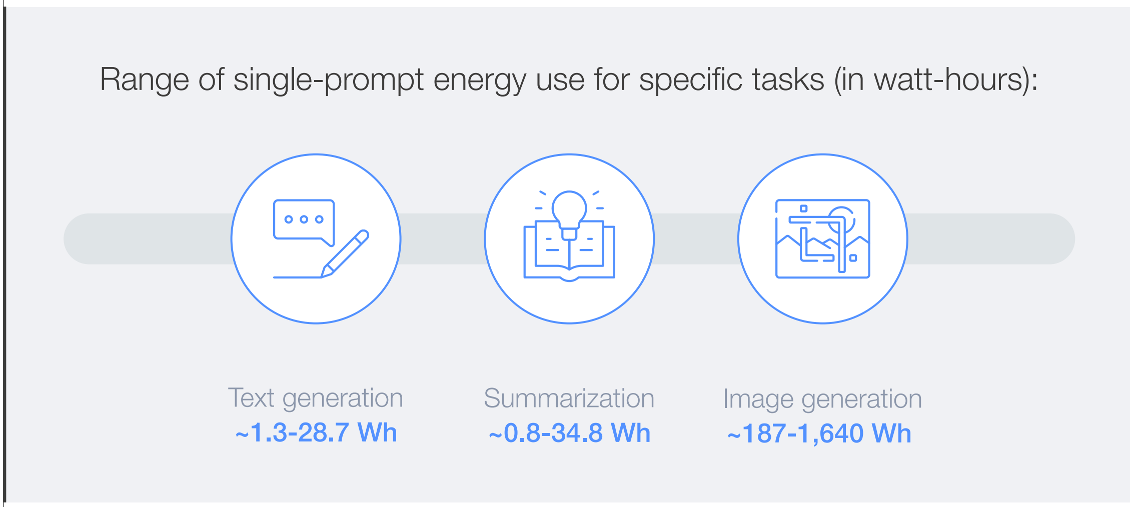



**Source:** Obin, A. et al. (2024). *Who Makes the Data Centre*. Bank of America (BofA) Securities.

Power demand for cooling increases in line with server rack densities. Power use effectiveness (PUE) is a common metric for understanding data centre power demand for cooling. The metric is calculated by dividing the total energy needed to operate a facility by the total energy used for computing, with typical values today around 1.4. In an ideal state, a data centre would have a PUE of 1, meaning 100% of energy used by the facility goes towards computing. Many popular data centre jurisdictions are adopting minimum efficiency regulations.[183] While helpful, PUE as a metric must be taken in context. Some organizations are proposing alternative, more holistic metrics for data centre operators to consider, such as the Data Centre Resource Effectiveness metric, or DCRE, from The Green Grid.[184]

Assessing how day-to-day use of AI contributes to data centre power demand is a new challenge for individuals and businesses. While analysing the energy demands of different AI models can be challenging with proprietary company data, a US company called Hugging Face developed and launched, in partnership with Salesforce, its AI Energy Score project to provide standardized energy ratings across various tasks for open-source and closed AI models submitted. Some tasks and their range of single-prompt energy use are shown in Figure A4.

FIGURE A4 **Data centres – single-prompt energy use for specific tasks**




**Source:** Hugging Face. (n.d.). *AI Energy Score*. https://huggingface.co/spaces/AIEnergyScore/Leaderboard.

This energy use adds up across the estimated 2 billion+ daily prompts across all AI models.[185] With 15 of the top 20 most-used AI models being closed source and these model providers not submitting models for testing, there remains a gap in understanding the real-world implications of AI energy use.[186]

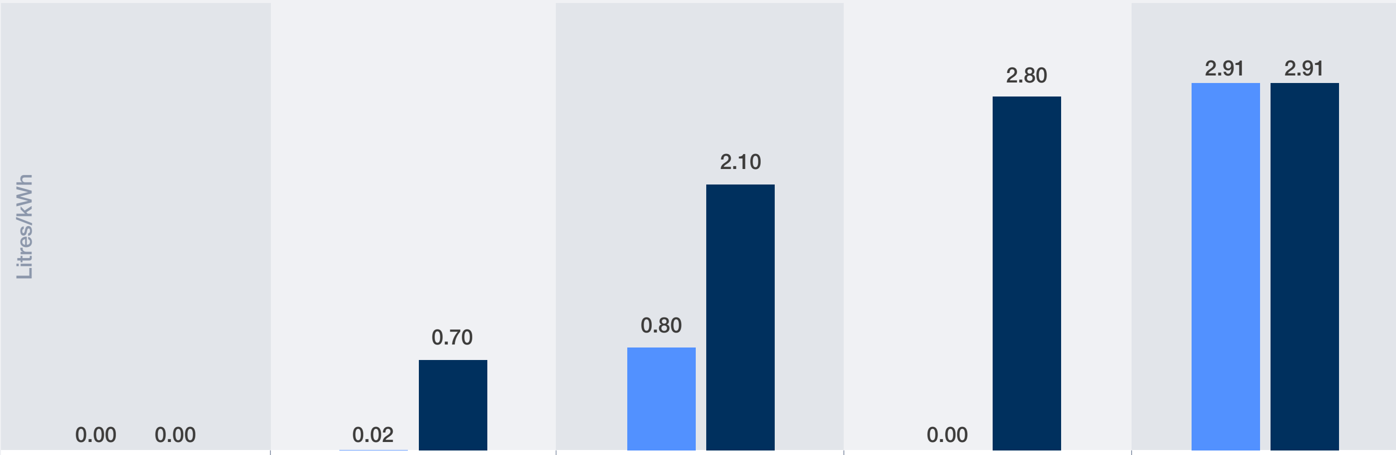
Finally, to address energy infrastructure constraints, some data centre operators are building captive, behind-the-metre solutions principally to meet their own energy needs as opposed to supplying the grid. While this approach may enable faster development and provide flexibility for grid operators during peak hours, it can further contribute to nature loss depending on the sources used.

## Water use

Water use in data centres is a growing area of concern. Historically, electric-powered air cooling could meet the requirements of data centres with server rack power densities of 20 kW or less.[187] As rack densities have increased, direct-to-chip water cooling has become the preferred method given its higher capability.[188] Data centre cooling typically involves two steps: server and facility-level cooling (to remove heat from computing equipment) and facility heat rejection (to remove heat from the facility); water may be required across both. Liquid cooling methods can be extremely water intensive, with even a small 1 MW data centre able to consume 25.5 million litres of water annually using evaporative cooling.[189] On average, a hyperscale facility can use 2.1 million litres of water per day, while a retail facility may use around 68,000.[190] With an average of 60% of water use consumed by evaporation and the remaining 40% going into local wastewater systems, managing water use is a key area for reducing data centres' impacts on local water supply.[191]

Water use effectiveness (WUE), which reflects the annual litres of water used for humidification and cooling divided by the total annual kWh used to power IT equipment,[192] can be a helpful if imperfect metric for tracking this nature impact. Figure A5 includes various technologies for rejecting heat from data centres and their range of WUE. As with PUE, WUE may not always equate to nature impact. A data centre with a high WUE in a region with low water stress is less concerning than a similar data centre in a region with substantial water stress, but generally a lower WUE figure close to zero is better.

FIGURE A5 | **Water use effectiveness (WUE) comparison across types of heat rejection**




| Free air cooling | Direct evaporative cooling | Indirect evaporative cooling | Mechanical cooling | Cooling tower |
|---|---|---|---|---|
| Filtered outside air directly used for cooling without additional refrigeration | Outside air passed through a water-saturated medium to be directly used for cooling | Indoor air or liquid cooled through a heat exchanger with outside air that has passed through a water-saturated medium | Equipment such as chillers and compressors used to mechanically cool air or liquid used for cooling | Water is cooled in a cooling tower through direct contact with outside air and then used for cooling |
| *Some water may be used in winter for humidification* | *Range driven by variation in regional climates and water quality – hotter, drier temperatures and lower air quality consume more water* | | *Low end of range reflects air-cooled chiller, while top end reflects water-cooled (and can range from 2.3 to 2.8 L/kWh)* | |

● Low end of range ● High end of range

**Note:** As these cooling technologies can be used with either air cooling or liquid cooling at the server level and in combination with each other, which will impact efficiency, achievable WUE values with each technology can range beyond the bounds listed.

**Source:** see endnote.[193]

Facilities seldom use only one type of cooling – liquid cooling may be used directly to cool the chips, but other equipment (such as power supplies) still needs to be air cooled.[194] Closed-loop server and facility-level cooling are another promising area – while these systems still require water input during set-up, compared to evaporative liquid cooling methods they can reduce dependency on freshwater withdrawals. A joint study by Ramboll and Grundfos estimated 25% potential water savings across data centres in Europe through a combination of reduction, reuse and reclamation measures.[195] Finally, data centre operators must also consider their indirect water requirements, such as from their power demand (e.g. for cooling at thermal power plants).

## Material inputs and land use

Construction inputs for data centres can be substantial. One study indicates that nearly 130 tonnes of emissions are embedded in a typical 530m$^2$ building's shell, through use of concrete, steel and other inputs. The same study found that a 1 MW data centre (very small relative to typical developments today) could require 66 tonnes of copper, 15 tonnes of plastic, 33 tonnes of aluminium and 171 tonnes of steel for the electrical operations alone, on top of the building's construction.[196]

For more details on the impacts of the metals in use in construction, refer to the following World Economic Forum reports:

- Nature Positive: Role of the Mining and Metals Sector
- Nature Positive: Role of the Cement and Concrete Sector

Developing data centres also requires land – and they are typically located in urban or suburban areas to limit latency concerns and utilize existing infrastructure. Land use for data centres currently remains low, with the global footprint estimated at ~100 square kilometres, or roughly the land area of Walt Disney World in Orlando.[197] However, data centre land use and energy consumption are interlinked, with the energy infrastructure required for digital infrastructure expanding the sector's effective land footprint.

## Waste

Heat from data centres, often captured in wastewater, can degrade local ecosystems if not adequately cooled prior to release. For example, industrial water returned to the Hudson River 11°C warmer than the withdrawal temperature led to the death of over 2 million fish a year.[198]

Beyond physical waste, a growing contributor to nature impact is data waste or "dark data" that is collected, stored and processed but rarely or never used. Such data can represent as much as 60-75% of an organization's stored information,[199] consuming resources for storage, replication, back-ups and networking, alongside the embodied impacts of the hardware it occupies. In data centres, unnecessary data retention drives demand for additional server capacity, higher storage rack densities and more cooling, increasing electricity and water requirements.

# Hardware and e-waste

## Hardware value chain impacts

Hardware manufacturing also has material nature impacts and dependencies. For example, 75% of a smartphone's carbon footprint (excluding end-of-life) comes from manufacturing,[200] generating 55 kg of $CO_2$.[201] One phone can require 34 kg of ore to be mined. With over 1.4 billion smartphones produced annually, this equates to 47.6 billion kg of mined ore, with its associated upstream nature impacts. This annual production generates 77 billion kg of $CO_2$, in addition to other nature impacts such as water use and pollution.[202] Manufacturing and transporting one laptop can emit between 160 and 480 kg of $CO_2$ and require over 600 kg of raw materials.[203] Though not within the scope of this report, transportation and packaging of hardware products have significant additional nature impacts and dependencies.

## E-waste and pollution

Land use is a substantial consideration given the volume of e-waste produced. The ~238 million cubic metres generated annually[204,205] could cover the land area of Manhattan four metres deep.

Given its concentration of metals, e-waste can be highly toxic. In 2020, e-waste made up 2% of solid waste but 70% of hazardous waste sent to landfills.[206] When not properly recycled, e-waste can release lead, mercury, beryllium, thallium, cadmium, arsenic and brominated flame retardants (BFRs), among other chemicals. These chemicals can lead to various health issues if not properly managed, including cancer, miscarriages, neurological damage, lung and respiratory impact and learning complications.[207,208]

A review of scientific studies conducted on e-waste sites for arsenic, cadmium, chromium, lead and mercury found that all but arsenic exceeded safe soil levels recommended by health organizations.[209,210,211] Cadmium and chromium had concentrations over 300 times the recommended limit, lead had concentrations almost 1,000 times the recommended limit and mercury was around 6 times the recommended limit.

Recycling e-waste is important to reduce the amount of waste produced, but it still has waste by-products. Pyrometallurgical processing recovers 45-85 kg of metals from 100 kg of waste, depending on the method used and the material being extracted.[212,213] The remainder remains waste, although most of the organic input material will be burned off during the process, which can lower the level of solid waste produced by 5-20%.[214] For hydrometallurgical processing, the quantity of remaining solid waste similarly varies, but research has shown that processing 100 kg of printed circuit boards (PCBs) typically still results in ~16 kg of solid waste to landfill.[215]

## E-waste and end-of-life greenhouse gas emissions

From 2014 to 2020, annual e-waste GHG emissions rose 53% to 580 million metric tonnes of $CO_2e$.[216] This figure is projected to increase to 852 million metric tonnes of $CO_2e$ by 2030 in a business-as-usual scenario.[217]

HCFCs and HFCs found within temperature exchange equipment reflect one significant source.[218] These refrigerants are potent GHGs, with GWP up to 12,000 times higher than $CO_2$.[219] In 2022, proper e-waste management prevented 41 million tonnes $CO_2e$ of these refrigerants from entering the atmosphere.[220] HCFCs are being phased out since the Montreal Protocol. Developed countries stopped use by 2020 and developing countries are on track to phase them out by 2030.[221] While initially slated to replace HCFCs given lower impact on the ozone layer, HFCs also have a very high GWP and are being phased out in line with the Kigali Amendment to the Montreal Protocol.

Aligned countries have agreed to cut production and consumption of HFCs by over 80% over the next 30 years, avoiding 70 billion metric tonnes of $CO_2$e across the global economy.[222] Until the phaseout is complete, managing the impact of HFCs will be critical.

The processing of e-waste generates its own emissions. Processing one tonne of e-waste for metal recovery using pyrometallurgy can result in 1.45 tonnes of $CO_2$e or more.[223] Additionally, copper and flame retardants can act as a catalyst when burned, leading to the production of dioxins and other toxic fumes.[224,225] While producing fewer emissions than incineration, processing e-waste using hydrometallurgy results in 0.82 tonnes of $CO_2$e per tonne of e-waste.[226]

## Water and electricity use in e-waste recycling

When assessing the most common methods of e-waste metal processing (pyrometallurgy and hydrometallurgy) energy and water use are again material. Processing 100 kg of e-waste through pyrometallurgy can require 7,500 kWh, just below what the average American household uses in an entire year.[227] Hydrometallurgy is less energy-intensive, consuming 150 kWh per 100 kg of e-waste. However, the process requires water to manage the use of acids throughout processing, as much as 800 litres per 100 kg of e-waste. This equates to approximately the same amount of water a single human needs per year.[228]

# Appendix B: Methodologies

## Opportunity sizing

The Forum's *New Nature Economy Report II: The Future of Nature and Business*,[229] published in 2020, identifies about 60 major business opportunities in the nature-positive economy and estimates their respective market sizes (defined as concentrated shifts in profit pools that generate specific opportunities for business). The sizing reflects the annual additional opportunity in 2030 based on estimated savings (e.g. value of land saved through restoration) or revenue upside (e.g. new market potential for new products). For each opportunity, the incremental size of the opportunity in a nature-positive versus a business-as-usual scenario is measured. The opportunities selected are based on existing, commercialized technologies. A detailed overview of this sizing can be found in the methodology note for the *Future of Nature and Business* report.[230]

Identifying the business opportunity potential of the priority actions for the tech sector in this report followed a two-step approach. First, relevant opportunities were selected from the *Future of Nature and Business* report (see Table 1). Second, the market potential for the tech sector was estimated across each selected opportunity, using the sector's share of global GDP as the most relevant adjustment factor.

This sizing approach may not cover the entire set of business opportunities for the sector. For example, the market potential of new technologies under development was not considered in the original 2020 report and is, therefore, not covered in this report. Similarly, the 2020 report did not aspire to exhaustively cover all present opportunities.

## Materiality matrix

The sector-average assessment of the top drivers of nature loss shown in Figure 9: Materiality matrix was developed through qualitative assessment, as shown in Table A2 below and supported by the UN Environment Programme's initiative *Exploring Natural Capital Opportunities, Risks and Exposure* (ENCORE).[231]

This output was tested with business, civil society and academic industry experts via interviews and consultation workshops and the final ratings were adapted based on the feedback provided. Note that e-waste is captured under Hardware/ electronics in the Pollution & waste row.

TABLE A2 **Criteria for determining materiality ratings**

| Nature-loss drivers | Rating criteria | | |
|---|---|---|---|
| | Low | Medium | High |
| **Water management**<br>Water abstraction and use as inputs | Industry has low demand or alternatives to minimize use, with minimal to no impact on local resources | Consistently utilized for industry growth, but alternatives to minimize use exist; has a noticeable impact on water resources but can be managed | Necessary for industry growth with few alternatives; creates significant impact on local water systems, impacting ecology and communities |
| **Pollution and waste**<br>Land, freshwater, and ocean pollution from storage & disposal of by-products, exhausts and wastes | Pollution and waste are minimal; any remaining outputs are consistently handled through an established processes | Pollution and waste are common by-products, but recycling and management practices exist and can be adopted | Substantial pollution and waste are produced, with costly solutions and low rates of formal management |
| **GHG**<br>Release of GHG emissions | Operations produce little to no GHG emissions or emissions exist in a closed system that enable full capture and mitigation | Moderate GHG emissions are produced, with opportunities to manage through a combination of efficiency, carbon capture or other methods | Substantial GHG emissions are a by-product of core operations, with limited or no ability to mitigate |
| **Land use**<br>Land clearance and exploitation for inputs and space for facility development | Little to no impact on land and local flora and fauna, with operations able to fully or almost fully coexist | Facilities require developed land but impact on local systems can be managed to minimize disruptions and coexist | Operations are dependent on irreparable land degradation with loss of local ecosystems and biodiversity |
| **Electricity use**<br>Electricity inputs | Daily power draw provides no strain on typical and existing energy infrastructure or is provided fully through onsite sources | Industrial levels of power requiring moderate upgrades to local energy infrastructure, utilizing a mix of sources | Substantial power draw required, requiring major upgrades to local energy infrastructure; regulators may limit new developments to manage |

# Data centre archetypes

Data centre archetypes, illustrated in Figure 12, were developed based on 15 global data centre hubs, made up of the 10 largest data centre hubs based on power load and five emerging hubs, as shown in Table A3 below.

TABLE A3 **Data centres – key metrics for existing and emerging hubs**[232]

| Location | # of data centers | IT load (MW) | 2023-2024 Cooling degree days above 15.5 C (C) | Water stress level | Renewable energy share (%) | Daily direct normal irradiation (kWh/sq m) | Wind power density (W/sq m) | Geothermal favourability (scale 1-5) |
|---|---|---|---|---|---|---|---|---|
| **Virginia** | 537 | 4,700 | 1387 | 40-80% | 9 | 4.3 | 294 | 0.9 |
| **Beijing** | 48 | 1,900 | 1667 | >80% | 31 | 3.2 | 93 | 2.8 |
| **Oregon** | 131 | 1,600 | 814 | <10% | 60 | 3.7 | 262 | 3.3 |
| **Phoenix** | 109 | 1,500 | 3920 | >80% | 16 | 7.4 | 44 | 2.6 |
| **Shanghai** | 51 | 1,400 | 2152 | >80% | 31 | 2.2 | 132 | 3.2 |
| **Dallas** | 156 | 1,300 | 2668 | 10-20% | 29 | 5.0 | 168 | 1.7 |
| **Columbus** | 108 | 1,200 | 1174 | 20-40% | 5 | 3.8 | 189 | 0.9 |
| **Atlanta** | 96 | 1,100 | 1917 | 40-80% | 6 | 4.5 | 183 | 0.9 |
| **Tokyo** | 84 | 1,000 | 1783 | 20-40% | 23 | 3.5 | 177 | 1 |
| **London** | 137 | 1,000 | 285 | 40-80% | 47 | 2.4 | 258 | 1 |
| **Brazil** | 162 | 880 | 2093 | 20-40% | 89 | 3.7 | 73 | 1 |
| **Sydney** | 82 | 700 | 1348 | 40-80% | 34 | 4.9 | 248 | 3.2 |
| **Mumbai** | 67 | 500 | 4852 | 10-20% | 20 | 3.9 | 129 | 1 |
| **UAE** | 32 | 240 | 5340 | >80% | 8 | 5.0 | 133 | 1 |
| **Johannesburg** | 31 | 230 | 2115 | >80% | 9 | 5.9 | 132 | 1 |

Metrics were applied against the framework shown in Table A4 below to determine ratings and identify the archetype. The different levels within the framework were designed based on global averages and industry analysis and validated through review and consultation with industry experts.

While these archetypes can be used to help inform design choices for cooling technology, there are additional nuances and specifics, including local regulatory requirements, that must be accounted for that are not included in this framework.

TABLE A4 **Archetype metrics and value ranges for each rating**

| Metric | | Low | Medium | High | Very high |
|---|---|---|---|---|---|
| **2-year cooling degree days above 15.5 C (C)** | | <730 | 730-1,459.99 | 1,460-2,190 | >2190 |
| **Water stress level (%)** | | <20 | 20-39.99 | 40-80 | >80 |
| **Region renewable energy share (%)** | | <10 | 10-19.99 | 20-30 | >30 |
| ***Potential for renewable energy*** | Daily direct normal irradiation (kWh/sq m) | <2.6 | 2.6-2.99 | 3-4 | >4 |
| | Wind power density (W/sq m) | <100 | 100-199 | 200-299 | >300 |
| | Geothermal favourability (scale 1-5) | <1.01 | 1.01-1.99 | 2-3.49 | 3.5-5 |

# Priority actions feasibility and leadership framework

To assess leadership and feasibility ratings for each priority action as shown in Figure 16, the qualitative framework shown in Table A5 below was used. Output based on this framework was tested with business, civil society and academic industry experts via interviews, consultation workshops and draft report reviews, and the final ratings were adapted based on the feedback provided.

TABLE A5 **Priority actions qualitative framework**

| **Action leadership** | Which actions achieve transformational vs. incremental benefit?<br>What is common practice vs. what will require time to achieve? | |
|---|---|---|
| **Foundational** | **Leading** | **Aspirational** |
| – Foundational, often incremental actions to achieve compliance, build credibility and mitigate risk<br>– Are or are becoming common practice among many tech players | – Strategic and proactive actions that expand nature benefits and create competitive advantage<br>– Have been adopted by several sector leaders, but are not common practice | – Ambitious, often transformative actions that shape the tech value chain towards nature-positive<br>– Have been adopted by few sector champions and may take several years to gain wider traction |

| **Action feasibility** | Which actions provide financial benefit vs. which are a cost driver?<br>Which actions have technical/implementation challenges? |
|---|---|
| **Low** | **High** |
| – Has high up-front cost with an unclear or delayed ROI<br>– Depends on early-stage or new technology with reliability, regulatory or integration risks<br>– Requires major shifts in business operations or stakeholder alignment | – Delivers ROI or creates cost savings<br>– Has no major technical barriers<br>– Requires no significant changes to core business models, infrastructure or customer behaviour |

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