Microsoft

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ADVANCE SUSTAINABILITY

Accelerating Sustainability with AI: Innovations for a Better Future

CONTENTS

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Foreword

AI Transformations for Sustainability

Throughout history, societal transformations have been driven by the emergence of general-purpose technologies that reshaped entire economies, industries, and ways of life.

The steam engine, the printing press, electricity, and the internet have each marked pivotal social and economic shifts, leading to lasting changes to how we live and work. Today, AI stands as the latest—and potentially most powerful—general-purpose technology, offering an unprecedented opportunity to drive the societal transformations we urgently need to achieve the world's sustainability goals.

In 2023, we published *Accelerating Sustainability with AI: A Playbook*, in which we highlighted that AI has three game-changing capabilities that make it an essential tool for accelerating sustainability. AI can enhance our ability to predict and optimize complex systems, accelerate the development and deployment of sustainable solutions, and empower the workforce to learn and achieve more—equipping society with the means to drive sustainability progress at a speed and scale previously beyond reach.

Over the last year, we have seen the potential of AI for sustainability in action, empowering the world with new tools for tackling the climate crisis and sustainability challenges more broadly. For example, earlier this year, Microsoft collaborated with Pacific Northwest National Laboratory to use AI in discovering a new battery material requiring less lithium—a breakthrough achieved in weeks rather than the years that traditional research and development would have required. Reducing lithium dependence is crucial to decarbonization as global demand for lithium is projected to outpace supply, potentially limiting the growth of the energy storage systems needed for the shift to electrification and renewable energy.[1]

AI's transformative capabilities extend far beyond sustainability, the world has an opportunity to harness AI to enhance both productivity and prosperity. By enabling smarter resource use, optimizing systems for efficiency, and fostering innovations in carbon-free energy and conservation, the AI economy also has the potential to advance both economic growth with environmental stewardship.

At Microsoft, we believe the world needs AI that is broadly accessible and trustworthy, this also includes addressing the sustainability challenges associated with this technology. The five plays outlined in our AI and sustainability playbook reflect the targeted actions needed to unlock full potential of AI for accelerating sustainability progress globally.

Across our sustainability work, we regularly assess our progress and adjust our strategies for greater impact. One lesson from this last year, is that minimizing the sustainability impact of AI operations requires more than minimizing resource use in datacenter operations; it also requires supporting the communities where datacenters are located and expanding access to zero-carbon electricity. Global electricity demand is growing rapidly, at an estimated average annual rate of 3-4%.[2] While AI currently consumes less than 0.3% of global electricity demand—and, according to the International Energy Agency (IEA), is expected to remain a small portion in the decade ahead—rapid growth in certain regions can strain local grids.[2]

In light of these realities, we have updated the third play of our playbook to include enhancing access to carbon-free energy on electricity grids and supporting local communities where we operate datacenters. In support of these goals, we are expanding our effort to build and operate digital infrastructure that addresses societal challenges and creates benefits for communities.

Five-point playbook

Play 1 Invest in AI to accelerate sustainability

Play 2 Develop digital and data infrastructure for the inclusive use of AI for sustainability

Play 3 Minimize resource use, expand access to carbon-free electricity, and support local communities

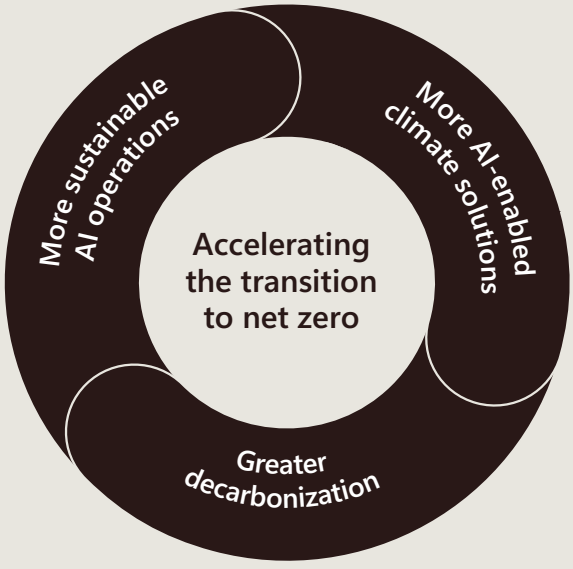
Play 4 Advance AI policy principles and governance for sustainability

Play 5 Build workforce capacity to use AI for sustainability

...to harness AI's game-changing capabilities

1. Measure, predict and optimize complex systems
2. Accelerate development of sustainability solutions
3. Empower the sustainability workforce

...to unlock a flywheel for accelerating sustainability



This report highlights Microsoft's innovations and actions to advance each of the five plays. Examples of our efforts across the five plays include:

Play 1
Invest in AI for sustainability

Microsoft is investing in building AI tools, such as MatterGen[3] and MatterSim[4], to enable researchers to design and test materials with ten-fold greater accuracy and vastly faster performance, and in AI foundation models such as Aurora, which predicts global weather and atmospheric processes with increased accuracy and at speeds up to 5,000 times greater than current forecasting systems[5]. We are also building AI-enabled tools to empower stakeholders to more effectively and efficiently manage agriculture and water resources and to expedite licensing process for carbon-free electricity.

Play 2
Develop digital and data infrastructure for the inclusive use of AI for sustainability

We are creating tools to fill critical data gaps, which can enhance AI models for better measuring and predicting complex systems such as biodiversity and climate. For instance, SPARROW captures images and acoustic recordings to gather data on biodiversity and ecosystem health in remote areas.[6] Additionally, we are partnering with G42 on a $1 billion digital ecosystem initiative in Kenya.[7]

Play 3
Minimize resource use, expand access to carbon-free electricity, and support local communities

Microsoft is innovating datacenter development with low-carbon materials like cross-laminated timber.[8] Through an agreement with Brookfield, we aim to add 10.5 gigawatts (GW) of renewable energy to the grid.[9]

> "The world needs every tool at its disposal, and the potential of AI to accelerate sustainability is already being realized."

10.5 GW

of new renewable energy capacity to be developed across the United States and Europe.

Play 4
Advance AI policy principles and governance for sustainability

We advocated for policies that accelerate grid decarbonization including Federal Energy Regulatory Commission (FERC) transmission rules and provisions in the Inflation Reduction Act in the United States. In addition, we continue to advance AI governance within Microsoft and globally.

Play 5
Build workforce capacity to use AI for sustainability

Microsoft Philanthropies' Skills for Social Impact program trained over 14 million people in digital and AI skills to support a workforce ready to deploy AI for sustainability.[10]

As the window for achieving global sustainability goals narrows, the urgency for action intensifies. The world needs every tool at its disposal, and the potential of AI to accelerate sustainability is already being realized. Sustainability is not a journey that can be taken alone and unlocking the full potential of AI for climate progress requires continued partnerships to combine expertise, technology, and innovation. As we continue to explore the ways AI can advance sustainability, we invite others to join us in this journey.

Brad Smith
Vice Chair and President

Melanie Nakagawa
Chief Sustainability Officer

Actions and Innovations

In 2023, Microsoft released our Accelerating Sustainability with AI playbook, where we highlighted that AI has three game-changing capabilities that are essential for accelerating sustainability, and outlined five plays that represent the necessary conditions for the world to be able to unlock them. This paper reports on our progress in each of the five plays and provides updates based on lessons learned.

In this section

Why AI is essential for sustainability: Three capabilities

Achieving global sustainability goals requires transformative progress at an unprecedented pace and scale. To meet these ambitions, scientists project that the world must triple carbon-free energy capacity[2], double energy efficiency by 2030[2], and reverse biodiversity loss to achieve a nature-positive future. However, progress is constrained by three key hurdles. First, many of the challenges of sustainability—such as managing energy grids, improving resource use, and protecting ecosystems—have grown too complex for traditional tools and approaches. Second, innovation often moves too slowly, as conventional research and development processes are time-consuming and costly. Third, there is a significant workforce gap, with too few people equipped with the tools and knowledge needed to advance sustainability solutions.

AI is essential for overcoming these hurdles because it brings three game-changing capabilities:

1

Measure, predict, and optimize complex systems

AI enables the analysis, modeling, and optimization of challenges like energy distribution, resource allocation, and environmental monitoring.

2

Accelerate the development of sustainability solutions

AI reduces the time and cost of innovation by rapidly analyzing data, predicting outcomes, and optimizing solutions.

3

Empower the sustainability workforce

AI enhances productivity by automating repetitive tasks, providing actionable insights, and making advanced tools accessible to more people.

These capabilities make AI a critical enabler of sustainability progress. By addressing complexity, speeding up innovation, and empowering people, AI helps deliver the scale and speed needed to achieve a sustainable future.

How to unlock AI's full potential: Five Plays

While AI is already being applied in transformative ways to measure and optimize complex systems, accelerate sustainability solutions, and empower the workforce, these game-changing capabilities can only be fully realized if key enabling conditions are in place. As outlined in our AI and sustainability playbook, achieving these conditions requires action across five strategies or "plays". Each play identifies the steps needed to lay the foundation for AI to deliver transformative impact on sustainability.

Play 1

The world must invest in AI to accelerate sustainability solutions

Without focused investments, AI's abilities to accelerate sustainability will remain underdeveloped and underutilized. AI cannot be a game-changer unless resources are directed to develop and deploy solutions that tackle challenges like decarbonization, water management, and biodiversity restoration.

Play 2

It is vital to develop digital and data infrastructure for the inclusive use of AI for sustainability

AI models rely on high-quality representative data and the infrastructure to process it. Without these, AI technologies will not realize the full potential of their game-changing capabilities for sustainability because the insights AI models generate will be limited, inaccurate, or biased, undermining their effectiveness.

Play 3

It is essential to minimize resource use in AI infrastructure design and operation, expand access to carbon-free energy, and support local communities

AI has its own energy and water demands, so minimizing resource use and ensuring that AI systems are powered by carbon-free energy is critical to scaling its use sustainably. In addition, because AI infrastructure is concentrated in certain regions, it is essential to support local communities where datacenters are located.

Play 4

AI policy principles and governance for sustainability must be advanced

Strong policies and governance are critical for accelerating decarbonizing the energy system, as well as incentivizing and guiding the proper use of AI for sustainability solutions. Without clear policies, the power of AI's three game-changing capabilities could be undermined by unintended consequences or inequitable deployment.

Play 5

The workforce capacity to use AI for sustainability must be built

Even the most advanced AI tools depend on people who can apply them effectively. Bridging the sustainability workforce gap requires investment in training, skills development, and capacity-building programs to ensure that AI game-changing capabilities can be broadly used.

AI is already making important contributions to accelerating sustainability progress, demonstrating its ability to deliver the speed, scale, and solutions needed to tackle urgent environmental challenges. However, more is needed. If action is taken across these five plays, the world can create the necessary conditions for AI to fully unlock its game-changing capabilities—equitably and responsibly—and further amplify its impact in building a more sustainable future.

Accelerating Sustainability with AI

Play 1: Invest in AI for sustainability

In this section, we highlight examples of investments being made to develop tools and apply AI for each of its three game-changing capabilities: measuring and optimizing complex systems, accelerating sustainability solutions, and empowering the workforce. These AI capabilities are already being applied across a range of sectors from energy to biodiversity and climate risk.

Following, we share some examples of how Microsoft is collaborating with various partners to apply AI's three game-changing capabilities in two areas: the net-zero energy transition and climate risk management.

1 Investing in AI to measure, predict, and optimize complex systems

AI's ability to analyze vast amounts of data, identify patterns, and make real-time predictions enables it to optimize complex systems that are central to sustainability, such as electricity grids and supply chains, while helping to transform understanding and management of biodiversity challenges and climate risks. The following examples showcase how AI's first game-changing capability—the ability to measure, predict, and optimize complex systems—is driving efficiencies and improving outcomes for people and the planet.

Net-zero energy transition

AI is already accelerating the path to net-zero energy by helping to integrate renewable energy sources like solar and wind into electricity grids and overcome challenges in balancing variable supply with demand, as well as enhancing grid efficiency and resilience. Organizations worldwide are using AI to accelerate progress. The US Department of Energy (DOE) is investing in AI to accelerate clean energy deployment, secure grid infrastructure, and reduce the costs of next-generation energy technologies—key steps in achieving a net-zero energy system.[11]

Microsoft is making similar investments in AI to help accelerate the net-zero energy transition. In 2024, the National Grid in western New York worked with LineVision, a company that Microsoft has invested in, to install the largest fully integrated operationalization of dynamic line ratings in the United States. LineRate, LineVision's AI-driven software with sensor validation, was deployed on four 115-kilovolt transmission lines in a renewable energy-rich region of New York state.[12]

This technology has been deployed around the world, providing predictive maintenance and load forecasting that has been designed to enhance reliability and efficiency. In some regions, it increased transmission capacity up to 60%.[12] Increased capacity in New York is highly correlated with increased renewable power transmitted over these lines.

We are also working directly with renewable energy companies, to optimize energy production. For example, by utilizing reinforcement learning and Microsoft Azure high-performance computing (HPC), Energy companies are optimizing wind farm performance, predicting maintenance needs, and enhancing energy production efficiency and reliability.[13]

In addition to renewable integration, Microsoft is collaborating with organizations around the world to develop and deploy AI-enabled tools to reduce methane emissions,[14] a powerful greenhouse gas, from a variety of sources, including the energy, agriculture, and waste sectors.[15,16] For example, in 2023, the Global FoodBanking Network (GFN) started developing the Food Recovery to Avoid Methane Emissions (FRAME) methodology to measure and track the methane emissions prevented by food recovery efforts in food banks within its network, covering 63 organizations in 53 countries.[17] GFN used Microsoft Sustainability Manager as a key tool for building a custom emissions dashboard.

This dashboard was piloted with food banks in Mexico and Ecuador to provide a clear, real-time view of their environmental impact and alignment with the United Nations (UN) Sustainable Development Goals.[17] The built-in guidelines, carbon activities settings, and standardized factors within Microsoft Sustainability Manager streamlined processes, enhanced precision and ease in use. GFN plans to expand the methane mitigation project in other parts of the world, such as sub-Saharan Africa and Southeast Asia, to help food banks that recover and redistribute surplus food demonstrate the impact of their actions to reduce methane emissions.

Climate risk management

Climate change has altered weather patterns and led to new extremes in 2024. Record heat, in excess of 46°C (115°F), closed schools, devastated crops, and killed hundreds of people across Asia.[18] Heavy precipitation and flooding in Kenya and Brazil displaced over 200,000 people.[19] Managing and mitigating these growing climate risks is difficult, in part due to the challenges of predicting weather and assessing vulnerabilities.[20] AI is starting to change this. Governments, businesses, and organizations globally are investing in AI to manage climate risks, from predicting extreme weather to developing resilient crops and workforce copilots. For instance, the UN's Global Initiative on Resilience to Natural Hazards[21] and the US Department of Homeland Security[22] are using AI to enhance disaster preparedness and community resilience.

INNOVATION SPOTLIGHT

Utilidata

Improving energy transmission and grid capacity

Through the Microsoft Climate Innovation Fund, Microsoft invested in Utilidata, which brings AI to the electric grid, transforming the way utilities operate. Utilidata's distributed AI platform, Karman, identifies, classifies, and predicts grid conditions, enabling the management of distributed energy resources in real time. In some regions, this technology has increased transmission capacity up to 60%.[12]

Microsoft is also investing in AI to increase the efficiency and effectiveness of climate risk management. AI is enhancing weather predictions by analyzing vast amounts of data from diverse sources, including satellite imagery, weather stations, and ocean buoys. AI-powered models can identify complex patterns and relationships within this data that traditional statistical methods might overlook, resulting in more accurate and granular predictions of extreme weather events. Additionally, AI enhances scientists' ability to refine predictions and explore trends related to climate change by complementing physical models with data-driven insights. This integration enables more informed projections about future climate trends while supporting the ongoing study of climate dynamics. Microsoft Research's AI for Science team developed an AI foundation model, Aurora, that predicts weather with unprecedented accuracy using 1.3 billion parameters to forecast global weather patterns and atmospheric processes like air pollution.[5] Aurora was trained on more than 1 million hours of weather and climate simulations, which allows it to understand complex atmospheric dynamics.[5] The model excels at a wide range of prediction tasks, even in data-sparse regions or for extreme weather scenarios, operating at approximately 5,000 times the rate of the most state-of-the-art integrated forecasting system that weather services currently employ.[5]

But to manage and mitigate climate risks, the world needs more than weather predictions. Climate risks arise from multiple characteristics of both natural and built environments. To effectively manage climate risks, solutions are needed to integrate multiple information sources to assess vulnerabilities to hazards and target rapid response across various systems in different locations. The Microsoft Climate Innovation Fund invested in Mitiga, a company that uses AI, high-performance computing, and cutting-edge climate models to predict the impact of physical climate change on any asset, anywhere in the world, from now until the century's end—within seconds. Mitiga's EarthScan platform enables infrastructure, commercial real estate, insurers, and companies across industries to manage risks and comply with climate disclosure regulations.[23] Microsoft's AI for Good Lab has collaborated with Planet Labs PBC, combining the power of AI with satellite imagery to help emergency responders and local authorities rapidly assess the extent of damage to buildings after disasters such as earthquakes, floods, and wildfires, and helping them better target efforts to deliver critical aid.[24]

Wildfire is a growing climate risk, causing devastation across the globe. In 2024, record-sized wildfires broke out in Canada, Greece, and the Amazon, while fast-moving wildfires in Hawaii and Chile killed hundreds of people.[25] Climate change is drying out landscapes with historically low burn rates, making them more flammable.[26] The risk of wildfires arises from a complex interplay of weather, vegetation, and land and water management practices.[25] Companies like Vibrant Planet are using AI to better predict and manage these risks.[27]

Biodiversity protection

The UN estimates that over 1 million species are now at risk from extinction, many within the next decade.[28] Tackling biodiversity loss requires monitoring and managing complex systems that are interconnected across the globe. AI is emerging as a game-changer in improving understanding and tracking changes and empowering conservation practitioners.[29–31] Microsoft has deployed AI-enabled technologies in the Amazon rainforest, which are far more effective than traditional biodiversity monitoring approaches. Project Guacamaya is an innovative partnership between Microsoft's AI for Good Lab, Planet Labs PBC, Instituto Sinchi, Universidad de los Andes, and the Alexander von Humboldt Institute in Colombia that uses a combination of camera trap footage and bioacoustics to identify species and track their recovery or loss in the Amazon rainforest.[32] Project Guacamaya's open-source algorithms help scientists to identify species in over 110,000 camera trap images with 90% accuracy, detecting not only native but non-native species indicative of ecosystem health.[32] These tools cut analyses from months to minutes.[30] In combination with high-resolution satellite data, they allow conservation practitioners to monitor and manage the critically important Amazon rainforest, which contains a large percentage of remaining biodiversity and plays an important role in regulating regional and global climate.[33]

2 Investing in AI to accelerate the development of sustainability solutions

Many sustainability solutions are slowed by time-intensive and costly research and development processes. But AI is transforming the speed and scale of innovation by rapidly analyzing complex data, quickly identifying potential optimal solutions, and automating processes that previously required significant time and resources. Organizations around the world are already investing in putting this second AI game-changing capability to work. For example, AI is starting to be used by organizations around the world to accelerate the discovery of new materials for low-carbon manufacturing[34] and the identification of crop varieties resilient to a changing climate,[35] and to design advanced energy catalysts to improve the efficiency of clean energy technologies.[36] Following are a few examples of how Microsoft is investing in AI's second game-changing capability to accelerate the development of sustainability solutions, drawing from two sectors: net-zero energy transition and climate risk management.

Net-zero energy transition

Organizations are using AI to accelerate research and development, demonstrating its transformative potential for advancing the net-zero energy transition. Advanced algorithms, machine learning, and vast datasets are enabling breakthroughs that were previously unimaginable.

The Microsoft AI for Science initiative focuses on applying advanced AI capabilities to accelerate scientific discovery and address some of humanity's most pressing challenges. Using deep learning and machine learning, the initiative aims to transform fields such as new materials discovery and green energy solutions while improving our ability to model and predict natural phenomena across varying scales of space and time. For example, the AI for Science team developed MatterGen[3] and MatterSim[4] generative models which enable predicting ground-state material structures and energetics and simulating their behavior under realistic temperatures and pressures, which can lead to up to tenfold enhancement in accuracy compared to the prior best-in-class approaches and orders of magnitude increase in speed.

INNOVATION SPOTLIGHT

Accelerating the discovery of new materials

Researchers are using AI to predict the properties of materials, dramatically reducing the time and cost associated with traditional, experimental materials design and leading to the discovery of entirely new materials. Microsoft and the Pacific Northwest National Laboratory (PNNL) used AI to discover a new battery material requiring less lithium—a breakthrough achieved in weeks rather than the years that traditional research and development would have required.[37] Reducing lithium dependence is crucial to decarbonization as global demand for lithium is projected to outpace supply.[1]

In another project, Microsoft Research and Microsoft's Cloud Operation and Innovation team have partnered with the University of Michigan to advance long-duration energy storage (LDES) technologies, a fundamental need for grid reliability as more intermittent renewable energy, such as wind and solar, are integrated into the electricity mix. Traditional flow batteries often rely on vanadium, an element that is costly and impractical for large-scale deployment.[40] To overcome this limitation, Microsoft researchers are using computational tools and generative machine learning models to design organic redox-active molecules as alternatives to high-cost vanadium.[41] These organic molecules offer lower costs, avoid reliance on critical high-cost minerals, reduce corrosion hazards, and are non-toxic.[41] This innovative energy storage solution is expected to enable greater grid integration of renewable energy sources like wind and solar.[41]

Climate risk management

Plants selected and cultivated as food crops by human communities over the last 10,000 years[42] are increasingly vulnerable to extreme weather and climate change.[43,44] Climate risk in agriculture is exacerbated by current modes of cultivation. For example, many staple crops, like maize, are cultivated in genetically-simplified monocultures with low resilience to climate variability.[45]

However, research institutions like the Consultative Group for International Agricultural Research have begun applying AI's second game-changing capability: it is using AI to scan the genomes of crops for resilient traits and selectively breed varieties that can tolerate a wider range of climate variability.[35] This is just one example of how AI is facilitating the creation of resilient, productive, and profitable crop varieties at unprecedented speed and scale.

Microsoft is investing broadly in AI to accelerate climate risk solutions for agriculture. We are collaborating with Bayer to develop Microsoft Azure Data Manager for Agriculture, which allows organizations to anticipate business challenges and manage operational risks like climate change by integrating diverse datasets—such as weather patterns, soil conditions, and crop health—into a unified AI-powered platform.[46] Bayer's AgPowered Services such as Historical Weather, Imagery Insights for scouting, and data connectors for Smart Irrigation are allowing organizations to increase the speed of predictive models, optimize farming practices, and simplify the development of digital solutions.[47] Generative AI tools from Bayer will also help to support regulatory and sustainability practices.[48]

INNOVATION SPOTLIGHT

Generative Chemistry

Unleashing a new wave of creativity for scientists

Generative Chemistry will unleash a new wave of creativity for scientists tasked with discovering and designing new molecules with wide-reaching sustainability applications.[38] Researchers can ask Generative Chemistry for molecules with desired characteristics, such as the ability to degrade rapidly or be recycled more easily.[39] They can also provide information about their targeted application and let the system help determine relevant molecular properties.[39] After a few more steps, they receive a set of candidates matching those parameters for further study.

However, simply generating candidates is not sufficient for transforming the discovery process with AI. The essential criteria for computational tools in chemistry are that they help scientists discover molecules that are novel, synthesizable, and useful in the real world. Generative Chemistry can suggest molecules that have not been seen before, with useful properties tuned for a specific application, and whose synthesis is feasible in a reasonable number of steps.

Generative Chemistry will offer researchers potential steps to consider as they develop their recipe for synthesizing these molecular candidates in a laboratory—further helping to accelerate the development and deployment of sustainability solutions.

3 Investing in AI to empower the sustainability workforce

Addressing sustainability challenges requires a workforce that is knowledgeable about a range of rapidly evolving environmental science, technologies, regulations, and more. But wide gaps in expertise, capacity, and resources exist, which can hinder progress.[49] AI is helping to close these gaps by providing access to knowledge, personalized training, and personalized assistants—such as Microsoft Copilot—that make the rapidly expanding sustainability data and information more broadly accessible. At the same time, AI is scaling the impact of people and organizations by enhancing decision-making, automating tasks, and delivering advanced insights. From streamlining sustainability reporting and supporting farmers with tailored guidance to helping stakeholders navigate vast and evolving sustainability information, the following examples highlight how Microsoft is investing in this third game-changing capability of AI to close gaps and amplify the workforce's impact in the energy and climate risk management sectors.

Net-zero energy transition

By integrating AI into daily operations, companies are enhancing productivity, streamlining processes, and enabling employees to focus on high-value tasks that contribute to sustainability goals.

Currently, the licensing and permitting process for carbon-free energy projects in the United States is costly. For instance, the permit approval and licensing processes alone for the average nuclear power plant can extend up to 12 years and cost $50–100 million.[50] Microsoft is working to help to expedite these processes. For example, Microsoft is developing an advanced generative AI-based solution aimed at enhancing the productivity of companies and licensing experts navigating the Nuclear Regulatory Commission (NRC) licensing process and other nuclear licensing processes globally.[51]

INNOVATION SPOTLIGHT

Streamlining processes

Helping to get carbon-free energy projects online faster

Microsoft is developing a generative AI-based solution to enhance the productivity of companies and licensing experts undergoing Nuclear Regulatory Commission (NRC) licensing and other nuclear licensing processes, globally. This solution trains on historic licensing data to streamline the licensing process for small modular reactors and utility partners. It automatically retrieves real-time or site-specific information, such as flood and earthquake history data for a particular area, and converts this information into documentation that can be used in licensing applications. This solution uses generative AI to apply multiple large language models designed for specific permitting or licensing tasks. Generative AI can assist with drafting documents using existing datasets, which are then plugged into a licensing workflow for human review and improvement, significantly enhancing the productivity of permitting engineers.

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Keeping up with the latest energy data presents another challenge for those working on energy issues. To help address this, the International Energy Agency (IEA) in cooperation with Microsoft developed the WEO-GPT tool hosted on IEA's website. Built on Microsoft Azure using Copilot Studio, the WEO-GPT tool has been trained on the full World Energy Outlook 2024 report and provides answers based on World Energy Outlook (WEO) content[2,52]. It allows users to ask questions about the report using natural, conversational language.[52] The tool is designed for anyone curious about the report's findings to more easily dig into its data, analysis, and projections.

Climate risk management

AI is being used to empower the workforce engaged in climate risk management. Microsoft has partnered with organizations around the world to develop AI-powered Copilot assistants that are helping people rapidly upskill and more effectively manage climate risks.

For example, Microsoft and the International Water Management Institute (IWMI) have partnered to develop a Water Copilot for the Limpopo River Basin, which includes parts of Botswana, Zimbabwe, South Africa, and Mozambique.[53] The copilot is based on a comprehensive knowledge base that integrates multilingual regulatory documents, scientific reports, remote-sensing workflows, and near real-time sensor data from across the watershed.[54] Users can interact with the copilot and retrieve data from these widespread sources through a chat interface powered by GPT-4, empowering decision-makers with critical insights on flows and water availability related to drought and other climate risks.[54] Microsoft's partnership with IWMI is facilitating informed, collaborative, and sustainable management of an important African river basin.

Climate change has also led to an estimated 21% decline in global agricultural productivity since 1961[55] and as temperatures increase so do the risks to food security around the world.[56] There is a widespread movement to improve management practices for both optimizing current yields and ensuring the future productivity of agroecosystems.[57] Microsoft uses AI to advance that research and bring it to farmers in the field.

INNOVATION SPOTLIGHT

AI for Good Lab

Empowering communities to respond to extreme weather

Microsoft's AI for Good Lab has collaborated with Planet Labs PBC to deploy AI models that improve the accuracy and speed of assessing vulnerabilities to and damage from natural disasters, including wildfires, floods, and hurricanes. These tools provide detailed insights—not just the number of buildings damaged, but also the extent of damage to each structure. This information has helped humanitarian organizations prioritize aid, guide recovery efforts, and accelerate the restoration of affected communities. Having already used these models to inform disaster response from Libya to Spain and Turkey to Granada, we are continually improving them and making them accessible to humanitarian and emergency response teams worldwide.

Biodiversity protection

The UN estimates that over half of the global economy is dependent on biodiversity and ecosystem services.[59] The Global Framework on Biodiversity explicitly names companies as important partners in halting and reversing declines in nature.[60] Several emerging environmental-social-governance (ESG) frameworks, such as the European Union's Corporate Sustainability Reporting Directive,[61] are beginning to require companies to measure and report how they affect and depend on critical aspects of nature like biodiversity. Microsoft partnered with Planet Labs PBC, the University of Vermont's Gund Institute for the Environment, and the Natural Capital Project to highlight how recent advancements in AI-enabled Earth observation technologies can be used to facilitate the measurement, reporting, and ultimately protection of biodiversity at scale.[62]

These technologies include AI-enabled camera traps, bioacoustics, and high-resolution satellite imagery, and potentially other tools like Microsoft Premonition, an automated environmental DNA measurement platform also enabled by cloud computing and AI.[63] Effective monitoring and reporting biodiversity and complex ecosystems, globally, will arguably be impossible without such AI-enabled tools.

INNOVATION SPOTLIGHT

AgPilot

Empowering farmers to create more resilient food systems

Microsoft's partner Headstorm developed a copilot, AgPilot, which provides farmers with actionable insights that facilitate more sustainable practices. AgPilot uses generative AI along with data from Microsoft Azure Data Manager for Agriculture to provide real-time access to critical agricultural data like soil health, crop conditions, weather forecasts, and pest and disease information.[58] Farmers can use AgPilot to identify potential pest and disease threats before they become widespread. This proactive approach allows for more effective and minimal use of chemicals, supporting eco-friendly pest control methods.

Accelerating Sustainability with AI

Play 2: Develop digital and data infrastructure for the inclusive use of AI for sustainability

Without access to sufficient, high-quality data and robust digital infrastructure, the full potential of AI's game-changing capabilities cannot be realized.

Play Two focuses on developing the digital and data infrastructure needed to ensure AI can be applied inclusively and effectively for sustainability. Microsoft is helping to address critical gaps in data and accessibility and expand access to the infrastructure required to unlock AI's transformative power on a global scale.

Filling gaps and making data more accessible

The effectiveness of AI tools to help manage and predict complex systems, accelerate development of solutions, and empower the workforce depends on the quality of data used to build AI models.[64,65] Insufficient or low-quality data can lead to inaccurate or biased model insights,[66] spurious predictions,[67] and unreliable recommendations.[68] Additionally, data must be available in formats that AI models can process effectively. Following, we highlight examples of how Microsoft is helping to fill gaps and increase accessibility of data that can help strengthen AI models to support three sectors: climate risk management, biodiversity, and carbon removal.

Climate risk management

Between 2010 and 2020, almost 18 million people in Asia were displaced by natural hazards, compared with around 1 million people in North America.[69] As the world experiences increasingly severe impacts of climate change, we need better tools to support communities before, during, and after extreme weather events. AI-enabled models can help people better understand and predict complex climate risks (AI's first game-changing capability) and inform risk prevention,[70] empowering disaster response teams[71] and resource mobilization[72] (AI's third game-changing capability). But poor data in many regions limit the effectiveness of these models to provide robust insights and predictions to support decision making.

For example, household census data and associated demographic metadata are often outdated and incomplete, failing to capture high-density clustering of populations in temporary and dynamic housing, particularly in the developing world.[73] To help fill these data gaps, Microsoft is working with the University of Washington's Institute of Health Metrics and Evaluation (IHME) to use high-resolution satellite imagery from Planet Labs PBC, spatial demographic analysis, and AI to estimate the extent of the built environment and how population is changing over time.[74]

Data access can also constrain the full potential of AI's game-changing capabilities. For example, satellites collect increasing amounts of data each year, creating a growing data repository of tremendous value for managing climate risks, accelerating the discovery of new insights to help address a range of sustainability challenges. But these data can be difficult to access, and if they cannot be easily accessed, then they cannot be widely used for sustainability solutions. To tackle these challenges, NASA IMPACT collaborated with Microsoft to develop Earth Copilot, which allows users to interact with NASA's data repository through plain language queries, facilitating a broader range of users in interacting with its Earth science data.[75]

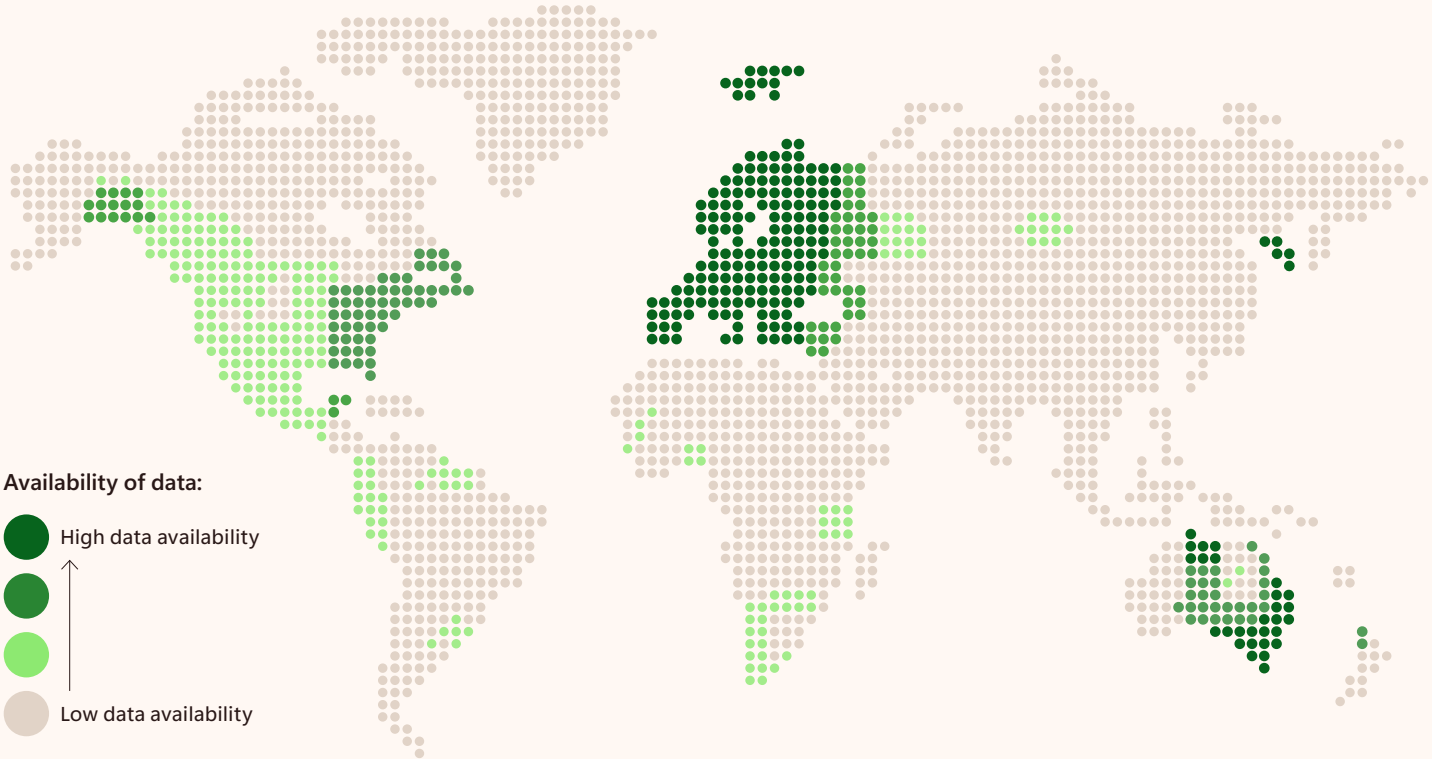
Biodiversity protection

Data limitations constrain the ability to use AI's full potential to measure, protect, and report on biodiversity. It is estimated that less than 7% of the world's ecosystems have been surveyed for biodiversity at a spatial resolution of 5 square kilometers or less,[76] with nearly 80% of the available data coming from just 10 countries in the Northern Hemisphere (Figure 1).[77]

These large data gaps persist in large part because traditional field-based biodiversity observations are expensive and time-consuming and are thus difficult to scale. However, new AI-enabled technologies like Microsoft's SPARROW can help overcome this challenge.[6,79] SPARROW—an autonomous Solar-Powered Acoustic and Remote Recording Observation Watch—integrates AI-enabled camera, bioacoustics, and other environmental sensors on a single platform that can be deployed to the remotest reaches of the planet and transmit resulting data directly to satellites overhead.[6] Thus, AI-enabled sensors used by Project Guacamaya[32] and SPARROW[6] not only fill gaps in observational biodiversity data but also incorporate new types of data from bioacoustics and satellites into biodiversity observation networks.[30,62,79]

Figure 1

Most of the world has low data availability for biodiversity



Representation of the limited observational data available, globally, for mammal species, adapted from a study by Daru and Rodriguez[78], which presents similar trends for biodiversity, more broadly. Low data availability means that scientists and policy-makers cannot effectively monitor biodiversity and manage change over large parts of the world.

INNOVATION SPOTLIGHT

18,000

Today, 18,000 researchers and organizations currently rely on biodiversity and ecosystem monitoring data.

SPARROW

Filling gaps in biodiversity data

Solar-Powered Acoustic and Remote Recording Observation Watch (SPARROW) is an innovative new AI-powered biodiversity monitoring tool developed by Microsoft's AI for Good lab. Its advanced solar-powered sensors record camera footage, bioacoustics, and other environmental data. SPARROW is enabled by species identification algorithms that run on low-energy graphical processing units, with data transmitted to satellites in orbit for use anywhere in the world. Every aspect of SPARROW, from its hardware that is designed to be 3D printed to its open-source algorithms, is designed to facilitate its large-scale deployment. Today, 18,000 researchers and organizations currently rely on biodiversity and ecosystem monitoring data, and this number is growing under new ESG reporting frameworks.[6] This tool offers to scale measurements and fill gaps in biodiversity data around the world.

The data collected by these innovative new sensors can serve as key inputs in emerging AI-enabled biodiversity observation networks.[76] Microsoft has also collaborated with an international team, led by GEO BON, to develop a framework for a Global Biodiversity Observation System (GBiOS).[76] GBiOS will use AI to integrate data collected around the world, monitor change, and help scientists and policy-makers halt and reverse declines in biodiversity.[76]

Carbon dioxide removal

Carbon dioxide removal technologies that depend on natural processes such as forest sequestration, soil sequestration, or enhanced-rock weathering (ERW) can vary in effectiveness over space and time. This is an example where AI's first game-changing capability is starting to be applied to optimize the deployment of carbon dioxide removal strategies by analyzing complex environmental datasets.[80] However, data gaps limit the effectiveness of many models.

Microsoft is investing in companies like Terradot, which is helping to fill data gaps to improve deployment of ERW. ERW involves a complex series of reactions between crushed rock, land, and water, which naturally absorb carbon dioxide from the atmosphere. But, these reactions vary across different environments. Terradot aims to remove gigatons of carbon dioxide from the atmosphere by using AI to optimize the deployment of ERW at scale.[81] By performing thousands of measurements in the field and laboratory on variables such groundwater pH, soil type, and organic carbon content, to name just a few,[81] Terradot is building the datasets needed to determine the locations where ERW will be most effective.[81] Such optimization will maximize carbon dioxide removal by this promising nature-based solution.

As multiple initiatives around the world work to fill gaps in data for sustainability solutions, these new data will need to meet standards of quality, formatting, and documentation to be accessible and interoperable by AI models.[82] Formatting guidelines are being developed for specific domains,[82] but will need to be expanded across domains, particularly for general-purpose foundation models.

Expanding access to digital infrastructure

The application of AI globally to accelerate sustainability is also hindered by limited access to digital infrastructure. As of 2023, one third of the world still lacked internet access.[83] While connectivity trends are improving, progress remains uneven.[84] More than half of the globe lacks internet connectivity at the broadband speeds that enable productive use of cloud services and AI.[83]

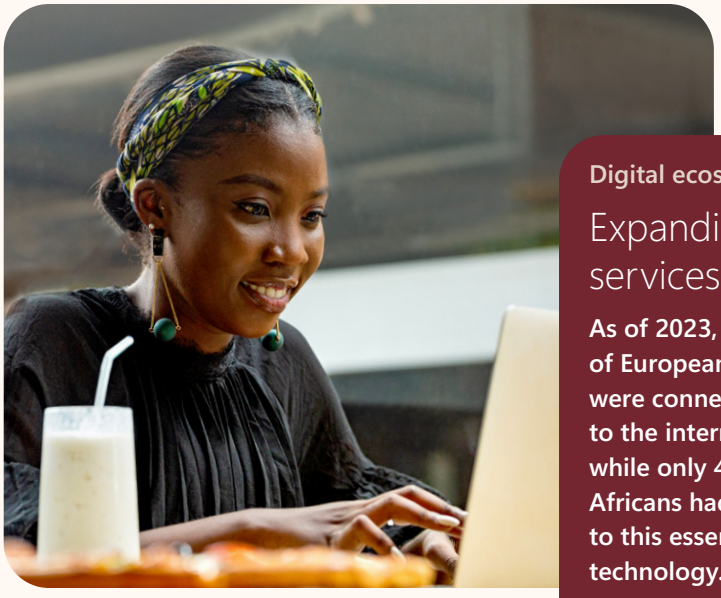
Globally, 2.7 billion people remain disconnected from the internet and therefore cannot use AI to accelerate sustainability or develop solutions to other challenges facing society.[83] At Microsoft, we believe that internet access and meaningful connectivity are fundamental rights that allow people to "work, learn, and interact with the world."[85] We are helping to expand access to internet and broadband, cloud services and AI, and even cellular networks.

Across Latin America and Africa, only 37% and 40% of the population, respectively, have internet access.[85] Microsoft's Airband Initiative is dedicated to helping to close this global digital divide. Airband fosters private sector investment and leverages innovative technologies while advocating for regulatory support and financial frameworks to expand connectivity access.[10,85] Airband is working to help extend internet coverage to 250 million people worldwide by the end of 2025.[85] Since 2017, Airband has helped bring high-speed internet access to over 100 million people around the world, including nearly 40 million in Africa.

These partnerships have also enabled the development of digital infrastructure and off-grid energy solutions in underserved communities, utilizing fiber, fixed wireless, solar energy, satellite, and other technologies to deepen digital access in these regions.[10,85]

Expanded access to the power of AI also requires access to both internet connectivity and significant computing power. Microsoft is helping to address this need in East Africa by partnering with G42 to build a new datacenter in Kenya powered entirely by geothermal energy.[7] This facility will provide access to scalable, secure, high-speed cloud and AI services, supporting the digital transformation of businesses, customers, and partners across Kenya and East Africa.

Lack of access to cell phone networks also prevents many communities around the world from benefiting from AI-enabled services. Microsoft, the IHME, Planet Labs PBC, and the University of Washington are helping the United Nations to create a "Global Map of the Unconnected" who remain outside of cell phone network coverage.[87] This data can help improve the development of AI-based models for climate vulnerability assessments and disaster response. For example, Microsoft is working with UN in its Early Warnings for All initiative, which will use AI to predict the likelihood of natural hazards like heat waves and tsunamis and alert people to seek cover with push notifications sent directly to individual cell phones.[88] Knowing where people lack connectivity could be used in these systems to improve the models to identify vulnerable regions and help target lifesaving response.



INNOVATION SPOTLIGHT

Digital ecosystem initiative

Expanding access to cloud services and AI in Africa

As of 2023, 89% of Europeans were connected to the internet, while only 40% of Africans had access to this essential technology.[83]

Africa is the fastest-growing and youngest continent on the planet, with 40% of its population under age 15.[86] Microsoft is helping to ensure that greater numbers of people in Africa, including this young, dynamic, and untapped talent, can achieve more. We are partnering with G42 on a $1 billion comprehensive digital ecosystem initiative for Kenya.[7] This initiative includes developing new digital infrastructure and Swahili-language AI models that will enable broader access to AI tools. Among other applications, these models aim to support farmers by providing recommendations for targeted applications of water and fertilizers, increasing productivity while reducing waste and minimizing environmental impacts.[7]

$1B

We are partnering with G42 on a $1 billion comprehensive digital ecosystem initiative for Kenya

Accelerating Sustainability with AI

Play 3: Minimize resource use, expand access to carbon-free electricity, and support local communities

AI operations require resources, such as energy and water. To expand the power and applications of AI's three game-changing capabilities for sustainability, AI operations must align with global sustainability goals to achieve a net zero and nature positive future. To this end, in our playbook released in 2023, we developed Play Three to focus on minimizing resource use in the development and operations of AI infrastructure. However, over the last year, it has become clear that minimizing the sustainability impact of AI operations requires more than minimizing resource use in datacenter operations; it also requires supporting the decarbonization of the local energy grids that datacenters and the rest of society's vital infrastructure rely upon.

Expanding Play 3

The continued development of AI will increase the demand for resources, but how much more electric power capacity is needed will depend on how AI models are designed and operated, how technologies advance, and the pace of AI adoption.

Currently, datacenters account for approximately 1.0–1.5% of global electricity demand, with the majority of datacenters being used for non-AI applications.[89] Even with current growth rates, the IEA projects that datacenters and AI will account for a relatively small share of global growth in electricity demand out to 2030 (see Figure 2).[2] Although AI and datacenters represent a small percentage of global electricity consumption, the projected growth is concentrated in a few regions.

For example, the IEA projects that in the next couple of years 20% of the expected increase in global datacenter electricity demand will come from Ireland and Denmark.[90] In the United States, the country with the most datacenters, the IEA projects electricity consumption to grow at a rapid pace, increasing from approximately 4% of US electricity demand to almost 6% by 2026.[90] This demand growth can be challenging in locations with aging transmission infrastructure and competing demand due in part to increased electrification in transportation, buildings, and other sectors.

The climate implications of increased electricity demand depend on the energy source. If demand is met by carbon-free energy, such as solar or wind, greenhouse gas emissions will not increase. However, in many regions, datacenters have limited access to highly consistent carbon-free power, which they require. To address the challenges of intermittency of renewable energy, energy storage solutions or non-variable energy sources—such as hydro, geothermal, nuclear, or gas with carbon capture and storage—are needed to ensure a continuous reliable electricity supply.[2]

In response to these challenges, we are focused on three areas for enhancing the sustainability of AI infrastructure: minimizing resource use, expanding access to carbon-free electricity, and supporting local communities in achieving their social, economic, and sustainability goals.

Minimizing resource use

Microsoft and the technology industry more broadly must minimize resource use across the whole tech stack by making AI compute more resource-efficient, redesigning AI operations for efficiency, and bringing to market new solutions for low carbon materials that minimize embodied carbon associated with AI hardware.

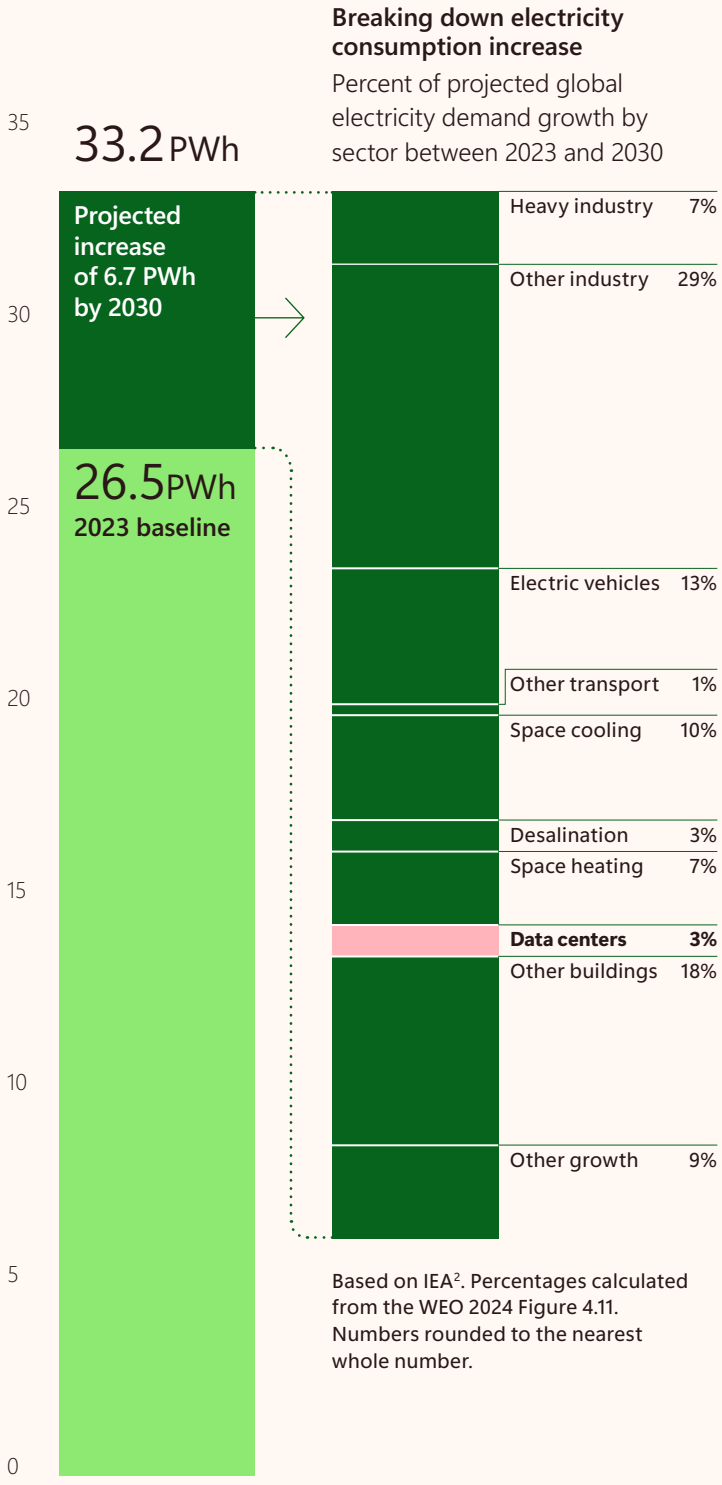
Efficiency in AI compute

Over the last year, large language models, such as the models that power tools like Copilot and ChatGPT, have become more powerful in helping people and organizations achieve more, faster, cheaper, and better. At the same time, we have been innovating to reduce the energy needed to run our models. For example, we have released a suite of small language models (SLMs) called "Phi" that reduce computational demands while matching and even outperforming for certain tasks models up to 25 times larger.[91] Microsoft Phi-3 models are the most proficient and economical SLMs available, consistently surpassing models of comparable and larger sizes across various language, reasoning, coding, and mathematical benchmarks.[91]

Another way we improve power efficiency involves distributing workloads intelligently across datacenters to safely harvest any unused power and maximize the use of our available power. Since 2019, this work has recovered about 800 MWh of electric energy from datacenters, enough to power an electric car for 2.8 million miles.[92] Also, we are working on multiple fronts to reduce the power and carbon footprint of AI datacenters, including active load management and time and spatial load shifting.[93]

Figure 2

Datacenters are projected to account for ~3% of global growth in electricity consumption between 2023 and 2030



Based on IEA[2]. Percentages calculated from the WEO 2024 Figure 4.11. Numbers rounded to the nearest whole number.

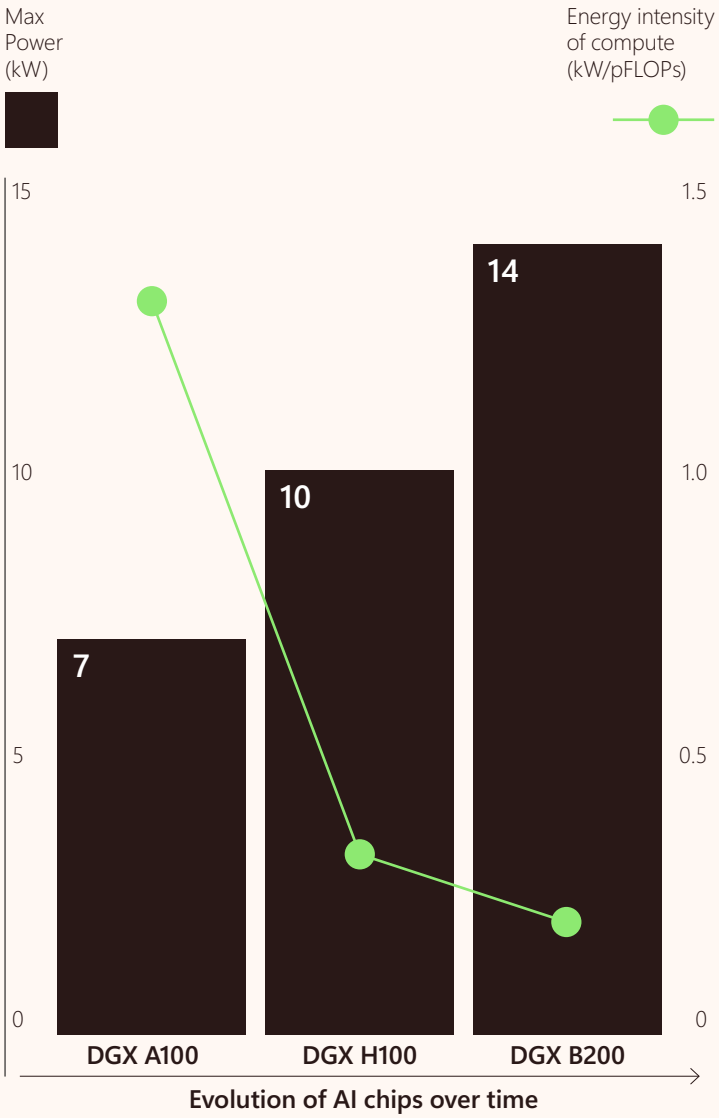
Hardware circularity and efficiency

To reduce the resource footprint of AI computing, the industry must increase the efficiency of hardware energy consumption and reduce the lifecycle impact of materials used in storage devices, processors, and related electronic components.

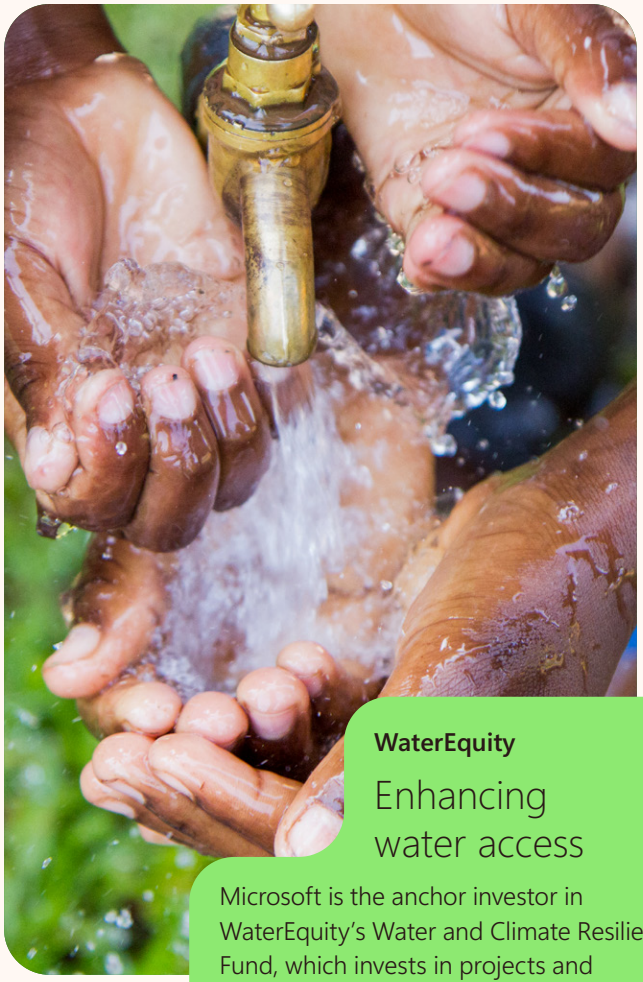
As AI chips are designed for higher performance capabilities, they can consume more total energy consumption per chip. For example, NVIDIA's H100 GPU has a power consumption of approximately 10 kW,[94] nearly 1.5 times that of its predecessor, the A100.[95] Innovation is driving down the energy intensity of compute, even as energy consumption per chip increases. This trend is expected to continue (see Figure 3).[96]

Figure 3

Energy intensity of compute is decreasing even as energy consumption of AI chips is increasing on a per unit basis



INNOVATION SPOTLIGHT



WaterEquity

Enhancing water access

Microsoft is the anchor investor in WaterEquity's Water and Climate Resilience Fund, which invests in projects and companies in emerging markets with the goal of delivering access to safe water and sanitation solutions. WaterEquity's strategy prioritizes communities vulnerable to the impacts of climate change and invests across the water value chain, including bulk water supply, water distribution, wastewater treatment, and water reuse. Microsoft's foundational investment has catalyzed more than $100M from corporates, foundations, and institutional investors to advance a water-positive future.

Microsoft is working to build circularity into hardware design. Microsoft Research has collaborated with the University of Washington to develop more sustainable and recyclable materials for electronic devices, utilizing AI in this endeavor.[97] To facilitate easier recycling, the team fabricated a prototype circuit board from a class of plastics called vitrimers that can be disassembled into its individual components.[97] They are also employing AI to design new vitrimers with specific properties for advanced materials.[97]

In addition, the Microsoft Climate Innovation Fund has invested in Cyclic Materials to scale recycling of magnets from hard disk drives. Currently, only 1% of rare earth elements are recovered globally.[98] Cyclic Materials helps reduce the need for mining and processing new materials. This circular solution also uses far less water and energy than extracting virgin materials.

Datacenter design and operations

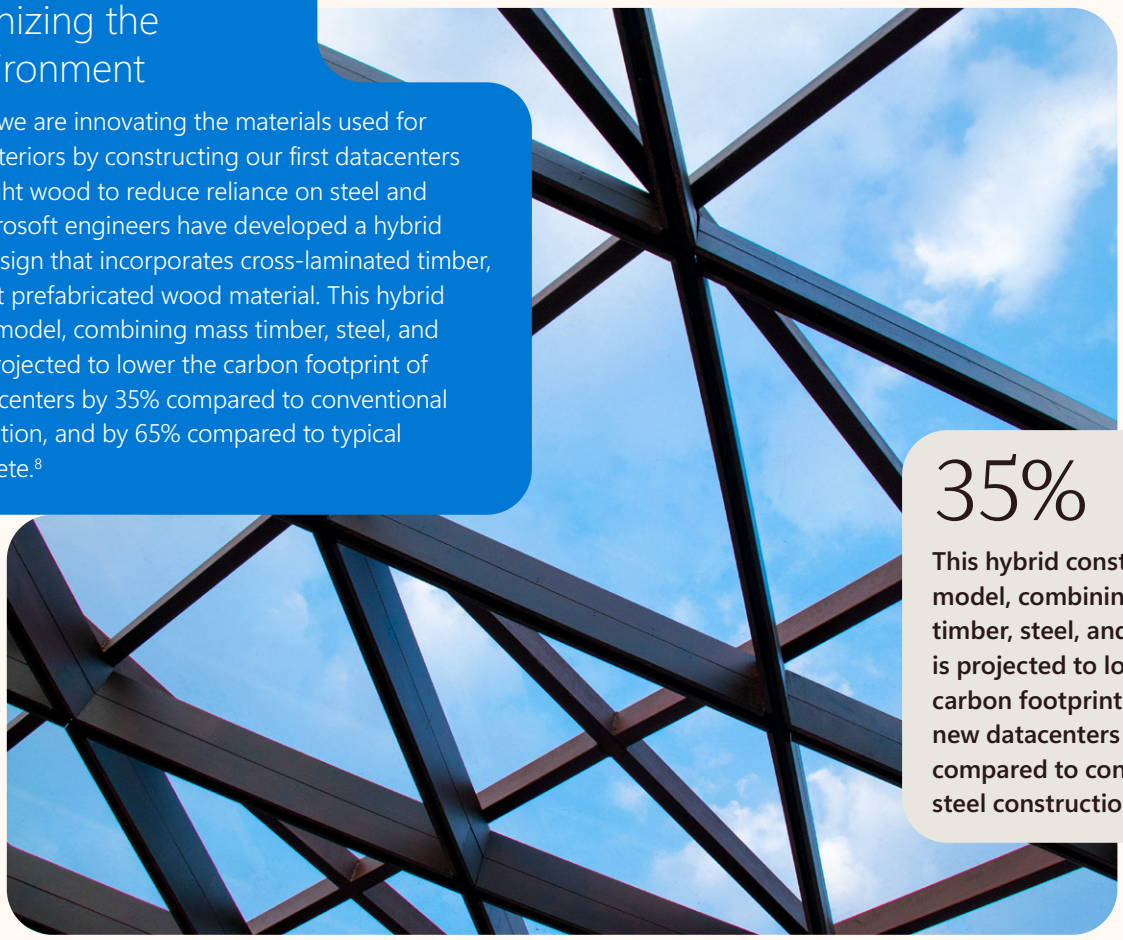
Microsoft is redesigning construction and management of datacenters for greater resource use efficiency and circularity. For example, we have just completed construction of a datacenter with cross-laminated timber, reducing the carbon footprint of its construction materials.[8] In addition, the Microsoft Climate Innovation Fund is supporting development of low-carbon construction materials, such as low-emissions steel, by investing in companies like Stegra (formerly known as H2 Green Steel), which produces steel with a reduction of up to 95% of the emissions of conventional steel production.[99] Microsoft Research is working with the datacenter team to harness the power of reinforcement learning to add intelligence to traditional HVAC controls, creating systems that enable real-time adjustments which can reduce energy and water use.[100]

INNOVATION SPOTLIGHT

Low-carbon materials

Decarbonizing the built environment

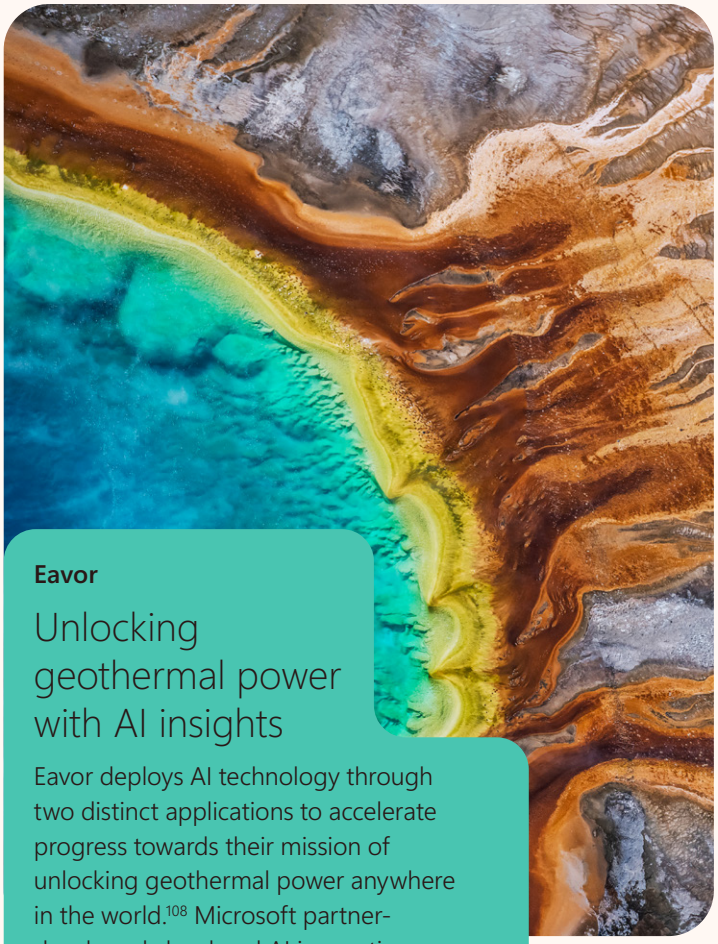
At Microsoft, we are innovating the materials used for datacenter exteriors by constructing our first datacenters with lightweight wood to reduce reliance on steel and concrete. Microsoft engineers have developed a hybrid datacenter design that incorporates cross-laminated timber, a fire-resistant prefabricated wood material. This hybrid construction model, combining mass timber, steel, and concrete, is projected to lower the carbon footprint of two new datacenters by 35% compared to conventional steel construction, and by 65% compared to typical precast concrete.[8]



35%

This hybrid construction model, combining mass timber, steel, and concrete, is projected to lower the carbon footprint of two new datacenters by 35% compared to conventional steel construction

INNOVATION SPOTLIGHT



Eavor

Unlocking geothermal power with AI insights

Eavor deploys AI technology through two distinct applications to accelerate progress towards their mission of unlocking geothermal power anywhere in the world.[108] Microsoft partner-developed cloud and AI innovations offer out-of-the-box compatibility with energy industry standard technologies. These AI solutions help Eavor to optimize operational safety, reduce costs, and drive innovation in geothermal energy development. By utilizing AI-powered predictive analytics, Eavor can anticipate drilling challenges and make proactive adjustments, downtime and increasing drilling efficiency.

Microsoft has also reduced water consumption with innovative cooling technologies in new datacenter designs. Through advancements in datacenter operations and chip design, we have cut water intensity (water consumed per kilowatt-hour) by over 80% since the early 2000s.[101] Direct-to-chip cooling, such as cold plates, dissipates heat more efficiently than traditional air cooling by directly chilling the silicon and recirculating the cooling fluid in a closed-loop system. This method enhances cooling efficiency and allows for precise temperature control. To take advantage of these benefits, Microsoft is developing new datacenter designs optimized for direct-to-chip cooling, which involves reconfiguring server and rack layouts to accommodate advanced thermal and power management techniques.

In existing facilities, innovations like the "sidekick" liquid cooling system are employed alongside racks of Microsoft Azure Maia AI Accelerator chips, circulating fluid to draw heat away from the cold plates attached to the chips' surfaces. Additionally, Microsoft is exploring microfluidics, a technology that integrates tiny fluid channels into chip designs, bringing coolant directly next to processors for increased efficiency and precision.

Our newest datacenter designs are optimized to support AI workloads and consume zero water for cooling. To achieve this, we're transitioning to chip-level cooling solutions, providing precise temperature cooling only where it's needed and without requiring evaporation. With these innovations, we can significantly reduce water consumption while supporting higher rack capacity, enabling more compute power per square foot within our datacenters.

Expanding access to carbon-free electricity

We are working to accelerate the decarbonization of electricity for our company, our customers, and the global community. Microsoft is one of the largest corporate purchasers of renewable energy and has contracted over 34 GW of renewable energy across 24 countries.[9] We are supporting the addition of carbon-free electricity generation and transmission capacity to the grids. For example, in Ireland, Microsoft has signed power purchase agreements (PPAs) with FuturEnergy Ireland, SSE Renewables, Statkraft, Energia Group, and Power Capital Renewable Energy to add 900 megawatts (MW) of new wind and solar capacity.[103]

We signed a five-year agreement with Brookfield Renewable Partners that sets out a pathway to develop more than 10.5 GW of new renewable energy capacity in the United States and Europe.[104] This is nearly eight times larger than the largest previous corporate PPA, contributing to grid decarbonization in locations where Microsoft uses electricity.[104]

Electricity grids powered by intermittent renewable energy sources, like wind and solar, cannot fully meet datacenter electricity demands unless they are complemented with long-term energy storage or non-intermittent ("firm") energy sources. For this reason, Microsoft is expanding investments in lowering the cost of energy storage and also developing PPAs with providers of firm carbon-free energy. We recently signed a PPA with Constellation, which will enable the restart of an 835-MW nuclear facility in Pennsylvania that was retired in 2019.[105]

We are also investing in advancing geothermal as an increasingly scalable firm renewable option.[106] For example, Microsoft's new datacenter in New Zealand will be supported by 100% carbon-free electricity as a result of the 10-year agreement that Microsoft signed with Contact Energy for the renewable attributes produced by Te Huka 3 geothermal power station.[107]

The long-term contract with Microsoft supported Contact's investment decision to construct the Te Huka 3 power station and can generate 51.4 MW of reliable and renewable generation throughout the year.[107] Earlier in 2024, we signed an agreement with G42, in collaboration with local partners, to design and build a state-of-the-art datacenter campus in Olkaria, Kenya, run entirely on renewable geothermal energy and designed with state-of-the-art water conservation technology.[7] Our Climate Innovation Fund is also investing in companies like Eavor, which is developing next-generation geothermal energy technology that can be deployed in a much wider variety of settings compared to traditional geothermal approaches.[108]

$2.5M

Microsoft has invested over $2.5 million in community programs across more than 70 partners in Iowa. The funding has supported financial and computer classes for immigrants and refugees, skilling and career development for underserved populations, and the Microsoft Datacenter Academy, a workforce development program for IT sector employment.

Supporting local communities

Microsoft's global network of advanced datacenters relies on the support of local suppliers, officials, stakeholders, and residents to plan, build, and run these facilities. We are committed to being responsible neighbors, contributing to local economies and ecosystems, and ensuring that our datacenters address community needs and priorities.[109] For example, in West Des Moines, Iowa, where Microsoft operates datacenters, we have invested directly in supporting the community through partnerships with educational institutions and support for infrastructure projects like the construction of a water tower, new schools, and new bridges.[110]

We collaborate to identify opportunities to create efficiency and bring value to local communities. For example, in Finland, we joined forces with the public utility Fortum to build a datacenter area that produces emission-free heat for Fortum's customers in the Helsinki metropolitan area.[111] Additionally, in Quincy, Washington, we partnered with the city to open the state's first industrial water reuse center. In Ireland, we integrated batteries into wind turbines for a wind energy project, allowing us to capture excess energy when the turbines over-perform and deliver it to the local grid. Similarly, in Denmark, excess heat generated from a Microsoft datacenter will be used to heat the local community, providing enough warmth for around 6,000 homes.[112] These are examples of how we are using our datacenters as a source of energy to relieve pressure on local electric grids.

We also partner with local stakeholders to provide educational programs, grants, and initiatives aligned with community needs, including digital skills training and STEM education. For example, Microsoft has invested over $2.5 million in community programs across more than 70 partners in Iowa.[113] The funding has supported financial and computer classes for immigrants and refugees, skilling and career development for underserved populations, and the Microsoft Datacenter Academy, a workforce development program for IT sector employment. In Singapore, Microsoft opened Asia's first Datacenter Academy in collaboration with the Institute of Technical Education, offering students hands-on experience and training for careers in the datacenter industry.[114] In Taiwan, as part of the "Reimagine Taiwan" initiative, Microsoft is establishing its first datacenter region, aiming to upskill over 200,000 workers through a variety of digital training programs.[115] Through these efforts, we aim to empower community members with future-ready skills necessary for the digital age.

Microsoft also contributes to the restoration of local ecosystems adjacent to its datacenter sites. For example, we have partnered with the Society for Ecological Restoration to implement science-based, community-driven ecological restoration projects at 18 datacenter sites worldwide.[116] We have also partnered with One Tree Planted,[117] American Forests,[118] and Forestami[119] on urban forestry projects in datacenter communities to plant over 100,000 trees. Similarly, we have restored degraded stream ecosystems near our datacenters from Racine, Wisconsin[120] to Jakarta, Indonesia.[117]

INNOVATION SPOTLIGHT

AI-powered Community Solar Microgrids

Developing energy transition programs

We are co-innovating with communities to develop energy transition programs that align their goals with broader sustainability objectives, such as decarbonization and building energy-efficient infrastructures.[121] In collaboration with organizations such as Remix Inc., Soul of Innovation, Ayika Solutions, West Atlanta Watershed Alliance, and Vicars Community Center Resilience Hub, we focus on promoting environmental literacy through co-design workshops, tabletop demonstrations of sustainable technologies, and participatory planning sessions that engage community members in shaping their energy futures. This project may also facilitate job creation within the community, such that residents gain skills and opportunities in sectors like renewable energy and sustainable infrastructure. Combining technical innovation with community-driven approaches, this project is helping to build both the knowledge and capacity needed to participate in power purchase agreements and create lasting, sustainable change.

Investing in Innovation & Scaling Markets

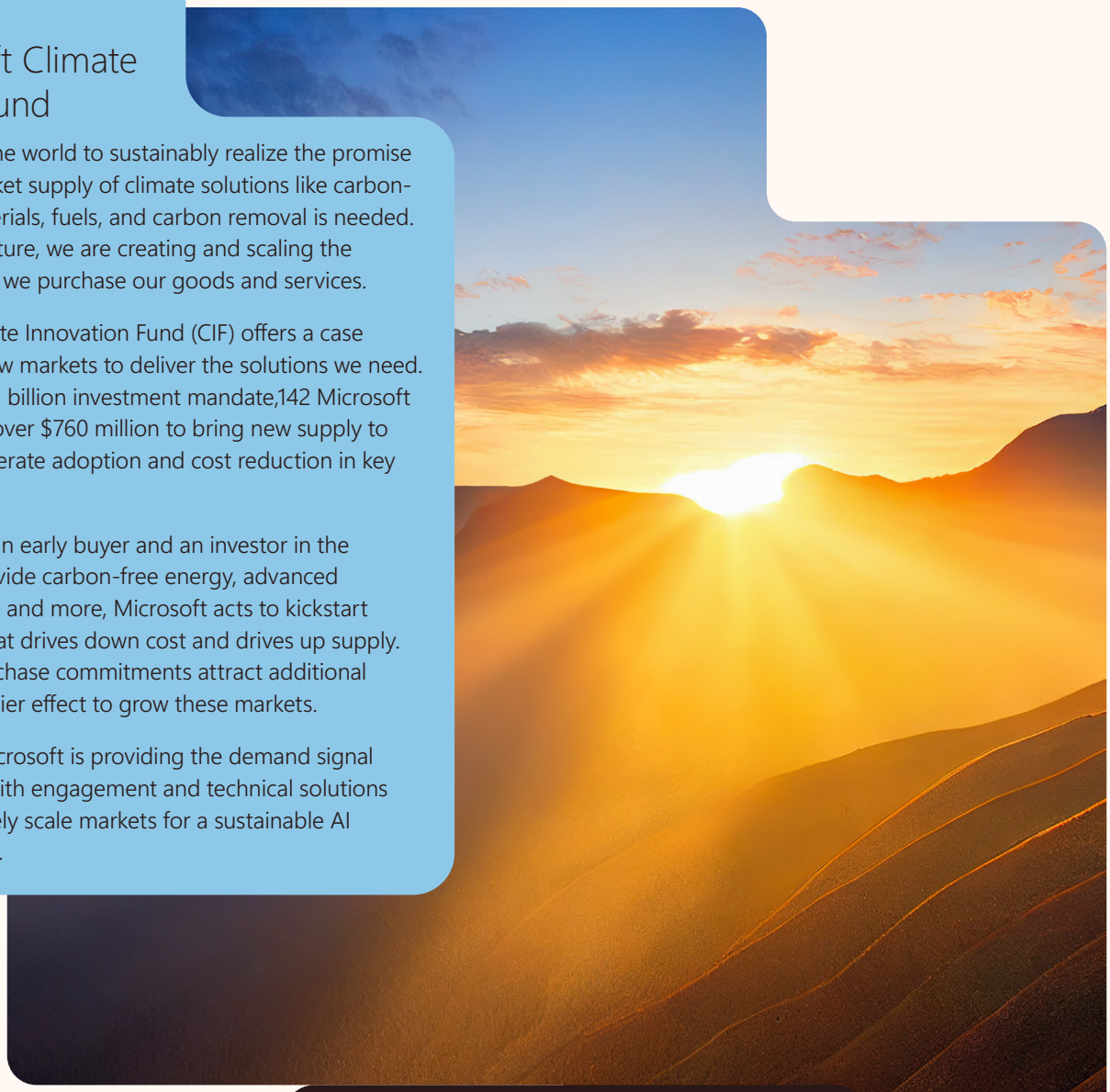
The Microsoft Climate Innovation Fund

For Microsoft and the world to sustainably realize the promise of AI, a greater market supply of climate solutions like carbon-free electricity, materials, fuels, and carbon removal is needed. To deliver on this future, we are creating and scaling the markets from which we purchase our goods and services.

The Microsoft Climate Innovation Fund (CIF) offers a case study in building new markets to deliver the solutions we need. Through the CIF's $1 billion investment mandate,142 Microsoft has so far invested over $760 million to bring new supply to market and to accelerate adoption and cost reduction in key target technologies.

By serving as both an early buyer and an investor in the technologies to provide carbon-free energy, advanced materials, circularity, and more, Microsoft acts to kickstart a market process that drives down cost and drives up supply. Our capital and purchase commitments attract additional partners in a multiplier effect to grow these markets.

Through the CIF, Microsoft is providing the demand signal and capital, along with engagement and technical solutions needed to proactively scale markets for a sustainable AI industrial revolution.



$760M

Microsoft has so far invested over $760 million to bring new supply to market and to accelerate adoption and cost reduction in key target technologies

Market development

Building new markets to deliver the solutions we need

The Microsoft Climate Innovation Fund invests to expand the market supply of climate technologies with the potential to address the industry's carbon, waste, and water footprints. For instance, Microsoft is an investor in LanzaJet, a renewable fuels producer, and is an investor and customer of WaterEquity's water replenishment projects, advancing these solutions across the industry's value chain for carbon reduction and water resources.

Accelerating Sustainability with AI

Play 4: Advance AI policy principles and governance for sustainability

Without effective policies and governance structures, the full potential of AI's three gaming-changing capabilities for accelerating sustainability progress cannot be realized. Play Four focuses on advancing AI policy principles and governance to help accelerate decarbonization of the energy system, as well as incentivizing and guiding the proper use of AI for sustainability solutions.

Policies and governance play a critical role in enabling AI to accelerate sustainability progress. Government policies are essential for facilitating the decarbonization of electricity grids and incentivizing the responsible use of AI in sustainability solutions. At the same time, ensuring that AI models are safe, secure, and trustworthy is vital for their deployment in managing the essential systems that underpin sustainability progress.

The following examples highlight how Microsoft is helping to advance the development of policies and governance frameworks that facilitate the development and widespread deployment of AI's three game-changing capabilities.

Advocating for policies that accelerate decarbonization of electricity grids

At Microsoft, we are working to accelerate carbon-free electricity, expand grid infrastructure, and scale markets through policy advocacy in the United States, Europe, and Asia. Over the past year, in the United States, we supported new Federal Energy Regulatory Commission (FERC) transmission rules to improve and expedite regional grid planning, as well as proposals to streamline permitting for energy and grid projects, and federal and state legislation advancing fusion energy and small modular reactors. Additionally, we advocated for policies that support clean energy, carbon removal, sustainable aviation fuel, and manufacturing initiatives, which formalized community benefits plan requirements to support historically disadvantaged communities.

Alongside our longstanding advocacy on renewable energy issues, we expanded our policy engagement on nuclear, fusion, and other advanced carbon-free solutions by joining the US Nuclear Industry Council, EU SMR Alliance, and Fusion Industry Association. As outlined in our policy brief *Accelerating A Carbon-Free Future*, we advocate for a diversity of technologies including advanced nuclear energy as critical to achieving net-zero energy systems, including resilient, decarbonized energy grids.[122]

Globally, we have collaborated with organizations to use AI to accelerate policy implementation. For example, Microsoft has partnered with the United Nations Framework Convention on Climate Change (UNFCCC) to develop an AI-enabled platform and global data hub to simplify the validation and analysis of climate data submitted by the 195 parties to the Paris Agreement, supporting transparency and reporting of greenhouse gas emissions.

Aligning policies to incentivize and guide the use of AI for sustainability

AI is proving to provide tremendous value in a wide range of sustainability-related areas, such as the management of energy systems,[123] water resources,[124] and supply chains,[125] as well as in ESG reporting.[62] But many organizations do not yet have the capacity to use these tools effectively. As discussed in Play Four, capacity building is critical, but policies and governance will also be important as these systems rapidly evolve and are deployed.

At Microsoft, we are engaging broadly to help shape the best practices for using AI for sustainability, including through engagements with the UNFCCC on climate, the IEA on energy, and the United Nations Convention on Biological Diversity (UN CBD) on biodiversity. For example, at COP16, Microsoft met with government and science leaders to demonstrate AI's potential in biodiversity monitoring and share best practices for its effective use. During these discussions, we highlighted initiatives like Project Guacamaya—developed in collaboration with PlanetLabs PBC and Colombian research institutions—which developed AI enabled solutions to monitor biodiversity.

Sustainability policies need to be aligned to incentivize and guide the use of AI for sustainability progress, including potential applications for AI to support energy efficiency and carbon-free energy deployment. With effective policies in place, AI can maximize its sustainability impacts across industries, optimizing systems, enhancing efficiencies, and improving systems from manufacturing to electric grid management. Enabling AI through supporting policies is critical to addressing complex sustainability challenges from climate and energy to biodiversity and water.

Microsoft is working with governments and policy stakeholders to responsibly use AI for sustainability outcomes. This past year, Microsoft provided input and comments to the US Department of Energy's request for information on the energy portions of the Executive Order on the Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence. Through our engagement, we outlined ways that AI can advance clean, reliable, and resilient electric power.

Governing AI to help ensure that it is safe, secure, and trusted

We are also committed to governance that ensures AI is safe, secure, and trustworthy. Transparency and accountability are crucial for building trust in AI systems, which is essential for their adoption in sustainability efforts. For example, in managing electricity grids, AI systems must provide reliable insights to optimize load generation and transmission resources (including variable renewable resources and new loads) without compromising grid stability. Transparency in AI operations ensures that grid operators can understand and validate the recommendations made by these systems, reducing the risk of system failures or inefficiencies.

To address these needs, Microsoft's internal Responsible AI standard aligns with the core functions of frameworks such as the US National Institute of Standards and Technology's AI Risk Management Framework, which provides guidance on identifying and mitigating potential risks in AI deployment.[126] Microsoft's 2024 *Responsible AI Transparency Report* details our commitment to safety and accountability in AI development and deployment.[127] We also collaborate with external stakeholders to advance AI governance and promote safety, security, and trust more broadly. For example, our Chief Responsible AI Officer was a member of the United Nations High-level Advisory Body on AI that produced the report Governing AI for Humanity.[128] The author panel brought together experts from diverse sectors to provide strategic guidance on developing and implementing global AI governance frameworks. The panel's work focused on providing guidance to help ensure that AI technologies are designed and deployed in ways that prioritize equity, accountability, and alignment with sustainable development goals.

Accelerating Sustainability with AI

Play 5: Build capacity for the workforce to use AI for sustainability

For AI's three game-changing capabilities to be put to work at scale, people across all sectors must have skills to use AI effectively and understanding of its capabilities and limitations. For this reason, the final play, Play Five, is to build capacity for the workforce to use AI for sustainability.

At Microsoft, we believe that building this workforce capacity requires action on two fronts. First, there is a need to build both AI fluency and sustainability fluency broadly across society. AI fluency refers to a broad understanding of what AI can do, what it cannot do, and how to use AI responsibly. Sustainability fluency refers to understanding Earth's life-supporting systems, as well as how humanity is changing them and what can be done to protect them. Second, there is a need to empower people with more specialized skills and support them in applying AI to specific sustainability challenges, such as advancing carbon-free energy systems, monitoring ecosystems, or accelerating circular economy solutions.

Building AI fluency

In the era of generative AI, building AI capacity is less about programming and more about building broader AI fluency where individuals learn to work with AI-enabled tools, such as Copilot, to enhance innovation, help build sustainability solutions, and scale impacts.

Microsoft has launched training programs focused on building AI fluency, supporting nonprofits, businesses, and governments in advancing workforce AI technical skills and promoting safe and responsible AI development. Over the past year, Microsoft has trained and certified over 23 million people in more than 200 countries in digital skills.[129] We also partner with local educational institutions and invest in organizations like TeachAI and UNESCO to build the capacity of educators globally.

> "Ultimately, our goal is to democratize AI to enable more people and organizations to benefit from this powerful technology and help create a more equitable and inclusive society."
>
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> CEO

As our CEO Satya Nadella has said: "Ultimately, our goal is to democratize AI to enable more people and organizations to benefit from this powerful technology and help create a more equitable and inclusive society."[130]

People and organizations can create their own learning path using our AI Skills Navigator.[131] We have also created curated learning paths such as Career Essentials in Generative AI, a LinkedIn Learning course that teaches the skills needed to apply generative AI in various careers, including core concepts of AI and generative AI functionality.[132]

Building sustainability fluency

In 2022, Microsoft published *Closing the Sustainability Skills Gap*, which highlighted the growing capacity gap in the workforce that needs to be filled if the world is to meet its sustainability goals.[133] To help close that gap, we have created the Microsoft Sustainability Skills program to provide educational resources to equip learners with the necessary skills for jobs in the environmental sector.[134] This program introduces learners to key sustainability concepts and offers a Career Essentials Certificate upon completion. In addition, LinkedIn created a Foundations in Sustainability Course[135] and a Sustainability Learning path[136] that is updated regularly with new information and tools development.

In today's world, understanding the implications of AI for sustainability is a key part of sustainability fluency. For this reason we have developed a new learning pathway, Career Essentials in Sustainable Tech,[137] which includes a course providing an introduction to AI and sustainability.[138]

Empowering entrepreneurs and practitioners to use AI for sustainability

Empowering entrepreneurs and practitioners to use AI for sustainability requires both specialized training in applying AI to sustainability challenges and fostering communities of practice. Microsoft has partnered with AI and technology leaders, along with sustainability experts, to develop targeted training programs on AI for sustainability. Additionally, we have supported collaborative networks and innovation hubs to help entrepreneurs advance scalable sustainability solutions. Here are three examples:

- **AI and Climate Change:** This publicly available course is part of the Coursera AI for Good specialization track, which teaches learners how to combine human and machine intelligence for positive, real-world sustainability impact.[139]
- **Green Digital Skills Program:** This program, developed in partnership with INCO Academy, includes coursework ranging from green design principles to AI-driven solutions for sustainability.[140] This includes how AI can be used for accounting, forecasting, and reducing carbon emissions.
- **Kinjani's African Climate Talent Accelerator:** Microsoft has established a strategic partnership with Kinjani's African Climate Talent Accelerator to empower entrepreneurs and science-driven innovators.[141] This collaboration aims to enhance skills, expand networks, and provide entrepreneurial and engineering assistance to develop talent in critical sectors. The inaugural cohort comprised 29 African founders, 55% of whom were female, and resulted in 11 new companies being built. Their focus areas include carbon removal and avoidance in industries such as food systems, critical minerals, materials, and urbanization.

Looking ahead

The opportunity is clear: AI can accelerate the transition to a net-zero, climate-resilient, and nature-positive world.

However, realizing the full potential of these capabilities requires not only advancing AI but also fostering the conditions for its effective, responsible, and widespread development and deployment—spanning investments, data and infrastructure, resource use and supply, policies and governance, and capacity-building.

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Continued investment and innovation are needed across each of the five plays in our *Accelerating Sustainability with AI* playbook. Each play is a critical role for fully unlocking AI's ability to drive sustainability progress at unprecedented speed and scale.

Partnerships are central to this vision of innovation and Microsoft is continuing to collaborate with researchers to accelerate breakthroughs in sustainability solutions for energy, agriculture, and many other sectors. We are partnering with governments and nonprofits to help close data gaps and build infrastructure to support inclusive AI-enabled solutions. Collaborations with educational institutions and entrepreneurial organizations are helping to equip the workforce with the skills and knowledge needed to use AI for sustainability. These efforts demonstrate the power of partnership in advancing progress, though much more remains to be done.

As the new AI economy unfolds, large-scale societal transformations will reshape industries, economies, and communities, offering immense potential to drive sustainability progress through innovation. AI can continue to be a powerful tool for progress but AI's impact on sustainability will depend on a range of social, economic, and technological shifts. This uncertainty underscores the need to develop robust forecasting scenarios to guide progress. Evidence-based scenarios offer structured pathways to explore how innovation for and with AI will influence the global sustainability path—helping to assess trade-offs, anticipate challenges, and inform strategic decisions. By aligning efforts and prioritizing actions based on scenarios that lead to positive outcomes, stakeholders can ensure that AI innovation accelerates sustainability in impactful and equitable ways.

By fostering innovation and collaboration, together we can unlock AI's full potential to create a more resilient, equitable, and sustainable future.

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