Google

Environmental Report

2023

What's inside

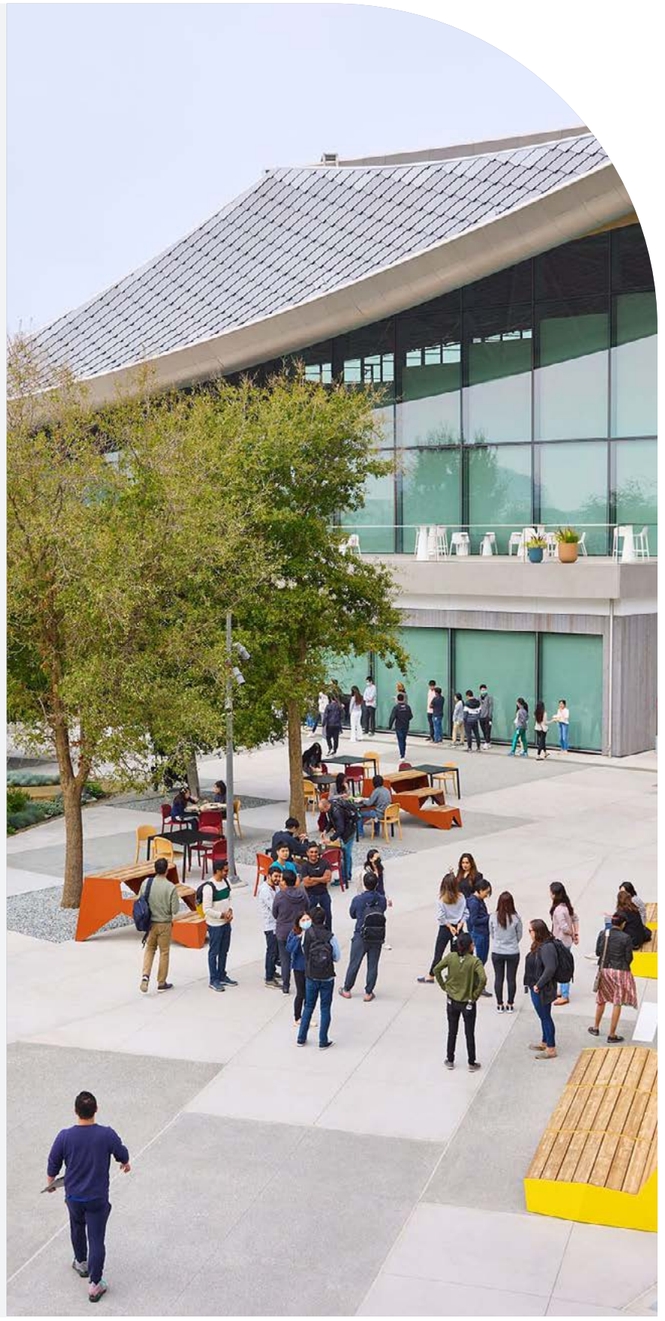
About this report

Google's 2023 Environmental Report provides an overview of our environmental sustainability strategy and targets and our annual progress towards them.[1] This report features data, performance highlights, and progress against our targets from our 2022 fiscal year (January 1 to December 31, 2022). It also mentions some notable achievements from the first half of 2023. After two years of condensed reporting, we're sharing a deeper dive into our approach in one place.

ADDITIONAL RESOURCES

- 2023 Environmental Report: Executive Summary
- Sustainability.google
- Sustainability reports
- Sustainability blog
- Our commitments
- Alphabet environmental, social, and governance (ESG)
- About Google

Introduction



Executive letters

A letter from our Senior Vice President of Learning and Sustainability

I was introduced to the problem of climate change in the late 1980s through a prescient class I took as an undergraduate. The models were less sophisticated and more uncertain than they are today, but the implications were already worrying. Thirty years later much has changed. The threat is now more immediate, but the world is also taking action—from governmental policy and technology innovation to actions by individuals and organizations—driven by a broader awareness of the danger.

I worked on Search for 20 years, leading the product for many of those, and learned a lot about the unique impact Google can have on the world. I've always been proud of Google's leadership in pushing the boundaries of sustainability in our data centers, including achieving carbon neutrality in 2007 (at the time, such accomplishments were uncommon). Going further, we've matched 100% of our global electricity use with renewable energy purchases for the last six years—a goal that seemed almost crazy when we set it in 2012.

Today our ambitions have evolved—we now have a bold goal to achieve net-zero emissions across all of our operations and value chain, and as part of that goal, to run on 24/7 carbon-free energy on every grid where we operate. The path to get to these goals is difficult, and we're committed to working through the challenges we face with the ultimate aim of driving larger systems change to create a more sustainable future. Further, predicting the future growth of energy use and emissions from AI compute in our data centers is difficult. Despite this, we remain focused on developing new ways to make AI computing more efficient while leveraging the opportunities that AI presents to have a positive environmental impact.

Beyond our own footprint, Google's founding mission—"Organize the world's information and make it universally accessible and useful"—can play a very important role in accelerating progress in climate information and action. A sustainable future will be built upon billions of decisions made by governments, organizations, and individuals, which will need to be grounded in good information. Increasingly, we see through Google Trends that more and more people are looking for ways to live sustainably. I believe that we have many strengths and capabilities in providing quality information that people are seeking to make decisions that'll drive positive action for our planet.

Helpful **information** can be critical in both efforts to reduce emissions as well as adapt to extreme climate events like floods, wildfires, and heat waves. But this information often lives in silos and is hard to access. Making the information accessible and useful can be a tough technical challenge. Our products like Environmental Insights Explorer, Earth Engine, and Data Commons are key solutions to support the decisions that cities and organizations will have to make. Information can also have a significant impact on the decisions of individuals—particularly in the areas of home energy and transportation. Our products like Maps, Search, and Nest reach billions of users around the world, and we're building many features to respond to the demand for that information in our products.

Given the scale of the problem, **innovation** will also be key to getting us to a better future. In order to push the frontiers of innovation, Google has long had a world-class research organization that's been at the forefront of AI and machine learning. These solutions can help in predicting more extreme weather (flood forecasting, for instance), optimizing systems from traffic lights to car routes, and mitigating climate change in new ways, for example.

> **By making information accessible and accelerating innovation, we can help create a more sustainable future.**

In our 2023 Environmental Report, we're highlighting how these themes of information and innovation run through much of our work:

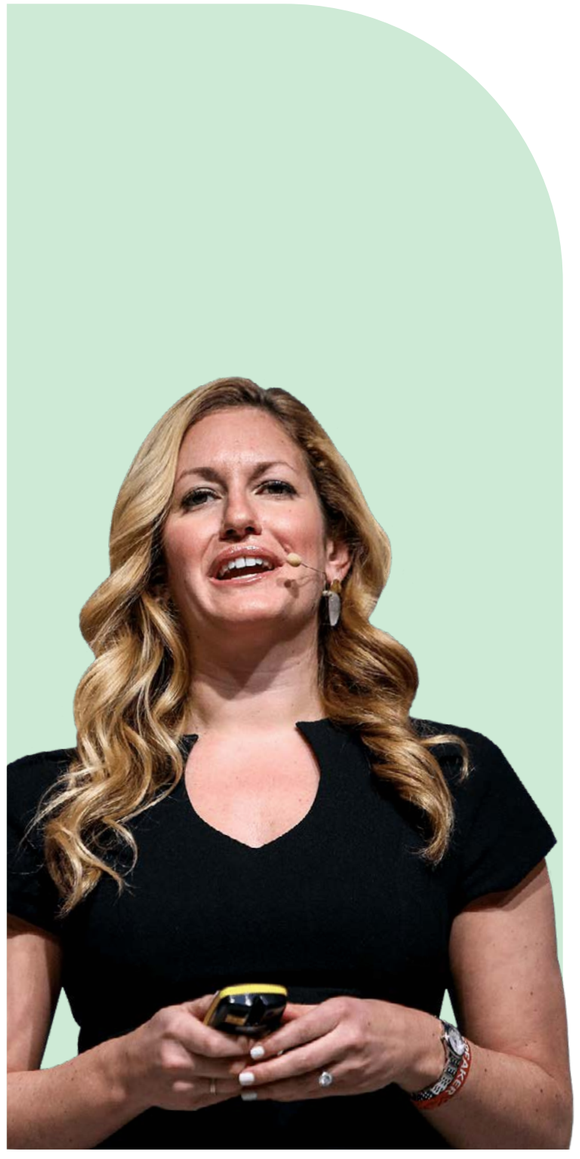
- For information, we'll feature Google Trends insights alongside key initiatives to show how our work is informed by societal trends and expectations.
- And for innovation, we'll call out the many places where AI is helping to break down barriers and advance our work.

Over my tenure at Google, I've seen how we've been working to integrate sustainability into our work. This transition is going to be challenging—both for us and for the world at large—and there's no playbook for making it happen. But we see our efforts as part of a bigger picture, setting our goals to help scale global solutions, and I'm optimistic that we can, through our efforts in both information and innovation, play a helpful role in building a more sustainable and resilient future.

Benedict Gomes

Benedict Gomes
SVP, Learning & Sustainability
Google

A letter from our Chief Sustainability Officer



I grew up in Muir Beach, California, and was fortunate to spend my childhood exploring its beautiful redwood forests and vibrant tidepools with my family. Today, I'm raising my daughter in these same special places, but now these delicate ecosystems are threatened, just like many other parts of the world.

Climate change affects all aspects of society, from food production and human health to infrastructure and the economy. These impacts are interconnected and can have a cascading effect on people and the planet. The response calls for systemic, global action to reduce emissions, improve watershed health, maximize the reuse of finite resources, and protect biodiversity.

Since Google was founded, our efforts to mitigate climate change have started with our own operations, and we've worked hard to lead by example with the ultimate goal of driving larger systemic change. In our third decade of climate action, we'll continue to take a science-based approach to our efforts, while sharing our own lessons and progress with others.

I joined Google eight years ago to lead our sustainability efforts, and have witnessed our sense of urgency and ambition firsthand. We're empowering individuals, governments, businesses, and other organizations to make decisions that can drive positive action for people and our planet.

The opportunity we have through our products and platforms is reflected in our updated environmental sustainability strategy, which focuses on where we can make the most significant positive impact. Our work is organized around three key pillars: empowering individuals to take action, working together with our partners and customers, and operating our business sustainably.

In 2022, we reached our goal to help 1 billion people make more sustainable choices through our products. We achieved this by offering sustainability features like eco-friendly routing in Google Maps, energy efficiency features in Google Nest thermostats, and carbon emissions information in Google Flights. Looking ahead, our aspiration is to help individuals, cities, and other partners collectively reduce 1 gigaton of their carbon equivalent emissions annually by 2030.[2]

After two years of condensed reporting, we're sharing a deeper dive into our approach in one place in our 2023 Environmental Report. In 2022, we continued to make measurable progress in many key ways, such as:

- We enhanced and launched **new sustainability product features**, such as eco-friendly routing in Maps, which is estimated to have helped prevent more than 1.2 million metric tons of carbon emissions from launch through 2022—equivalent to taking approximately 250,000 fuel-based cars off the road for a year.[3]
- We expanded the availability of **Google Earth Engine**—which provides access to reliable, up-to-date insights on how our planet is changing—to include businesses and governments worldwide as an enterprise-grade service through Google Cloud.

> **In 2022, we signed contracts for approximately 2.8 GW of clean energy generation capacity—more than in any prior year.**

- We opened our new **Bay View campus**, which is all-electric, net water-positive, restores over 17 acres of high-value nature, and incorporates the leading principles of circular design.
- We signed 20 more **renewable energy agreements**, bringing our total to more than 80 agreements totaling approximately 10 GW of clean energy generation capacity—we estimate we'll spend approximately $10 billion to purchase clean energy through 2040.[4]

We expect this new era of technological innovation to open up even greater opportunities to accelerate system-level change. It's a big part of the reason we're optimistic about what's possible in the years ahead. If we move forward collectively and decisively, there's no limit to what we can achieve.

Kate E. Brandt

Kate E. Brandt
Chief Sustainability Officer
Google

Highlights

This section provides a snapshot of our highlights as of the end of 2022, and select highlights from the first half of 2023. For a more complete overview of our performance over time, see the Targets and progress summary section and our Environmental data tables.

Empowering individuals

1 billion users

Our core products helped more than 1 billion **users** make more sustainable choices in 2022

1.2 million metric tons

of estimated carbon emissions reductions enabled by **Google Maps** eco-friendly routing as of the end of 2022—equivalent to taking approximately 250,000 fuel-based cars off the road for a year[5]

113 billion kWh

of energy cumulatively saved by customers using **Nest thermostats** from 2011 to 2022[6]—more than double Portugal's annual electricity consumption[7] and equivalent to preventing an estimated 36 million tCO_2e emissions[8]

99% of itineraries

on **Google Flights** included carbon emissions estimates

Working together

40,000+ cities

Environmental Insights Explorer made actionable climate data available to more than 40,000 **cities** and provided Tree Canopy Insights to more than 350 cities

400 startups

supported by our **Startups** for Sustainable Development program in over 60 countries, and global **researchers**, **academics**, and **NGOs** supported with climate- and nature-related data and analytics

80 countries

are included in our Flood Hub platform, covering 460 million **people** globally, and real-time wildfire boundaries in Search and Maps are available in cities around the world

100s of sources

of sustainability data, from most OECD **countries**, aggregated by Data Commons—making data more accessible and useful for addressing sustainability challenges

Operating sustainably

10+ GW

of **clean energy** generation capacity from more than 80 signed agreements from 2010 to 2022—the equivalent capacity of more than 31 million solar panels

271 million gallons

of **water** replenished as of the end of 2022—equivalent to more than 400 Olympic-sized swimming pools

100%

of Pixel, Nest, and Chromecast devices launched in 2022 include recycled **materials**[9]

44 acres

of native **habitat** restored on our Bay Area campuses as of the end of 2022

Our sustainability strategy

We believe Google has a unique opportunity that extends beyond managing the environmental impacts of our own operations and value chain.

By making information accessible and by driving innovation forward through our products and platforms that billions of people engage with every day, we're helping individuals, businesses, and other organizations make decisions that can drive positive action for people and our planet. In shaping our strategy, we consider where we can make the most significant positive impact. Our work is focused on three key pillars: empowering individuals to take action, working together with our partners and customers, and operating our business sustainably.

Information and innovation

We're helping to lead the transition to a more sustainable future by making information accessible and by driving innovation forward.

Empowering individuals to take action

We're empowering people with the information they're seeking to help make more sustainable choices in their everyday lives.

Learn more in the **Empowering individuals** section

Working together with our partners and customers

We're helping partners and customers to reduce their emissions and achieve sustainability goals by advancing transformative technology for sustainability and climate action.

Learn more in the **Working together** section

Operating our business sustainably

We're building on our legacy of sustainability leadership by accelerating the transition to a net-zero carbon future, advancing water stewardship, building a circular economy, and protecting nature and biodiversity.

Learn more in the **Operating sustainably** section

Targets and progress summary

		Topic	Target	Unit	2021	2022	Target year	Status
Product impact		Products	**Help 1 billion people make more sustainable choices through our products by 2022**	Users	N/A	**More than 1 billion**[10]	2022	Achieved (see pg. 14)
Operational targets	**Net-zero carbon**		**Achieve net-zero emissions across all of our operations and value chain by 2030**					
		Carbon reduction	**Reduce 50% of our combined Scope 1, 2 (market-based), and 3 absolute emissions (versus our 2019 baseline) before 2030**	tCO_2e emissions	N/A	**10.2 million**[11]	before 2030	Ongoing (see pg. 36)
		Carbon-free energy	**Run on 24/7 carbon-free energy on every grid where we operate by 2030**	% carbon-free energy	66%	**64%**[12]	2030	Ongoing (see pg. 43)
	Water stewardship		**Replenish more water than we consume and help improve water quality and ecosystem health in the communities where we operate**					
		Water replenishment	**Replenish 120% of the freshwater volume we consume, on average, across our offices and data centers by 2030**	% freshwater replenished	N/A	**6%**	2030	Ongoing (see pg. 52)
	Circular economy		**Maximize the reuse of finite resources across our operations, products, and supply chains**					
		Data centers	**Achieve Zero Waste to Landfill for our global data center operations**	% of data centers at Zero Waste to Landfill	30%	**38%**	N/A	Ongoing (see pg. 57)
		Offices	**Divert all food waste from landfill by 2025**	% food waste diverted	N/A	**85%**	2025	Ongoing (see pg. 60)
		Consumer hardware products	**Use recycled or renewable material in at least 50% of plastic used across our consumer hardware product portfolio by 2025**	% recycled/ renewable material	36%	**41%**	2025	Ongoing (see pg. 62)
			Make product packaging 100% plastic-free by 2025	% plastic-free packaging	97%	**96%**	2025	Ongoing (see pg. 63)
		Supply chain	**Achieve UL 2799 Zero Waste to Landfill certification at all final assembly consumer hardware manufacturing sites by 2022**	% of sites certified	9%	**90%**	2022	Significant progress (see pg. 65)

Emerging opportunities

As the world becomes increasingly aware of the need for sustainability, individuals, businesses, and communities are looking for new ways to reduce their environmental impact. Artificial intelligence (AI) and the power of information to help individuals and organizations reduce emissions are two emerging opportunities that Google is focusing on to help build a more sustainable future.

AI for sustainability

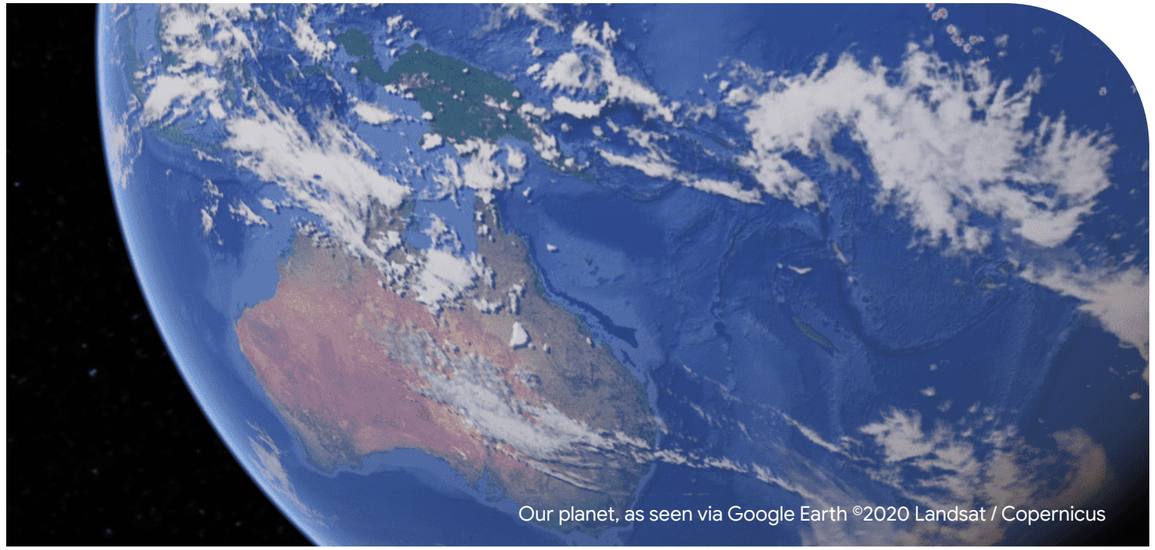
Seven years into our journey as an AI-first company, we've made AI foundational to every part of our business and all Google products. Our approach to AI must be both bold and responsible. To us, that means developing AI in a way that maximizes the positive benefits to society while addressing the challenges, guided by our AI Principles.

We can use AI to help accelerate solutions to tackle climate change by providing better **information** to individuals, operational **optimization** for organizations, and improved **prediction** and forecasting. We must also continue to find ways to reduce the **environmental footprint** of AI models.

Information: Empowering people to live more sustainably through AI. In 2022, searches for "solar energy," "electric bicycles," and "electric cars" reached all-time highs.[13] People are interested in how to live more sustainably, and our goal is to make it easier for them to do so. Features like eco-friendly routing in Google Maps leverage AI to help people get to their destinations as quickly as possible while minimizing fuel or battery consumption. Eco-friendly routing has helped prevent 1.2 million metric tons of estimated carbon emissions since launch—equivalent to taking approximately 250,000 fuel-based cars off the road for a year.[14]

Additionally, for over a decade, our Nest Learning Thermostats have used machine learning (ML) to help people save energy and money at home. From 2011 to 2022, Nest thermostats have helped customers cumulatively save more than 113 billion kWh of energy[15]—more than double Portugal's annual electricity consumption[16] and equivalent to avoiding an estimated 36 million tCO_2e emissions.[17]

Optimization: Bringing carbon-efficient computing to customers and partners. We've made significant investments in cleaner cloud computing by making our data centers some of the most efficient in the world and sourcing more carbon-free energy. We're helping our customers make real-time decisions to reduce emissions, and mitigate climate risks with data and AI. For example, Google Cloud customers can reduce their cloud footprint with a feature called Active Assist, which uses machine learning to identify unused (and potentially wasteful) workloads that could reduce carbon emissions if removed.



Our planet, as seen via Google Earth ©2020 Landsat / Copernicus

We believe that AI is a foundational and transformational technology that will provide compelling and helpful benefits to people and society through its capacity to assist, complement, empower, and inspire people in almost every field of human endeavor. It has the potential to contribute to tackling some of society's most pressing challenges and opportunities—among these, climate and sustainability, where we're researching and innovating to help unlock scientific discoveries and to assist people in making informed choices and communities impacted by climate change.

We believe that getting AI right—which to us involves innovating and delivering widely accessible benefits to people and society, while mitigating its risks—must be a collective effort involving us and others, including researchers, developers, users (individuals, businesses, and other organizations), governments, regulators, and citizens. It's critical that we collectively earn public trust if AI is to deliver on its potential for people and society. As a company, we embrace the opportunity to work with others to get AI right.

James Manyika
SVP, Research, Technology, & Society
Google

> We're making advancements in many transformative areas of AI, but I'm particularly excited about AI for Social Good, including climate adaptation. AI has great potential to both reduce overall emissions as well as help us address the effects of climate change, including helping people adapt to new challenges.
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> **Jeff Dean**
> Chief Scientist
> Google DeepMind and
> Google Research

Optimization: Helping communities with AI-powered climate action planning. Green Light is an AI-based tool that helps city traffic engineers optimize the timing of light changes to reduce stop-and-go traffic. Our recent tests in Hamburg, Germany, showed that at traffic lights with our AI-driven recommendations, cars made over 25% fewer stops, resulting in approximately 10% fewer emissions.[18] The Environmental Insights Explorer (EIE) is a freely available online tool built with and for cities and regions to support effective climate action planning. Many features in EIE are made possible through machine learning, such as estimating the solar potential of rooftops, calculating transportation emissions, and mapping tree canopy coverage.

Prediction: Using AI to help communities address extreme weather events. AI-powered tools can help address some of the worst impacts of climate-related disasters, from early warnings of natural disasters to reducing the impact of wildfires. In 2022, we launched Flood Hub, which allows local governments and aid organizations to identify when a riverine flood will occur, up to seven days in advance. In early 2023, we expanded this tool from 20 to 80 countries across the globe. By using AI to analyze satellite imagery, we're also helping to enable rapid detection when a wildfire starts and to predict how it will spread, enabling authorities to better manage fires and provide emergency alerts to individuals who are at risk.

Prediction: Using AI to predict locust outbreaks, helping farmers protect their crops. Locust infestations can have a devastating effect on food crops. Through collaborations with AI product-focused company InstaDeep and the Food and Agriculture Organization (FAO) of the United Nations, the Google AI Center in Ghana is building a model that forecasts locust breeding grounds using historical data from the FAO and environmental variables like rainfall and temperature. This model will help to better detect locust outbreaks and enable farmers to implement control measures.

Prediction: Using generative modeling for nowcasting rain. We're using generative modeling to make detailed and plausible predictions, up to two hours ahead, that capture the amount, timing, and location of rainfall. With such methods, we can both accurately capture large-scale events, while also generating alternative rain scenarios. We're interested in the ability of these models to make predictions on medium- to heavy-rain events, which most impact people and the economy.

Environmental footprint: Leveraging AI to optimize our own operations, and working to reduce energy use and emissions from AI computing in our data centers. AI and machine learning workloads are quickly becoming larger and more capable, raising concerns about their energy use and their impact on the environment.

With AI at an inflection point, predicting the future growth of energy use and emissions from AI compute in our data centers is challenging. Historically, research has shown that as AI/ML compute demand has gone up, the energy needed to power this technology has increased at a much slower rate than many forecasts predicted. We have used tested practices to reduce the carbon footprint of workloads by large margins; together these principles have reduced the energy of training a model by up to 100x and emissions by up to 1,000x. We plan to continue applying these tested practices and to keep developing new ways to make AI computing more efficient.

Google data centers are designed, built, and operated to maximize efficiency—even as computing demand grows. On average, a Google-owned and -operated data center is more than 1.5 times as energy efficient as a typical enterprise data center[19] and, compared with five years ago, we now deliver approximately three times as much computing power with the same amount of electrical power.[20] To support the next generation of fundamental advances in AI, our latest TPU v4 is proven to be one of the fastest, most efficient, and most sustainable ML infrastructure hubs in the world.

We're excited about the progress we've already made in developing more sustainable tools and products that harness the power of AI, and we're optimistic about the progress we'll unlock in the years ahead.

> AI is one of the most transformational technologies of our time. I believe it has the potential to unlock major benefits for us all, including tackling climate change. At Google DeepMind, we're committed to driving responsible research that can make a positive and lasting impact on society. I'm hopeful AI will accelerate scientific progress and help us address a number of global challenges to leave the world a better place for the generations that follow.
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> **Lila Ibrahim**
> Chief Operating Officer
> Google DeepMind

A row of servers in our St. Ghislain, Belgium, data center