Google

Environmental Report

2025

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Introduction

Foreword

At Google, we're applying AI to transform how people engage with information across our core products and platforms, to enhance business and economic growth, to enable scientific breakthroughs, and to drive sustainable innovation for society. We're proud to release our tenth annual Environmental Report, which details how we're working to address the increased energy demands of AI to enable this positive impact, while also showcasing how AI can be used to build a more energy-efficient and resilient world. These three topics—energy, AI, and resilience—are the key themes of this year's report. **Within these pages, we detail our 2024 progress, offering our perspective and insights from a year marked by unprecedented global change driven by AI, energy demand, policy, and more.**

Energy

We reduced our data center energy emissions by 12%, even with growing energy demands.

Reliable and abundant energy can help power global prosperity and expand economic opportunity. This requires bringing more energy online, optimizing how we use it, advancing new energy solutions, and partnering with suppliers as they make progress toward clean energy. At Google, through a combination of these efforts, we reduced our data center energy emissions [1] by 12% in 2024—even in the face of increased energy demands—while building for the future through new advanced energy innovations and deeper supplier engagement.

We added new clean energy generation by signing contracts for 8 GW and bringing 2.5 GW online in 2024 alone.
Google's work to accelerate clean energy began in 2010 when we signed our first power purchase agreement (PPA). Since then, from 2010 to 2024, we've signed more than 170 agreements to purchase over 22 GW of clean energy generation,[2] similar to Portugal's total renewable energy in 2024.[3] In 2024 alone, Google signed contracts to purchase over 8 GW of additional clean energy generation [4]—the largest annual total in our history and twice the volume we contracted for the prior year. We've maintained a 100% renewable energy match on a global basis every year since 2017,[5] and are going even further by pursuing our 24/7 carbon-free energy (CFE) ambition (one of our climate moonshots). In 2024, we increased our 24/7 CFE percentage from 64% to 66%,[6] and nine out of 20 grid regions with Google-owned and -operated data centers achieved at least 80% CFE.

We innovated across hardware and software to enable our data centers to deliver six times more computing power per unit of electricity than they did just five years ago.
We want to use energy in the most efficient way possible—which is good for both our business and the planet. Google data centers—which power all of our products including Search, YouTube, Google Cloud, Gemini, and more—are some of the most efficient in the world. They deliver over six times more computing power per unit of electricity than they did just five years ago. [7] This is in part thanks to pioneering hardware innovations. As just one example, Google's seventh-generation Tensor Processing Unit (TPU), Ironwood, is nearly 30 times more power efficient than our first Cloud TPU from 2018.[8]

We pushed the frontiers of advanced energy development and grid optimization to ensure reliable, abundant power for everyone, and to fuel the next wave of innovation and economic growth.
Google signed a first-of-a-kind partnership to unlock new, clean power from a series of small modular nuclear

reactors, which will be developed by Kairos Power. We also partnered with a clean energy startup to develop a geothermal power project in Nevada that's now contributing carbon-free energy to the electric grid. And a collaboration between Google, Tapestry, and grid operator PJM aims to develop AI-driven data capabilities for a smarter, more reliable electricity system. It'll also speed up grid interconnection—with the goal of making electricity more reliable and affordable for the 67 million people PJM serves in the United States.

We worked with our suppliers to accelerate their path to 100% clean electricity.
While we're encouraged by our operational progress, obstacles to decarbonizing our supply chain remain.[9] Bringing new clean energy online for Google and our suppliers is particularly difficult in the Asia-Pacific region, where wind and solar resources aren't readily accessible in many markets. And though we've announced long-term agreements for new clean energy in the region for our own operations, our suppliers face similar hurdles in obtaining these resources.

To help address these challenges, the Google Clean Energy Addendum (CEA) has become central to our work with suppliers. This agreement asks them to commit to a 100% clean electricity match for the electricity they use to manufacture Google products.[10] Many key suppliers have signed our CEA as of the end of 2024. Building on this progress, in 2025 we collaborated directly with a major hardware supplier in Japan to transition its Google product production to be matched with 100% clean electricity. We're continuing to invest to accelerate clean energy in Asia Pacific and working to offer clean energy from our BlackRock partnership to semiconductor suppliers and manufacturers in the region.

We made progress toward our climate moonshots, which require broader change.
While we remain committed to our climate moonshots, it's become clear that achieving them is now more complex and challenging across every level. Even though we've successfully reduced our data center energy emissions, supply chain emissions have risen. Additional external factors—largely outside our direct control—are converging to create significant uncertainty, including the slower-than-needed deployment of CFE technologies, AI's energy demands, policy uncertainties, resource-challenged markets, and more.

AI products

Our products enabled others to reduce 26 million tCO_2e emissions.

AI isn't just a tool—it's a catalyst. It's helping people make smarter decisions faster, and its potential to help manage emissions in key sectors—like transportation and energy—is transformational. With this in mind, we've set an aspiration to help individuals, cities, and other partners collectively reduce 1 gigaton (GT) of their carbon equivalent emissions annually by 2030.

In 2024 alone, just five of Google's products—Nest thermostats, Google Earth Pro, Solar API, fuel-efficient routing in Google Maps, and Green Light (which represent only a subset of our efforts)—enabled others to collectively reduce an estimated 26 million metric tons of greenhouse gas emissions (tCO_2e),[11] roughly equivalent to the emissions from the annual energy use of over 3.5 million U.S. homes.[12] For context, Google's total emissions in 2024 were 11.5 million tCO_2e.[13]

In energy, three products enabled others to reduce approximately 24 million tCO_2e emissions.
We estimate that our Nest thermostats helped customers cumulatively save more than 162 billion kWh of energy from 2011 to 2024,[14] which is more than the total annual electricity consumption of Poland in 2023.[15] Google Earth Pro helps solar and wind developers accelerate clean energy project development by evaluating potential sites and streamlining site design and construction estimates. And, on an annual

accounting basis, we estimate that 0.6 million metric tons of GHG emissions reductions were enabled by solar panels installed by our partners using the Solar API in the United States in 2024.[16]

In transportation, two products enabled others to reduce over 2 million tCO_2e emissions.
We estimate that our AI-powered fuel-efficient routing in Google Maps saved users fuel and cumulatively enabled more than 2.7 million metric tons of GHG emissions reductions in 2024 alone[17]—that's equivalent to taking approximately 630,000 gasoline-powered cars off the road for a year.[18] Google researchers also built Green Light, an AI-based tool that helps city traffic engineers optimize the timing of traffic lights, which has shown the potential to reduce stops at intersections by up to 30% and reduce emissions at intersections by an average of over 10%.[19]

Resilience

Our innovative research is bolstering resilience to protect communities, save lives, and reduce damage-related costs.

Over the last ten years (2015–2024), the United States alone experienced 190 separate billion-dollar weather and climate disasters totaling $1.4 trillion in damage.[20] At Google, we're developing advanced AI-powered tools to help people prepare, adapt, recover, and build resilience in these critical moments. This means powerful and accurate forecasting of extreme events like wildfires with FireSat and floods through Google's Flood Hub, and improving global weather prediction through WeatherNext.

FireSat, with its first satellite launched in March 2025, will enhance wildfire detection and response.
FireSat is a partner-driven constellation of high-resolution multispectral satellite imagery and AI that will provide near real-time insights on wildfires, enabling faster detection and giving first responders a better understanding of a situation as it unfolds.

Flood Hub predicts riverine floods up to seven days in advance.
Google's Flood Hub displays forecasts for riverine floods around the world based on a breakthrough global hydrological AI model. It predicts floods up to seven days in advance in over 100 countries, covering territories where more than 700 million people live.[21]

WeatherNext Graph provides single, precise predictions 10 days in advance.
The WeatherNext family of AI models from Google DeepMind and Google Research produces state-of-the-art weather forecasts, learning directly from vast amounts of historical weather data to generate affordable, fast, and accurate weather prediction—often 10 to 15 days in advance.

Tools like Google Earth Engine, Global Fishing Watch, and Environmental Insights Explorer also provide valuable information for conservation, restoration, and environmental management efforts. These technologies aren't just scientific innovations—they can save lives and enable communities to recover faster in the face of disaster.

Looking ahead

We're proud of the solutions we're building, the progress we're making, and the impact we're achieving with our products and partners. We believe that by continuing to push AI innovation forward, we can help address the significant challenges facing people and the planet. This report provides more detailed information on our operations, our products, and our progress. We invite you to learn more.

2024 highlights

This section provides a snapshot of our highlights as of the end of 2024 and select highlights from the first half of 2025.

Reduced data center energy emissions by 12%

We reduced our data center energy emissions by 12%, compared to 2023. We achieved this important accomplishment despite a 27% increase in our electricity consumption, demonstrating that our operational decarbonization efforts are bearing fruit.

The Google solar field at our data center in St. Ghislain, Belgium.

Procured over 8 GW of clean energy

We signed contracts to purchase over 8 gigawatts (GW) of additional clean energy generation[23]—more than in any prior year.

Delfzijl wind farm in the Netherlands (63 MW for Google).

Partnered to enable 1 GW of solar in Taiwan

We announced a partnership with BlackRock's Climate Infrastructure business that will enable 1 GW of new solar energy in Taiwan, advancing clean energy for both the local electricity grid and our own operations.

Eliminated plastic from our product packaging

Packaging for new Google products launched and manufactured in 2024 was 100% plastic-free.[22] To help other companies create more sustainable packaging, we published our Plastic-Free Packaging Design Guide.

A fiber-based unglued packaging set.

Reached 1 billion users to inform more sustainable choices

For the past three years, we've provided information to over 1 billion users to help them make more sustainable choices annually through our products.[24]

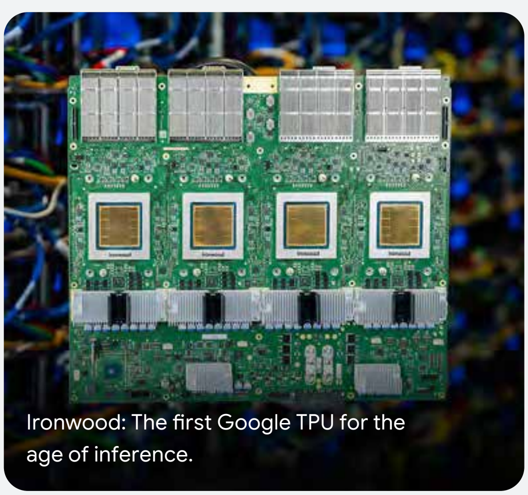
Launched the first FireSat satellite to detect wildfires

The first satellite for the FireSat constellation launched and officially made contact with Earth. This satellite is one of more than 50 in a first-of-its-kind constellation designed to use AI to detect and track wildfires as small as a garage (roughly 5x5 meters).

The launch of the first satellite for the FireSat constellation.

Improved TPU power efficiency by 30x from 2018

Ironwood—the first Google TPU designed to power thinking, inferential AI models at scale—is nearly 30 times more power efficient than our first Cloud TPU from 2018.[27]



Ironwood: The first Google TPU for the age of inference.

Replenished 64% of our freshwater consumption, up from 18%

Our water stewardship projects replenished approximately 4.5 billion gallons of water (17 billion liters or 17 million cubic meters) in 2024 alone, roughly 64% of our freshwater consumption.[25]

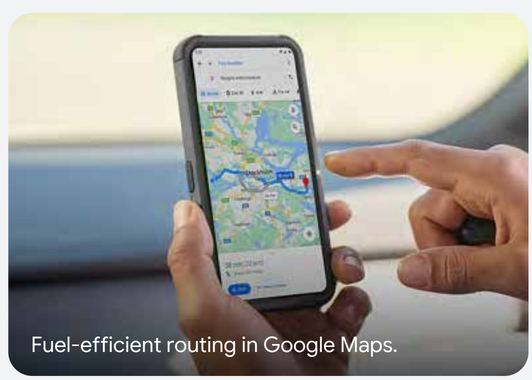
Multi-benefit floodplain restoration along the Tuolumne and San Joaquin rivers in California.

Enabled 26 million tCO_2e emissions reductions through five products

Five of our products (Nest thermostats, Google Earth Pro, Solar API, fuel-efficient routing in Google Maps, and Green Light, which represent only a subset of our efforts) enabled individuals, cities, and other partners to collectively reduce an estimated 26 million metric tons of GHG emissions.[26]

Expanded fuel-efficient routing worldwide

As of January 2025, fuel-efficient routing in Google Maps is available globally.



Fuel-efficient routing in Google Maps.

Global challenges and dependencies

Progress toward environmental ambitions requires navigating a web of interconnected challenges. Many external factors shape the pace and impact of these efforts, each demanding collaboration. Understanding these global complexities provides crucial context for our strategic approach, highlighting both where we're making progress and where significant work remains.

Growing demand for digital services

As AI and other technologies expand to unlock new economic and social benefits, the demand for digital services has grown rapidly, which in turn creates demand for data centers that require increased energy for operations and water for cooling. As a result, meeting corporate environmental ambitions isn't simply a matter of reducing today's footprint—it requires working to reduce emissions while simultaneously scaling infrastructure to meet growing demand and realize the opportunity of AI. This greatly increases the scale of the challenge.

Market barriers to sourcing carbon-free energy

Companies face a range of market barriers when working to source carbon-free energy for their operations and supply chains: constrained transmission grids, higher effective costs for clean energy, fragmented and insufficiently connected electricity grids, energy technologies in varying states of maturity, regulatory and tax considerations, and more. These challenges are particularly pronounced in certain regions like Asia Pacific and parts of the United States. Addressing these barriers will require coordinated efforts across companies, policies, and technological innovation to drive meaningful change.

Data gaps and evolving standards

Gathering accurate data on indirect emissions from supply chains remains a challenge. Further, regulations and reporting standards continue to evolve—creating complexity for companies as they work to develop and implement effective strategies. Faster reform and better alignment of climate standards would help bring consistency and comparability and drive better measurements and incentives—especially for long-term clean energy investments and supply-chain emissions reductions.

Turning corporate action into real impact on nature

The biodiversity crisis, evident in the rapid decline of species and vital habitats around the world, requires real, on-the-ground action. Translating corporate actions into positive, measurable results can be challenging—especially with the complexity of local contexts, the interconnected value-chain dependencies of sectors like consumer hardware and agriculture, and the lack of standardized metrics for tracking nature's recovery. Harnessing the analytical and predictive capabilities of AI could help untangle these complexities.

Age of AI

Age of AI

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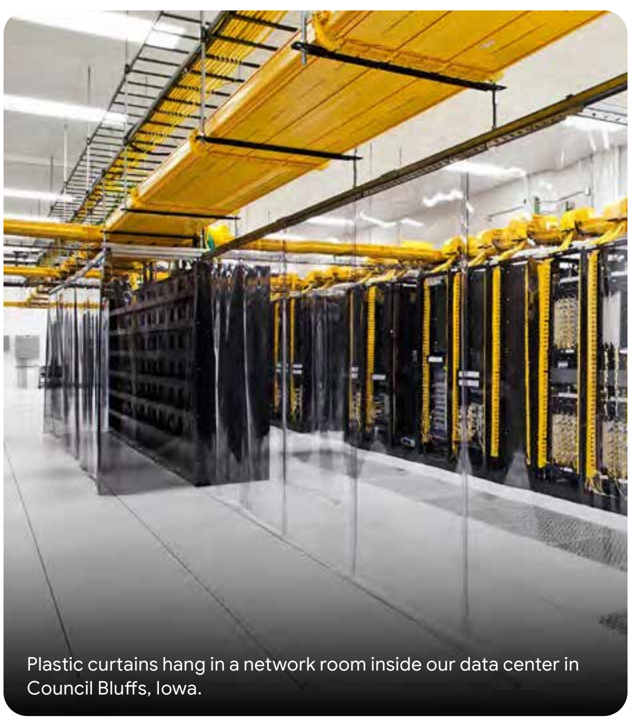
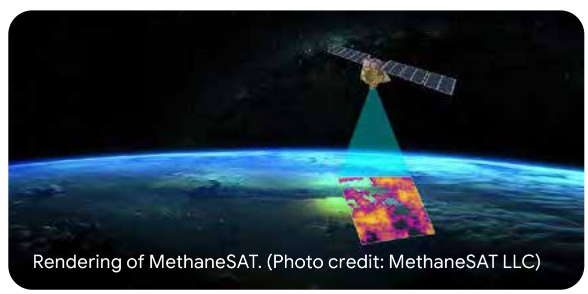
We believe the technological advancements in AI are profoundly transformational and will provide compelling and helpful benefits across four key areas: people, the economy, science, and society. These benefits stem from AI's capacity to assist, complement, empower, and inspire people in almost every field of human endeavor. AI has the potential to contribute to tackling some of society's most pressing challenges and opportunities, including serving as a crucial climate solution.

Our approach to developing and harnessing the potential of AI is grounded in Google's founding mission—to organize the world's information and make it universally accessible and useful—and is shaped by our commitment to improve the lives of as many people as possible. It's our view that AI is now, and more than ever, critical to delivering on that mission and commitment.

We take a full-stack approach to AI innovation, meaning we build and optimize every layer of the AI development process—from the physical infrastructure in our data centers and the design of our chips to the development of AI models and the products that use them. This allows us to drive efficiencies throughout the entire system, not only minimizing our environmental footprint but also making good business sense, as it enables us to develop and deploy cutting-edge AI technologies with greater speed and agility.



Plastic curtains hang in a network room inside our data center in Council Bluffs, Iowa.



Rendering of MethaneSAT. (Photo credit: MethaneSAT LLC)

Sundar Pichai, CEO of Google and Alphabet, shares Trillium—our sixth-generation TPU—at Google I/O in 2024.

Powering prosperity

The economic upside of AI and the energy required to power it

AI is fueling progress across sectors—from accelerating innovation in advanced energy technologies and optimizing grid systems to improving energy security and advancing areas like materials science and energy production forecasting. To realize its promise, AI itself needs energy to power these solutions.

Zooming out, the rise in energy consumption isn't only about AI—it's a symptom of a bigger shift happening across the globe. As the digital economy expands, so does our collective need for electricity. It's not just data centers driving this demand, we're seeing this shift everywhere: from industrial production and the electrification of industries to increasing cooling needs amid record-breaking temperatures.

The good news? Economists have long found a direct causal relationship between energy consumption and economic growth.[28] Energy is a key driver of productivity and income, not just a byproduct of expansion. Technological development drives growth and prosperity, and AI is poised to be a central driver of the next wave of expansion.

While there's a large focus on the energy consumption of data centers, they account for a relatively small portion of both current and projected electricity use. **In 2024, data centers made up just 1.5% of global electricity consumption.**[29] They're projected to account for about one-tenth of the growth in global electricity demand by 2030—a smaller share than industrial motors, air conditioning, or electric vehicles. With this growth, data centers are projected to represent only about 3% of total global electricity demand in 2030,[30] despite delivering an outsized contribution to economic growth and scientific advancement.

We realize the opportunity before us demands bold action, such as investing in infrastructure, creating smarter grids, and ramping up both mature and emerging sources of energy generation. It also means partnerships between governments and businesses to innovate faster and train a workforce capable of building the energy systems of the future.

Powering a new era of innovation

AI presents a generational opportunity for extraordinary innovation and growth. The deployment of AI will grow the economy, create jobs, accelerate scientific advances, and more.

Fully realizing these opportunities requires an effort to rapidly increase the capacity of existing, and sometimes antiquated, energy systems. This in turn requires accelerating innovation and investment in advanced energy technologies, optimizing use of the existing grid and unlocking construction of new transmission infrastructure, and developing the labor force needed to build new energy infrastructure.

In a paper titled Powering a New Era of American Innovation, we share 15 policy opportunities for the United States. Many of these proposals have been incubating in policy circles for some time. They reach across a broad base of stakeholders and are drawn from the broader discussion of policy options. Unlocking advanced electricity resources and grid infrastructure would enable all sources of electricity to contribute to a more reliable and affordable energy future—an outcome that will require constructive public and private collaboration to advance. Additionally, many of these solutions could be applied around the world to advance a more secure energy future for all.

Optimal scenario

AI's net-positive potential

AI remains at an inflection point, and many factors will influence its ultimate impact. These include the extent of AI adoption, the size of AI's energy footprint, the emergence of regulatory frameworks, and the pace of continued innovation and efficiency.

Consequently, the net impact of AI on emissions similarly depends on how these factors play out. The International Energy Agency (IEA) estimates that by 2035, widespread adoption of existing AI applications could lead to emissions reductions nearly three to five times greater than projected data center emissions.[31] Furthermore, the IEA projects that—in a scenario with broad implementation—existing AI applications could potentially reduce emissions by around 4% of global energy-related emissions in 2035 (not including any breakthrough AI discoveries that may emerge in the coming decade).[32]

In an attempt to make this potential net-positive impact a reality, our approach to AI development is twofold. We're focused on breakthrough innovation while also diligently managing the environmental impact and energy consumption of this powerful technology.

Take the Solar API as one example. In the United States alone, the Solar API supported installations in 2024 that we estimate will help enable partners to reduce around 6 million metric tons of lifetime GHG emissions (which considers emissions reductions throughout the solar installations' entire lifetime),[33] which is about 6,000 times greater than the approximately 1,000 metric tons of GHG emissions from the model's compute in 2024.[34] We're making solar installation easier, faster, and smarter—and it's working.

Visual of potential solar capacity in the Solar API.

AI efficiency gains

Improvements across models, TPUs, and infrastructure

As a company, we consider it an imperative to pursue AI responsibly—to innovate and deliver widely accessible benefits to people and society, while mitigating environmental impacts. We'll continue to optimize our models and hardware, pursue infrastructure efficiencies, and procure clean energy to minimize the overall impact and resource demands of AI.

Models

Google has long been at the forefront of AI and machine learning, evolving years of deep learning research into techniques that make training faster and more efficient—enabling models that are higher quality, faster, and less compute-intensive to serve.

We've sped up AI model training through techniques like quantization, boosting large-language model training efficiency by 39% on Cloud TPU v5e.[35] Gemini 2.5 Flash is our first fully hybrid reasoning model, giving developers the ability to turn thinking on or off. The model also allows developers to set thinking budgets to find the right tradeoff between quality, cost, and latency.

For model deployment and usage, we've improved underlying ML efficiency through pioneering techniques like blockwise parallel decoding, improved confidence-based deferral, and speculative decoding that reduce the inference times of LLMs, allowing them to generate responses more quickly. These improvements are used across Google products and set a standard throughout the industry.

Initiatives like these have led to generational model efficiency gains. For example, Google's Gemini 1.5 Pro delivers dramatic improvements and achieves comparable quality to Gemini 1.0 Ultra while using less compute.[36]

TPUs

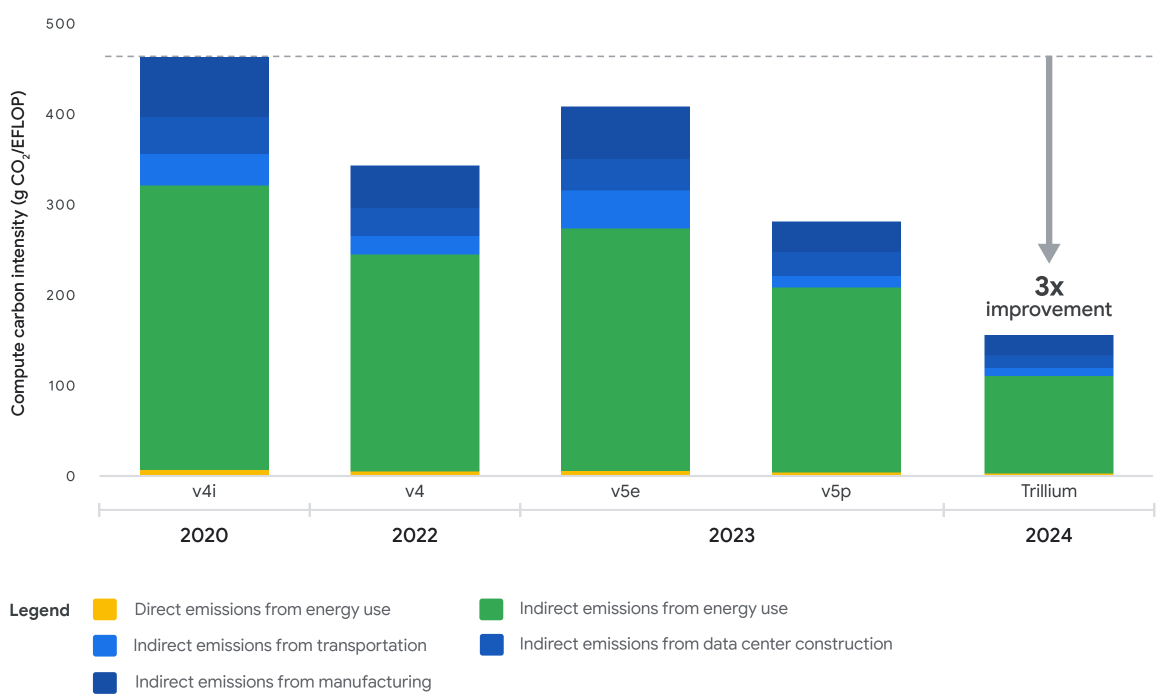
For a decade, Google's AI innovations have been powered by a range of AI accelerator options, including our own custom-built TPUs (Tensor Processing Units). They've come a long way since their first generation in 2015, evolving each generation to deliver better performance while improving their carbon compute efficiency. In early 2025, we continued this trend by building even more powerful TPUs, ensuring that our AI systems keep pushing forward—faster, smarter, and more efficient.

When it comes to powering AI, efficiency isn't just about performance—it's about using less energy to do more. Announced in April 2025, Ironwood, our seventh-generation TPU, is a game-changer. Built specifically for inference, Ironwood performance per watt is double that of Trillium, our sixth-generation TPU announced last year. **In fact, Ironwood is nearly 30 times more power efficient than our first Cloud TPU from 2018.**[37]

Trillium already delivers impressive performance—67% more energy efficient than the previous TPU v5e,[38] and it delivers 14 times more compute per watt of power compared to the first generation of Cloud TPUs.[39] And Google Axion Processors, our first custom Central Processing Unit (CPU) designed for the data center, are up to 60% more energy efficient than comparable current-generation x86-based instances.[40] Additionally, we now offer NVIDIA's next-generation Blackwell Graphics Processing Unit (GPU) to Cloud customers, which NVIDIA estimates will train large models using 75% less power than older GPUs to complete the same task[41] and are 25 times as energy efficient compared to NVIDIA H100.[42]

In 2025, we published a first-of-its-kind study on the lifetime emissions of our TPU hardware—from raw material extraction and manufacturing to energy consumption during operation. The results? **A threefold improvement in the Compute Carbon Intensity[43] of our TPU chips over four years, from TPU v4 to Trillium[44] (Figure 1).** Newer generations of TPUs like Trillium provide cutting-edge performance while generating fewer carbon emissions for the same AI workload.

Figure 1. Generational trends of AI hardware life-cycle emissions intensity show a threefold improvement over four years



Infrastructure

To help minimize our environmental footprint, we've built world-leading efficient infrastructure for the AI era. But we're taking it a step further by using AI itself to directly enhance the efficiency of our data center infrastructure.

For example, we announced AlphaEvolve, an evolutionary coding agent powered by large language models for general-purpose algorithm discovery and optimization. AlphaEvolve enhanced the efficiency of our data centers, chip design, and AI training processes—including training the large language models underlying AlphaEvolve itself.

In fact, one of AlphaEvolve's solutions to help orchestrate Google's data centers more efficiently continuously recovers, on average, 0.7% of Google's worldwide compute resources.[45] This sustained efficiency gain means that at any given moment, more tasks can be completed on the same computational footprint.

Piece of the puzzle

Situating AI in our overall electricity growth

While improving AI efficiency is critical, it's only one piece of the puzzle. A broader understanding of AI's total electricity consumption is essential for a more comprehensive picture of its footprint—and how we can effectively manage it.

A lot has changed over the past few years. We launched Gemini, our most capable and general AI model, and have rapidly integrated it across our core products and platforms. Millions of people are now using generative AI in ways they couldn't even have imagined in 2022, from enhancing daily tasks to powering new applications for developers, startups, and enterprises worldwide.

To support all our products and digital services—including AI—our total data center electricity consumption grew by 27% in 2024, compared to 17% growth in the prior year. However, it's important to note that our growing electricity needs aren't solely driven by AI. The accelerating growth of Google Cloud, continued investments in Search, the expanding reach of YouTube, and more, have also contributed to this overall growth.

We remain committed to maximizing AI's potential to advance scientific discovery, accelerate human progress, and improve lives for people everywhere. To achieve this responsibly, we'll continue to pursue model optimization, efficient infrastructure, and clean energy procurement to further drive efficiencies across AI and minimize its overall resource demands.

Wind turbines spin near our data center in Eemshaven, Netherlands.

Energy for our data centers

Energy for our data centers

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The global energy landscape has undergone a dramatic transformation over the last two decades, marked by the rapid rise of clean energy technologies. This progress, however, is now met with a new challenge: After a long period of stagnation, the world is now experiencing significant growth in electricity demand—a surge driven primarily by the electrification of transportation and industry, increased demand for air conditioning, and also the expanding computational needs of data centers.

Running the global infrastructure behind our products and services, including AI, takes considerable energy. From the beginning, we've focused intensely on how we manage our energy use—and how we can accelerate the shift to cleaner sources.

We've built a pipeline of new clean energy deals that we expect to help us stay ahead of the curve as our energy use grows. In fact, we estimate that—once operational—**the new clean energy agreements we signed in 2024 could generate nearly four times more electricity than our incremental load growth from 2023 to 2024.**[46] This proactive approach is intentional. We're aiming to not just keep up with growth, but to stay ahead of it—with 60 new clean energy agreements signed in 2024 alone.

Our strategy focuses on what we can directly control, like improving energy efficiency and procuring clean energy for our data centers. In parallel, we invest in the breakthroughs needed for the future—including next-generation energy sources like enhanced geothermal and advanced nuclear, as well as grid-enhancing technologies.

The clean energy advances we made in 2024 aren't just about megawatts or milestones. They're about building an energy future that's equipped to meet tomorrow's challenges—faster, cleaner, and more reliably than ever before.

Norther Offshore wind farm in Belgium (92 MW for Google).

Rødby solar farm in Denmark (55 MW for Google).

Scaling smarter

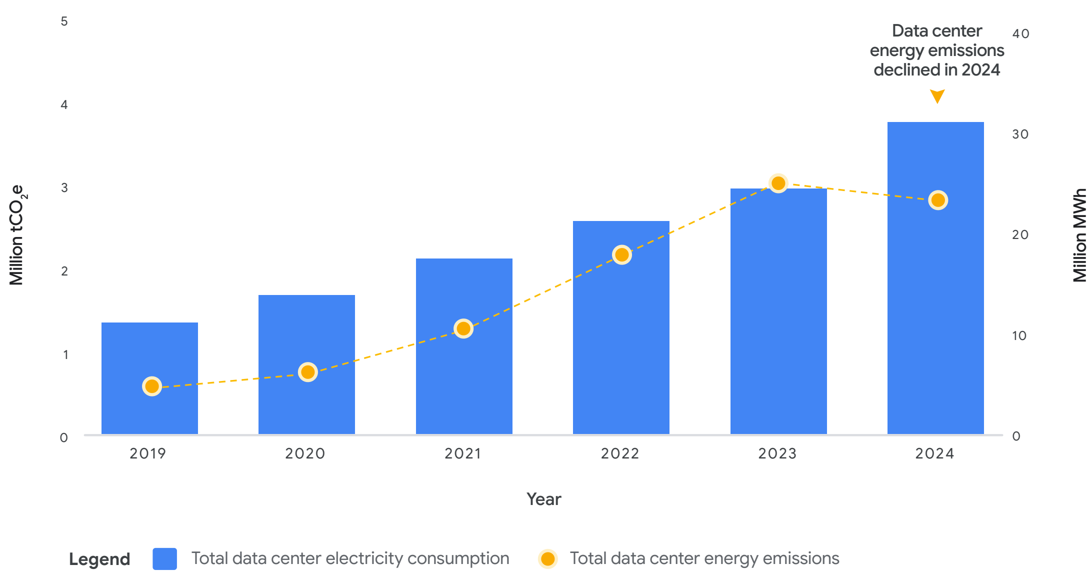
Successfully reducing our data center energy emissions

In 2024, the world's appetite for energy grew substantially faster than the average growth from the previous decade.[47] This surge highlights the increasing energy demands of our modern infrastructure, from powering homes and industries to supporting the expanding digital world and emerging technologies.

In 2024, we reduced our data center energy emissions by 12% compared to 2023 (Figure 2). We achieved this reduction despite our data center electricity consumption increasing 27% year-on-year due to the growth of our business and increasing product adoption, including AI.

That may sound counterintuitive, but we've long known that reducing the emissions from our data center energy use is about scaling smarter. For us, it's the result of more than a decade of work—and a strategy that continues to deliver real-world results.

Figure 2. Trajectory of data center electricity consumption and data center energy emissions



Clean energy procurement

We've been at this for a while: our first clean energy PPA dates back to 2010. Since then, we've scaled procurement efforts to continue to meet the demands of our growing infrastructure—and to help shift the energy systems that power it. As electricity needs have surged, particularly with the rise of AI, these long-term efforts have delivered results.

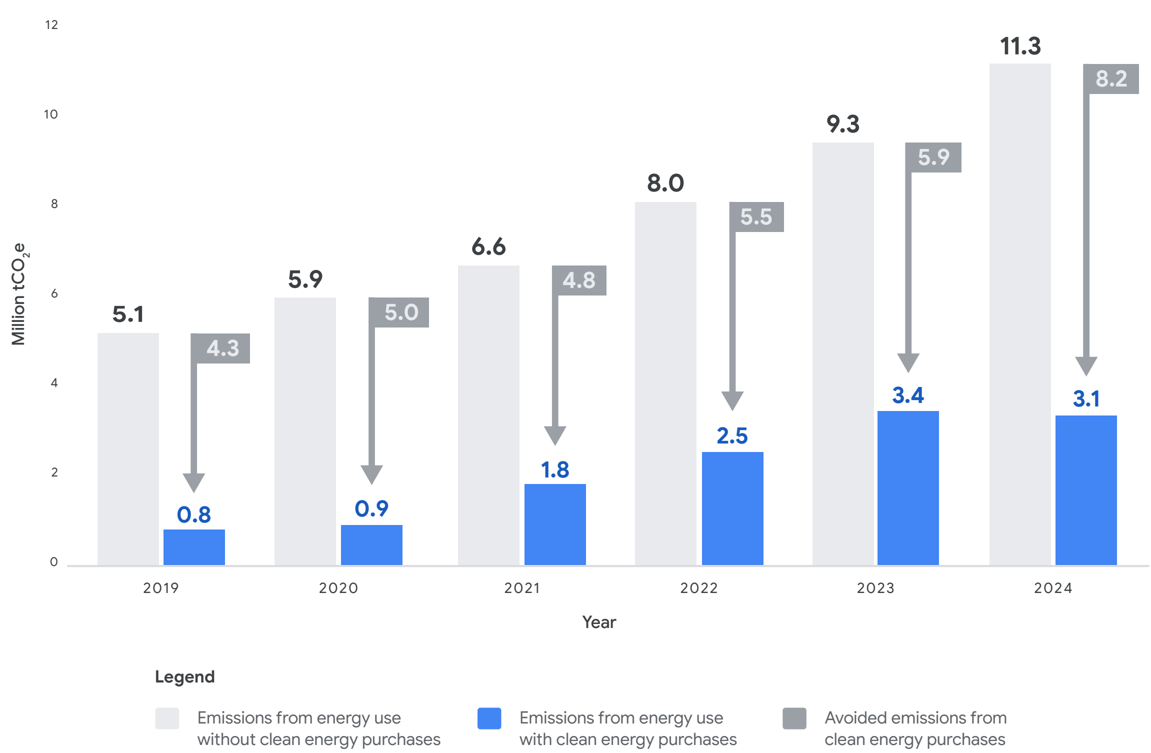
In 2024, more than 25 clean energy projects we'd contracted over the past several years—some as far back as 2019—came online. **Together, they added 2.5 GW of new clean energy to the grids that serve our operations.**

Bringing a clean energy project online requires years of planning, permitting, contracting, and construction. When a project reaches commercial operation, it's not just a milestone—it's the realization of hard work done years ago finally delivering clean electricity where it's needed.

We also continue to make progress in bringing more clean energy to our office operations. In 2024, from across 14 agreements, we allocated over 140 megawatts (MW) of clean energy generation in the electricity grids where our offices operate.[48]

By working to provide clean energy for our data centers and other operations, we're also avoiding a substantial amount of emissions. In 2024 alone, we estimate our clean energy purchases avoided more than 8.2 million tCO_2e[49] (Figure 3). **And from 2011 to 2024, we estimate our clean energy purchasing cumulatively avoided more than 44 million tCO_2e**[50]—more than the emissions from the combined annual electricity use of every home in New York State.[51]

Figure 3. Avoided emissions from clean energy purchases



There are additional clean energy factors that led to our 2024 decrease in data center energy emissions. For example, in North America—a region that accounts for the majority of our electricity consumption—we made progress sourcing clean energy from within the same regions as our data centers, helping reduce our emissions. We also benefited slightly from broader grid decarbonization: across much of the United States, the electricity on the grid became cleaner, with associated carbon emissions dropping—some by as much as 10%—between 2023 and 2024.[52] That means the electricity we consumed from those grids became less carbon-intensive, helping us further reduce emissions.

Energy efficiency

Our long-standing energy efficiency efforts are just as important as our clean energy procurement. Striving to build and operate the world's most energy-efficient data center infrastructure, as well as continuing to make our offices more energy efficient, is a core strategy for minimizing our footprint. This means pursuing ways to squeeze more out of every watt of power we consume.

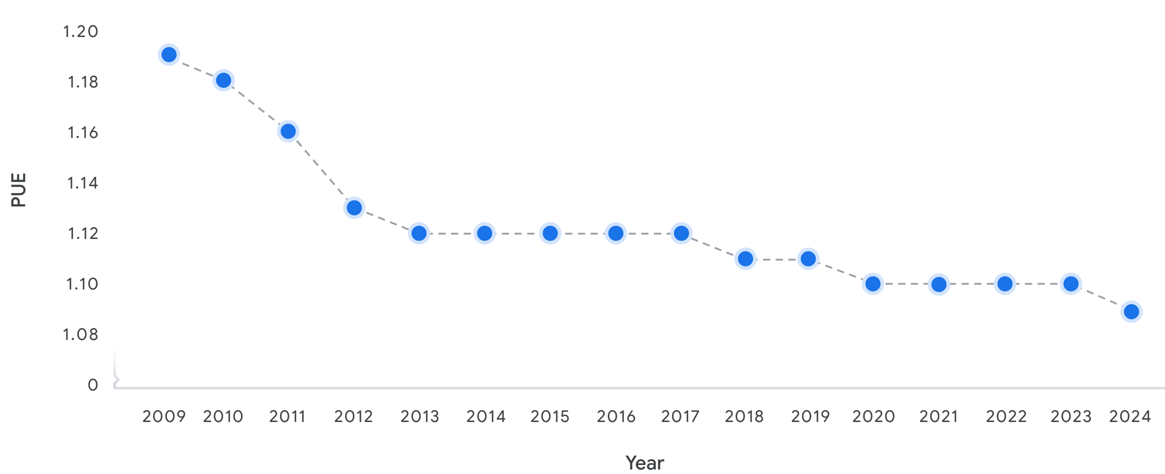
We outfit each data center with high-performance servers that are custom-designed to use as little energy as possible compared to the amount of compute they process. We continuously innovate within our facilities, implementing smart temperature and lighting controls and redesigning power distribution systems to eliminate energy loss. And our sustained efforts have paid off. **For the first time in six years, the average annual power usage effectiveness (PUE) for our global fleet of data centers dropped below 1.10 to 1.09** (Figure 4).

While a PUE improvement of 0.01 might appear small, at the scale of our global data center operations, this efficiency gain avoids significant electricity consumption. This means our global computing network requires less electricity and produces fewer emissions than it otherwise would have, yielding meaningful savings even as our overall computing demands grow.


The server floor in our data center in Hamina, Finland.

Our data centers deliver over six times more computing power per unit of electricity than they did just five years ago.[53] Much of this improvement has come from deploying AI accelerators, such as our TPUs, the highly efficient computer chips we designed specifically for AI and machine-learning applications.

Figure 4. Energy efficiency (PUE) across Google data centers



Legend Fleet-wide trailing 12-month PUE

Powering today

Our record year for clean energy

Electricity is a key input for nearly everything we do—from training AI models to providing Search results to sharing YouTube videos and more. And as our energy demands grow, in part due to the expansion of AI, so does our responsibility to meet that demand in a way that's cleaner, smarter, more reliable, and more resilient.

In 2024, we set a new record for ourselves for clean energy procurement: **we signed contracts to purchase over 8 GW of additional clean energy generation in 2024 alone**[54]—the largest annual total in our history and twice the volume we contracted for the prior year. That isn't just an achievement, it's a turning point—one that's putting us on a path toward reaching our environmental ambitions. These new energy deals will help bring new clean energy to the grids where we operate, support advanced technology deployment, and model new ways of doing business that others can follow.

22 gigawatts and counting

Google is one of the largest corporate purchasers of clean energy, and from 2010 to 2024, we signed more than 170 agreements to purchase over 22 GW of clean energy generation,[55] similar to Portugal's total renewable energy in 2024.[56] These purchases include agreements for over 17.3 GW in North America, over 4.5 GW in Europe, over 400 MW in Latin America, and over 300 MW in Asia Pacific.

In the United States, we signed new deals in Arizona, Nebraska, and across the PJM grid region in the Mid-Atlantic. In Europe, we expanded our offshore wind portfolio in the Netherlands, signed new PPAs in Italy, Poland, and Belgium, and are helping bring new onshore wind farms online across the region. In Asia Pacific, we advanced clean energy projects in Taiwan, Japan, Singapore, and India—with contract structures tailored to the unique energy and market conditions in each country. When these projects come online, they don't just help reduce our environmental impact—they also add clean power to the grids that support our operations.

Golden Hills wind farm in California (43 MW for Google).

Innovative purchasing models

Part of what made 2024 stand out wasn't just the volume of clean energy we contracted—it was the strategy behind it.

We piloted new contract structures like the Clean Transition Tariff, a utility-rate mechanism that provides for long-term investment in clean power whenever it's needed. We upscaled a new request for proposal model to reduce procurement time and accelerate PPA execution. We also entered into a front-of-meter co-location partnership in the United States where data centers and grid-connected renewable energy infrastructure are developed side by side, easing strain on transmission networks.

These moves are signals of what clean energy procurement will increasingly look like in the years ahead: more flexible, more collaborative, and more integrated with the needs of the grid. And we're doing it in ways that try to account for the real-world constraints facing today's energy markets—addressing interconnection bottlenecks, aligning procurement with utility planning cycles, and designing projects that require fewer upgrades to connect to the grid.

Investments with global impact

In addition to buying clean energy through PPAs, we're also accelerating the transition to a cleaner grid by making direct financial investments. This is about actively funding the construction of new clean energy sources that benefit everyone, contributing to a larger, more resilient clean energy ecosystem while stimulating local economic growth. **From 2010 to 2024, we entered into agreements to invest more than $3.7 billion in clean energy projects and partnerships, which are expected to produce around 6 GW of clean electricity.**[57]

For instance, we've developed an investment framework that allows us to invest in, and buy power from, a 1.5 GW portfolio of new solar projects throughout the PJM grid region. By providing both investment capital and energy offtake, these projects have a clearer path to construction.

Essentially, we're not just consumers of clean energy; we're also investing in order to create more of it, using our resources and engineering-minded approach to help these vital projects get established and scale.

Solar panels line up side-by-side at our data center in St. Ghislain, Belgium.

Powering tomorrow

Accelerating advanced energy sources

Clean energy sources that we can count on anytime and can turn on or off as needed play an important role in creating a reliable, affordable, and clean energy system that can power economic and scientific opportunity.

We're accelerating the development and deployment of next-generation energy sources—from enhanced geothermal to advanced nuclear and innovative biomass solutions—expanding energy opportunities through innovation and pushing the boundaries of what's possible.

Enhanced geothermal

Imagine tapping into the Earth's core, a virtually limitless source of heat. That's the power of geothermal energy. Traditional geothermal plants utilize naturally occurring underground reservoirs of steam or hot water, but these resources are limited to specific geological locations. Enhanced geothermal energy takes a different approach, expanding the reach of this clean power source.

Enhanced geothermal involves either engineering underground reservoirs where none existed before or enhancing production from existing ones. It's similar to creating a custom-designed plumbing system deep beneath the surface. Using advanced drilling techniques adapted from the oil and gas industry to access hot, dry rock formations, water is then injected into these formations, heated by the Earth's intense thermal energy, and circulated back to the surface to drive turbines and generate electricity. This process produces clean, consistent power with only a small land footprint and without burning fossil fuels.

Google and clean-energy startup Fervo signed the world's first corporate agreement to develop a next-generation geothermal power project.

First-of-its-kind geothermal project in Nevada

We recognized the potential of enhanced geothermal early on. **In 2021, we signed the first corporate agreement to develop a next-generation geothermal power project with Fervo Energy in Nevada.** This wasn't just a theoretical exercise; it was a real-world collaboration to prove that enhanced geothermal could deliver reliable, carbon-free energy. That project became operational in 2023, and carbon-free energy started flowing onto the local grid that serves our data centers in Nevada.

Since then, Fervo has achieved remarkable reductions in the time and cost of its drilling process, demonstrating the power of early customer demand to help drive rapid improvements to early-stage technologies. Building upon the success of our commercial pilot, in 2024, we scaled up our partnership with Fervo Energy, contracting for a larger 115 MW project through a new utility rate structure with NV Energy—the Clean Transition Tariff. This expansion signifies a shift from pilot-scale to commercial deployment and will increase the amount of enhanced geothermal generation enabled by Google by almost 25 times.

Geothermal's global potential

We're also exploring the global potential of geothermal energy. In 2024, we announced a partnership with the University of Newcastle and its research institute Newcastle Institute for Energy and Resources (NIER) to further de-risk and develop geothermal energy resources in Australia. We're also working with Project Innerspace on GeoMap, a free online tool that provides essential subsurface data and analytics for assessing geothermal potential worldwide. Think of it as providing a detailed map to help others explore this hidden energy resource.

Lastly, in early 2025, we expanded our geothermal efforts to Taiwan, through a partnership with Baseload Capital aiming to enable 10 MW of 24/7 clean power to the grid and help catalyze Taiwan's geothermal market. We're also excited about the potential to replicate these types of projects in markets across Asia Pacific, such as Japan and Indonesia, as well as other places where we have electricity demand globally.

Advanced nuclear and small modular reactors

Nuclear energy has long been a clean source of electricity, but traditional large-scale nuclear power plants can be complex and costly to build. Small modular reactors (SMRs) offer a new approach, promising a more streamlined and flexible way to harness the power of the atom.

SMRs are smaller than conventional nuclear reactors and designed to be manufactured in factories and assembled on-site. This modular design allows for faster construction, reduced costs, and greater flexibility in siting. SMRs also incorporate advanced safety features, often relying on passive safety systems that shut down the reactor automatically in case of an emergency.

In 2024, we took a major step toward supporting this next generation of nuclear technology: **we signed the world's first corporate agreement to purchase nuclear energy from multiple SMRs, which will be developed by Kairos Power.** This agreement will bring up to 500 MW of clean energy to U.S. grids by 2035—the first reactor is expected to be operational by 2030, with additional deployments through 2035.

Kairos Power's SMR design uses a molten salt cooling system and a unique ceramic pebble fuel. This system allows the reactor to operate at low pressure, simplifying the design and enhancing safety. The company is following an iterative development process, building and testing multiple demonstration units before deploying its first commercial plant. This approach allows for continuous learning and improvement, ultimately leading to a more reliable and cost-effective technology.

This agreement is important for several reasons:

- **Providing "always-on" energy:** Nuclear solutions offer a clean, round-the-clock power source that can help reliably meet electricity demands with carbon-free energy every hour of every day. Advancing these power sources in close partnership with supportive local communities will help rapidly drive the decarbonization of electricity grids around the world.
- **Supporting AI demand:** The grid needs new electricity sources to support AI technologies that are powering major scientific advances, improving services for businesses and customers, and driving national competitiveness and economic growth. This agreement helps accelerate a new technology to meet energy needs cleanly and reliably, and it unlocks the full potential of AI for everyone.
- **Benefiting the economy:** Investing in advanced nuclear technology can provide direct economic benefits to communities across the United States since nuclear power has the highest economic impact of any power generation source and creates high-paying jobs.[58] In fact, the U.S. Department of Energy estimates that reaching 200 GW of advanced nuclear capacity in the U.S. by 2050 will require an additional 375,000 workers.[59]

By procuring electricity from multiple reactors—what experts call an "orderbook" of reactors—we'll help accelerate the repeated reactor deployments that are needed to lower costs and bring Kairos Power's technology to market more quickly. This is an important part of our approach to scale the benefits of advanced technologies to more people and communities.

Turning biomass into energy

Clean energy innovation also involves finding resourceful ways to utilize existing resources. Our partnership with PacificLight Energy and Rexus Bioenergy demonstrates this approach. Together, we're supporting a "waste wood-to-energy" plant in Singapore.

This facility will convert waste wood, such as horticultural waste and wood from the logistics industry, into a renewable energy source. The plant is designed with advanced technology and is expected to be more efficient than traditional waste-to-energy facilities in Singapore.

Expected to begin commercial operations in 2026, the plant will operate continuously. It'll also include a pilot-scale carbon capture system, exploring ways to further reduce its environmental impact. This project showcases how innovative engineering can transform waste into a valuable energy source.

Our data center in Singapore lit up at night.

Flexible future

Demand response to enable smarter electricity grids

In the not-so-distant past, data centers were seen as static power users. But today, the equation is shifting, and the impact of this shift is more important than many may realize. At Google, we're reimagining our data centers as dynamic players in the broader electricity ecosystem. That means developing smarter ways to manage when and how we use power and finding new ways to work with grids.

By designing data centers that flex—to the grid, to the weather, and to times when cleaner energy is available—we can reduce the need for investment in new generation or new infrastructure, alleviate strain during peak hours, make better use of clean energy, and support overall grid reliability.

That shift matters more than ever. As electricity demand grows, especially with the rise of AI and cloud computing, grids around the world are facing increasing demands. At the same time, more clean energy is coming online—but it's not always available when and where it's needed most. Flexibility can help create a more cost-effective, reliable, efficient, cleaner grid—and we believe data centers can help deliver it.

Let's break that down a bit.

Data centers that flex

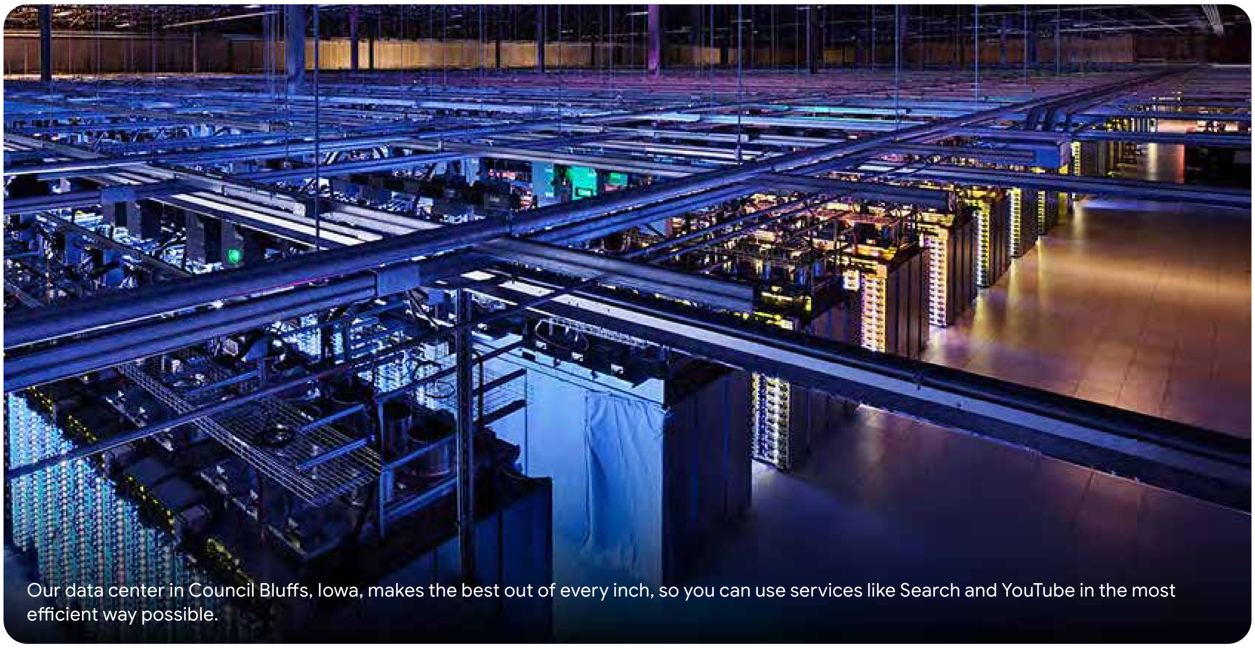
Imagine a world where computational tasks can be dynamically moved in response to the natural rhythms of the sun and wind: as solar power peaks in one region or winds strengthen in another, workloads are intelligently routed to harness these cleaner energy sources. Now imagine that this flexibility doesn't compromise the user experience, as many non-urgent compute tasks—like creating new filter features on Google Photos, processing YouTube videos, or adding new words to Google Translate—don't need to happen instantaneously. They can be strategically scheduled for off-peak hours or routed to data centers running on more readily available clean energy.

This vision isn't merely a future aspiration; much of it is current practice at Google. Developing flexible data centers means figuring out how to operate them differently—a vital evolution for a world increasingly committed to smarter energy use and enhanced resilience. At its heart, this approach is about the sophisticated alignment of our computing demands with the optimal resources, in the best locations and when it matters most.

So how do we do this? **Our carbon-intelligent computing platform shifts computing tasks across locations and times of day, based on local grid carbon intensity.** This means we're going beyond focusing on when we use energy to also considering the type of energy we're using—shifting tasks to times and places where cleaner electricity is available.

We're also collaborating with utilities and other grid partners to develop our demand response capabilities, reducing power consumption during peak periods and ramping back up when the grid can handle it. By adjusting when and where computing tasks run—based on coordinated requests from local grid partners—we can ease pressure on local grids during high-stress periods, like extreme weather events. The platform does all this while still getting everything that needs to get done, done—meaning you can keep streaming YouTube videos, uploading photos, finding directions, or whatever else.

In Belgium, we're working with our grid partners Centrica Energy and the transmission system operator Elia to integrate our demand response capability at our local data center in conjunction with the data center's


Our data center in Council Bluffs, Iowa, makes the best out of every inch, so you can use services like Search and YouTube in the most efficient way possible.

battery storage system. As a next step, we're joining the country's capacity remuneration mechanism, helping stabilize the grid by reducing power consumption at critical times. In Asia Pacific, Taiwan Power Company expressed its appreciation for our continued participation in its summer load management program, which has helped grid operators manage the power system by reducing peak electricity loads during strained summer months.

These strategies and demand response initiatives are making our computing system smarter, cleaner, and more flexible—helping to optimize how we allocate compute tasks across our infrastructure.

Collaborating for the future

We're not doing this alone. Through our partnership, Carrier plans to leverage Google Cloud's WeatherNext AI models as part of its Home Energy Management System (HEMS) to help enhance grid flexibility and enable smarter energy management. Once deployed, WeatherNext AI models are expected to help HEMS intelligently manage energy flows in real time—charging, discharging, and redirecting energy based on grid conditions, energy demands, and weather forecasts—contributing to a more balanced and sustainable energy grid.

We've also joined forces with the Electric Power Research Institute (EPRI) through the Data Center Flexibility (DCFlex) initiative. This multi-stakeholder effort brings together energy experts, utilities, and hyperscale operators to develop new tools, standards, and best practices that help make data center energy use more grid friendly.

Why it all matters

Data centers are known for their energy footprint—and as demand for digital services grows, so do their electricity needs. But in a world where electricity demand is surging, we believe data centers can be part of the solution to meeting the world's needs for reliable, affordable, clean energy.

That's good for the grid. It's good for our business. And it's a model that's built for the energy systems of the future. Call it a quiet kind of power shift, but one that has the potential to create a more reliable, flexible, cost-effective, and resilient energy system.

Ambitious vision, complex reality

Our efforts to decarbonize global grids

The global energy transition isn't just about generating more clean electricity. It's also about aligning supply with demand in real time—hour by hour, grid by grid. That's the vision behind 24/7 carbon-free energy, where every kilowatt-hour of electricity we use is matched with clean power produced on the same grid during the same hour.

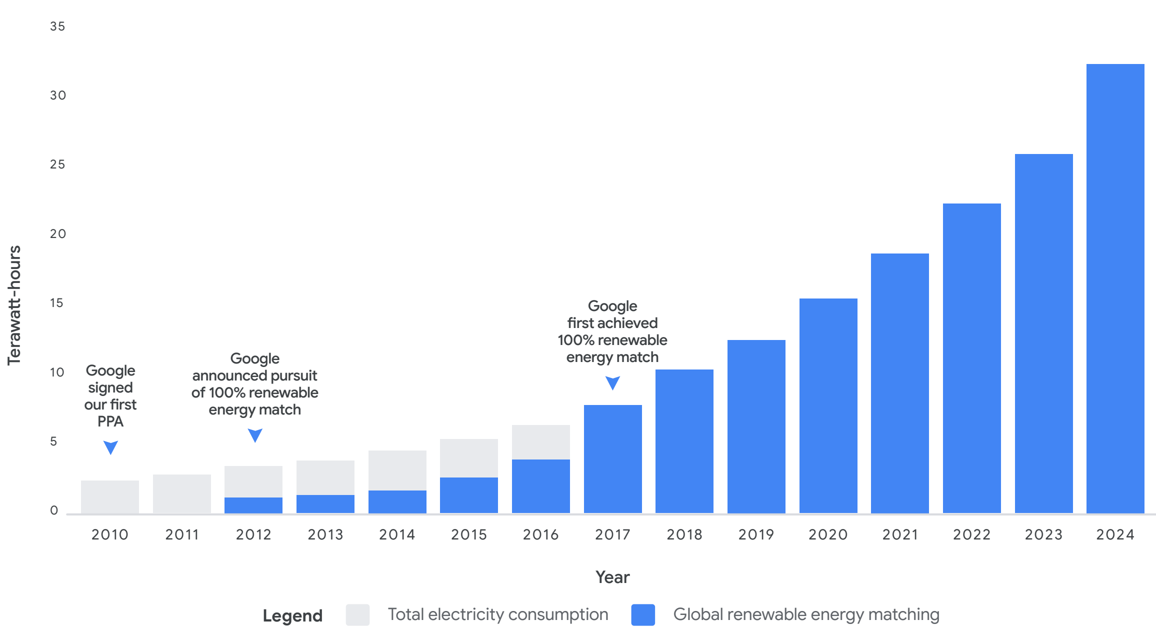
While we've made great progress over the years, the path ahead is anything but simple. It requires new tools, deeper collaboration, and systemic shifts across markets. But the reason we're dedicated to this work is clear: 24/7 CFE offers a way to drive real-world reductions, accelerate grid decarbonization, mitigate electricity price volatility, and make the overall clean energy transition more reliable and enduring.

Beyond the annual match

For the last eight years, since 2017, we've matched 100% of our global electricity use with renewable energy purchases[60]—a pursuit that seemed almost impossible when we set out on it back in 2012 (Figure 5).

This milestone was an important step—but annual matching only tells part of the story. The reality is that most grids today still rely on fossil fuels for portions of the day, especially during evenings or times when renewable sources aren't producing electricity. Even if a company buys clean energy in bulk and applies it to match its total usage over the course of the year, its real-time energy mix likely includes electricity generated from fossil fuels.

Figure 5. Clean energy purchases compared to total electricity use



24/7 CFE aims to address this discrepancy. Through this approach, we're working to match our electricity use with clean energy generated locally and in real time—matching electricity consumption with clean power generation on the same grid, in the same hour. This requires a portfolio of solutions—clean energy generation, energy storage, smarter computing loads, and advanced market instruments like time-based energy attribute certificates (T-EACs).

Real impact, shared outcomes

We believe that 24/7 CFE isn't just a wonky metric or our own moonshot—it's a blueprint for global grid decarbonization. By aligning our purchases to fill clean energy gaps on grids, we can help shift demand to lower-carbon hours, create new markets for emerging technologies, and send clearer investment signals to energy developers.

That's why we're not just doing this for ourselves. We're working with partners across sectors to scale this model, sharing methodologies, collaborating on procurement standards, and supporting policy frameworks that make 24/7 CFE more accessible for everyone.

Navigating real-world constraints

Still, there are structural barriers that no single company can overcome on its own. Interconnection delays, market fragmentation, and regulatory bottlenecks continue to limit how fast clean energy can come online—and how easily it can be matched to local demand. Even as we expand our contracting in emerging markets and regions with higher carbon intensity, we still face logistical and economic constraints: limited local supply, permitting challenges, and other hurdles that can slow technology deployment.

In 2024, we continued to navigate a complex global energy landscape. **We achieved significant progress by increasing our global carbon-free energy percentage across our data centers and offices to 66%.**[61] This 2% increase compared to last year is particularly noteworthy given the 27% increase in our electricity consumption to support our growing business, including AI. While this global average reflects strong progress, our journey varied by region. In Asia Pacific, for instance, our regional average Google CFE was 12%—well below that of other regions, like 70% in North America and 92% in Latin America.[62] In response, we're advancing new paths for clean energy in Asia Pacific specifically, like solar aggregation and piloting investments in new clean energy projects.

This regional variability is a reminder of what makes 24/7 CFE so powerful, and so complex: it doesn't hide the gaps. It shines a light on them.

Accelerating new tools like T-EACs

To overcome these challenges, we're developing new tools and strategies—like time-based energy attribute certificates (T-EACs), sometimes referred to as Granular Certificates.

T-EACs are an important tool for achieving our own climate moonshots, as well as for making hourly energy procurement more accessible to more companies in support of broader efforts to fully decarbonize electricity systems worldwide. That's because T-EACs enable clean energy generation to be purchased, traded, and tracked on an hourly basis, offering a more credible and impactful clean energy procurement instrument than traditional energy attribute certificates (EACs).

T-EACs can help enable reliable clean energy procurement in an era of rapid load growth. We retire T-EACs, which come bundled with our PPAs, to match a portion of our hourly electricity demand. Many of these instruments are now certified by Flexidao and can be traded to allow for hourly matching by others.

After being the first major company to pilot T-EACs in 2021, we achieved two new milestones in 2024. We were the first company to receive bundled T-EACs issued directly by an EAC-issuing body in Europe, and we tested the purchase of unbundled T-EACs[63]—both milestones that are helping build a market for these instruments.

We've also invested in the data infrastructure to make this possible. In 2024, we supported Electricity Maps' expansion to global coverage of real-time grid-emissions data, adding over 100 countries to its platform. And through our partnership with LevelTen Energy and a coalition of energy innovators, we helped launch the Granular Certificate Trading Alliance to create a marketplace for hourly energy matching instruments.

Because market standards are still evolving, we're working to help shape them. In 2024, we co-authored a set of contracting principles with the Eurelectric 24/7 CFE Hub, aimed at helping clean energy buyers and sellers move toward greater hourly energy matching. Our published procurement principles for advanced clean energy technologies also guide our approach, ensuring that what we buy helps accelerate grid impact.

Evolving energy markets

Equally important to our own operational efforts to achieve 24/7 CFE is our work to help create an energy system that's fit for the future—one that can scale to meet the demands of AI, electrification, and economic development with minimal environmental impact.

Beyond focusing on clean energy contracts, we're working on market transformation—from new electricity rates to grid planning. Through partnerships with utilities and system operators, we're supporting smarter infrastructure design and load shaping that makes 24/7 CFE more feasible. We're even partnering with other companies to capitalize on our combined demand for advanced clean energy solutions, such as enhanced geothermal, advanced nuclear, clean hydrogen, and long-duration energy storage.

An interconnection substation at Fervo Energy's enhanced geothermal plant in Nevada, a first-of-its-kind project developed in partnership with Google.

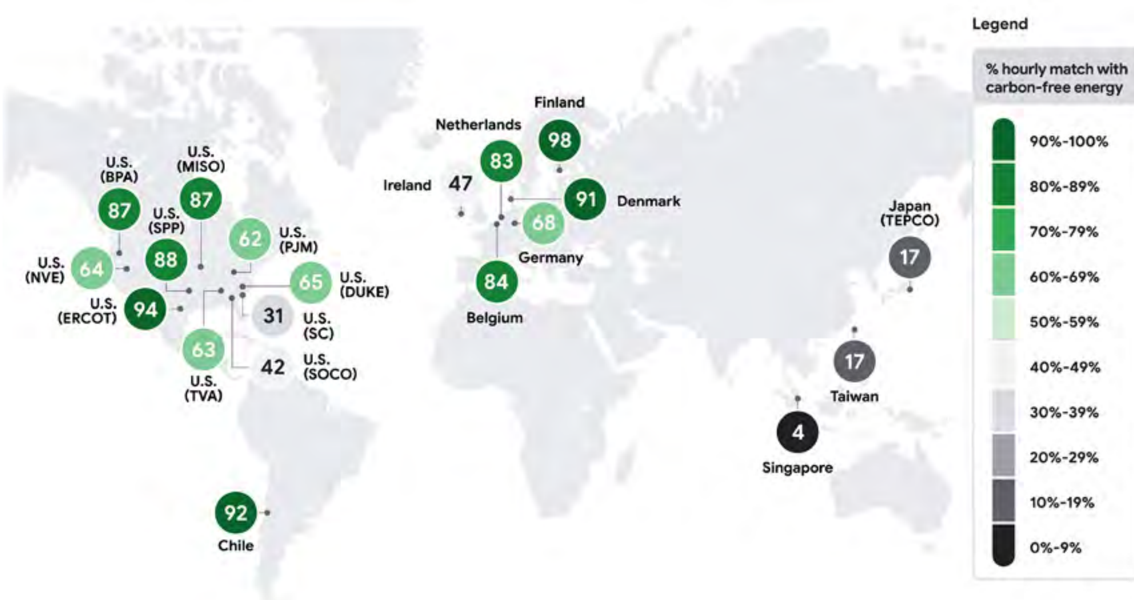
While 24/7 CFE is a long-term challenge, the progress we've made so far shows what's possible when ambition meets collaboration, data, and transparency (Figure 6). And we'll keep expanding our toolkit: contracting innovative projects, refining how we measure real-world impact, and building the infrastructure for others to join us.

Ultimately, 24/7 CFE isn't about any one company hitting a perfect score. It's about rethinking clean energy as something you don't just buy—but something you match, precisely when and where it's needed. This takes decades-long clean energy contracts, new infrastructure, grid-level coordination, and detailed systems planning—layered with flexibility, investment, and long-term thinking.

In many ways, this work is constant. Data centers don't stop running to wait for clean power. Offices don't turn off the lights while we negotiate energy contracts. But every watt of cleaner electricity we bring online makes a difference.

We'll keep doing what we've done from the start: tackle the parts we can directly control, stay accountable to real-world impact, and help build an energy system that can meet the demands of the future while protecting the planet. That means smarter energy use, more clean power, and a grid that works better for everyone.

Figure 6. Carbon-free energy map for grid regions with Google-owned and -operated data centers [64]



Energy for our supply chain

Energy for our supply chain

Contents

When people think about reducing environmental impacts, they might picture electric vehicles, rooftop solar panels—maybe even plastic alternatives. But there's a part of the climate story that doesn't get as much attention: the supply chain behind your phone, thermostat, or smart speaker, and the data center hardware they rely on. And it's one of the trickiest parts of the puzzle; the further you zoom out—from the device in your hand to the global network that made it—the more complex the system becomes.

For Google, much of that challenge starts in Asia Pacific, where our suppliers manufacture many of the core components of our hardware. These facilities often require lots of energy—especially when it comes to making semiconductors, the chips that power everything from your phone to our data centers. Manufacturing at this scale also demands constant, stable, reliable electricity. And in many parts of the world, especially where these factories are located, that often means tapping into regional grids that are heavily reliant on fossil fuels.

Expanding clean energy access across much of Asia Pacific faces significant hurdles, including policy barriers, grid infrastructure that struggles to integrate clean energy, and gaps in financing mechanisms—although notable developments are accelerating access in specific markets like India and Vietnam. And despite its challenges, this transition to clean energy brings meaningful co-benefits to our supply chain—like fostering greater resilience and stability.

Changing how energy is sourced isn't as simple as walking into a supplier's factory and flipping a clean energy switch. These are independent businesses, navigating their own regulatory environments, infrastructure limitations, and financial constraints. Our role is to partner—bringing resources, incentives, and technical support to help suppliers make meaningful, measurable progress toward clean energy, which in turn can help them manage energy costs and prepare for evolving regulations.

Rows of machinery on a production floor.

Supplier synergy

Shared tools, partnerships, and clean energy agreements

We're working to tackle our supply chain emissions with a mix of technical tools, direct supplier partnerships, and clean energy agreements and investments.

One practical resource we developed is an Energy Assessment tool. This is a free tool designed to be used without deep technical expertise that helps supplier facility managers identify energy efficiency opportunities across their operations. These managers can get a snapshot of where energy is being lost—whether it's outdated chillers, inefficient motors, or poor lighting—and get guidance on which upgrades could yield the biggest energy consumption improvements and cost reductions. But efficiency alone isn't enough. That's where carbon-free energy comes in.

In 2023, we began rolling out the Google Clean Energy Addendum (CEA)—an agreement asking suppliers to commit to achieving a 100% clean electricity match by the end of 2029 for the electricity they use to manufacture Google products.[65] We see this as a cornerstone of our strategy—not just a recommendation, but a shared agreement to market change. It's already become a central part of how we work with our key suppliers—especially those with the highest energy use. By the end of 2024, many key suppliers signed our CEA, and we plan to continue driving clean energy progress within our supply chain through our CEA, clean energy investments, and other initiatives.

We know this takes time, which is why we're working directly with suppliers to identify practical next steps, offer hands-on support, and share tools that make the transition more manageable—from navigating clean energy procurement to tracking progress—all of which ultimately strengthen the resilience of our supply chain.

Minco II wind farm in Oklahoma (102 MW for Google).

APAC's brighter future

A solar solution in Taiwan

Of course, even the most motivated suppliers can't switch to clean energy if it's not available. That's why Google isn't just supporting clean energy procurement—we're helping create it.

In 2024, we announced an investment to support the development of a 1 GW pipeline of new solar energy in Taiwan, an investment that focuses on a region that plays a prominent role in global technology supply chains. We expect to procure solar energy from these projects, and we may offer a portion of this clean energy to our semiconductor suppliers and manufacturers in the region so they can advance their own sustainability ambitions while helping reduce emissions in our shared supply chain. It's a model that goes beyond carbon accounting to enable broader action—removing barriers so others in our supply chain can make better and cleaner choices too.

This kind of intervention is becoming more important as the global clean energy sector faces bottlenecks. Many countries in Asia Pacific face unique challenges when it comes to adding new carbon-free energy, including land constraints, low availability of commercially scalable wind and solar resources, and high construction costs. By getting directly involved in energy markets, we aim to help bridge some of those gaps, grow the supply of available renewable energy sources, and promote emerging technologies that enable the decarbonization of regional electricity systems.

The work builds on more than five years of collaboration to accelerate the clean energy transition through market and policy development across Asia Pacific. Our advocacy and engagement efforts were a key driver of the 2017 amendment of Taiwan's Electricity Act, which opened up the market to allow non-utility companies to directly purchase renewable energy. This effort led to us becoming the first corporate buyer to sign a PPA in the market.

Looking beyond Taiwan, we continue to drive progress throughout the Asia-Pacific region—marked by announcements in Australia, India, Japan, and Singapore. These examples show meaningful strides in our ongoing journey, yet they also serve as a reminder that a far greater collective effort is needed—both within the dynamic landscape of Asia Pacific and around the world—to truly tackle this challenge.

Our data center in Changhua County, Taiwan, is a center of community building and innovation.

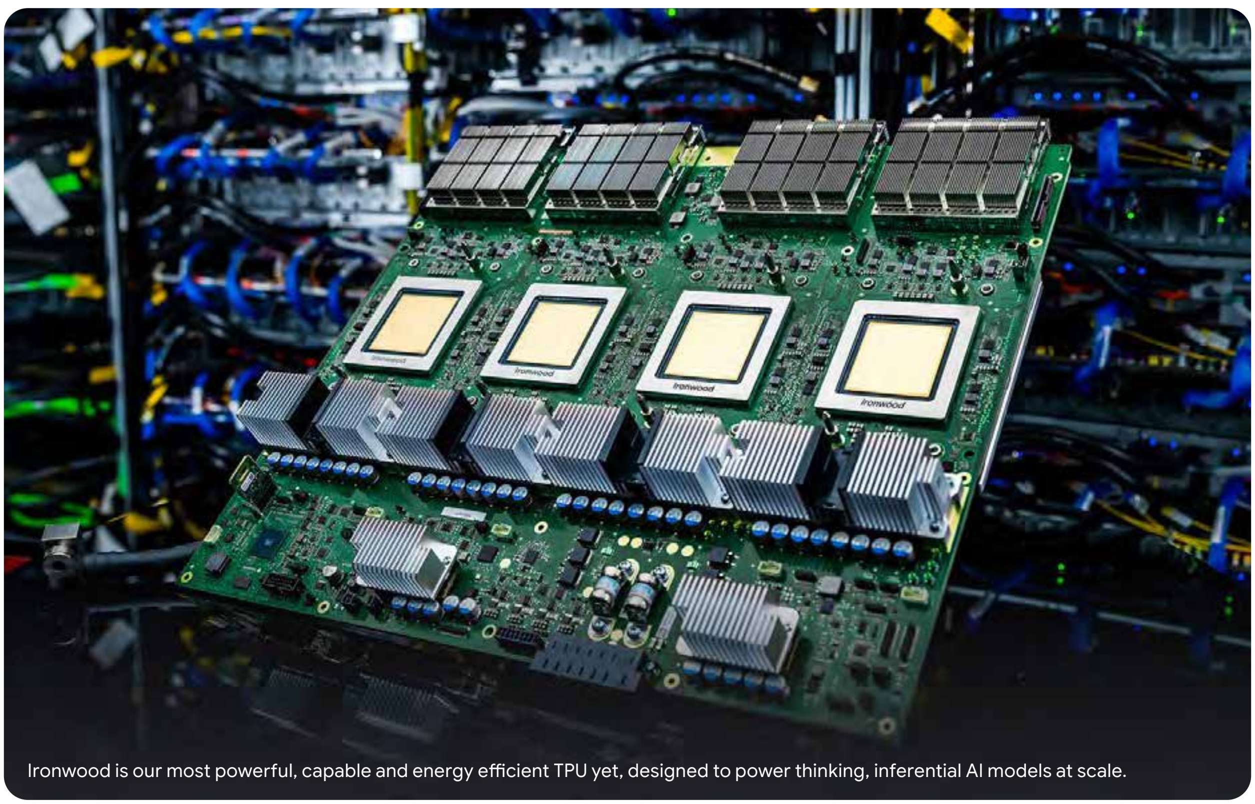
Conducting change

Focusing on high-impact semiconductor suppliers

Not every part of a supply chain has the same level of impact. Some processes are far more carbon-intensive than others, and the semiconductor industry is among the most emissions-intensive for Google. Making chips requires not only lots of electricity but also the use of extremely potent greenhouse gases.

We're actively focusing on this "hotspot"—a specific part of our supply chain where emissions are disproportionately high. We're a founding member of Catalyze, a group working to decarbonize semiconductor manufacturing, and we partner with industry-wide efforts like the Sustainable Semiconductor Technologies and Systems program and SEMI's Semiconductor Climate Consortium. We're also a steering committee member of the Clean Energy Buyers Association's Clean Energy Procurement Academy, which delivers tailored trainings to help our suppliers make high-impact clean energy purchases. These partnerships are about more than just advocacy: they also help drive shared research and development, advance manufacturing processes, and create standards that ripple across the industry.

Collaborating creates real momentum—especially when the work is shared and sustained across the supply chain. When we pull in the same direction, things move faster.



Ironwood is our most powerful, capable and energy efficient TPU yet, designed to power thinking, inferential AI models at scale.

Supply chain transformation

Why it's slow, why it's messy, and why it really matters

Transforming a global supply chain is never quick or easy. It's a long game filled with logistical hurdles, economic trade offs, regional challenges, and infrastructure constraints. Our efforts go beyond our own operations—we're working to influence the broader systems and structures that shape how our industry uses energy.

That's why progress can often look like a patchwork of small wins—from suppliers upgrading their facilities and sharing decarbonization roadmaps to signing our CEA and committing to clean energy procurement. Taken together, we believe these moves have great collective impact, and when they happen at scale, they can shift market demand, create new norms, and accelerate broader change. These steps also bolster supply chain resilience and help companies stay ahead of potential regulatory requirements or reporting needs.

There's often a temptation to focus only on what's most visible—what the consumer sees. But much of the progress needs to happen upstream, in the guts of the system. Clean energy transitions are often described in terms of breakthroughs—technology, policy, or pricing. But perhaps equally important are the slow, painstaking efforts to build trust, share risk, and coordinate action across companies and boundaries. It's not always flashy, but it's essential.

We believe that's the power of supplier engagement. And it's one of the most powerful tools we have for scaling solutions to meet the urgency of the moment, while simultaneously building a more stable, resilient, and competitive supply chain for the future.

A logistics program manager at our data center in Singapore.

Resource efficiency

Water stewardship

Contents

Water is one of the most essential resources on Earth. And though water risk varies by location and isn't present everywhere, growing concerns in many regions mean managing this precious resource is no longer just a responsibility, but a necessity. We're working to do just that through a strategy centered on advancing responsible water use at Google, benefiting watersheds and communities, and supporting water security with technology.

Advancing responsible water use

Our approach to climate-conscious data center cooling

Google's data centers are the engine of our company, powering products like Google Workspace (which includes Gmail, Drive, Docs, and more), Google Cloud, Search, and YouTube for billions of people around the world. And as we grow to serve more users globally, building new data center infrastructure is essential.

To operate smoothly, these facilities rely on cooling systems that frequently use water due to its energy efficiency. This dependency highlights a critical balance between technological needs and responsible environmental stewardship. In 2024, we consumed a total of approximately 8.1 billion gallons (31 billion liters or 31 million cubic meters) of water across our data centers (excluding those operated by third parties) and offices. To put that consumption into perspective, that's about what it takes to irrigate 54 golf courses annually, on average, in the southwestern United States.[66] Crucially, the majority of this consumption occurred in regions where water resources are abundant: **in 2024, 72% of our freshwater withdrawals came from sources at low risk of water depletion or scarcity.**[67]

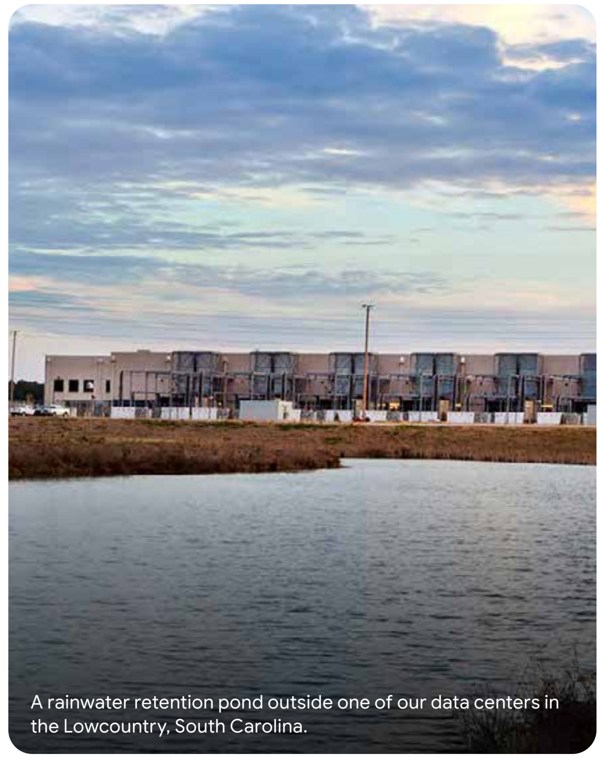
Enter Google's climate-conscious cooling strategy, our multidimensional methodology for choosing cooling systems for our data center campuses. This approach recognizes that water is the most efficient means of cooling in many places and, when used responsibly, water cooling can play an important role in reducing emissions. So, at each data center campus, we look at balancing the availability of carbon-free energy and responsibly sourced water to minimize the net climate impact both today and in the future.

Climate-conscious cooling in the United Kingdom

The area surrounding our new data center location in Waltham Cross in the United Kingdom receives water from sources along the Lea and Thames valleys, which are under stress from recent severe drought events.


Cooling towers at our data center in Mayes County, Oklahoma.


An overhead view of one of our cooling plants in Hamina, Finland.


A rainwater retention pond outside one of our data centers in the Lowcountry, South Carolina.

This situation is exactly what our data center water risk framework is designed to help us navigate. The framework is a data-driven tool we use globally to evaluate the specific risks of water scarcity and depletion in the watersheds where we plan to operate, guiding our technology choices before construction begins. We don't take a one-size-fits-all approach; instead, we use data to understand the local environmental context.

We applied the framework to the specific water sources serving Waltham Cross, and the results did indeed present a high risk of water depletion and scarcity. So, to operate responsibly and minimize our impact on this vital local freshwater resource, we decided to utilize air cooling technology at this site—an approach that doesn't consume water for cooling during routine operations.

We're taking a similar approach in other areas identified as having high water risk through our framework, such as our facilities under development in Mesa, Arizona and Canelones, Uruguay. For us, the assessment of the water sources for Waltham Cross was more than just a site- or region-specific decision; it's another proof point that our global, data-driven framework aligns with and supports responsible water use tailored to local environmental conditions.

Responsibly using water isn't only relevant for our data centers—we're also developing and implementing responsible water use practices across our global office portfolio. We've intentionally designed these water practices to cover all aspects of water use in our offices, including food preparation, cleaning and sanitation, campus landscape irrigation, and workspace cooling systems. For example, our new hardware office in Taiwan features water infrastructure innovations like a stormwater capture system as well as other infrastructure improvements like water-efficient fixtures and the use of non-potable water for toilet flushing.

As our business continues to grow, so does our water use: our overall water consumption increased by 28% from 2023 to 2024. However, making informed, locally attuned decisions—like choosing air cooling in Waltham Cross, Mesa, and Canelones—is central to our responsible water use. It's how we strive to implement climate-conscious cooling strategies and manage our water footprint carefully, even as demand for our services expands around the world.

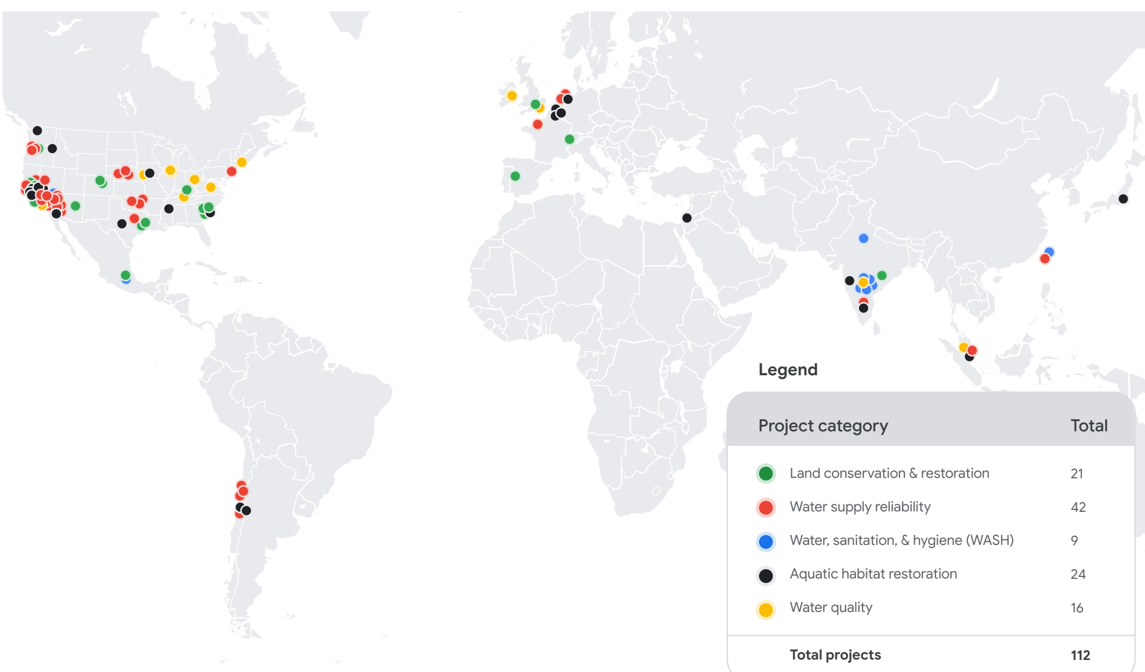
Replenishing water

A local approach to water stewardship

Water stewardship isn't just about managing our consumption. It's also about ensuring that we give back more than we take—especially in regions that have a higher risk of water scarcity or depletion. That's why our water replenishment strategy focuses not only on replenishing more water than we consume, but also on improving water quality and ecosystem health in the communities where we operate.

In 2024, our water stewardship projects replenished approximately 4.5 billion gallons of water (17 billion liters or 17 million cubic meters), roughly 64% of our 2024 freshwater consumption.[68] We added 38 new water stewardship projects, increasing our total portfolio to 112 projects spanning 68 watersheds in 2024 (Figure 7). Many of these projects go beyond replenishing water to also support watershed health by improving water quality, biodiversity, and community co-benefits.

Figure 7. Global water stewardship project map as of the end of 2024



Groundwater recharge in California's Central Valley

Local water issues are often complex and contextual. That's why Google's approach to water stewardship is rooted in partnerships with local communities and organizations. We focus on projects that have a tangible impact—such as restoring ecosystems, improving irrigation efficiency, and supporting communities' water supply reliability.

Take the San Joaquin River, which winds through California's Central Valley, a region that acts as an agricultural engine for the nation. Think fruits, vegetables, nuts—a staggering share of the U.S. supply originates here,[69] all cultivated through reliance on irrigation. But this vital production faces a challenge simmering beneath the surface: groundwater depletion, making the health and restoration of the San Joaquin River more critical than ever for sustaining this food production powerhouse.

Addressing this critical need for water resilience requires innovative approaches and collaboration with local actors. Recognizing this, Google stepped in, partnering with the North Fork Mono Tribe, the Sierra National Forest, and Trout Unlimited. We worked together to restore eight degraded wet meadows—key areas that act like natural sponges when healthy. They soak up melting snowpack and rainfall, storing water near the surface and slowly releasing it over time.

The restoration involved techniques tailored to bring back the meadows' natural water-holding function, which in turn can unlock multiple benefits: reduced downstream flooding, improved wildlife habitats, and crucially, increased groundwater recharge. This type of intervention is vital for replenishing the underground supplies that the communities and farms of the Central Valley depend on, helping to secure a healthier water future for the region.

Just upstream, we worked on another water stewardship effort that brought together public and private partners to tackle groundwater depletion directly within the Central Valley. Using insights from state studies, we planned on-the-ground recharge projects and conducted feasibility studies on four additional San Joaquin River tributary watersheds with Sustainable Conservation. This work will also improve groundwater resilience, helping local farmers adapt to changing water availability.

Through partnerships spanning headwaters to floodplains, these San Joaquin River projects embody our approach to water stewardship: actively replenishing water and enhancing ecosystem health in a region critical to both California and the nation.

For more details on all the water stewardship projects we've supported as of the end of 2024, refer to the 2025 Google Water Stewardship Project Portfolio.

A farm in California's Central Valley. (Photo credit: Paolo Vescia)

Waste reduction

Contents

Accelerating the circular economy through innovation and enhanced resource efficiency is critical to managing raw material extraction and minimizing environmental impacts. That's why we set out to become a more circular Google by maximizing the reuse of finite resources across our operations, products, and supply chains—while enabling others to do the same.

Reverse supply chain

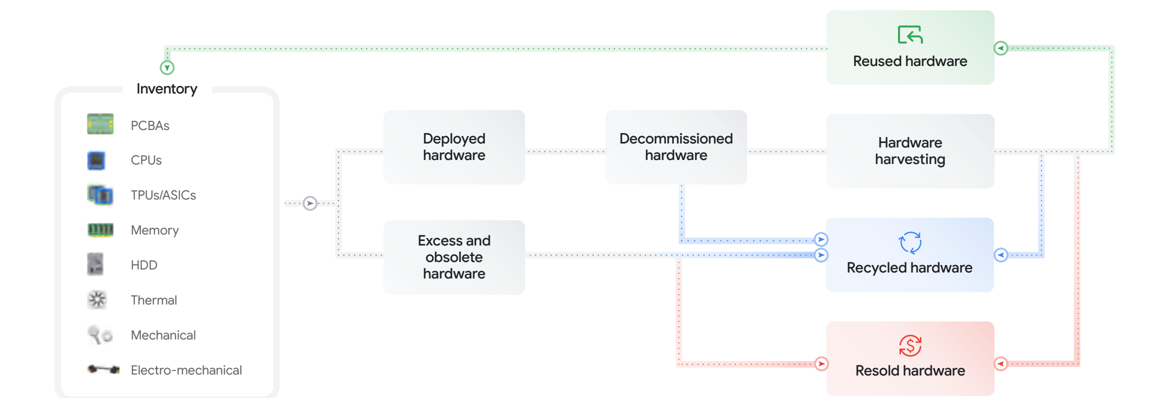
Giving hardware a second life

When you think about strategies for reducing the environmental impact of data center hardware, the obvious approaches may be energy efficiency or clean energy procurement. But there's a less talked about—yet also important—piece of the puzzle: hardware longevity via the reverse supply chain.

What is a reverse supply chain?

At its core, a reverse supply chain is the process of moving products back through the supply chain after they've served their original purpose. For us, that means repurposing hardware components through reuse, recycling, or resale—keeping them out of landfills (Figure 8). It's about extending the life of things that could otherwise be discarded and therefore reducing the need to extract raw materials to produce new hardware. And it's one of the most impactful strategies to make our data center operations more circular.

Figure 8. Data center hardware reverse supply chain



Why does a reverse supply chain matter so much?

As we continue to scale our data centers to meet the growing demand for our products and services, including AI, reducing waste is essential: **in 2024, we diverted 84% of our operational waste from disposal across our global Google-owned and -operated data centers.** A large part of that success comes from our Reverse Supply Chain program, which enables us to reclaim components from decommissioned hardware and repurpose them, cutting down on material consumption and emissions.

We're not just recycling—we're giving our data center hardware a second life. **In 2024, we harvested approximately 8.8 million components from our decommissioned hardware for reuse or resale through our Reverse Supply Chain program**—including over 3 million hard drives that were securely wiped and reused or resold. That's millions of parts kept in circulation instead of being newly made. As an example of our efforts in this space, in 2024, 44% of components used for Google-managed server builds, maintenance, and upgrades were from reused inventory.[70] Reused components generally mean fewer raw materials, less energy, and fewer emissions from manufacturing new components—three things we're working hard to reduce.

In addition to our reverse supply chain efforts, a portion of this impact was driven by our Fleet Deployment Sustainability programs, which strategically target decommissioning of specific data center hardware for harvesting. In 2024, our hardware harvesting program helped us reuse more than 293,000 components to fulfill new demand.

Reselling data center hardware components isn't always easy. It requires us to securely wipe data, maintain component functionality, and ensure that any reused components are reliable. But we believe it's essential for reducing the environmental impact of hardware. Since 2015, we've resold more than 51 million hardware components from our data centers into the secondary market for reuse by other organizations, including more than 6.7 million resold components in 2024 alone. These are components that can still be used by other organizations, saving them from having to source new materials, in turn avoiding the corresponding impacts of the manufacturing process.

When reuse or resale aren't viable options, we responsibly recycle our data center hardware. In 2024, this included securely crushing and deforming or shredding on-site (to protect data security) and then recycling approximately 1.9 million hard drives.

So, the next time you're using a Google product powered by our data centers, know that some of the hardware that supports it had a second life.

A Googler swaps out a motherboard at our data center in The Dalles, Oregon.

Food waste

Resourceful recipes and smarter services

Tackling operational waste extends beyond our data center hardware to another critical area: food. The journey from farm to fork is fraught with potential food loss and waste—along with the water, energy, and other resources that went into producing it. Addressing this complex food waste challenge requires a comprehensive strategy focused on both waste reduction and diversion.

Prevention is paramount. We're enhancing strategies across the entire food life cycle—from responsible sourcing and procurement to optimizing kitchen operations and finding innovative uses for surplus food. This focus on reduction minimizes the amount of waste that needs subsequent diversion from landfills.

Consider our Bay View campus in Mountain View, California, which exemplifies this multipronged approach. We're tackling food waste by creatively incorporating ingredients that might otherwise be discarded. This includes using upcycled products and sourcing "imperfect" but perfectly good items—think surplus farm tomatoes transformed into pizza sauce, or visually blemished yet still delicious apples. We've also put guidelines in place to donate surplus food to those in need, and we're working with local communities to improve composting infrastructure.

Simultaneously, we optimize kitchen workflows through inventory management and demand forecasting. Crucially, AI enhances these efforts, providing chefs with data-driven insights to refine menus and reduce waste, while generative AI helps synthesize findings and tailor solutions unique to Bay View's needs, preventing waste before it even occurs for the many Googlers dining there daily.

At Bay View and elsewhere, these integrated efforts—combining operational changes with behavioral nudges—are yielding results. In 2024, we reduced food waste per Googler by approximately 39% compared to 2019.[71] For the waste that does occur, our focus shifts to responsible diversion. **In 2024, we diverted 85% of food waste from landfill through composting, donations, or other recovery efforts.**

This work isn't isolated to one campus; these principles are applied across our global operations, because every bite counts. And surprisingly, the difficult part is actually repeating the easy stuff—ensuring sustained efforts in every cafe and kitchen across our global operations every day. In 2025, we're doubling down on reducing preventable food waste, such as overproduction and expired products, and focusing on specific regions and offices where we have larger gaps to close.

In our kitchen and cafe operations, we're focused on ways to stop food waste before it starts.

Nature on our campuses

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Both businesses and humanity depend on nature and the essential services it provides, such as clean air and water, healthy soils, flood prevention, nutrient cycling, pollination, and climate stability. But that's not all—nature can also positively impact human health by reducing stress and improving wellbeing. Protecting and enhancing nature is also critical for supporting biodiverse ecosystems, for maintaining healthy communities, and for building resilience.

Restoring habitat

Cultivating nature on our campuses

When people think of nature, they usually picture somewhere far away: forests, open spaces, a national park. But in many of the places we live and work, the closest thing to wilderness might be a strip of grass along a sidewalk. Nature and the built world often feel like two separate realms—and for decades, they've been treated that way. But what if they didn't have to be?

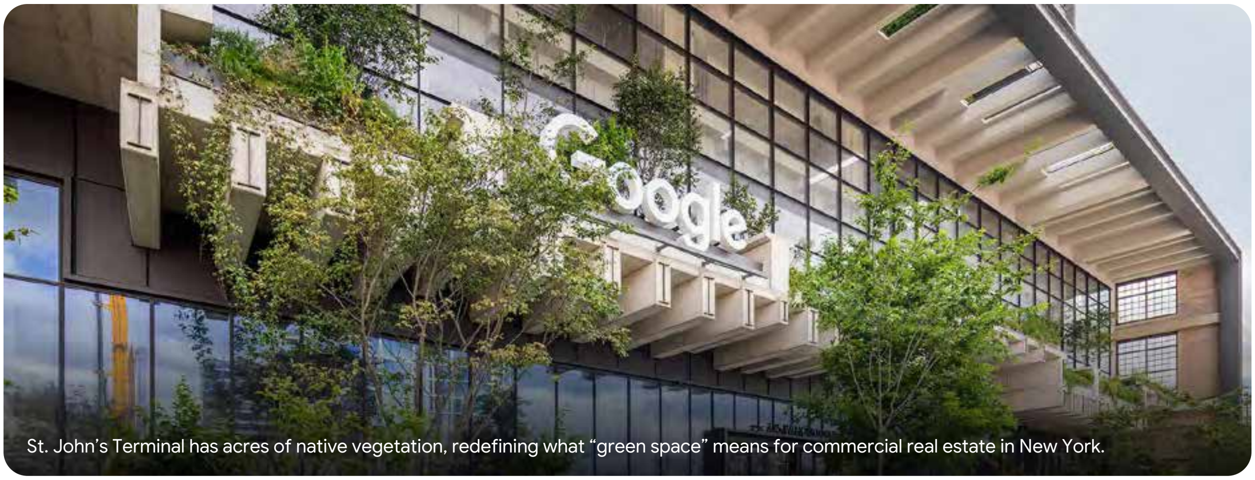
At Google, we're trying to help change that—by rebuilding nature in the very places it's been paved over: office campuses, sidewalks, former industrial land—places where rebuilding biodiversity can help people feel more connected, make cities more livable, and give ecosystems a real chance to thrive. The big idea: bring nature back to where people already are.

Pollinator-friendly campuses

Take our 1265 Borregas office in Sunnyvale, California. The building sits in the heart of Silicon Valley, surrounded by roads, businesses, and tech campuses.

But around the building, we planted three acres of pollinator-friendly landscape—using native species like coast live oak, native milkweed, California sagebrush, and California wild rose. The result? It won't just be prettier—it'll be a better functioning ecosystem.

A monarch butterfly rests on a stalk of lupine at a Google campus in California. (Photo credit: Rick Miskiv for Google)



St. John's Terminal has acres of native vegetation, redefining what "green space" means for commercial real estate in New York.

In the San Francisco Bay Area, we're rebuilding oak woodlands and willow groves damaged by decades of development. We're reintroducing native plant species and creating the right conditions for wildlife to return—not just to pass through, but to stay.

Building and monitoring thriving habitats

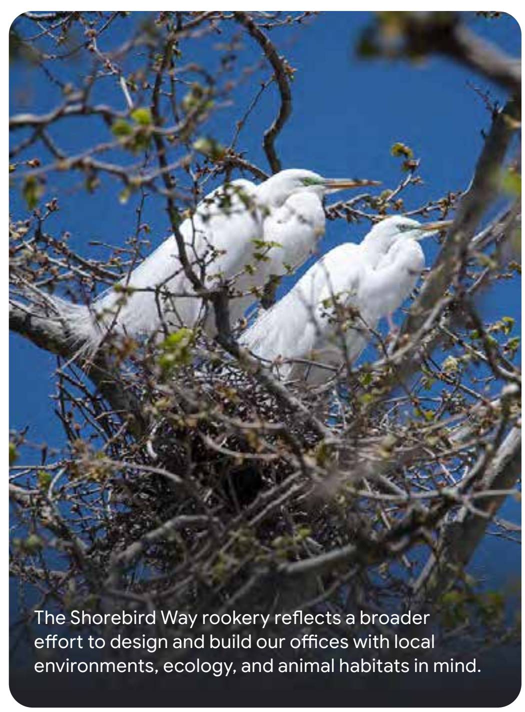
As of the end of 2024, we created or restored approximately 74 acres of habitat and planted roughly 5,200 native trees on Google's campuses and the surrounding urban landscape, primarily in the San Francisco Bay Area. That includes new tree plantings, drought-tolerant native species, and pollinator gardens. It also includes lawn conversions—like turning grass into a monarch butterfly habitat in Mountain View.

And as we go, we're keeping track of what's working—and where we can do more. At our Bay View campus in Mountain View in 2024, we documented more than 70 bird species that have returned to the restored habitats we've created to forage, roost, and raise their young. At our St. John's Terminal building in New York City, working with NYC Bird Alliance, we've documented more than 60 bird species between fall 2023 and fall 2024—including 11 species that our expert partners say were never before documented on green roofs in the city, like Golden-crowned Kinglets and Yellow Warblers.

Bringing nature closer to our employees and communities

Bringing back biodiversity isn't just about plants and animals—it's about people too. We want nature to feel close, accessible, and part of daily life. That's why we've created spaces where employees and the public can connect with wildlife, like "Egret Office Hours" hosted by the Santa Clara Valley Bird Alliance in the Shorebird Way rookery in Mountain View.

In New York City, we partnered with the NYC Bird Alliance to host "Learning about Birds" events for Googlers at St. John's Terminal, and we collaborated with NYC Parks Tree Time and the Arbor Day Foundation to plant native trees in two neighborhoods, Chelsea and Hudson Square, near our New York City campuses. The goal isn't just entertainment or shade—it's about reconnecting communities to local ecosystems and making cities more resilient.


The Shorebird Way rookery reflects a broader effort to design and build our offices with local environments, ecology, and animal habitats in mind.

Ripple effects

How our water efforts bloom into biodiversity gains

We know the loss of nature isn't limited to cities, which is why our restoration efforts extend far beyond our campuses. In fact, our water replenishment portfolio intentionally includes projects that have co-benefits for nature and biodiversity.

- In California, we've partnered with the Bonneville Environmental Foundation and American Rivers to help project partners restore wetland meadows in Yosemite National Park that provide habitat for species like the northwestern pond turtle. These ecosystems don't just support wildlife—they help regulate water, reduce fire risk, and make the landscape more climate resilient.
- In Tennessee, we're supporting the Cumberland River Compact's efforts to reforest previously mined land—bringing back native species and building healthier local ecosystems.
- In Arizona, we're supporting the Cocopah Indian Tribe and National Audubon Society to restore habitat along the lower Colorado River floodplain.
- In Israel, we're supporting the restoration of former fish farms that are being converted back to wetland habitat, which will provide a stopover for migratory birds.

The thread through all of it: bring nature back where it's been pushed out. Make it count for biodiversity. Make it meaningful for people. And make it part of how we design and build—not just something we try to protect at the edges.

It's about rethinking how we live with nature in the present—and what we want our future to look like. Because in a world shaped by concrete, asphalt, and glass, choosing to build for biodiversity is one of the most hopeful decisions we can make.

Oriental storks in a flooded rice paddy.

Consumer hardware devices

Contents

At Google, we're building consumer devices with recycled materials, ditching plastic in our packaging, and working to make it easier for users to repair, reuse, and recycle our devices. The more circular we make our approach, the less we waste and the more value everyone can get from the materials we already have.

Recycled content

Giving materials in our devices a second life

You might not notice it when you hold a Pixel or Nest product, but recycled materials can be found in many different components—from the rare-earth magnets to the aluminum enclosures and plastic parts, even the tin in the solder in our Pixel phones and smartwatches. Overall, at least 20% of all material Google used in our new products launched and manufactured in 2024 was recycled content.[72] We've incorporated recycled materials across our devices in a number of ways:

- The magnets in Pixel Watch 3 and in the haptics engine of Pixel 9 and Pixel 9 Pro phone series are made with 100% recycled rare-earth elements.[73]
- Pixel Watch 3 and Pixel 9 and Pixel 9 Pro phones use 100% recycled tin in the solder of all rigid and flexible printed circuit boards, including the main logic board.[74]
- **The aluminum enclosure of all Pixel phones since Pixel 6 through Pixel 9 series have been made with 100% recycled aluminum**, reducing the carbon footprint of the aluminum portion of the enclosures by at least 35% compared to 100% primary aluminum.[75]
- We're also using recycled or renewable material in plastic used across our consumer hardware product portfolio: 40% of the plastic Google used in products manufactured in 2024 was recycled content.[76]

Choosing recycled content helps reduce the environmental impact of extraction, supports more sustainable supply chains, and enables designing products differently from the start. This kind of design thinking helps reduce the impact of our consumer hardware—without compromising performance or quality. We're also sharing what we've learned, for example in our Consumer Hardware Carbon Reduction Guide.

Packaging progress

How we solved the challenge of going plastic-free

Recycling is one side of the equation. Eliminating plastic in our packaging is the other.

Product packaging traditionally relies heavily on mixed materials, particularly those incorporating plastic. This poses a challenge for recycling and creates a significant waste stream, especially if it isn't accepted in recycling facilities. So packaging felt like the right place to focus.

By 2020, we had already reached 94% plastic-free packaging.[77] But that last 6%? It hid in places like box liners, seals, and adhesives—and it wasn't easy to swap out.

So we got creative. We tested stretchier, stronger paper to replace wraps. We built a new molded fiber pulp made partly from recycled newspapers. Sometimes materials are recyclable but consumers don't recognize them as such, so we redesigned packaging structures and ditched glossy coatings in favor of uncoated, speckled textures that looked—and felt—recyclable for consumers.

The result: **the packaging for new Google products launched and manufactured in 2024 was 100% plastic free.**[78] Packaging isn't just what holds the product, it's part of the product experience. And rethinking how it's made can make sustainability feel more tangible from the start. Our Plastic-Free Packaging Design Guide shares design, engineering, and operational insights from our new packaging design and encourages other companies to share their innovations too.

Google consumer hardware devices in their product packaging.

Building to last

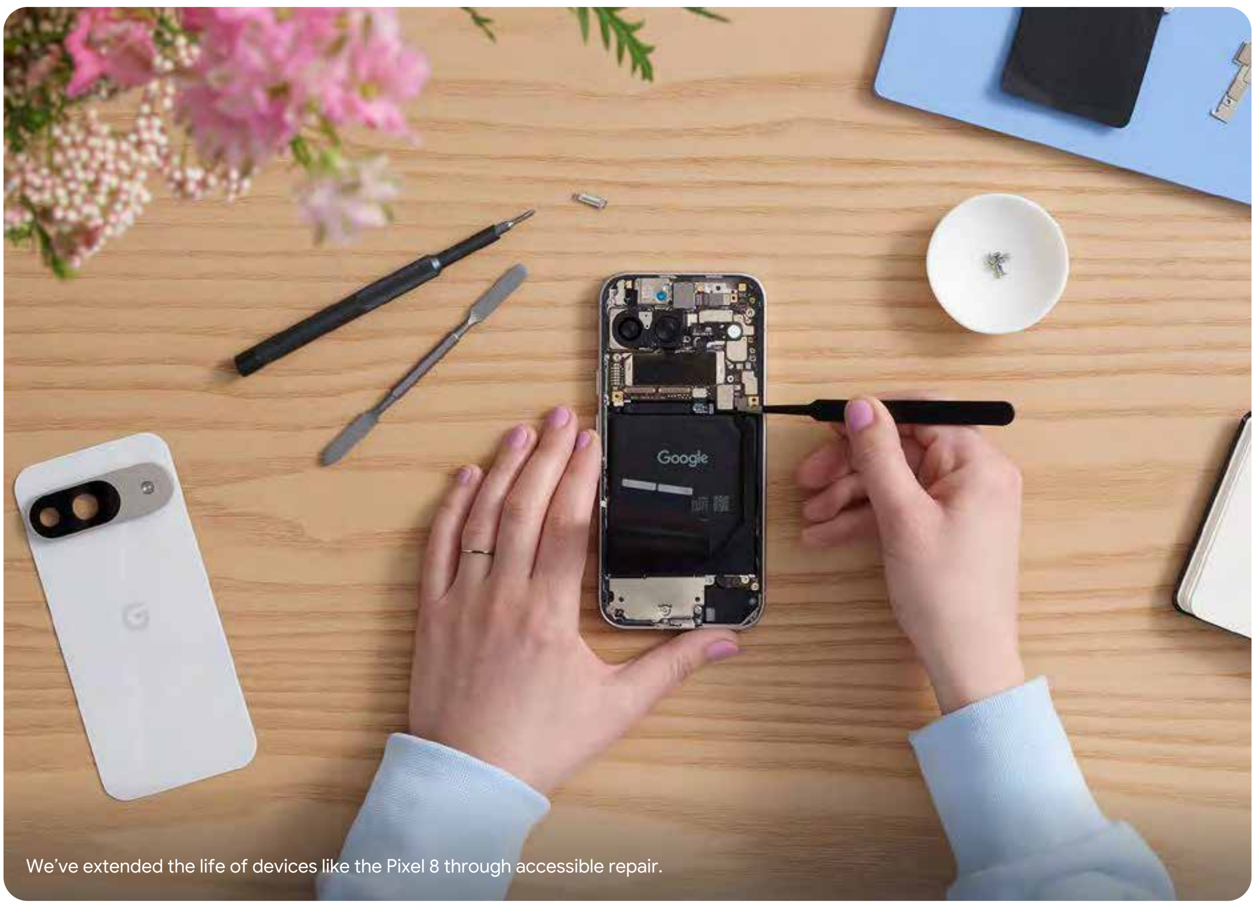
Our approach to product longevity

One of the best ways to reduce e-waste and drive customer savings? Make devices that last. That's why we're putting more focus on software support, repairability, and second-life options like refurbishment.

Pixel 8 and later phones get seven years of software support, including Android operating system upgrades and security updates. Google Nest devices receive automatic security updates for at least five years after launch. Chromebooks come with 10 years of automatic updates.

We're advocating for "Right to Repair" legislation while also empowering everyone with more repair options. For example, users can access the same parts and tools to fix Pixel phones themselves as are available at official repair centers. We're pairing this with better documentation, how-to guides, and a self-repair hub for DIY users. Our goal is simple: make repair accessible, understandable, and worthwhile for consumers.

We also launched a Certified Refurbished Pixel program in the United States in 2024—giving returned devices a second life and reducing waste along the way.



We've extended the life of devices like the Pixel 8 through accessible repair.

Partnering for impact

Collaborating on manufacturing, safer chemistry, and product shipping

We're also rethinking the upstream and downstream processes—working with suppliers and partners to make our manufacturing systems more circular from the inside out.

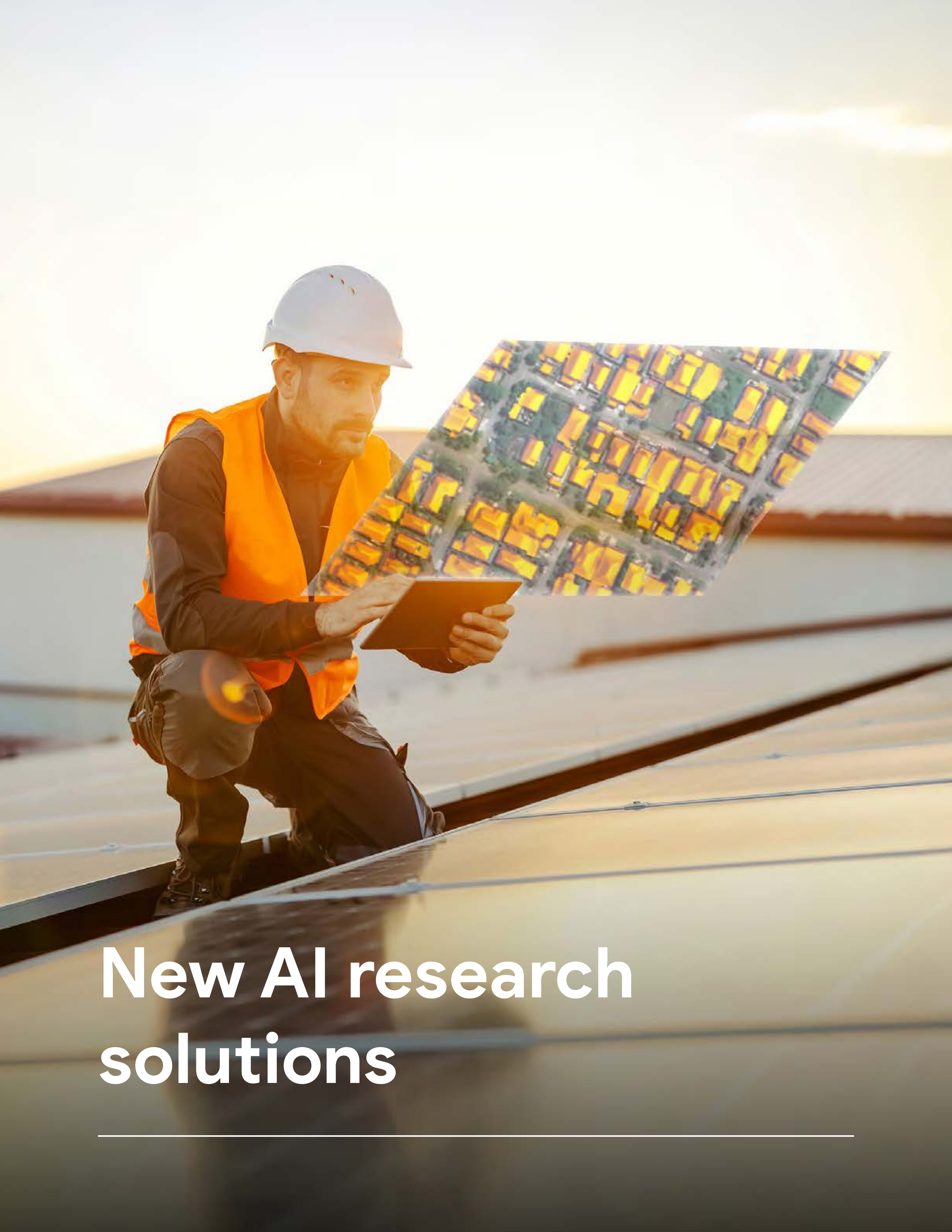
In 2024, 82% of final assembly manufacturing sites for our consumer hardware products achieved UL 2799 validation for waste diversion[79]—with 89% of those sites achieving Zero Waste to Landfill Gold or Platinum classification.

Through our consumer hardware product Restricted Substances Specification and Manufacturer Restricted Substances List, we restrict many hazardous substances and ensure our suppliers have processes in place to detect and prevent them from entering our products or the manufacturing process.

We're collaborating to improve materials too. In partnership with ChemFORWARD, we commissioned chemical hazard assessments for more than 190 individual chemicals from 2019 to 2024, to help inform the material choices we make for our consumer hardware products. To further accelerate safer chemistry across the industry, in 2024, we co-funded the Safer Chemistry Impact Fund—helping researchers and organizations find alternatives to hazardous substances.

We're also reducing the emissions tied to how our products move around the world. In 2024, we partnered with DHL to use sustainable aviation fuel (SAF) for shipping products across the Americas, Asia, and Europe. And we're exploring ways to reduce emissions even further—from lighter packaging to smarter shipping routes.

Assembly in progress in a warehouse.



New AI research solutions

New AI research solutions

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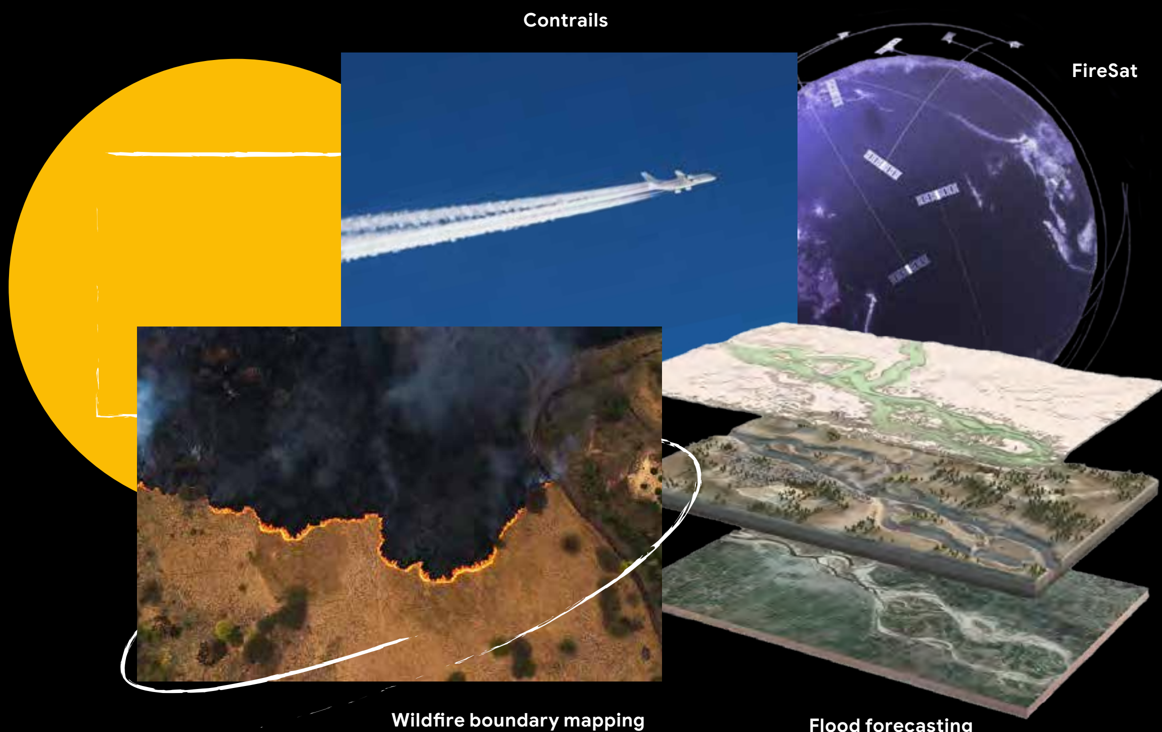
We believe technology—specifically AI—has the potential to accelerate the changes we need to protect people and the planet, and we're focusing on some surprising areas where AI is already making a real difference today.

Some of the most exciting innovations are happening in places you might never notice—in the clouds formed behind airplanes, the timing of a traffic light at a busy city intersection, the route of your local commute, and the untapped solar potential of your neighbor's rooftop.

The cutting-edge solutions we're developing and deploying in these areas represent enormous opportunities. And they all share something important: they're complex problems with numerous variables that—while challenging for a human to manage—are perfectly suited for AI to help solve.



A visual showcase of various Google Research projects.

1 gigaton aspiration

Unlocking climate action at scale

You might wonder what optimized traffic lights, smart thermostats, tools for solar developers, and fuel-efficient driving directions all have in common? Well, these are some of the ways we're advancing our aspiration to help individuals, cities, and other partners collectively reduce 1 gigaton (GT) of their carbon equivalent emissions annually by 2030. To put the scale of this ambition into perspective, 1 GT of emissions reductions is comparable to the entire annual emissions of Japan.[80]

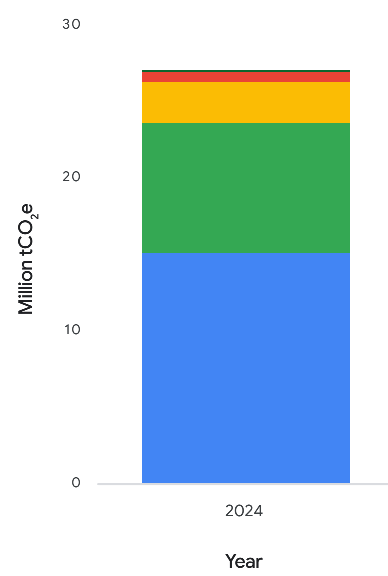
This aspiration is different from our operational ambitions. It's a way for us to use our unique technological capabilities and our global reach to inspire and enable others with information that can help mitigate climate change. This monumental opportunity—while inherently difficult and imprecise to measure—represents one of the most consequential environmental contributions we can make for the planet.

While we still have a long way to go toward our 1 GT aspiration, we're motivated by our progress to date and the opportunity for real-world impact at scale: **In 2024 alone, just five of our products—Nest thermostats, Google Earth Pro, Solar API, fuel-efficient routing in Google Maps, and Green Light (which represent only a subset of our efforts)—enabled individuals, cities, and other partners to collectively reduce an estimated 26 million metric tons of GHG emissions**[81] (Figure 9), roughly equivalent to the emissions from the annual energy use of over 3.5 million U.S. homes.[82] For context, Google's total emissions in 2024 were 11.5 million tCO_2e.[83]

Read more about the role each of these products played in 2024 below:

- **Fuel-efficient routing:** In 2024, we estimate that fuel-efficient routing enabled more than 2.7 million metric tons of GHG emissions reductions[84]—equivalent to taking approximately 630,000 gasoline-powered cars off the road for a year.[85] Want to dive deeper into how this product feature is making a tangible difference for drivers and the planet? Explore the full story in Fuel-efficient routing: Driving smarter while saving more.

Figure 9. Emissions reductions enabled by five Google products in 2024



Fuel-efficient routing

- **Green Light:** In 2024, we estimate that Green Light enabled over 3,000 metric tons of GHG emissions reductions[86]—and we expect even greater impact as we continue to expand Green Light from 20 cities to hundreds of cities over the next few years. Continue reading for more details on this innovative traffic management tool in Green Light: AI for more efficient city streets.
- **Solar API:** In 2024, we estimate that around 6 million metric tons of lifetime GHG emissions reductions were enabled by solar panels installed by our partners using the Solar API in the United States.[87] And using the annual accounting basis, we estimate that in 2024, 0.6 million metric tons of GHG emissions reductions were enabled by solar panels installed by our partners in the United States alone.[88] This partnership-driven approach not only enables emissions reductions, but it also helps companies scale their businesses and create new jobs, and it directly contributes to a cleaner energy future. Read Solar API: How we're democratizing solar power from rooftops to the grid to learn more about exactly how we're enabling more people to harness the sun's energy.
- **Google Earth Pro:** In 2024, we estimate that Google Earth Pro helped enable our partners to reduce more than an estimated 15 million metric tons of GHG emissions in the United States.[89] Solar and wind developers use Google Earth Pro for everything from evaluating potential sites to streamlining design and construction estimates. The platform's ability to overlay critical datasets like flood plains, habitat information, and topography, combined with historical imagery, allows developers to identify potential constraints and optimize layouts. This precision helps them develop projects more efficiently and cost-effectively.
- **Nest thermostats:** In 2024, we estimate that our Nest thermostats helped customers save more than 25 billion kWh of energy,[90] enabling approximately 8.4 million metric tons of GHG emissions reductions.[91] For over a decade, our Nest Thermostats have used machine learning to help people save energy and money at home by automatically adjusting temperatures based on habits and preferences. In fact, we estimate that our Nest thermostats helped customers cumulatively save more than 162 billion kWh of energy from 2011 to 2024,[92] which is more than the total annual electricity consumption of Poland in 2023.[93]


Green Light


Solar API


Google Earth Pro

Nest thermostat

Fuel-efficient routing

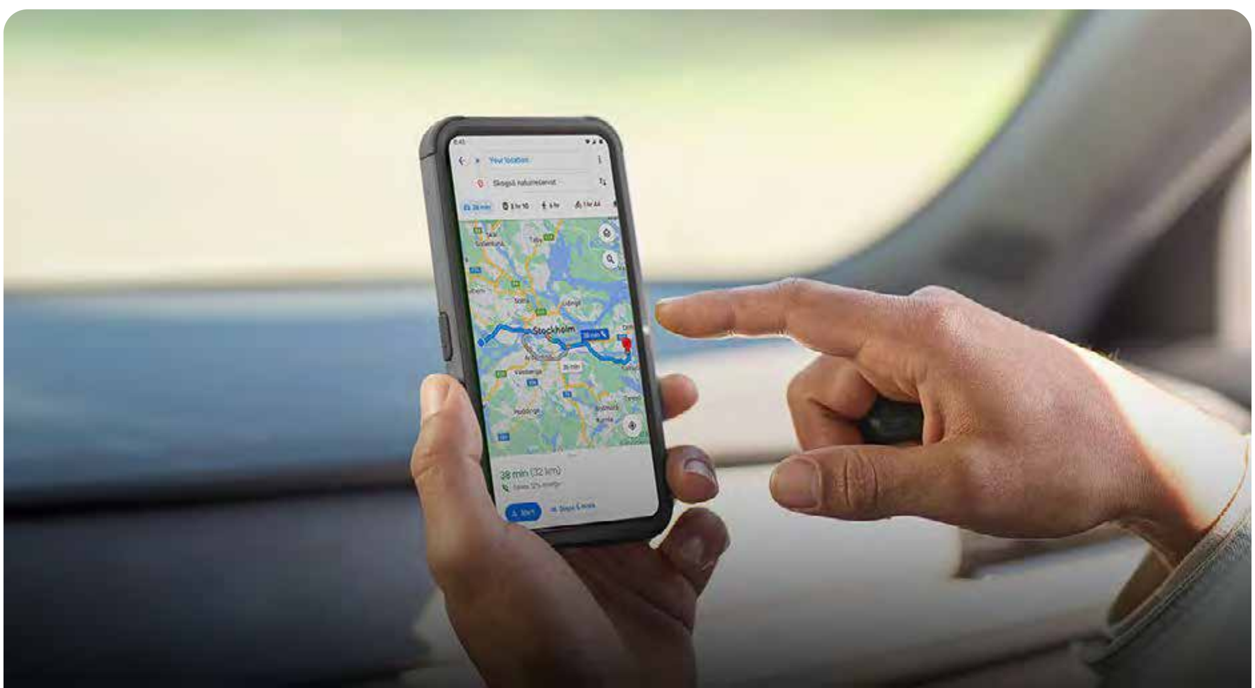
Driving smarter while saving more

Looking for information about how to reduce your environmental footprint when in transit, from heading to work to picking up groceries? What if you learned that you could easily do just that—while also optimizing your fuel or energy use and saving money—every time you drive? Thanks to AI-powered fuel-efficient routing in Google Maps, you can.

We've taken the guesswork out of how to drive more efficiently by suggesting the route that gets you to your destination in roughly the same time. Here's how it works: our AI models analyze factors like your vehicle's engine type, real-time traffic, and road conditions to pick the most fuel-efficient path. For example, a diesel vehicle's efficiency is generally greatest in highway driving, while hybrid and electric vehicles tend to provide progressively greater efficiency in stop-and-go city driving and hilly driving where they benefit from regenerative braking. The result? A more fuel-efficient drive, regardless of your vehicle type, without sacrificing time or convenience.

In 2024, we estimate that fuel-efficient routing enabled over 2.7 million metric tons of GHG emissions reductions[94]—equivalent to taking approximately 630,000 gasoline-powered cars off the road for a year.[95] And it's not just for cars. In places like Southeast Asia, where motorcycles and scooters rule the road, we've expanded the model to include two-wheelers as well.

As of January 2025, fuel-efficient routing is available globally, helping people all over the world cut down on fuel or energy use, reduce their impact, and help their wallet. It's a seemingly simple approach that underscores the power of technology to facilitate more sustainable choices in everyone's daily lives.


Fuel-efficient routing in Google Maps.

Green Light

AI for more efficient city streets

Anyone who's spent time in a major city knows the feeling: long periods sitting in traffic, bumper to bumper, waiting for that light to turn green. But beyond the inconvenience, stop-and-go traffic has an environmental toll. Emissions from idling cars, constant acceleration, and braking contribute to air pollution and fuel waste—and city intersections are a hotspot for this problem.

While some amount of stop-and-go traffic is unavoidable, part of it is preventable through the optimization of traffic light timing. To improve this timing, cities need to either install costly hardware or run manual vehicle counts. Both of these solutions are expensive, and neither provides all the necessary information.

So what can cities do? The solution: Green Light, Google's AI-powered traffic optimization tool.

Green Light by Google

Green Light uses AI and Google Maps driving trends to optimize traffic light timing, ensuring that cars spend less time idling and more time moving. It works by analyzing traffic flow at intersections, using data to recommend timing adjustments for red and green lights to reduce fuel-wasting stop-and-go traffic. The AI model looks at factors like traffic volume, vehicle speed, and intersection congestion to find the most efficient traffic light schedules.

In cities where Green Light has been implemented, the results have been promising. Our analysis from intersections implementing Green Light recommendations indicates the potential to reduce stops at intersections by up to 30% and reduce emissions at intersections by an average of over 10%.[96] It's like giving the city a smoother flow, without the need for costly infrastructure overhauls.

Real-world results

Recommendations from Green Light have been implemented across many intersections, helping to save fuel and lower emissions for more than 47 million car rides monthly.[97] **In fact, in 2024, we estimate that Green Light enabled over 3,000 metric tons of GHG emissions reductions.**[98]

These impressive results certainly warrant a green light for further expansion. So we brought the tool to several new U.S. cities in 2024—including Seattle and Boston—and to Santiago, Chile in early 2025. We're now working to scale Green Light from 20 cities to hundreds of cities and tens of thousands of intersections over the next few years.

The impact of Green Light goes beyond just reducing traffic jams or the frustration of waiting at a red light. This tool is a way to help make cities smarter, more efficient, and more sustainable. By optimizing traffic flow, we're not only helping reduce emissions—we're also easing congestion, reducing pollution, benefiting resident health and quality of life, and contributing to a more efficient urban environment.

Solar API

How we're democratizing solar power from rooftops to the grid

The promise of clean, abundant energy from the sun is a compelling one. But despite its potential, many people still find solar adoption challenging. Between the up-front costs, understanding how much energy you could generate, and figuring out where to install panels, it can feel like a daunting challenge.

We've focused on making solar more accessible by using technology to eliminate some of these barriers. Whether you're a homeowner wanting to switch to residential solar, a solar installer looking for data, or a city planner aiming to expand solar infrastructure—Google's tools are helping to make solar energy a reality for more people.

Bringing solar to your roof with Project Sunroof

We launched Project Sunroof in 2015 to help homeowners assess their solar potential. Using aerial imagery, the tool provides personalized solar savings estimates, showing how much sunlight your roof receives and how much you could save on energy bills by installing solar panels. With just your address, you can find out whether your home is a good candidate for solar, how much energy you could save, and how much it would cost. Project Sunroof also provides information about financial incentives—helping users understand available rebates and tax credits that can make solar adoption even more affordable.

Making solar accessible for cities and developers

At the core of this effort is our Solar API, which provides detailed, high-resolution solar potential data for buildings around the world. This tool can be used by solar installers, city planners, and energy companies to target rooftops with the highest potential. **Using machine learning, high-resolution imagery, and advanced modeling, we've mapped the solar potential of nearly 540 million buildings across more than 40 countries.**[99]

This dataset includes information vital for solar assessment: roof size and shape, orientation, shading from nearby objects, and estimated sunlight hours throughout the year. For solar installers and energy companies, having this information readily available can reduce the time and cost of initial assessments, allowing them to focus resources on installations.

In 2024, we pushed this technology even further, using AI to estimate solar potential from satellite imagery for 125 million previously unmapped buildings across 23 countries, including many in the Global South—regions where detailed building information was previously unavailable. This expansion marks an important milestone in overcoming key barriers to solar adoption in emerging markets with limited infrastructure.

Project Sunroof interface showing solar capacity in downtown San Francisco, California.

Enabling others to reduce emissions

As the Solar API has continued to grow with new partners and in new regions, we've been developing an understanding of the impact it's having on the world. **We estimate that around 6 million metric tons of lifetime GHG emissions reductions were enabled by solar panels installed by our partners using the Solar API in 2024 in the United States.**[100] Using an annual accounting basis, we estimate that in 2024, 0.6 million metric tons of GHG emissions reductions were enabled by solar panels installed by our partners in the United States alone.[101]

In the future, we envision a world where every building with solar potential—whether in an urban center or a rural town, in the Global North or the Global South—has access to clean, affordable solar energy. We're working to democratize solar energy, making it accessible to everyone, regardless of where they live, and empowering people with the information they need, when they need it, to harness the power of the sun.

The Solar API offers coverage (illustrated in yellow) for nearly 540 million buildings across more than 40 countries.

Contrails

How AI can help mitigate the warming effects of aviation

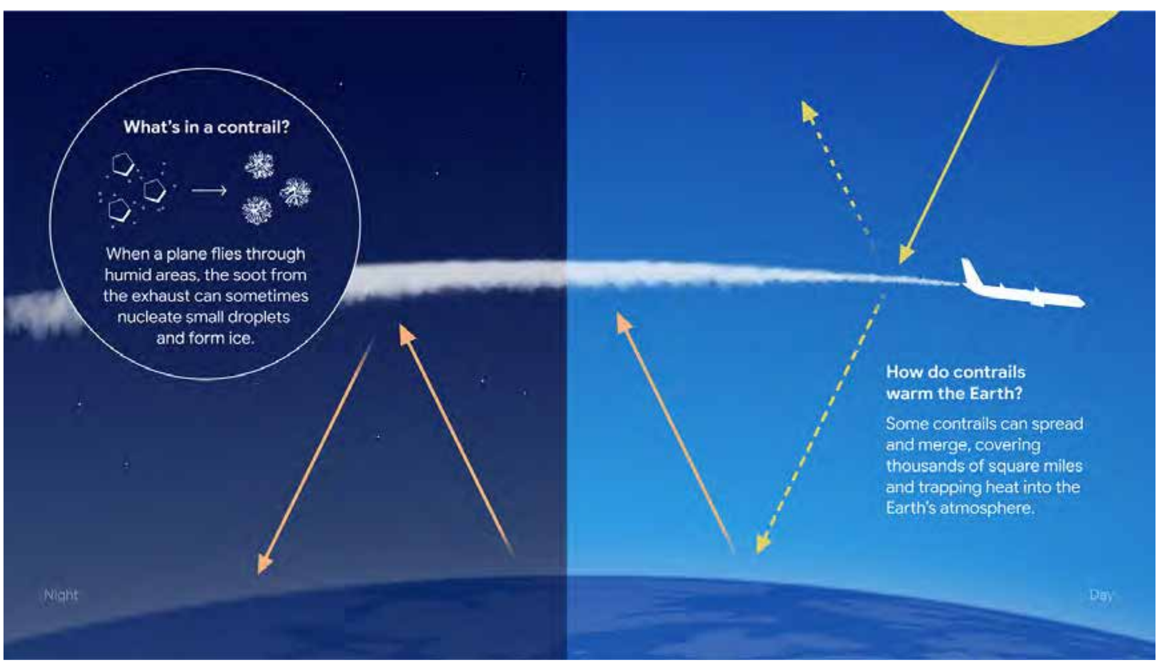
What exactly are contrails?

Contrails, short for condensation trails, are the line-shaped clouds that you sometimes notice behind airplanes. They form when water vapor in the air condenses around tiny particles of soot and other pollutants emitted by airplane engines (Figure 10).

While they might seem temporary, contrails can persist for hours and spread into cirrus-like clouds that trap heat in Earth's atmosphere. This heat-trapping effect is particularly potent because it happens high in the atmosphere where temperatures are already low. Scientists have determined that contrails account for approximately 35% of aviation's global warming impact[102]—a surprisingly large percentage that receives relatively little attention in climate discussions.

Planes don't always make contrails. Contrails only occur when planes fly through humid regions. If planes intentionally avoid flying through these regions, then they can avoid creating warming contrails, often with minimal impact on fuel usage. The challenge is knowing where these regions will occur.

Figure 10. What are contrails?



A cost-effective and scalable solution without the wait

Unlike many solutions that require completely rebuilding infrastructure or waiting for new technologies to develop, contrail reduction is something that could be implemented almost immediately with existing aircrafts. Airlines and their pilots just need to know exactly where and when contrails will form to avoid those specific atmospheric conditions.

That's why we partnered with Breakthrough Energy and American Airlines to develop AI models that analyze atmospheric data to predict contrail formation with remarkable accuracy. The system processes massive quantities of weather, satellite, and flight data to identify when and where contrails are likely to form.

With these predictions, airlines can make slight adjustments to flight paths—sometimes changing altitude by just a few thousand feet—to avoid these contrail-forming zones while maintaining safety and with minimal additional fuel consumption.

From testing to takeoff

Our testing has shown extraordinary promise. **In one trial consisting of 70 test flights, flights that adjusted their routes using our AI-based contrail predictions showed a 54% reduction in contrail kilometers**, when compared to control flights that didn't have access to the AI predictions.[103] In this trial, we also found that the flights that were rerouted to avoid creating contrails only used an average of 2% additional fuel, compared to control flights.

What makes this approach particularly attractive is its efficiency. A study found that only a small percentage of flights would need adjustments to avoid the majority of potential contrail formation.[104]

Our analysis suggests that the cost of reducing contrails through navigational avoidance could be in the range of \$5–\$25 per tCO_2e—making it a cost-effective climate solution that's available today.[105] For comparison, many carbon removal technologies cost hundreds of dollars per ton[106] while sustainable aviation fuel costs thousands of dollars per ton.[107]

In 2024, we expanded this work by beginning a collaboration with EUROCONTROL to apply our contrail prediction technology in Europe's airspace—a busy and complex air-traffic environment. This partnership represents a key step toward mainstreaming contrail avoidance as a standard practice in aviation.

The flight path toward clearer skies

The contrail reduction opportunity points to a broader theme in climate innovation: some of the most impactful solutions don't require waiting for breakthrough technologies or completely rebuilding infrastructure. Sometimes they simply require using existing information in new ways.

As we continue this work, we're seeing growing interest from airlines and air navigation service providers. The aviation industry, which has struggled to find immediate pathways to significant emissions reductions, has a near-term opportunity in contrail avoidance that can be implemented while longer-term technologies like sustainable aviation fuels and electric aircraft continue to develop.

For passengers, the changes are virtually invisible—an occasional slight change in altitude that most won't even notice. But these small adjustments could collectively be substantial, reducing aviation's overall climate impact.

AI for extreme events and disaster response

AI for extreme events and disaster response

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As extreme weather events intensify—like we saw in 2024 with devastating floods in Spain and other parts of Europe and heatwaves that brought record-breaking temperatures across Asia, with India recording its hottest day in May 2024[108]—it's clear that the need for novel research and engineering innovations to enhance resilience is only growing.

Building resilience is about the ability of communities, ecosystems, and economies to cope, adapt, and thrive despite the challenges posed by a changing planet. This means proactive preparation for future impacts, coupled with effective management of current ones. We're helping the world adapt and transform, emerging stronger and better equipped to face what's ahead.

At Google, we're using our technological capabilities to tackle this head on. We're focused on developing advanced forecasting and early warning systems that give communities the critical tools they need to predict, prepare for, and respond to these growing threats. By combining AI, data, and machine learning, we're working to ensure that when disaster strikes, people have the information they need to act fast.

But disaster response doesn't start when the storm hits—and it doesn't end when the skies clear. That's why we're focused on the full timeline of support: before an event occurs, during the disaster, in the immediate aftermath, and in the long-term work of understanding risk and preparing for what's next. We're also working closely with state and local governments, as well as organizations like the World Meteorological Organization, under the banner of the UN's Early Warnings For All initiative, so that we can ensure the information we provide is accurate, timely, and accessible.

We've seen firsthand how our platforms—like Search and Maps—become vital resources during disasters, so we're looking for ways to better serve our users during extreme weather events. In the United States, for example, we know that users turned to Google Search as a key resource during major disasters like hurricanes Helene and Milton in the fall of 2024 and the Los Angeles wildfires in January 2025.[109] We've also seen that extreme events can act as a stimulus—including for those not directly affected by the event itself—to investigate how climate change can affect the frequency and intensity of extreme events.

We'll continue to research and develop new ways to support users and scale these tools globally—especially for the most vulnerable communities, so they can protect what matters most.

Battling the blaze

How AI, satellites, and maps are helping us fight fire faster

In January 2025, wildfires swept across the hills outside Los Angeles. Working in tandem with satellite data and mapping technology, Google Search and Maps provided information to help manage the wildfire, such as road closures and nearby hotels that were offering free or discounted accommodations to anyone displaced by the wildfires. It was a clear example of how technology is transforming disaster response—and building resilience to such events—thanks to AI, satellites, and a whole lot of data.

FireSat, a system to identify wildfires earlier

Imagine being able to detect a wildfire as small as the size of a garage anywhere on Earth (Figure 11). That's the promise behind FireSat. Born from an idea at Google Research, the FireSat initiative officially launched its first wildfire-detecting satellite in March 2025. This pioneering effort leverages technology to gather high-resolution and frequent data, and employs AI to analyze it—providing critical, rapid insights to firefighters. The idea became a reality through key partnerships across philanthropy, scientists, industries, and the establishment of the Earth Fire Alliance in 2024.

FireSat satellites were developed by Muon Space in collaboration with Earth Fire Alliance, with leadership and support from Google, the Gordon and Betty Moore Foundation, Environmental Defense Fund, and others. Funding for the first satellite in the FireSat constellation came in part from Google.org (Google's philanthropic arm), which provided $13 million as part of the AI Collaborative: Wildfires, an initiative to harness AI's potential in reducing the economic, humanitarian, and environmental damages from catastrophic wildfires and building long-term resilience to such disasters.

Figure 11. FireSat is the first satellite constellation to focus on early detection in high resolution imagery

The first satellite launched in early 2025, with plans for more than 50 to follow in the years to come, led by the Earth Fire Alliance coalition. Once fully operational, the FireSat program will provide near real-time data on the location, size, and intensity of all wildfires on Earth every 20 minutes or less. This means emergency crews will be able to act quickly—often before a small fire has the chance to escalate. The ability to detect fires early in their life cycle could significantly reduce the damage they cause, making firefighting efforts more effective and ultimately saving more lives, homes, and communities.

Wildfire mapping

Wildfires spread rapidly, change direction unpredictably, and often begin in remote areas where early signs could go unnoticed. Once a fire ignites, it can engulf large areas in a matter of hours, devastating communities and ecosystems, so the window of time between detection and response is narrow.

One of our most visible tools is AI-powered wildfire boundary tracking, which uses satellite data to refresh fire maps every 15 to 20 minutes, offering a near real-time picture of the fire's spread. These updates appear in Google Search, Google Maps, and even in location-based push notifications. **In 2024, our crisis alerts provided timely wildfire information to over 26 million users across more than 480 wildfire events around the world**—including the devastating fires in the Attica region of Greece in August 2024.

This work not only helps emergency responders assess where the fire is currently, but also assists in creating evacuation routes and alerting nearby residents to evacuate or take protective measures. By providing timely and accurate information, this technology aids community resilience in the face of these challenging events. The updates provided by this technology can be the difference between safety and catastrophe, offering essential information to people when they need it most.

Bridging the gap from detection to prediction

The best way to address wildfire risk is before a fire even starts. To help, Bellwether—a prediction engine for the Earth and everything on it, and a part of X, Alphabet's moonshot factory—has built an AI-first wildfire risk forecasting system to understand the future probability of wildfire in the United States, Canada, and Australia.

Named one of TIME's "Best Inventions of 2024," Bellwether will offer insights that can help governments and communities plan ahead based on the probability of wildfires before they happen. Instead of reacting after the fire starts, the system will give communities and emergency responders the foresight to take action before a disaster strikes.

Through partnerships with agencies like the U.S. Forest Service, we're also improving fire-spread prediction models. These models use machine learning to simulate how fires might move across landscapes, based on a range of factors such as weather, terrain, and past fire data. This means firefighters can arrive at strategic locations and begin mitigating damage before the fire becomes too large to contain, potentially saving lives and reducing destruction. The ability to predict fire behavior gives communities the chance to protect themselves and minimize losses.

Taken together, these efforts represent a shift from reacting to wildfires to getting ahead of them. The future of fire response is faster, smarter, and increasingly powered by AI.

Future of forecasts

A new AI revolution is reshaping how we predict weather

If you checked the weather this morning, there's a strong chance it was powered in part by AI. And not just any AI—but a growing suite of deep-learning models that are pushing the boundaries of what weather prediction can do.

The latest breakthrough? WeatherNext, a family of AI models from Google DeepMind and Google Research that produces state-of-the-art weather forecasts. These aren't just upgrades to your standard forecast—they represent a whole new approach.

How it's different

Traditional forecasts rely on physics-based models—essentially solving equations about how air moves through the atmosphere. They're powerful, but slow. Weather systems are also chaotic, involving massive amounts of data, and we can't account for—or measure—every variable. Even small inaccuracies in measurement are quickly magnified.

In contrast, AI models like WeatherNext learn directly from vast amounts of historical weather data, generating predictions much faster.

WeatherNext includes two primary models.

- WeatherNext Graph provides single, precise predictions up to 10 days in advance.
- WeatherNext Gen generates ensemble forecasts—a range of possible scenarios—up to 15 days ahead, helping decision-makers plan for uncertainty.

These models aren't just concepts—they're already transforming how we forecast the weather, helping us make better decisions and improving disaster response, grid reliability, and global food security. We're also sharing our models with scientists and forecasters, to accelerate their work and ultimately benefit billions of people around the world.

More models, more possibilities

Other innovations are joining the forecast revolution. NeuralGCM, developed in collaboration with the European Centre for Medium-Range Weather Forecasts, uses neural networks to simulate the Earth's atmosphere faster than traditional climate models.[110] SEEDS, a generative AI model, can create massive collections of weather forecasts at a fraction of the cost compared to the operational U.S. forecast system.[111]

Some of these models—including MetNet-3 and WeatherNext Graph—are starting to power user experiences on Google Search and Maps improving forecasting of precipitation, cyclones, flooding, and extreme heat.

This work is more than a technology showcase—it's building a foundation for more accurate, accessible weather information everywhere. And as climate change brings more extreme weather, that foundation for resilience will matter more than ever.

Seven-day lead time

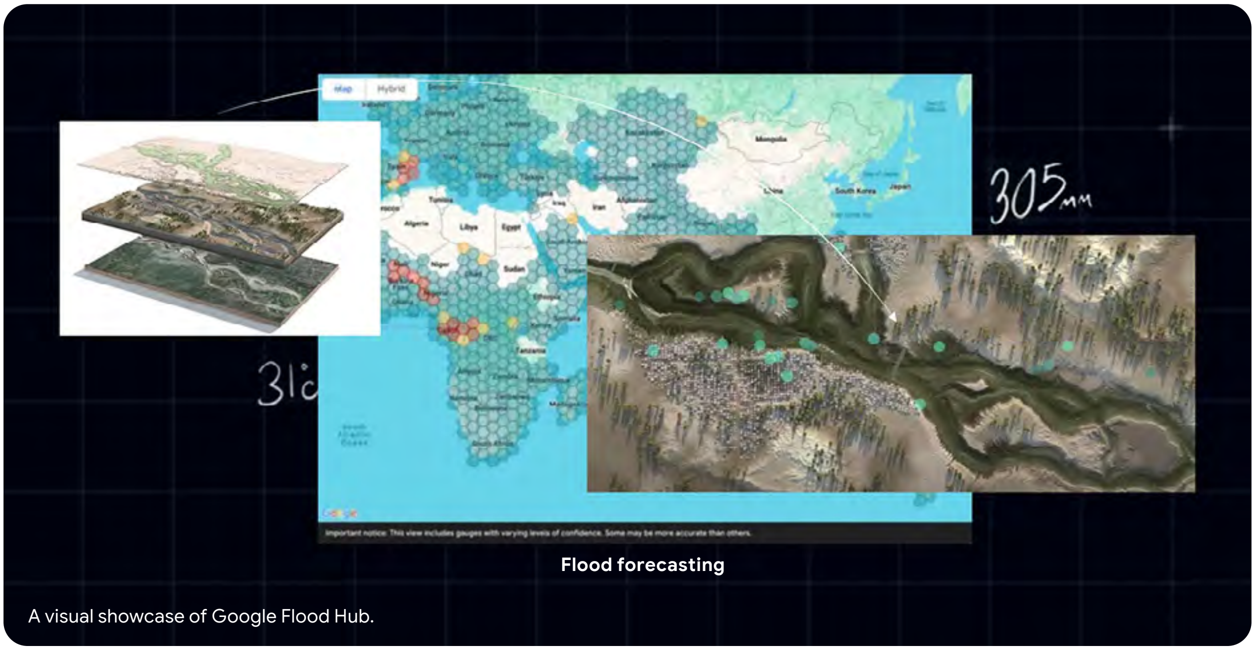
How AI is giving flood-prone communities time to act

Floods are one of the most common types of natural disaster, and roughly 19% of the global population is directly exposed to substantial risks from severe flood events worldwide.[112] When a flood approaches, the difference between chaos and preparedness often comes down to timing: a few extra days can mean sandbags in place, supplies distributed, and people evacuated. That's why Google's flood forecasting initiative, launched in 2018, has focused on giving people more time.

The real-time operational system—visualized on Google Flood Hub—provides alerts via Google Search, Google Maps, and Android notifications and also displays flood forecasts to help governments, aid organizations, and at-risk communities take timely action. **As of the end of 2024, Flood Hub's AI-powered riverine flood forecasting system covered over 100 countries and over 700 million people globally**[113] (Figure 12).

In 2024, we improved our flood forecasting system to offer warnings up to seven days in advance with the same accuracy as the previous model had at five days. That extra window is possible thanks to a new AI model and is crucial for anticipatory action.

Figure 12. Flood Hub view showing extended coverage



A visual showcase of Google Flood Hub.

Making an impact on the ground

In 2024, we generated more than 1,100 crisis alerts that shared critical flood information, including mappings of estimated flooded areas, which were viewed by more than 33 million users. These alerts give people the vital information they need to act before a crisis hits.

Take Brazil, for instance. Aid organizations including World Vision Brazil and its local partners used our flood forecasts to predict the regions that would be affected by floods and quickly deliver child protection services, distribute direct assistance, and provide essentials—such as drinking water, food baskets, and bedding kits—in less than two days.

And in countries like Nigeria and Bangladesh, Google.org supported nonprofits like GiveDirectly and the International Rescue Committee to distribute pre-emptive cash assistance, helping families prepare, boosting their resilience, and shortening recovery time.

New tools for a global problem

For most of history, accurate flood forecasting at scale wasn't possible due to the complexity of the problem and lack of resources and data. Given that only a small percentage of the world's rivers are equipped with streamflow gauges, this provided an extra barrier to safety for people in developing countries as well as in underserved and vulnerable communities.

To fill the gaps in data, we've introduced "virtual gauges"—AI-driven estimates of water levels in regions without physical flood sensors. This means we're able to use AI-based forecasting to improve forecasts in regions in Africa and Asia to a similar quality as those currently available in Europe.

As the effects of climate change become more severe, floods could strike in increasingly unexpected places. So we'll continue using our research capabilities and technology to further increase our coverage as well as forecast other types of flood-related events and disasters, including flash floods and urban floods.

The goal is simple: give people all over the world the information they need—early enough to make it count—and build resilience against increasing flood risks. Because when water rises, seven days can mean the difference between devastation and the critical chance to save lives.

Protecting the planet with our AI products

Protecting the planet with our AI products

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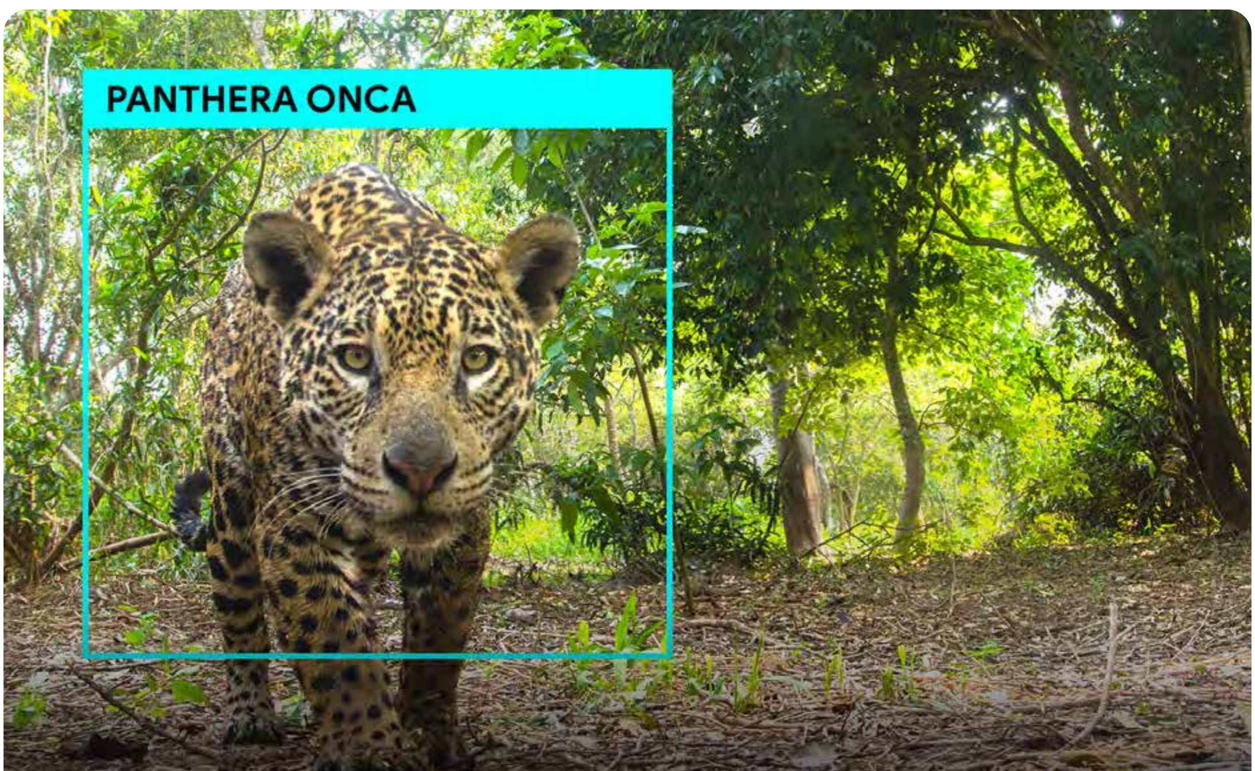
The world's ecosystems are undergoing significant transformation. We're observing changes in forest coverage, shifts in freshwater systems, and impacts on marine environments—trends that highlight the growing pressures on natural resources. While these changes are unfolding at a rapid pace, our ability to track and respond to them effectively has often lagged. We're working to bridge this gap, using cutting-edge technology to make the invisible visible and empower action at unprecedented scales.

We're developing powerful tools that allow us to monitor environmental changes from the vast stretches of the Amazon to the remote waters of the Pacific in real time. But our efforts go beyond tracking ecosystem data—we're working to drive real solutions. With AI-powered tools that protect forests and acoustics that monitor ocean life, we're providing the actionable information and insights that governments, organizations, and communities need to act swiftly and decisively. Through innovation and collaboration, we're working to protect the planet through our products at scale.



Google's AI models identify animal species by analyzing photos from camera traps.

Forests in focus

Empowering the fight against deforestation

We're building tools and working with partners to make spotting signs of deforestation easier and faster to act on—while there's still time to respond.

From satellite images to on-the-ground action

One of the most powerful tools we've built is Google Earth Engine. It's a planetary-scale platform that helps people map, analyze, and monitor changes in land use—from tree cover to water to urban growth. In forest protection, that means being able to see not just where trees are, but where they're being lost—and why.

In partnership with the World Resources Institute (WRI), we've mapped deforestation drivers like agriculture, fire, and logging down to a one-kilometer scale. That kind of detail can help land managers, companies, and governments respond with precision—not just with policies, but with boots-on-the-ground protection where it's needed most.

We're a founding partner of the Forest Data Partnership, which aims to stop deforestation caused by commodity production. To support this partnership, in 2024 we released new global datasets—like maps of rubber-, palm-, and cocoa-growing regions. Now people can see where these deforestation-linked crops are expanding and assess the risk to nearby forests. It's a foundational step for companies trying to develop more resilient supply chains and for regions working to shift toward sustainable production.

Tools that scale around the world

Earth Engine, with its built-in AI capabilities, powers land-use monitoring from Brazil to Indonesia, from the Congo Basin to the American West. It's how the United Nations Environment Programme–World Conservation Monitoring Centre monitors progress toward global biodiversity goals. It's how MapBiomas tracks land change in Brazil. It's even how countries get paid for protecting forests through the REDD+ (Reducing Emissions from Deforestation and Forest Degradation) program. These maps aren't just pixels—they're data that drives decisions, whether that's enforcing protections, documenting illegal clearing, or planning forest restoration.

We're also supporting organizations using AI to track illegal logging from the ground up. With funding from Google.org and in-kind contributions from Google employees, The Nature Conservancy in Brazil developed the Forest Fingerprints (Digitais da Floresta) project—an initiative that uses AI and biochemical analysis to identify and trace the origin of timber extracted from the Amazon. The project aims to reinforce the fight against environmental crimes related to the illegal timber trade. The idea is to bring more transparency—and more accountability—to forest products, starting in the Amazon.

Making deforestation harder to hide—and easier to stop

None of these tools fix deforestation on their own. But they can help put the right information in the right hands at the right time. When businesses can trace their supply chains, they can clean them up. And when policymakers can monitor real-time forest loss, they can act before it becomes irreversible. Forests don't fall all at once, and the right tools can help stop a chain reaction before it begins.

Surfacing solutions

Safeguarding the world's vital freshwater and ocean resources

The story doesn't end with forests. The intricate networks of rivers, lakes, wetlands, and oceans are the planet's circulatory system, and they too are under immense strain. Pollution, overuse, and the impacts of a changing planet are taking a toll.

Through partnerships with scientists, governments, and NGOs, we're building tools that help protect these essential systems. Whether it's monitoring reservoirs in near real time or tracking illegal fishing halfway across the globe, we're working to bring critical insights to light, so action can follow.

Mapping the world's freshwater

Freshwater ecosystems support millions of species and billions of people. But many of them are poorly monitored, especially in regions where data is scarce or outdated.

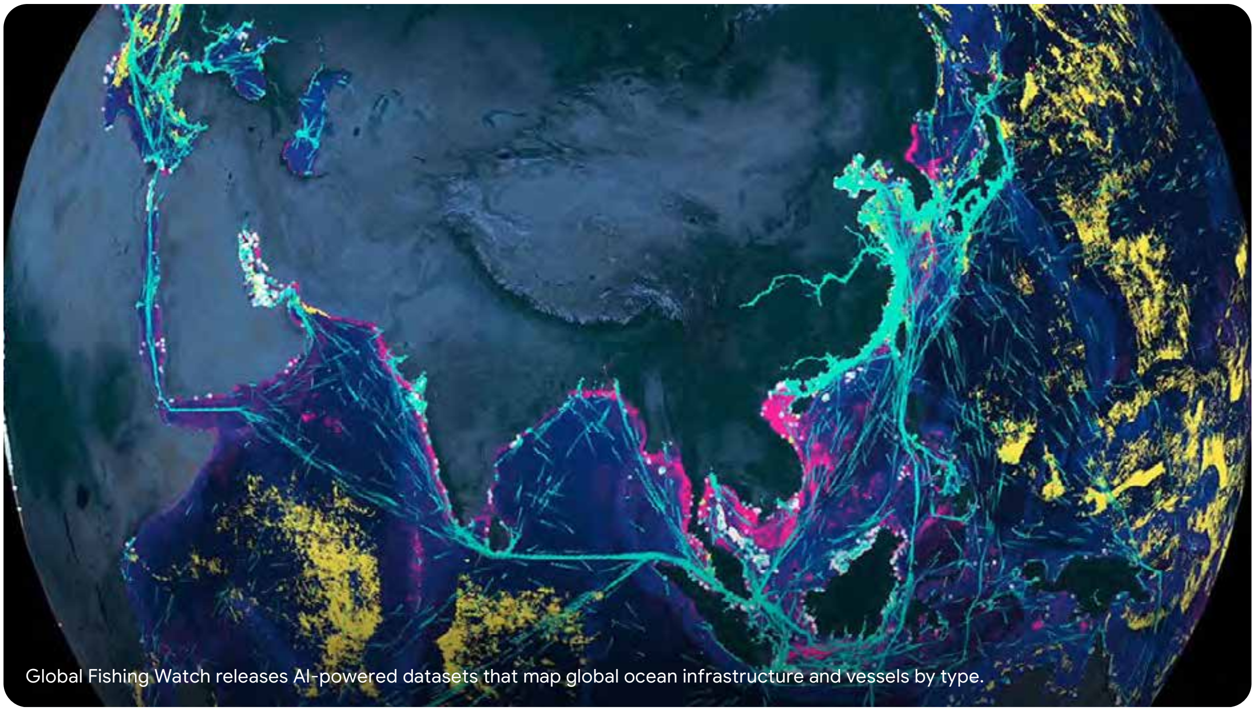
Given this reality, we teamed up with the United Nations Environment Programme and DHI to build the Freshwater Ecosystems Explorer—a free platform that brings together satellite data, AI, and hydrological models. The easy-to-use geospatial platform helps policymakers and scientists see how freshwater systems are changing across countries, river basins, and watersheds. The Freshwater Ecosystems Explorer helps track water levels in reservoirs and spot changes in wetlands—offering a clearer picture of how these systems are shifting over time.

We've also supported other tools aimed at making water data more actionable:

- LeadOut Map, a tool launched by BlueConduit in 2024, uses AI to help cities locate lead pipes for removal in the United States.
- Global Wetland Watch is mapping global wetlands with satellite imagery and AI.
- Global Water Watch offers near-real-time updates on reservoir levels.

And with $2.5 million in funding from Google.org, we're supporting new AI-powered platforms to improve water reuse in drought-prone regions like Mexico and the Middle East. Because clean water isn't just about what you save—it's also about what you can safely use again.

The Global Water Watch tool.



Global Fishing Watch releases AI-powered datasets that map global ocean infrastructure and vessels by type.

Watching and listening to the ocean

The ocean's challenges are as deep and vast as its waters, from overfishing and illegal fleets to warming sea surface temperatures. That's why we co-founded Global Fishing Watch with SkyTruth and Oceana in 2015. The open-source platform uses satellite data and AI to publicly map more than one million ocean-going vessels and fixed infrastructure in near real time—helping governments spot anomalies and take action.

In 2024, the platform expanded to include data on marine infrastructure, GHG emissions, and biodiversity pressures. Governments are now using the tool to plan marine protection areas, guide offshore wind development, and monitor activity from marine vessels.

But not all data shows up on a map. Some signals are easier to hear than see—which is why we're also working with scientists to monitor ocean life using underwater acoustics.

AI-powered acoustic tools are analyzing whale calls to track migration. In the Philippines and Indonesia, we're listening to coral reefs to assess their health. These projects offer new windows into fragile ecosystems that are otherwise hard to study. And when paired with imagery, they become powerful conservation tools.

The challenges facing freshwater and oceans are real, but they're no longer out of sight. Satellite images, sound data, and AI are helping turn murky signals into clear, actionable tools—and helping communities protect the planet.

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About Google

As our founders explained in their first letter to shareholders, Google's goal is to "develop services that significantly improve the lives of as many people as possible."

We believe in the potential of technology to have a positive impact on the world. That unconventional spirit has been a driving force throughout our history, inspiring us to tackle big problems and invest in moonshots, such as our long-term opportunities in AI. We continue this work under the leadership of Alphabet and Google CEO Sundar Pichai.

Alphabet is a collection of businesses—the largest of which is Google. Google comprises two segments: Google Services and Google Cloud, and all non-Google businesses are referred to collectively as Other Bets. Supporting these businesses, we have centralized certain AI-related research and development. Google Services' core products and platforms include ads, Android, Chrome, devices, Gmail, Google Drive, Google Maps, Google Photos, Google Play, Search, and YouTube. Our devices include Fitbit, Google Nest, and Google Pixel devices. Our Google Cloud products include Google Cloud Platform and Google Workspace.

Our headquarters are located in Mountain View, California. We own and lease office facilities and data centers around the world, primarily in Asia, Europe, and North America. In 2024, Google had offices and data centers on six continents, in over 200 cities, across nearly 60 countries. To learn more, refer to our data center locations and our office locations.

About this report

Google's 2025 Environmental Report highlights how our technologies—including cutting-edge AI and emerging research—are driving progress for both people and the planet. Throughout this report, we use the term "sustainability" to refer to environmental sustainability. This report features data from our 2024 fiscal year (January 1 to December 31, 2024), and mentions some notable achievements from 2025 to date.

Additional resources

- Explore our 2025 Environmental Report
- Sustainability.google
- Sustainability reports
- Sustainability blog
- About Google
- Google's commitments
- Alphabet additional information: Environmental
- Alphabet SASB and TCFD Index

Ambitions

Google builds technology for everyone—working to solve complex challenges, advance the field of AI, and help as many people as possible. We approach sustainability the same way we approach our business—by seeking to unlock bold and responsible innovations that create benefits for people everywhere.

To guide our efforts, we set "moonshots"—environmental ambitions that may seem impossible at the time we set them. Progress is often non-linear and may take longer than expected, but continuing to pursue these moonshots can lead to significant, systemic change that might not otherwise be achieved. They help us prioritize our efforts, direct our investments to the highest-impact outcomes, and catalyze deep innovation across the company. Environmental ambitions are particularly unique because they can't be achieved by us in isolation. Instead, they demand broader ecosystem-level change, which requires close collaboration with partners and other stakeholders to reach these crucial outcomes for the planet.

Climate moonshots

We're at the halfway point of the decade, and we've made meaningful progress. **In 2024, we reduced our data center energy emissions by 12% due to new clean energy we brought online**—successfully decoupling our operational energy growth from its associated carbon emissions. **We achieved at least 80% carbon-free energy on an hourly basis across nine out of 20 grid regions with Google-owned and -operated data centers.** We've signed the world's first corporate agreements to purchase advanced geothermal and advanced nuclear energy from small modular reactors (SMRs), used AI to accelerate grid interconnections, created new rate structures for large energy users to buy reliable power, shifted some compute tasks to reduce stress on the local power grid, and more.

And while we remain committed to our climate moonshots, it's become clear that achieving them is now more complex and challenging across every level—from local to global. Several external factors, largely outside our direct control, are converging to create significant uncertainty:

1. **Scalable carbon-free energy technology:** A key challenge is the slower-than-needed deployment of carbon-free energy technologies at scale, and getting there by 2030 will be very difficult. While we continue to invest in promising technologies like advanced geothermal and SMRs, their widespread adoption hasn't yet been achieved because they're early-stage, relatively costly, and poorly incentivized by current regulatory structures.
2. **AI energy demand:** The rapid evolution of AI is fundamentally reshaping our business and the technology industry as a whole. This may drive non-linear growth in energy demand, which makes our future energy needs and emissions trajectories more difficult to predict.
3. **Policy uncertainty:** Shifts in climate- and energy-related policies and regulations introduce significant uncertainty. This policy instability poses new challenges to our planning and progress as it's anticipated to impact clean energy supply and development timing.
4. **Resource-challenged markets, including Asia Pacific:** Some regions are still early in their decarbonization journeys and have electricity grids that are undersupplied with carbon-free energy. For example, many countries in Asia Pacific face unique challenges when it comes to adding new carbon-free energy—including land constraints, low availability of commercially scalable wind and solar resources, and high construction costs.

These external factors could affect the cost, feasibility, and timeline of our progress—and navigating them requires flexibility. To maintain momentum toward our climate moonshots, we'll continue to evaluate a broad range of solutions, balancing cost, quality, and the speed of emissions reductions.

Over the last several years, we've also learned many valuable lessons. We're entering the second half of the decade with a stronger understanding of what's required to make progress, what's achievable in different regions, and how best to maximize the impact of our efforts and investments. Looking ahead, we're charting pathways that are highly ambitious in their approach—taking into account the lessons we've learned, the specific needs and challenges of each region where we operate, and the opportunities we see to drive systemic change.

Carbon-free energy moonshot

We aim to run on 24/7 carbon-free energy on every grid where we operate by 2030.

In 2024, we achieved approximately 66% global average carbon-free energy across our data centers and offices.[114]

One of the most important impacts of our 24/7 carbon-free energy efforts isn't on our own electricity-related emissions, but on the broader power grids in which we operate. Modeling by leading research organizations shows that 24/7 carbon-free energy procurement drives greater impact on grid decarbonization than alternative procurement approaches, with comparative benefits achieved starting at roughly 80% hourly matching.[115] Therefore, we view exceeding 80% as a significant achievement in driving system-level decarbonization, and we're proud to have already achieved at least 80% CFE across nine out of 20 grid regions with Google-owned and -operated data centers (refer to the Environmental metrics data tables for details). What's most important is forward progress.

And while we're making meaningful strides toward this moonshot, progress is uneven across regions. As the table below illustrates, North America, Europe, and Latin America are showing improvements, but the Asia-Pacific region largely remains undersupplied with carbon-free energy.

Year-on-year progress

Regional average Google CFE across Google data center grid regions	Unit	2022	2023	2024
North America	**%**	**69**	**68**	**70**
United States	%	69	68	70
Canada & Mexico[116]	%	96	96	88
Europe, Middle East, & Africa	**%**	**76**	**83**	**83**
Europe	%	76	84	84
Middle East & Africa	%	3	4	5
Latin America	**%**	**90**	**91**	**92**
Asia Pacific	**%**	**11**	**12**	**12**
Global CFE across Google data centers	**%**	**64**	**64**	**66**

Trend

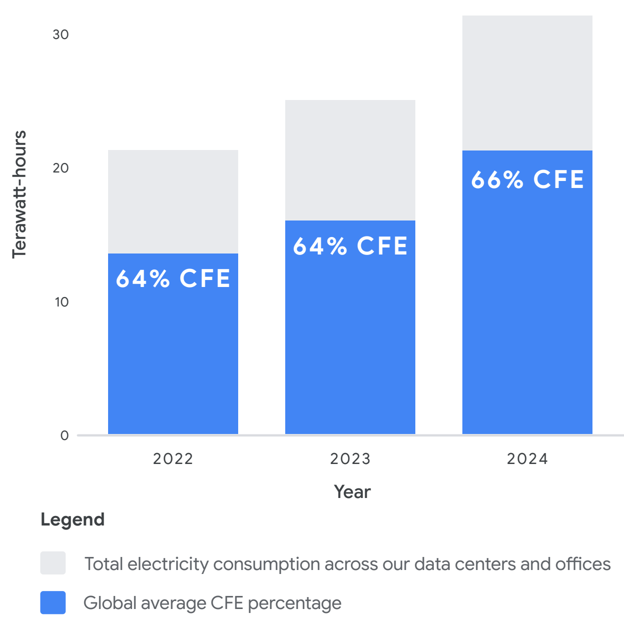
For our global average across our data centers and offices, we increased our Google CFE percentage from 64% in 2022 and 2023 to 66% in 2024[117]—despite significant growth in electricity demand over this period (which was driven, in part, by AI). This was a result of increases in Contracted CFE and overall increases in global Grid CFE, specifically in North America where our energy consumption is highest.

Overall, we increased our Google CFE in over half of our grid regions that contain Google-owned and -operated data centers, and achieved at least 80% CFE in nine out of 20 of these grid regions in 2024.

Details

We set this ambition in 2020. The load-weighted average of carbon-free energy percentages across Google's global portfolio of data centers and offices is referred to as "Google CFE." This metric is inclusive of third-party data centers, and it represents the clean energy purchased to meet our electricity needs at every hour of every day, and within every grid where we operate. For more details, refer to 24/7 Carbon-Free Energy: Methodologies and Metrics.

Graph



Carbon reduction moonshot

We aim to reduce absolute, combined scope 1, 2 (market-based), and 3 emissions by 50% from a 2019 base year by 2030.

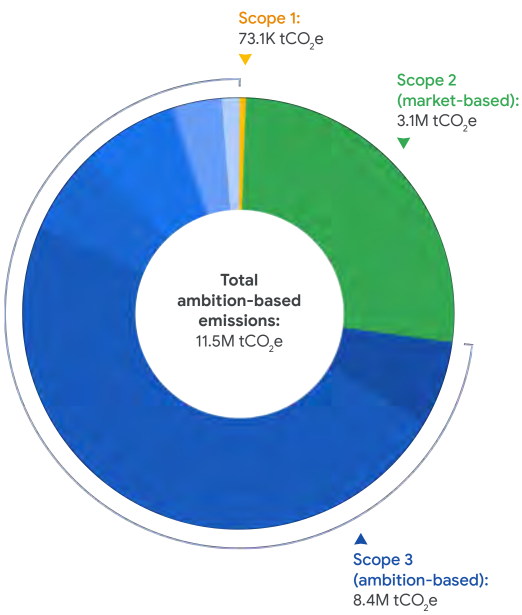
Ambition-based carbon footprint

In February 2025, the SBTi (Science Based Targets initiative) validated Alphabet's near-term science-based emissions reduction ambition based on our data, company structure, and activities at that time, ensuring our ambition meets the most rigorous standards for emissions reductions and contributes to limiting climate change. [118]

In 2025, we adjusted the boundary for our carbon reduction and net-zero ambitions to exclude certain scope 3 emissions activities that are peripheral to our core operations or where our ability to influence emissions reductions is limited (Figure 13). Accordingly, we use the term "ambition-based" to describe the subset of emissions from our total carbon footprint that are within the boundaries we've set for our climate ambitions. The boundary of our ambition-based emissions, and how we measure and report progress, doesn't affect the completeness of our total emissions inventory, which is presented in our Environmental metrics data table.

In 2024, our total ambition-based emissions were approximately 11.5 million tCO_2e, which represent our scope 1, scope 2 (market-based), and scope 3 (ambition-based) emissions.

Figure 13. Our 2024 ambition-based carbon footprint



Legend

Scope	tCO_2e	%
Scope 1	73,100	1%
Scope 2 (market-based)	3,059,100	26%
Scope 3 (Category 1: Purchased goods and services)	739,000*	7%
Scope 3 (Category 2: Capital goods) and (Category 11: Use of sold products)	5,561,000*	48%
Scope 3 (Category 3: Fuel- and energy-related activities)	714,000	6%
Scope 3 (Category 4: Upstream transportation and distribution)	853,000	7%
Scope 3 (Category 5: Waste generated in operations)	12,000	0.1%
Scope 3 (Category 6: Business travel)	399,000	4%
Scope 3 (Category 7: Employee commuting)	137,000	1%
Total ambition-based emissions	**11,547,200**	**100%**

* These totals reflect our ambition-based boundary and therefore exclude certain scope 3 emissions activities. These exclusions collectively account for 25% of our 2019 scope 3 footprint, well within SBTi's guidelines to exclude no more than 33% of base year scope 3 emissions.

Scope 1

The primary sources of our scope 1 emissions are natural gas use for building heating, refrigerant leakage, fuel use from backup generators, and transportation from company vehicles. In 2024, our scope 1 emissions were approximately 73,100 tCO_2e, representing less than 1% of our total 2024 ambition-based carbon footprint.

Compared to 2023, we reduced our scope 1 emissions by 8%, primarily due to building efficiencies and warmer weather conditions that resulted in decreases in natural gas, changes to generator utilization that resulted in decreases in diesel and other fuel usage, and improvements to refrigerant data quality. Our scope 1 emissions reduction efforts to date have focused on electrification, refrigerant mitigation, and renewable fuel use.

Scope 2

The primary source of our scope 2 emissions is purchased electricity for our data centers and offices. In 2024, our scope 2 (market-based) emissions were approximately 3.1 million tCO_2e, representing 26% of our total 2024 ambition-based carbon footprint.

Compared to 2023, we reduced our scope 2 (market-based) emissions by 11%, primarily due to clean energy procurement. For scope 2 emissions accounting, clean energy purchases must be matched following GHG Protocol regional market boundaries. In 2024, we were successful in sourcing more clean energy from within the same regions as our data centers, specifically in North America.

As we have more control over our data centers and offices than many other parts of our value chain, scope 2 emissions are a key focus of our decarbonization efforts. Our scope 2 emissions reduction efforts to date include energy management and clean energy procurement. Our path forward details our forward-looking strategy for clean electricity for our data centers to further reduce scope 2 emissions.

Scope 3 (ambition-based)

Scope 3 emissions are indirect emissions that occur across the supply chain, making them further removed from our direct control and therefore requiring a longer runway to make significant progress. In 2024, our total scope 3 (ambition-based) emissions were approximately 8.4 million tCO_2e, representing 73% of our total 2024 ambition-based carbon footprint.

Compared to 2023, our total scope 3 (ambition-based) emissions increased by 22%, primarily due to increases in data center capacity delivery (i.e., emissions generated from the manufacturing and assembly of technical infrastructure hardware—including for AI—and their logistics, as well as from data center construction).

We expect to increase, relative to 2024, our investment in our technical infrastructure—including servers, network equipment, and data centers—to support the growth of our business and our long-term initiatives, in particular in support of AI products and services. We're focused on decoupling this growth from a proportional increase in emissions, and Our path forward outlines two key areas where we're helping our suppliers to reduce their emissions: clean electricity for our supply chain and low-carbon data center construction.

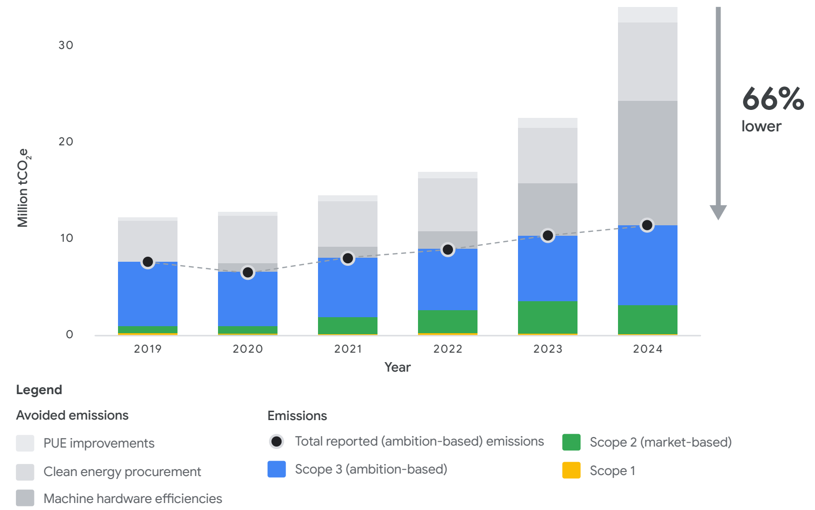
Avoided emissions

For over two decades, we've been implementing initiatives and technological improvements that have helped decarbonize our operations and supply chain.

While our total reported emissions have increased in recent years, these initiatives continue to make a meaningful impact—without them, our emissions would have been higher.

In 2024, we estimate our ambition-based emissions were 66% lower than they would have been without clean energy procurement, machine hardware efficiencies, and PUE improvements[119] (Figure 14).

Figure 14. Avoided emissions

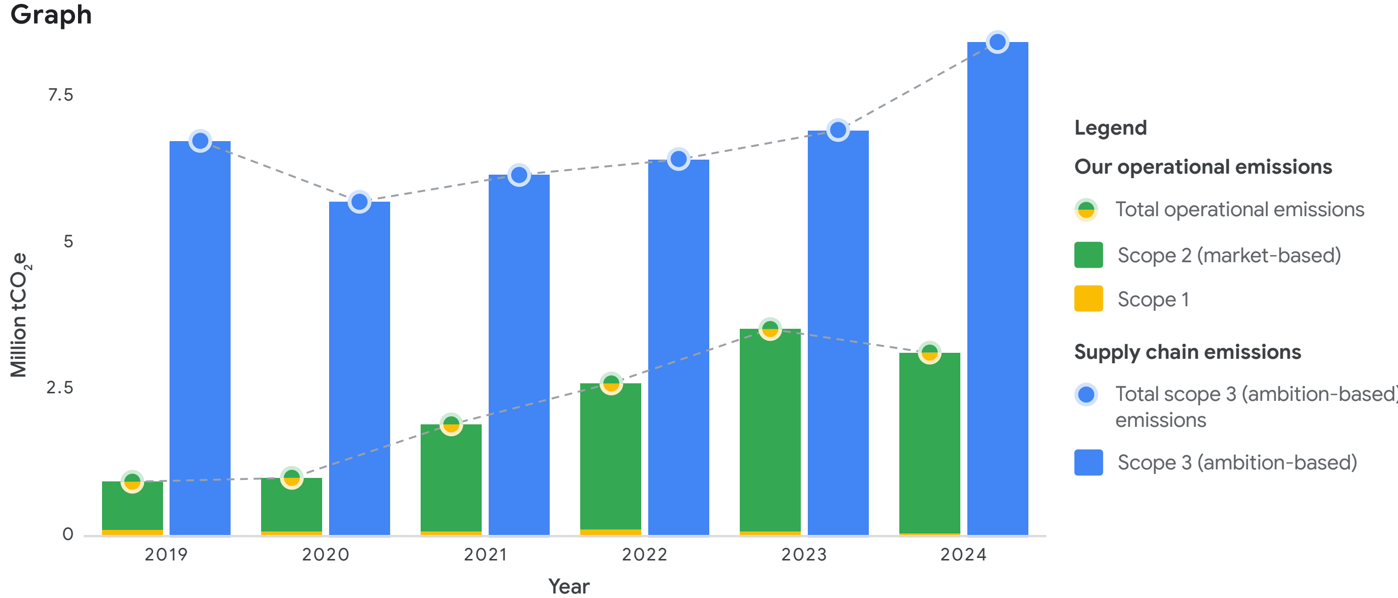


Carbon reduction progress

In 2024, our total ambition-based emissions were 11.5 million tCO_2e, representing a 51% increase compared to 2019.

- Operations: Combined scope 1 and scope 2 (market-based) emissions were 3.1 million tCO_2e, representing a 241% increase compared to 2019.
- Supply chain: Scope 3 (ambition-based) emissions were 8.4 million tCO_2e, representing a 25% increase compared to 2019.

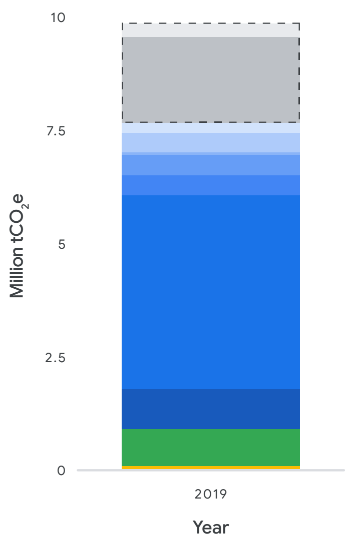
Graph



Year-on-year progress

	Unit	2022	2023	2024
Operations: Scope 1 + scope 2 (market-based)	Year-on-year % change	37% increase	36% increase	11% reduction
Supply chain: Scope 3 (ambition-based)	Year-on-year % change	4% increase	7% increase	22% increase
Total ambition-based emissions	**Year-on-year % change**	**12% increase**	**15% increase**	**11% increase**

2019 base year



Legend

Legend	tCO_2e
Exclusions from scope 3 (Category 2: Capital goods) and (Category 11: Use of sold products)	292,000
Exclusions from scope 3 (Category 1: Purchased goods and services)	1,914,000
Scope 3 (Category 7: Employee commuting)	203,000
Scope 3 (Category 6: Business travel)	461,000
Scope 3 (Category 5: Waste generated in operations)	14,000
Scope 3 (Category 4: Upstream transportation and distribution)	476,000
Scope 3 (Category 3: Fuel- and energy-related activities [not included in scope 1 or scope 2])	425,000
Scope 3 (Category 2: Capital goods) and (Category 11: Use of sold products)	4,292,000
Scope 3 (Category 1: Purchased goods and services)	873,000
Scope 2 (market-based)	835,900
Scope 1	81,900
Total 2019 ambition-based emissions	7,661,800

Trend

In 2024, our total ambition-based emissions were 11.5 million tCO_2e, representing an 11% year-on-year increase and a 51% increase compared to our 2019 base year—primarily driven by increases in supply chain emissions.

The year-on-year increase was slightly offset in that we reduced our scope 1 and scope 2 (market-based) emissions by 8% and 11%, respectively—demonstrating that our operational decarbonization efforts are bearing fruit. This achievement is particularly significant given the 27% increase in our electricity consumption compared to 2023.

Details

Science Based Targets initiative (SBTi) validation:
In February 2025, the SBTi validated Alphabet's near-term science-based emissions reduction ambition based on our data, company structure, and activities at that time.[120]

Scope:
All Alphabet scope 1, 2 (market-based), and 3 emissions with the exception of food program purchases, certain purchased goods and services associated with Alphabet's day-to-day operations,[121] and Other Bets capital goods.[122] Starting this year, in line with SBTi's guidelines, we've excluded these scope 3 activities given they are peripheral to our core operations or our ability to influence emissions reductions is limited. These exclusions are reflected for all reported years of our ambition-based emissions data. These exclusions collectively account for 25% of our 2019 scope 3 footprint, which is well within SBTi's guidelines to exclude no more than 33% of base year scope 3 emissions.[123] To learn more about the methodology behind our GHG accounting and carbon reduction ambition, refer to the <u>Methodology</u> section.

Base year:
When setting our carbon reduction ambition in 2021, the most recent emissions inventory available was from 2020. However, since operations were significantly impacted by the COVID-19 pandemic that year, we determined it wasn't representative of a typical year. Instead, we selected 2019—the most recent year with representative data—as the base year.

Our path forward

In 2021, we set out an ambition to reach net-zero emissions across all of our operations and value chain by 2030. To meet this ambition, we aim to reduce over time our absolute, combined scope 1, 2 (market-based), and 3 emissions by 50% from a 2019 base year, and we plan to invest in a range of carbon removal solutions to neutralize our remaining emissions.[124] This year, we're sharing more details about our approach to this moonshot.[125]

We outline how we're working toward net-zero emissions over the next five years. Our path forward is guided by science, grounded in robust measurement and reporting, and designed to deliver real-world results. It outlines our expected carbon reductions in the coming years, which are based on a multi-year process we've followed to identify and prioritize carbon reduction initiatives,[126] resulting in three key areas that help drive reductions across our operations and supply chain.

A note on the expectations in this section:
We're at an extraordinary inflection point, not just for our company specifically, but for the technology industry as a whole—driven by the rapid growth of AI. This evolving landscape introduces significant uncertainties that may impact our future trajectories and the precision of our forecasting, including:

- Infrastructure, energy, and non-linear growth: The combination of AI's potential for non-linear growth driven by its unprecedented pace of development and the uncertain scale of clean energy and infrastructure needed to meet this growth makes it harder to predict our future emissions and could impact our ability to reduce them.
- Evolving government policies: The policy landscape is constantly evolving, creating uncertainty around future regulations, tax considerations, and other government programs that could impact our business and emissions trajectories.
- New opportunities and risks: The development of AI could create both new business opportunities and unforeseen risks that may alter our plans.

While based on current estimates, the expectations in this section should be considered in light of these factors.

Emissions trajectories

We made meaningful progress in 2024, particularly across our operational emissions (i.e., scope 1 and scope 2):

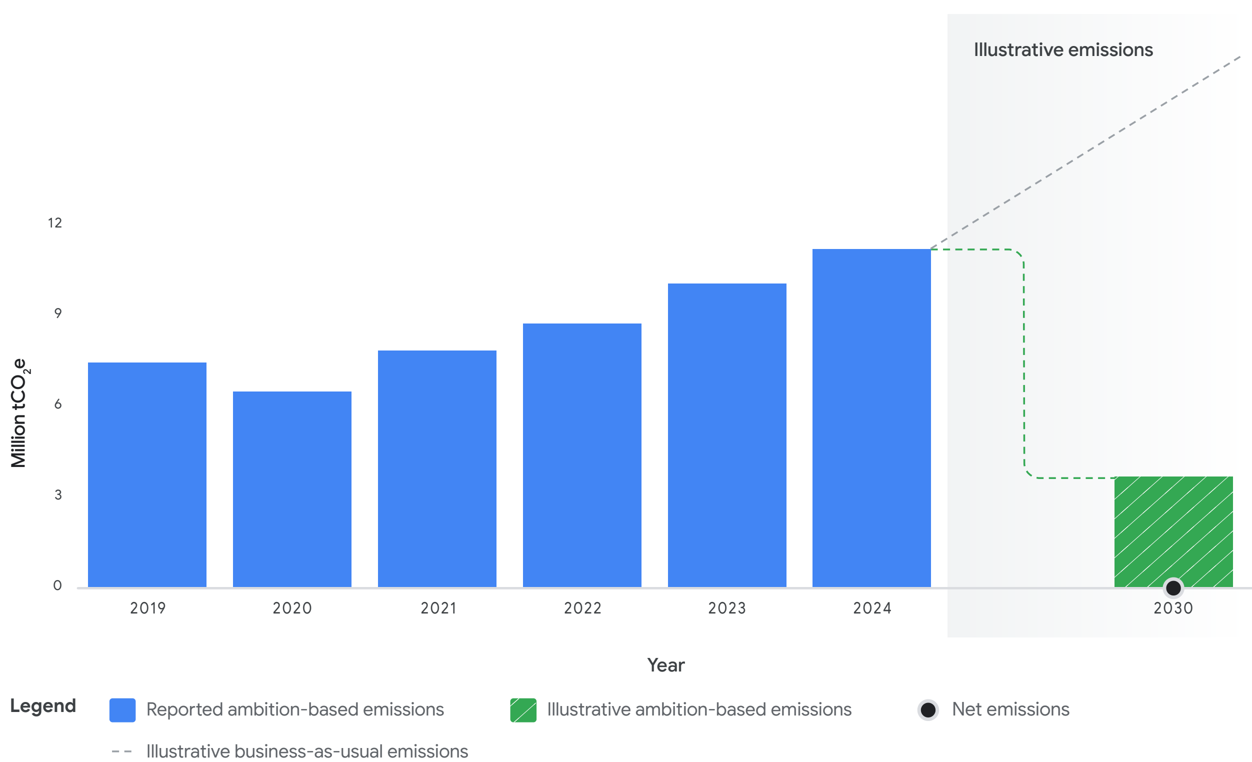
- Scope 1: Our scope 1 emissions decreased by 8% year-on-year in 2024, following a 13% year-on-year reduction in 2023.
- Scope 2: Our scope 2 (market-based) emissions decreased by 11% year-on-year in 2024.

However, the emissions from our supply chain (i.e., scope 3)—which are further removed from our direct control—are still increasing:

- Scope 3: Our ambition-based scope 3 emissions increased by 22% year-on-year in 2024.

Overall, total emissions have grown in recent years alongside the growth of our business and growing product adoption by users around the world (Figure 15). The majority of these emissions are indirect, coming from our supply chain. We're actively working to bend our emissions curve toward our net-zero ambition.

Figure 15. Our path forward[127]



Key reduction areas

Building on the lessons and achievements from our first two decades of climate action, we developed a company-wide approach to guide our progress. Our net-zero approach includes carbon reduction initiatives across scopes 1, 2, and 3. We're prioritizing three key areas of emissions reductions, which we estimate will collectively contribute to the majority[128] of our projected 2030 emissions reductions: clean electricity for our data centers, clean electricity for our supply chain, and low-carbon data center construction (Figure 16).

Figure 16. Expected carbon reductions from key reduction areas and additional carbon reduction initiatives in 2030

Clean electricity for our data centers

We're prioritizing the decarbonization of our operational electricity consumption because it represents the largest reduction opportunity and is an area where we have more direct control—specifically over the energy supply for our data centers and offices—compared to our broader value chain.

In 2024, our scope 2 (market-based) emissions were approximately 3.1 million tCO_2e, about 95% of which resulted from the electricity needed to power our data centers and offices.

Our approach to this key reduction area begins with increasing the energy efficiency of our data centers to help minimize our electricity demand. In 2024, the average annual PUE for our global fleet of data centers was 1.09, compared with the industry average of 1.56, meaning that Google data centers used 84% less overhead energy than the industry average.[129] We'll continue to build on this progress by driving additional energy efficiency and flexibility measures in our data centers—with a focus on our machine learning fleet.

After efficiency, our next focus is on scaling our clean energy procurement across all regions: In 2024, we signed contracts to purchase over 8 GW of additional clean energy generation[130]—more than in any prior year. We're also using Google's engineering expertise and purchasing demand to accelerate the commercialization of advanced CFE technologies and scale their climate impact, and advocating for energy policies that can unlock access to cost-effective and reliable clean energy. And while we're prioritizing clean energy procurement, we're also purchasing T-EACs when local clean energy options aren't available.

Clean electricity for our supply chain

Electricity-related emissions from activities outside our direct operations come from both supplier and non-supplier sources.[131] We use life cycle assessments (LCAs) to determine emissions hotspots, enabling us to focus our efforts on the commodities and suppliers where we can drive the largest carbon reduction.

In 2024, our total scope 3 (ambition-based) emissions were approximately 8.4 million tCO_2e, representing 73% of our total 2024 ambition-based carbon footprint. Approximately 60% of these emissions came from electricity use across our value chain, so our largest opportunity for reducing scope 3 emissions is in enabling our value chain's adoption of clean electricity.

Our approach to this key reduction area is to engage our suppliers to commit to directly procuring clean electricity—or matching their energy use with clean energy—for our most carbon-intensive components. The Google Clean Energy Addendum (CEA) asks suppliers to commit to achieving a 100% clean electricity match by the end of 2029 for the electricity they use to manufacture Google products.[132] By the end of 2024, many key suppliers signed our CEA, and we plan to continue driving clean energy progress within our supply chain through our CEA, clean energy investments, and other initiatives.

While our primary focus will remain on engaging our suppliers to reduce their emissions through clean energy procurement, we'll also continue to explore purchasing EACs for select scope 3 categories in the near term—while continuing to strongly advocate for policy and market intervention efforts that expand supplier access to clean energy.

Low-carbon data center construction

Our data center construction projects are generally multi-year projects with multiple phases. Emissions primarily come from the embodied carbon of construction materials, such as steel and concrete, as well as from vehicles and generators used during construction.

In 2024, emissions from data center construction increased 54% year-on-year, reaching approximately 1.6 million tCO_2e and representing 19% of our total 2024 ambition-based scope 3 emissions. Our data center construction emissions—which are already meaningful and expected to increase in the near term as we build more data centers to meet demand—therefore represent a key area for decarbonization.

Our approach to this key reduction area begins with carbon-aware data center design. We design our data centers with standardization and optimization as core principles, focusing on efficiency and modular scalability to meet our computing needs. The standardized nature of Google's data center designs allow us to reduce the materials required for construction. Our data center design teams have already optimized several core elements of Google's standard data center design—which collectively have the potential to reduce the embodied carbon emissions intensity of a data center building by around 9%. [133]

The use of low-carbon construction materials is another important part of our work in this area. We plan to scale the use of low-carbon concrete across our data center construction projects, as well as expand the use of low-carbon steel—which has the potential to reduce embodied carbon emissions from data center construction by up to 40%. [134] The electrification of on-site construction activities, supported by clean electricity procurement for data center construction, is another way we're addressing data center construction emissions. Additionally, we're maximizing the utilization of our data center capacity, ensuring fully utilized infrastructure and greater space efficiency.

Managing remaining emissions

While our primary focus is on decarbonizing our operations and value chain, we're also committed to neutralizing our remaining emissions by 2030 through a portfolio of carbon credits that serve as high-impact climate solutions, with an eye toward maximizing positive impact on the atmosphere. We're focusing on accelerating a range of projects and forging strategic partnerships that will help us achieve our net-zero ambition.

In 2024, we significantly expanded our carbon removal portfolio, signing 16 new offtake deals representing over $100 million for a total of approximately 728,300 tCO_2e of removal credits. This brings our cumulative total portfolio to approximately 782,400 tCO_2e—a 14-fold increase from our 2023 removal credits portfolio. For more details, refer to the Environmental metrics data tables section.

A core component of this strategy is to play a meaningful role in advancing the development and deployment of a range of carbon removal solutions, which are vital for broader climate change mitigation efforts.

We prioritize two fundamental criteria when considering the climate impact of these efforts: scale and certainty. For scale, we consider whether the solution can become big and affordable enough to make a difference for the planet. Ideally, the most effective solutions will be able to scale up to at least half a gigaton per year of CO_2e reductions and become affordable and widely available in the foreseeable future. For certainty, we strive to ensure that projects deliver their claimed climate impact by rigorously assessing factors like additionality, leakage, permanence, and verifiability.

Water and waste

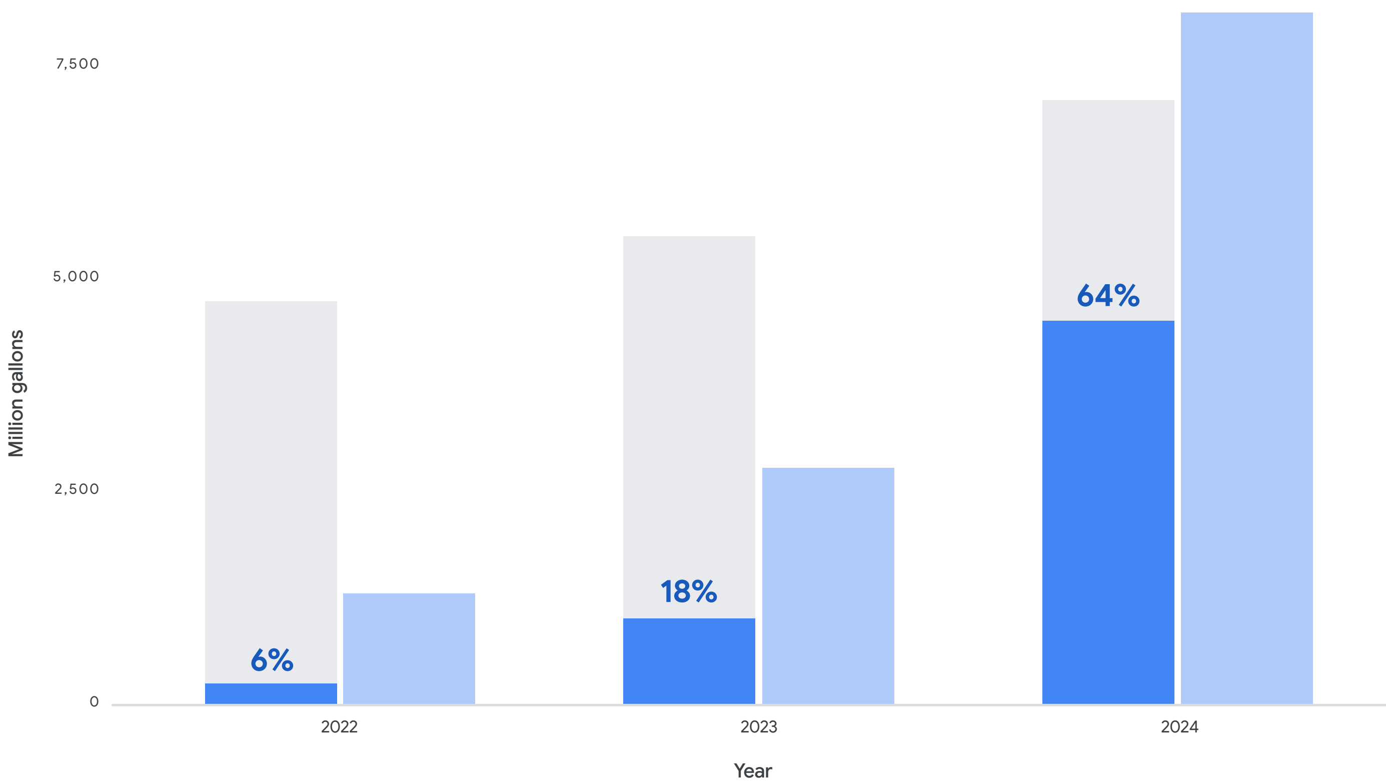
Beyond climate, we've also set ambitions across other operational areas like water and waste. Many of the challenges and uncertainties described above also relate to these ambitions, particularly for water replenishment and data center Zero Waste to Landfill, which are both connected to our data center capacity delivery.

Water replenishment

We aim to replenish 120% of the freshwater volume we consume, on average, across our offices and data centers by 2030.

In 2024, our water stewardship projects replenished approximately 4.5 billion gallons of water (17 billion liters or 17 million cubic meters), or roughly 64% of our freshwater consumption. [135]

Graph



Legend

- Estimated water replenished
- Total freshwater consumption for offices and Google-owned and -operated data centers
- Capacity of all contracted water replenishment projects once fully implemented

Trend

Our water stewardship projects replenished approximately 4.5 billion gallons of water (17 billion liters or 17 million cubic meters) in 2024 alone, increasing replenishment of our freshwater consumption from 18% in 2023 to 64% in 2024. [136] This was the result of both the continued success of our existing projects and the implementation of new projects that have further expanded our replenishment portfolio.

Details

We set this ambition in 2021, and it covers water that's replenished as a percentage of the amount of freshwater we consume each year at our offices and data centers (i.e., excluding seawater and reclaimed wastewater). We count replenishment benefits from projects that are active within the watersheds that our operations rely on and that have confirmed volumetric benefits from the reporting year.

Data center Zero Waste to Landfill

We aim to achieve Zero Waste to Landfill for our global data center operations.

In 2024, 35% of Google-owned and -operated data center campuses achieved Zero Waste to Landfill.

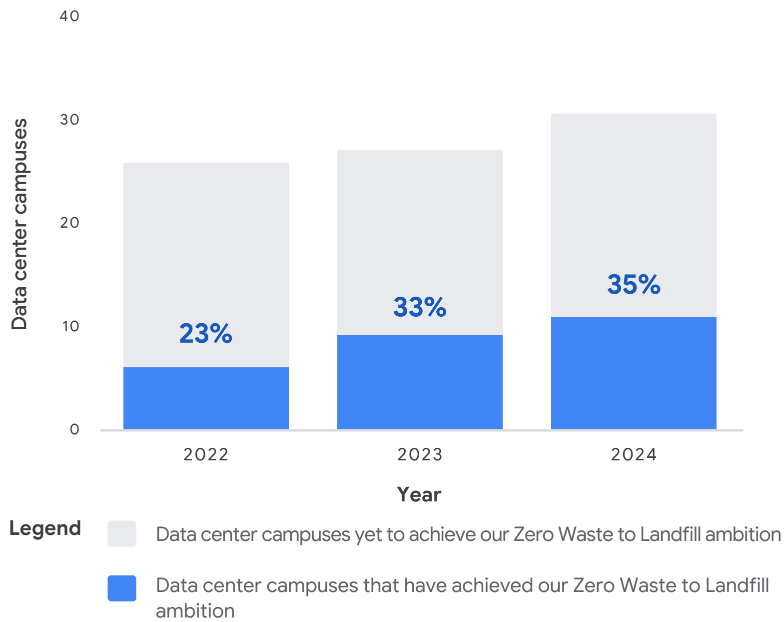
Trend

35% of Google-owned and -operated data center campuses met our Zero Waste to Landfill ambition, up from 33% in 2023.[137] While two additional data center campuses achieved this milestone in 2024, four data center campuses that came into the scope for our ambition did not achieve greater than 90% landfill diversion, impacting our overall progress toward this ambition.

Details

We set this ambition in 2016. With regard to annual operational waste for all Google-owned and -operated data center campuses globally, we consider "Zero Waste to Landfill" for our data center operations to mean that more than 90% of waste is diverted from landfill and incineration, in line with industry standards. Our waste diversion methodology considers thermally processed waste (i.e., incineration), with or without energy recovery, as waste disposal.

Graph



Food waste

We aim to divert all food waste from landfill by 2025.

In 2024, we diverted 85% of food waste from landfill.

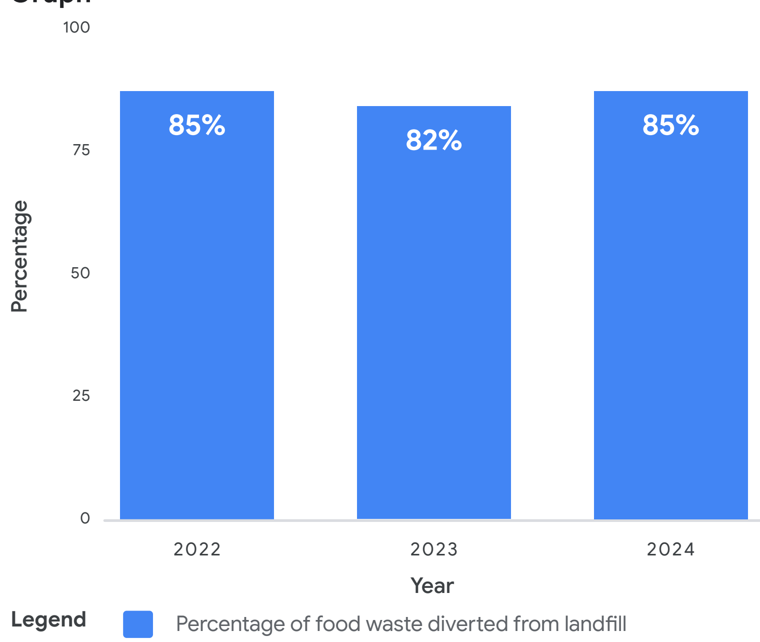
Trend

Our food waste diversion rate increased from 82% in 2023 to 85% in 2024 due, in part, to our focus on improving waste bin sorting guidance and signage. Challenges remain amid limited composting infrastructure in certain regions—including Asia Pacific—which continues to impact our ability to divert food waste from our kitchen and cafe operations.

Details

We set this ambition in 2022, and it covers annual food waste that's diverted from landfills and incinerators in kitchens and cafes at Google's offices globally. We consider sending "zero food waste to landfill" as 99% diversion via composting, anaerobic digestion, donations, or other on-site processing methods—which goes further than the 90% industry standard for Zero Waste to Landfill.

Graph



Recycled plastic

We aim to use recycled or renewable material in at least 50% of plastic used across our consumer hardware product portfolio by 2025.

40% of the plastic Google used in products manufactured in 2024 was recycled content. [138]

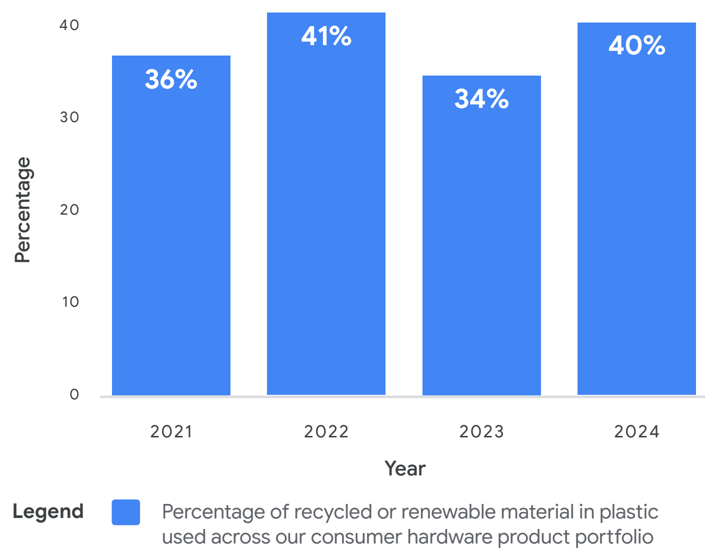
Trend

The percentage of plastic used in our manufactured consumer hardware products that was recycled content increased from 34% [139] in 2023 to 40% [140] in 2024, due to changes in our product mix, primarily driven by a decrease in the manufacturing of Google products with low recycled content in 2024.

Details

We set this ambition in 2020, and it includes the minimum percentage of recycled or renewable plastic content calculated as a percentage of total plastic (by weight) in Google's consumer hardware portfolio for products manufactured in a given year. The following may be excluded from the calculation of percentage: printed circuit boards, labels, cables, connectors, electronic components and modules, optical components, electrostatic discharge components, electromagnetic interference components, films, coatings, and adhesives. Renewable content consists of plastic made from bio-based material. This ambition doesn't include third-party products such as the Nest x Yale Lock.

Graph



Plastic-free packaging

We aimed to make product packaging 100% plastic-free by 2025.

We reached our ambition early: Packaging for new Google products launched and manufactured in 2024 was 100% plastic-free. [141]

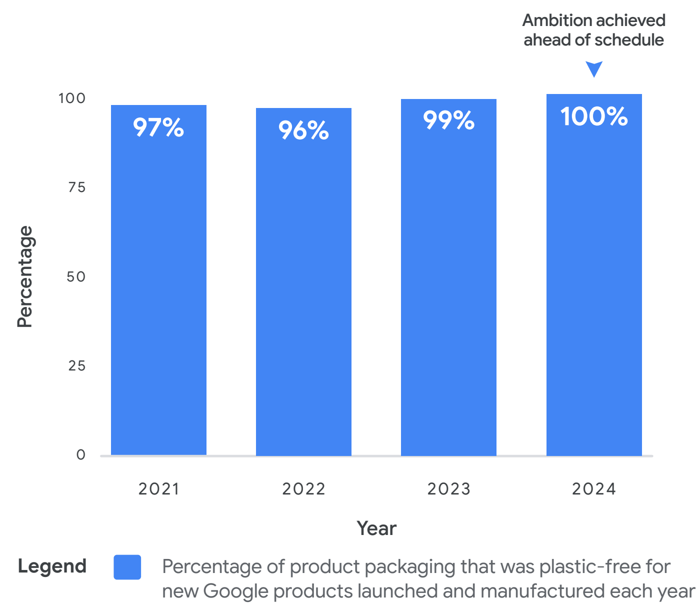
Trend

The increase from at least 99% plastic-free packaging in 2023 to 100% in 2024 was primarily due to packaging innovations, including implementing fiber-based solutions in our packaging material catalog. [142]

Details

We set this ambition in 2020, and it is based on the total weight of new Google Pixel, Nest, and Fitbit retail packaging globally (excluding adhesive materials and required plastic stickers) for products launched and manufactured in a given year, as shipped by Google.

Graph



Governance and risk management

Sustainability governance

Alphabet's Audit and Compliance Committee has the primary responsibility for the oversight of a number of risks facing our businesses. It reviews and discusses with management any major risk exposures, including sustainability risks, and the steps that Alphabet takes to detect, monitor, and actively manage such exposures. Our Sustainability Focus Area, an internal management team led by our Chief Technologist, Learning and Sustainability, provides centralized management oversight of sustainability and climate-related issues. The Sustainability Focus Area includes the Chief Sustainability Officer and executives from across the company with diverse skills, from teams such as operations, products, finance, marketing, legal, communications, and policy, among others. Through the Sustainability Focus Area, sustainability and climate ambitions are built into our company-wide goals, plans of action, management policies, performance objectives, and how we monitor progress.

Net-zero governance

Our net-zero ambition is governed by a framework to ensure accountability at all levels. We've launched a company-wide net-zero governance model that includes cross-functional planning processes, a company-wide carbon reduction and net-zero approach, and central resourcing. A critical part of the framework is our net-zero working group, a monthly forum of cross-functional leaders who convene and drive the execution and operationalization of our carbon reduction and net-zero ambitions, primarily through advancing progress on key carbon reduction initiatives. In this forum, a central team coordinating the cross-company efforts provides updates that help the working group align on priority areas, foster effective collaboration, and make informed decisions. We also share quarterly updates and hold bi-annual engagement sessions across our senior leadership (which can include our VPs, SVPs, CFO, and CEO), providing a direct line of communication between the leadership team and the teams responsible for executing our net-zero strategy. This engagement enables senior leaders to provide guidance, remove roadblocks, and ensure that resources are allocated effectively to support our net-zero initiatives.

Risk management

Our Enterprise Risk Management (ERM) team works with subject matter experts across the enterprise to identify, assess, and report risks related to the company's operations, financial performance, and reputation. As with financial, operational, and strategic risks, Google assesses environmental risks as part of the company's overall risk management framework.

Risks and opportunities identified support public disclosures and inform Google's environmental sustainability strategy. Our Chief Sustainability Officer and sustainability teams work to address risks by identifying opportunities to reduce the company's environmental impact from its operations and value chain, and by improving climate resilience.

Climate-related risks

Climate-related risks and opportunities can span multiple time horizons and may have varying levels of uncertainty regarding how climate trends, policy, and socioeconomic factors might evolve in the future. We've used qualitative and quantitative risk assessments to identify climate-related risks and opportunities and understand their associated impact. We've aligned our climate risk assessment process closely with the recommendations of the Task Force on Climate-Related Financial Disclosures (TCFD), and we've leveraged the TCFD categories of risks and opportunities and conducted climate scenario analyses. We use our ERM rating scales (i.e., impact, frequency, likelihood, control effectiveness) to identify and prioritize areas of focus. We've analyzed climate-related risks and opportunities across three time horizons—short term (through 2030), medium term (through 2040), and long term (through 2050)—for financial, operational, legal, and strategic risks. Climate risks were modeled under high- and low-emissions scenarios for both physical and transition risks using scenarios developed by the Intergovernmental Panel on Climate Change (IPCC) and the Network for Greening the Financial System (NGFS). We considered acute and chronic physical risks (e.g., heat stress, water stress, and extreme weather events), as well as risks associated with transitioning to a low-carbon economy (e.g., energy costs, future regulations, and technology). We also assessed climate-related opportunities (e.g., developing low-carbon products and services, improving energy efficiency, and advancing energy technologies). For more details, refer to our CDP Climate Change Response.

Water-related risks

To identify and assess water-related risks in our direct operations, Google annually undertakes a water risk assessment of our data centers and offices to identify potential water-related risks and opportunities for water stewardship action and risk mitigation. Indicators from available risk assessment tools, including the WRI's Aqueduct Water Risk Atlas 3.0 and the World Wildlife Fund (WWF) Water Risk Filter 6.0, are blended with other metrics to evaluate risks related to scarcity, flooding, water quality, sanitation and hygiene, reputation, and regulatory stressors.

We also apply our data center water risk framework to measure and evaluate site-level water risks and the potential watershed impact to inform our decision-making process for new site selection, cooling system design, and ongoing operations. We apply this framework to every new data center site (including new sites before acquisition and future developments on existing campuses) and aim to repeat these assessments across our existing Google-owned and -operated data center portfolio every three to five years to evaluate water risks that may require mitigation. We also use this framework to inform our water replenishment efforts, by prioritizing replenishment in locations with higher risk.

To identify and assess water-related risks in our supply chain, we've conducted a supply chain water use analysis and a supplier risk assessment using WRI's Aqueduct Water Risk Atlas, WWF's Water Risk Filter, and WULCA AWARE. The key risks identified included baseline water stress, flood risk, access to safe drinking water, and the level of sanitation and hygiene services.

Stakeholder engagement and partnership

We recognize that achieving our own sustainability ambitions and addressing the urgency of climate change and sustainability requires engagement, collaboration, and partnership across a diverse set of stakeholders—both within our operations and supply chain, as well as beyond. That's why we actively engage with a wide range of stakeholders, including employees, suppliers, policymakers, NGOs, customers, researchers and academics, and more. These engagements and partnerships are essential for:

- **Overcoming barriers to unlock new opportunities:** We work together to overcome obstacles and accelerate advancements in sustainability. Only through collaboration can we develop and implement solutions on a global scale.
- **Shared learning:** Our engagement work also enables us to better understand our stakeholders' perspectives, elaborate on our environmental strategy, and advance key ambitions. This creates a vital two-way dialogue that informs our approach to the work.
- **Driving systemic change:** These partnerships are crucial for advancing carbon-free energy technology investment, shaping effective policies, and scaling up climate solutions around the world.

The following content summarizes how we engage with these stakeholder groups.

Employees

Sustainability is embedded within Google's culture. We foster this culture by actively engaging employees through internal groups and learning platforms, while also supporting sustainable commuting and reducing the environmental impact of our employees' business travel.

Community groups and learning
Employees can join global and local internal community groups focused on sustainability. These groups engage in a variety of activities focused on organizing local sustainability activities and raising awareness about environmental topics for interested Googlers. For example, one sustainability-related internal community group has roughly 3,500 members globally. This community group hosts weekly climate talks featuring internal and external speakers and biannual events highlighting sustainability-related 20% opportunities. Google has a program called "20% Time" whereby Google employees are allowed to use 20% of their work time to explore innovative ideas beyond their current roles, enabling engineers with technical skill sets to contribute to addressing climate and sustainability challenges.

Employees can also learn about sustainability through online sustainability courses, internal newsletters, campaigns, and websites.

Employee commuting and business travel
Our transportation team supports sustainable commuting options to help Googlers get to work—like offering shuttles and encouraging carpooling, public transit, biking, and walking. We strive to provide electric vehicle charging stations for 10% of the total parking spaces at our San Francisco Bay Area headquarters, and we continue to work toward this design standard for new development projects. As of 2024, we've installed more than 6,000 electric vehicle charging ports at our offices in the United States and Canada. Google also offers commuter shuttles to many of its campuses to reduce individual vehicle commuting. On average, in 2024, electric vehicles comprised 24% of our commuter "GCab" fleet in India.

We're also working to reduce the impact of our employees' business travel by exploring ways to make air travel less carbon-intensive and supporting the production of SAF at scale. In 2023, Google joined the Avelia Sustainable Aviation Fuel program, which offers SAF credits to corporate customers. Additionally, in 2024, Google joined the United Airlines Ventures Sustainable Flight Fund, a first-of-its-kind effort to provide catalytic investment to drive SAF production. And as a member of the Sustainable Aviation Buyers Alliance, we're also collaborating with other companies to drive SAF adoption.

Suppliers

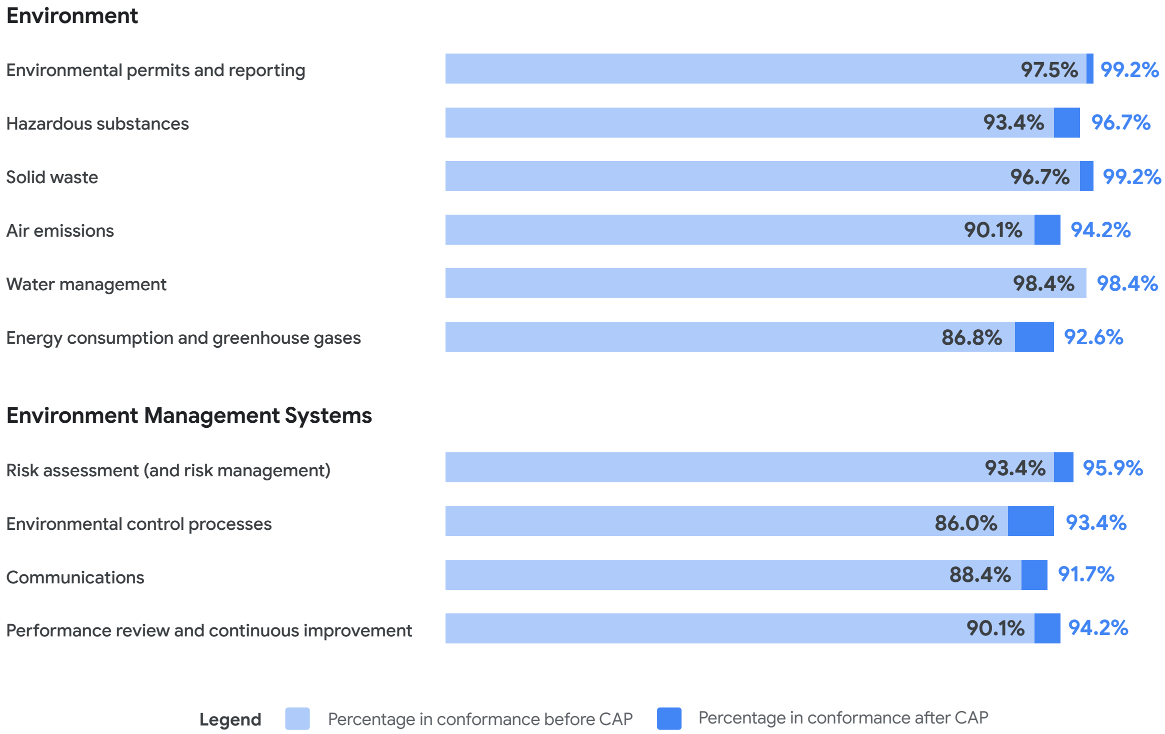
Through our Supplier Responsibility Program, we're working to build an energy-efficient, low-carbon, circular supply chain. We focus on the areas where we can make an immediate and lasting impact, such as helping our suppliers improve their environmental performance.

Google's Supplier Code of Conduct includes requirements that enable us to ensure that those we partner with are responsible environmental stewards. Along with having suppliers evaluate their operations, we perform our own ongoing due diligence and audits with select suppliers to verify compliance and understand our supply chain's current and potential risks.

We investigate any issues identified during an audit, and when we find that a supplier isn't conforming to our expectations, we expect the supplier to provide a corrective action plan that outlines the root cause of the finding, how and when they will resolve the issue, and what steps will be taken to prevent recurrence. We determine whether the plan is acceptable based on our Supplier Code of Conduct requirements. Lastly, we monitor and verify all corrective actions are completed in the agreed-upon time frame, with a process for escalation if necessary to the Supplier Responsibility Steering Team, which comprises our Chief Compliance Officer and leaders from our data center, devices, and extended workforce teams.

In 2024, we audited a subset of our suppliers to verify compliance for various environmental criteria (Figure 17):

Figure 17. 2024 audit conformance data for environmental criteria
The lighter bars show the percentage of unique audited supplier facilities that had no findings for the listed criteria after their audit. The darker bars show the percentage that had no findings after the corrective action plan process was completed.



Reporting environmental data

We work directly with some of our suppliers to collect data. We also encourage suppliers to participate in CDP's corporate questionnaire by asking them to disclose climate- and water-related data via the CDP supply chain platform. In 2024, we invited 227 suppliers to participate, and 96% responded. Of the suppliers that we invited to respond in 2024, 76% reported having GHG emissions reduction targets.

To support these efforts, we work with our suppliers to improve their environmental data collection and accounting, including for their scope 1, 2, and 3 emissions. For example, we provide training on CDP reporting, as well as on setting carbon reduction and renewable electricity targets. In 2024, we hosted a summit for our consumer hardware device suppliers where we discussed Google's ambitions.

Restricted substances

Through our consumer hardware product Restricted Substances Specification and Manufacturer Restricted Substances List, we restrict many hazardous substances with hazard-based requirements and ensure our suppliers have processes in place to detect and prevent them from entering the manufacturing process. We also maintain a Responsible Chemical Management program, which includes assessments, guidance, and training resources to help suppliers better mitigate occupational and environmental risks related to the chemicals they use.

Customers

We're committed to helping our customers achieve their sustainability ambitions, and we offer a variety of tools and resources to support them. We recognize that collaboration and information sharing are crucial for accelerating progress toward a more sustainable future, and we're dedicated to providing our customers with the support they need to make a positive impact.

Google Cloud

Google Cloud offers organizations Cloud and AI products and solutions to drive impact for their business and sustainability. We help organizations harness AI for improved sustainability measurement to build resilience, AI-powered insights to use energy and resources more efficiently in operations and supply chains to reduce costs, and AI tools to unlock new growth opportunities and markets while accelerating sustainability impact and reducing the carbon footprint of Cloud.

- **Measure:** We help organizations use AI-powered insights to monitor their progress toward sustainability targets in order to build business resilience. For example, our Cloud partner Watershed's software platform is used by companies to manage climate and ESG data, produce audit-ready metrics for reporting, and drive real decarbonization.

- **Optimize:** We help organizations work more efficiently by using AI to streamline energy and resource usage across their operations and supply chains. For example, Google Cloud, in partnership with NGIS (and their solution TraceMark), is helping brands gain a deeper understanding of sustainable sourcing practices across supplier networks. By combining the power of our cloud computing, AI, and geospatial analytics, we're helping companies get real-time, global, reliable information into operations at a local supplier level.
- **Grow:** We help organizations adapt their business by using AI to uncover new growth opportunities in the low-carbon transition. For example, we launched SpatiaFi with our Cloud partner Climate Engine—an Earth Finance Company—to help the banking sector harness the power of geospatial analytics to support climate finance.
- **Build:** We help developers take action to reduce the carbon footprint and cost of their applications in their use of Cloud. For example, we've created a Carbon Sense suite so customers can accurately measure, report, and reduce their cloud carbon emissions (through Carbon Footprint) with recommendations for carbon reduction actions (through Region Picker, Carbon-free energy disclosure, and Active Assist). The Carbon Sense suite has experienced significant adoption, with customers monitoring over 65% of total Google Cloud emissions as of the end of 2024. Enhancements to the suite included the addition of scope 2 market-based emissions data, complementing the existing location-based data, which underscores Google's aim of providing transparent and comprehensive emissions reporting for our customers.

Customer carbon footprints

In addition to equipping Cloud customers, we also provide tools to empower Google Workspace and Google Ads customers to measure, understand, and manage the environmental impact of using our products:

- **Google Workspace:** Our Google Workspace carbon footprint report provides data on total and monthly carbon emissions based on the use of various Google Workspace applications.
- **Google Ads:** To help advertising customers measure their emissions from using Google advertising products, we now offer Carbon Footprint for Google Ads. This provides comprehensive carbon emissions reporting data aligned with the Greenhouse Gas Protocol and developed in accordance with the Global Media Sustainability Framework. The reports provide detailed breakouts of scope 1, scope 2 (both market- and location-based), and scope 3 emissions—allocated at the account level.

Researchers and academics

We recognize the vital role that research plays in addressing complex environmental challenges, so we partner with researchers and academics in our collective pursuit of knowledge, innovation, and thought leadership on topics ranging from energy, decarbonization, AI, and more.

In 2024 and early 2025, we published our own studies or collaborated with academics and other partners on the following research:

Topic	Research
Adaptation and resilience	• "A Data-Centric Perspective on the Information Needed for Hydrological Uncertainty Predictions," Hydrology and Earth Systems Sciences, September 2024. • "An Artificial Neural Network to Estimate the Foliar and Ground Cover Input Variables of the Rangeland Hydrology and Erosion Model," Journal of Hydrology, March 2024. • "Generative Emulation of Weather Forecast Ensembles with Diffusion Models," Science Advances, March 2024. • "Global Prediction of Extreme Floods in Ungauged Watersheds," Nature, March 2024. • "Neural General Circulation Models for Weather and Climate," Nature, July 2024. • "Neural General Circulation Models Optimized to Predict Satellite-Based Precipitation Observations," arXiv, December 2024. • "Reproducing Flash Flood Warnings with Machine Learning," European Geosciences Union General Assembly 2024, April 2024.
AI and climate	• "Assessing Large Language Models on Climate Information," arXiv, May 2024. • "Life-Cycle Emissions of AI Hardware: A Cradle-to-Grave Approach and Generational Trends," arXiv, February 2025.
Clean energy	• "24/7 Carbon-Free Electricity Matching Accelerates Adoption of Advanced Clean Energy Technologies," Joule, February 2025. • "Granular Scope 2 Accounting: Achievable Pathways to More Accurate Emissions Reporting," Boston Consulting Group, September 2024.
Manufacturing	• "Overview of F-GHG and Nitrous Oxide Semiconductor Abatement Technologies," Semiconductor Climate Consortium, February 2025.

Topic	Research
Mitigation	• "CANOS: A Fast and Scalable Neural AC-OPF Solver Robust To N-1 Perturbations," arXiv, March 2024. • "OPFData: Large-Scale Datasets for AC Optimal Power Flow with Topological Perturbations," arXiv, June 2024. • "Do Earthquakes "Know" How Big They Will Be? A Neural-Net Aided Study," arXiv, August 2024. • "Feasibility Test of Per-Flight Contrail Avoidance in Commercial Aviation," Communications Engineering, December 2024. • "Google's Quiet Nuclear Quest: For a Decade, Google Has Advanced Fusion R&D and Other Frontiers," IEEE Spectrum, December 2024. • "Probabilistic Weather Forecasting with Machine Learning," Nature, December 2024. • "Satellite Sunroof: High-res Digital Surface Models and Roof Segmentation for Global Solar Mapping," arXiv, August 2024. • "Scalable Learning of Segment-Level Traffic Congestion Functions," arXiv, September 2024. • "On the Relationship of Speed Limit and CO_2 Emissions in Urban Traffic," SSRN, March 2024.
Nature	• "Patterns in Bird and Pollinator Occupancy and Richness in a Mosaic of Urban Office Parks Across Scales and Seasons," Ecology and Evolution, March 2024. • "To Crop or Not to Crop: Comparing Whole-Image and Cropped Classification on a Large Dataset of Camera Trap Images," The Institution of Engineering and Technology, November 2024.

Policymakers

Public policy and advocacy

Policy measures and corporate commitments will continue to play an important role in driving emissions reductions in the next decade.

We've shared sustainability policy positions on the following topics:

- Carbon-free energy: A Policy Roadmap for 24/7 Carbon-Free Energy
- Climate action with AI: Accelerating Climate Action with AI
- Device repairability: Google & Repairability

The following table includes a detailed list of our sustainability policy engagements in 2024:

Global and cross-cutting initiatives
Advanced clean electricity technologies: In 2023, Google published a paper outlining how corporate clean energy buyers can accelerate clean energy technologies by supporting favorable policies, signing long-term purchase agreements, and providing early-stage project funding. In 2024, we published an updated version of this paper to include our detailed procurement criteria for carbon-free energy technologies.
United Nations Framework Convention on Climate Change (UNFCCC) 29th Conference of the Parties (COP-29): Google participated in COP-29, in Baku, Azerbaijan, in over 150 engagements with officials and sustainability industry leaders, partners, and priority stakeholders.
United Nations General Assembly (UNGA): Google participated in 2024 UNGA meetings in New York City, participating in events and discussions with over 200 officials and industry leaders. At UNGA, CEO Sundar Pichai delivered a keynote address that laid out Google's vision for closing the digital divide and how AI can accelerate progress on the UN Sustainable Development Goals.
Policy to deploy digital solutions for climate: In partnership with Deloitte, Google launched the Digital Sprinters: The Road to Sustainability report, which explores how digital solutions like AI can help reduce global emissions and aid in climate adaptation, outling steps governments can take to accelerate this work.
United States
Engagement on U.S. federal sustainability, climate, and energy policy
Executive branch engagement: Google had multiple engagements across the White House; Departments of State, Defense, Energy, and Transportation; and the U.S. Environmental Protection Agency to discuss the role of digital technology and AI in accelerating climate mitigation and adaptation.
Federal Energy Regulatory Commission (FERC) colocation engagement: In November 2024, Google testified before FERC on colocation and, in December 2024, submitted post-conference comments articulating our colocation position on the record. Google views colocation as a potentially helpful tool to address load growth, when done in close partnership and collaboration with utilities and grid planners. Google's position was used to inform positions developed by our trade associations.

Western energy market expansion: Google was an active participant in the West-Wide Governance Pathways Initiative, organized by a group of state regulators. The initiative proposes the creation of a regional organization overseen by an independent governing board that could deliver an electricity market comprising all states in the Western Interconnection—including California. Google filed public comments related to stakeholder engagement and the group's step 2 proposal.

Engagement with coalitions and sustainability initiatives

Electricity customer coalitions: In 2024, the Electricity Customer Alliance (ECA) testified on behalf of Google and other member companies before the U.S. House Energy and Commerce Committee on the issue of AI-driven growth of electricity demand. Additionally, ECA formally submitted comments advocating for the implementation of grid-enhancing technologies at FERC and collaborated with other organizations—including Clean Energy Buyers Association (CEBA), Data Center Coalition (DCC), and Electricity Consumers Resource Council (ELCON)—to advocate for colocation approach consistent with Google's position.

U.S. state engagement

Clean Transition Tariff (utility rate): Google announced a new, first-of-its kind clean energy partnership with NV Energy called a "Clean Transition Tariff" (CTT) that enables Google and other energy users to meet growing power demand cleanly and reliably. The CTT brings utilities and customers together into a long-term energy agreement that can facilitate investments into new projects that deliver clean firm energy to the grid.

Utility regulation: Google participated in many regulatory proceedings and dockets across the United States, collaborating with coalition partners to promote the cost-effective adoption of clean energy resources.

Regulatory frameworks for decarbonization: Google led discussions with the National Association of Regulatory Utility Commissioners on how Google's 24/7 CFE ambition can be a supportive framework to drive cost-effective grid decarbonization.

Europe

Engagement on European sustainability, climate, and energy policy

Energy Efficiency Directive: Google engaged with EU policymakers through DIGITALEUROPE to inform the development of a new EU-wide scheme for rating data center sustainability under an upcoming delegated act.

EU Agency for the Cooperation of Energy Regulators (ACER) PPA templates: We participated in ACER's expert group on PPAs and shared views on the role of voluntary standardized PPA templates in Europe.

European electricity market redesign: In partnership with the RE-Source Platform, we successfully advocated for a stronger role for corporate clean energy buyers in the EU's energy transition, with the adoption of several measures in the final legislation that enhance the role of PPAs.

Granular Guarantees of Origin: Google signed and helped organize a letter from leading companies, NGOs, and industry associations to EU policymakers calling for the faster introduction of Granular Guarantees of Origin (GOs) throughout Europe. Granular GOs help companies track clean energy more accurately, enabling the matching of energy production to consumption on an hourly basis.

Wind power action plan: We worked with other clean energy buyers and developers within RE-Source on input to the European Commission's consultation on design elements of renewable energy auctions' to ensure a level playing field between contracts for difference and corporate PPAs.

Engagement with coalitions and sustainability initiatives

RE-Source Platform: In 2024, Google continued supporting and working with RE-Source to advocate for a stronger role for corporate clean energy buyers within European energy markets. We informed RE-Source's input to the European Commission's consultation on design elements of renewable energy auctions to advocate for policy changes that help unlock the ability of large customers to purchase renewable energy.

European Green Digital Coalition: We helped develop a science-based methodology and guidelines to assess the reduction and avoidance of GHG emissions by information and communication technologies solutions across sectors, which launched in April 2024.

Partnership with European Aviation Safety Agency (EASA): Google collaborated with EASA on the technical development of a ReFuelEU ecolabel, a uniform methodology for calculating flight emissions data. This will increase transparency and empower informed choices by travelers within the aviation sector.

European 24/7 Hub: We worked with the European 24/7 Hub, a collaboration with Eurelectric, to create a platform where energy buyers, suppliers, and policymakers can meet to learn more about 24/7 CFE and receive technical training and implementation guidance.

24/7 Carbon-Free Coalition: Google was one of six companies to join the pilot launch of the Climate Group's 24/7 Carbon-Free Coalition, launched at New York Climate Week in 2024. The Coalition seeks to encourage and support companies to move toward local and hourly matching of their electricity demand with carbon-free electricity.

Corporate Leaders Group (CGL) Europe: Google became members of CLG Europe to advance policies that support Europe's decarbonization objectives.

Asia Pacific

Energy policy in Asia Pacific: Google participated in engagements with energy policymakers and regulators across Asia Pacific via regionally-focused coalitions and initiatives—like the Asia Clean Energy Coalition (ACEC), the SEMI Energy Collaborative (SEMI EC), and the Clean Energy Demand Initiative (CEDI)—to promote cost-effective access to clean energy resources. Google also participated in events with energy policymakers—such as Renewable Energy Markets Asia and Singapore International Energy Week—to advocate for policies that accelerate the decarbonization of grids in Asia Pacific and showcase our 24/7 CFE efforts.

24/7 CFE in Asia Pacific: Google supported and contributed to a paper by Bloomberg New Energy Finance and the Global Renewables Alliance on how 24/7 CFE procurement can advance Asia Pacific's energy transition.

Expanding clean energy procurement in Asia Pacific: We supported a paper by the Clean Energy Buyers Association (CEBA) and the Asia Clean Energy Coalition (ACEC) on how high-impact utility green tariffs can allow utilities and companies to partner to decarbonize grids in the Asia-Pacific region.

Supply chain decarbonization: We supported Singapore's National Climate Change Secretariat, part of the country's Prime Minister's Office, with the Climate Leaders' Assembly held during New York Climate Week in 2024. In particular, we convened a roundtable on "APAC's role in decarbonizing supply chains."

Trade associations and third-party groups

We belong to many sustainability-focused third-party groups through which we engage on sustainability policy issues around the world. Refer to Figure 18 for an overview of our participation in these groups.

Figure 18. Select list of Google's participation in sustainability-focused trade associations, memberships, and groups

- Advanced Energy Buyers Group
- Advanced Energy United
- Advanced Power Alliance
- American Clean Power Association
- American Council on Renewable Energy
- Americans for a Clean Energy Grid
- Asia Clean Energy Coalition
- Beyond Alliance
- Business Environment Leadership Council of the Center for Climate and Energy Solutions
- Carolinas Clean Energy Business Association
- Clean Air Task Force
- Clean Energy Buyers Association
- Clean Energy Demand Initiative
- Clean Grid Alliance
- Corporate Eco Forum
- Corporate Leaders Group Europe
- Data Center Coalition
- DIGITALEUROPE
- Electric Power Research Institute
- Energy Alabama
- Energy Systems Integration Group
- EnergyTag
- Eurelectric
- GeSI
- Hydrogen Europe
- Japan Climate Leaders Partnership
- Keystone Energy Board
- Long Duration Energy Storage Council
- Marktoffensive Erneuerbare Energien
- North Carolina Sustainable Energy Association
- Nuclear Innovation Alliance
- Princeton ZERO Lab
- RE100
- Renewable Northwest
- RE-Source Platform
- SEMI Energy Collaborative
- Singapore Carbon Market Alliance
- Singapore Sustainable Finance Association
- SolarPower Europe
- Southeast Asia Partnership for Adaptation through Water
- smartEn
- Southwest Energy Efficiency Project
- Trellis Network
- U.S. EPA Green Power Partnership
- Utah Clean Energy
- We Are Still In
- WindEurope

International and nonprofit organizations

Google engages in many international partnerships and with many nonprofit organizations to accelerate progress toward shared sustainability ambitions. Some of our key partnerships include:

Organization	Details
24/7 Carbon-Free Energy Compact	In 2021, Google helped launch the 24/7 Carbon-Free Energy Compact in partnership with Sustainable Energy for All and UN-Energy to help grow the movement to enable zero-carbon electricity.
Ad Net Zero	Google is a founding supporter of and active participant in Ad Net Zero—a global initiative to help the advertising industry tackle the climate crisis.
Bonneville Environmental Foundation (BEF)	Google has partnered closely with BEF since 2019 on the implementation of our water strategy, including identifying and facilitating impactful water replenishment and watershed health projects globally, with a variety of local organizations and partners.
Building Transparency	We work with Building Transparency to advance the development of tools to measure, model, and track the embodied carbon of building materials.
Business for Social Responsibility (BSR)	Google has been a BSR member for many years and is one of a few select Spark Members. We participate in a number of BSR collaboration initiatives, and one of our senior leaders sits on its board.
C40 Cities	C40 and Google launched the 24/7 Carbon-Free Energy for Cities program to empower cities around the world to run entirely on clean energy. C40 is a strategic partner of Google's Environmental Insights Explorer (EIE).
Climate Group 24/7 Carbon-Free Coalition	In 2024, Google supported the pilot launch of the Climate Group's 24/7 Carbon-Free Coalition at New York Climate Week, a new initiative designed to encourage energy consumers to move toward 24/7 CFE.
Coalition to End Wildlife Trafficking Online	In 2018, Google and other companies launched the Coalition to End Wildlife Trafficking Online, collectively creating a wildlife policy framework for online trade and an industry-wide approach to reduce online wildlife trafficking.
CDP	At Google, we've been reporting our carbon footprint to CDP since 2009. We've also collaborated with CDP on various initiatives in the past, such as hosting its annual conference, hosting a hackathon, and launching CDP scores in Google Finance.
Clean Energy Buyers Association (CEBA)	Google was actively involved in the creation of CEBA in 2018. A Google representative continues to serve as the board chair of this organization.
Climate Neutral Data Centre Pact (CNDCP)	Google helped establish the CNDCP, a coalition of European data center operators who commit to a set of voluntary sustainability targets to set them on a path toward climate neutrality.
Ellen MacArthur Foundation (EMF)	Google joined the Ellen MacArthur Foundation's Network in 2015 and, as a Network Partner, has jointly co-authored thought leadership white papers and case studies covering safer chemistry, building deconstruction and reuse, electronics, and the role of AI in the circular economy.
Environmental Defense Fund (EDF)	Since 2012, Google has partnered with EDF to map air quality using Street View cars in the United States, Europe, and Southeast Asia—as well as to detect methane leaks in U.S. cities. We've launched a partnership with EDF's MethaneSAT to help power its satellite data analysis, quantify leaks from oil and gas infrastructure around the globe, and put methane insights into the hands of scientists and decision-makers.
EnergyTag	Google is an active member of the EnergyTag Advisory Committee, working to enable markets, publish standards, and encourage policies critical for the adoption of Granular Certificates and hourly matching.
European 24/7 Hub	Google supported the launch of the European 24/7 Hub with Eurelectric, which provides education on the "what, why, and how" of 24/7 CFE for buyers and suppliers in Europe. Google is an active member of the Hub.
European Green Digital Coalition (EGDC)	Google is an active member of the EGDC—a group of technology companies committed to supporting the green and digital transformation of the European Union and harnessing the emission-reducing potential of digital solutions for all other sectors.
Exponential Roadmap Initiative (ERI)	In 2021, Google joined ERI and the UN Race to Zero Campaign, the largest ever alliance committed to halving emissions by 2030 and achieving net-zero emissions by no later than 2050.
Frontier	In 2022, Google co-founded Frontier, an advance market commitment that will accelerate the development of carbon removal technologies by guaranteeing future demand. As one of the founding members of this public benefit LLC, we aim to use Frontier as a catalyst for the most effective technologies in long-duration carbon removal.
Global Covenant of Mayors for Climate & Energy (GCoM)	Google's Environmental Insights Explorer was developed in partnership with GCoM through a shared vision to support city climate action with useful and accessible data and insights. GCoM is a strategic partner, sharing EIE data with its alliance of cities and local governments to accelerate climate action.
Global Renewables Alliance (GRA)	Google is a supporter of GRA's campaign to triple renewable energy globally by 2030 and has supported efforts to encourage high-impact corporate clean energy purchasing as a key strategy to accelerate progress toward this ambition.
ICLEI Africa, ICLEI Europe, ICLEI USA	Google is a partner of the regional secretariats of ICLEI—Local Governments for Sustainability—in Africa, Europe, and the United States. Through these partnerships, ICLEI regional teams support sustainable development projects in cities, using data and insights from EIE.
International Energy Agency (IEA)	We've partnered with the IEA on multiple energy-related projects, including research on advancing decarbonization through clean electricity procurement. We also surfaced information through Search about the European energy crisis, providing energy-saving tips and electric vehicle and home heating information. In 2024, Google partnered with the IEA and others on a two-year "Energy and AI" initiative to explore the challenges of meeting electricity demand for AI, as well as the opportunities for using AI to decarbonize the energy sector.
iMasons Climate Accord	Google is a founding member and an active participant in the Governing Body of the iMasons Climate Accord, a coalition united on carbon reduction in digital infrastructure.
Linux Foundation Energy	Since 2022, we've partnered with LF Energy to develop standards that accelerate secure and scalable data portability for the energy transition. In 2024, we focused on industry engagement through webinars and conferences to gather feedback from key stakeholder groups.
ReFED	Since 2018, Google has been working with ReFED—a nonprofit with a mission to catalyze the food system toward evidence-based action to stop wasting food—supporting its technical teams and exploring ways to convene businesses.
Responsible Business Alliance (RBA)	In 2024, we supported the Responsible Business Alliance in developing its Waste Minimization Toolkit, which includes a Waste Tracking Record Tool and an online learning module to train supply chain facility personnel on waste stream tracking, reporting, and management.
Symbiosis	In 2024, Google co-founded Symbiosis, a new coalition of corporate buyers committed to following the latest science to scale high-quality, nature-based carbon removal.
The Nature Conservancy (TNC)	Google has supported TNC on watershed projects in Chile and the United States, and separately, Google.org has provided support to TNC for nature-related projects, including the restoration of giant kelp forest ecosystems across south-eastern Australia.
United Nations Food and Agriculture Organization (UN FAO)	Since 2015, Google and the UN FAO have partnered on forest monitoring, natural resources, livelihoods, and the environment.
United Nations Environment Programme (UNEP)	In collaboration with UNEP and the European Commission Joint Research Centre, Google launched the Freshwater Ecosystems Explorer. This platform enables all countries to freely measure and monitor freshwater resources (toward Sustainable Development Goal 6.6.1) as well as learn when and where surface water is changing. In 2023, Google.org supported the UNEP International Methane Emissions Observatory in developing a new AI-based automated methane emission detection, alerting, and notification system.
World Business Council for Sustainable Development (WBCSD)	A member of the WBCSD since 2019, Google actively participates in initiatives related to improving well-being for both people and the planet—including shifting diets, accelerating climate change standards and policy progress, and supporting regenerative agriculture.
World Economic Forum (WEF)	Google partners with WEF on various initiatives, including: the First Movers Coalition, the Chief Sustainability Leaders Community, Tech for Climate Adaptation, the Alliance for Clean Air, and the AI Governance Alliance with a focus on the AI and Energy workstream.
World Resources Institute (WRI)	Google has supported WRI since 2007. Some key WRI projects include developing a near real-time land cover dataset (Dynamic World), launching deforestation monitoring and alerts (Global Forest Watch), ending commodity-driven deforestation and accelerating restoration (Forest Data Partnership), measuring and mitigating extreme heat (supported by Google.org), and educating stakeholders on 24/7 CFE.

Startups

Google for Startups Accelerators

Our sustainability-focused accelerator programs work to identify, support, and scale startups that are building technologies to combat climate change and advance sustainability efforts. Google for Startups Accelerators are 10-week programs designed to bring the best of Google's products, people, and technology to Seed to Series A technology startups. In addition to mentorship and technical project support, programming also focuses on product design, customer acquisition, and leadership development for participating founders. Since launching the Google for Startups Accelerator: Climate Change program in 2021, we've hosted seven climate accelerators across five continents, which have collectively supported 83 startups, as of the end of 2024.

In 2024, we announced another cohort for the Google for Startups Accelerator: Climate Change in Europe. The cohort comprises 15 startups with solutions that use Cloud technologies—including AI, geospatial data analysis, and advanced analytics—to develop groundbreaking approaches to environmental challenges. We also launched our first-ever Google.org Accelerator: Generative AI, focused on supporting organizations harnessing the power of generative AI for a wide range of solutions. One participant, Materiom, is using Vertex AI and Gemini to accelerate the development of sustainable plastic alternatives, while another participant, Climate Policy Radar, is using AI to provide insights about climate law and policy decisions.

Looking ahead in 2025, a new cohort of startups will be able to participate in the Climate Change Accelerator in Europe, and we'll also launch two new accelerator programs. Google for Startups Accelerator: AI for Energy will focus on supporting startups enabling grid flexibility and optimization for clean energy deployment and grid resilience, and Google for Startups Accelerator: AI for Nature will assist startups in accelerating their environmental impact by using Google's advanced AI technology for nature protection, conservation, and restoration efforts.

Startups for Sustainable Development

Through our Startups for Sustainable Development program, we're working with impact-driven startups using technology to address one or more of the UN's 17 Sustainable Development Goals, from eradicating poverty and hunger to improving healthcare and advancing climate action. Startups receive long-term support to scale their impact, including mentoring from expert advisors, connections to funding partners, and access to cutting-edge research and technology. In 2024, we began pairing Googlers with startups to add AI solutions to their most impactful projects. Through this engagement, startups were able to use machine learning and other models for various applications, including identifying and monitoring tree species to support reforestation efforts, predicting utilization rates for electric vehicle chargers, and monitoring marine life. As of the end of 2024, the program has supported more than 600 startups in over 75 countries, working with a network of over 200 partner organizations.

Supported organizations

Google.org—Google's philanthropy—applies our innovation, research, and resources to promote progress and expand opportunity for everyone. Google.org's efforts are focused across three pillars: knowledge, skills, and learning; scientific advancement; and resilient communities. We empower nonprofits, civic entities, and academic organizations with a unique blend of funding, in-kind donations, and technical expertise from Google employees—accelerating scientific advancement and catalyzing societal impact.

Catalyzing early-stage innovation

We accelerate scientific discovery through support for the global research community. Through the Google Academic Research Awards we funded research to create machine learning benchmarks for climate problems. Google.org is also supporting a coalition of global experts using satellite imagery and AI to improve agricultural decision making, including advancements in landscape monitoring, soil analysis, crop health assessment, and weather integration. Google.org has supported AVPN's APAC Sustainability Seed Fund since 2022, providing $10 million in funding directly and via capacity building programs to support local organizations focused on underserved communities in the region. In 2024, we highlighted AVPN's 18 funding recipients that are using AI and cloud technologies to build sustainability solutions. Through Google.org's support for the ICLEI Action Fund—a grant program supporting data-driven solutions for environmental and climate action across Europe—projects have received funding for innovative solutions in cities, tackling issues like energy poverty, renewable energy adoption, and sustainable mobility.

Creating scaled impact for sustainability

A key focus of Google.org is supporting efforts to accelerate climate action through enabling scientific discovery and the application of technological innovation. We do this by supporting organizations that use technology and data, especially AI and machine learning, to support the creation of free, open-sourced tools and datasets for the global community. As of the end of 2024, we've provided more than $75 million to social impact organizations for projects that use AI to build a more sustainable world, primarily through the Google.org Impact Challenge on Climate Innovation, AI for the Global Goals, and the Google.org Accelerator: Generative AI, as well as through other funding initiatives and opportunities. We're also supporting AI for scientific breakthroughs through the Google.org AI and Science Fund, which will provide $20 million in funding to support academic and nonprofit organizations around the world using AI to address complex problems at the intersections of different disciplines of science.

Collaborating with others

Google.org actively champions increased corporate philanthropy for innovation, and we'll continue encouraging other private actors to join these efforts. Our open-call programs demonstrate strong interest from the social impact and social enterprise sectors to use AI to help transition the world to a sustainable future. Corporate philanthropy has the opportunity to play an important role in catalyzing innovation and impact by providing resources for bold experimentation. That's why we've joined the WEF's Giving to Amplify Earth Action initiative and have joined other corporate philanthropies and foundations to help launch the Corporate Philanthropy Challenge for People and Planet.

Environmental data

Methodology

The reporting period for our environmental data covers our fiscal year January 1, 2024, through December 31, 2024. Most of our environmental data covers Alphabet Inc. and its subsidiaries. All reported data is global and annual unless otherwise specified. The below methodologies apply to our GHG emissions, as well as certain other carbon, energy, water, and waste metrics, for all years presented in our Environmental metrics data tables.

Greenhouse gas emissions

GHG emissions reporting standards
GHG emissions are calculated according to the Greenhouse Gas Protocol standards and guidance developed by the World Resources Institute (WRI) and The World Business Council for Sustainable Development (WBCSD), including A Corporate Accounting and Reporting Standard (Revised Edition) and the WRI/WBCSD GHG Protocol Scope 2 Guidance (an amendment to the GHG Protocol Corporate Standard)(collectively, the "Corporate Standard"), as well as the Technical Guidance for Calculating Scope 3 Emissions ("Scope 3 Technical Guidance"), and the Corporate Value Chain (Scope 3) Accounting and Reporting Standard ("Scope 3 Standard")(collectively, "the Greenhouse Gas Protocol").

Our inventory
We use the operational control approach to define our organizational boundary, which means that we account for all emissions from operations over which we have control. The Greenhouse Gas Protocol defines operational control as having the authority to introduce and implement operational policies over an asset, and we report all emissions for Alphabet Inc. and its subsidiaries' data centers, offices, and other assets under our operational control.

Our inventory includes all of the seven GHGs addressed by the Kyoto Protocol, where relevant: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). However, perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3) aren't emitted as a result of our operations and are therefore appropriately excluded from our "GHG emissions by type" data table. We report emissions both in the unit of metric tons per gas (e.g., tCO_2, tCH_4, etc.) and in the standardized unit of metric tons of carbon dioxide equivalent (tCO_2e), with the exception of biogenic emissions which are reported as tCO_2 only.

We source the global warming potentials (GWP) for each GHG from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4), IPCC Fifth Assessment Report (AR5), and IPCC Sixth Assessment Report (AR6), and we use the most up-to-date emission factors available when calculating our emissions, based on our reporting timelines and requirements.

We round all reported emissions values to the nearest hundred, except for scope 3 emissions (which we round to the nearest thousand) and emissions per gas (which we round to the nearest hundred unless the total is less than 50 tons, in which case we report to the nearest one).

Scope 1 emissions
Scope 1 emissions are direct emissions from sources such as company vehicles or generators at our offices and data centers. They represent direct emissions from Google-owned and -operated data centers, offices, and other assets, including fuel use from back-up generators, fuel consumption from our operated vehicles and aircraft, methane and nitrous oxide from biogenic fuel sources, natural gas usage, and refrigerant leakage. Where actual data isn't available, for example from a utility bill, we estimate natural gas consumption using the square footage of our data centers, offices, and other assets and internally developed natural gas intensity factors by office type, based on data from the reporting period. Where actual refrigerant leakage data isn't available, we estimate refrigerant leakage by using an average of GWP values from known refrigerants within our portfolio and leakage rates at our data centers, offices, and other assets.

The emission factors used to calculate scope 1 emissions include the 2024 WRI/WBCSD GHG Protocol Emission Factors from Cross Sector Tools, the 2025 U.S. Environmental Protection Agency (EPA) Emission Factors for Greenhouse Gas Inventories, the 2024 Climate Registry Default Emission Factors, and the 2024 Department for Environment, Food and Rural Affairs (DEFRA) UK Government GHG Conversion Factors.

Scope 2 emissions
Scope 2 emissions are indirect emissions from purchased electricity; natural gas use and refrigerant leakage in our leased offices; and purchased steam, hot water, and chilled water from district energy systems. We report scope 2 emissions using both location-based and market-based methods. The **location-based method** reflects the average carbon intensity of the electric grids where our operations are located and thus where our electricity consumption occurs. The **market-based method** incorporates our procurement choices, primarily our renewable energy purchases via contractual instruments, such as power purchase agreements (PPAs).

We use actual data (such as third-party invoices, monthly utility bills, or meter readings) to calculate scope 2 emissions. Where actual data isn't available, we estimate electricity consumption, natural gas consumption, and activity from district energy systems using the square footage of our data centers, offices, and other assets and internally developed intensity factors by office type, based on data from the reporting period.

The emission factors used to calculate scope 2 (location-based) emissions include the 2024 WRI/WBCSD GHG Protocol Emission Factors from Cross Sector Tools, the 2025 EPA Emission Factors for Greenhouse Gas Inventories, the 2024 DEFRA UK Government GHG Conversion Factors, the 2024 International Energy Agency (IEA) Emission Factors, the 2025 EPA eGRID Emission Factors, and the 2024 Climate Registry Default Emission Factors.

The emission factors used to calculate scope 2 (market-based) emissions are the same as scope 2 (location-based) with the addition of emission factors specific to energy attribute certificates (EACs), as well as residual mix emission factors where available. Residual grid mix removes the proportion of renewable energy contracted to other parties—that have the rights to claim those clean electricity attributes through EACs—from the grid electricity mix, and therefore avoids double-counting. Comprehensive residual mix emission factors are currently only available for Europe (the 2023 Association of Issuing Bodies' European Residual Mixes). Outside of Europe, residual emission factors aren't available from third-party sources to account for voluntary purchases, and this may result in double counting between electricity consumers.

Scope 3 emissions

Scope 3 emissions are indirect emissions from other sources in our value chain. We calculate our scope 3 emissions using methodologies from the Scope 3 Technical Guidance for the following categories identified as relevant:

- Category 1: Purchased goods and services
- Category 2: Capital goods
- Category 3: Fuel- and energy-related activities (not included in scope 1 or scope 2)
- Category 4: Upstream transportation and distribution
- Category 5: Waste generated in operations
- Category 6: Business travel
- Category 7: Employee commuting
- Category 11: Use of sold products

We've determined that the remaining scope 3 categories were either not relevant or not applicable based on the Scope 3 Standard's relevance criteria, which is described further in our 2025 (FY2024) Independent Accountants' Review Report. The emissions associated with categories deemed not relevant are not significant to scope 3 emissions individually or in the aggregate.

For each relevant scope 3 category, we report emissions according to their minimum boundaries listed by the Scope 3 Standard. For certain categories, we've also included activities which the Scope 3 Standard deems optional. None of the scope 3 categories have associated biogenic carbon dioxide emissions.

In 2024, we stopped reporting a scope 3 (Other categories) metric—a previously aggregated total that included certain emissions from category 2 (Capital goods), category 11 (Use of sold products), and category 12 (End-of-life treatment of sold products). Instead, we now present all emissions from category 2 (Capital goods) and category 11 (Use of sold products) as an aggregated total for business confidentiality purposes. The emissions from category 11 (Use of sold products) are not a material component of total scope 3 emissions. We've determined that category 12 (End-of-life treatment of sold products) is not relevant based on the relevance criteria in the Scope 3 Standard, and is therefore no longer included in our inventory boundary.

For each relevant scope 3 category, we provide the following details, as applicable: the minimum and optional activities included, calculation methods, activity data, emission factors, percentage of category emissions from value chain partners, allocations, and any significant estimates or assumptions.

"Category 1: Purchased goods and services" includes upstream emissions generated from manufacturing consumer devices and spare parts, our food program, and additional goods and services purchased for our operations. We use a combination of the average-data method and spend-based method, as defined by the Scope 3 Technical Guidance. To calculate supply chain emissions generated from manufacturing consumer devices and spare parts, we perform third-party-verified Life Cycle Assessments (LCAs) in accordance with International Organization for Standardization (ISO) 14040 and ISO 14044. To calculate emissions generated from our food program, we use LCA emission factors from WRI's Cool Food Pledge Calculator and annual procurement volumes from our San Francisco Bay Area offices. Where procurement volume data isn't available for the remaining offices, we estimate remaining emissions by scaling the San Francisco Bay Area emissions based on global building admittance data. Where emission factors from WRI aren't available, we estimate remaining emissions using spend data and the EPA's U.S. Environmentally-Extended Input-Output ("USEEIO") Supply Chain GHG Emission Factors (2024 v1.3), which are then adjusted for inflation using the U.S. Bureau of Labor Statistics' Consumer Price Index Inflation Calculator ("USEEIO supply chain emission factors"). To calculate emissions generated from the remaining goods and services purchased for our operations, we estimate supplier emissions using spend data and USEEIO supply chain emission factors. Approximately 2% of the data we use to calculate category 1 emissions are obtained from value chain partners.

"Category 2: Capital goods" includes upstream emissions generated from final goods that are used in the manufacturing and assembly of servers and networking equipment used in our technical infrastructure, materials and fuels used in the construction of data centers and offices, and additional capital goods purchased for Alphabet's operations. We use a combination of the average-data, and spend-based methods, as defined by the Scope 3 Technical Guidance, as well as LCAs that are in accordance with ISO 14040, ISO 14044, and ISO 14067. To calculate emissions generated from the manufacturing and assembly of servers and networking equipment used in our technical infrastructure, we transitioned in 2024 to primarily using LCAs as we continue to increase the accuracy of our estimates. This improved approach uses configurable LCA models (third-party reviewed) for high-impact components (which account for the majority of our total technical infrastructure hardware emissions). This allows us to tailor calculations to our specific mix of data center hardware and incorporate supplier-specific process-level data. For technical infrastructure components where LCA data is unavailable, we apply our previous spend-based method. For these remaining components, we collect supplier emissions data from our contract manufacturers as well as component and fabless suppliers through the CDP Supply Chain Program. Alphabet's share of these suppliers' emissions is determined via economic allocation (i.e., based on revenue and spend). Where available and valid, we use scope 2 market-based method emissions from these suppliers. Where supplier-specific emissions data isn't available through CDP, we estimate supplier emissions using spend data, USEEIO supply chain emission factors or proxy supplier emissions data. To calculate emissions generated from materials used in data center and office construction, we use data on annual construction area and lifecycle emission factors derived from LCAs conducted on our data centers and offices, as well as invoice-based material information. We input building mass by material data—either collected or estimated based on actual data when unknown—into LCA software (Tally, One Click LCA, and SimaPro—which reference emission factors from ecoinvent and Sphera) and the Embodied Carbon in Construction Calculator (EC3) webtool. For offices, the LCA results undergo third-party review (e.g., by the U.S. Green Building Council for Leadership in Energy and Environmental Design [LEED] certification). To calculate emissions generated from additional capital goods purchased for our operations, we estimate supplier emissions using spend data and USEEIO supply chain emission factors. Approximately 15% of the data we use to calculate category 2 emissions are obtained from value chain partners.

"Category 3: Fuel- and energy-related activities (not included in scope 1 or scope 2)" includes upstream emissions from purchased fuels (e.g., natural gas, diesel, and gasoline) and purchased energy (i.e., electricity, steam, heating, and cooling), as well as emissions from transmission and distribution losses from purchased energy. We use the average-data method, as defined by the Scope 3 Technical Guidance. We calculate upstream emissions from purchased fuel, steam, heating, and cooling, in addition to emissions from transmission and distribution losses from steam, heating, and cooling using 2024 DEFRA UK Government GHG Conversion Factors. We calculate emissions from upstream electricity by country using the 2024 IEA Emission Factors. We calculate emissions from electricity transmission and distribution losses using grid loss values and emission factors derived from the 2024 IEA Emission Factors and, for the United States, the 2025 EPA eGRID Emission Factors. For upstream electricity, we calculate emissions using scope 2 market-based data (i.e., by using the remaining electricity not addressed by renewable energy). For electricity transmission and distribution losses, we use the market-based method to account for EACs that we've purchased to cover a portion of grid losses.

"Category 4: Upstream transportation and distribution" includes emissions generated primarily from the transportation and warehousing of our consumer products and data center equipment. We also include the optional activities of upstream emissions of transportation. For transportation emissions, we use a combination of the fuel-based and distance-based methods, as defined by the Scope 3 Technical Guidance. For transportation emissions, we collect well-to-wheel (WTW) emissions data, calculated based on fuel use or weight-distance data, and routing associated with a shipment from logistics providers. Logistics providers determine Alphabet's share of a shipment's transportation emissions via physical allocation (i.e., based on how much of the total shipment's weight is from Alphabet's goods). Where actual logistics provider emissions data isn't available, we calculate WTW emissions using weight and distance data by shipment collected from our logistics providers, using emission factors from the 2024 Global Logistics Emissions Council (GLEC) Framework v3.1 or EPA SmartWay carrier performance data. Where logistics provider weight and distance data isn't available, we estimate emissions based on reported data from other transportation providers and the weight shipped. For warehousing emissions, we use the site-specific method, as defined by the Scope 3 Technical Guidance. To calculate consumer product and data center equipment warehousing emissions, we collect energy data (from both) and refrigerant leakage data (data center equipment warehousing only) directly from the warehouses and calculate emissions using lifecycle electricity and fuel emission factors from the Sphera Professional database 2024. Alphabet's share of a third party's warehouse energy and refrigerant leakage activity is determined via physical allocation (e.g., based on how much of the total warehouse area is used for Alphabet's goods). Nearly 100% of the data we use to calculate category 4 emissions are obtained from value chain partners.

"Category 5: Waste generated in operations" includes emissions from solid waste generated at our offices, Google owned- and operated data centers, and Google-owned warehouses. The waste is either composted, recycled, landfilled, or incinerated (with or without energy recovery). We calculate this category's emissions to also include the optional activity of waste transportation, which is embedded in the emission factors we use. We use a combination of the waste-type-specific method and the average-data method, as defined by the Scope 3 Technical Guidance. The waste generation data comes from a combination of data from invoices and on-site measurements. Where actual waste data isn't available for a specific facility, we estimate waste tonnage using waste container size and pickup frequency, actual waste data from similar facilities, or historical waste data from the same facility. We use waste type- and disposal type-specific emission factors from the 2025 EPA Emission Factors for Greenhouse Gas Inventories. We exclude the emissions from wastewater treatment from this category.

"Category 6: Business travel" includes emissions from business-related air, rail, bus, personal vehicle (when the employee's car is used for business purposes), taxi, rideshare, shuttle, and rental car travel—including emissions from relocation travel. We also include the optional activity of upstream emissions from business travel. We use a combination of the distance-, fuel-, and spend-based calculation methods, as defined by the Scope 3 Technical Guidance. We collect all travel data through either our online booking system or a third-party travel agency. To calculate emissions from the majority of our air travel, we use the Travel Impact Model, an emissions estimation model developed by Google that's built from public and licensable external datasets. We calculate total plane WTW emissions and allocate an amount to the employee passenger based on the plane's percentage of occupied seats (i.e., the passenger load factor) and the mass of cargo being carried. For all other modes of transport—including rail, taxi, rideshare, non-U.S. personal vehicles, non-U.S. shuttle travel, and a minority of air travel modes—we use the WTW emission factors from the 2024 DEFRA UK Government GHG Conversion Factors. We calculate emissions from car rental, U.S. personal vehicle, and U.S. shuttle travel using well-to-tank (WTT) emission factors from the 2024 DEFRA UK Government GHG Conversion Factors and tank-to-wheel (TTW) emission factors from the 2025 EPA Emission Factors for Greenhouse Gas Inventories. Approximately 6% of the data we use to calculate Category 6 emissions are obtained from value chain partners.

"Category 7: Employee commuting" includes emissions from the transport of our full-time employees between their homes and their worksites by passenger car (i.e., carpool, dropoff, taxi, rideshare, or single-occupied vehicle), rail, bus, motorcycle, and gas-powered scooter. We also include the optional activity of upstream emissions of employee commuting. We use the distance-based method, as defined by the Scope 3 Technical Guidance. We survey our employees to determine typical commuting patterns and apply these patterns to our global employee population. We use a mode-specific commuting distance obtained from the American Public Transportation Association's 2023 Fact Book and the U.S. Department of Transportation's 2022 National Household Travel Survey. We calculate employee commuting emissions using mode-specific WTT emission factors from the 2024 DEFRA UK Government GHG Conversion Factors and TTW emission factors from the 2025 EPA Emission Factors for Greenhouse Gas Inventories. We use passenger distance-based emission factors for shared vehicles (i.e., carpool, taxi, rideshare, rail, bus) in order to allocate the total vehicle emissions to the employee passenger. In 2024, we removed home energy emissions generated by our full-time employees working remotely (i.e., teleworking) from our inventory boundary because this emissions activity is optional under the Scope 3 Standard and because it would've required separate tracking and reporting from our SBTi-validated carbon reduction ambition.

"Category 11: Use of sold products" includes direct use-phase emissions generated by Google's flagship consumer devices [143] sold in the reporting period that directly consume electricity during use. [144] These emissions also include the optional activity of upstream electricity emissions of these devices by using LCA emission factors. We perform LCAs that are in accordance with ISO 14040 and ISO 14044 and are third-party reviewed. We publish summaries of the LCA results in Product Environmental Reports on Google's Sustainability Reports webpage. We use laboratory power draw measurements, data on use patterns, common industry assumptions on product lifetimes, and LCA electricity emission factors from the 2024 Sphera LCA for Experts database.

Biogenic emissions
In accordance with the Greenhouse Gas Protocol, we report biogenic emissions separately from other scope 1 emissions. Our biogenic carbon dioxide emissions are generated from our operated vehicles and generators that consume biofuels. We calculate biogenic emissions using emission factors from the 2025 EPA Emission Factors for Greenhouse Gas Inventories.

Other carbon and energy metrics

Ambition-based emissions

For our **ambition-based emissions**, we include all Alphabet scope 1 and scope 2 (marked-based) emissions. We exclude certain scope 3 activities [145] that are peripheral to our core operations or where our ability to influence emissions reductions is limited. These exclusions include food program purchases, certain purchased goods and services associated with Alphabet's day-to-day operations, [146] and Other Bets [147] capital goods. For more details, refer to our Ambition-based emissions reconciliation presented in our Environmental metrics data table.

Carbon intensity

We calculate our **carbon intensity metrics** as defined by the Global Reporting Initiative (GRI) Disclosure 305-4. Carbon intensity metrics are based on global combined scope 1 and scope 2 (market-based) emissions. We round reported carbon intensity per unit of revenue and per full-time equivalent (FTE) employee values to the nearest hundredth, and reported carbon intensity per megawatt-hour (MWh) of energy consumed values to the nearest ten thousandth.

Carbon removal credits

In 2024, we did not apply any carbon removal credits to our emissions inventory. We plan to begin applying these credits in 2030. When we do, we'll provide detailed information about our methodology. In the meantime, we've reported our total procurement to date for transparency.

Energy and electricity

We calculate **total energy consumption** as defined by GRI Disclosure 302-1e-f. Total energy consumption includes all fuel and natural gas consumption; purchased electricity, steam, heating, cooling; and all electricity generated on-site from carbon-free energy technologies. We round reported energy consumption metrics to the nearest hundred.

We calculate **total electricity consumption** as defined by GRI Disclosure 302-1c(i) and 302-1f. Total electricity consumption includes both purchased and self-generated electricity. Where actual natural gas or electricity consumption for facilities isn't available, we estimate consumption using building square footage and internally developed intensity factors based on data from the reporting period. Total electricity consumption differs slightly from **purchased electricity**, which is electricity sourced from an electrical grid and purchased from a local electric utility company.

We calculate **electricity procured from renewable sources (%)** on an annual basis by dividing the megawatt-hours of renewable electricity procured (i.e., through contractual instruments, on-site renewable electricity generation, and renewable electricity in the electric grids where our facilities are located) by the total megawatt-hours of electricity consumed by our global operations. The numerator includes all renewable electricity procured, regardless of the market in which we consumed the renewable electricity. To achieve our 100% renewable energy match, we first consider both our on-site renewable electricity generation and the renewable electricity already in the electric grids where our facilities are located (using the residual mix where data is available). We then procure renewable electricity through contractual instruments. We have a few facilities located in geographies where we're not currently able to source large volumes of renewable electricity, so we make up for this by procuring surplus renewable electricity in regions where it's abundant. For example, by procuring larger amounts of wind energy in places like Europe, we compensate for our lack of renewable energy purchases in the Asia-Pacific region. Refer to "Achieving Our 100% Renewable Energy Purchasing Goal and Going Beyond" for additional details on our custom criteria and methodology.

Carbon-free energy

Google's Carbon-free energy (CFE) metric is the percentage of Google's electricity consumption on a given regional grid that is matched hourly with CFE. We calculate this metric at an hourly granularity, using both CFE under contract by Google (Contracted CFE) as well as CFE from the electricity grid (Grid CFE). **Grid CFE** is defined as the percentage of energy on the grid that's supplied by carbon-free energy sources (e.g., wind or solar) at that particular hour. Grid CFE is applied to Google's electricity consumption for any hour where Google's Contracted CFE is less than the electricity consumption. Grid CFE values are calculated by a third party, Electricity Maps.

Regional average Google CFE across Google data center grid regions refers to the percentage of carbon-free energy sources consumed by Google's data centers within a given global region per the previously-defined methodology.

- The eastern North America regional CFE percentage includes the following grid regions: Duke Energy Carolinas (DUKE), Independent Electricity System Operator (IESO), Hydro-Québec, Pennsylvania-New Jersey-Maryland Interconnection (PJM), South Carolina Regional Grid (SC), Southern Company (SOCO), and Tennessee Valley Authority (TVA).
- The central North America regional CFE percentage includes the following grid regions: Electric Reliability Council of Texas (ERCOT), Midcontinent Independent System Operator (MISO), Southwest Power Pool (SPP), and Sistema Eléctrico Nacional (SEN).
- The western North America regional CFE percentage includes the following grid regions: Salt River Project (SRP), Bonneville Power Administration (BPA), California Independent System Operator (CAISO), NV Energy (NVE), and PacifiCorp East (PACE).

We calculate **Contracted CFE** as a percentage of our electricity consumption that's matched with CFE on an hourly basis from clean energy projects contracted by Google, and without consideration of the CFE already on the grids where we operate. If Google's total Contracted CFE exceeds our electricity consumption in a given hour and region, the contracted CFE consumed by Google is capped at the total electricity consumption; this means the CFE percentage in this hour would be 100% and that "consumed" Contracted CFE can never exceed 100%. The "excess CFE" from the projects under contract that generate MWhs of clean electricity above what Google consumes in a particular hour is not counted toward our Google CFE percentage, however it still contributes to decarbonization of the broader grid.

We calculate **Consumed Grid CFE** as a percentage of our electricity consumption in a given market that's matched with CFE from the grid after the application of Contracted CFE. For hours when Contracted CFE is equal to or exceeds our electricity consumption, Consumed Grid CFE is equal to zero. If our Contracted CFE is less than our electricity consumption in an hour, then the Consumed Grid CFE is calculated by applying the hourly Grid CFE percentage to the remaining electricity consumption, and then dividing that product by the total electricity consumption in that hour.

For more details on how we calculate **carbon-free energy** percentages, refer to 24/7 Carbon-Free Energy: Methodologies and Metrics. Our approach to CFE measurement may evolve as we continue to enhance our methodology and data availability improves. For example, we don't currently use residual grid mix when calculating grid contributions to Google CFE because hourly residual grid mix data doesn't yet exist. We're supporting the development of time-based tracking methods, which are essential for making this calculation possible in the future.

Power Usage Effectiveness

PUE is a standard industry ratio that compares the amount of non-computing overhead energy (used for things like cooling and power distribution) to the amount of energy used to power IT equipment. A PUE of 2.0 means that for every watt of IT power, an additional watt is consumed to cool and distribute power to the IT equipment. A PUE closer to 1.0 means nearly all the energy is used for computing.

We take a comprehensive approach to measuring our data center PUE:

- Include all data centers: We consider our entire global fleet, not just the newest or most efficient facilities.
- Continuous measurement: We measure PUE throughout the year, not just during cooler seasons.
- Comprehensive data: We include all sources of overhead energy in our calculations.

We begin reporting PUE for each data center once it reaches stable operations. This fleet-wide data, along with quarterly and trailing 12-month PUE, is publicly disclosed on our Data Centers: Efficiency site on a quarterly basis.

Water metrics

Global operational water

Relevant operations for water metrics include our owned and fully leased data centers and owned and leased offices and other assets. Our reported water metrics exclude seawater. We report water metrics in million gallons, and we round global operational water metrics to the nearest million and water use by data center location to the nearest hundred thousand gallons. If water use by data center location is less than fifty thousand gallons, we round to the nearest ten thousand gallons.

We calculate **water consumption** by subtracting water discharge from water withdrawal.

Water withdrawal is based on actual metered or invoiced data when it's available. At offices where actual metered or invoiced data isn't available, we estimate water withdrawal using facility square footage and internally developed water withdrawal intensity factors by office type based on data from the reporting period. At data centers where actual data isn't available, we estimate water withdrawal using engineering principles.

Water discharge is based on actual metered or invoiced data when it's available. Where actual domestic wastewater discharge data isn't available, we apply an industry-standard 90% discharge flow factor to a facility's domestic water withdrawal to estimate domestic water discharge and a 0% discharge flow factor to a facility's irrigation water withdrawal to estimate irrigation water discharge. We apply this water discharge estimation methodology at all offices and at data centers where metered water discharge data isn't available. At data centers where actual data isn't available, we estimate water discharge using engineering principles.

Water replenishment

Our water replenishment metrics are based on the volumetric water benefits from water stewardship projects in our water replenishment portfolio. We engage our independent third-party volumetric benefit quantification partner LimnoTech, which applies industry standard methodologies and assumptions to calculate two metrics following the Volumetric Water Benefit Accounting (VWBA) methodology. We calculate **water replenished** by estimating the total volumetric water benefits of our current water replenishment portfolio during the year. We calculate **contracted water replenishment capacity** by estimating the annual expected volumetric water benefits of our water replenishment project portfolio throughout each project's implementation and respective duration.

Once projects are funded and completed, volumetric water benefits are first accounted for in the year the project begins delivering them and in subsequent years—provided there's reasonable evidence that the project is maintained and continues to function as intended, which is confirmed via an annual review. If a project has multiple funders, the volumetric water benefit is adjusted to reflect our proportional financial contribution compared to the total project cost. The specific calculations applied to each project depend on the project's objectives, activities implemented, and available information.

Water scarcity

To define water scarcity levels, Google assesses operational water risks for data centers and offices. For data centers, we assess water scarcity and depletion by applying our Data Center Water Risk Framework, and assign a low, medium, or high water scarcity level. For our office operations, we assess water scarcity using the WRI Aqueduct Water Risk Atlas and the WWF Water Risk Filter, and where appropriate we adjust the assigned level of water scarcity based on local context.

Waste metrics

We report all waste metrics for Alphabet Inc. and its subsidiaries' data centers (that are owned and operated), offices, and other assets under our operational control.

We calculate **waste generated** by quantifying solid waste generated that's either composted, recycled, landfilled, or incinerated (with or without energy recovery). The waste generation data comes from a combination of data from invoices and on-site measurements. Where actual waste data isn't available for a specific facility, we estimate waste tonnage using waste container size and pickup frequency, actual waste data from similar facilities, or historical waste data from the same facility. We round reported waste generation metrics to the nearest hundred.

We calculate **waste diversion** by quantifying the percentage of total waste generated that is diverted from disposal (defined as diversion of waste from landfills or incinerators, with or without energy recovery). Our approach to data center waste accounting tracks operational waste and integrates data sources and assumptions to account for parts and materials that enter our reverse supply chain—inclusive of decommissioned data center hardware, racking infrastructure, and packaging waste. We also classify waste that's thermally processed (i.e., incinerated) when it leaves our data centers as disposed, rather than diverted—even when energy is recovered. For office waste, we actively assess contamination rates and exclude contaminated waste from our diversion rate calculations—which is unlike the typical approach, which assumes zero contamination in recycling and compost bins. We round reported waste diversion metrics to the nearest one percent.

Recalculation of previous environmental metrics

To maintain consistency over time so that meaningful metric comparisons can be made, it may be necessary to recalculate our historical metrics, including base year emissions, to the extent a change is significant.

Our internal recalculation policy, which follows guidance from the Greenhouse Gas Protocol, informs how we apply updates made in the current reporting period to metrics from prior reporting periods—including our 2019 base year for our emissions reduction ambition. Updates may include structural changes, changes in calculation methodologies, improvements in data accuracy, changes in the categories or activities included in the scope 3 inventory, and the correction of errors. We continually review emissions calculation methodologies and are committed to implementing best practices.

In line with our recalculation policy, in 2024 we recalculated the following previously-reported metrics, due to the following primary drivers:

- We recalculated 2019–2023 scope 3 emissions metrics—including all reported scope 3 categories, "scope 3 (total)," and "total emissions: scope 1, 2 (market-based), and 3"—due to the following:
    - For emissions associated with manufacturing equipment used in our technical infrastructure, we transitioned from a spend-based to a primarily LCA-based calculation methodology, and we improved the spend data accuracy for our remaining spend-based emissions calculations associated with manufacturing equipment used in our technical infrastructure.
    - For emissions associated with data center construction, we updated the LCA we use, sourced more accurate construction area data, and began calculating emissions from additional construction activities.
    - For emissions associated with additional capital goods purchased for Alphabet's operations for which we use a spend-based approach, we improved our approach to mapping USEEIO supply chain emission factors to spend items, and we incorporated capital goods spend related to construction and hardware not otherwise captured by our LCA-based emissions calculations associated with capital goods purchased for Alphabet's operations.
- We recalculated 2020 energy consumption metrics—including purchased steam, purchased cooling, and total energy consumption—due to the correction of a calculation error.
- We recalculated our 2020 "Total electricity consumption" metric to source more accurate energy data.
- We recalculated our 2021 "CFE across Google data centers (hourly)" metric to include CFE data from third-party data center consumption. CFE data from third-party data centers was already included in our previously reported 2022 and 2023 metrics.
- We recalculated 2019–2023 waste metrics—including data center waste diversion rate, total waste generated, and total waste diversion rate—due to data improvements for data center recycled e-waste and packaging and refinement of the metric boundary to exclude low quality data from warehouses and third-party data centers.

Definition of key terms

- **Business-as-usual (BAU) emissions** represent our projected emissions without new carbon reduction efforts. Our BAU emissions forecast shows how much carbon we need to reduce to reach our 2030 ambitions given our company growth projections. As a result, it serves as the baseline by which we calculate the impact of our carbon reduction initiatives.
- **Carbon-free energy (CFE)** technologies include types of electricity generation that don't directly emit carbon dioxide, including solar, wind, geothermal, hydropower, and nuclear. In addition, when deployed with the appropriate guardrails, low-carbon technologies including sustainable biomass and carbon capture and storage can contribute to a CFE portfolio. Energy storage systems can contribute as well. For more details, refer to The Corporate Role in Accelerating Advanced Clean Electricity Technologies.
- **Energy Attribute Certificates (EACs)** are tradable instruments issued to a unit of generation (generally, one MWh) which are used to aggregate and track energy attributes. Depending on the system that issues them and the market where they are used, corporate buyers may purchase them bundled with or unbundled from the underlying generation to secure the property rights to energy attributes. EACs are often interchangeably referred to as Renewable Energy Certificates (RECs).
- We define **freshwater** as naturally occurring water from surface or groundwater sources that isn't salty, and is suitable for consumption if clean or processed. Freshwater excludes seawater and reclaimed wastewater.
- A **grid region** (or regional grid) corresponds to the area over which a single entity manages the operation of the electric power system and ensures that demand and supply are finely balanced. In the United States, this generally means the Independent System Operator (ISO) or Regional Transmission Organizations (RTOs) in regions that have these regional market structures. If no such structure exists, then Google defines the grid region as the electricity-balancing authority where our data centers are located. Outside of the United States, the grid region most often refers to the geographic boundary of a country, because most grid system operators operate at the national level. Certain regions that span multiple countries are well interconnected and could be considered as one grid. However, our grid mix calculations already include import and export considerations and therefore take into account power flows from neighboring grids. In the future, we may update our definition as we work with grid operators to better understand how transmission constraints or congestion impact CFE measurement within and across grid regions.
- **Time-based energy attribute certificates (T-EACs)**—commonly referred to as "Granular Certificates" (GCs)—are a type of Energy Attribute Certificate (EAC) that track and verify clean energy production on an hourly basis, and may be used to buy and sell energy attributes on an hourly basis. Traditional EACs typically certify energy production monthly or annually.

Data measurement and uncertainty

All reported values represent the best data available at the time of publication. Where actual data isn't available, we may use estimates. We base our estimates and methodologies on historical experience, available information, and on various other assumptions that we believe to be reasonable.

All environmental data found in this report is subject to measurement uncertainties resulting from limitations inherent in the nature, methods, and standards used for determining such data. The methodologies and standards for tracking, calculating, and reporting environmental matters—including emissions, emissions reductions, offsets, and related issues—continue to evolve. The selection of different but acceptable measurement techniques can result in materially different measurements. The precision of different measurement techniques may also vary.

Forward-looking information

References to information in this report should not be construed as a characterization regarding the materiality of such information to our financial results or our operations. While certain matters discussed in this report may be significant, any significance should not be read as necessarily rising to the level of materiality used for the purposes of complying with applicable securities laws and regulations in the United States or any other jurisdiction. The information in this report may contain projections, future estimates, plans, expectations, ambitions, and other forward-looking statements. Forward-looking statements are based on current expectations and assumptions and may also be based on estimates and assumptions under developing standards that may change in the future. Such statements are subject to certain risks and uncertainties, which could cause our actual results to differ materially from those reflected in the forward-looking statements. Our ability to achieve any ambition, target, or objective outlined in this report—whether through our products, projects, or funding efforts—is subject to numerous risks, many of which are outside of our control, such as the adoption of certain behaviors and activities by third parties, including our customers and partners. Performance data are not a guarantee of future performance nor intended to be a demonstration of linear progress against aspirations, targets, or objectives. There can be no guarantee that our products, projects, or funding efforts will have the effects we anticipate or intend. Any changes in methodology may result in material changes to our calculations and may result in the current and previous periods, including our base year, to be adjusted. This report represents our current policy and intent and is not intended to create legal rights or obligations. Except as required by law, we undertake no obligation to correct, revise, or update any information included in this report. Neither future distribution of this material nor the continued availability of this material in archive form on our website should be deemed to constitute an update or re-affirmation of these figures or statements as of any future date. Any future update will be provided only through a public disclosure indicating that fact.

Environmental metrics data tables

Greenhouse gas emissions

Greenhouse gas emissions inventory	Unit	2019	2020	2021	2022	2023	2024	
Scope 1	tCO_2e	81,900	55,800	64,100	91,200	79,400	73,100	✓
Scope 2								
Scope 2 (location-based)	tCO_2e	5,116,900	5,865,100	6,576,200	8,045,400	9,252,900	11,283,200	✓
Scope 2 (market-based)	tCO_2e	835,900	911,600	1,823,500	2,492,100	3,423,400	3,059,100	✓
Total operational (scope 1 + market-based scope 2) emissions	tCO_2e	**917,800**	**967,400**	**1,887,600**	**2,583,300**	**3,502,800**	**3,132,200**	✓
Scope 3								
Scope 3 (Category 1: Purchased goods and services)	tCO_2e	2,787,000	2,404,000	2,886,000	3,504,000	3,951,000	3,601,000	✓
Scope 3 (Category 2: Capital goods) and (Category 11: Use of sold products)[148]	tCO_2e	4,584,000	4,176,000	4,462,000	3,886,000	4,583,000	6,337,000	✓
Scope 3 (Category 3: Fuel- and energy-related activities [not included in scope 1 or scope 2])	tCO_2e	425,000	512,000	753,000	1,004,000	1,295,000	714,000	✓
Scope 3 (Category 4: Upstream transportation and distribution)	tCO_2e	476,000	440,000	460,000	533,000	570,000	853,000	✓
Scope 3 (Category 5: Waste generated in operations)	tCO_2e	14,000	7,000	7,000	7,000	8,000	12,000	✓
Scope 3 (Category 6: Business travel)	tCO_2e	461,000	179,000	36,000	268,000	291,000	399,000	✓
Scope 3 (Category 7: Employee commuting)	tCO_2e	203,000	52,000	29,000	115,000	96,000	137,000	✓
Scope 3 (total)	tCO_2e	8,950,000	7,770,000	8,633,000	9,317,000	10,794,000	12,053,000	✓
Total emissions: Scope 1, 2 (market-based), and 3 (total)	tCO_2e	**9,867,800**	**8,737,400**	**10,520,600**	**11,900,300**	**14,296,800**	**15,185,200**	✓
Biogenic emissions	tCO_2e	21,900	5,400	3,800	17,900	18,700	17,200	✓

Note: In 2024, we recalculated certain previously reported GHG emissions metrics in accordance with our internal recalculation policy for improved accuracy. For more details, refer to the *Recalculation of previous environmental metrics* *section.*

Ambition-based emissions reconciliation	Unit	2019	2020	2021	2022	2023	2024	
Total emissions: Scope 1, 2 (market-based), and 3 (total)	tCO_2e	9,867,800	8,737,400	10,520,600	11,900,300	14,296,800	15,185,200	✓
Scope 3 exclusions, per SBTi ambition[149]								
Category 1: Purchased goods and services exclusions	tCO_2e	1,914,000	1,722,000	2,036,000	2,388,000	3,171,000	2,862,000	
Category 2: Capital goods exclusions	tCO_2e	292,000	333,000	418,000	518,000	750,000	776,000	
Total excluded scope 3 emissions	tCO_2e	2,206,000	2,055,000	2,454,000	2,906,000	3,921,000	3,638,000	
Total ambition-based emissions	tCO_2e	**7,661,800**	**6,682,400**	**8,066,600**	**8,994,300**	**10,375,800**	**11,547,200**	

Legend ✓ Subject to third-party limited assurance procedures. For more details, refer to our 2025 (FY2024) Independent Accountants' Review Report.

Carbon intensity	Unit	2020	2021	2022	2023	2024	
Carbon intensity per unit of revenue	tCO_2e/million USD ($)	5.30	7.33	9.13	11.40	8.95	✓
Carbon intensity per full-time employee (FTE) equivalent	tCO_2e/FTE	7.62	13.00	14.76	19.02	17.33	✓
Carbon intensity per megawatt-hour of energy consumed	tCO_2e/MWh	0.0624	0.1012	0.1155	0.1352	0.0957	✓

		2024					
GHG emissions by type	Unit	Scope 1		Scope 2 (market-based)		Scope 2 (location-based)	
CO_2	tCO_2e	50,700	✓	3,027,400	✓	11,207,600	✓
CH_4	tCO_2e	100	✓	4,200	✓	22,300	✓
N_2O	tCO_2e	200	✓	8,500	✓	34,300	✓
HFCs	tCO_2e	22,100	✓	19,000	✓	19,000	✓
Total	**tCO_2e**	**73,100**	✓	**3,059,100**	✓	**11,283,200**	✓
CO_2	tCO_2	50,700	✓	3,027,400	✓	11,207,600	✓
CH_4	tCH_4	5	✓	100	✓	800	✓
N_2O	tN_2O	1	✓	32	✓	100	✓
HFCs	tHFCs	14	✓	13	✓	13	✓

		2024					
GHG emissions by region	Unit	Scope 1		Scope 2 (market-based)		Scope 2 (location-based)	
North America	tCO_2e	53,600	✓	1,161,200	✓	8,293,200	✓
Europe, Middle East, & Africa	tCO_2e	8,800	✓	82,700	✓	1,033,800	✓
Latin America	tCO_2e	1,900	✓	13,900	✓	147,100	✓
Asia Pacific	tCO_2e	8,800	✓	1,801,300	✓	1,809,100	✓
Global total	**tCO_2e**	**73,100**	✓	**3,059,100**	✓	**11,283,200**	✓

Carbon removal credits[150]

Project type	Company	Estimated contracted credits (tCO_2e)	Project location	Year deal was signed	Expected timeframe for delivery	Credit type	Market commitment
Biomass carbon removal and storage (BiCRS)	Varaha	100,000	India	2024	2026–2030	Removal	Bilateral
	Charm Industrial	100,000	United States	2024	2026–2030	Removal	Bilateral
	CO280	61,226	United States	2024	2028–2030	Removal	Frontier
	Stockholm Exergi	41,636	Sweden	2024	2028–2030	Removal	Frontier
	Charm Industrial	22,635	United States	2023	2025–2030	Removal	Frontier
	Vaulted Deep	18,786	United States	2024	2024–2027	Removal	Frontier
	NULIFE	78	Canada	2024	2025	Removal	Frontier
Direct air capture (DAC)	Holocene	100,000	United States	2024	Early 2030's	Removal	Bilateral
	280 Earth	13,301	United States	2024	2026–2030	Removal	Frontier
Enhanced rock weathering (ERW)	Terradot	200,000	Brazil	2024	2029–2030	Removal	Bilateral
	Lithos Carbon	31,514	United States	2023	2025–2029	Removal	Frontier
	Terradot	17,324	Brazil	2024	2025–2029	Removal	Frontier
	CREW	12,851	United States	2024	2025–2030	Removal	Frontier
	Alt Carbon	185	India	2024	2028	Removal	Frontier
	Flux	114	Kenya	2024	2026	Removal	Frontier
	Silica	127	Mexico	2024	2030	Removal	Frontier
Restoring natural carbon sinks	Mombak	50,000	Brazil	2024	2029–2030	Removal	Bilateral
	CarbonRun	12,695	Canada	2024	2025–2029	Removal	Frontier
Total		**782,472**					

Legend ✓ Subject to third-party limited assurance procedures. For more details, refer to our 2025 (FY2024) Independent Accountants' Review Report.

Energy

Energy consumption by source type	Unit	2020	2021	2022	2023	2024	
Fuel	MWh	181,800	205,200	374,800	301,200	289,700	✓
Purchased electricity[151]	MWh	15,125,700	18,238,400	21,685,300	25,252,600	32,106,200	✓
Purchased heat[152]	MWh	124,900	119,300	219,100	278,500	237,500	✓
Purchased steam	MWh	22,100	22,600	23,500	14,500	17,100	✓
Purchased cooling	MWh	38,400	45,600	54,800	53,000	56,800	✓
On-site renewable electricity	MWh	7,200	8,800	9,600	10,700	20,500	✓
Total energy consumption	**MWh**	**15,500,100**	**18,639,900**	**22,367,100**	**25,910,500**	**32,727,800**	✓

		2024			
Energy consumption by source type	**Unit**	**Renewable sources**	**Non-renewable sources**	**Total**	
Fuel	MWh	63,200	226,500	289,700	✓
Purchased electricity[153]	MWh	23,995,800	8,110,400	32,106,200	✓
Purchased heat[154]	MWh	0	237,500	237,500	✓
Purchased steam	MWh	0	17,100	17,100	✓
Purchased cooling	MWh	0	56,800	56,800	✓
On-site renewable electricity	MWh	20,500	0	20,500	✓
Total energy consumption	**MWh**	**24,079,500**	**8,648,300**	**32,727,800**	✓

Electricity consumption	Unit	2020	2021	2022	2023	2024	
Data centers	MWh	14,426,600	17,659,000	20,806,200	24,294,900	30,825,600	✓
Office and other facilities	MWh	740,200	628,100	970,000	1,012,100	1,354,300	✓
Total electricity consumption[155]	**MWh**	**15,166,800**	**18,287,100**	**21,776,200**	**25,307,000**	**32,179,900**	✓

Renewable energy consumption	Unit	2020	2021	2022	2023	2024	
Renewable electricity procured (PPAs and other renewable energy agreements)	MWh	12,069,200	14,109,400	16,693,600	19,089,200	24,504,500	✓
Renewable electricity procured (on-site)	MWh	7,200	8,800	9,600	10,700	20,500	✓
Renewable electricity (grid)	MWh	3,062,100	4,168,900	5,073,000	6,207,100	7,654,900	✓
Total electricity procured from renewable sources	**MWh**	**15,138,500**	**18,287,100**	**21,776,200**	**25,307,000**	**32,179,900**	✓

Global renewable energy match	Unit	2020	2021	2022	2023	2024	
Electricity procured from renewable sources	%	100	100	100	100	100	✓

Global average carbon-free energy (CFE)	Unit	2020	2021	2022	2023	2024
CFE across Google data centers (hourly)	%	67	65	64	64	66
CFE across Google offices (hourly)	%	-	-	54	56	60
CFE across Google data centers and offices (hourly)	**%**	**-**	**-**	**64**	**64**	**66**

		2024			
Electricity and renewable electricity allocated by region	**Unit**	**Total electricity[156]**		**Total renewable electricity allocated[157]**	
North America	MWh	23,233,300	✓	18,747,600	✓
Europe, Middle East, & Africa	MWh	4,951,900	✓	4,822,000	✓
Latin America	MWh	500,400	✓	411,900	✓
Asia Pacific	MWh	3,494,300	✓	14,300	✓
Global total	**MWh**	**32,179,900**	✓	**23,995,800**	✓

Note: In 2024, we recalculated certain previously reported energy consumption and global average carbon-free energy metrics in accordance with our internal recalculation policy for improved accuracy. For more details, refer to the Recalculation of previous environmental metrics section.

Legend ✓ Subject to third-party limited assurance procedures. For more details, refer to our 2025 (FY2024) Independent Accountants' Review Report.

Regional average Google CFE across Google data center grid regions	Unit	2022	2023	2024
North America	**%**	**69**	**68**	**70**
United States	%	69	68	70
Canada & Mexico[158]	%	96	96	88
Europe, Middle East, & Africa	**%**	**76**	**83**	**83**
Europe	%	76	84	84
Middle East & Africa	%	3	4	5
Latin America	**%**	**90**	**91**	**92**
Asia Pacific	**%**	**11**	**12**	**12**
Global CFE across Google data centers	**%**	**64**	**64**	**66**

Data center grid region CFE[159]			2024			
Country	Regional grid	Unit	Google CFE	Contracted CFE	Consumed Grid CFE	Grid CFE
Europe, Middle East, & Africa						
Belgium	Elia	%	84	32	52	78
Denmark	Energinet	%	91	35	56	88
Finland	Fingrid	%	98	73	25	94
Germany	Germany	%	68	8	60	66
Ireland	EirGrid	%	47	5	42	44
Netherlands	Tennet	%	83	70	13	56
Asia Pacific						
Japan	TEPCO Power Grid (TEPCO)	%	17	0	17	17
Singapore	Energy Market Authority of Singapore	%	4	0	4	4
Taiwan	Taiwan Power Company	%	17	1	16	16
Latin America						
Chile	Sistema Interconectado Central	%	92	79	13	67
North America						
United States	Bonneville Power Administration (BPA)	%	87	0	87	87
United States	Duke Energy Carolinas (DUKE)	%	65	18	47	58
United States	Electric Reliability Council of Texas (ERCOT)	%	94	91	3	44
United States	Midcontinent Independent System Operator (MISO)	%	87	82	5	36
United States	NV Energy (NVE)	%	64	55	9	30
United States	Pennsylvania-New Jersey-Maryland Interconnection (PJM)	%	62	36	26	41
United States	South Carolina Regional Grid (SC)	%	31	9	22	25
United States	Southern Company (SOCO)	%	42	13	29	34
United States	Southwest Power Pool (SPP)	%	88	83	5	48
United States	Tennessee Valley Authority (TVA)	%	63	26	37	50

Data center energy efficiency (PUE)[160]							
Country	**Location**	**Unit**	**2020**	**2021**	**2022**	**2023**	**2024**
Belgium	St. Ghislain	PUE	1.08	1.08	1.09	1.09	1.08
Chile	Quilicura	PUE	1.08	1.09	1.09	1.09	1.09
Denmark	Fredericia	PUE	-	-	1.12	1.10	1.07
Finland	Hamina	PUE	1.09	1.09	1.09	1.09	1.10
Ireland	Dublin	PUE	1.09	1.09	1.09	1.08	1.08
Netherlands	Eemshaven	PUE	1.09	1.08	1.07	1.08	1.08
Singapore	1st facility	PUE	1.14	1.13	1.13	1.13	1.13
Singapore	2nd facility	PUE	-	-	1.21	1.19	1.15
Taiwan	Changhua County	PUE	1.13	1.12	1.12	1.12	1.13
United States	Berkeley County, South Carolina	PUE	1.11	1.10	1.10	1.10	1.10
United States	Columbus, Ohio	PUE	-	-	-	-	1.06
United States	Council Bluffs, Iowa (1st facility)	PUE	1.11	1.12	1.12	1.11	1.11
United States	Council Bluffs, Iowa (2nd facility)	PUE	1.09	1.09	1.08	1.08	1.07
United States	The Dalles, Oregon (1st facility)	PUE	1.10	1.11	1.10	1.10	1.10
United States	The Dalles, Oregon (2nd facility)	PUE	1.07	1.06	1.07	1.07	1.06
United States	Douglas County, Georgia	PUE	1.10	1.09	1.09	1.09	1.09
United States	Henderson, Nevada	PUE	-	-	1.11	1.08	1.09
United States	Jackson County, Alabama	PUE	-	1.13	1.12	1.10	1.10
United States	Lenoir, North Carolina	PUE	1.09	1.09	1.09	1.09	1.13
United States	Loudoun County, Virginia (1st facility)	PUE	-	1.10	1.09	1.08	1.09
United States	Loudoun County, Virginia (2nd facility)	PUE	-	1.13	1.09	1.08	1.08
United States	Mayes County, Oklahoma	PUE	1.12	1.10	1.10	1.10	1.11
United States	Midlothian, Texas	PUE	-	-	1.16	1.13	1.10
United States	Montgomery County, Tennessee	PUE	-	1.10	1.11	1.10	1.10
United States	New Albany, Ohio	PUE	-	-	1.14	1.10	1.07
United States	Papillion, Nebraska	PUE	-	-	1.13	1.09	1.09
United States	Storey County, Nevada	PUE	-	-	-	1.19	1.16
Average annual fleet-wide PUE across Google-owned and -operated data center campuses		**PUE**	**1.10**	**1.10**	**1.10**	**1.10**	**1.09**

Waste

Waste generation		Unit	2020	2021	2022	2023	2024
Data centers	Waste diverted	Metric tons	18,000	34,500	27,800	35,100	39,100
	Waste disposed	Metric tons	3,700	6,800	6,000	5,900	7,400
	Subtotal waste generated	**Metric tons**	**21,700**	**41,300**	**33,800**	**41,000**	**46,500**
	Waste diversion rate	**%**	**83**	**83**	**82**	**85**	**84**
Offices[161]	Waste diverted	Metric tons	6,900	1,200	4,900	8,600	10,100
	Waste disposed	Metric tons	2,900	700	1,600	2,600	1,900
	Subtotal waste generated	**Metric tons**	**9,800**	**1,900**	**6,500**	**11,200**	**12,000**
	Waste diversion rate	**%**	**71**	**64**	**75**	**77**	**84**
Total	Waste diverted	Metric tons	24,900	35,700	32,700	43,700	49,200
	Waste disposed	Metric tons	6,600	7,500	7,600	8,500	9,300
	Total waste generated	**Metric tons**	**31,500**	**43,200**	**40,300**	**52,200**	**58,500**
	Total waste diversion rate	**%**	**79**	**83**	**81**	**84**	**84**

Note: In 2024, we recalculated certain previously reported waste metrics in accordance with our internal recalculation policy for improved accuracy. For more details, refer to the Recalculation of previous environmental metrics section.

Data center hardware circularity	Unit	2020	2021	2022	2023	2024
Reused inventory used for Google-managed server builds, maintenance, and upgrades[162]	%	10	13	21	29	44
Components resold into the secondary market	Million components	8.2	4.9	5.0	7.0	6.7

Water

Global operational water use	Unit	2020	2021	2022	2023	2024	
Water withdrawal	Million gallons	5,689	6,297	7,600	8,653	11,011	✓
Water discharge	Million gallons	1,940	1,735	2,035	2,301	2,876	✓
Water consumption	Million gallons	3,749	4,562	5,565	6,352	8,135	✓

		2024					
Water use by data centers and offices	Unit	Water withdrawal		Water discharge		Water consumption	
Data centers	Million gallons	9,866	✓	2,079	✓	7,787	✓
Offices and other facilities	Million gallons	1,145	✓	797	✓	348	✓
Total	**Million gallons**	**11,011**	✓	**2,876**	✓	**8,135**	✓

Freshwater withdrawal from sources at risk of water depletion or scarcity[163]	Unit	2024
Low risk of water depletion or scarcity	%	72
Medium risk of water depletion or scarcity	%	14
High risk of water depletion or scarcity	%	14

Freshwater replenishment	Unit	2022	2023	2024
Freshwater consumption	Million gallons	4,770	5,601	7,210
Water replenished	Million gallons	271	1,036	4,590
Water replenished	%	6	18	64
Contracted water replenishment capacity	Million gallons	1,317	2,815	8,268

Water use by data center location		2024						Golf course equivalents (estimated)[165]
Location	Unit	Withdrawal[164]		Discharge		Consumption		
Ashburn, VA	Million gallons	59.5	✓	3.5	✓	56.0	✓	<1
Berkeley County, SC	Million gallons	853.8	✓	77.3	✓	776.5	✓	5.2
Bristow, VA	Million gallons	105.7	✓	21.3	✓	84.4	✓	<1
Council Bluffs, IA	Million gallons	1,410.3	✓	400.1	✓	1,010.2	✓	6.7
The Dalles, OR	Million gallons	461.1	✓	99.7	✓	361.4	✓	2.4
Douglas County, GA	Million gallons	444.1	✓	77.2	✓	366.9	✓	2.4
Potable water		7.4						
Reclaimed wastewater		436.7						
Dublin, Ireland[166]	Million gallons	0.9	✓	0.8	✓	0.1	✓	<1
Eemshaven, Netherlands	Million gallons	416.9	✓	86.9	✓	330.0	✓	2.2
Potable water		2.9						
Non-potable water[167]		414.0						
Frankfurt, Germany	Million gallons	2.3	✓	1.8	✓	0.5	✓	<1
Fredericia, Denmark	Million gallons	48.4	✓	10.6	✓	37.8	✓	<1
Hamina, Finland	Million gallons	3.0	✓	2.7	✓	0.3	✓	<1
Hanau, Germany	Million gallons	1.2	✓	0.6	✓	0.6	✓	<1
Henderson, NV	Million gallons	359.9	✓	152.5	✓	207.4	✓	1.4
Inzai, Japan	Million gallons	26.0	✓	7.8	✓	18.2	✓	<1
Jackson County, AL	Million gallons	201.6	✓	18.8	✓	182.8	✓	1.2
Lancaster, OH	Million gallons	207.4	✓	106.3	✓	101.1	✓	<1
Leesburg, VA	Million gallons	246.7	✓	55.1	✓	191.6	✓	1.3
Lenoir, NC	Million gallons	351.7	✓	23.9	✓	327.8	✓	2.2
Lockbourne, OH	Million gallons	177.3	✓	34.0	✓	143.3	✓	<1
Mayes County, OK	Million gallons	1,108.3	✓	275.1	✓	833.2	✓	5.6
Middenmeer, Netherlands	Million gallons	9.3	✓	2.8	✓	6.5	✓	<1
Midlothian, TX	Million gallons	221.0	✓	38.7	✓	182.3	✓	1.2
Montgomery County, TN	Million gallons	387.9	✓	66.1	✓	321.8	✓	2.1
Montreal, Canada[168]	Million gallons	0.6	✓	0.5	✓	0.1	✓	<1
New Albany, OH	Million gallons	405.3	✓	52.6	✓	352.7	✓	2.4

Legend ✓ Subject to third-party limited assurance procedures. For more details, refer to our 2025 (FY2024) Independent Accountants' Review Report.

Water use by data center location		2024						Golf course equivalents (estimated)[170]
Location	Unit	Withdrawal[169]		Discharge		Consumption		
Omaha, NE	Million gallons	44.3	✓	12.2	✓	32.1	✓	<1
Papillion, NE	Million gallons	532.3	✓	115.4	✓	416.9	✓	2.8
Pflugerville, TX[171]	Million gallons	0.1	✓	0.1	✓	0.01	✓	<1
Phoenix, AZ[172]	Million gallons	0.2	✓	0.2	✓	0.03	✓	<1
Quilicura, Chile	Million gallons	219.0	✓	97.2	✓	121.8	✓	<1
San Bernardo, Chile[173]	Million gallons	0.3	✓	0.3	✓	0.03	✓	<1
St. Ghislain, Belgium	Million gallons	511.7	✓	118.4	✓	393.3	✓	2.6
Potable water		13.7						
Non-potable water[174]		498.0						
Sterling, VA	Million gallons	201.2	✓	43.0	✓	158.2	✓	1.1
Storey County, NV[175]	Million gallons	14.9	✓	13.4	✓	1.5	✓	<1
Sydney, Australia[176]	Million gallons	1.0	✓	0.9	✓	0.1	✓	<1
Wilmer, TX[177]	Million gallons	1.9	✓	1.7	✓	0.2	✓	<1
Other data center locations	Million gallons	828.9	✓	60.0	✓	768.9	✓	5.1
Potable water		10.7						
Non-potable water		377.9						
Reclaimed wastewater		440.3						
Data centers total	**Million gallons**	**9,866**	✓	**2,079**	✓	**7,787**	✓	**51**
Potable water		7,699						
Non-potable water		1,289						
Reclaimed wastewater		877						

Legend ✓ Subject to third-party limited assurance procedures. For more details, refer to our 2025 (FY2024) Independent Accountants' Review Report.

Assurance

We obtain limited third-party assurance from an independent auditor for certain environmental metrics, including select GHG emissions, energy, and water metrics as indicated in our Environmental metrics data tables. Ernst & Young LLP reviewed these metrics within the Schedules of Select Environmental Metrics for the fiscal year ended December 31, 2024. For more details, refer to our 2025 (FY2024) Independent Accountants' Review Report below.

Due to rounding, recalculation, and footing, some of the reported values in our Environmental metrics data tables for prior years no longer directly match the associated Independent Accountants' Review Reports or data tables from those years.

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Independent Accountants' Review Report

To the Board of Directors and Management of Alphabet Inc.

We have reviewed Alphabet Inc.'s Schedules of Select Environmental Metrics for the year ended December 31, 2024 (the "Subject Matter") included in Appendix A in accordance with the criteria also set forth in Appendix A (the "Criteria"). Alphabet Inc.'s management is responsible for the Subject Matter in accordance with the Criteria. Our responsibility is to express a conclusion on the Subject Matter based on our review.

Our review was conducted in accordance with attestation standards established by the American Institute of Certified Public Accountants (AICPA) AT-C section 105, *Concepts Common to All Attestation Engagements*, and AT-C section 210, *Review Engagements*. Those standards require that we plan and perform our review to obtain limited assurance about whether any material modifications should be made to the Subject Matter in order for it to be in accordance with the Criteria. The procedures performed in a review vary in nature and timing from and are substantially less in extent than, an examination, the objective of which is to obtain reasonable assurance about whether the Subject Matter is in accordance with the Criteria, in all material respects, in order to express an opinion. Accordingly, we do not express such an opinion. Because of the limited nature of the engagement, the level of assurance obtained in a review is substantially lower than the assurance that would have been obtained had an examination been performed. As such, a review does not provide assurance that we became aware of all significant matters that would be disclosed in an examination. We believe that the review evidence obtained is sufficient and appropriate to provide a reasonable basis for our conclusion.

We are required to be independent of Alphabet Inc. and to meet our other ethical responsibilities, in accordance with the relevant ethical requirements related to our review engagement. Additionally, we have complied with the other ethical requirements set forth in the Code of Professional Conduct and applied the Statements on Quality Control Standards established by the AICPA.

The procedures we performed were based on our professional judgment. Our review consisted principally of applying analytical procedures, making inquiries of persons responsible for the subject matter, obtaining an understanding of the data management systems and processes used to generate, aggregate and report the Subject Matter and performing such other procedures as we considered necessary in the circumstances.

As described in Appendix A, the Subject Matter is subject to measurement uncertainties resulting from limitations inherent in the nature and the methods used for determining such data. The selection of different but acceptable measurement techniques can result in materially different measurements. The precision of different measurement techniques may also vary.

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Furthermore, Scope 3 emissions are calculated based on a significant number of estimations and management assumptions due to the inherent nature of the Greenhouse Gas Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard as well as the Technical Guidance for Calculating Scope 3 Emissions criteria.

The information included in the Company's annual Environmental Report and submission to the CDP, formerly known as the Carbon Disclosure Project, other than the Subject Matter, has not been subjected to the procedures applied in our review and, accordingly, we express no conclusion on it.

Based on our review, we are not aware of any material modifications that should be made to the accompanying Schedules of Select Environmental Metrics for the year ended December 31, 2024 included within Appendix A in order for them to be in accordance with the Criteria.

Ernst & Young LLP

San Jose, California
June 16, 2025

Appendix A: Schedules of Select Environmental Metrics

Alphabet Inc.[1] Schedule of Selec Environmenta Metrics
For the Year Ended December 31 2024[2]

Metric [3, 4]	Reported Value	Unit	Criteria
GREENHOUSE GAS (GHG) EMISSIONS			
Emissions Inventory			
Scope 1	73,100	Metric tons of carbon dioxide equivalent (tCO_2e)	World Resources Institute (WRI)/World Business Council for Sustainable Development's (WBCSD): 1. The GHG Protocol: A Corporate Accounting and Reporting Standard as amended by the GHG Protocol Scope 2 Guidance (Corporate Standard) 2. Corporate Value Chain (Scope 3) Accounting and Reporting Standard (Scope 3 Standard) 3. Technical Guidance for Calculating Scope 3 Emissions (Scope 3 Technical Guidance) Collectively, these are referred to as the GHG Protocol.
Biogenic emissions	17,200	Metric tons of carbon dioxide (tCO_2)	
Scope 2 location-based	11,283,200	tCO_2e	
Scope 2 market-based	3,059,100		
Total operational (scope 1 + market-based scope 2) emissions	3,132,200		
Scope 3 (Category 1: Purchased goods and services) [6]	3,601,000		
Scope 3 (Category 2: Capital goods) and (Category 11: Use of sold products) [6]	6,337,000		
Scope 3 (Category 3: Fuel- and energy-related activities [not included in scope 1 or scope 2]) [6]	714,000		
Scope 3 (Category 4: Upstream transportation and distribution) [6]	853,000		
Scope 3 (Category 5: Waste generated in operations) [6]	12,000		
Scope 3 (Category 6: Business travel) [6]	399,000		
Scope 3 (Category 7: Employee commuting) [6]	137,000		
Scope 3 (total)	12,053,000		
Carbon Intensity			
Carbon intensity per unit of revenue [7]	8.95	tCO_2e / million USD ($)	GRI Disclosure 305-4: GHG emissions intensity These metrics are calculated using Scope 1 and Scope 2 market-based GHG emissions. The GHGs included in these metrics are CO2, CH4, N2O, and HFCs.
Carbon intensity per full-time equivalent employee (FTE) [7, 8]	17.33	tCO_2e / FTE	
Carbon intensity per MWh of energy consumed [9]	0.0957	tCO_2e / MWh	

[1] References to Alphabet Inc. includes its subsidiaries (collectively, Alphabet).
[2] All metrics are reported for the period January 1, 2024 through December 31, 2024.
[3] The ambitions and progress against related ambitions are not included in this presentation of the Subject Matter.
[4] Non-financial information is subject to measurement uncertainties resulting from limitations inherent in the nature and the methods used for determining such data. The selection of different but acceptable standards and frameworks provide acceptable measurement techniques, which may result in materially different measurements. The precision of different measurement techniques may also vary.
[5] All reported values are rounded to the nearest hundred unless otherwise noted.
[6] All reported scope 3 GHG emissions values are rounded to the nearest thousand.
[7] Reported carbon intensity per unit of revenue and per FTE employee values are rounded to the nearest hundredth.
[8] FTEs are based on the annual average FTEs.
[9] Reported carbon intensity per MWh of energy consumed value is rounded to the nearest ten thousandth.

Alphabet Inc.[1] Schedule of Selec Environmenta Metrics
For the Year Ended December 31 2024[2]

Metric [3, 4]	Reported Value	Unit	Criteria
ENERGY			
Energy Consumption			
Total energy consumption[10]	32,727,800	MWh[11]	As defined by GRI Disclosure 302-1: Energy consumption within the organization a, b, c, e, f, g[12, 13]
Electricity procured from renewable sources	100	%	Alphabet calculates electricity procured from renewable sources (%) on an annual basis by dividing the MWhs of electricity procured from renewable sources (i.e., through contractual instruments, on-site renewable electricity generation, and renewable electricity in the electric grids where facilities are located) by the total MWhs of electricity consumption of Alphabet's global operations.
WATER			
Global Operational Water Use			
Water withdrawal	11,011	Million gallons	Total water withdrawal, excluding seawater, for any use by Alphabet.[12]
Water discharge	2,876		Total water discharge, excluding seawater, for which Alphabet has no further use.[12]
Water consumption	8,135		Total water consumption, excluding seawater, that has been withdrawn and incorporated into Alphabet's operations, including through evaporation, and is therefore not released back to surface water, groundwater, or a third party.[12]

Boundaries and general methodology

The metrics in the following schedules are reported in alignment with the criteria outlined in the Schedule of Select Environmental Metrics above. The reporting boundary for the GHG emissions, energy, and water metrics included in the Schedule of Select Environmental Metrics is Alphabet, globally. Alphabet utilizes the operational control approach, as defined by the GHG Protocol, to establish the relevant operations for the emissions, energy, and water metrics at Alphabet's owned and leased data centers, offices, and other assets (Global Facilities). Where possible, based on Alphabet's reporting timeline and requirements, Alphabet uses the most up-to-date emission factors available at the time of their emissions inventory calculation and calculates emissions by multiplying relevant activity data by the applicable emission factors, and global warming potentials (GWPs) (if applicable). Many of the emission factor sources provide emission factors in CO_2e and therefore GWPs are not required. In cases where Alphabet calculates CO_2e from emission factors for individual GHGs, the GWPs for each GHG are sourced from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4), IPCC Fifth Assessment Report (AR5), and IPCC Sixth Assessment Report (AR6).

Scope 1

"Scope 1" represents direct emissions from natural gas, back-up generator fuel use, and fugitive emissions of hydrofluorocarbons (HFCs) from refrigerant leaks at owned Global Facilities, fuel consumption from Alphabet's operated vehicles and aircraft, and methane (CH_4) and nitrous oxide (N_2O) from biogenic sources. Where actual data isn't available, for example from a utility bill, Alphabet estimates natural gas consumption using square footage of the data centers, offices, and other assets and internally developed natural gas intensity factors by office type, based on data from the reporting period. Where actual refrigerant leakage data isn't available, Alphabet estimates refrigerant leakage by taking an average of GWP values from known refrigerants within the portfolio and a 20% leakage rate at data centers, offices, and other assets. The emission factors used to calculate scope 1 GHG emissions include the 2024 WRI/WBCSD GHG Protocol Emission Factors from Cross Sector Tools, the 2025 U.S. Environmental Protection Agency (EPA) Emission Factors for

[10] Total energy consumption includes all fuel and natural gas consumption; purchased electricity, steam, heating, cooling; and all electricity generated on-site from renewable sources.
[11] Metric is reported in MWh, using a conversion factor of 3600 MJ/MWh.
[12] Significant contextual information necessary to understand how the data has been compiled has been disclosed.
[13] Other criteria included in GRI Disclosure 302-1 (e.g., 302-1d: electricity, heating, cooling, and steam consumed sold) are excluded.

Greenhouse Gas Inventories, the 2024 Climate Registry Default Emission Factors, and the 2024 Department for Environment, Food and Rural Affairs (DEFRA) UK Government GHG Conversion Factors.

Biogenic emissions

"Biogenic emissions" represent direct CO_2 emissions from Alphabet 's operated vehicles and generators that consume biogenic fuels. In accordance with the Corporate Standard, biogenic CO_2 emissions are reported separately from other scope 1 GHG emissions. The emission factors used to calculate biogenic emissions come from the 2025 EPA Emission Factors for Greenhouse Gas Inventories.

Scope 2 location-based and Scope 2 market-based

"Scope 2 location-based" and "**Scope 2 market-based**" represent indirect emissions from natural gas, fugitive emissions from refrigerant leaks at leased Global Facilities, purchased steam, hot water, and chilled water from district energy systems, and purchased electricity consumption at Global Facilities. All purchased electricity includes purchased electricity for owned and operated global data centers and purchased electricity related to the operation of Alphabet's information technology assets at leased data centers and other locations. Alphabet reports scope 2 emissions using both location-based and market-based methods. The location-based method reflects the average carbon intensity of the electric grids where Alphabet's operations are located and thus where the electricity consumption occurs. The market-based method incorporates Alphabet's procurement choices, primarily renewable energy purchases via contractual instruments, such as power purchase agreements (PPAs). Alphabet uses actual data (such as third-party invoices, monthly utility bills, or meter readings) to calculate scope 2 emissions. Where actual data isn't available, Alphabet estimates electricity consumption, natural gas consumption, and activity from district energy systems using square footage of our data centers, offices, and other assets and internally developed intensity factors by office type, based on data from the reporting period. The emission factors used to calculate scope 2 (location-based) emissions include the 2024 WRI/WBCSD GHG Protocol Emission Factors from Cross Sector Tools, the 2025 EPA Emission Factors for Greenhouse Gas Inventories, the 2024 DEFRA UK Government GHG Conversion Factors, the 2024 International Energy Agency (IEA) Emission Factors, the 2025 EPA eGRID Emission Factors, and the 2024 Climate Registry Default Emission Factors. The emission factors used to calculate scope 2 (market-based) emissions are the same as scope 2 (location-based) with the addition of emission factors specific to energy attribute certificates (EACs), as well as residual mix emission factors where available. Residual grid mix removes the proportion of renewable energy contracted to other parties—that have the rights to claim those clean electricity attributes through EACs—from the grid electricity mix, and therefore avoids double-counting. Comprehensive residual mix emission factors are currently only available for Europe (European Residual Mixes 2023, Association of Issuing Bodies). Outside of Europe, residual emission factors aren't available from third-party sources to account for voluntary purchases, and this may result in double counting between electricity consumers.

Alphabet's Schedule of GHG Emissions by Region
For the Year Ended December 31 2024
(tCO_2e)

GHG emissions by region	Scope 1	Scope 2 (market-based)	Scope 2 (location-based)
North America	53,600	1,161,200	8,293,200
Europe, Middle East, & Africa	8,800	82,700	1,033,800
Latin America	1,900	13,900	147,100
Asia Pacific	8,800	1,801,300	1,809,100
Global total	73,100	3,059,100	11,283,200

Alphabet's Schedule of GHG Emissions by Type
For the Year Ended December 31 2024
(tCO_2e)

GHG emissions by type	Scope 1	Scope 2 (market-based)	Scope 2 (location-based)
CO_2	50,700	3,027,400	11,207,600
CH_4	100	4,200	22,300
N_2O	200	8,500	34,300
HFCs	22,100	19,000	19,000
Total	73,100	3,059,100	11,283,200

Alphabet's Schedule of GHG Emissions by Type
For the Year Ended December 31 2024
(metric tons per gas type)

GHG emissions by type	Scope 1	Scope 2 (market-based)	Scope 2 (location-based)
CH_4	5	100	800
N_2O	1	32	100
HFCs	14	13	13

Scope 3 GHG emissions

"**Scope 3 GHG emissions"** are indirect emissions from other sources in Alphabet's value chain. Alphabet calculates the reported values in the Schedule of Select Environmental Metrics using methodologies from the Scope 3 Technical Guidance for the following categories identified as relevant:

- Category 1: Purchased goods and services
- Category 2: Capital goods
- Category 3: Fuel- and energy-related activities (not included in scope 1 or scope 2)
- Category 4: Upstream transportation and distribution
- Category 5: Waste generated in operations
- Category 6: Business travel
- Category 7: Employee commuting
- Category 11: Use of sold products

Alphabet evaluated the remaining categories using the Scope 3 Standard's relevance criteria and determined the following categories to be either not applicable or not relevant. The emissions associated with categories deemed not relevant are not significant to scope 3 emissions individually or in the aggregate.

- Category 8: Upstream leased assets. Not applicable because Alphabet accounts for upstream leased assets within scope 2.
- Category 9: Downstream transportation and distribution. Not relevant because category 9 emissions are insignificant.
- Category 10: Processing of sold products. Not applicable because Alphabet does not sell intermediate goods that require further processing.
- Category 12: End-of-life treatment of sold products. Not relevant because category 12 emissions are insignificant.
- Category 13: Downstream leased assets. Not relevant because category 13 emissions are insignificant.
- Category 14: Franchises. Not applicable because Alphabet does not have franchises.
- Category 15: Investments. Not relevant because category 15 emissions are insignificant, based on a screening estimate of equity investments in which Alphabet has greater than 5% ownership.

Alphabet's reported values in the Schedule of Select Environmental Metrics are presented according to the minimum boundaries listed by the Scope 3 Standard. For certain categories, Alphabet also includes activities which the Scope 3 Standard deems optional. None of the scope 3 categories have associated biogenic carbon dioxide emissions.

Alphabet presents emissions from category 2 (Capital goods) and category 11 (Use of sold products) as an aggregated total for business confidentiality purposes. The emissions from category 11 (Use of sold products) are not a material component of total scope 3 emissions.

For each relevant scope 3 category, Alphabet provides the following details, as applicable: the minimum and optional activities included, calculation methods, activity data, emission factors, percentage of category emissions from value chain partners, allocations, and any significant estimations or assumptions.

"Category 1: Purchased goods and services" includes upstream emissions generated from manufacturing consumer devices and spare parts, the Real Estate & Workplace Services (REWS) food program, and additional goods and services purchased for Alphabet's operations. Alphabet uses a combination of the average-data method and spend-based method, as defined by the Scope 3 Technical Guidance. To calculate supply chain emissions generated from manufacturing consumer devices and spare parts, Alphabet performs third-party-verified Life Cycle Assessments (LCAs) in accordance with International Organization for Standardization (ISO) 14040 and ISO 14044. To calculate emissions generated from the REWS food program, Alphabet uses LCA emission factors from WRI's Cool Food Pledge Calculator and annual procurement volumes from San Francisco Bay Area offices. For the remaining offices where procurement data is unavailable, Alphabet estimates remaining emissions by scaling the San Francisco Bay Area emissions based on global building admittance data. Where emission factors from WRI aren't available, Alphabet estimates remaining emissions using spend data and the EPA's U.S. Environmentally-Extended Input-Output ("USEEIO") Supply Chain GHG Emission Factors (2024 v1.3), which are then adjusted for inflation using the U.S. Bureau of Labor Statistics' Consumer Price Index Inflation Calculator ("USEEIO supply chain emission factors"). To calculate emissions generated from the remaining goods and services purchased for operations, Alphabet estimates supplier emissions using spend data and USEEIO supply chain emission factors. Data obtained from value chain partners is used to calculate approximately 2% of Category 1 emissions.

"Category 2: Capital goods" includes upstream emissions generated from final goods that are used in manufacturing and assembly of servers and networking equipment used in technical infrastructure, materials and fuels used in the construction of data centers and offices, and additional capital goods purchased for Alphabet's operations. Alphabet uses a combination of the average-data, and spend-based methods, as defined by the Scope 3 Technical Guidance, as well as LCAs that are in accordance with ISO 14040, ISO 14044, and ISO 14067. To calculate emissions generated from manufacturing and assembly of servers and networking equipment used in technical infrastructure, Alphabet primarily uses configurable LCA models (third-party reviewed) for high-impact components (which account for the majority of total technical infrastructure hardware emissions). This allows tailored calculations to Alphabet's specific mix of data center hardware and incorporation of supplier-specific process-level data. For technical infrastructure components where LCA data is unavailable, Alphabet applies the spend-based method. For these remaining components, Alphabet collects supplier emissions data from contract manufacturers as well as component and fabless suppliers through the CDP Supply Chain Program. Alphabet's share of these suppliers' emissions is determined via economic allocation (i.e., based on revenue and spend). Where available and valid, Alphabet uses scope 2 market-based method emissions from these suppliers. Where supplier-specific emissions data is not available through CDP, Alphabet estimates supplier emissions using spend data and either USEEIO supply chain emission factors or proxy supplier economic allocation. To calculate emissions generated from materials used in data center and office construction, Alphabet uses data on annual construction area and lifecycle emission factors derived from LCAs conducted on Alphabet data centers and offices, as well as invoice-based material information. Alphabet inputs building mass by material data– either collected, or estimated based on actuals where unknown–into LCA software (Tally, One Click LCA and SimaPro–which reference the emission factor databases from ecoinvent and Sphera), and the Embodied Carbon in Construction Calculator (EC3) webtool. For offices, the LCA results undergo third-party review (e.g., by the US Green Building Council for LEED certification). To calculate emissions generated from additional capital goods purchased for operations, Alphabet estimates supplier emissions using spend data and USEEIO supply chain emission factors. Data obtained from value chain partners is used to calculate approximately 15% of emissions.

"Category 3: Fuel- and energy-related activities (not included in scope 1 or scope 2)" includes upstream emissions from purchased fuels (e.g., natural gas, diesel, and gasoline) and purchased energy (i.e., electricity, steam, heating, and cooling), as well as emissions from transmission and distribution losses from purchased energy. Alphabet uses the average-data method, as defined by the Scope 3 Technical Guidance. Alphabet calculates upstream emissions from purchased fuel, steam, heating, and cooling and emissions from transmission and distribution losses from steam, heating, and cooling using 2024 DEFRA UK Government GHG Conversion Factors. Alphabet calculates emissions from upstream electricity by country using the 2024 IEA Emission Factors. Alphabet calculates emissions from electricity transmission and distribution losses using grid loss values and emission factors derived from the 2024 IEA Emission Factors and, for the United States, the 2025 EPA eGRID Emission Factors. For upstream electricity, Alphabet calculates emissions using scope 2 market-based data (i.e., by using the remaining electricity not addressed by renewable energy). For electricity transmission and distribution losses, Alphabet uses the market-based method to account for EACs that Alphabet has purchased to cover a portion of grid losses.

"Category 4: Upstream transportation and distribution" includes emissions generated from transportation and warehousing of Alphabet's consumer products and data center equipment. Report Values also include the optional activities of upstream emissions of transportation. For transportation emissions, Alphabet uses a combination of the fuel-based and distance-based methods, as defined by the Scope 3 Technical Guidance. For transportation emissions, Alphabet collects well-to-wheel (WTW) emissions data, calculated based on fuel use or weight-distance data, and routing associated with a shipment from suppliers. Logistics providers determine Alphabet's share of a shipment's transportation emissions via physical allocation (i.e., based on how much of the total shipment's weight is from Alphabet's goods). Where actual logistics provider emissions data isn't available, Alphabet calculates WTW emissions using weight and distance data by shipment collected from providers, using emission factors from the 2024 Global Logistics Emissions Council (GLEC) framework v3.1 or EPA SmartWay carrier performance data. Where logistics provider weight and distance data is not available, emissions are estimated based on reported data from other transportation providers and the weight shipped. For warehousing emissions, Alphabet uses the site-specific method, as defined by the Scope 3 Technical Guidance. To calculate consumer products and data center equipment warehousing emissions, Alphabet collects energy data (both) and refrigerant leakage data (data center equipment warehousing only) directly from the warehouses and calculates emissions using lifecycle electricity and fuel emission factors from the Sphera Professional database 2024. Alphabet's share of a third party's warehouse energy and refrigerant leakage activity is determined via physical allocation (i.e., based on how much of the total warehouse area is used for Alphabet's goods). Data obtained from value chain partners is used to calculate nearly 100% of emissions.

"**Category 5: Waste generated in operations**" includes emissions from solid waste generated at Alphabet's offices, Google[14] owned-and operated data centers, and Google-owned warehouses. The waste is either composted, recycled, landfilled, or incinerated (with or without energy recovery). Alphabet calculates this category's emissions to also include the optional activity of waste transportation, which is embedded in the emission factors used. Alphabet uses a combination of the waste-type-specific method and the average-data method, as defined by the Scope 3 Technical Guidance. The waste generation data comes from a combination of data from invoices and on-site measurements. Where actual waste data isn't available for a specific facility, Alphabet estimates waste tonnage using waste container size and pickup frequency, actual waste data from similar facilities, or historical waste data from the same facility. Alphabet uses waste type- and disposal type-specific emission factors from the 2025 EPA Emission Factors for Greenhouse Gas Inventories for U.S. activity and the 2024 DEFRA UK Government GHG Conversion Factors for non-U.S. activity. Alphabet excludes from this category the emissions from wastewater treatment. Although category 5 emissions are insignificant, Alphabet determined that waste generated in operations is relevant based on other criteria for relevance such as influence, risk, and stakeholders.

"**Category 6: Business travel**" includes emissions from business-related air, rail, bus, personal vehicle (when the employee's car is used for business purposes), taxi, rideshare, shuttle, and rental car travel, including emissions from relocation travel. Report Values also include the optional activity of upstream emissions of business travel. Alphabet uses a combination of the distance-, fuel-, and spend-based calculation methods, as defined by the Scope 3 Technical Guidance. Alphabet collects all travel data through an online booking system or a third-party travel agency. To calculate emissions from the majority of air travel, Alphabet uses the Travel Impact Model, an emissions estimation model developed by Google that's built from public and licensable external datasets. Alphabet calculates total plane WTW emissions and allocates an amount to the employee passenger based on the plane's percentage of occupied seats (i.e., the passenger load factor) and the mass of cargo being carried. For all other modes of transport, including rail, taxi, rideshare, non-U.S. personal vehicles, non-U.S. shuttle travel, and a minority of air travel, Alphabet uses WTW emissions factors from the 2024 DEFRA UK Government GHG Conversion Factors. Alphabet calculates emissions from car rental, U.S. personal vehicle, and U.S. shuttle travel using well-to-tank (WTT) emission factors from the 2024 DEFRA UK Government GHG Conversion Factors (WTT) and tank-to-wheel (TTW) emission factors from the 2025 EPA Emission Factors for Greenhouse Gas Inventories. Data obtained from value chain partners is used to calculate approximately 6% of emissions.

"**Category 7: Employee commuting**" includes emissions from the transport of full-time employees between their homes and their worksites by passenger car (i.e., carpool, dropoff, taxi, rideshare, or single-occupied vehicle), rail, bus, motorcycle and gas-powered scooter. Report Values also include the optional activity of upstream emissions of employee commuting. Alphabet uses the distance-based method, as defined by the Scope 3 Technical Guidance. Alphabet surveys its employees to determine typical commuting patterns and applies these commuting patterns to its global employee population. Alphabet uses a mode-specific commuting distance obtained from the American Public Transportation Association's 2023 Fact Book and the U.S. Department of Transportation's 2022 National Household Travel Survey. Alphabet calculates employee commuting emissions using mode-specific WTT emission factors from the 2024 DEFRA UK Government GHG Conversion Factors and TTW emission factors from the 2025 EPA Emission Factors for Greenhouse Gas Inventories. Alphabet uses passenger distance-based emission factors for shared vehicles (i.e., carpool, taxi, rideshare, rail, bus) in order to allocate the total vehicle emissions to the employee passenger.

"Category 11: Use of sold products" includes direct use-phase emissions generated by Google's consumer devices sold in the reporting period that directly consume electricity during use.[15, 16] These emissions also include the optional activity of upstream electricity emissions of these devices by using LCA emission factors. Alphabet performs LCAs that are in accordance with ISO 14040 and ISO 14044 and are third-party reviewed. The LCA results are published on Google's Sustainability Reports webpage. Alphabet uses laboratory power draw measurements, data on use patterns, common industry assumptions on product lifetimes, and LCA electricity emission factors from the 2024 Sphera LCA for Experts database.

Energy

Alphabet calculates electricity procured from renewable sources (%) using a custom methodology based on a global approach. Alphabet calculates electricity procured from renewable sources (%) on an annual basis by dividing the MWhs of renewable electricity procured (i.e., through contractual instruments, on-site renewable electricity generation, and renewable electricity in the electric grids where facilities are located) by the total MWhs of electricity consumed by Alphabet's global operations. Contractual instruments may include

[14] Alphabet is the parent holding company of Google.
[15] Flagship consumer devices are products that can provide their main functionality without connection to another product. For example, this generally doesn't include accessories such as cases.
[16] Network and end-user devices used to access web-based software are not considered to be direct-use phase emissions and are not within the reporting boundary for use of sold products.

PPAs, tax equity investments, PPA-linked Renewable Energy Certificates (RECs) / guarantee of origin (GO) agreements, and utility renewable energy tariffs, which may result in RECs or GOs. The numerator includes all renewable electricity procured, regardless of the market in which Alphabet consumed the renewable electricity. To achieve Alphabet's 100% renewable energy match, Alphabet first considers both on-site renewable electricity generation and the renewable electricity already in the electric grids where the facilities are located (using the residual mix where data is available). Alphabet then procures renewable electricity through contractual instruments. Alphabet has a few facilities located in geographies where it is not currently able to source large volumes of renewable electricity, so Alphabet procures surplus renewable electricity in regions where it's abundant. Refer to "Achieving Our 100% Renewable Energy Purchasing Goal and Going Beyond" for additional details on Alphabet's custom criteria and methodology.

Alphabet's Schedule of Electricity and Renewable Electricity by Region For the Year Ended December 31 2024 (MWh)		
Electricity and renewable electricity allocated by region	**Total electricity**	**Total renewable electricity allocated**
North America	23,233,300	18,747,600
Europe, Middle East, & Africa	4,951,900	4,822,000
Latin America	500,400	411,900
Asia Pacific	3,494,300	14,300
Global total	**32,179,900**	**23,995,800**

Alphabet's Schedu e of Energy Consumption For the Year Ended December 31 2024 (MWh)			
Energy consumption by source type	**Renewable sources**	**Non-renewable sources**	**Total**
Fuel	63,200	226,500	289,700
Purchased electricity [17]	23,995,800	8,110,400	32,106,200
Purchased heat	0	237,500	237,500
Purchased steam	0	17,100	17,100
Purchased cooling	0	56,800	56,800
On-site renewable electricity	20,500	0	20,500
Total energy consumption	**24,079,500**	**8,648,300**	**32,727,800**

[17] "Total electricity consumption" includes both purchased and self-generated electricity from renewable and non-renewable sources. Where actual natural gas or electricity consumption for facilities isn't available, Alphabet estimates consumption using building square footage and internally developed intensity factors based on data from the reporting period. Total electricity consumption differs slightly from "Purchased electricity," which is electricity sourced from an electrical grid and purchased from a local electric utility company.

Alphabet's Schedule of Electricity Consump ion For the Year Ended December 31 2024 (MWh	
Data centers	30,825,600
Offices and other facilities	1,354,300
Total electricity consumption [17]	**32,179,900**

Alphabet 's Schedule of Electricity Procured from Renewable Sources For the Year Ended December 31 2024 (MWh	
Renewable electricity procured (PPAs and other renewable energy agreements)	24,504,500
Renewable electricity procured (on-site)	20,500
Renewable electricity (grid)	7,654,900
Total electricity procured from renewable sources	**32,179,900**

Water

Relevant operations for water metrics include owned and fully leased data centers and owned and leased offices and other assets. Water withdrawal data is based on actual metered or invoiced data when it is available. At offices where actual metered or invoiced data is not available, water withdrawal is estimated using facility square footage and internally developed water withdrawal intensity factors by office type based on data from the reporting period. Water discharge is based on actual metered or invoiced data when it's available. Where actual domestic wastewater discharge data isn't available, Alphabet applies an industry-standard 90% discharge flow factor to a facility's domestic water withdrawal to estimate domestic water discharge and a 0% discharge flow factor to a facility's irrigation water withdrawal to estimate irrigation water discharge. Alphabet applies this water discharge estimation methodology at all offices and at data centers where metered water discharge data isn't available. At data centers where actual data isn't available, Alphabet estimates water discharge using engineering principles. Alphabet calculates "water consumption" by subtracting "water discharge" from "water withdrawal."

Alphabet's Schedule of Water Use by Data Centers and Offices For the Year Ended December 31 2024 (mil ion gallons			
Water use by data centers and offices	**Withdrawal**	**Discharge**	**Consumption**
Data centers	9,866	2,079	7,787
Office and other facilities	1,145	797	348
Total	**11,011**	**2,876**	**8,135**

Alphabet's Schedule of Water Use by Data Center Location For the Year Ended December 31 2024 (mil ion gallons)[18]			
Location	**Withdrawal**	**Discharge**	**Consumption**
Ashburn, VA	59.5	3.5	56.0
Berkeley County, SC	853.8	77.3	776.5
Bristow, VA	105.7	21.3	84.4
Council Bluffs, IA	1,410.3	400.1	1,010.2
The Dalles, OR	461.1	99.7	361.4
Douglas County, GA	444.1	77.2	366.9
Dublin, Ireland	0.9	0.8	0.1
Eemshaven, Netherlands	416.9	86.9	330.0
Frankfurt, Germany	2.3	1.8	0.5
Fredericia, Denmark	48.4	10.6	37.8
Hamina, Finland	3.0	2.7	0.3
Hanau, Germany	1.2	0.6	0.6
Henderson, NV	359.9	152.5	207.4
Inzai, Japan	26.0	7.8	18.2
Jackson County, AL	201.6	18.8	182.8
Lancaster, OH	207.4	106.3	101.1
Leesburg, VA	246.7	55.1	191.6
Lenoir, NC	351.7	23.9	327.8
Lockbourne, OH	177.3	34.0	143.3
Mayes County, OK	1,108.3	275.1	833.2
Middenmeer, Netherlands	9.3	2.8	6.5
Midlothian, TX	221.0	38.7	182.3
Montgomery County, TN	387.9	66.1	321.8
Montreal, Canada	0.6	0.5	0.1
New Albany, OH	405.3	52.6	352.7
Omaha, NE	44.3	12.2	32.1
Papillion, NE	532.3	115.4	416.9
Pflugerville, TX	0.1	0.1	0.01
Phoenix, AZ	0.2	0.2	0.03
Quilicura, Chile	219.0	97.2	121.8
San Bernardo, Chile	0.3	0.3	0.03
St. Ghislain, Belgium	511.7	118.4	393.3
Sterling, VA	201.2	43.0	158.2
Storey County, NV	14.9	13.4	1.5
Sydney, Australia	1.0	0.9	0.1
Wilmer, TX	1.9	1.7	0.2
Other data center locations	828.9	60.0	786.9
Total	**9,866**	**2,079**	**7,787**

[18] Water use by data center location metrics are rounded to the nearest tenth. If water use by data center location is less than fifty thousand gallons, we round to the nearest hundredth.

Certifications and recognitions

Certification	Details
ISO 50001: Energy management	In 2024, we maintained our ISO 50001 certification at five of our six[178] Google-owned and -operated data centers in Europe and expanded the scope of the energy management system to our Google-owned and -operated data center in Chile. We were the first major internet company to achieve a multi-site energy management system certification to ISO 50001, which we first obtained in 2013.
ISO 14001: Environmental management	We maintain ISO 14001 certification for our mobile phones, laptop, and tablet consumer hardware in the United States. In 2024, we achieved ISO 14001 certification for our data centers in Dublin, Ireland and Eemshaven, Netherlands, and we're working on certifications for our remaining Google-owned and -operated data centers in Europe.
Climate Neutral Data Centre Pact (CNDCP)	As of 2021, Google is a signatory of the Climate Neutral Data Centre Pact. The Pact sets targets in five areas: energy efficiency, renewables, water, circular economy, and heat recovery. In 2024, we maintained third-party verification for five of our six[179] Google-owned and -operated data centers in Europe, meeting the five pact targets in line with the Self-Regulatory Initiative.
EU Code of Conduct on Data Centre Energy Efficiency	In 2024, five of our six[180] Google-owned and -operated data centers in Europe were "Participants" in the EU Code of Conduct on Data Centre Energy Efficiency.
Leadership in Energy and Environmental Design (LEED)	As of the end of 2024, over 300 Google offices and facilities have achieved LEED certification, including 79 with a Platinum rating and 166 with a Gold rating. In 2024 alone, we achieved LEED certification for 12 Google offices and facilities, including 10 with a Platinum rating and one with a Gold rating. For a list of some of Google's LEED-certified projects, refer to the U.S. Green Building Council's project library.

Below is a selection of sustainability-related recognitions, mainly received in 2024. While most focus on environmental topics exclusively, some also recognize additional achievements.

American Society of Landscape Architects (ASLA)

2024 ASLA Professional Awards

Honor Award in General Design

for "St. John's Terminal: An Ecology for Technology and Innovation"

Anthem Awards

Anthem Brand of the Year

Winner

Cannes Lions International Festival of Creativity

Environmental Innovation award

Bronze award

for "Contrails: Making Flying More Sustainable"

Corporate Knights

2025 Carbon Clean200

Ranked #13

CoreNet Global

2024 Award for Professional Excellence and Sustainable Leadership in Corporate Real Estate

Winner

for "Adapting St. John's Terminal as Google's Workplace of the Future"

Fast Company

World Changing Ideas 2024

World-Changing Company of the Year

for Google's suite of projects that use AI to address climate change

Forbes

America's Best Companies 2025

Ranked #2

(Alphabet ranked well in the sustainability category)

The Repair Association

2024 Right to Repair Advocacy Award

Repair Advocate of the Year

Royal Academy of Engineering

2024 MacRobert Award

Winner

for Google DeepMind's pioneering AI weather forecasting technology, GraphCast

S&P Dow Jones Indices, a division of S&P Global

Best-in-Class North America Index

Included (Alphabet)

Sustainability Magazine

Top 10: Sustainable Data Center Providers

Ranked #1

Sustainability Magazine

Top 10: Sustainable Technology Companies

Ranked #1

TIME

The Best Inventions of 2024

Winners

in AI category for X's Bellwether (along with others like Google DeepMind's AlphaFold 3 and Google's NotebookLM)

TIME

World's Best Companies of 2024

Ranked #25 (Alphabet)

(This ranking considers environmental data)

U.S. Environmental Protection Agency

Green Power Partnership National Top 100

Ranked #2

U.S. Green Building Council

California Green Building & Community Award

Honored

in Health and Wellbeing category for Gradient Canopy

Endnotes

1 We use the term data center energy emissions to describe scope 1 and 2 (market-based) emissions that result from our Google data center operations.
2 The total GW figure represents primarily PPAs, and includes some generation from targeted clean energy investments where we also receive EACs. Actual generation may vary from the signed amounts based on changes during construction or project terminations.
3 The comparison is based on data from Portugal's Directorate-General for Energy and Geology from December 2024: Total renewable energy installed in 2024 was 20,777 MW.
4 Refer to endnote 2 above.
5 For details about the calculation, refer to the Methodology section in the Appendix.
6 Refer to endnote 5 above.
7 According to Google's platform-neutral measurement analyzed over a five-year period from 2019–2024.
8 These calculations are based on internal data, as of March 2025. Google's TPU power efficiency relative to the earliest generation Cloud TPU v2 is measured by peak FP8 flops delivered per watt of thermal design power per chip package.
9 When we use the term "supply chain" or "supply chain emissions," we're referring to the indirect emissions that happen outside of our direct operations. This includes both upstream and downstream emissions, also referred to as "value chain emissions."
10 The Google Clean Energy Addendum applies to the electricity consumed by suppliers in the manufacturing of Google technical infrastructure and consumer hardware products.
11 To estimate aggregate enabled emissions reductions, we first estimated annual reductions for five products individually (Google Earth Pro, Solar API, Nest thermostats, fuel-efficient routing, and Green Light) and then combined the totals. For details about the individual calculation methodologies, refer to endnotes 89, 16, 91, 17, and 86, respectively.
12 "Greenhouse Gas Equivalencies Calculator," U.S. Environmental Protection Agency, November 2024, accessed June 2025.
13 This figure reflects our "ambition-based" emissions boundary, which represents the subset of emissions from our total carbon footprint that are within the boundaries we've set for our climate ambitions.
14 Estimated energy savings are calculated based on the average percentages for heating and cooling savings found in real-world studies of the Nest Learning Thermostat in the U.S. and U.K., and generalized for Nest thermostat usage worldwide, assuming user opt-in for available energy-saving features. To calculate the total Nest savings, we applied the savings percentages to the actual heating and cooling hours of all Nest thermostats in use since 2011. As of January 2023, we use an updated energy savings calculation methodology to account for changes in common HVAC sizes and efficiencies, applying the respective energy savings percentages to Nest thermostats in North America and in European countries.
15 According to the IEA's Energy Statistics Data Browser, Poland's total electricity consumption was approximately 160 TWh in 2023.
16 The data used is the same used in the lifetime accounting basis—refer to endnote 33. For both annual and lifetime methods, we use a 25-year estimated lifespan. The difference is that the estimated annual enabled emissions reduction takes into account solar installations enabled by Solar API prior to 2024 (dating back to 2022) to calculate the total impact in 2024 alone. It estimates a single year's worth of emission reductions each year of a solar panel's 25-year lifespan.
17 Google uses an AI prediction model to estimate the expected fuel or energy consumption for each route option when users request driving directions. We identify the route that we predict will consume the least amount of fuel or energy. If this route is not already the fastest one and it offers meaningful energy and fuel savings with only a small increase in driving time, we recommend it to the user. To calculate enabled emissions reductions, we tally the fuel usage from the chosen fuel-efficient routes and subtract it from the predicted fuel consumption that would have occurred on the fastest route without fuel-efficient routing and apply adjustments for factors such as: CO_2e factors, fleet mix factors, well-to-wheels factors, and powertrain mismatch factors. This figure covers estimated enabled emissions reductions for the calendar year, from January through December. Enabled emissions reductions estimates include inherent uncertainty due to factors that include the lack of primary data and precise information about real-world actions and their effects. These factors contribute to a range of possible outcomes, within which we report a central value. The data and claims have not been verified by an independent third-party.
18 Refer to endnote 12 above.
19 Reductions in stops estimates are based on early data points from Google's analysis of traffic patterns before and after recommended adjustments to traffic signals that were implemented during tests conducted in 2024 and 2025. The reduction in stops can vary significantly, in some cases exceeding 30% for a period of time. Emissions reductions estimates are modeled using a Department of Energy emissions model. A single fuel-based vehicle type is used as an approximation for all traffic, adjusted for country-level fleet mix from IEA data. These data points are averaged from coordinated intersections, and are subject to variation based on existing scenarios. We expect these estimates to evolve over time and look forward to sharing continued results as we perform additional analysis.
20 "2024: An Active Year of U.S. Billion-Dollar Weather and Climate Disasters," Climate.gov, January 2025.
21 The estimated population covered is based on the forecasted flood risk area, using the WorldPop Global Project Population dataset.
22 Based on retail packaging (excluding adhesive materials and required plastic stickers) as shipped by Google. To meet the request of some retail partners, stickers and/or security tags are applied to some packaging variations and may contain plastic.
23 Refer to endnote 2 above.
24 Unique, signed-in Google users that were provided information to make a more sustainable choice by at least one sustainable product feature.
25 Refer to endnote 5 above.
26 Refer to endnote 11 above.
27 Refer to endnote 8 above.
28 "High-Income Low-Energy Countries Don't Exist," Energy for Growth Hub, September 2024.
29 "Energy and AI: World Energy Outlook Special Report," IEA, April 2025.
30 Refer to endnote 29 above.
31 "Energy and AI: World Energy Outlook Special Report," IEA, April 2025. The IEA projects that in a "Widespread Adoption Case," existing AI applications in end-use sectors could lead to 1.4 GT of carbon emissions reductions in 2035. In comparison, emissions from electricity use by data centers are projected to be 300 million tCO_2e in the "Base Case" and up to 500 million tCO_2e in the "Lift-Off Case" in 2035. Therefore, the potential emissions reductions from AI applications are approximately 3 times (1,400/500 = 2.8) to 5 times (1,400/300 = 4.7) larger than the projected emissions from data centers.
32 Refer to endnote 29 above.
33 To estimate the lifetime emissions reductions enabled in 2024, Google counted the number of buildings that used the Solar API and had a solar permit issued shortly thereafter (based on publicly available permit data). We then used Berkeley Lab's Tracking the Sun (open source NREL dataset) to estimate the average installation size per state, NREL PVWatts to provide insolation data, and the NREL Cambium model to estimate the amount of emissions reduced by the energy generated due to those panels over a 25-year estimated lifespan. Enabled emissions reductions estimates include inherent uncertainty due to factors that include the lack of primary data and precise information about real-world actions and their effects to date, as well as forward-looking projections. Google is relying on its own substantiation of the enabled emissions reduction impact, in consultation with multiple third-party partners that have reviewed and support the methodology discussed herein. The data and claims have not been verified by an independent third-party. We will continue to work to refine our methodologies and inputs for these estimates.
34 We estimated location-based, electricity emissions for the Solar API model in 2024 by measuring the energy consumption of training and inference workloads supporting the Solar API model, and applying location-based, hourly grid emissions factors from ElectricityMaps. We include all relevant compute workloads from January 2024 to December 2024 in this analysis. These findings are a point-in-time measurement of the annual emissions of the Solar API, and may vary as the Solar API model continues deployment. This analysis has not been third-party verified or validated.
35 This estimate is based on our internal analysis comparing the BFLOAT16 / INT8 model step time ratio measured on the MLPerf 3.1 GPT-3 175B model. The results (11,798ms / 8,431ms = 139%) can be interpreted as a 39% speed improvement and, in turn, training efficiency.
36 "Gemini 1.5: Unlocking Multimodal Understanding Across Millions of Tokens of Context," Google, 2024.
37 Refer to endnote 8 above.
38 This calculation is based on internal data, as of May 2024.
39 Refer to endnote 8 above.
40 This calculation is based on internal data, as of April 2025.
41 According to "What NVIDIA's New Blackwell Chip Says About AI's Carbon Footprint Problem," NVIDIA compared the total power needed to train the latest ultra-large AI models using the new Blackwell GPUs (4 megawatts) to the power required with older GPUs (15 megawatts) and found the new GPUs use roughly 25% of the power (or 75% less) of the older ones.
42 "NVIDIA Blackwell Platform Arrives to Power a New Era of Computing," NVIDIA, March 2024.
43 To measure emissions relative to computational performance and enable apples-to-apples comparisons between chips, we developed a new metric—Compute Carbon Intensity (CCI)—that we believe can enable greater transparency and innovation across the industry. CCI quantifies an AI accelerator chip's carbon emissions per unit of computation (measured in grams of CO2e per Exa-FLOP). Lower CCI scores mean lower emissions from the AI hardware platform for a given AI workload—for example training an AI model. CCI includes both estimates of lifetime embodied and operational emissions in order to understand the impact of improved chip design on our TPUs. In this study, we hold the impact of carbon-free energy on carbon intensity constant across generations, by using Google's 2023 average fleetwide carbon intensity. We did this purposefully to remove the impact of deployment location on the results.
44 A February 2025 Google case study quantified the full lifecycle emissions of TPU hardware as a point-in-time snapshot across Google's generations of TPUs. To estimate operational emissions from electricity consumption of running workloads, we used a one month sample of observed machine power data from our entire TPU fleet, applying

Google's 2023 average fleetwide carbon intensity. To estimate embodied emissions from manufacturing, transportation, and retirement, we performed a life-cycle assessment of the hardware. Data center construction emissions were estimated based on Google's disclosed 2023 carbon footprint. These findings do not represent model-level emissions, nor are they a complete quantification of Google's AI emissions. Based on the TPU location of a specific workload, Compute Carbon Intensity (CCI) results of specific workloads may vary.

45 The figure represents the average percentage of Google's global compute resources that were identified as recoverable and reallocated for more efficient use over this period as a result of using AlphaEvolve.

46 We estimated the expected annual generation based on our contracted clean energy, applying an average capacity factor. Actual generation may vary from the signed amounts based on changes during construction or project terminations.

47 "Growth in Global Energy Demand Surged in 2024 to Almost Twice Its Recent Average," IEA, March 2025.

48 The total MW figure represents primarily PPAs, and includes some generation from targeted clean energy investments where we also receive EACs. Actual generation may vary from the signed amounts based on changes during construction or project terminations.

49 To calculate avoided emissions from our carbon-free energy purchases, we compare our scope 2 (market-based) emissions to the emissions we would have had if we didn't use any market-based interventions like PPAs or other clean energy agreements and instead only used electricity from the local grid (location-based).

50 These emissions savings represent the cumulative difference between our scope 2 location-based emissions—which don't take into account our CFE procurement—and our scope 2 market-based emissions, from 2012 to 2024.

51 We input the estimated avoided emissions into the EPA's Greenhouse Gas Equivalencies Calculator to calculate the equivalent number of homes' electricity use for a year, which was approximately 9.1 million homes (accessed April 2025). The comparison is based on the data from the U.S. Census: New York State had an estimated 8.7 million housing units as of July 2024.

52 Based on a comparison of EPA eGRID Emission Factors that we used for our GHG inventory for U.S. grid regions where we had operations.

53 Refer to endnote 7 above.

54 Refer to endnote 2 above.

55 Refer to endnote 2 above.

56 Refer to endnote 3 above.

57 The total GW figure includes generation from targeted clean energy investments. Actual amounts funded and generation developed may vary from the amounts anticipated when the agreements were signed.

58 "Pathways to Commercial Liftoff: Advanced Nuclear," U.S. Department of Energy, March 2023.

59 Refer to endnote 58 above.

60 Refer to endnote 5 above.

61 Refer to endnote 5 above.

62 Refer to endnote 5 above.

63 Google has purchased "Configuration 3" T-EACs. According to the EnergyTag standard, Configuration 3 "enables Granular Certificate Issuance where the EAC Issuing body does not oversee the coordination with Granular Certificates for the same production. Instead, the Granular Certificate Issuer takes such coordination upon itself. This involves canceling Granular Certificates upon their Issuance, for the same beneficiary as the beneficiary of the associated EACs for the same represented energy."

64 This represents Google CFE percentages for grid regions with Google-owned and -operated data centers in 2024. In previous reports, we included Google CFE percentages for all grid regions where we had data center operations, including third-party-operated facilities. All our data center operations, including third-party-operated facilities, are still included in our global and regional Google CFE metrics.

65 Refer to endnote 10 above.

66 Based on the average annual irrigation of golf courses in the southwest U.S. of 459 acre-ft or around 150 million gallons. Source: "How Much Water Does Golf Use and Where Does It Come From?" U.S. Golf Association, November 2012.

67 Refer to endnote 5 above.

68 Refer to endnote 5 above.

69 "California's Central Valley," U.S. Geological Survey, accessed March 2025.

70 For Google-managed server assembly and maintenance, there was a year-on-year increase in the quantity of reused components in 2024 compared to 2023. This percentage excludes components used to build servers through original equipment manufacturers (OEM), which experienced increased deployment in 2024.

71 Percent reduction in food waste per Googler was calculated as food waste generated in kitchens and cafes at Google's global offices per unique building badge swipes, against a 2019 base year.

72 Based on total weight of new Google Pixel and Fitbit products launched and manufactured in 2024.

73 For Pixel 9 and Pixel 9 Pro phones, the recycled rare earth elements are a minimum of 27% of the magnet total weight. Pixel Watch 3 docking, speaker, and haptic magnets contain 100% recycled rare earth elements, but the majority of the magnet weight consists of other materials.

74 Solder paste is made with multiple materials and contains at least 80% tin. The tin in the solder paste is made with 100% recycled content.

75 Carbon footprint reduction claim based on third-party-verified life cycle assessment. Recycled aluminum in the enclosures is at least 9% of applicable product based on weight.

76 Based on total plastic weight of Google Pixel, Nest, Chromecast, and Fitbit products manufactured in 2024. This does not include plastics in printed circuit boards, labels, cables, connectors, electronic components and modules, optical components, electrostatic discharge (ESD) components, electromagnetic interference (EMI) components, films, coatings, and adhesives.

77 Refer to endnote 22 above.

78 Refer to endnote 22 above.

79 This includes all final assembly manufacturing sites globally for Google consumer hardware products with at least one year of data and which have had up to 4 months to obtain the UL 2799 validation.

80 "Japan's Greenhouse Gas Emissions Fall 2.5% in FY22/23 to Record Low," Reuters, April 2024.

81 Refer to endnote 11 above.

82 Refer to endnote 12 above.

83 This figure reflects our "ambition-based" emissions boundary, which represents the subset of emissions from our total carbon footprint that are within the boundaries we've set for our climate ambitions. For more details, refer to the Ambition-based carbon footprint and Methodology sections.

84 Refer to endnote 17 above.

85 Refer to endnote 12 above.

86 Emissions reductions estimates are modeled using a Department of Energy emissions model. A single fuel-based vehicle type is used as an approximation for all traffic, adjusted for country-level fleet mix from IEA data. To estimate fuel savings at an intersection, we first estimate the number of cars passing through an intersection, as well as the behavior: stopping, slowing, turning, etc. Using this in combination with the Department of Energy emissions model, Google can estimate the fuel emitted at each intersection. Google ran a study on a subset of intersections in 2024, estimating emissions before and after implementing recommendations on optimal signal timing. Based on this study, we estimate that the recommendations for optimal signal timing at these intersections enabled an average of over 10% emissions reductions. We applied this savings factor to all intervened-upon intersections in 2024 to arrive at the estimated enabled emissions reduction figure. Enabled emissions reductions estimates include inherent uncertainty due to factors that include the lack of primary data and precise information about real-world actions and their effects. These factors contribute to a range of possible outcomes, within which we report a central value. The data and claims have not been verified by an independent third-party.

87 Refer to endnote 33 above.

88 Refer to endnote 16 above.

89 To estimate the annual enabled emissions reductions in 2024, Google first interviewed partners that use Google Earth Pro to understand the significance it played in their process (from siting to construction) and considered all the solar and onshore wind power plants built by the developers. For solar plants, we estimated the capacity factor via an EIA published dataset, then estimated the per-hour-of-the-year generation profile via NREL PVWatts. For wind plants, we leveraged Berkeley Lab's Land-Based Wind Market Report to estimate a capacity factor and assume that the wind generation profile is steady throughout the year. For both solar and wind, we used the NREL Cambium model to estimate the amount of emissions reduced due to the clean energy generated in 2024. The estimated annual emissions reduction takes into account projects enabled by Google Earth prior to 2024 (dating back to 2020) to calculate the total impact in 2024 alone. Enabled emissions reductions estimates include inherent uncertainty due to factors that include the lack of primary data and precise information about real-world actions and their effects to date, as well as forward-looking projections. Google is relying on its own substantiation of the enabled emissions-reduction impact, in consultation with multiple third-party partners that have reviewed and support the methodology discussed herein. The data and claims have not been verified by an independent third-party. We will continue to work to refine our methodologies and inputs for these estimates.

90 Estimated energy savings are calculated based on the average percentages for heating and cooling savings found in real-world studies of the Nest Learning Thermostat in the U.S. and U.K., and generalized for Nest thermostat usage worldwide, assuming user opt-in for available energy-saving features. To calculate the total Nest savings, we applied the savings percentages to the actual heating and cooling hours of all Nest thermostats in use in 2024.

91 The enabled emissions reductions are calculated based on these energy savings, applying standard emission factors for fossil fuels, and using U.S. EPA AVERT marginal emissions for the 95% of electricity savings that occur in the U.S., with an adjusted value for the 5% of electricity savings outside the U.S. The data and claims have not been verified by an independent third-party.

92 Refer to endnote 14 above.

93 According to the IEA's Energy Statistics Data Browser, Poland's total electricity consumption was approximately 160 TWh in 2023.

94 Refer to endnote 17 above.

95 Refer to endnote 12 above.

96 Refer to endnote 19 above.

97 This is based on estimated daily car rides at the intersections where Green Light has been implemented from 2021 to 2024, multiplied by the average workdays in a month.

98 Refer to endnote 86 above.

99 The Solar API estimates the rooftop solar potential of buildings around the world using high-resolution, 3D models of individual roofs from our aerial imagery in Google Maps. We've counted the number of individual buildings for which we have data, and which can be queried via a lat-long in Google Maps Platform.

100 Refer to endnote 33 above.

101 Refer to endnote 16 above.

102 "The Contribution of Global Aviation to Anthropogenic Climate Forcing for 2000 to 2018," Atmospheric Environment, January 2021. Calculated using Supplementary data to compare the global warming potential (GWP100) of contrails to the total global warming potential of the three primary aviation pollutants (CO_2, NOx, and contrails).

103 Using satellite imagery, large-scale weather data, and flight data, we trained a contrails prediction model. For this trial, we partnered with American Airlines to integrate contrail likely zone predictions into the tablets that their pilots used in flight so they could make real time adjustments in altitude to avoid creating contrails. We evaluated the model's performance using satellite imagery, comparing contrail formation (measured in contrail kilometers) in flights where pilots used predictions to avoid contrails, to contrail formation in flights where pilots didn't use contrail predictions. For more details, refer to the Project Contrails website and the Feasibility test of per-flight contrail avoidance in commercial aviation paper.

104 "Aviation Contrail Climate Effects in the North Atlantic from 2016 to 2021," Atmospheric Chemistry and Physics, vol. 22, iss. 16, August 2022.

105 We estimated a cost efficiency range based on our trial's results in combination with published contrail literature. There is inherent uncertainty for this cost range due to estimations of the impact of contrails to the climate system. For more detail, refer to the Project Contrails website.

106 "CDR.fyi 2024 Year in Review," CDR.fyi, February 2025.

107 "Global Outlook for Air Transport—A World with Lower Oil Prices?," International Air Transport Association, December 2024.

108 "India's Met Office Warns of Intense Heatwave This Summer," BBC, March 2025.

109 Based on an analysis of change in Google Search interest for "hurricanes," "wildfires," and "climate change" topics during extreme weather events between 2022 and 2025.

110 Based on a comparison of simulation speeds of the NeuralGCM model, the NOAA X-SHiELD, and the NCAR CAM6 (AMIP) model, which were run at different resolutions.

111 Based on a comparison of the computational costs for the SEEDS model and estimated computational costs for the U.S. operational forecast system, Global Ensemble Forecast System (GEFS) version 12. For more details, refer to the Generative emulation of weather forecast ensembles with diffusion models paper.

112 "People in Harm's Way: Flood Exposure and Poverty in 189 Countries," World Bank Group, October 2020.

113 Refer to endnote 21 above.

114 Refer to endnote 5 above.

115 Based on research from the International Energy Agency (Advancing Decarbonisation through Clean Electricity Procurement, 2022), Princeton University (The Influence of Demand-Side Data Granularity on the Efficacy of 24/7 Carbon-Free Electricity Procurement, 2024), and Technical University of Berlin (System-Level Impacts of 24/7 Carbon-Free Electricity Procurement in Europe, 2024).

116 For 2022 and 2023, the Canada & Mexico regional average Google CFE metric includes only Canadian grid regions where we had data center operations. We didn't have data center operations in Mexico prior to 2024.

117 Refer to endnote 5 above.

118 Our carbon reduction ambition was validated using the SBTi Corporate Near-Term Criteria Version 5.2 and following the cross-sector absolute reduction method. This approach aligns with a 1.5°C scenario and utilizes the standard validation route for target setting.

119 Avoided emissions are emissions that would have otherwise occurred but were avoided because of actions taken either as part of normal operations or in service of climate ambitions. We calculate avoided emissions by comparing our actual emissions to a scenario where we didn't take action. To calculate avoided emissions from our power usage effectiveness (PUE) improvements, we compare our fleet-wide trailing 12-month (TTM) PUE in each year from 2019 to 2024 to a baseline from our earliest fleet-wide TTM PUE (which was 1.21 in 2008). This baseline assumes that our PUE would have remained the same without our efficiency improvements. We translate this efficiency improvement into avoided energy consumption, and then calculate avoided emissions using an annual emissions rate (emissions/GWh) derived from reported scope 2 electricity data in our corporate GHG inventory for the relevant year. To calculate avoided emissions from our machine hardware efficiency improvements, we compare the actual emissions from our servers in 2019 to 2024 and other hardware to a hypothetical scenario where we didn't implement any efficiency measures and continued to deploy older, less efficient hardware which could have resulted in increased machines deployed and increased energy consumption. By comparing the actual energy consumption to this hypothetical baseline, which is defined by the machines deployed in 2019, we estimate the energy savings and associated scope 2 emissions avoided through our machine hardware efficiency initiatives. Similarly, we estimate the scope 3 emissions avoided by comparing actual hardware manufacturing and logistics emissions to the same hypothetical baseline. For both PUE and machine hardware efficiency, we assume additional energy consumption in the avoided baseline scenario would not have been matched with additional clean energy procurement. Refer to endnote 49 for the calculation of avoided emissions from our carbon-free energy procurement. The data and claims have not been verified by an independent third-party.

120 Currently, SBTi validates near-term (by 2030) carbon reduction targets and long-term (by or before 2050) net-zero targets ("SBTi Corporate Net-Zero Standard Version 1.2," Science Based Targets initiative, March 2024). Our carbon reduction ambition was validated using the SBTi Corporate Near-Term Criteria Version 5.2 and following the cross-sector absolute reduction method. This approach aligns with a 1.5°C scenario and utilizes the standard validation route for target setting. Because our net-zero ambition allows for 50% remaining emissions by our 2030 ambition date, we don't meet SBTi's criteria of only 10% residuals (for a long-term net-zero target by 2050). For this reason, we've only validated our near-term carbon reduction ambition with SBTi to date.

121 This covers many of the procured goods and services related to our day-to-day operations such as IT, marketing, professional services, legal services, software, real estate management, etc.

122 Alphabet is a collection of businesses—the largest of which is Google. We refer to all non-Google businesses collectively as Other Bets. See Alphabet's 2023 Form 10-K for more detail.

123 "SBTi Corporate Near-Term Criteria V5.2," Science Based Target Initiative, March 2024. Criteria C5 and C6 outline the requirements for GHG inventory emissions coverage and target boundaries.

124 In 2025, the SBTi validated Alphabet's near-term science-based emissions reduction ambition, aligning our measurements with rigorous standards for emissions reduction. Our carbon reduction ambition was validated using the SBTi Corporate Near-Term Criteria Version 5.2 and following the cross-sector absolute reduction method.

125 Moving forward, we may share updates to this roadmap when there are significant changes or revisions to our strategy.

126 Carbon reduction initiatives refer to all of the specific projects or initiatives that play some role in reducing footprint emissions by 2030. Key reduction areas are groupings of similar carbon reduction initiatives into higher-level buckets and represent the key areas of focus for our decarbonization plan.

127 Future emissions expectations are illustrative and rely on assumptions about the implementation of the key reduction areas outlined in this roadmap. The actual emissions reductions achieved in the future may differ.

128 We're prioritizing reductions across scopes 2 and 3, which have much larger emissions reduction potential. In fact, the vast majority of reductions rely on accelerating the deployment of clean electricity across both our operations and suppliers—which is why a significant portion of our plan focuses specifically on unlocking new clean energy. Reducing scope 1 emissions is important—not only because they're within our direct control, but also because they're part of our broader sustainability efforts. However, they represent less than 1% of our total 2024 ambition-based carbon footprint.

129 PUE is a standard industry ratio that compares the amount of non-computing overhead energy (used for things like cooling and power distribution) to the amount of energy used to power IT equipment. For example, a PUE of 2.0 means that for every watt of IT power, an additional watt is consumed to cool and distribute power to the IT equipment. A PUE closer to 1.0 means nearly all the energy is used for computing. According to the Uptime Institute's 2024 Global Data Center Survey, the global average PUE of respondents' data centers was 1.56. The overhead energy use comparison was calculated as follows: (1 - (Google's overhead energy use [0.09] divided by the industry average overhead energy use [0.56])) x 100 = 84%.

130 Refer to endnote 2 above.

131 Supplier scope 3 electricity includes hardware supplier electricity (e.g., electricity used to manufacture semiconductors, servers, Google consumer hardware devices, etc.), office construction (data center construction supplier electricity is separately covered in the scope 3 low-carbon data center construction key reduction area), and food (i.e., electricity used by suppliers of food for Google cafes). Non-supplier scope 3 electricity includes product use phase electricity (e.g., electricity used to charge Pixel phones), and transmission and distribution losses from our scope 2 electricity use. There are also scope 3 emissions from the upstream impacts of electricity use: "Category 3: Fuel- and energy-related activities (not included in scope 1 or 2)." These are the upstream emissions from purchased electricity consumed by the reporting company: extraction, production, and transportation of fuels consumed during the generation of electricity, steam, heating, and cooling. Although these emissions fall under scope 3, our scope 2 clean electricity reduction activities are the drivers of reductions in this scope 3 category because any reduction in fossil fuel-based electricity use will translate into a reduction in these upstream electricity emissions.

132 Refer to endnote 10 above.

133 We calculated the reduction in embodied carbon emissions intensity by comparing Google's 2019 baseline standard data center design to our revised standardized data center designs which incorporate design updates to server hall hot air containment systems, electrical distribution systems, and cooling tower units.

134 Based on an internal life cycle assessment of Google's 2019 standard data center design.

135 Refer to endnote 5 above.

136 Refer to endnote 5 above.

137 We recalculated data center waste diversion metrics. For additional details, refer to the

Methodology section.

138 Refer to endnote 76 above.

139 Based on total plastic weight of Google Pixel, Nest, Chromecast, and Fitbit products manufactured in 2023. This does not include plastics in printed circuit boards, labels, cables, connectors, electronic components and modules, optical components, electrostatic discharge (ESD) components, electromagnetic interference (EMI) components, films, coatings, and adhesives.

140 Refer to endnote 76 above.

141 Refer to endnote 22 above.

142 Refer to endnote 22 above.

143 Flagship consumer devices are products that can provide their main functionality without connection to another product. For example, this generally doesn't include accessories such as cases.

144 Network and end-user devices used to access web-based software are not considered to be direct-use phase emissions and are not within the reporting boundary for use of sold products.

145 Excluded scope 3 categories include specific activities within "Category 1: Purchased goods and services" and "Category 2: Capital goods."

146 Refer to endnote 121 above.

147 Refer to endnote 122 above.

148 We present all emissions from category 2 (Capital goods) and category 11 (Use of sold products) as an aggregated total for business reasons.

149 While we haven't excluded any Alphabet scope 1 or scope 2 emissions from our carbon reduction ambition boundary, we've excluded specific activities within scope 3 that are peripheral to our core operations and where our ability to influence emissions reductions is limited: food program purchases, certain purchased goods and services associated with Alphabet's day-to-day operations, and Other Bets capital goods. This boundary is in line with SBTi's guidelines for target validation. For more details, refer to the Ambitions section.

150 Estimated contracted credits and expected timeframe for delivery may vary based on changes during the project, supplier circumstances, and contract terminations. This table reflects the best available information as of April 2025, for agreements signed as of the end of 2024. At the time of publication, the following information wasn't available for all of the projects except for Vaulted Deep and CREW: registry, project identification number, project name, and protocol used to estimate removal benefits. Removals credits undergo independent third-party verification prior to registry issuance and delivery to Google. Details for the Vaulted Deep project include: Registry: Isometric; Project Identification Number: 01P4; Project Name: Great Plains Organic Waste Sequestration; Protocol: Biomass Geological Storage v1.1 (Isometric). Details for the CREW project include: Registry: Isometric; Project Identification Number: X8KC; Project Name: Greater New Haven Municipal WAE Project; Protocol: Wastewater Alkalinity Enhancement v1.0 (Isometric).

151 "Purchased electricity" is electricity sourced from an electrical grid and purchased from a local electric utility company.

152 "Purchased heat" includes both natural gas in leased facilities and district heat in applicable facilities.

153 Refer to endnote 151 above.

154 Refer to endnote 152 above.

155 "Total electricity consumption" includes both purchased and self-generated electricity.

156 Refer to endnote 155 above.

157 "Total renewable electricity allocated" includes renewable electricity generation from contractual instruments (i.e., EACs), which have been used in the calculation of Scope 2 market-based emissions per the Greenhouse Gas Protocol Scope 2 Quality Criteria.

158 Refer to endnote 116 above.

159 Refer to endnote 64 above.

160 We report individual campus PUE only for campuses with at least twelve months of data. All reported PUE values are rounded to the hundredths place.

161 In 2023, we adjusted our methodology for calculating waste generated and diversion for our offices, integrating new data sources for reused furniture and recycled e-waste. These changes are reflected in our reported office waste data for 2023 and 2024, but not for prior years.

162 We've adjusted the terminology used for this metric to clarify that the reported percentage is applicable to reused inventory for Google-managed server assembly and maintenance. The scope of the metric remains unchanged.

163 We've adjusted the terminology used for this metric to clarify that the reported percentages are based on sources (which can include watersheds) at risk for both water scarcity or depletion. The scope of the metric remains unchanged.

164 Unless otherwise specified, water withdrawals are potable water.

165 Refer to endnote 66 above.

166 Air-cooled facility.

167 For more details, refer to the Google Data Centers Location website.

168 Refer to endnote 166 above.

169 Refer to endnote 164 above.

170 Refer to endnote 66 above.

171 Refer to endnote 166 above.

172 Refer to endnote 166 above.

173 Refer to endnote 166 above.

174 Refer to endnote 167 above.

175 Refer to endnote 166 above.

176 Refer to endnote 166 above.

177 Refer to endnote 166 above.

178 We'll also pursue this for our data center in Hanau, Germany, which became operational in 2024.

179 Refer to endnote 178 above.

180 Refer to endnote 178 above.

Photo details

On the cover/Introduction: Street View image of Redwood State and National Park, used with permission. ©2025 Google
Age of AI: Street View image of the International Space Station, used with permission. ©2025 Google
Energy for our data centers: El Romero solar farm in Chile (80 MW for Google).
Energy for our supply chain: A technician scans hardware components, a critical step for tracking parts through every stage of the production process.
Resource efficiency: Clear waters reflect the beauty of our data center in Eemshaven, Netherlands.
New AI research solutions: The Solar API generates detailed rooftop data based on Google's extensive geospatial data and computing resources in order to evaluate rooftop solar energy potential.
AI for extreme events and disaster response: A wide river basin during low water levels illustrates the type of flood-prone environment where flood forecasting is critical.
Protecting the planet with our AI products: Street View image of the Great Barrier Reef, used with permission. ©2025 Google
Appendix: Our Bay View campus, as seen from across its stormwater retention pond. (Photo credit: Iwan Baan)

Google

Environmental Report

2025

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Publication date: June 2025