Google

Environmental Report

2024

What’s inside

About this report

Google’s 2024 Environmental Report provides an overview of our environmental sustainability strategy, our targets, and our annual progress toward them. Throughout this report, we use the term “sustainability” to refer to environmental sustainability. This report features data, performance highlights, and progress against our targets from our 2023 fiscal year (January 1 to December 31, 2023), and mentions some notable achievements from 2024 to date.

Additional resources

- Explore the 2024 Environmental Report with AI
- Sustainability.google
- Sustainability reports
- Sustainability blog
- Google’s mission, values, and commitments
- Alphabet SASB and TCFD Index
- About Google

Table of contents

Introduction

A letter from our Chief Sustainability Officer and our Senior Vice President of Learning and Sustainability

Since our earliest days, we've been on an ambitious journey to help build a more sustainable future.

An important part of that is sharing what we've learned along the way and being transparent about our progress and our challenges. This is especially true given the urgency of the moment—a time when technological advancement is converging with the need for energy transition.

Our annual Environmental Report offers a deep dive into our efforts to harness technology—particularly AI—to drive positive environmental change and operate our business sustainably. This year, we're also offering a new experimental AI chatbot, powered by NotebookLM, to help summarize key findings, clarify complex topics, and explore the details about our environmental work.

Our approach to enabling AI for sustainability

We know that scaling AI and using it to accelerate climate action is just as crucial as addressing the environmental impact associated with it.

To help minimize our environmental footprint, we've built world-leading efficient infrastructure for the AI era, including Trillium, our sixth-generation Tensor Processing Unit (TPU), which is over 67% more energy-efficient than TPU v5e.[1] We've also identified tested practices that our research shows can, when used together, reduce the energy required to train an AI model by up to 100 times and reduce associated emissions by up to 1,000 times.[2] All these practices are used at Google today.

We strive to build the world's most energy-efficient computing infrastructure, supported by responsible water use practices and a commitment to minimizing waste. A Google-owned and -operated data center is, on average, approximately 1.8 times as energy efficient as a typical enterprise data center.[3] In 2023, the average annual power usage effectiveness for our data centers was 1.10 compared with the industry average of 1.58,[4] meaning that our data centers used about 5.8 times less overhead energy for every unit of IT equipment energy.

Last year we introduced a water risk framework to further identify climate-conscious cooling solutions that consider carbon-free energy (CFE) availability, watershed health and future water needs. We see our growing infrastructure as an opportunity to drive the innovations and investments needed to power a low-carbon economy.

AI holds immense promise to drive climate action. In fact, AI has the potential to help mitigate 5–10% of global greenhouse gas (GHG) emissions by 2030.[5] We're advancing climate action through AI in three key areas:

- **Organizing information:** Fuel-efficient routing uses AI to analyze traffic, terrain, and a vehicle's engine to suggest the most efficient route. It's estimated to have helped enable more than 2.9 million metric tons of GHG emissions reductions since the feature launched in late 2021 to the end of 2023—that's equivalent to taking approximately 650,000 fuel-based cars off the road for a year.[6]
- **Improving prediction:** We built a breakthrough global hydrological AI model and combined it with publicly available data sources to predict floods up to seven days in advance in over 80 countries. This covers territories where more than 460 million people live,[7] helping these communities prepare for and respond to riverine floods.
- **Better optimization:** Green Light is an AI-based tool that helps city traffic engineers optimize the timing of traffic lights to reduce stop-and-go traffic and fuel consumption. This technology has the potential for up to 30% reduction in stops and up to 10% reduction in emissions at intersections.[8]

Through our products, we aim to help individuals, cities, and other partners collectively reduce 1 gigaton of carbon equivalent emissions annually by 2030, and we'll continue to develop technologies that help communities adapt to the effects of climate change.

How we're driving sustainability across our operations

In 2017, Google became the first major company to match 100% of our annual electricity consumption on a global basis with renewable energy, which we've achieved every year since.[9]

Building on our first two decades of progress, in 2020 we launched our third decade of climate action—our most ambitious yet.

We have a bold goal to reach net-zero emissions across all of our operations and value chain by 2030, supported by a goal to run on 24/7 CFE on every grid where we operate. In addition, we're working to advance water stewardship, build a circular economy, and restore and enhance nature and biodiversity. This year's report shows how we continue to make progress across all of these areas:

- Ten of our grid regions[10] achieved at least 90% CFE, and even with our total electricity load increasing across our data centers, we maintained a global average of 64% CFE. We also celebrated a first-of-a-kind enhanced geothermal project now delivering CFE to the grid.
- We signed contracts to purchase approximately 4 gigawatts of clean energy generation capacity[11] in locations such as Texas, Belgium, and Australia—more than in any prior year.
- We implemented a Google Renewable Energy Addendum that asks our largest hardware manufacturing suppliers, based on spend, to commit to achieving a 100% renewable energy match by 2029.[12]
- Our water stewardship projects replenished an estimated 1 billion gallons of water,[13] which represents 18% of our 2023 freshwater consumption and tripled our replenishment progress of 6% in 2022.
- For new Google products launched and manufactured in 2023, our packaging was at least 99% plastic-free.[14] Plus, packaging for our Pixel 8 and Pixel 8 Pro uses 100%plastic-free materials.[15]

Our ongoing work to build a sustainable future

In spite of the progress we're making, we face significant challenges that we're actively working through. In 2023, our total GHG emissions increased 13% year-over-year, primarily driven by increased data center energy consumption and supply chain emissions.

While we advanced clean energy on many of the grids where we operate, there are still some hard-to-decarbonize regions like Asia Pacific where CFE isn't readily available. In addition, we often see longer lead times between initial investments and construction of clean energy projects and the resulting GHG reductions from them.

To continue to drive progress toward a low-carbon economy, we most recently introduced a clean transition rate that brings customers and utilities together to drive new clean energy projects in the United States, and we unveiled an investment to enable 1 gigawatt of new solar capacity in Taiwan.

A sustainable future requires systems-level change, strong government policies, and new technologies. We're committed to collaboration and playing our part, every step of the way.

Kate E. Brandt
Chief Sustainability Officer, Google

Benedict Gomes
SVP, Learning & Sustainability, Google

Our sustainability strategy

We believe Google has a unique opportunity that extends beyond managing the environmental impact of our own operations and value chain. Our products, which are used by billions of people every day, can enable decisions that drive positive action for the environment. The figure below illustrates these two pillars of our sustainability strategy, supported by our dedication to accessible information and technological innovation. To learn more about our sustainability governance, stakeholder engagement, environmental data, and more, see the Appendix.

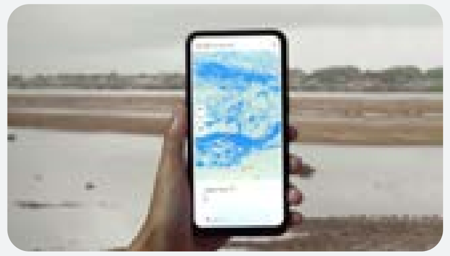
Our products

We're empowering people with information to mitigate and adapt to climate change—focusing on sectors like energy and transportation where Google's unique capabilities can have a meaningful impact.

Mitigation

Energy

Transportation



Adaptation and resilience

Extreme event forecasting and early warning systems

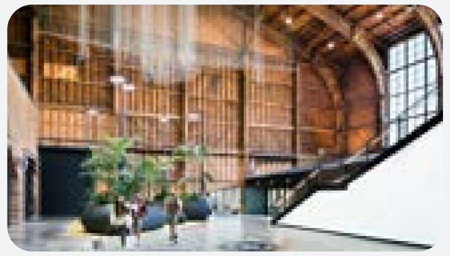
Learn more in the Our products section.

Our operations

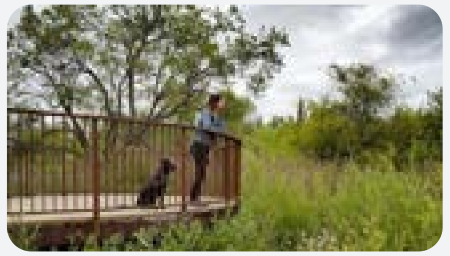
We're working to drive sustainability across our operations in four key ways: accelerating the transition to a net-zero carbon future, advancing water stewardship, building a circular economy, and restoring nature and biodiversity.

Net-zero carbon

Water stewardship



Circular economy



Nature and biodiversity

Learn more in the Our operations section.

Information and innovation

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

2023 highlights

For additional highlights, see the approach page of each report section. And for a more complete overview of our performance over time, see the Appendix for our Environmental data tables.

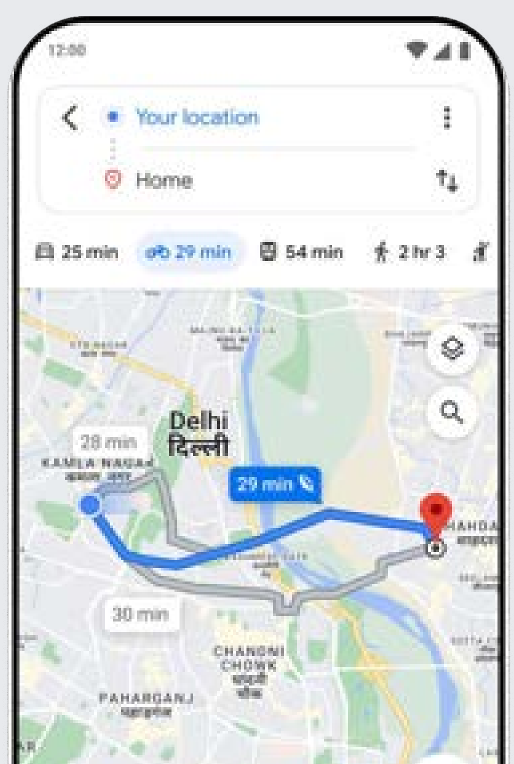
Our products

Reached 1 billion users

For the past two years, Google has provided information to over 1 billion users to help them make more sustainable choices annually through our products.[16]
Learn more on page 15

Displayed flood forecasts for over 80 countries covering 460 million people

Flood Hub displayed forecasts for over 80 countries on five continents—covering more than 460 million people globally.[17]
Learn more on page 25



Enabled 2.9 million metric tons of GHG emissions reductions from fuel-efficient routing

Fuel-efficient routing is estimated to have helped enable more than 2.9 million metric tons of GHG emissions reductions since the feature launched in late 2021—equivalent to taking approximately 650,000 fuel-based cars off the road for a year.[18]
Learn more on page 20

Net-zero carbon

Achieved at least 90% carbon-free energy in 10 grid regions

Ten of our grid regions[19] achieved at least 90% CFE and we maintained a global average of 64% CFE across our data centers and offices—even as our total electricity consumption increased.
Learn more on page 35

Maintained 100% renewable energy match for 7 years

We achieved seven consecutive years of 100% renewable energy matching on a global and annual basis.[20]
Learn more on page 33

Contracted 4 GW of clean energy

We signed contracts to purchase approximately 4 GW of clean energy generation capacity[21]—more than in any prior year.
Learn more on page 35

Water stewardship

Doubled our water replenishment portfolio

We nearly doubled our water replenishment portfolio, increasing from 38 water stewardship projects in 2022 to 74 projects in 2023.
Learn more on page 46

Circular economy

Achieved 100% plastic-free packaging for Pixel 8 and 8 Pro

Packaging for Pixel 8 and Pixel 8 Pro uses 100% plastic-free materials.[22]
Learn more on page 55

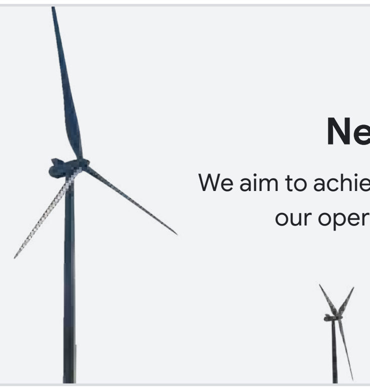
Nature and biodiversity

Created or restored 67 acres of habitat

As of the end of 2023, we created or restored approximately 67 acres of habitat and planted roughly 4,500 native trees on Google's campuses and the surrounding urban landscape, primarily in the San Francisco Bay Area.
Learn more on page 58

Targets and progress summary

This table summarizes our targets and progress as of December 31, 2023. For additional details and year-over-year trends, see the target boxes in relevant report sections and the Targets data table in the Appendix.



Net-zero carbon

We aim to achieve net-zero emissions across all of our operations and value chain by 2030

Targets	2023 progress
Run on 24/7 carbon-free energy on every grid where we operate by 2030	We maintained a global average of approximately 64% carbon-free energy across our data centers and offices from 2022 to 2023—despite growth in electricity demand over this period. Learn more on page 35
Reduce 50% of our combined Scope 1, 2 (market-based), and 3 absolute emissions (compared to our 2019 base year) by 2030[23]	Our total GHG emissions were 14.3 million tCO_2e, representing a 13% year-over-year increase and a 48% increase compared to our 2019 target base year—primarily due to increases in data center energy consumption and supply chain emissions. Learn more on page 31

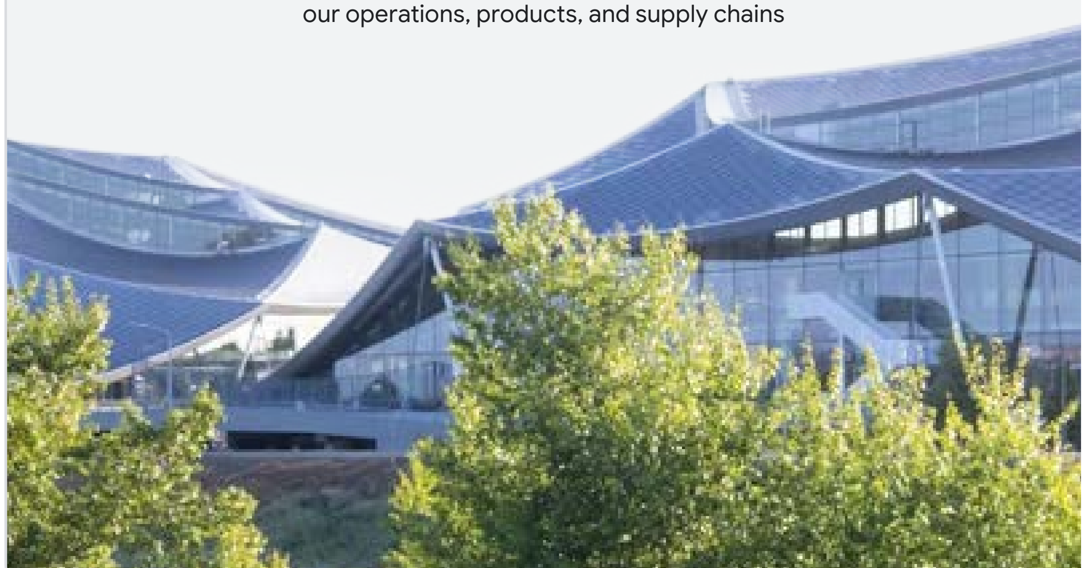
Water stewardship

We aim to replenish more water than we consume and help improve water quality and ecosystem health in the communities where we operate

Targets	2023 progress
Replenish 120% of the freshwater volume we consume, on average, across our offices and data centers by 2030	Our water stewardship projects replenished approximately 18% of our freshwater consumption from our data centers and offices—tripling our replenishment progress of 6% in 2022. Learn more on page 46

Circular economy

We aim to maximize the reuse of finite resources across our operations, products, and supply chains



Targets	2023 progress
Achieve Zero Waste to Landfill[24] for our global data center operations	Following our updated waste accounting methodology, 29% (8 out of 28) of our Google-owned and -operated data center campuses met our Zero Waste to Landfill goal.[25] Learn more on page 53
Divert all food waste from landfill by 2025	We diverted 82% of food waste from landfill—a slight decrease from 85% in 2022—due, in part, to limited composting infrastructure in certain regions. Learn more on page 52
Use recycled or renewable material in at least 50% of plastic used across our consumer hardware product portfolio by 2025	34% of the plastic Google used in products manufactured in 2023 was recycled content.[26] This decrease from 41% in 2022[27] was due to changes in our product mix—some product types use less plastic than others, which can reduce opportunities to use recycled content. Learn more on page 54
Make product packaging 100% plastic-free by 2025	For new Google products launched and manufactured in 2023, our packaging was at least 99% plastic-free,[28] an increase from at least 96% plastic-free packaging in 2022, primarily due to packaging innovations.[29] Learn more on page 55

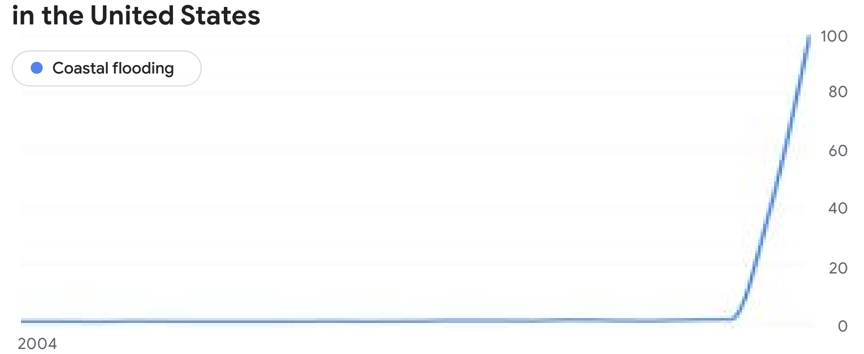
Searching for sustainability

Google Search provides a unique lens into the world's perspectives on sustainability and the issues people care about most. Google Trends[30] show that the world is searching for sustainability information and insights like never before. For example **in 2023, search interest in "jobs related to sustainability" reached an all-time high.**[31] In fact, we estimate that **36% of Google Search users in the United States have searched for a sustainability-related topic over the course of a year.**[32] Below are trends that demonstrate the impact climate change is having around the world, and what people are searching for to better understand it.

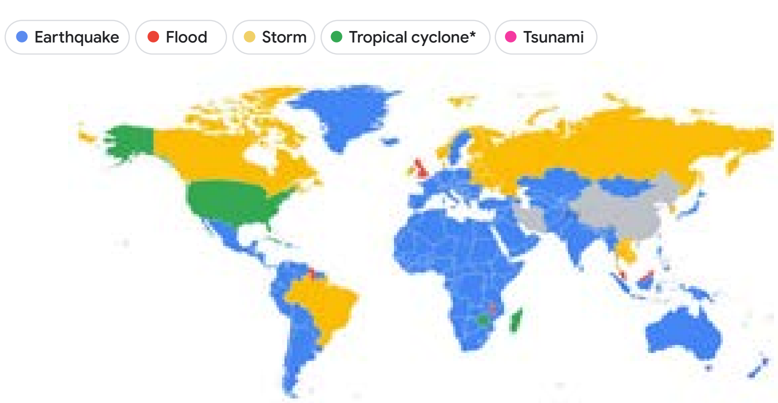
Extreme weather events

Search interest in "coastal flooding" in the United States reached an all-time high in January 2024,[33] and the top natural disasters searched for worldwide in 2023 include earthquakes, floods, tsunamis, storms, and tropical cyclones.[34]

Search interest in coastal flooding since 2004, in the United States



Top searched natural disasters in 2023, worldwide

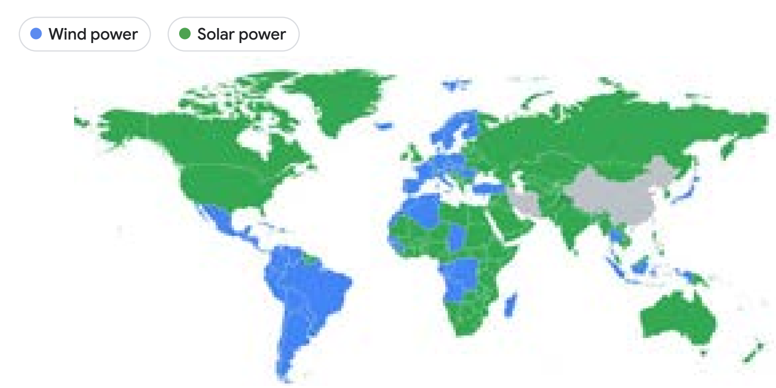


*includes hurricane searches

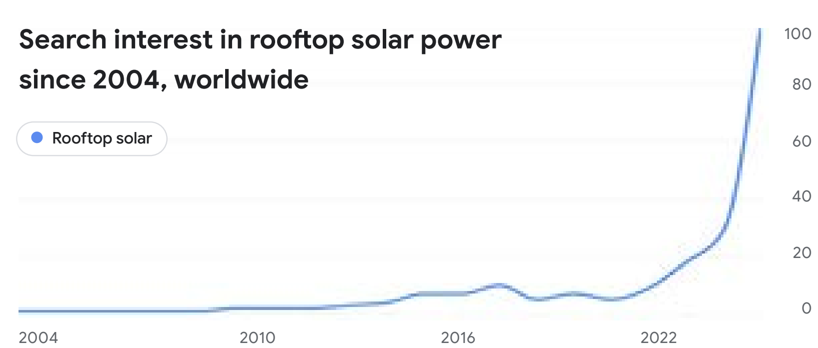
Clean energy

"Energy development" and "solar power" were among the top five trending topics searched with "climate change mitigation" in 2023.[35] "Solar" and "wind power" are the two most searched renewable energy types in the world,[36] and global searches for "rooftop solar power" specifically reached an all-time high in 2024.[37]

Search interest in solar power versus wind power in 2023, worldwide



Search interest in rooftop solar power since 2004, worldwide

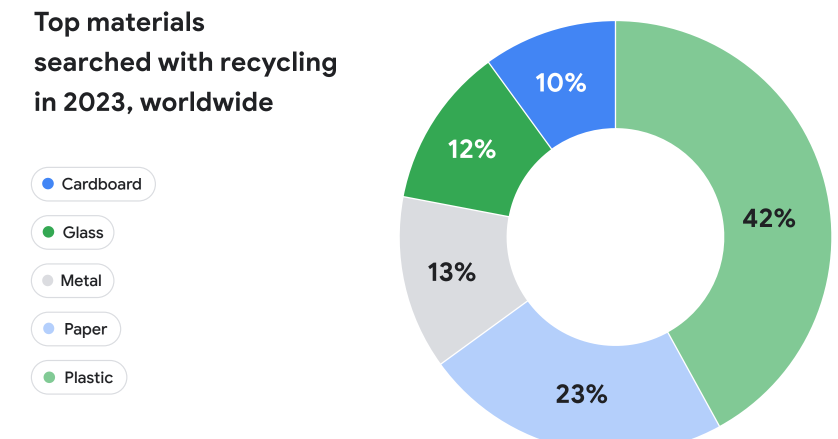


Recycling

In the United States, "electronic waste recycling" was searched more than ever in 2023,[38] and top materials searched with "recycling" worldwide in 2023 included plastic, paper, metal, glass, and cardboard.[39]

Search interest in electronic waste recycling since 2004, in the United States

Top materials searched with recycling in 2023, worldwide



AI for sustainability

Our approach to enabling AI for sustainability

AI can have a transformative effect on climate progress. We're harnessing our years of experience as an AI-first company to enable others—people, businesses, communities, and governments—to use AI for both mitigation and adaptation.

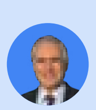
As highlighted in our AI Opportunity Agenda, we're currently at an inflection point where choices made today will ensure that AI is used to benefit as many people as possible.

With a bold and responsible approach, we're taking steps to make this technology helpful for everyone.

While scaling these AI applications and finding new ways to use AI to accelerate climate action is crucial, we're also working to responsibly manage the environmental impact associated with it.

Our strategy on enabling AI for sustainability is underpinned by the following approach (see Figure 1):

> "The world has in its hands the potential to apply artificial intelligence (AI) and machine learning (ML) to drive forward the net-zero transition and give us a chance to stay within 1.5°C. AI and ML can contribute massively to the pace of processes, can drive higher productivity, and can help design and run better systems. Together, they can unlock new growth that is sustainable, resilient, and equitable—whilst managing the immense and urgent risks of climate change, biodiversity loss, and pollution.



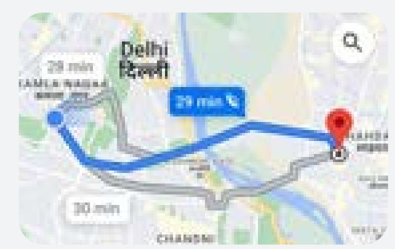
Nicholas Stern
Chair, Grantham Research Institute on Climate Change and the Environment, London School of Economics

To read the full article from Nicholas Stern, see Green and Intelligent: The Global Economy in the 21st Century.

FIGURE 1 **Harnessing AI-powered climate solutions with environmental responsibility**

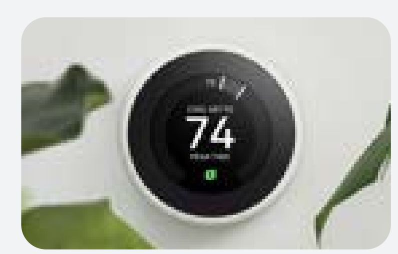
Boldly accelerating climate action with AI

By providing solutions for information, prediction, and optimization across sectors, AI can play a transformative role in climate progress.



Information

Prediction



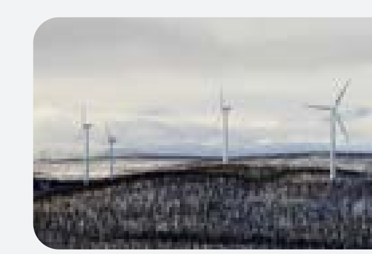
Optimization

Responsibly managing the resource consumption of AI

We're committed to developing AI responsibly by working to address its environmental footprint through model optimization, efficient infrastructure, and emissions reductions.

Model optimization

Efficient Infrastructure



Emissions reductions

Working together to enable AI for climate progress

Working together across industry, governments, experts, international organizations, and individuals is essential to unlock the potential of AI for tackling climate change.

Boldly accelerating climate action with AI

AI has a critical enabling role to play in accelerating **mitigation**, supporting **adaptation**, and building foundational capabilities for the transition to a low-carbon future.

According to an estimate from Boston Consulting Group, AI has the potential to help mitigate 5–10% of global GHG emissions by 2030[40]—the equivalent of roughly the total annual emissions of the European Union.[41] And the positive impact of AI could grow as it contributes to breakthroughs that open new pathways for climate action.

In this context, the three distinct capabilities that AI enables are information, prediction, and optimization.

Information

Information generated by AI through the rapid processing and analyzing of vast amounts of data can empower individuals and organizations in their own sustainability efforts.

- **Cool roofs:** We're exploring how AI algorithms and aerial imagery can help implement reflective roofs—called "cool roofs"—which save energy and reduce indoor and outdoor temperatures. As of the end of 2023, this pilot was available in 15 cities (see Figure 2 and page 26).
- **Near-real time data and monitoring:** By combining data from MethaneSAT, Environmental Defense Fund's new methane-tracking satellite, with Google's AI and infrastructure mapping capabilities, we'll create a more comprehensive view of methane emissions from oil and gas—enabling a better understanding of how to mitigate them (see page 22).

Prediction

Breakthroughs in forecasting by using AI enable improvements in preparedness efforts and facilitate interventions in climate mitigation.

- **Extreme heat:** When people search for information on extreme heat, they'll see details on when a heat wave is predicted to start and end, tips on staying cool, and related health concerns to be aware of—all prominently displayed in Search results. Since launching, we've provided information about extreme heat on Search in more than 100 countries (see page 25).
- **Contrails:** We're working with the airline industry to develop contrail forecast maps using AI-based predictions, allowing pilots and airlines to optimize routes that avoid creating climate-warming contrails. In one trial consisting of 70 test flights, use of the predictive technology reduced contrails by 54%[42] (see page 21).

Optimization

One of the challenges of addressing climate change is the fragmented way that information is gathered and used. AI offers a transformative solution by not only gathering and interpreting vast amounts of data, but also optimizing complex systems with unprecedented efficiency.

- **Home energy use:** For over a decade, our Nest Learning Thermostats have used machine learning to help people save energy and money at home. In 2023, we estimate that Nest thermostats helped customers save more than 20 billion kWh of energy[43] (see page 19).
- **Grid decarbonization:** Tapestry—a part of X, Alphabet's moonshot factory—is creating a single virtualized view of the electricity system through AI-powered tools that can predict and simulate what might happen on the grid from milliseconds to decades into the future (see page 19).

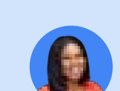
These solutions demonstrate that the applications of AI to meaningfully bolster mitigation, adaptation, and climate resilience aren't just speculative, but rather are having real impact today.

FIGURE 2 **Cool Roofs tool**

Our Cool Roofs tool uses AI and aerial imagery to generate high resolution roof solar reflectivity measurements

"

The deployment of AI in crafting and executing energy strategies presents an unparalleled opportunity to transform the narrative in the Global South to sustainable growth and development while meeting their future energy needs.



Damilola Ogunbiyi
CEO and Special Representative of the UN Secretary-General for Sustainable Energy for All, and Co-Chair of UN-Energy

To read the full article from Damilola Ogunbiyi, see AI-Powered Pathways: Advancing SDG7 for a Sustainable Energy Future.

Responsibly managing the resource consumption of AI

While AI offers new solutions for climate action, it also has its own environmental impact. We have an understanding of its current demands, but its future trajectory remains uncertain. Here's what we know and what we're still learning.

Contextualizing Google's impact

Based on the most recent estimates as of 2022, global data center electricity consumption is 240–340 TWh, or around 1–1.3% of global electricity demand.[44] Using these estimates as a proxy for 2023, Google's data center consumption of more than 24 TWh in 2023 translates to approximately 7–10% of global data center electricity consumption and approximately 0.1% of global electricity demand.[45]

While data centers consume electricity and contribute to emissions, cloud and hyperscale data centers collectively represent only an estimated 0.1–0.2% of global GHG emissions, based on the most recent global estimates as of 2022.[46] Google's emissions contribute a smaller fraction—in 2023, our total GHG emissions were approximately 14.3 million tCO_2e.

AI's resource demands

AI has been deeply integrated into our products for years, and we've invested heavily in improving the efficiency of our AI models and infrastructure. While these efforts have helped mitigate some of AI's environmental footprint, the rapid advancement of AI has brought necessary increased attention to its energy consumption and resource demands.

In 2023, our total data center electricity consumption grew 17%, despite maintaining a 100% global renewable energy match. As Google's infrastructure continues to power the digital transition, providing numerous economic benefits across the globe, we expect this trend to continue in the future. But we see our growing infrastructure as an opportunity to drive the innovations and investments needed to power a low-carbon economy.

Overall, our total GHG emissions increased by 13%—highlighting the challenge of reducing emissions while compute intensity increases and we grow our technical infrastructure investment to support this AI transition. For more details, see the Net-zero carbon section.

Predicting the future environmental impact of AI is complex and evolving, and our historical trends likely don't fully capture AI's future trajectory. As we deeply integrate AI across our product portfolio, the distinction between AI and other workloads will not be meaningful.

So, we're focusing on data center-wide metrics since they include the overall resource consumption (and hence, the environmental impact) of AI.

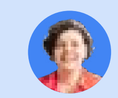
Uncertainty ahead

AI is at an inflection point and many factors will influence its ultimate impact—including the extent of AI adoption, our ability to mitigate its footprint, and the pace of continued innovation and efficiency. Additionally, system-level changes are needed to address challenges such as grid decarbonization, evolving regulations, hard-to-decarbonize industries, and the availability of carbon-free energy. While we remain optimistic about AI's potential to drive positive change, we're also clear-eyed about its potential environmental impact and the collaborative effort required to navigate this evolving landscape.

We're committed to responsibly managing the environmental impact of AI by deploying three major strategies: model optimization, efficient infrastructure, and emissions reductions.

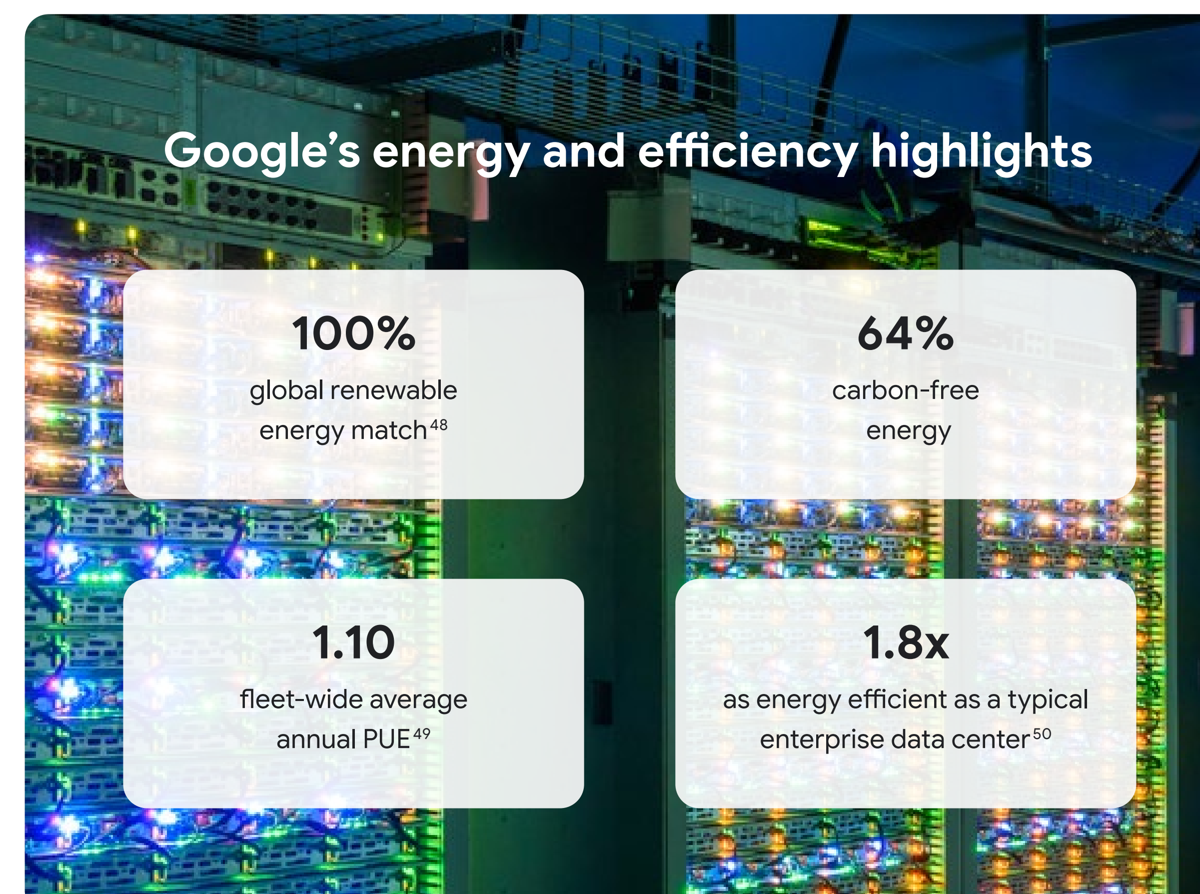
According to the IEA, estimated global data center electricity consumption represents around **1–1.3%** of global electricity demand.[47]

> Through increased collaboration, innovation, and implementation, together with the development of robust governance and ethical frameworks that include minimizing the environmental impact of AI itself, we must ensure that AI remains unbiased and benefits all. This is critical, because what is undeniable is AI's potential to address the environmental challenges of our time and help steer our planet towards a more sustainable and prosperous future.



Golestan (Sally) Radwan
Chief Digital Officer, United Nations Environment Programme

To read the full blog from Golestan (Sally) Radwan, see Harnessing AI to Accelerate the Sustainable Development Goals.



Working together

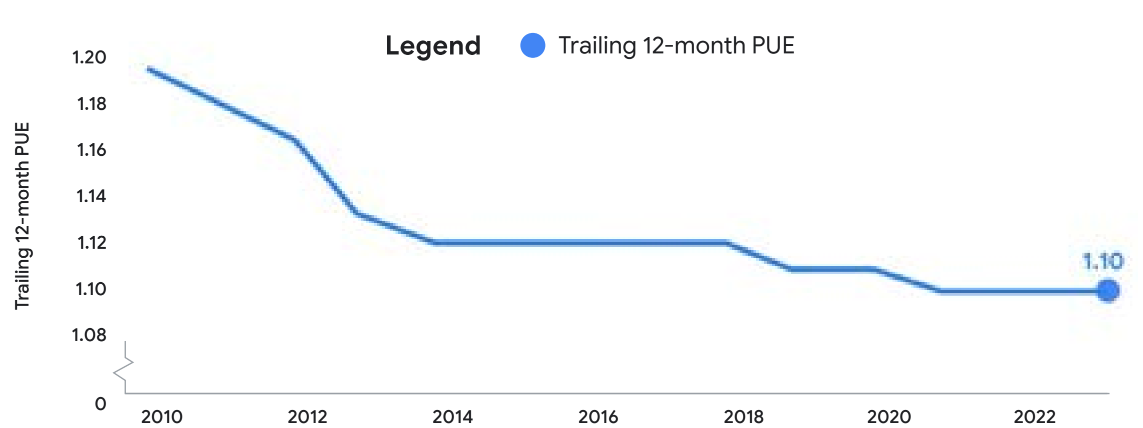
Model optimization

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.

Development and training: We've identified tested practices that our research shows can, when used together, reduce the energy required to train an AI model by up to 100 times and reduce associated emissions by up to 1,000 times,[51] which are all used at Google today. We've sped up AI model training through techniques like quantization, boosting large-language model training efficiency by 39% on Cloud TPU v5e.[52] And our Go Green Software guide helps developers reduce their digital footprints.

Deployment and usage: Google's Gemini 1.5 Pro delivers dramatic improvements and achieves comparable quality to Gemini 1.0 Ultra while using less compute.[53]

FIGURE 3 **Energy efficiency at Google data centers**



Efficient infrastructure

We strive to build the world's most energy-efficient computing infrastructure, supported by responsible water use practices and a commitment to minimizing waste.

Chip hardware efficiency: We're continually improving the power efficiency of AI hardware. For example, our TPU v4 was 2.7 times more energy efficient than our TPU v3,[54] and we'll soon offer Nvidia's next-generation Blackwell GPU to Cloud customers, which Nvidia estimates will train large models using 75% less power than older GPUs to complete the same task.[55] Additionally, our new Google Axion Processors are up to 60% more energy efficient than comparable current-generation x86-based instances.[56] These advancements, including AI-powered optimizations like AlphaZero, show how we're constantly improving hardware efficiency.

Data center energy efficiency: Our data centers remain some of the most efficient in the world, and we continue working to optimize their use of electricity, water, and materials. In 2023, the average annual power usage effectiveness[57] (PUE) for our global fleet of data centers was 1.10 (see Figure 3), compared with the industry average of 1.58[58]—meaning that Google data centers used about 5.8 times less overhead energy for every unit of IT equipment energy. For more details, see the Net-zero carbon section.

Responsible water use: The expansion of AI products and services is leading to an increase in data center workloads and the associated water footprint required to cool them efficiently. In 2023, our data centers consumed 6.1 billion gallons of water—17% more water than the previous year, mirroring similar growth in electricity use. To put this into perspective, in 2023 our data centers used the same amount of water needed to irrigate roughly 41 golf courses annually, on average, in the southwestern United States.[59] We're committed to responsible water use—using our water risk framework to identify climate-conscious cooling solutions that consider carbon-free energy availability, watershed health, and future water needs. For more details, see the Water stewardship section.

Waste: In 2023, we diverted 78% of operational waste from disposal across our global fleet of Google-owned and -operated data centers, and 29% (8 out of 28) of our data centers met our Zero Waste to Landfill goal.[60] We also maintain servers for as long as possible by refurbishing, reusing, or reselling components, and we work to ensure device longevity. For more details, see the Circular economy section.

Emissions reductions

We aim to reach net-zero emissions across all of our operations and value chain by 2030. In 2023, we achieved 64% carbon-free energy on average across all of our data centers, and we purchased over 25 TWh of renewable electricity—including from PPAs, on-site renewable energy generation, and grid renewable energy.

We deployed innovations like advanced geothermal, carbon-intelligent computing, and demand response capabilities, and partnered with others to leverage our demand, like our demand aggregation and procurement model for advanced clean electricity technologies with Microsoft and Nucor and our participation in Frontier.

We work with our supply chain, partnering to improve environmental data collection and reporting and to develop decarbonization roadmaps—focusing on reducing emissions in high-impact areas.

We're also working to reduce the embodied carbon impact of growing machine learning demand at our data centers by optimizing machine placement, promoting the reuse and upcycling of technical infrastructure hardware, and collaborating with organizations like Building Transparency and the iMasons Climate Accord.

These efforts help to reduce the emissions associated with our products, including AI, and we remain dedicated to their prioritization as we continue to innovate. For more detail, see the Net-zero carbon section.

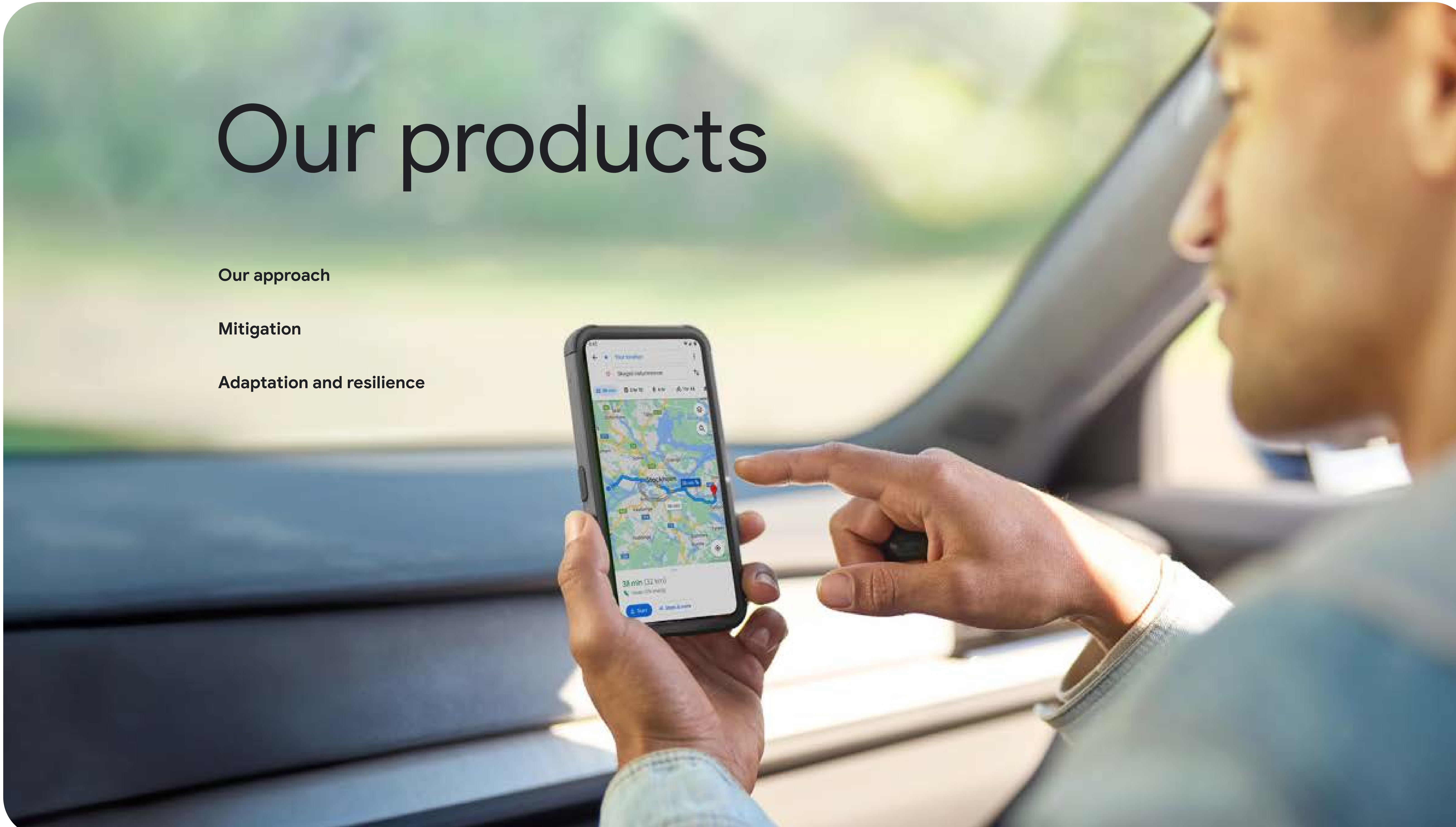
Our AI for climate policy agenda

Harnessing the potential of AI for climate action requires collective action. Policymakers, in particular, can help by:

Encouraging data sharing, ensuring affordable technology access, and building awareness: Accessible and standardized data (exemplified by tools like Data Commons and MethaneSAT), robust AI compute availability, and widespread AI expertise (fostered through programs like the Government AI Campus, with funding from Google.org) are crucial for developing effective climate-related AI solutions.

Defining market-specific priorities, delivering on public sector use cases, and encouraging private sector action: Policymakers can reduce regulatory hurdles, invest in enabling infrastructure, encourage innovation, and align incentives. In turn, the private sector can focus on high-impact areas, pilot solutions, and partner to scale them—exemplified by Google Research's partnership with Breakthrough Energy and American Airlines to develop technology that predicts contrail formation zones and informs flight paths accordingly.

Promoting environmentally responsible AI deployment: Policymakers can promote transparency into the impact of AI, encourage voluntary commitments from AI providers to mitigate this impact, and work to better enable AI providers to source carbon-free energy for their operations and supply chain.



Our products

Our approach

Mitigation

Adaptation and resilience

Our approach to product sustainability

We're developing tools and technologies that help people mitigate and adapt to climate change through our products

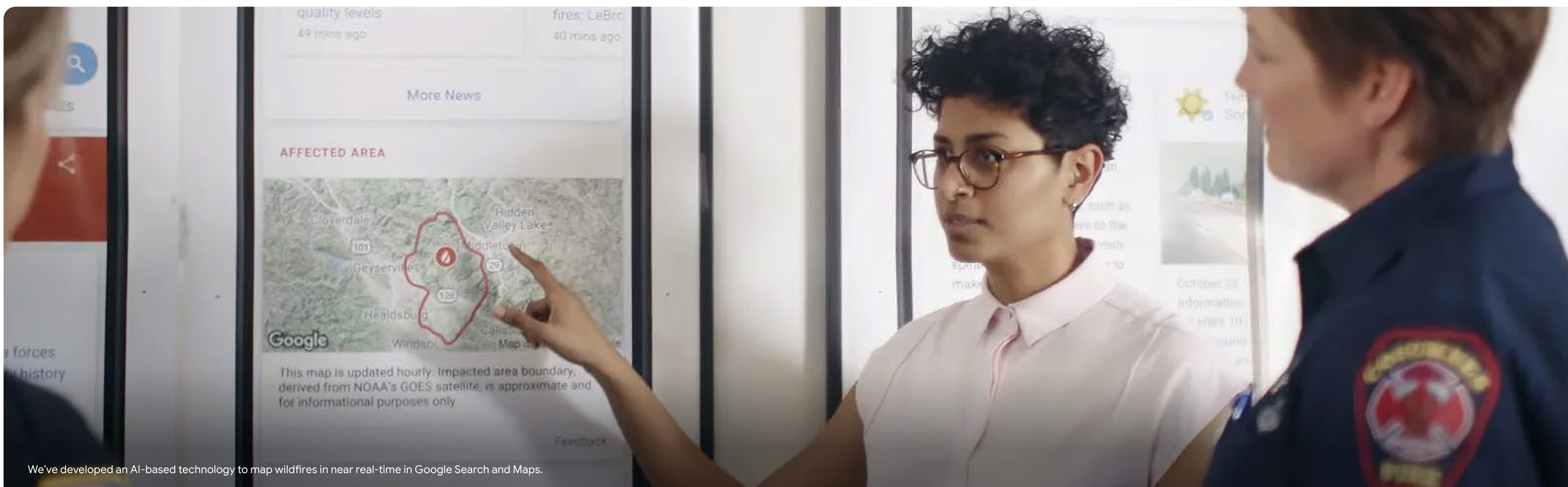
A sustainable future will be built upon countless decisions made by governments, organizations, businesses, and individuals, which will need to be grounded in helpful and authoritative information.

As an information company, we bring accurate, authoritative information to people to help them make key decisions in their lives, including information about sustainability. We don't tell people what choice to make, but we know that when they are given high quality information, they often make more sustainable choices.

For the past two years, Google has provided information to over 1 billion users to help them make more sustainable choices annually through our products.[61] We achieved this by offering sustainability features like fuel-efficient routing in Google Maps and more transportation options in Search, such as train routes.

We're tackling climate change by focusing on some of the most critical challenges: reducing emissions in sectors like energy and transportation, and better predicting extreme weather to lessen its effects. By applying AI and other cutting edge technologies to these problems, we can help individuals and organizations achieve their goals and maximize impact.

In addition to our own products, our platforms like Google Cloud enable partners to build solutions that help others mitigate and adapt to climate change. For more details on Google Cloud, see the Multi-sector products section in the Appendix.



We've developed an AI-based technology to map wildfires in near real-time in Google Search and Maps.

Mitigation

We aim to help people make more sustainable choices to mitigate climate change

Our approach to climate mitigation

In 2023, global searches for "climate change mitigation" reached an all-time high.[62]

With solutions across Google products, we aim to help individuals make informed choices about their environmental impact. Providing people with information on sustainable alternatives often provides co-benefits—like saving them time or money, or improving their health. We also strive to enable businesses to track emissions, optimize operations, and drive climate action throughout their value chains.

Across sectors that have been identified by experts as having the largest mitigation potential,[63] we've chosen to focus on **energy** and **transportation**—which collectively account for roughly half of global emissions[64] (see Figure 4 and Figure 5). With expertise in areas like geospatial mapping (Google Maps, Google Earth), smart home technology (Nest thermostats), and grid decarbonization (24/7 CFE), Google is uniquely positioned to have the most impact in these sectors through our products and research.

We're also developing tools that support a broad range of mitigation solutions across multiple sectors. For more details, see the Multi-sector solutions section in the Appendix.

FIGURE 4 **Our sector-based approach to mitigation**

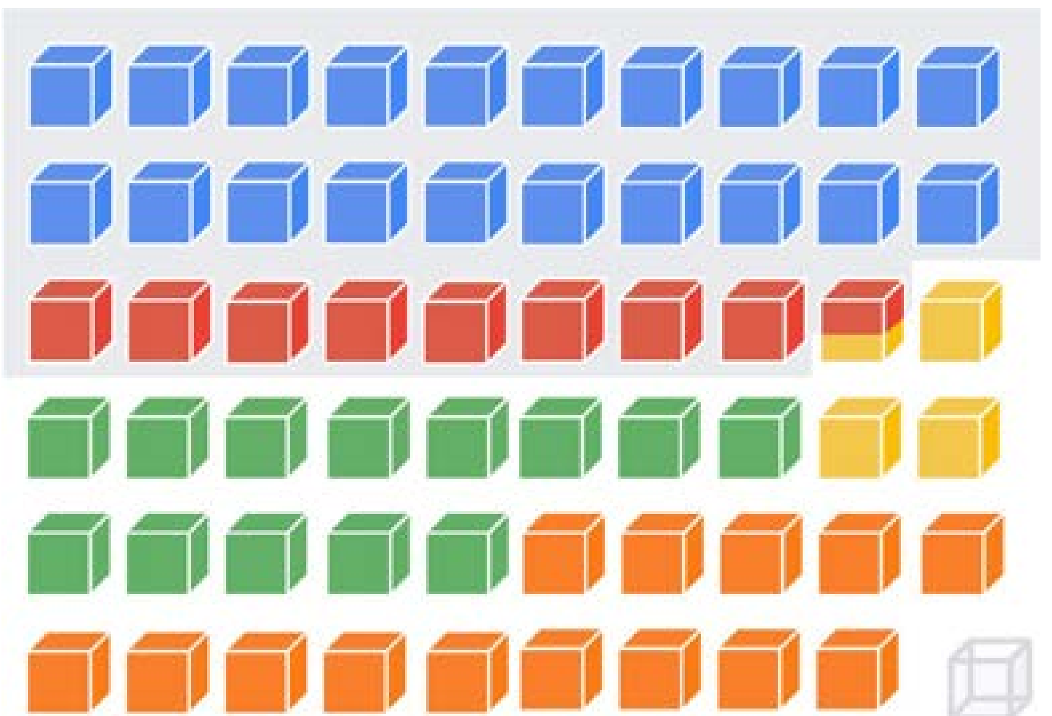
2023 highlights

- **Green Light:** Recommendations from Green Light—an AI tool for optimizing traffic signals—were implemented in 12 cities across four continents. Early numbers from Green Light indicate the potential to reduce stops by up to 30% and reduce emissions at intersections by up to 10%.[65]
- **Transportation options in Search:** We now feature more transportation options in Search, showcasing long-distance train routes in 38 countries and long-distance bus routes in 15 countries.
- **Solar API:** Our Solar API helps accelerate solar development, and now covers more than 472 million buildings across 40 countries, including newly expanded coverage to over 95% of all buildings in the United States.[66]

Global challenges

- **Say-do gap:** There's a significant opportunity to help consumers bridge the gap between their sustainability values and their daily choices—or the "say-do gap."
- **Information quality:** Deliberately false or misleading information about climate change can make it difficult for people to distinguish credible sources, undermine public trust in science, hinder informed decision making, and impede effective climate action.
- **Need for localized solutions:** The complex, localized nature of climate impacts, combined with a fragmented global market, presents a challenge for developing product sustainability features with widespread applicability and scalability.

FIGURE 5 **Estimated global emissions (by sector)**



Sector	GT	Sector	GT
Energy	20	Forest, land use, and agriculture	13
Transportation	8.7	Industrial	14
Buildings	3.3	A gigaton of emissions	1

Source for global emissions estimates: IPCC Climate Change 2023 Synthesis Report

A view of Earth shows the vast network of electric grids worldwide.

SPOTLIGHT

Our 1 gigaton aspiration

We've set an aspiration to help individuals, cities, and other partners collectively reduce 1 gigaton 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.[67]

So far, we've estimated the enabled GHG emission reductions from two products:

- **Fuel-efficient routing:** In 2023 alone, we estimate that fuel-efficient routing enabled more than 1.7 million metric tons of GHG emissions reductions—equivalent to taking approximately 380,000 fuel-based cars off the road for a year.[68]
- **Nest thermostats:** In 2023, we estimate that Nest thermostats helped customers save more than 20 billion kWh of energy,[69] which we estimate enabled approximately 7 million metric tons of GHG emissions reductions.[70]

As other products continue to be developed and mature—including some of those described throughout this chapter—we're working to understand their real-world impact in enabling GHG emissions reductions. We expect to share additional enabled GHG emissions reduction estimates in the future as we progress toward our 1 GT aspiration.

While we've made some progress, many of the solutions to help others achieve a gigaton of carbon emission reductions are either still in development or don't yet exist, and estimating enabled emissions reductions is inherently difficult and imprecise (see the Our gigaton aspiration section of our 2023 Environmental Report to learn more about our estimation approach).

This ambition pushes us to innovate and be audacious in our approach and to collaborate with others to drive systemic solutions.

Energy

To support the clean energy transition, we're working to enable more informed choices and reduce the climate impact of energy use.

Home heating and cooling

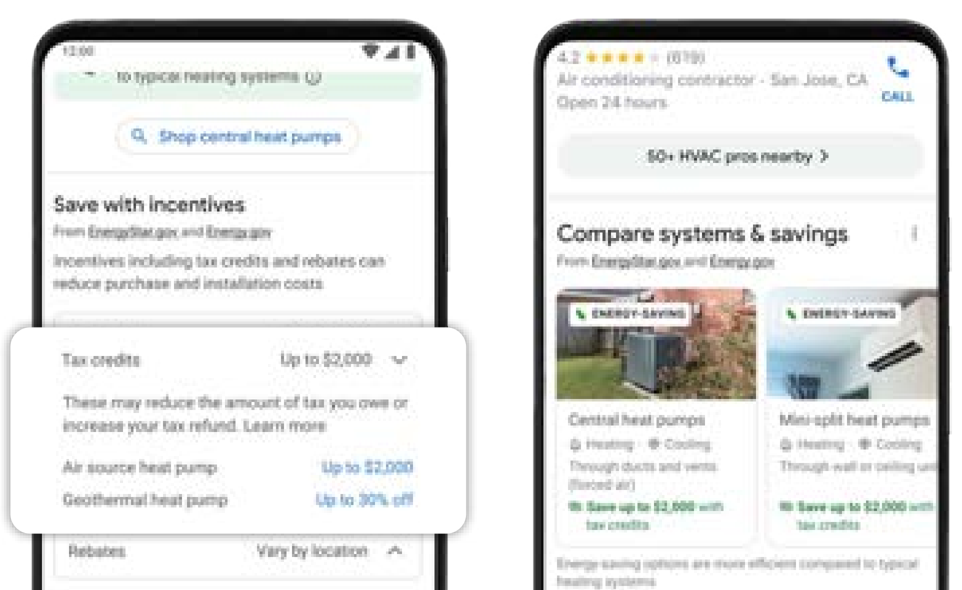
Energy use in residential buildings contributes 50% to global building carbon emissions.[71] But making sense of the options can be overwhelming, from navigating financial incentives and total costs, to understanding efficiency ratings.

Nest thermostats use algorithms powered by AI and machine learning to optimize residential heating and cooling systems and reduce energy consumption.

They can help save energy in a number of ways, including setting up energy-efficient schedules or automatically making small changes to temperature settings when energy use is surging and prices are high. These actions lead to a significant collective impact. In 2023, we estimate that Nest thermostats helped customers save more than 20 billion kWh of energy[72]—which we estimate enabled approximately 7 million metric tons of GHG emissions reductions.[73]

We're also making it easier for people looking to upgrade their **home heating or cooling** system. Search queries like "boilers," "heat pumps," or "furnaces" in the United States, Germany, and France now show information about sustainable options—including their capabilities, energy efficiency, and financial incentives—all in one place (see Figure 6).

FIGURE 6 **Sharing information about home cooling and heating options in Search**



Solar

Solar plays a significant role in the clean energy transition.[74] To help, we've developed several products and tools to make solar more accessible, bringing solar information and technology to homeowners, solar companies, and city planners around the world.

In 2015, we launched Project Sunroof to help people determine their homes' solar potential. Demand for solar data continues to grow and in 2023, with help from our partners, we launched the **Solar API** on the Google Maps Platform. This enables us to provide data on solar potential, high resolution rooftop imagery, and financial insights to our customers and partners—making obtaining solar energy more efficient, transparent, and effective.

We've used AI to provide detailed rooftop solar potential data for more than 472 million buildings across 40 countries. This includes newly expanded coverage to over 95% of all buildings in the United States.[75] Solar companies, like Monalee, are using our solar data to transition more people to renewable energy at a fraction of the time and cost of traditional processes.

In 2023, we introduced a new **generative design feature in Google Earth** that makes it easier for planners to determine the best building designs and solar options for urban areas. It's especially helpful when optimizing designs for places with ample space, like car parks. This will help cities plan for development with the right information to meet their sustainability goals.

Electricity grid decarbonization

One of the biggest barriers to bringing more clean energy online is the complexity of connecting it to the grid while maintaining overall reliability. Since renewable sources like wind and solar are intermittent, governments and utilities need to use sophisticated models to do so safely. This can be a slow process, with barriers like aging infrastructure and the inability to plan for severe weather events often causing delays.

That's why we started **Tapestry**, a part of X, Alphabet's moonshot factory. Tapestry aims to unlock access to clean, reliable, and affordable electricity worldwide by providing greater insight into our increasingly dynamic and complex electricity system. Tapestry is creating a single virtualized view of the electricity system through AI-powered tools that can predict and simulate what might happen on the grid from milliseconds to decades into the future.

Tapestry worked with Google DeepMind to improve the grid planning process by applying and enhancing GraphCast, an AI model designed for fast and accurate global weather forecasting. Tapestry and GraphCast's collaborative model outperformed the state-of-the-art model, the European Centre for Medium-Range Weather Forecasts' HRES, by up to 15%.[76] These highly accurate wind forecast insights have already aided wind prediction in Chile and can give grid operators worldwide higher confidence in relying on variable renewable energy to power their network.

Clean energy partners

We have a number of Google Cloud partners that are building solutions to decarbonize the energy sector, including mCloud, ElectricityMaps and Flexidao. Among these, LevelTen Energy not only provides access to the world's largest clean energy marketplace and the tools needed for efficient transactions, but is also the first partner to benefit from Google's partnership with HSBC to finance fast-growing climate technology firms.

We've worked to integrate their solutions on our Google Cloud Marketplace, supporting companies like Iron Mountain who share our ambition to reach 24/7 CFE and accelerate progress toward grid decarbonization.

Our predictive analytics are offering innovative ways to promote clean energy. For example, Engie partnered with Atlas AI to use its Google Cloud-powered analytics platform to successfully identify potential off-grid solar customers in Kenya, boosting their sales by 48% in one region.


Rødby solar farm in Denmark (55 MW for Google)

Transportation

How to get around is a high-impact choice people make every day. We've designed our products to help people make more informed travel decisions.

Driving

70% of direct transport emissions come from road vehicles,[77] so we're helping to make driving more sustainable by providing information on the most fuel- or energy-efficient route, available and compatible EV chargers, sustainable commuting options, and more.

Fuel-efficient routing

By building AI models on the emissions profile of different vehicle types, fuel-efficient routing in Google Maps analyzes traffic, terrain, and the vehicle's engine (gas/petrol, diesel, hybrid, or electric) to find the most efficient route. This may mean fewer stops for gas engines, routes favoring highway speeds for diesel vehicles, and maximizing downhill stretches for electric cars to boost regenerative braking—all while providing the same or similar ETA.

As of the end of 2023, fuel-efficient routing is estimated to have helped enable more than 2.9 million metric tons of GHG emissions reductions since the feature launched in late 2021—equivalent to taking approximately 650,000 fuel-based cars off the road for a year.[78] In 2023, we started rolling out fuel-efficient routing to India and Indonesia, adding to our existing coverage in the United States, Canada, Egypt, and nearly 40 European countries. And, in India and Indonesia, we're including fuel-efficient routes for two-wheelers to help even more people travel more sustainably.

Electric vehicles

Electric vehicles (EVs) are a key solution for decarbonizing road transport and an increasingly popular option with consumers. We've improved the experience for searching for EVs with new comparison features and tools to understand cost and range (see Figure 7).

- **EV comparison:** In the United States, when people search for terms like "best electric cars," they can quickly compare the prices, battery range, and power output of individual models. They can also find federal government incentives for qualifying vehicles in the United States and parts of Europe.
- **Fuel Cost Calculator:** Our updated Fuel Cost Calculator, currently available in 21 countries, now includes results for both electric and fuel-based cars, helping drivers understand the cost of charging compared with filling up at the pump.
- **Battery Range Explorer:** With Battery Range Explorer, searching for an EV shows how far one can drive on a single charge, specific to that model. These battery range insights launched in the United States in 2023 and are planned to roll out in Europe in 2024.

We're also making the charging experience easier for EV drivers in Google Maps and Waze. This starts with having EV charging locations in Google Maps—by the end of 2023, Google Maps included more than 400,000 EV charging locations globally. Additionally, in the Waze app, drivers can find compatible charging stations along their route. Thanks to local map editors from our Waze Community, EV data is reviewed and updated in near-real time.

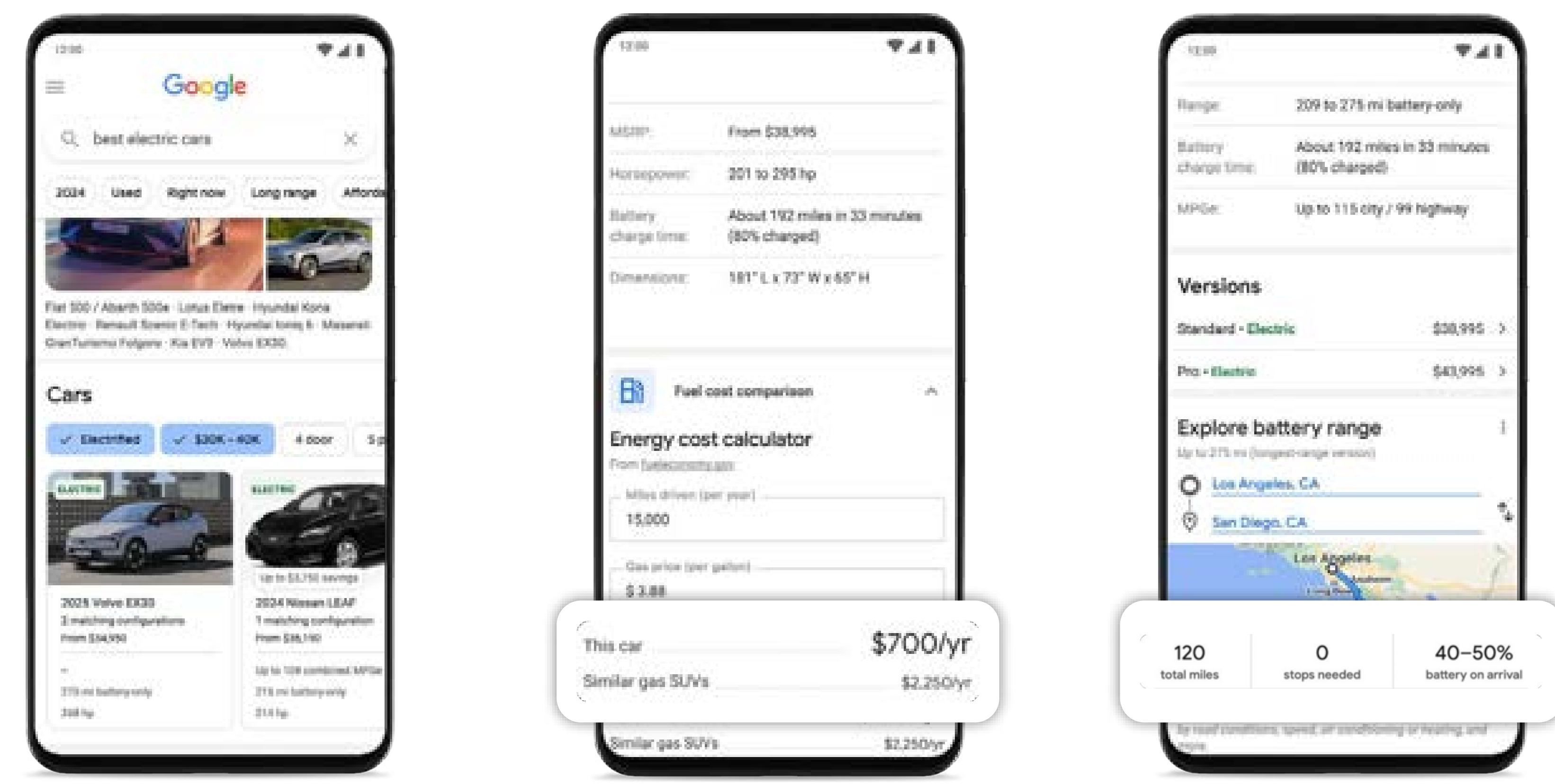
When EV drivers who have cars with Google built-in search for "EV charging" on Google Maps, they'll see charging stations nearby with charger availability and last use. Google Maps users on Android and iOS are routed to the most convenient charging location based on factors like traffic, charge levels, and charger speed, and can see data on real-time charging availability, charger compatibility with their vehicle, and charger speed.

Urban traffic

Many cities suffer from congested urban road traffic which results in excessive fuel consumption and harmful air pollution. That's why we created Green Light, an AI tool that measures driving trends at intersections and develops recommendations that city traffic engineers can use to optimize the timing of traffic light changes to reduce stop-and-go traffic.

In 2023, recommendations from Green Light were implemented in 12 cities across four continents, including Bengaluru, Kolkata, Rio de Janeiro, and Budapest. Recommendations in these cities can save fuel and lower emissions for up to 32 million car rides monthly.[79] Early numbers from Green Light indicate the potential to reduce stops by up to 30% and reduce emissions at intersections by up to 10%.[80]

FIGURE 7 **EV features in Search**



EV comparison — Fuel Cost Calculator — Battery Range Explorer

Transit and urban mobility

We're working to empower people with information on a wider range of transit and urban mobility options. We now feature more transportation options in Search, showcasing long-distance train routes in 38 countries and long-distance bus routes in 15 countries. For instance, high-speed rail suggestions may appear when searching for flights when the travel time is similar.

We're also making public transit and commuting in urban areas easier with Google Maps:

- **Public transit:** Users can access bus, train, subway, and ferry directions by tapping on the Google Maps transit icon. Google Maps provides, on average, more than 3 billion kilometers (1.86 billion miles) of public transit results per day.
- **Bike routes and bike shares:** In 2023, we added over 30,000 kilometers (18,000 miles) of bike lanes to Google Maps. Individuals can also find nearby bike and scooter shares in over 400 cities around the world.
- **Walking directions:** Pedestrians can easily get walking routes, turn-by-turn directions, and use Live View to get augmented reality assistance on the go. Google Maps offers Immersive View and Street View to preview a route before you go.

Flying

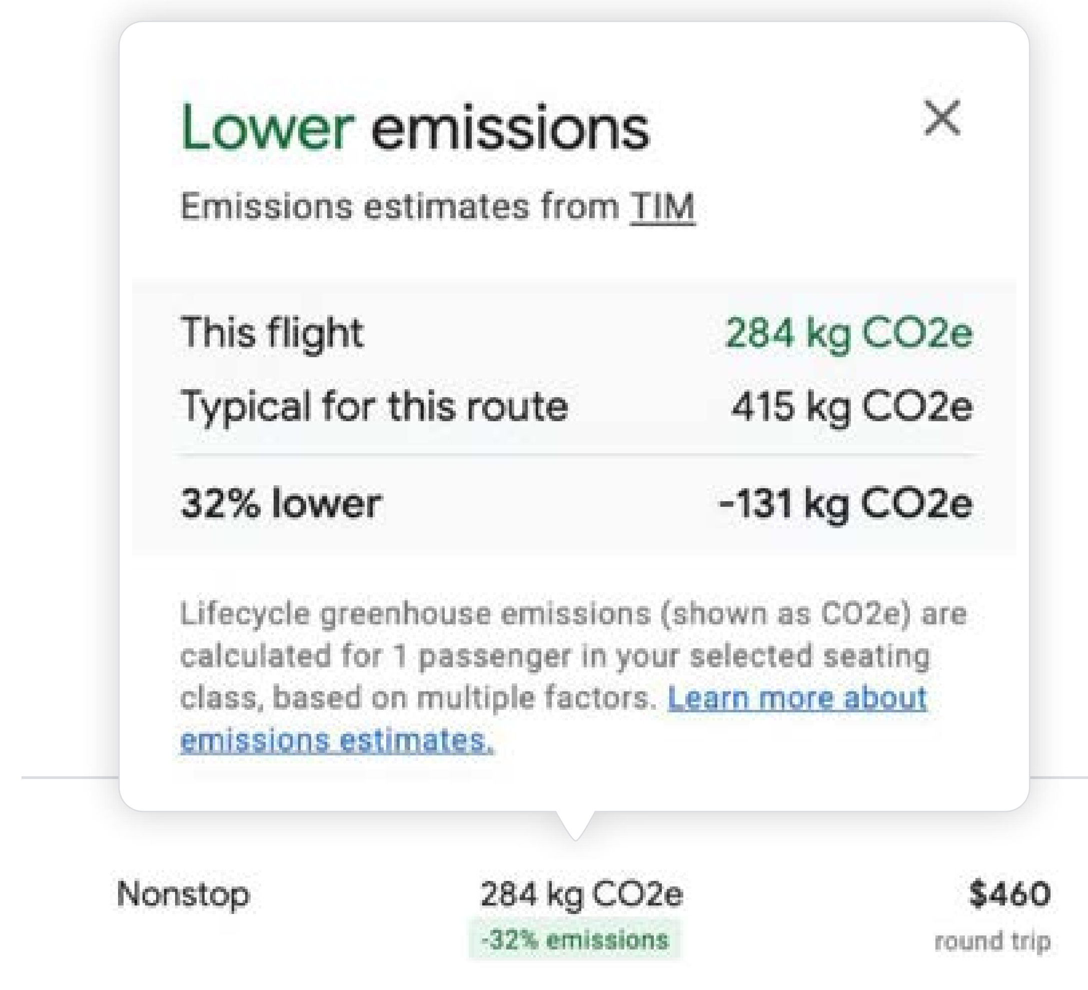
We're working on a number of solutions that help mitigate the climate impact of flying. When individuals search in Google Flights, they see **carbon emissions estimates** for nearly every flight—right next to price and duration (see Figure 8). If people want to view only flights that have lower emissions compared to the average for similar trips, they can simply tap the "Less emissions only" filter.

We created the **Travel Impact Model** (TIM), a public model for predicting the per-passenger CO_2e emissions produced by a flight. This powers the emissions estimates you see on Google Flights as well as other leading travel sites through our work in the Travalyst coalition. We've seen positive industry adoption of our model in aviation and, in 2023, we formalized our efforts by establishing an independent advisory committee to oversee future changes to the TIM.

Contrails—the thin, white lines that can appear behind aircraft—trap heat within the earth's atmosphere and are significant contributors to climate change, accounting for about 35% of aviation's contribution to global warming emissions.[81] To mitigate contrails, Google Research partnered with Breakthrough Energy and American Airlines to develop an AI-based tool to predict where contrails will form. We share insights from this tool with the aviation community so it can safely reroute planes to reduce the chances of contrail formation. In one trial consisting of 70 test flights, use of the predictive technology reduced contrails by 54%.[82]

Since only a small number of flights need to be adjusted to avoid the majority of contrail warming, the incremental fuel impact could be quite small when considering an airline's entire fleet—potentially as low as 0.3%.[83] Our analysis suggests that the cost of reducing contrail formation through navigational avoidance could be in the range of $5–$25/ton CO_2e, making it a very cost-effective climate solution.[84] Now, we're broadening our efforts via a new partnership with EUROCONTROL to test contrail avoidance technology in dense European airspace.

FIGURE 8 **Google Flights emissions estimates**



Authoritative information

When people come to our products and platforms looking for answers, we aim to provide high-quality, authoritative, and decision-useful information.

On Search, for example, we're making it easier for people to find climate change information by highlighting authoritative resources from the UN. When people search for "climate change" in certain languages, they'll see authoritative information, such as its causes and effects, and individual actions they can take to live more sustainably.

On YouTube, we raise authoritative voices on climate and provide contextual information panels in search results and videos, particularly for newsworthy environmental events or climate change-related searches.

And we have a monetization policy for Google advertisers, publishers, and YouTube creators that prohibits ads for, and monetization of, content that contradicts well-established scientific consensus around the existence and causes of climate change.

Additional sectors

Forests, land use, and agriculture

Forests

Every year the world loses around 10 million hectares (24.7 million acres) of forest,[85] an area roughly the size of Hungary.[86]

Google's geospatial tools are empowering innovative solutions to protect forests and **avoid deforestation**. For example, we're a founding partner of the Forest Data Partnership, which aims to stop deforestation caused by commodity production. Our Cloud partners, like NGIS (and their solution TraceMark) and Satelligence, help companies on their journey toward compliant and sustainable supply chains by assessing deforestation and other environmental risks using satellite technology and data processing on Google Cloud. And our Cloud partner Kumi Analytics can help estimate the carbon captured from reforestation for carbon credit issuance, using a scalable, transparent, and Google Cloud-powered assessment tool.

The UN Food & Agricultural Organization has been working for nearly a decade to create **measurement, reporting, and verification** (MRV) tools that countries can use to map, monitor, and report their forest change. Google Earth Engine and Google Earth are being used for MRV, enabling countries to better measure associated emissions reductions and receive payments based on positive results. For more details on Google Earth Engine and Google Earth, see the Multi-sector products section in the Appendix.

Farmland

Increasing agricultural productivity and sustainability is imperative to feed the planet's growing population.[87]

Google Cloud provides customers and partners with a number of insights related to agricultural productivity. Our Cloud partner Airbus owns and operates optical and radar satellites, and uses their data to, for example, help farmers minimize excessive water and fertilizer use while maintaining or increasing crop yields. KfW—a German development bank—uses satellite data through our Cloud partner UP42 to monitor irrigation infrastructure along the Niger River, which is key to food security across the region.

Ocean ecosystems

Understanding and protecting ocean ecosystems is essential for promoting sustainable practices and healthy marine environments.

Founded in 2015 as a collaboration between Oceana, SkyTruth, and Google, **Global Fishing Watch** is an open-source platform that uses satellite data and machine learning to monitor the planet's fisheries. In 2023, Global Fishing Watch was awarded $60 million by the TED Audacious Project. To learn more, see Global Fishing Watch's 2023 TED talk.

Tidal—founded as a project at X—uses underwater camera systems and machine perception tools to bring visibility to our ocean ecosystems, so we can better understand and protect them and help solve some of humanity's biggest challenges—from food production to climate change. In 2023, Tidal was included in Time Magazine's Best Inventions of 2023 for its undersea AI capabilities. Tidal is currently working with aquaculture partners across the globe, including Norway-based Mowi, the world's largest Atlantic salmon producer. From launching commercially in early 2023 to February 2024, Mowi has installed Tidal systems in nearly 300 pens across Norway—making Tidal's insights available for improving the sustainability and efficiency of its aquaculture operations.

Industrial

The industrial sector is critical in the fight against climate change and it presents unique challenges in mitigating GHG emissions. At Google, we're using cutting-edge technologies to support organizations in addressing emissions like methane leaks from the oil and gas sector.

Methane leaks

Methane is a potent greenhouse gas, over 80 times more powerful than carbon dioxide. Tackling methane emissions effectively will require collaboration between industry stakeholders and the public sector to track emissions and implement mitigation efforts.

To help, the Environmental Defense Fund (EDF) will use a new satellite—**MethaneSAT**—to map, measure, and track methane with unprecedented precision, offering a comprehensive view of oil and gas methane emissions globally. EDF's algorithms, powered by Google Cloud, will calculate the amount of methane emitted in specific places and track those emissions over time (see Figure 9).

As part of a partnership with EDF, we're using this information to build a global map of oil and gas infrastructure to help identify the components most responsible for methane emissions. These insights will be available later this year on MethaneSAT's website, and accessible through Google Earth Engine.

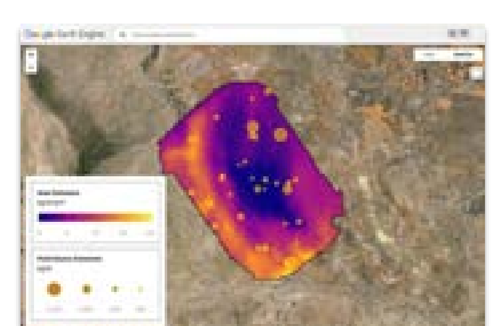
Additionally, our Cloud partner BlueSky Resources uses Google Earth Engine to integrate a range of sensor data and satellite imagery, empowering organizations to pinpoint methane emission sources and develop targeted mitigation strategies.

Recycling

In addition to recycling features within our products, we're working on technology pilots that advance recycling process optimization for the industry. In 2023, X deployed its first advanced sortation technology pilot in a materials recovery facility in Oregon, demonstrating the ability to achieve high resolution materials identification and intelligent sortation at industrial speeds and scale.

Meanwhile, Google's AI technology, **CircularNet**, powers Recykal's waste management platform—Asia's largest circular economy marketplace—enabling the identification of recyclable materials with high accuracy.

FIGURE 9 **MethaneAIR on Google Earth Engine**



EDF's aerial methane emissions data, or MethaneAIR—available in Earth Engine—shows both high-emitting point sources as yellow dots, and diffuse area sources as a purple and yellow heat map. MethaneSAT will collect this data with the same technology, at a global scale and with more frequency.

RESOURCES

- Google Cloud Sustainability
- Searching for Sustainability with Google
- Sustainable with Google 2023
- The Search for Sustainability

Adaptation and resilience

We aim to develop tools and technologies that help communities adapt to the effects of climate change

Our approach

Extreme event forecasting and early warning systems

- Weather and climate forecasting
- Wildfire detection
- Flood forecasting
- Extreme heat
- Air quality conditions

Our approach to climate adaptation and resilience

We've discussed the ways we're helping people make more sustainable choices to mitigate climate change, but its effects are already here. 2023 was the hottest year on record, the past decade was the hottest ever recorded,[88] and communities worldwide—especially the most vulnerable—are experiencing the devastating effects of floods, wildfires, food insecurity, and more.

During extreme weather events, people often turn to our platforms for information. Global search interest in "heat wave" and "heat exhaustion" both spiked during the month of July 2023,[89] during the warmest July ever recorded.[90] For events like these, timely information is critical to help minimize damage and loss.

To help communities adapt to the effects of climate change and stay safe, we're building technologies to model, predict, and respond to extreme weather events, wildfires, floods, extreme heat, and air quality conditions (see Figure 10).

AI plays a critical role in powering these platforms—enabling more accurate predictions, real-time data analysis, and personalized insights to aid in adaptation efforts. We're also leveraging AI to create more accurate models in data-scarce regions, improving and expanding extreme event forecasting and early warning systems.

FIGURE 10 **Areas of focus for extreme event forecasting and early warning systems**

2023 highlights

- **Crisis Alerts for wildfires:** Our Crisis Alerts provided timely wildfire information to over 30 million users across 180 wildfire events around the world.
- **Flood Hub:** Flood Hub displayed forecasts for over 80 countries on five continents, including some of the territories with the highest percentages of population exposed to flood risk—covering more than 460 million people globally.[91]
- **Extreme heat information:** Since launching, we've provided information about extreme heat on Search in more than 100 countries.
- **Cool Roofs pilot:** Our Cool Roofs pilot was available in 15 cities.
- **Tree Canopy data:** We expanded Tree Canopy data in EIE to more than 2,000 cities globally on four continents.

Global challenges

- **Data gaps and uncertainties:** Accessing reliable local climate projections remains a barrier to effective adaptation planning. Data quality, resolution, and availability can vary significantly by region, hindering accurate risk assessments and tailored solutions.
- **Long-term planning:** Climate adaptation often requires long-term investments and complex trade-offs which can be difficult to prioritize, especially when decision-makers face competing needs like immediate economic concerns.
- **Local collaboration:** Successful adaptation requires collaboration across multiple stakeholders: governments, businesses, communities, and individuals. Coordination, communication, and resource alignment can be challenging, slowing down the implementation of solutions.
- **Metrics and measurement:** The inherent complexity of measuring the effectiveness of adaptation actions is compounded by uncertainty about future climate scenarios, making it challenging to evaluate success.

Extreme event forecasting and early warning systems

Weather and climate forecasting

Our innovative weather and climate forecasting tools are providing communities with crucial information to plan for and respond to a changing climate.

Weather forecasting

Google's MetNet-3 is a state-of-the-art neural weather model that outperforms leading operational forecasting systems. Its precise precipitation forecasts for 12 hours into the future have been integrated into various Google products, enhancing the information and tools available to people. Meanwhile, Google DeepMind's GraphCast model delivers 10-day weather predictions at unprecedented accuracy in under one minute, and offers earlier warnings of extreme weather events. And, in 2023, Google Research launched WeatherBench 2, a platform that enables researchers to compare global weather models and drive innovation in this field.

Cloud simulations

Google Research, in collaboration with a Climate Modeling Alliance (CliMA) lead, is achieving breakthroughs in cloud modeling, significantly improving climate model accuracy. Today's climate predictions vary widely, largely because it's so difficult to simulate clouds accurately—which is why we're focusing on simulating stratocumulus clouds, the most prevalent cloud type. Using TPUs and high-performance computing originally designed for machine learning applications, we're able to simulate cloud patterns with unprecedented detail, offering a glimpse into the future climate.

Wildfire detection

Climate change is increasing the frequency and severity of wildfires, which are having a devastating impact on communities and ecosystems around the world.[92] This growing threat is reflected in the all-time high global searches for "air quality index" and "wildfire" in June 2023,[93] coinciding with the peak of the Canada wildfires that year.[94]

To minimize the impact of wildfires on communities, Google has developed an AI-based technology to map wildfires in near real time in Google Search and Maps. The tool uses data from geostationary satellites such as NOAA's GOES constellation to show the size of a wildfire, with data refreshed roughly every 15 to 20 minutes. In 2023, our Crisis Alerts provided timely wildfire information to over 30 million users across 180 wildfire events around the world.

We've also been working closely with U.S. agencies, such as the U.S. Forest Service (USFS), on wildfire research by using advanced simulation and AI techniques to improve their fire-spread model. Additionally, USFS used Google Earth Engine and Google Cloud technology to build a Landscape Change Monitoring System to map and monitor land cover change across the United States, supporting forest planning and post-fire recovery.

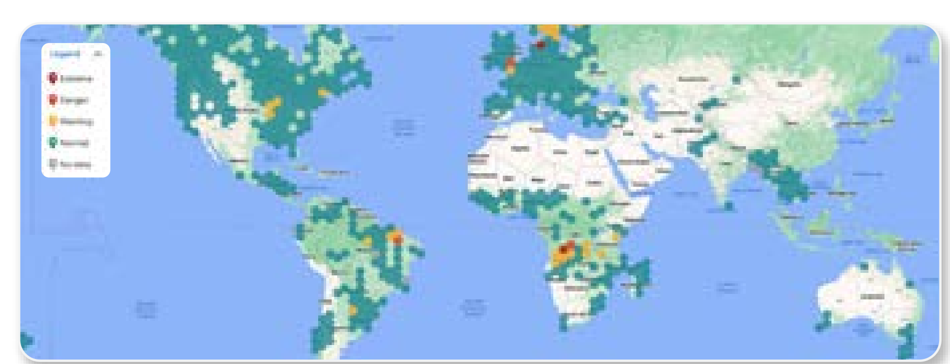
To help prevent catastrophic fires in the future, X's Project Bellwether—as part of its prediction engine for the Earth and everything on it—has built an AI-first wildfire risk forecasting system to understand the future probability of wildfire in the United States, Canada, and Australia. X partnered with SwissRe Reinsurance Solutions and others to bring these critical insights to the insurance market, where better tools are needed to keep homeowners insured.

This work is important for fostering a more resilient society, as it enables better understanding of wildfire risks and informs actions that can protect communities and homeowners from the devastating impacts of these events.

Flood forecasting

Floods are among the world's deadliest natural disasters, and climate change is causing more frequent and severe floods.[95] Our Flood Forecasting Initiative, launched in 2018, uses advanced AI and geospatial analysis to predict when and where riverine flooding will occur up to seven days in advance.

FIGURE 11 **Google's Flood Hub platform**



The system, called Flood Hub, displays flood forecasts to help governments, aid organizations, and at-risk communities take timely action (see Figure 11). These breakthroughs are a result of innovative modeling approaches that use machine learning to create scalable models in real-world settings.

In 2023, Flood Hub displayed forecasts for over 80 countries on five continents, including some of the territories with the highest percentages of population exposed to flood risk—covering more than 460 million people globally.[96] In late 2023, we announced the expansion of riverine flood forecasts on Flood Hub to the United States and Canada, covering more than 800 locations by rivers where more than 12 million people live.[97]

In 2023, we generated nearly 700 Crisis Alerts that shared critical flood information, including mappings of estimated flooded areas, which were viewed by more than 10 million users.

Extreme heat

In 2023, we launched extreme heat alerts, so when people search for information on extreme heat, they see details they need about when a heat wave is predicted to start and end, tips for staying cool, and related health concerns to be aware of from the Global Heat Health Information Network (see Figure 12). Since launching, we've provided information about extreme heat on Search in more than 100 countries.

FIGURE 12 **Extreme heat alerts**

Tree canopy

Cities are looking for ways to prevent "heat islands"—urban areas that experience higher temperatures due to structures like roads and buildings that absorb and re-emit heat. Our **Tree Canopy tool**, part of our EIE platform, uses AI and aerial imagery to detect and map tree canopy coverage in cities to help them plan future tree planting projects more effectively (see Figure 13).

For example, the city of Austin, Texas used insights from this tool to develop Austin's Community Tree Priority Map, helping to focus tree planting efforts in the eastern part of the city where tree coverage was lower and ambient temperatures were higher.

In 2023, we expanded Tree Canopy data to more than 2,000 cities globally on four continents. With the aim of making shade in cities more equitably distributed, we partnered with American Forests in the United States to make our tree canopy data available on its Tree Equity Score tool. American Forests now provides tree canopy data for nearly 80% of the U.S. population. The success of this project has led to the development of a similar tool for the United Kingdom.

FIGURE 13 **Tree Canopy data for Lisbon, Portugal**

Cool roofs

We're exploring how our technology, such as AI algorithms and aerial imagery, can help implement reflective roofs—called "cool roofs."

These energy-saving roofs reduce indoor and outdoor temperatures, making them especially impactful in communities without reliable air conditioning. By mapping urban solar reflectivity, we can help planners and governments identify areas where cool roofs would be most impactful. As of the end of 2023, this pilot was available in 15 cities.

Addressing extreme heat requires collaboration, so Google.org is supporting nonprofit projects that identify which communities are most affected by extreme heat and where there are opportunities to help. In 2022, we announced a $30 million Google.org Impact Challenge—an open call for nonprofits to submit big ideas for climate action.

In 2023, we announced the first recipient: World Resources Institute (WRI). WRI received $5 million to support its project to use sensors, satellite imagery, and AI to close data gaps and model air temperature, humidity, surface reflectivity, tree cover, and heat vulnerability. Alongside Google.org's efforts, WRI's project will help decision-makers understand where to implement cool surface infrastructure—such as trees and reflective surfaces—to reduce the impact of extreme heat.

Air quality conditions

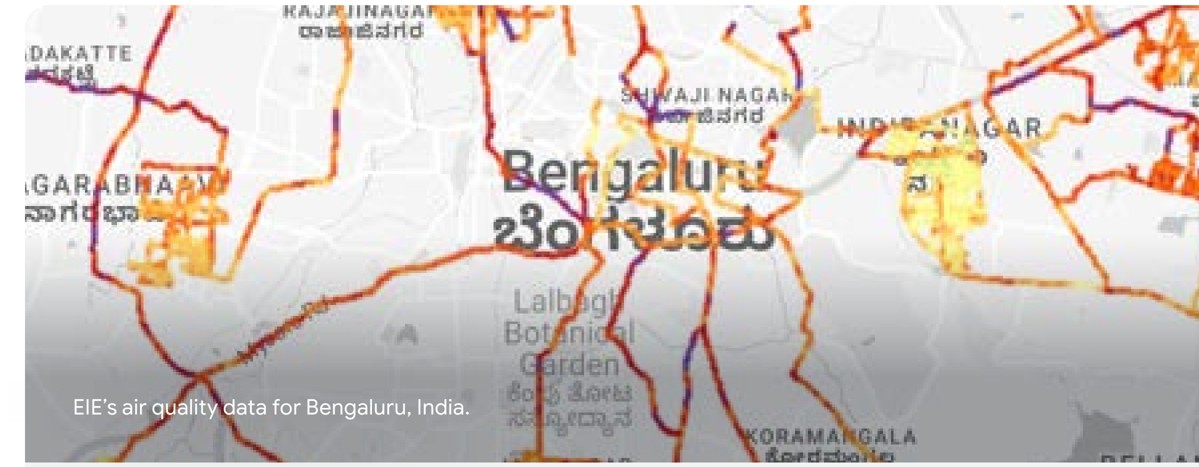
With climate change intensifying wildfires, ozone pollution, and allergy seasons,[98] Google's hyperlocal air quality data empowers individuals, companies, researchers, and policymakers to make informed health choices and develop strategies for cleaner air.

In 2023, we introduced a new suite of Environment APIs from Google Maps Platform, which included:

- **Air quality:** The Air Quality API shows robust air quality data, pollution heatmaps, and pollutant details for nearly 100 countries around the world. IKE Smart Cities is using this data to alert residents of poor air quality and provide city partners with a dashboard to monitor conditions alongside other relevant data. This helps cities implement protective measures for citizens and visitors.
- **Pollen:** Our new Pollen API shows current pollen information for the most common allergens in over 65 countries. The API provides localized pollen count data, heatmap visualizations, detailed plant allergen information, and actionable tips for allergy-sufferers to limit exposure.

RESOURCES

- How We're Using AI to Combat Floods, Wildfires and Extreme Heat
- How We Are Using AI for Reliable Flood Forecasting at a Global Scale
- Sustainable with Google 2023



EIE's air quality data for Bengaluru, India.

SPOTLIGHT

Hyperlocal air quality data in Bengaluru, India

EIE provides select cities with street-by-street air quality data, helping them identify opportunities for improvement.

By equipping Google Street View vehicles with air pollution sensors and partnering with local organizations, we've collected nearly 2 billion air quality measurements across more than 230 million locations—and have integrated all this data into EIE. With real-time, hyperlocal modeled air quality intelligence, Google aims to make invisible air pollution easier to address.

In 2023, we launched street-by-street air quality data for Bengaluru in EIE—our first city to launch in India. This launch was the result of a year and a half of deep scientific partnership with the Center for Study of Science, Technology and Policy (CSTEP) and ILK Labs.

CSTEP collected air quality data by installing sensors on its cars and driving them around precalculated routes in Bengaluru, and published its methodology for collecting and analyzing hyperlocal data.

We then integrated CSTEP's calibrated data into EIE, with the goal of making it easily accessible to policymakers, pollution authorities, and the local scientific community to identify air pollution hotspots in Bengaluru. We plan to collect additional data for more pollutants in Bengaluru with our partners.

Our operations

Our approach to operating sustainably

We're working to advance our ambitious sustainability goals, showing the way forward through our own operations

In 2023, Google had offices and data centers on six continents, in over 200 cities, across nearly 60 countries.

We use energy and natural resources to build and operate our data centers and offices around the world, and to power the many products and services that our customers and users rely on—including Google Cloud, Google Search, Google Workspace, and YouTube.

That's why our work on sustainability started with understanding and working to address the environmental footprint of our operations.

At Google, we're working to drive sustainability across our operations in four key ways: accelerating the transition to a net-zero future, advancing water stewardship, building a circular economy, and restoring and enhancing nature and biodiversity.

We're also working worldwide with suppliers through our Supplier Responsibility Program. We collaborate with stakeholders across our supply chain to uphold our high standards for respecting workers and the environment.

FIGURE 14 **Google's global operations**

6 continents	**200+** cities	**~60** countries
24 Google-owned data center locations[99]	**44** data center electricity grid regions (including third party)	**~40** Google Cloud regions


Wind turbines spin near our Eemshaven, Netherlands data center.

Net-zero carbon

We're working to accelerate the transition to a net-zero future at Google and beyond

Our approach to net-zero carbon

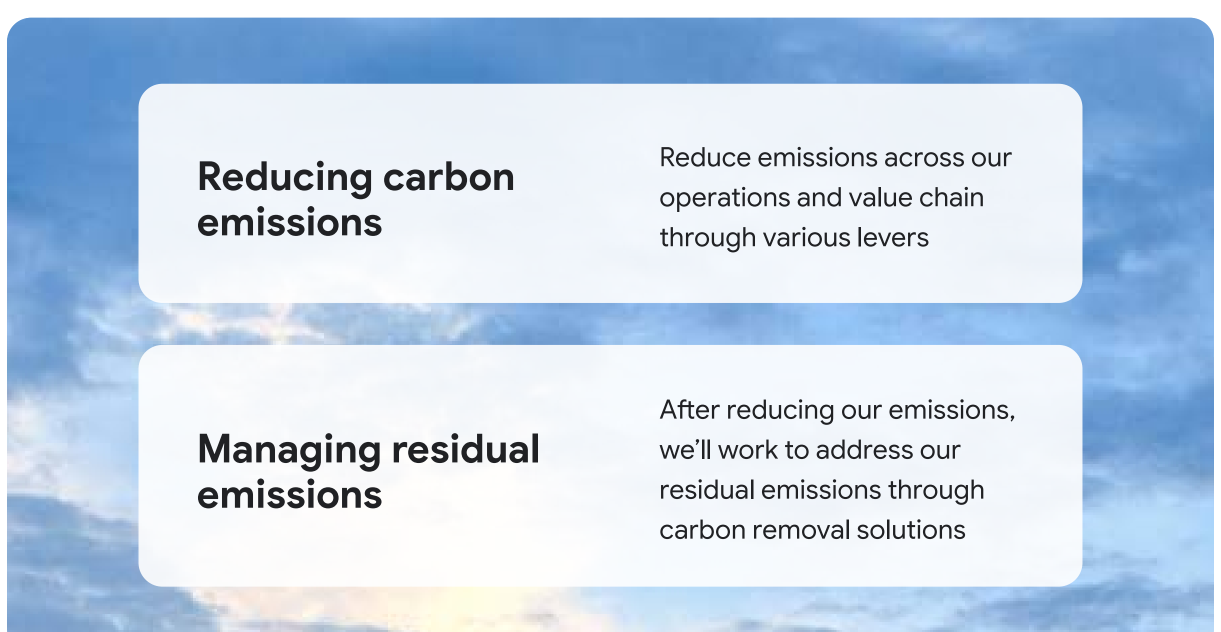
We're working to accelerate the transition to a net-zero future, and we've taken significant steps over the past two decades to minimize our GHG emissions.

In 2021, we set an ambitious goal to reach net-zero emissions across all of our operations and value chain by 2030. We're working toward this goal in two key ways: first, we're focused on reducing emissions across our operations and value chain (including advancing 24/7 CFE), and after reducing our emissions, we're addressing our residual emissions with carbon removals (see Figure 15).

Ultimately this isn't just about Google—our net-zero goal is a key tool by which we can help accelerate global decarbonization. To ensure our efforts maximize impact, we'll continue evaluating our plan on a regular basis to ensure it's rigorous, grounded in science, and realistic in light of evolving challenges and standards.

We're engaging in advocacy efforts, exploring data center innovations, accelerating global grid decarbonization, and advocating for GHG Protocol reform to help drive system-level change. For more details, see the Policymakers and Partners sections in the Appendix, as well as Energy in the Our products section for how we're working to advance clean energy development through Google's core capabilities in data and software.

FIGURE 15 **We prioritize emissions reductions first before compensating for residual emissions**



2023 highlights

- **CFE:** We maintained 64% carbon-free energy, on average, across every grid where we operate—even as our electricity use increased.
- **Clean energy procurement:** We signed contracts to purchase approximately 4 GW of clean energy generation capacity[100]—more than in any prior year.
- **100% renewable energy:** We achieved seven consecutive years of 100% renewable energy matching on a global and annual basis.[101]
- **Energy innovation:** We developed, piloted, and advanced innovative new approaches to energy management and tracking, including demand response and time-based energy attribute certificates (T-EACs).
- **Carbon removal procurement:** We completed our first carbon removal credit offtake deals through Frontier in 2023—including deals with Charm Industrial, CarbonCapture, and Lithos Carbon.

Global challenges

- **Need for systemic changes:** Transitioning to a net-zero future will require stronger government policies and partnerships, new technologies, and structural changes to the broader systems that support our operations and value chain, such as electricity grids and hardware supply chains. Reform is needed across clean energy transmission, interconnection, and generation in order to upgrade and expand grid infrastructure to meet the needs of a more electrified and decarbonized world.
- **Evolving standards and regulations:** Faster reform and greater harmonization of various climate-related standards and regulations would help further streamline corporate decision-making, particularly for long-term emissions reductions strategies.
- **Hard-to-decarbonize industries and regions:** Global operations and value chains that span a diverse range of industries and regions present a unique decarbonization challenge, particularly within hard-to-abate sectors and carbon-intensive geographies like the Asia-Pacific region.
- **Collaborating with suppliers:** The maturity of supplier climate programs and their commitments to taking action can vary widely when working with a large number of direct and indirect suppliers—which can impact engagement strategies and the availability and quality of supplier-specific data.
- **Availability of carbon-free energy:** There are often long lead times between investments and resulting GHG reductions. With new carbon-free energy projects, it can take years before contracted projects are constructed and begin to generate clean electricity. These delays are often due to slow permitting processes, inadequate grid infrastructure, and challenges in the renewable energy supply chain. Sometimes these issues can also lead to projects failing and CFE contracts terminating prior to those projects becoming operational.
- **Cost and availability of carbon removals:** Due to the early stage of the carbon removals market, the volumes of removal credits available for purchase, as well as the quality and permanence of credits, may vary. Additionally, many solutions will require long lead times to scale, as well as significant improvements in measurement and system design.

Our net-zero goal

In 2021, we set a goal to reach net-zero emissions across all of our operations and value chain by 2030.

To meet this goal, we aim to reduce 50% of our combined Scope 1, Scope 2 (market-based), and Scope 3 absolute emissions (compared to our 2019 base year) by 2030, and we plan to invest in nature-based and technology-based carbon removal solutions to neutralize our remaining emissions. We've formally committed to the **Science Based Targets initiative** (SBTi) to validate our absolute emissions reduction target.

Reaching net-zero emissions by 2030 is an extremely ambitious goal and we know it won't be easy. Our approach will continue to evolve and will require us to navigate significant uncertainty–including the uncertainty around the future environmental impact of AI, which is complex and difficult to predict. In addition, solutions for some key global challenges don't currently exist, and will depend heavily on the broader clean energy transition.

As our business and industry continue to evolve, we expect our total GHG emissions to rise before dropping toward our absolute emissions reduction target.

Our net-zero goal is aligned with the IPCC's definition of "net zero emissions," which is "when anthropogenic emissions of greenhouse gasses to the atmosphere are balanced by anthropogenic removals over a specified period." The world's understanding of "net zero" remains in a dynamic state and is subject to refinement as global consensus develops. We'll proactively monitor the evolution of global standards to ensure our definition maintains general alignment while maximizing our positive impact on the planet.

In 2023, our total GHG emissions were 14.3 million tCO_2e, representing a 13% year-over-year increase and a 48% increase compared to our 2019 target base year. This result was primarily due to increases in data center energy consumption and supply chain emissions. As we further integrate AI into our products, reducing emissions may be challenging due to increasing energy demands from the greater intensity of AI compute, and the emissions associated with the expected increases in our technical infrastructure investment.


Rødby solar farm in Denmark (55 MW for Google)

TARGET

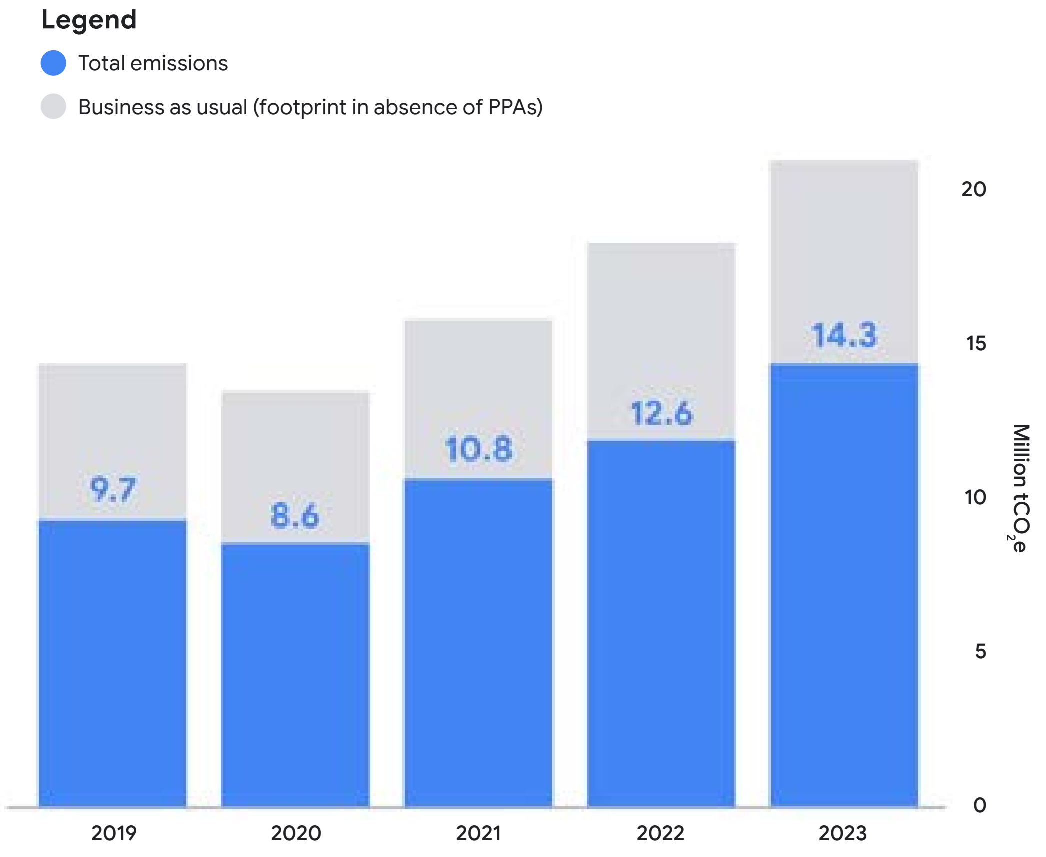
Reduce 50% of our combined Scope 1, 2 (market-based), and 3 absolute GHG emissions by 2030,[102] and invest in nature-based and technology-based carbon removal solutions to neutralize our remaining emissions

Year set: 2021; Base year: 2019[103]; Target year: 2030

2023 PROGRESS

Emissions reductions: Total GHG emissions were 14.3 million tCO_2e, representing a 48% increase compared to 2019

Residual emissions: Signed offtake deals for approximately 62,500 tCO_2e of removal credits



TREND

Emissions reductions: In 2023, our total GHG emissions increased 13% year-over-year, partially driven by a 37% year-over-year increase in our Scope 2 (market-based) emissions. Our total GHG emissions increased at a slower rate compared to the previous two years. For trend details for each scope, see the Scope 1 emissions, Scope 2 emissions, and Scope 3 emissions sections.

Residual emissions: 2023 marks the first year of implementation of our carbon removals strategy, and while we have a long way to go to meet our 2030 target, we've begun establishing impactful partnerships and have started contracting for carbon removal credits. For more detail, see the Managing residual emissions section.

DETAILS

Emissions reductions: All Scope 1, 2 (market-based), and 3 absolute emissions across our operations and value chain, including our data center and office operations, supply chain, and consumer hardware devices.

Residual emissions: Carbon removal credits to neutralize our residual emissions by 2030.

Reducing carbon emissions

In 2023, our total GHG emissions were approximately 14.3 million metric tons of carbon dioxide equivalent (tCO_2e), which represents our Scope 1, Scope 2 (market-based), and Scope 3 emissions (see Figure 16).

We've analyzed our operations and value chain to pinpoint specific levers that will drive carbon reductions across Scope 1, Scope 2, and Scope 3 emissions. While our reduction efforts are crucial, they alone won't get us all the way to our net zero goal.

Carbon footprint recalculation

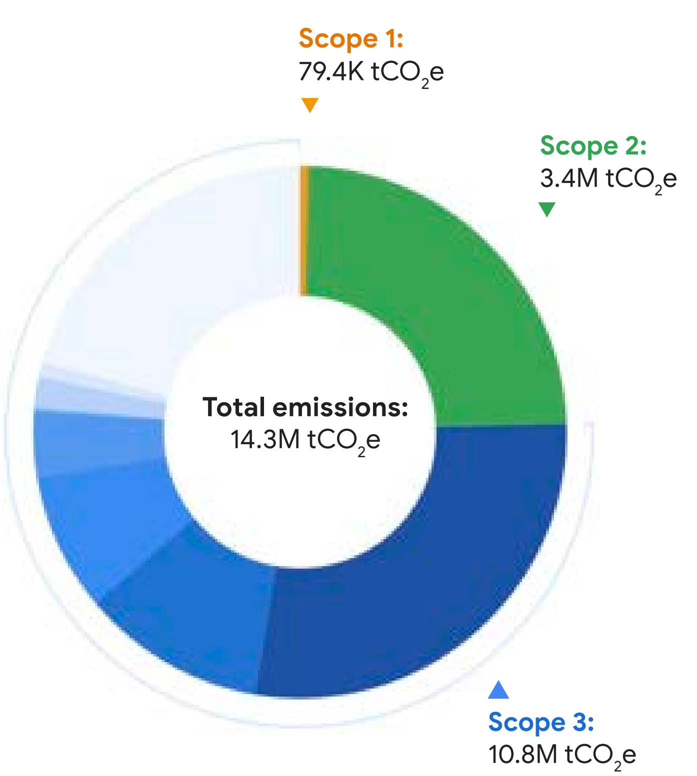
In 2023, we recalculated certain previously reported GHG emissions metrics in accordance with our internal recalculation policy for improved accuracy.

See the Recalculation of previous environmental metrics section in the Appendix for more information on our carbon footprint recalculation, and the Environmental data tables for more details on our GHG emissions.

Scope 1 emissions

In 2023, our Scope 1 emissions were approximately 79,400 tCO_2e, representing approximately 1% of our total carbon footprint. Compared to 2022, we reduced our Scope 1 emissions by 13% due to building electrification and decreases in emissions from transportation and data center generator use. Our main sources of Scope 1 emissions include natural gas use, refrigerant leakage in our data centers and offices, fuel use from back-up generators, and transportation (i.e., company vehicles and aircraft). Given this, some of our key Scope 1 emissions reduction levers include electrification, refrigerant mitigation, and renewable fuels.

FIGURE 16 Our 2023 carbon footprint



Scope	tCO_2e	%
Scope 1	79,400	1%
Scope 2 (market-based)	3,423,400	24%
Scope 3: (1) Purchased goods and services	4,038,000	28%
Scope 3: (2) Capital goods	1,605,000	11%
Scope 3: (3) Fuel- and energy-related activities (not included in Scope 1 or 2)	1,186,000	8%
Scope 3: (4) Upstream transportation	584,000	4%
Scope 3: (5) Waste generated in operations	10,000	<1%
Scope 3: (6) Business travel	283,000	2%
Scope 3: (7) Employee commuting (including teleworking)	113,000	<1%
Scope 3: Other categories	2,993,000	21%
Scope 3 (total)	10,812,000	75%
Total emissions	**14,314,800**	**100%**

Electrification

Electrification—followed by clean energy procurement—is an essential first step toward decarbonizing our office and shuttle fleet operations.

We're working to electrify our office portfolio, including retrofitting existing building systems, incorporating electrification standards into new developments (such as designing all-electric kitchens), and working with property owners on lease terms that support building electrification.

In 2023, we completed 14 full or partial office building electrification projects around the world—including in India, Brazil, and the San Francisco Bay Area—and we pledged to upgrade the iconic Thompson Center in Chicago to an all-electric office building. And in 2023, we signed our first leases in the Google office portfolio with electrification provisions—located in the Asia-Pacific region—with more currently under negotiation.

Our **Moffett Park Thermal Plant** in Sunnyvale, California, demonstrates electrification at scale—as an all-electric central utility plant that will efficiently deliver heating and cooling services to some nearby Google offices.

And for our shuttle fleet operations, in 2023 we incorporated additional electric shuttle buses into our fleet in the San Francisco Bay Area, increasing the electric vehicles in our fleet to 14%.

Refrigerant mitigation

We're working to more accurately measure refrigerant leak rates and develop new technologies to reduce them. At our data centers, we're developing and deploying cooling solutions that include natural, low-GWP refrigerants. And in 2023, we completed 24 Technical Feasibility Studies for refrigerant phase-out for offices in the Asia-Pacific region.

We also continued working with industry partners to identify innovations in technology and refrigerants. In 2023, we submitted a follow-on patent to the one we filed in 2022, incorporating the use of large language models for "intelligent diagnostics." Based on our pilots, intelligent diagnostics can provide operators with guidance to locate leaks, helping to both curb refrigerant emissions and reduce energy consumption from faulty equipment.

Renewable fuels

We're exploring ways to reduce the carbon footprint of our data center backup power. One solution is renewable diesel, which offers lower life cycle carbon emissions compared to fossil fuels. In 2023, we piloted renewable diesel in select U.S. and European data centers, and plan to scale this program globally as renewable diesel availability increases. And we use renewable diesel for some of the non-electric vehicles in our corporate fleet.

Scope 2 emissions

In 2023, our Scope 2 (market-based) emissions were approximately 3.4 million tCO_2e, representing 24% of our total carbon footprint. Our main source of Scope 2 emissions is purchased electricity for our data centers and offices. Given that we have more direct 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. Some of our key Scope 2 emissions reduction levers include energy management and carbon-free energy procurement.

As of the end of 2023, we achieved seven consecutive years of 100% renewable energy matching on a global and annual basis, even as our electricity consumption increased (see Figure 17).[104] Through our power purchase agreements (PPAs), we achieved a 63% reduction in the emissions from our electricity use in 2023 (see Figure 18). And from 2011 to 2023, our carbon-free energy purchasing has resulted in cumulative emissions savings of more than 36 million tCO_2e[105]—equivalent to taking more than 8 million fuel-based cars off the road for a year, or the carbon sequestered by more than 42 million acres of U.S. forests in a year.[106]

However, compared to 2022, our Scope 2 (market-based) emissions—which originate primarily from our data center electricity consumption—increased by 37%, despite considerable efforts and progress on carbon-free energy. This was due to data center electricity consumption outpacing our ability to bring more CFE projects online, specifically in the United States and Asia-Pacific region, CFE contracts terminating prior to those projects becoming operational, and the current mismatch between our approach to CFE and the GHG Protocol's Scope 2 guidance. In fact, despite achieving a 100% global renewable energy match, our Scope 2 emissions have increased (see more details on this mismatch on the following page).

Energy management

Our data centers remain some of the most efficient in the world, and we continue working to optimize their use of electricity, water, and materials.

To optimize energy consumption at our data centers, we strive to build the world's most **energy-efficient compute infrastructure**, outfitting each data center with high-performance servers designed to use as little energy as possible compared to the amount of compute they process. On average, a Google-owned and -operated data center is approximately 1.8 times as energy efficient as a typical enterprise data center,[107] and compared to five years ago, our data centers deliver nearly four times as much computing power with the same amount of electrical power.[108]

In 2023, the average annual power usage effectiveness (PUE) for our global fleet of data centers was 1.10, compared with the industry average of 1.58[109]—meaning that Google data centers used about 5.8 times less overhead energy for every unit of IT equipment energy. Since 2012, our average annual fleet-wide PUE has stayed at or below 1.12. For more information on our practices managing AI's energy consumption and environmental impact, see the AI for sustainability section.

In 2023, we piloted a new **demand response** capability. By shifting some non-urgent compute tasks to other times and locations, we work with local utilities to reduce our data centers' power consumption during high-stress periods to help grids operate more reliably and meet the needs of local communities.

To improve energy efficiency in our offices, we use data analytics to guide strategies like equipment upgrades, optimized building settings, and efficient lighting retrofits. For example, in 2023, we rolled out nearly 20 energy conservation initiatives across our offices in the Asia-Pacific region, which we estimate helped reduce energy consumption by nearly 290 MWh, as compared to the prior year.

FIGURE 17 **Renewable energy purchasing compared with total electricity**

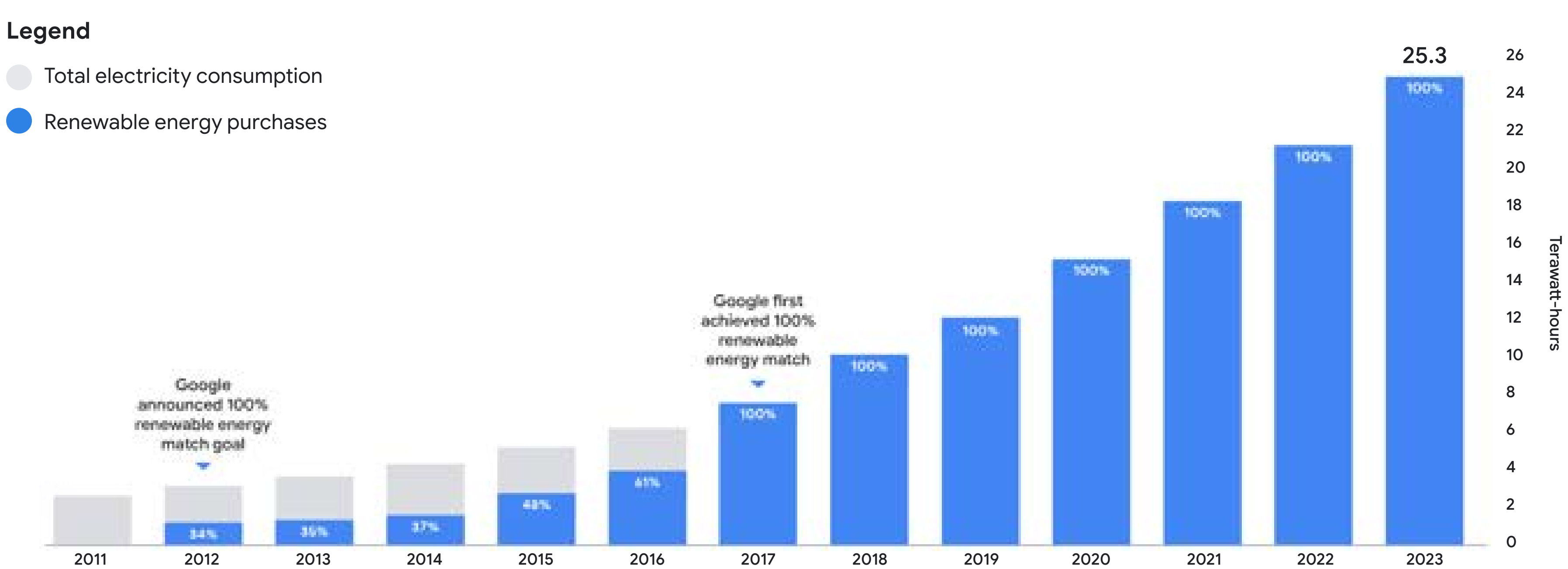
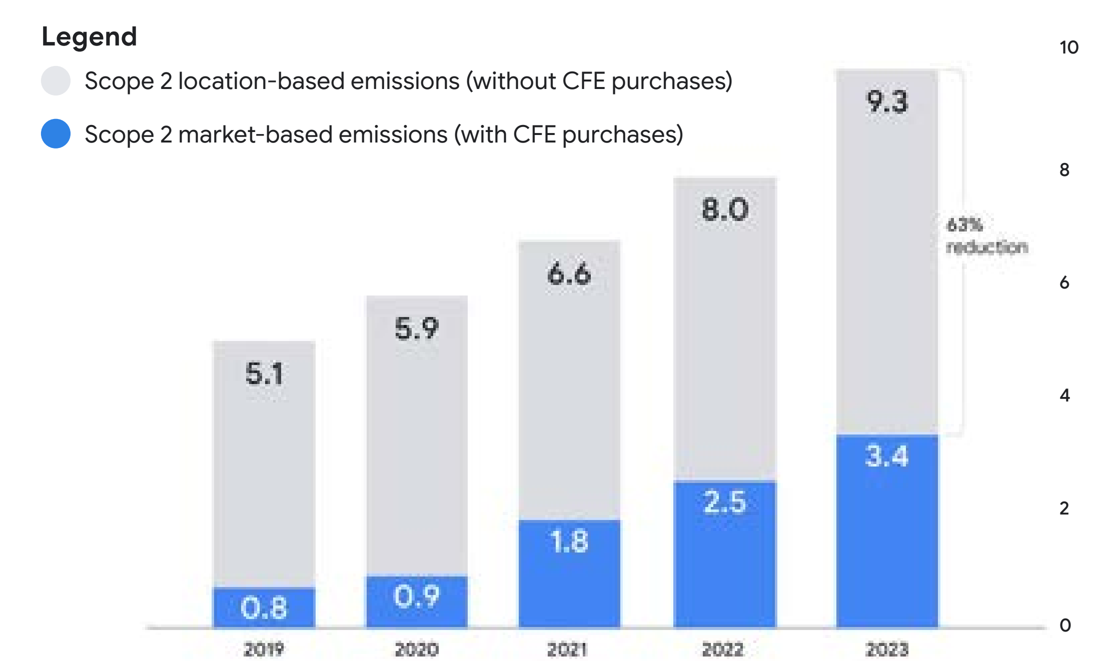


FIGURE 18 **Annual impact of CFE purchases on Scope 2 emissions**




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

SPOTLIGHT

Why our Scope 2 emissions have increased despite achieving a global 100% renewable energy match and maintaining 64% carbon-free energy

We believe that our greatest impact lies not only in advancing CFE for our own operations, but also in accelerating decarbonization of electrical grids around the world.

We started addressing our Scope 2 emissions in 2010 with our first power purchase agreement from a new wind farm, and in 2017, we became the first major company to match 100% of the annual electricity consumption of our global operations with renewable energy purchases. However, despite achieving a 100% global renewable energy match in 2023 for the seventh consecutive year, our reported Scope 2 emissions increased.

If we're matching 100% of our electricity consumption with renewable energy, why does the accounting for our Scope 2 (market-based) emissions show an increase instead of being zero? It's because our approach to date for 100% renewable energy matching differs from the way Scope 2 emissions are calculated in accordance with the Greenhouse Gas Protocol (GHG Protocol) (see Figure 19):

Key differences

- **Global vs. market boundaries:** We've taken a global approach to our 100% renewable energy matching goal. In contrast, the GHG Protocol establishes regional market boundaries for clean energy sourcing to reduce Scope 2 emissions. In some regions, we purchase more clean energy than our electricity consumption (such as in Europe), while in other regions we purchase less (such as in the Asia-Pacific region) due to significant regional challenges in sourcing clean energy. The discrepancy between our energy consumption and clean energy purchases in these regions results in Scope 2 emissions.
- **Bundled energy and EACs:** Our approach to clean energy procurement to date prioritizes purchasing physical electricity along with associated "bundled" EACs.[110] This helps ensure the additionality of our clean energy projects (i.e., that they're new to the grid). While the GHG Protocol allows companies to apply "unbundled" EACs to their Scope 2 footprint, including from existing clean energy projects, our "bundled" approach prioritizes new clean energy projects, which helps drive the clean energy transition but leaves us with some regional gaps.

Looking ahead to 24/7 CFE

While our approach to date has resulted in a discrepancy between our Scope 2 emissions trend and our 100% renewable energy match, we believe our shift in focus to 24/7 CFE procurement—matching our consumption on an hourly basis from within the same grid—will have a more significant impact on grid decarbonization and the clean energy transition. Our pursuit of 24/7 CFE remains one of our primary approaches to reducing our Scope 2 emissions. For more details about our methodologies, see the Methodology section in the Appendix.

Further, we believe standards should move toward this approach, and to that end, we've shared feedback on how the GHG Protocol could update its Scope 2 Guidance to improve the accuracy of carbon inventories and still allow companies to take actions that demonstrably support decarbonization. The even more granular local and hourly accounting of 24/7 CFE provides a more accurate representation of corporate carbon footprints, and research has found that targeting 24/7 CFE drives greater impact on grid-level decarbonization than other procurement goals, such as a 100% annual renewable energy match.[111]

Learnings

- Our various goals (e.g., 100% renewable energy matching and 24/7 CFE) are divergent from the Scope 2 accounting rules, making progress more complex. To simplify our execution, we'll need to better align across these approaches.
- We'll continue to evaluate all high-quality options to manage Scope 2 emissions, including and beyond corporate PPAs, in the future.

FIGURE 19

Our 100% renewable energy matching and implications for Scope 2 emissions

Key differences	Google's 100% renewable energy match	Scope 2 emissions implications
Global vs. market boundaries	Clean energy purchases are matched **globally**, which is broader than GHG Protocol regional market boundaries.	Clean energy purchases must be matched following GHG Protocol **regional market boundaries**, creating a gap where we operated but didn't purchase enough clean energy in 2023.
Bundled energy and EACs	Prioritization of **purchasing bundled** energy and EACs, with some market-specific exceptions (see the Carbon-free energy procurement section for more details).	Given our prioritization of new-to-the-grid CFE projects, we **didn't purchase unbundled** EACs to reduce our Scope 2 emissions in 2023.

Carbon-free energy

Our primary approach to reducing our Scope 2 emissions is through the procurement of carbon-free energy.[112] In 2020, we set a goal to run on 24/7 carbon-free energy—every hour of every day on every grid where we operate—by 2030. We're working to achieve this through three main initiatives: purchasing carbon-free energy, accelerating new and improved technologies, and transforming the energy system through policy, partnerships, and advocacy.[113]

Carbon-free energy procurement

Achieving 24/7 CFE is a far more complex and technically challenging pursuit than annually matching our energy use with renewable energy purchases, but we see this effort as crucial to a bigger picture: scaling new, global solutions for clean energy.

We buy electricity directly from new clean energy projects through various methods depending on the market, including: contracting directly via long-term PPAs; working with utilities or developers to buy and deliver carbon-free energy; structuring energy supply contracts with energy providers through the CFE Manager model; and making targeted investments in renewable energy to enable additional projects on the grids where we operate.

From 2010 to 2023, we signed more than 115 agreements to purchase over 14 GW of clean energy generation capacity[115]—the equivalent of more than 36 million solar panels.[116] Through these agreements, we estimate we'll spend more than $16 billion to purchase clean energy through 2040.[117]

In 2023, we signed contracts to purchase approximately 4 GW of clean energy generation capacity[118]—more than in any prior year—including:

- **North America:** In Texas, Google signed a contract for 150 MW of clean energy generation capacity. We also signed a contract for new wind, solar, and battery storage in Arizona.
- **Europe:** In Poland, Google signed our first contract for 42 MW of clean energy generation capacity from the Przyrów wind farm. And in Ireland, we signed our first contract for 50 MW of clean energy generation capacity from the Tullabeg solar farm. In 2023, Google also signed contracts for new clean energy generation capacity in Belgium and the Netherlands.
- **Asia Pacific:** In Australia, we signed a contract to add 25 MW of clean energy generation capacity, with the solar farm expected to be operational in 2025.

In early 2024, we announced a new set of PPAs—including our largest offshore wind projects to date—that will bring 700 MW of clean energy generation capacity to European grids.

CFE beyond our operations

Beyond purchasing CFE for our own operations, we also make targeted investments in CFE development. From 2010 to 2023, we entered into agreements to invest more than $3.1 billion in renewable energy projects with an expected combined generation capacity of approximately 4.5 GW.[114]

Our 24/7 carbon-free energy goal

In 2023, we maintained a global average of approximately 64% carbon-free energy across our data centers and offices.

Data centers
Despite our total electricity load across all data centers increasing by roughly 3.5 TWh (17%), in 2023, we maintained a global average of approximately 64% CFE across all of our data center sites, inclusive of those operated by third parties. This is due to both an increase in Contracted CFE[119] (up by roughly 1.2 TWh, or 9%, from 2022) as well as improvements in overall Grid CFE.[120]

We've worked hard to continue advancing CFE in parallel with load growth across our data center portfolio. In 2023, 10 of our 44 grid regions[121] achieved at least 90% CFE (see Figure 20).

Four grid regions—Great Britain, Brazil, France, and Switzerland—reached or surpassed 90% CFE for the first time, while one grid region—IESO (Canada)—fell to slightly below 90% CFE due to accelerated load growth in that region. Google's CFE percentage in the ERCOT grid region, which powers our Texas data center, nearly doubled from 41% in 2022 to 79% in 2023.

TARGET

Run on 24/7 carbon-free energy on every grid where we operate by 2030

Year set: 2020; Target year: 2030

2023 PROGRESS
64% global average carbon-free energy across our data centers and offices

TREND
We maintained our CFE percentage for Google's global portfolio of data centers and offices at 64% from 2022 to 2023, despite growth in electricity demand over this period. While we had increases in both our contracted CFE as well as in the availability of CFE on many of the grids where we operate, progress was also impacted in part by project owners terminating some CFE projects prior to those projects becoming operational.

DETAILS
The load-weighted average of carbon-free energy percentages[122] across Google's global portfolio of data centers and offices (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, every hour of every day, within every grid where we operate.

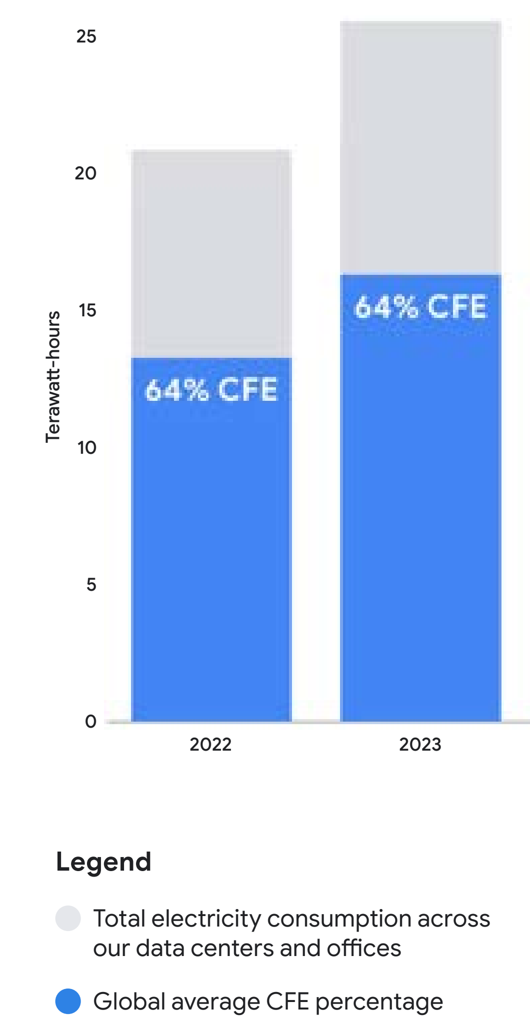
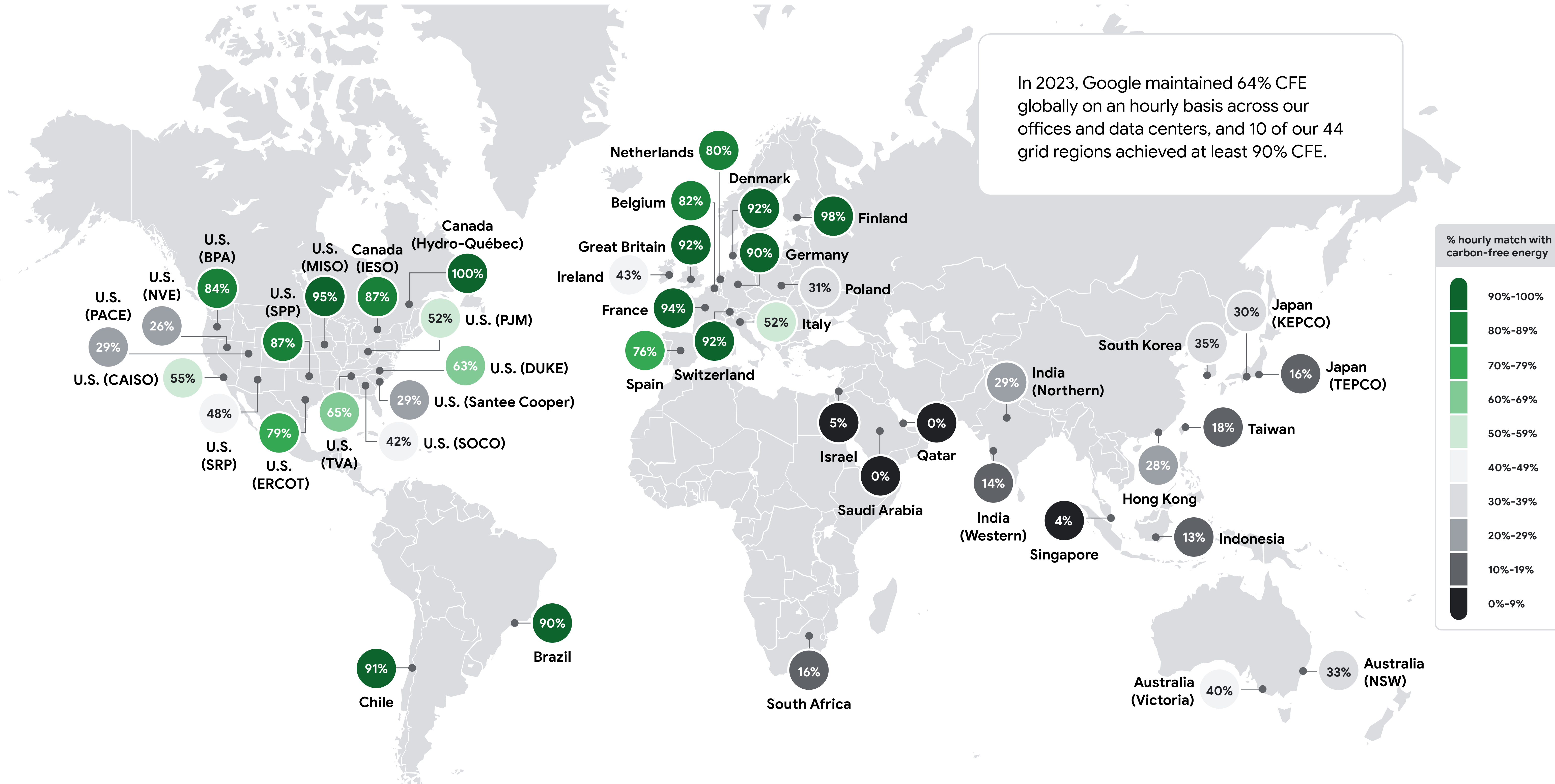


FIGURE 20 **Global data center carbon-free energy map**

Google CFE percentage in every grid region in which we have data center operations, including third-party-operated facilities



More broadly, we're seeing great progress on CFE in some parts of the world: in central North America[123] and Latin America, our average regional Google CFE[124] across our data centers are both above 90%. However, other regions remain challenging for CFE, such as the Asia-Pacific region and eastern North America,[125] where our average regional Google CFE across our data centers are 12% and 47%, respectively.

As we continue to enhance our CFE reporting, we're newly disclosing our Contracted CFE[126] and Consumed Grid CFE[127] percentages by grid region, helping to demonstrate the impact of our global CFE procurement. For example, in Finland in 2023, we achieved 98% Google CFE, and over three-quarters of this percentage was matched with our Contracted CFE within the Finnish grid region. This is meaningful because, despite Finland's Grid CFE being 92%, our Consumed Grid CFE was only 21%. For more details, see the Environmental data tables in the Appendix.

While this represents our approach to date, this approach may evolve as we continue to enhance our methodology and data availability improves. For example, we don't currently use residual grid mix[128] when calculating grid contributions to Google CFE because hourly residual grid mix data does not yet exist. We're supporting the development of time-based tracking methods, which are essential for making this calculation possible in the future.

Offices

For our offices—which represent a small portion of our global CFE percentage—we achieved a global average of approximately 56% CFE in 2023, up from 54% in 2022.[129]

CFE procurement headwinds

In 2023, our efforts to increase CFE procurement faced a number of headwinds, including interconnection delays (such as in the PJM grid region), higher development costs and project demand, supply chain issues, U.S. regulatory tariffs for solar modules, natural variability in generation, and continued load growth in certain regions with CFE market constraints (such as in the United States and the Asia-Pacific region).

Notably in 2023, the termination of some CFE projects by their owners prior to those projects becoming operational also impacted our data center CFE progress. We estimate that without these project terminations, our 2023 data center CFE percentage would have been approximately 2% higher, reaching 66% instead of 64%.[130] Google isn't alone in facing these challenges, and addressing these systemic challenges will be essential for rapid global grid decarbonization. Without policy changes, technology innovations, and collaborations to increase CFE access in regions like Asia Pacific, we expect our CFE progress—and broader grid decarbonization—to lag behind regions where these obstacles are less prevalent.

CFE for commercial real estate faces different challenges, including variability in building characteristics, work patterns, and geographic locations with a broad range of electricity grid carbon intensities. Still, we continue to work toward advancing CFE across our offices: In late 2022, we signed a contract to add clean energy generation capacity to the grid that powers Google's offices in New York City—our first office-only deal outside of the San Francisco Bay Area.

Innovative purchasing models

We've pioneered innovative contracting models and industry partnerships, accelerating the adoption of corporate clean energy practices and improving access to more buyers. In 2023, we advanced the following:

- **New, scalable procurement approaches:** We piloted a new approach to clean energy requests for proposals (RFPs) that can reduce the time to negotiate and execute a PPA, enabling easy, transparent, reliable, and efficient contracting in today's market.
- **Contracting principles:** We partnered with the Eurelectric 24/7 CFE Hub on a set of contracting principles that clean energy buyers and sellers can use to move toward greater hourly energy matching.
- **CFE transition tariffs:** We worked with the Regulatory Assistance Project to define the optimal design of 24/7 CFE transition tariffs and contracts, which can make 24/7 CFE more accessible for electricity users of all sizes.

Accelerating new and improved technologies

We're using Google's engineering expertise and purchasing power to accelerate the commercialization of a wide range of CFE technologies, working to demonstrate and scale their climate impact:

- **Optimizing generation from existing CFE technologies:** In addition to using innovative dragonscale solar rooftops, we've installed facade solar panel systems (which are mounted vertically on building walls) at our Moffett Park Thermal Plant and at our Humboldt office campus. These systems are designed to generate power during times of the day when traditional rooftop solar might be less productive. And, at wind farms in the United States, we're deploying machine learning solutions to optimize wind power forecasting and project economics.
- **Managing energy demand across our global operations:** We developed a "carbon-intelligent computing platform" that optimizes the timing and location of computing tasks based on local grid carbon intensity. This allows us to shift some of our computing tasks to different times and relocate tasks geographically across data centers so that we can do more computing in regions where and when the grid is cleaner. We're also working on demand response at our data centers.
- **Accelerating next-generation energy sources:** In 2021, we signed the first corporate agreement to develop a next-generation geothermal power project in Nevada, which became operational in 2023.
- **Improving clean energy data, tracking, and trading:** Google is driving the development of advanced methods for tracking and validating clean energy, including time-based energy attribute certificates (T-EACs). We're also working to improve the quality, consistency, and granularity of grid electricity data through collaborations with organizations including EnergyTag, Electricity Maps, Flexidao, and Linux Foundation Energy. And we've partnered with LevelTen Energy and others to launch the Granular Certificate Trading Alliance, which aims to incentivize new clean energy availability, reduce energy costs, enable quick transactions, and help more buyers and sellers achieve their clean energy goals.

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

Scope 3 emissions

In 2023, our total Scope 3 emissions were approximately 10.8 million tCO_2e, representing 75% of our total carbon footprint. Our Scope 3 emissions are indirect emissions from sources in our value chain. The majority of these emissions are generated from the production of goods and services purchased for our operations, including the upstream manufacturing and assembly of servers and networking equipment used in our technical infrastructure. For details on how we calculate Scope 3 emissions, see the Scope 3 GHG emissions section in the Appendix. Some of our key Scope 3 emissions reduction levers include supplier engagement, minimizing embodied carbon, and sustainable travel.

Compared to 2022, our total Scope 3 emissions increased by 8% due to increases in emissions generated from goods and services purchased for our operations, upstream emissions from purchased electricity, and emissions related to data center construction. We expect our Scope 3 emissions will continue to rise in the near term, in part due to increased capital expenditures and expected increases in our technical infrastructure investment to support long-term business growth and initiatives, particularly those related to AI.

According to the GHG Protocol, emissions from the upstream manufacturing and assembly of servers and networking equipment used in our technical infrastructure, and emissions from materials used in the construction of data centers should be accounted for in the year the assets are purchased and not over the life of the assets, as is the case for financial accounting.

Addressing our Scope 3 supply chain emissions is particularly challenging due to the geographic diversity of our suppliers, which span many countries and grid regions. In many regions where our suppliers operate, they face many of the same challenges we do: insufficient CFE capacity and limited or nonexistent credible clean energy procurement mechanisms. In particular, the Asia-Pacific region, which is a critical region for our suppliers, is one of the most challenging regions for contracting and investing in carbon-free energy projects.[131]

The effectiveness of our supplier engagement strategy and the quality of supplier-specific data we collect can also be impacted by the varying maturity of supplier climate programs and the supplier tier we're working with (i.e., whether they're a direct supplier or further down our supply chain).

Supplier engagement

We partner with many suppliers—from manufacturing to indirect services suppliers. All suppliers are required to sign our Supplier Code of Conduct, which states that suppliers should seek to minimize energy consumption and GHG emissions. We evaluate supplier performance in reporting, managing, and reducing their emissions, and incorporate these factors into our supplier scorecards and key procurement tools.

Reporting environmental data

Primary activity data is essential for more accurately calculating our supply chain carbon footprint and developing life cycle assessments. We expect all of our suppliers to set public GHG reduction targets and report their environmental data, which helps us guide our priorities for our supplier sustainability program.

We engage some of our suppliers to directly collect data, and also encourage some suppliers to respond to CDP's Climate Change survey. In 2023, we invited 312 suppliers to participate, a 40% increase compared to 2022. At least 90% of our hardware suppliers, by spend, provided data. Of the suppliers that we invited to respond to the CDP Climate Change survey in 2023, 60% reported having structured GHG emissions reduction targets,[132] and 74% of those targets were science-based.

To support this, we engage 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 reporting to CDP as well as on setting GHG reduction and renewable electricity targets. In 2023, we hosted summits for both our technical infrastructure and consumer hardware device suppliers, where we discussed Google's net-zero ambitions, among other topics.

Developing roadmaps to reduce emissions

In 2023, we worked closely with our largest hardware manufacturing suppliers, by spend, to obtain decarbonization roadmaps, some of which include GHG emissions reduction targets, and we implemented a Google Renewable Energy Addendum asking these suppliers to commit to achieving 100% renewable energy match by 2029.[133]

Focusing on emissions hotspots in our value chain

We're also working directly with suppliers of hotspot commodities—or commodities with disproportionately high emissions—to identify and collaborate on carbon reduction initiatives that support our own emissions reduction target.

The semiconductor industry is a prime example of an emissions hotspot due to the electricity and associated emissions from the manufacturing and powering of chips in electronics devices. We actively engage in consortia and industry organizations to drive systemic change and support scalable research and development within the semiconductor industry (see Figure 21).

Through these organizations and our direct supplier engagement, we're collecting primary manufacturing data that allows us to more accurately model our carbon footprint

FIGURE 21 **Google's engagement with the semiconductor industry**

Catalyze

In 2023, Google became a founding sponsor of Catalyze, a decarbonization program that aims to accelerate access to renewable energy across the global semiconductor value chain by combining energy purchasing power and enabling supplier participation in renewable energy projects.

Imec's Sustainable Semiconductor Technologies and Systems

Google is a founding member of Imec's Sustainable Semiconductor Technologies and Systems program, which seeks to drive innovation needed to decarbonize the semiconductor industry at scale using transparent data, methods, and early stage trial testing.

SEMI's Semiconductor Climate Consortium

Google is an active member of SEMI's Semiconductor Climate Consortium, an industry group focused on the semiconductor value chain.

in the hardware supply chain through life cycle assessments.

Separately, as part of our efforts to enable 5 GW of new carbon-free energy through investments in our key manufacturing regions, in 2023, we continued to invest toward this goal as part of a holistic strategy to increase the availability of CFE across our hardware supply chain.

Embodied carbon

We work to minimize the carbon footprint of our data centers, offices, and consumer devices by considering the embodied carbon of the materials we use.

Buildings and construction

We pursue **adaptive reuse** of existing buildings to reduce the embodied carbon from data center and office construction. When constructing new office buildings, we work to incorporate low-carbon materials—like mass timber—when appropriate. These materials help reduce our carbon footprint by storing or "sequestering" carbon within the building material itself. At our newly opened YouTube campus in San Bruno, California, we used low-carbon materials and **mass timber** for the buildings' structures, which are estimated to have approximately 50% fewer embodied carbon emissions compared to traditional materials like concrete and steel, factoring in sequestration.[134]

In 2023, we focused on reducing the embodied carbon impact of growing AI demand at our data centers. We optimized space utilization by fitting more high-density machines within existing and new buildings. Additionally, we're running data-driven programs to guide carbon-aware fleet decisions, such as reusing or upcycling technical infrastructure hardware. These programs integrate sustainability into the planning, deployment, and management of our data center machine fleet.

To further advance this work, we're working with groups like Building Transparency to advance the development of tools to measure, model, and track the embodied carbon of building materials, and the iMasons Climate Accord, an industry coalition working to reduce GHG emissions across the technical infrastructure systems that support the digital economy.

Consumer devices

We're using recycled materials in our consumer devices to lower our product manufacturing carbon footprint. For example, the **aluminum** in the enclosure of Pixel 5, launched in 2020, was made with 100% recycled content, and the aluminum in the enclosure of all Pixel phones since Pixel 6 through Pixel 8 and 8 Pro have also been made with 100% recycled content, reducing the carbon footprint of the aluminum portion of the enclosures by over 35% compared to 100% primary aluminum.[135] For more details, see the Circular economy section.

Sustainable 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 2023, we've installed more than 6,000 electric vehicle charging ports at our offices in the United States and Canada.

Google offers **commuter shuttles** to many of its campuses to reduce individual vehicle commuting. For 2023, our shuttle buses in the San Francisco Bay Area produced savings of approximately 14,900 tCO_2e emissions—the equivalent of avoiding more than 61 million vehicle kilometers (38 million vehicle miles) or taking, on average, more than 3,500 fuel-based cars off the road for a year.[136]

We're working to reduce our impact from business travel by exploring ways to make air travel less carbon-intensive and supporting the production of **sustainable aviation fuel** (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.

An electric shuttle bus outside of Google's Bay View campus.

Managing residual emissions

We're first focused on decarbonizing our operations and value chain to reach our net-zero emissions goal, but as the IPCC stated, "the deployment of carbon dioxide removal to counterbalance hard-to-abate residual emissions is unavoidable if net-zero emissions are to be achieved."[137]

Our approach to carbon credits

We aim to neutralize our residual emissions with high-quality carbon removal credits by 2030, and to do so in a way that maximizes our positive impact on global decarbonization. This approach represents an evolution of our strategy: starting in 2023, we're no longer maintaining operational carbon neutrality.[138] We're instead focusing on accelerating an array of carbon solutions and partnerships that will help us work toward our net-zero goal, and are aiming to play an important role in advancing the development and deployment of nature-based and technology-based carbon removal solutions required to mitigate climate change.

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, some of the best solutions could scale up to at least half a gigaton per year of CO_2e impact and be available affordably in the foreseeable future.
- For **certainty**, we strive to ensure that projects have the potential positive climate impact they claim to by rigorously assessing factors like additionality, leakage, permanence, and verifiability.

Technology- and nature-based removals

We're supporting the advancement of both technology- and nature-based removals toward their highest possible level of scale and certainty, working to address key challenges that these solutions face today.

The main problem with technology-based solutions is that they currently lack scale—they're often too expensive and typically only operate as small pilots.

To help address this problem, in 2022, we pledged $200 million to **Frontier**, an advance market commitment that's accelerating the development of carbon removal technologies by guaranteeing future demand. We're excited about completing our first carbon credit offtake deals through Frontier in 2023—including deals with Charm Industrial, CarbonCapture, and Lithos Carbon—and about the broader contributions the Frontier collective has made for the field of carbon removals, such as publishing the buyer's guide to enhanced weathering.

We're also a member of the **First Movers Coalition** and a champion for their Carbon Dioxide Removal sector.

Another pressing challenge is that corporations may currently be reluctant to participate in this nascent market. As with many emerging technologies, governments and companies have a critical and complementary role to play in demonstrating promising carbon removal approaches and bringing them to a commercial scale. In March 2024, Google pledged to match the U.S. Department of Energy's Carbon Dioxide Removal Purchase program dollar for dollar: through our own initiatives, we plan to contract for at least $35 million of carbon removal credits over the next 12 months following the announcement. We look forward to working with our partners to identify and scale the most promising technology- and nature-based carbon removal solutions and hope that other companies will join us.

In addition to these partnerships, in 2023, Google.org provided a $1 million grant to the Integrity Council on Voluntary Carbon Markets (ICVCM) to help them orient the market toward various high-integrity solutions with adequate certainty to merit support. This grant brings Google.org's cumulative contributions to strengthening carbon markets to more than $7 million as of the end of 2023—supporting organizations including The Gold Standard, Rocky Mountain Institute, the Voluntary Carbon Market Initiative, and Climate Action Data Trust.

Beyond our purchases and partnerships, Google is uniquely positioned to help drive forward advancements in research and technology in this area. For example, we introduced our Google Carbon Removal Research Awards in 2023, which provided more than $3 million in funding to universities and academic research institutions for scientific studies in areas of carbon removals that would benefit from additional investigation, ranging from studying the effects of ocean alkalinity enhancement on coastal ecosystems and the potential of enhanced weathering projects in forests.

Carbon removal procurement

As of the end of 2023, we signed three carbon credit offtake deals representing a total purchase of approximately 62,500 tCO_2e of removal credits, which are contracted for delivery by 2030 (see Figure 22).

We recognize that this is just the beginning, and we look forward to accelerating our carbon removal efforts in the years to come. We'll continue evolving our approach to counterbalancing our residual emissions.

FIGURE 22 **Contracted carbon removals portfolio**

Company	Charm Industrial	Lithos Carbon	CarbonCapture
Project type	Biomass carbon removal and storage (BiCRS)	Enhanced rock weathering (ERW)	Direct air capture (DAC)
Credit type	Removal	Removal	Removal
Project location	United States	United States	United States
Estimated contracted credits	22,600 tCO_2e	31,500 tCO_2e	8,400 tCO_2e
Year deal was signed	2023	2023	2023
Expected timeframe for delivery	2024–2030	2024–2028	2025–2028
Project details	Charm Industrial collects waste biomass that's left over from agricultural harvests or forest fire management, and heats it to a very high temperature in an oxygen-deprived environment. The resulting bio-oil is then injected into EPA-regulated wells, where it sinks and solidifies permanently.	Lithos Carbon accelerates the natural ability of rocks to absorb carbon dioxide by spreading superfine crushed basalt on farmlands and empirically measuring the resulting carbon removal.	CarbonCapture's technology involves DAC machines that use solid sorbents to soak up atmospheric carbon dioxide and then release it via heating. The carbon dioxide stream is captured and can be paired with a permanent storage solution.
Market commitment	Frontier	Frontier	Frontier

Note: At the time of publication, the following information wasn't available: registry, project identification number, project name, and protocol used to estimate removal benefits. We don't obtain an independent third-party verification of company data and claims related to our contracted carbon removals.


Some of our partnerships are helping bring clean energy and its benefits to historically underserved communities through grid-connected solar and home energy upgrades.

SPOTLIGHT

Supporting environmental justice, climate justice, and a just transition

We're using our expertise and advocacy to accelerate the transition to a low-carbon economy while also prioritizing equity and support for vulnerable communities.

Clean energy procurement: We're exploring how our clean energy procurement can support historically underserved communities that haven't typically benefited from the clean energy transition. Two unique projects have emerged from our efforts to lower barriers for an equitable clean energy transition:

- Through a first-of-its-kind partnership with EDP Renewables North America, we're creating a 500 MW community-based solar portfolio, adding clean energy to the regional U.S. PJM power grid where we operate. A portion of the portfolio's revenues will be redirected as utility bill credits to households facing a high energy burden.
- Through a partnership with Sol Systems, we're providing funding to three rural electric cooperatives and one regional organization in North Carolina and South Carolina to undertake critical home pre-weatherization and safety upgrades for low- and moderate-income households. The partnership will deliver new solar energy and battery storage resources, bringing clean energy to one of the most challenging grids to decarbonize.

In 2023, Google was recognized for this work with a DEI Impact Award from Smart Energy Decisions and a Changemaker Award from RE100. We'll continue to build on these programs to extend the benefits of our energy investments to underserved communities.

Climate adaptation: During Climate Week NYC in 2023, Google Cloud and Google.org ran a design sprint to explore how geospatial technologies can help vulnerable communities understand and adapt to the impact of climate change. For more ways we're supporting climate adaptation efforts, see Adaptation and resilience in the Our products section.

Funding solutions: In 2022, Google.org launched the Environmental Justice Data Fund (EJDF), a collection of grants that aim to help frontline communities that have been historically underserved and disproportionately impacted by climate change and environmental injustice. The EJDF supports efforts focused on air quality, water quality, and environmental hazards. In 2023, Google.org expanded its funding for the EJDF. Google.org also supported the Asian Venture Philanthropy Network's APAC Sustainability Seed Fund, which provides grant funding to local organizations focused on sustainability solutions for vulnerable and underserved communities in the Asia-Pacific region. For more details, see the Google.org grantees section in the Appendix.

Green jobs skilling and alternative livelihoods: In 2022, we partnered with ASU to offer an online training program in sustainability—complementing Google Career Certificates in Project Management—teaching skills needed for entry-level sustainability jobs. We've also supported initiatives that help communities pursue alternative livelihoods as economies transition away from extractive industries. We sponsored the Congo Power program, which launched community power projects for people in the Democratic Republic of the Congo and in conservation areas and national parks that are of critical importance to the Congolese and the planet. For more details, see our 2023 Supplier Responsibility Report.

RESOURCES

- 24/7 Carbon-Free Energy: Methodologies and Metrics
- Accelerating Climate Action at Google and Beyond: A Progress Update
- The CFE Manager: A New Model for Driving Decarbonization Impact
- Corporate Role in Accelerating Advanced Clean Electricity Technologies
- How Do Offices Run on 24/7 Clean Energy
- A Policy Roadmap for 24/7 Carbon-Free Energy
- Timely Progress Toward Around-the-Clock Carbon-Free Energy

Water stewardship

We aim to replenish more water than we consume and help improve water quality and ecosystem health in the communities where we operate

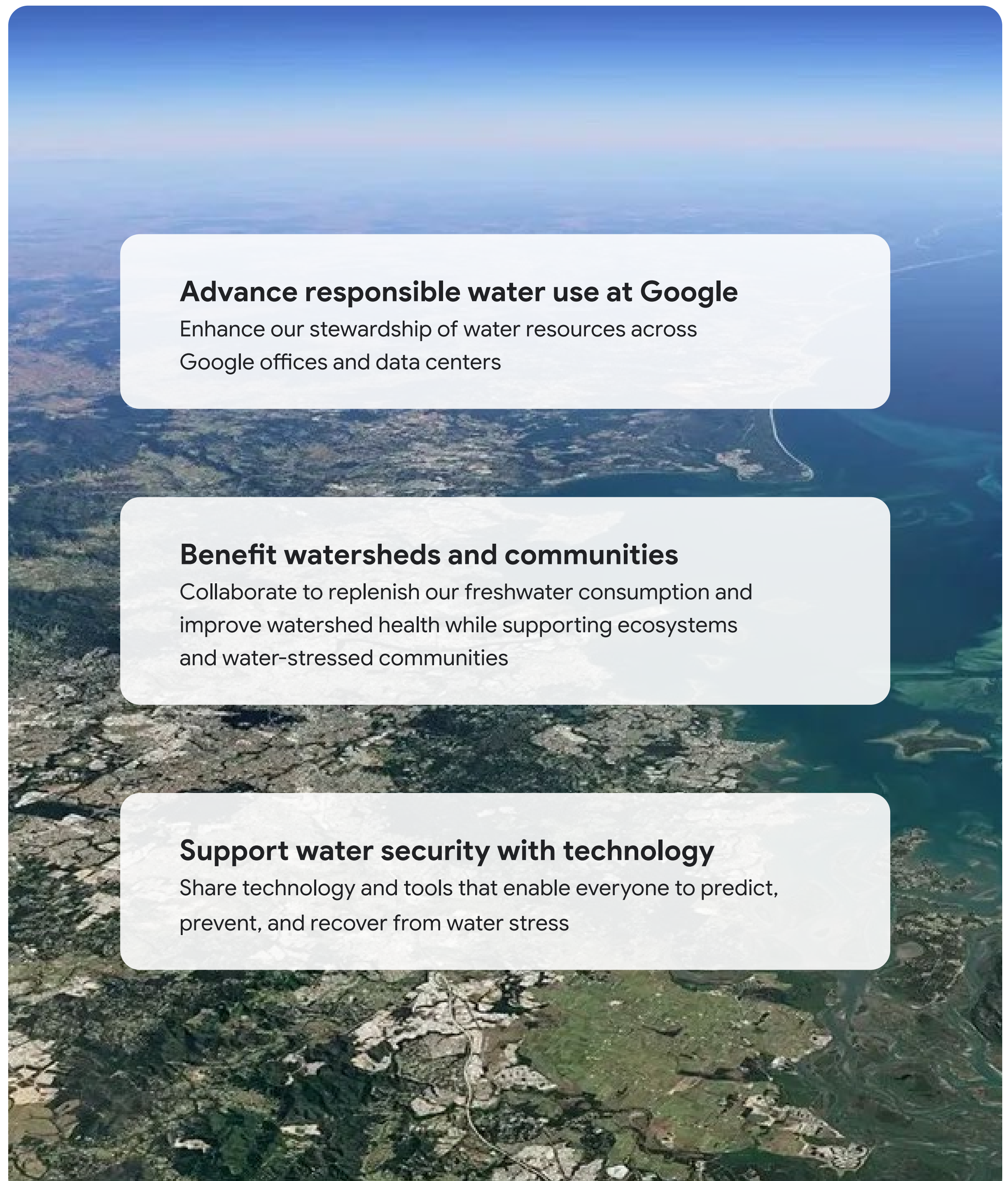
Our approach to water stewardship

Our water stewardship strategy is centered on enhancing responsible water resource management across our data centers and offices, sharing tools and technology that can help address water challenges, and improving watershed health and ecosystems in water-stressed communities (see Figure 23).

In 2021, we announced our goal to replenish 120% of the freshwater[139] volume we consume, on average, across our offices and data centers by 2030, and help restore and improve the quality of water and health of ecosystems in the communities where we operate.

To achieve our water replenishment target, we're channeling our ongoing investments into projects located within the watersheds where we operate. We work with external partners to implement these projects, delivering volumetric water benefits and improving other locally relevant aspects of watershed health such as water quality, community water access, and biodiversity.

FIGURE 23 **How we support our commitment to water stewardship**



2023 highlights

- **Water stewardship projects:** We've supported 74 water stewardship projects spanning 46 watersheds.
- **Water replenishment:** Our water stewardship projects replenished an estimated 1 billion gallons of water[140] (approximately 3.9 billion liters or 3.9 million cubic meters), representing 18% of our 2023 freshwater consumption for our data centers and offices.
- **Freshwater withdrawal by water scarcity:** 69% of our freshwater withdrawals came from watersheds with low water scarcity, 16% came from watersheds with medium water scarcity, and 15% came from watersheds with high water scarcity.[141]
- **Water risk framework:** In 2023, we shared our water risk framework, which describes our data-driven approach to responsible water use in our Google-owned data centers.

Global challenges

- **Energy efficiency vs. local water use:** Utilizing water cooling in data centers can play an important role in reducing energy use and energy-related emissions, but can also impact local water resources—particularly in regions where water resources are stressed. It's critical to evaluate local watershed health and water risks, and to find innovative solutions that minimize both energy and water use.
- **Availability of water stewardship projects:** Water stewardship projects that meet robust criteria aren't abundant in many watersheds around the world, so organizations need to work to identify and develop opportunities across geographies for investment or partnership.
- **Navigating the local context of stewardship projects:** There are often unique water challenges that must be assessed and navigated across each watershed. Bespoke challenges require tailored solutions and partnerships in order to improve watershed health in a locally relevant way.

Advancing responsible water use

We prioritize responsible water use in our data centers and our office operations around the world.

We're accelerating water reuse practices across our offices and data centers, and tailoring site-specific solutions based on facility types, locations, and local water contexts. We also use non-potable sources and freshwater alternatives whenever feasible.

In 2023, the total water consumption at our data centers and offices was 6.4 billion gallons (approximately 24 billion liters or 24 million cubic meters)—the equivalent of what it takes to irrigate 43 golf courses annually, on average, in the southwestern United States.[142] This represents a 14% increase from 2022, primarily due to water cooling needs at our data centers, which experienced increased electricity consumption year-over-year.

In 2023, 69% of our freshwater withdrawals came from watersheds with low water scarcity, 16% came from watersheds with medium water scarcity, and 15% came from watersheds with high water scarcity.[143] Through our water replenishment program, we focus on higher volumetric water benefits in water-scarce regions to ensure we're positively impacting the areas that need it most.

Data centers

Water plays an important role in our data centers—cooling our servers, regulating indoor temperatures, and keeping our products up and running. In fact, water cooling has been shown to help reduce energy consumption and related carbon emissions when compared to air-based cooling. While it will take more time for electricity grids to decarbonize, we'll continue using water cooling to improve our energy efficiency in certain geographies. Recognizing that this tradeoff will increase our data center water footprint, we're prioritizing responsible water use and water replenishment at new sites from the start.

Water risk framework

In 2023, we shared our water risk framework, which describes our data-driven approach to responsible water use in our Google-owned data centers.

Building on our **climate-conscious approach** to data center cooling, this framework provides an actionable and repeatable process for evaluating local watershed health and water risks across our portfolio, focusing on water scarcity and the risk of a freshwater source being depleted. The evaluation results help us determine when we should consider using air cooling technologies instead of water, and when we should consider alternative water sources—such as reclaimed wastewater, industrial water, or seawater.

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 data center portfolio every three to five years to evaluate water risks that may require mitigation.

These assessments are in addition to an annual enterprise-wide water risk assessment of all of Google's data centers and offices, which provides us with a more holistic view of water challenges and trends—see more details in the Risk management section in the Appendix.

This framework is already informing our cooling technology selection. For example, our new data center campuses under development in Mesa, Arizona, and Canelones, Uruguay, will use air-cooling technology because the source watersheds didn't meet our responsible use threshold for water cooling. And we already employ air-cooling technology at our data centers in Storey County, Nevada, and Dublin, Ireland.

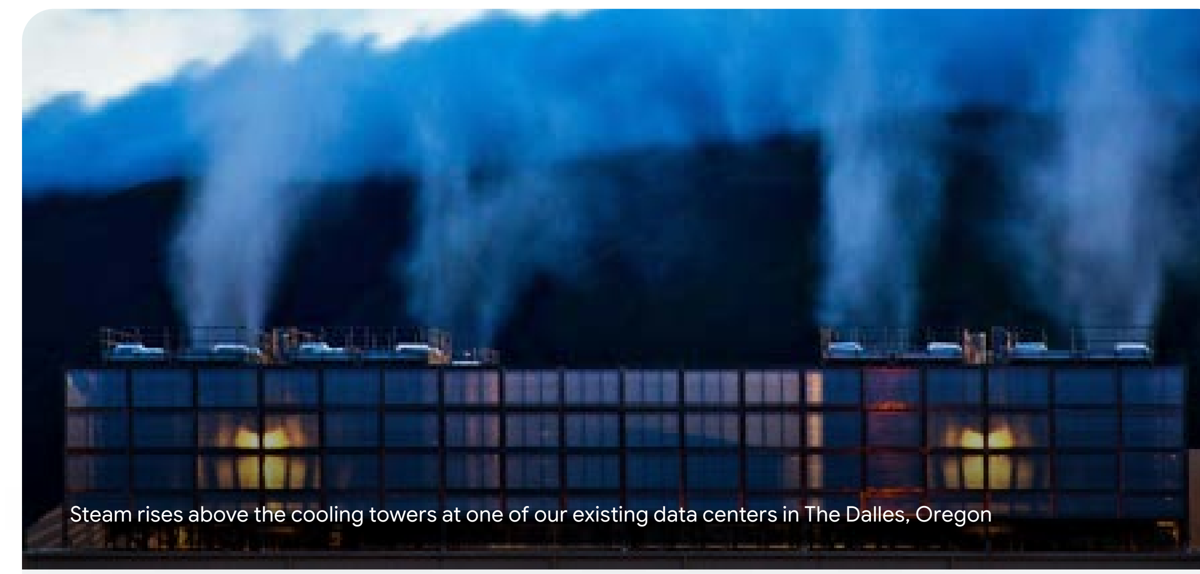
Alternative water sources

In 2023, 22% of our total data center water withdrawal (excluding seawater) was reclaimed wastewater and other non-potable water, and roughly one-third of our data center campuses used air cooling or non-potable water sources.

We use reclaimed water at our data centers in Singapore and in Douglas County, Georgia, where the wastewater would otherwise be discharged in the Chattahoochee River. Our data centers in St. Ghislain, Belgium, Changhua County, Taiwan, and Eemshaven, Netherlands, use industrial water. In Hamina, Finland, we use seawater to cool our data center, and then return it to the sea at close to its original temperature.

Water efficiency in Singapore

In 2024, Google received a Water Efficiency Award from PUB, Singapore's National Water Agency, which recognizes the top water efficiency performers in their respective sectors.


Steam rises above the cooling towers at one of our existing data centers in The Dalles, Oregon

SPOTLIGHT

Innovative water system at The Dalles

In 2006, Google opened our first data center in The Dalles, Oregon.

We're now working on a new campus and its supporting water and sewer infrastructure. A vital component is an innovative Aquifer Storage and Recovery (ASR) system, initiated in 2023, which will pump excess surface water into an existing aquifer for later use during drier months—functioning as an underground "savings account." The surplus water available during the rainy season, which would otherwise be unusable as runoff, will help meet the City of The Dalles' higher water demand in the summer and offset its reliance on local streams. The ASR system is also expected to improve local water quality by storing treated surface water for the City and reducing its untreated groundwater usage.

Offices

In 2023, Google had offices in nearly 60 countries around the world. To manage our global environmental footprint, we're developing responsible water use practices that can be applied in every region where we operate and for the many ways we use water in our offices, including for preparing food, cleaning and sanitation, irrigating campus landscapes, and keeping our workspaces cool.

Sustainability design standards

One of the main ways we conserve water in Google offices is by adopting sustainability design standards aligned with leading third-party certifications, including the Living Building Challenge (LBC).

Our building design requirements for new construction include the incorporation of water-efficient fixtures, such as faucets, toilets, and irrigation systems. For existing buildings, our design standards also include replacing old fixtures with highly efficient ones in any space we move into and installing water meters with automatic leak detection.

Water infrastructure innovation

Beyond these standards, we drive water stewardship in our offices.

A flagship example of this work is our Bay View office in Mountain View, California, which has a treatment system that's designed to capture and reuse water on-site via stormwater retention ponds and constructed wetlands.

A central plant treats stormwater gathered from retention ponds and wastewater collected from buildings, producing recycled water that can be used for cooling towers and irrigation.

As of 2023, Bay View is still on track to be the largest development project in the world to achieve Water Petal certification from the LBC. Bay View's adjacency to the San Francisco Bay makes water an important focus and we hope that others can learn from these innovative solutions.

Another example is our all-electric Moffett Park Thermal Plant in Sunnyvale, California, which opened in 2023. By centralizing cooling towers and using heat recovery, the plant is expected to save up to 2 million gallons of water per year, roughly 30%, compared with a building-by-building approach to heating and cooling, per our predictive models.

We continue to work toward responsible water use in the water-stressed regions where we have offices, like the San Francisco Bay Area. Our Gradient Canopy building in Mountain View, California, uses municipal and onsite-generated recycled water for toilets, irrigation, and cooling, and our new YouTube offices in San Bruno are expected to capture up to roughly 1.3 million gallons of stormwater per year, which will be treated to meet on-site, non-potable water demands. The stormwater capture system is expected to help reduce our municipal water use by approximately 18%.[144]

Supply chain

Water is also used in our supply chain in the manufacturing of our consumer hardware devices and technical infrastructure hardware. Addressing water challenges throughout our supply chain requires high-quality water data. That's why we ask suppliers to disclose water-related data via the CDP supply chain platform.

This reporting includes data on water withdrawal from all sources, the portion of water permanently lost in withdrawal, and water effluents discharged, among other metrics. In 2023, we received an 87% response rate (108 out of 124) from suppliers that we invited to participate in the Water Security survey via the CDP Supply Chain program.

Our Bay View campus, as seen from across its stormwater retention pond. (Photo: Iwan Baan)

Benefiting watersheds and communities

Improving watershed and ecosystem health is a critical part of our water stewardship strategy, and it's integrated with our water replenishment goal.

We designed our strategy to prioritize a range of watershed health issues, enabling us to invest in a diverse set of impactful projects and partnerships that are appropriate for each local context.

In addition to pursuing replenishment projects with volumetric benefits to water systems, we also identify watershed health projects with the potential to provide co-benefits for nature, biodiversity, and communities.

As of the end of 2023, we've supported **74 water stewardship projects** spanning 46 watersheds (see Figure 24). These projects focus on land conservation and restoration, water supply reliability, ecosystem restoration, water supply improvements, and increasing water quality improvements, and increasing water, sanitation, and hygiene (WASH) access.

In 2023, these projects replenished an estimated 1 billion gallons of water[145] (approximately 3.9 billion liters or 3.9 million cubic meters). This figure represents 18% of our 2023 freshwater consumption for our data centers and offices. Once fully implemented, we estimate that these 74 projects will have the capacity to replenish more than 2.8 billion gallons of water annually.[146]

Our process for working toward our water replenishment target includes:

- Conducting water risk assessments to identify priority watersheds for water stewardship projects.
- Assessing local water challenges through data analysis and local stakeholder engagement to guide us toward context-specific solutions.
- Engaging project partners who are working on the ground to identify existing replenishment opportunities that address shared water challenges.
- Co-developing water replenishment opportunities with local partners if none are readily available.

Once we decide to move forward with a water stewardship project, implementation can take up to a few years to complete, depending on the activities. Projects often involve extensive planning, community engagement, and permitting, in addition to the actual restoration or construction activities. After projects are operational, we use the **Volumetric Water Benefit Accounting** (VWBA) methodology to determine the estimated eligible replenishment benefits Google can claim. For more details, see the Water replenishment section in the Appendix.

In 2023, we co-funded the development of VWBA 2.0, the next iteration of water replenishment quantification methodologies.

TARGET

Replenish 120% of the freshwater volume we consume, on average, across our offices and data centers by 2030

Year set: 2021; Target year: 2030

2023 PROGRESS

1 billion gallons of water replenished, or 18% of our 2023 freshwater consumption

TREND

We estimate that our water stewardship projects replenished approximately 1 billion gallons of water[147] in 2023 alone, increasing our freshwater replenishment from 6% in 2022 to 18% in 2023. This is the result of adding 36 new water stewardship projects to our replenishment portfolio—nearly doubling the portfolio size from 38 projects in 2022 to 74 projects in 2023.

DETAILS

Water replenished annually 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).[148] Replenishment benefits are counted from projects that are active within the watersheds that our operations rely on and that have confirmed volumetric benefits from the reporting year.

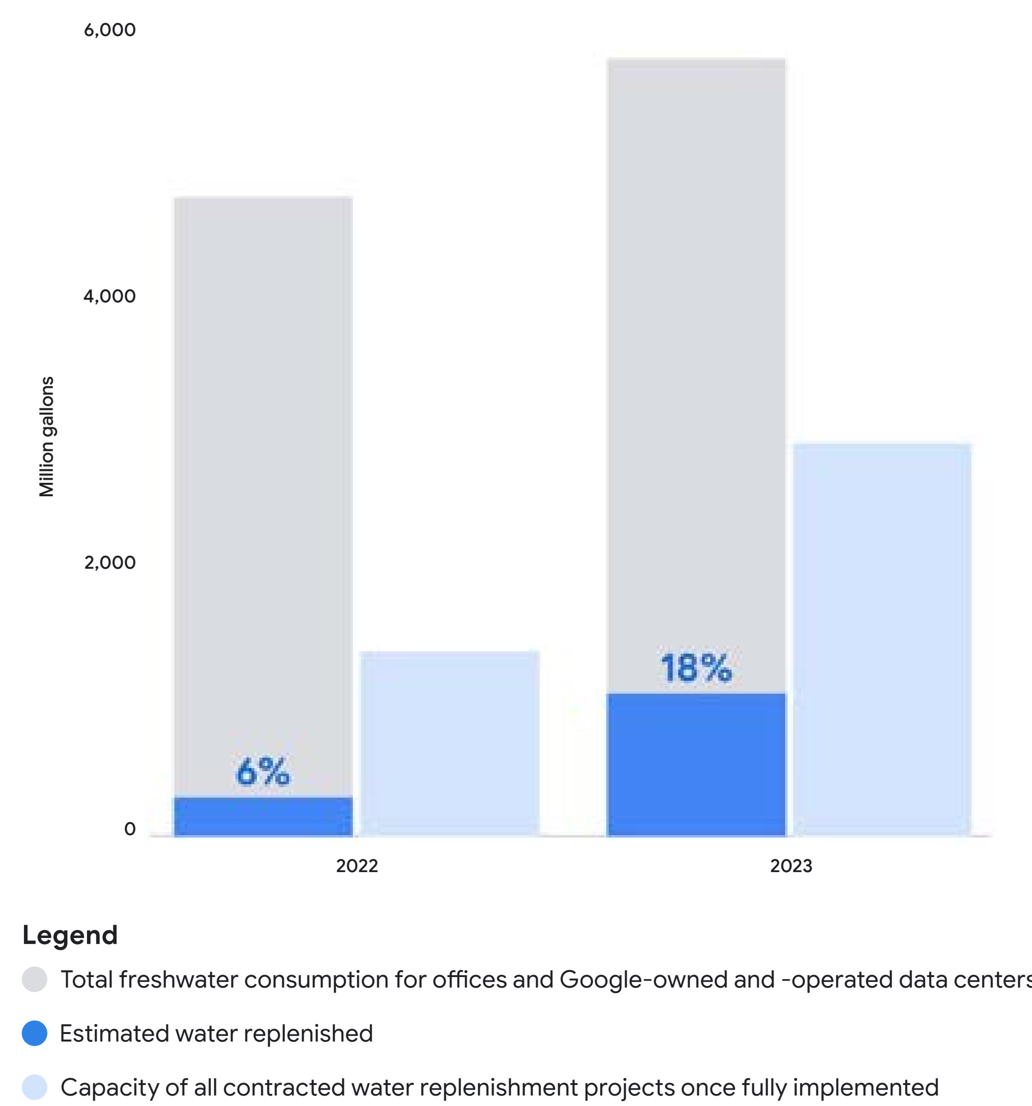
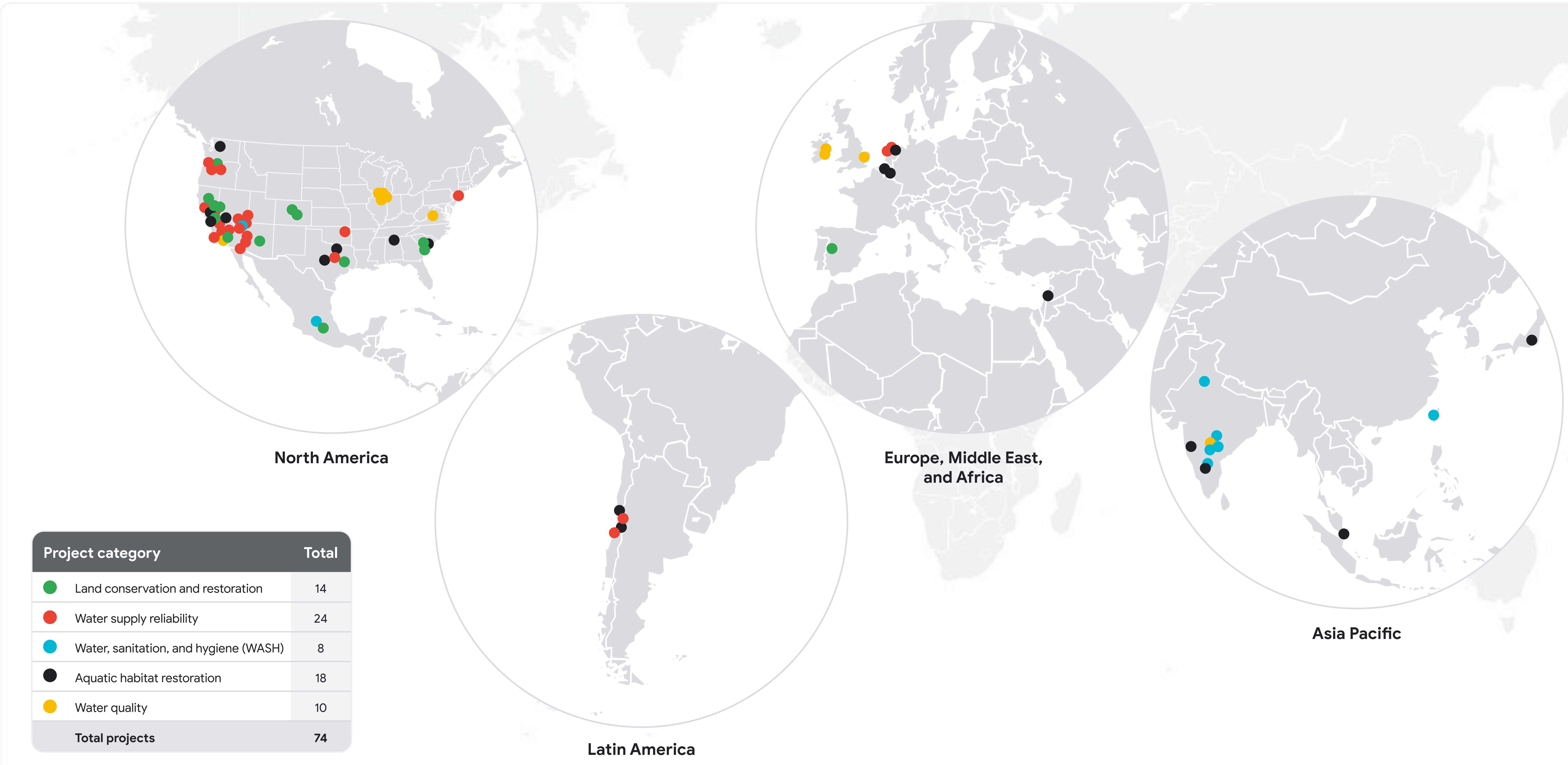
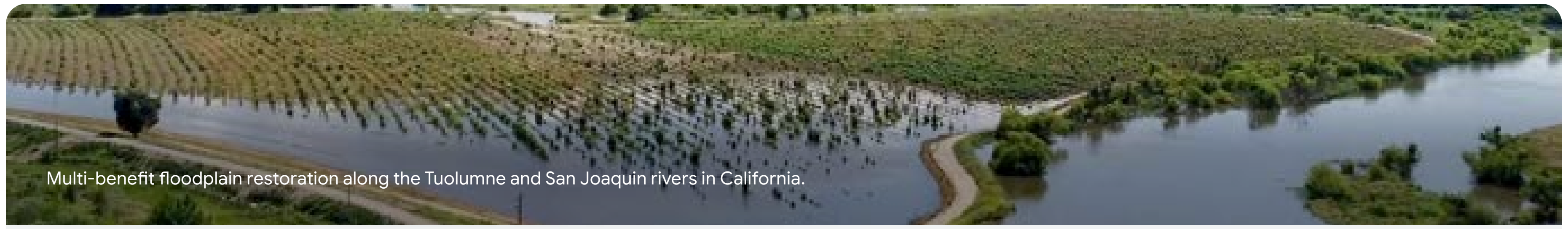


FIGURE 24
Global water replenishment project map

This map shows all 74 water stewardship projects we've supported as of the end of 2023.



Project category	Total
Land conservation and restoration	14
Water supply reliability	24
Water, sanitation, and hygiene (WASH)	8
Aquatic habitat restoration	18
Water quality	10
Total projects	**74**


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

SPOTLIGHT

Water stewardship projects

Below are some examples of impactful projects and partnerships from the 36 new water stewardship projects we supported in 2023.

Arizona, United States: To further support water security in Mesa, Arizona, we contributed to the Salt River Project's efforts to restore the local watershed and reduce wildfire risk. We partnered with the Colorado River Indian Tribes (CRIT) and N-Drip to fund conversion of flood irrigation to precision drip irrigation, and to support farmers to enable water-saving crop rotations. We also partnered with the Quechan Tribe on a farmland initiative whose water savings will bolster efforts to improve water security in the Colorado River Basin.

Illinois, United States: In the Chicago River's Wild Mile, we're supporting the creation of a freshwater mussel habitat to improve water quality and provide other important ecological benefits. We'll also support green infrastructure projects at two sites to improve stormwater management in Chicago.

Texas, United States: We partnered with Texan by Nature on a watershed health initiative to improve the stewardship of an old-growth longleaf pine forest. This initiative employed several tactics, including removing invasive species, planting a diverse understory, and conducting prescribed burns. We provided critical funding to The Nature Conservancy and farmers in the Upper Colorado and Upper Trinity River Basins to implement Environmental Water Transfers that increased streamflow and developed regenerative agricultural practices on 1,000 acres, aiming to reduce runoff and improve water quality.

Chile: We expanded our partnership with Kilimo and are installing precision irrigation management systems that will use AI on approximately 1,980 acres (800 hectares) of farmland in Chile's Maipo Basin to conserve water used for irrigated agriculture.

Spain: We partnered with Fundación Naturaleza y Hombre to create watering ponds and clear vegetation in the Sierra de Gata Biological Reserve. This effort will help improve forest health and reduce fire risk in the watershed surrounding our Madrid office campus.

Netherlands: We're working with Acacia Water on two projects: increasing the efficiency and capacity of an ASR system on the island of Texel, and using smart technology to prevent saltwater intrusion by monitoring water salinity and efficiently routing freshwater. We're also working with the Province of Groningen and other partners to develop water control structures to increase flood protections for salt marsh habitats and aquacultures near our data center—which will also improve local water quality.

India: Building on our portfolio of stewardship projects in India, we partnered with CLEAN International on lake restoration projects in Pune and Bengaluru that, combined, will restore 18 acres of lake and plant approximately 1,000 waterfront trees. We also expanded our partnership with WaterAid by providing clean water access in Hyderabad.

Japan: We're supporting Ramsar Network Japan to create and improve wetland habitat in and around the Watarase Retarding Basin, which serves as critical habitat for the endangered Oriental Stork.

Taiwan: We're working with CLEAN International on installing rainwater harvesting systems and storage tanks at schools in Taipei City, New Taipei City, and Changhua County. The schools will use water from the rainwater harvesting systems for cleaning, landscape maintenance, sanitation, and cooking.

Supporting water security with technology

We're using Google's products and technology to help others study and respond to water security challenges.

Global searches for "water security" reached an all-time high in 2023, demonstrating a growing awareness of this critical issue.[149]

We work to put environmental information about the world's forests, fisheries, watersheds, and air into the hands of decision-makers, in support of our aims to both address a key need for informed decision-making, and to support efforts to scale models and solutions that make water resource information visible and actionable.

For example, we partnered to develop the Freshwater Ecosystems Explorer, a free, easy-to-use geospatial platform that provides national, sub-national, and basin-level data on freshwater ecosystems. And in collaboration with OpenET, as well as government and academic research groups, we supported the automation and scaling of evapotranspiration (ET) models to help improve water management.

At World Water Week 2023, we highlighted the launch of Global Water Watch, a new tool featuring near-real-time reservoir storage data that Google.org supported through the 2020 Google.org Impact Challenge on Climate.

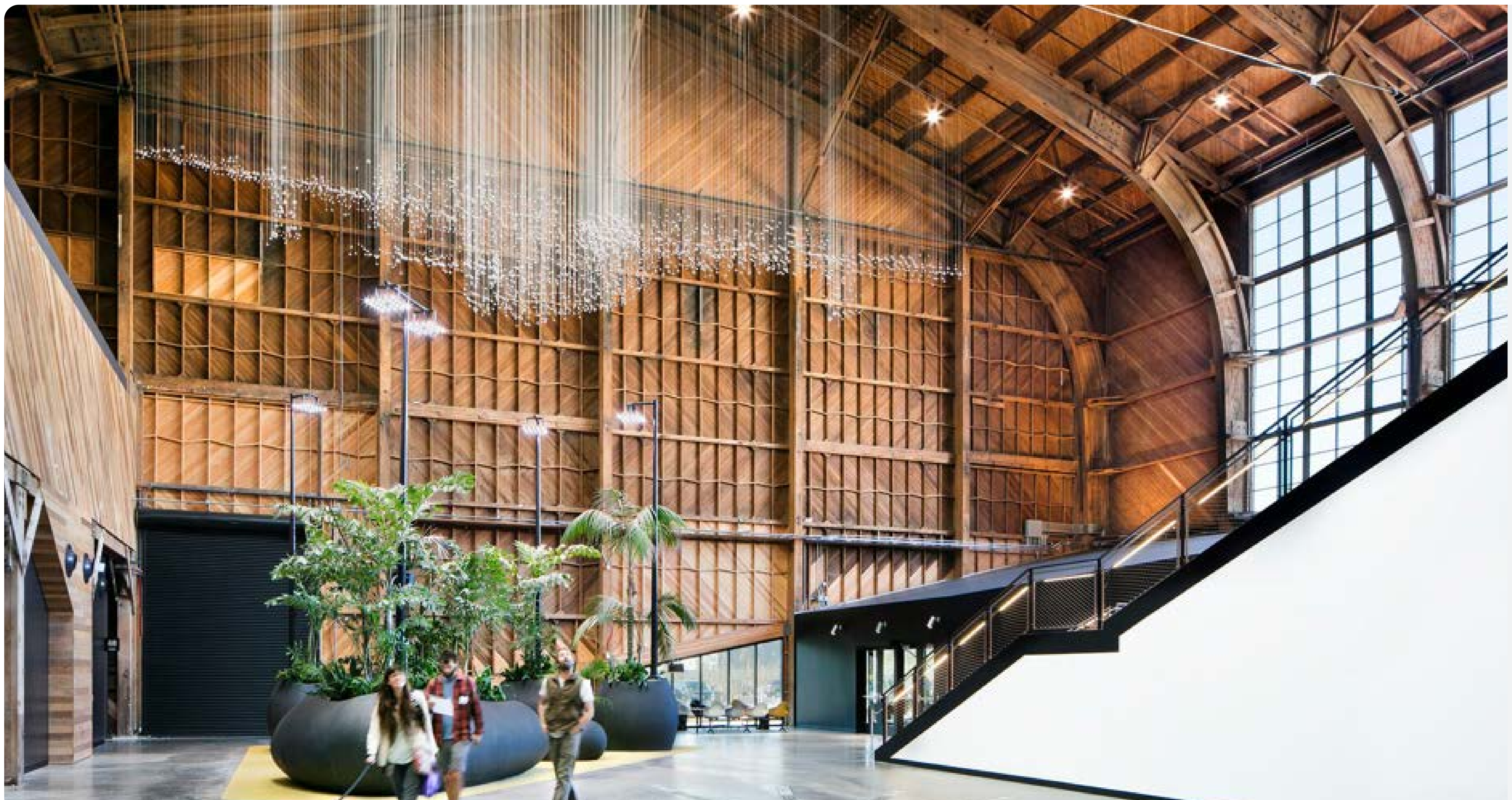

The Global Water Watch tool

RESOURCES

- Google Arts & Culture Freshwater Education Page
- Passage of Water
- Responsible Water Use: Assessing Watershed Health in Data Center Communities
- Working toward LBC Water Petal Certification

Circular economy

We aim to maximize the reuse of finite resources across our operations, products, and supply chains



Our approach to the circular economy

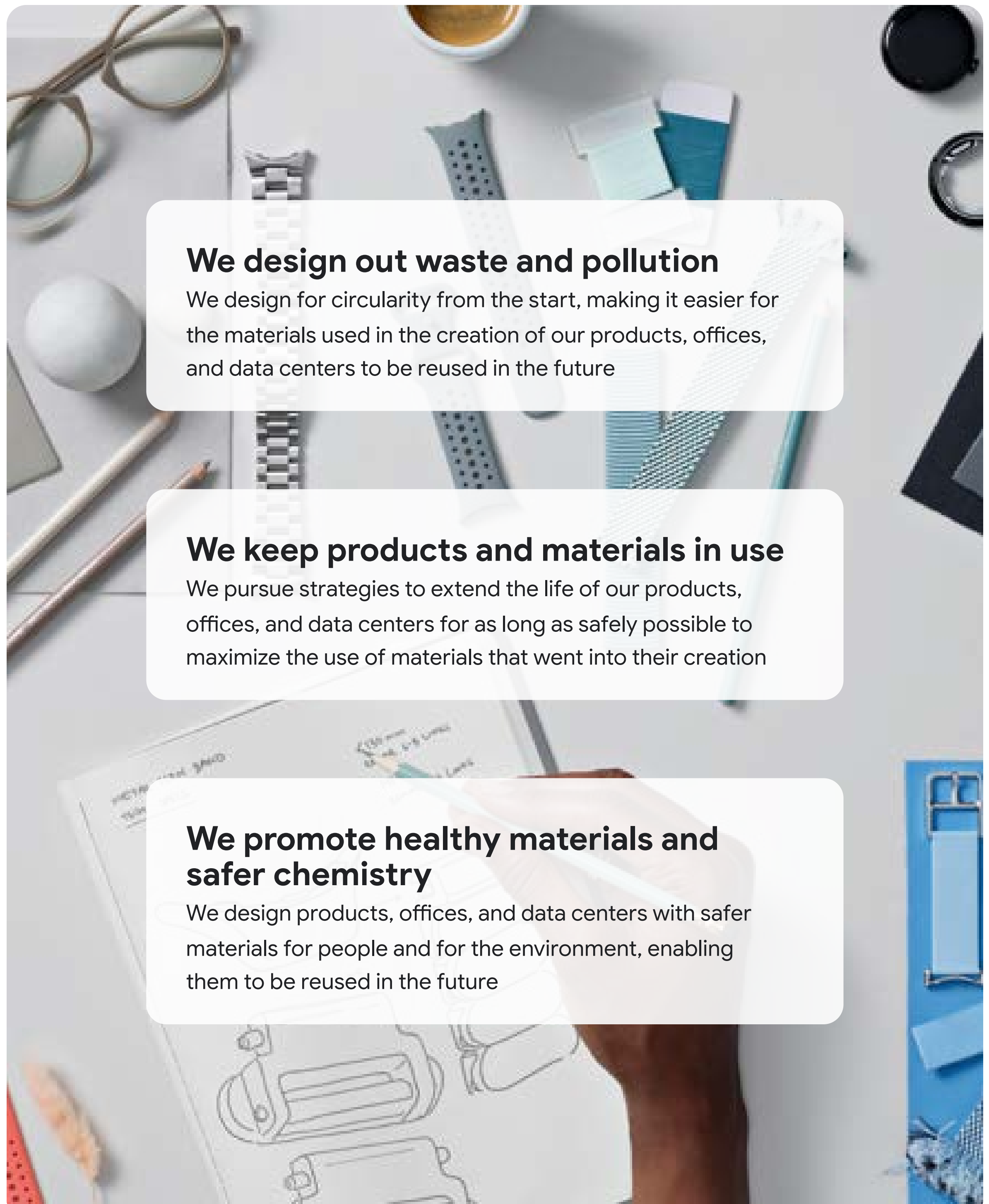
We believe the world must accelerate the circular economy in order to achieve net-zero carbon emissions.

We set out to become a circular Google by maximizing the reuse of finite resources across our operations, products, and supply chains—and enabling others to do the same. Global searches for "circular economy" reached an all-time high in 2023, underscoring the growing awareness and demand for a shift toward a more sustainable economic model.[150]

Our circularity principles focus on designing out waste and pollution from the start, keeping products and materials in use, and promoting healthy materials and safer chemistry (see Figure 25).

To this end, we're pursuing innovative strategies—from adaptive reuse building projects to recycled materials in our consumer hardware devices. Our impact on the circular economy spans our business operations and value chain—including our data centers, offices, stores, products, and suppliers.

FIGURE 25 **How we're working toward becoming a more circular Google**



2023 highlights

- **Waste diversion:** We diverted 78% of our global data centers and offices' operational waste away from disposal.
- **Food waste reduction:** We reduced food waste per Googler by 38% compared to 2019,[151] building on an 18% reduction per Googler in 2022.
- **Resold components:** Since 2015, we've resold more than 44 million hardware components from our data centers into the secondary market for reuse by other organizations,[152] including more than 7 million resold components in 2023 alone.
- **Pixel software support:** We announced our commitment to providing seven years of software support for Pixel 8, Pixel 8 Pro, and future Pixel phones.[153]

Global challenges

- **Infrastructure:** Recovering and diverting resources from disposal requires robust collection and recovery infrastructure around the world, beyond what exists today. Many markets face challenges due to the lack of recycling and composting infrastructure and services at the local level.
- **Markets:** Enabling circularity requires supportive fiscal policy, financially healthy end-markets, and localized solutions. These mechanisms keep materials in use in the economy by making circularity make financial sense.
- **Metrics and measurement:** Achieving a circular economy will require better measurement, metrics, and data to enable more efficient use of resources. Higher quality data is needed to inform capital investments, infrastructure priorities, business plans, policies, and other interventions.
- **Single-use plastics:** Accelerating the switch from using single-use plastics to more durable and reusable solutions requires innovation in both materials and the systems that enable movement of goods through the economy. Additionally, transitioning away from plastic packaging is challenging because plastic-free alternatives are often not available for specific packaging needs.

Building circular workplaces

When we design, build, and operate Google data centers, offices, and stores around the world, we strive to deliver on our commitment to accelerating the circular economy.

Circular design and construction

When the right opportunity comes up, we pursue adaptive reuse projects, renovating existing buildings to serve a new purpose rather than demolishing them for new builds. These reuse projects tend to use fewer materials, produce less construction waste, and have lower embodied carbon than new construction projects. Adaptive reuse projects also help preserve community history, giving historic structures new life as Google offices and, in some cases, as community spaces too.

For more than a decade, we've prioritized building materials that demonstrate safer chemistry to create healthy indoor environments. One way we do this is by leveraging third-party standards that encourage transparency in the building industry, like the **Living Building Challenge** (LBC). As of the end of 2023, Google's Gradient Canopy building in Mountain View, California, was the largest new construction project to attain the LBC Materials Petal Certification. And as of the end of 2023, our 237 Moffett Park Drive building in Sunnyvale, California, remained the world's largest renovation typology project to have attained the LBC Materials Petal Certification.

We use the **Rheaply platform**, which helps locate and reuse office furniture and other materials to support real estate circularity. In 2023, Rheaply helped Google reuse more than 40,000 pieces of furniture and equipment internally, contributing to over 317,000 kilograms (700,000 pounds) of waste diverted from disposal, including landfill and incineration. We also sponsored the launch of public Rheaply marketplaces in the San Francisco Bay Area, New York City, and Chicago to bring this solution to more users in those cities.

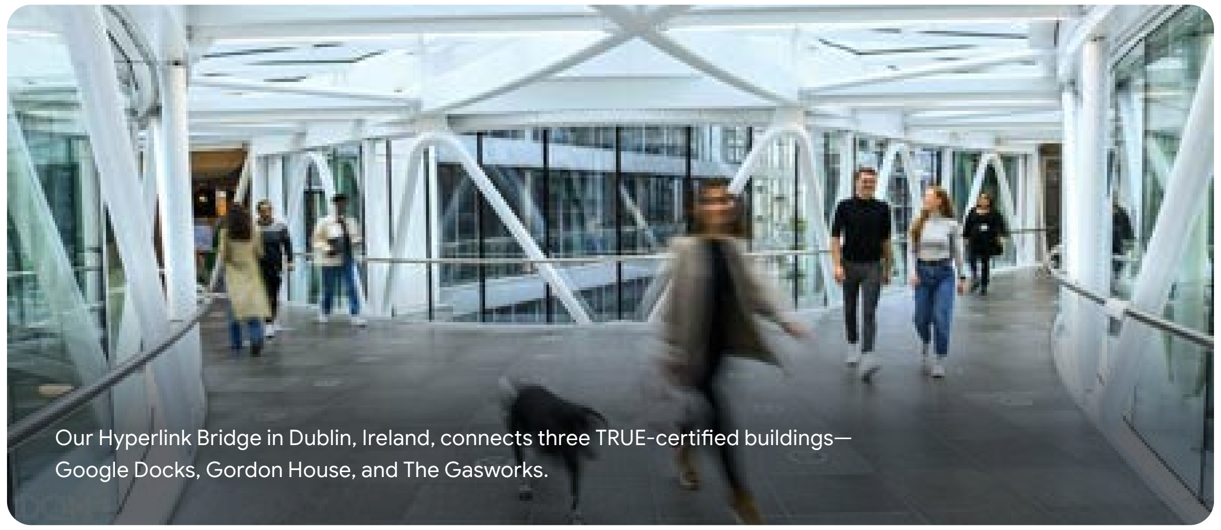
Waste diversion

We strive to divert solid waste from disposal (defined as diversion of waste from landfills or incinerators) and aim to minimize the amount of materials we use and maximize their lifespan within our ecosystem and the surrounding community.

In 2023, the global waste diversion rate for our offices was 77%.[154] We prioritize diverting high-quality materials to maximize the success of our waste recovery efforts. We assess the contamination rates of our recycling and composting streams, and remove contaminated waste from our calculations. This effort contrasts with the typical approach to calculating diversion rates, which makes the assumption that anything placed in recycling or compost bins has zero contamination.

Our office circularity efforts extend beyond waste diversion when possible. In 2023, our main campus in Dublin, Ireland achieved **TRUE Zero Waste** Platinum certification, which recognizes the integration of circularity practices into building operations—including procurement, infrastructure, and employee engagement. For details on our TRUE precertifications, see the Certifications section in the Appendix.

Additionally, across our office portfolio in 2023, we made efforts to refurbish and recover computing devices and other corporate electronics, diverting nearly 90% of material from disposal via reuse, donation, and recycling.



Our Hyperlink Bridge in Dublin, Ireland, connects three TRUE-certified buildings—Google Docks, Gordon House, and The Gasworks.

A view of Gradient Canopy's interior canopy with clerestory windows.

SPOTLIGHT

Circular design and construction at Gradient Canopy

Our Gradient Canopy building in Mountain View, California is a flagship example of how we approach circular building design in a holistic way—with an emphasis on reducing construction waste and incorporating healthy, reclaimed, and responsibly sourced materials.

Here are a few examples from the launch of the building in 2023:

- **Construction waste:** At Gradient Canopy, we diverted more than 90% of construction waste from disposal through sorting waste materials onsite, which helps recycle materials that might otherwise go to landfills. This amounted to nearly 23,000 metric tons (51,000 pounds) of diverted construction waste.
- **Healthy materials:** Materials installed at Gradient Canopy were reviewed with manufacturers to ensure they were free of LBC's Red List ingredients, which represent "worst-in-class" chemicals that negatively impact human and environmental health. We also encouraged manufacturers to incorporate Declare labels in their product lines, particularly in industries and product categories where material transparency may be less common. As an example, many of the wooden doors and frames used in the project obtained a Declare label, which they didn't have at the start of this project.
- **Reclaimed materials:** Throughout Gradient Canopy, we installed over 30 elements from salvaged sources—including reclaimed wood, bike racks, lockers, carpets, and tiles that would have otherwise gone to landfill.

Food waste

We're taking a holistic approach to address food waste, focused on the "three R's"—reduce, reuse, and recycle. Reducing food waste generated in our kitchens is a key lever, as it decreases the food waste that must be diverted from landfills. That's why in 2022, we set a goal to cut food waste in half for each Googler by 2025, compared to a 2019 base year. We're seeing measurable progress toward this goal by using different intervention levers to drive operational change (such as just-in-time cooking) and spark behavior change (such as communications campaigns). In 2023, we reduced food waste per Googler by approximately 38% compared to 2019,[155] building on an 18% reduction in 2022. We also have an ambitious goal to send zero food waste to the landfill by 2025. In 2023, we diverted 82% of food waste from landfill.

To further reduce food waste, we're strengthening our efforts in three key areas across our food program:

- **Sourcing and procurement:** We're working with our suppliers, distributors, and vendors to prevent food waste before it happens. We buy from innovative businesses that make food products from upcycled and imperfect ingredients.
- **Kitchen and cafe operations:** We're reducing food waste across our back-of-house operations through improved culinary practices and demand planning to ensure our food production levels are consistent with user dining patterns.
- **Excess food:** We continue to install new waste containers and signage to help separate food waste effectively, and we're working to ensure excess food is either donated or properly composted. We're expanding partnerships with municipal and community organizations to develop composting infrastructure and, in markets with limited or emerging composting infrastructure, we're exploring ways to process our food waste on-site.

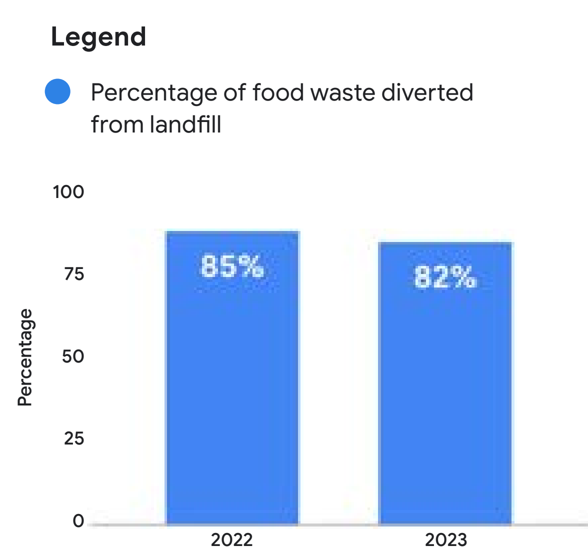
TARGET

Divert all food waste from landfill by 2025

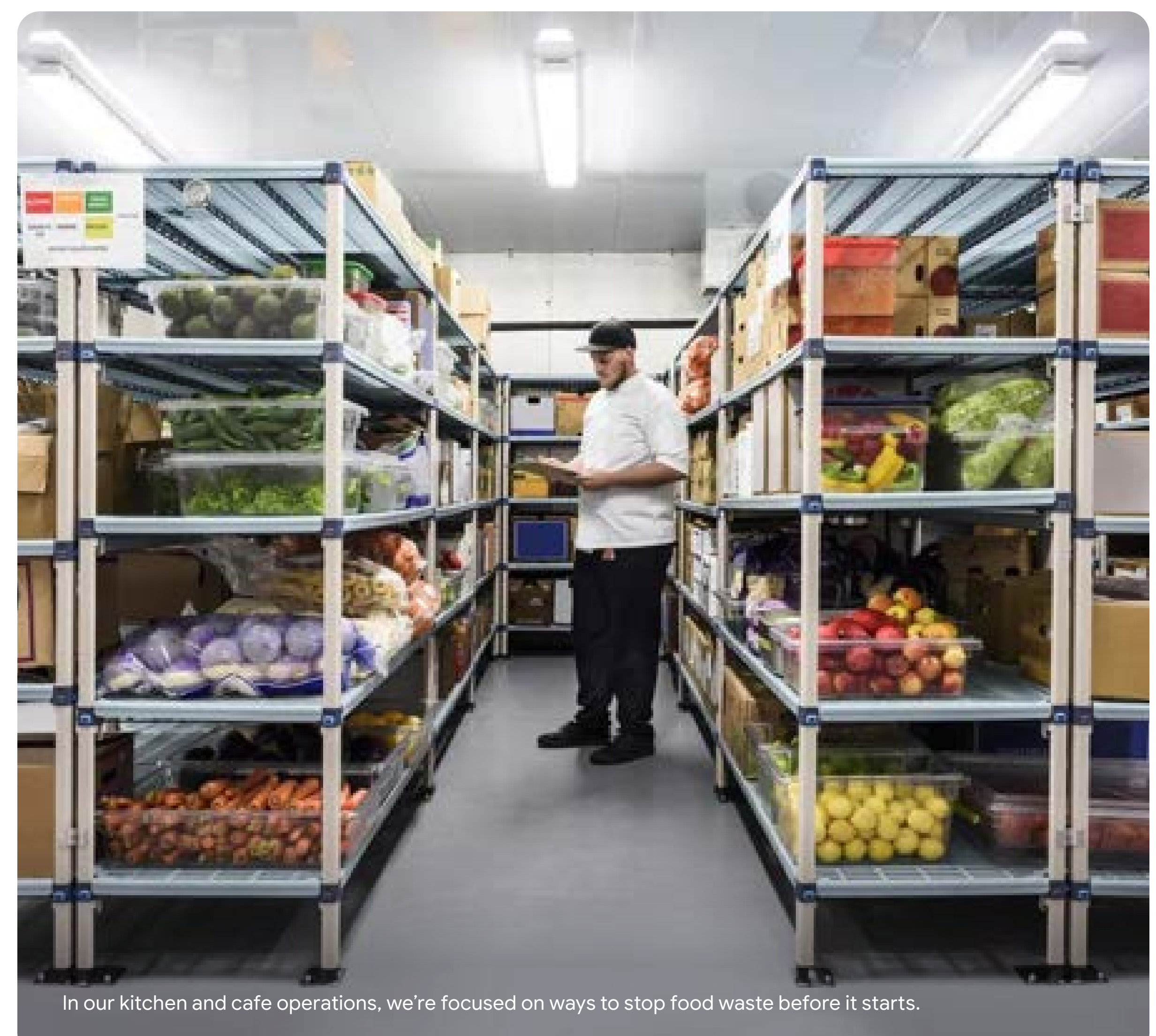
Year set: 2022; Target year: 2025

2023 PROGRESS
82% of food waste diverted from landfill

TREND
Our food waste diversion rate decreased from 85% in 2022 to 82% in 2023 due, in part, to 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
Annual food waste 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 of food waste from landfills and incinerators via composting, anaerobic digestion, or other on-site processing—which goes further than industry standards for Zero Waste to Landfill.


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

Single-use plastics

Global search interest in "plastic pollution" reached an all-time high in 2023, underscoring the urgency of finding solutions to this environmental challenge.[156] We're working with vendors and suppliers to phase out products with single-use plastics. These changes involve rethinking how we handle, store, prepare, and serve food and beverages.

We're piloting and scaling plastic-free processes and products in our kitchens and we're partnering with distributors that are using more reusable and durable containers to transport goods. In April 2023, we launched our **Single-Use Plastics Challenge**, giving food companies that don't use single-use plastics in their packaging the opportunity to test their products in Google's U.S. campus cafes and kitchens. In December 2023, we announced the nine finalist companies, with solutions ranging from reusable snack bags to edible cutlery, refillable commercial cooking oil vessels, data-powered bulk food dispensers, and more.

Reducing data center waste

We design, build, and operate our data centers to maximize efficient use of resources and materials. This includes exploring adaptive reuse projects for some of our data centers (see Figure 26), and focusing on data center waste.

In 2016, we announced our aim to achieve Zero Waste to Landfill for our global data center operations. Working to address waste at our data centers will require collaboration, innovation, and high-quality data to accurately measure performance and identify opportunities.

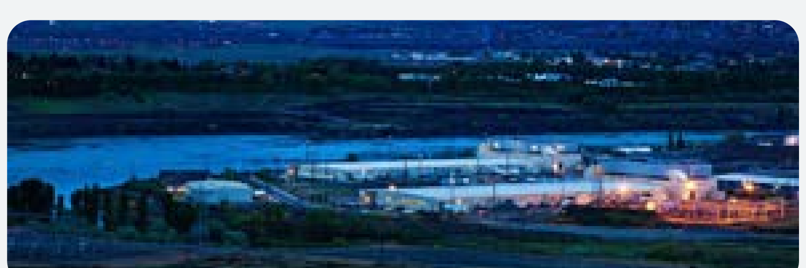
Updating our approach to zero waste
In 2023, we refined our approach to data center waste accounting to better align with circular economy principles and more accurately track progress toward Zero Waste to Landfill. We integrated new data sources and assumptions to account for parts and materials that enter our reverse logistics recycling value chain—inclusive of e-waste, racking infrastructure, and packaging waste. We also refined our approach to diversion accounting for waste that's thermally processed (i.e., incinerated) when it leaves our data centers—reclassifying it as disposed instead of diverted, even when energy is recovered.

In 2023, following our updated waste accounting methodology, we diverted 78% of operational waste from disposal across our global fleet of Google-owned and -operated data centers, and 29% (8 out of 28) of our Google-owned and -operated data center campuses met our Zero Waste to Landfill goal.

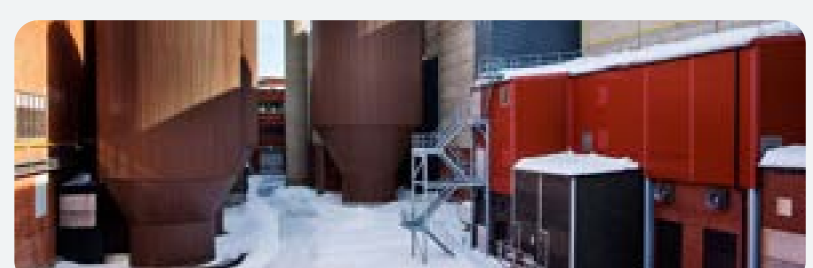
As we further refine our waste governance, we're working with our data center site teams, partners, and vendors to improve our waste data collection processes and systems. We're committed to continuous improvement of our waste management practices, particularly at our data centers, with the ultimate goal of becoming a more circular Google.

For data center equipment, our approach to circularity aims to maintain servers for as long as possible by refurbishing, reusing, or reselling components (following a rigorous security process)—and recycling any components that can't be reused. Since 2015, we've resold more than 44 million hardware components from our data centers into the secondary market for reuse by other organizations,[157] including more than 7 million resold components in 2023 alone. As of the end of 2023, 29% of components used for server deployment, maintenance, and upgrades were refurbished inventory.

FIGURE 26 **Adaptive reuse examples for our data centers**



The Dalles, Oregon
In 2023, we started construction on a third campus in The Dalles on a former U.S. Superfund site that previously housed an aluminum smelter. The development will also leverage an existing drainage channel for stormwater management.

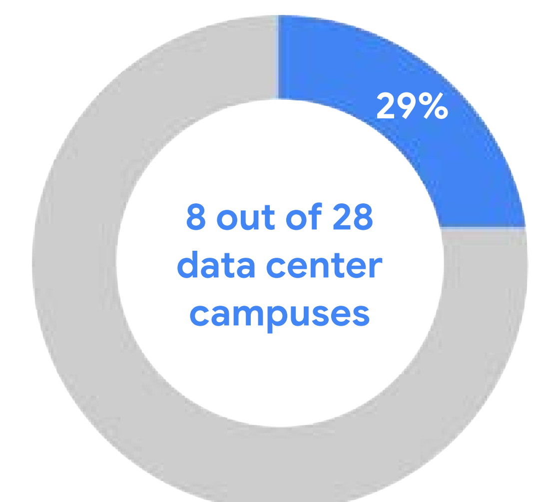


Hamina, Finland
We converted a decommissioned paper mill in Hamina, Finland, into our second data center in Europe. In addition to the buildings, we also repurposed the existing electrical substation and a seawater cooling tunnel, which we use to cool the data center.

TARGET

Achieve Zero Waste to Landfill for our global data center operations
Year set: 2016; Target year: N/A

2023 PROGRESS
29% of Google-owned and -operated data center campuses achieved Zero Waste to Landfill



Legend
- Data center campuses that have achieved our Zero Waste to Landfill goal
- Data center campuses yet to achieve our Zero Waste to Landfill goal

TREND
Due to changes in methodology that have only been applied to data center waste data for 2023, we're not reporting year-over-year progress against this target this year. Had we not made these methodology changes, we estimate that our reported 2023 percentage of data centers to reach Zero Waste to Landfill would have been 43%, or a 5% increase compared to our reported 2022 percentage.

DETAILS
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. As of 2023, our waste diversion methodology considers thermally processed waste (i.e., incineration), with or without energy recovery, as waste disposal.

Designing more sustainable consumer hardware devices

Since launching our first consumer hardware devices,[158] we've set out to integrate sustainability considerations into every aspect of our operations—from how we source our materials, engineer and package our products, run our supply chain operations, and design our retail stores.

We aim to decrease our use of virgin materials through our procurement of recycled materials and extend the life of our products through software updates and expanded repair options (see Figure 27).

We also support electronics standards and certifications, including UL 110, IEEE 1680.1, and the UL ECOLOGO Program,[159] that establish robust sustainability criteria for electronic devices. For more information about our products, including their recycled material content and packaging, see our Product Environmental Reports.

Recycled materials

We'd set a goal to include recycled materials in 100% of Google consumer hardware products launching in 2022 and every year after.[160] We first achieved this goal in 2020 for our Nest, Pixel, and Chromecast devices, and have maintained it for these products launched each year since—through 2023.[161]

Additionally, Fitbit devices launched in 2023 included recycled materials—the first year Fitbit devices were included in this goal.[162]

We also set a target to use recycled or renewable material in at least 50% of plastic used across our consumer hardware product portfolio by 2025, prioritizing recycled plastic where we can. 34% of the plastic Google used in products manufactured in 2023 was recycled content.[163] This represents a decrease in overall recycled content of plastics across our portfolio from 41% in 2022,[164] which was due to changes in our product mix—some product types use less plastic than others, which can reduce opportunities to use recycled content. At least 20% of the material Google used in our new products launched and manufactured in 2023 was recycled content.[165] This effort includes recycled material used in our devices, such as aluminum, stainless steel, rare-earth magnets, glass, and plastic parts.

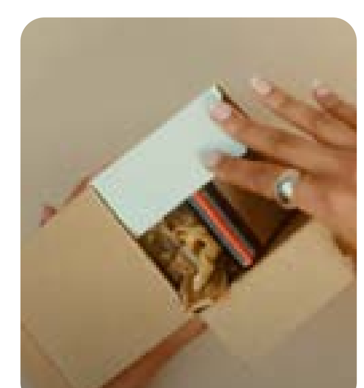
FIGURE 27 **Our consumer hardware devices are built with sustainability in mind**

Recycled materials
Made with recycled metals, glass, and plastics, and now recycled tin, as well

Packaging
Focused on using fiber-based materials and making our packaging more easily recyclable

Product longevity
Designed to be repairable and used for as long as possible with feature drops, and OS and security updates

Low-carbon design
Using recycled aluminum in the enclosure of Pixel phones to reduce the carbon footprint, compared to using primary aluminum



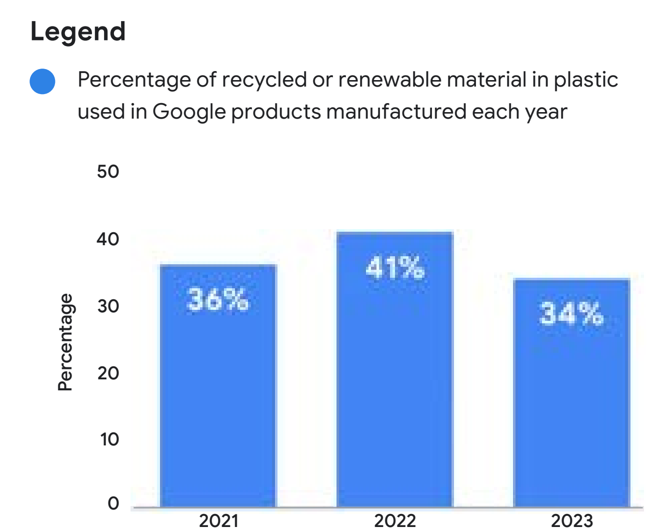
E-waste
Offering programs to recycle and trade-in old devices to help reduce e-waste

TARGET

Use recycled or renewable material in at least 50% of plastic used across our consumer hardware product portfolio by 2025

Year set: 2020; Target year: 2025

2023 PROGRESS
34% of the plastic Google used in products manufactured was recycled content[166]



TREND
The percentage of plastic used in our manufactured consumer hardware products that was recycled content decreased from 41% in 2022[167] to 34% in 2023[168] due to changes in our product mix. Some product types use less plastic than others, which can reduce opportunities to use recycled content. This change in product mix contributed to the decrease in overall recycled-content plastics across our portfolio. We're continuing to explore ways to use more recycled content across plastics in our product portfolio.

DETAILS
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 target doesn't include third-party products such as the Nest x Yale Lock.

Sustainable packaging

Our goal is to eliminate plastic from our hardware product packaging by 2025. We're working to achieve this target by designing Pixel, Nest, Chromecast, and Fitbit packaging to minimize the use of plastic. For new Google products launched and manufactured in 2023, our packaging was at least 99% plastic-free,[169] and packaging for Pixel 8 and Pixel 8 Pro uses 100% plastic-free materials.[170] By focusing on fiber-based materials, we're also making our packaging more easily recyclable. We'll continue to work with suppliers to create plastic-free packaging solutions that are protective and aesthetic.

When comparing the packaging of our first Pixel phone to Pixel 8 and Pixel 8 Pro, we've made significant progress—eliminating plastic from Pixel 8 and Pixel 8 Pro packaging, and reducing packaging weight and volume by at least 50%.[171] Smaller and lighter Pixel 8 Pro packaging means more devices can be transported in a single shipping container and therefore more natural resources can be conserved.

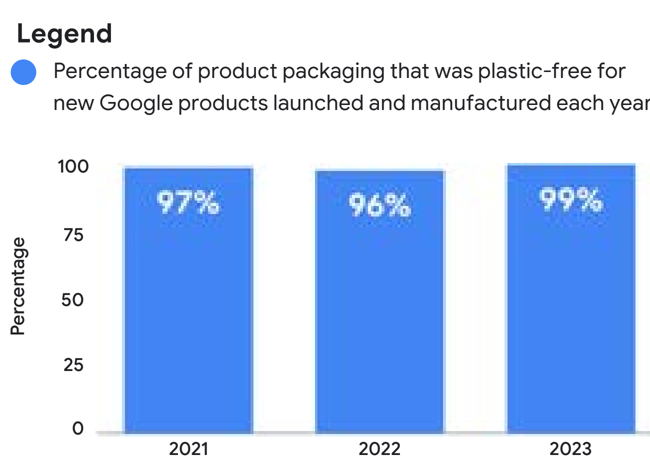
TARGET

Make product packaging 100% plastic-free by 2025

Year set: 2020; Target year: 2025

2023 PROGRESS

For new Google products launched and manufactured in 2023, our packaging was at least 99% plastic-free[172]



TREND

The increase from at least 96% plastic-free packaging in 2022 to 99% in 2023 was primarily due to packaging innovations, including implementing fiber-based solutions in our packaging material catalog.[173]

DETAILS

Based on the total weight of new Google Pixel, Nest, Chromecast, 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.

Product longevity

We want our devices to be used and valued for as long as possible, which we work to achieve by guiding consumers through the care, repair, reuse, and recycling of their products.

Enabling security updates and bug fixes helps promote product longevity. In 2023, we announced our commitment to providing **seven years of software support** for Pixel 8 and Pixel 8 Pro, including Android operating system upgrades and security updates.[174] And, for Google Nest products, we provide critical bug fixes and patches for at least five years after launch.

We're working to empower everyone with more repair options to extend the useful lifespan of consumer hardware technology because we believe that consumers should have the **"Right to Repair"**—including access to the same documentation, parts, and tools that original equipment manufacturer (OEM) repair channels have. Pixel repair options are available in all countries where we sell Pixel phones. We also offer customer support, self-repair options, and an online community help center. In tandem with our trade-in program, these efforts can extend the useful life of Pixel phones.

In 2023, we announced that all Chromebook platforms will get regular automatic updates for 10 years. ChromeOS Flex continues to offer an alternative for extending the useful life of aging devices by modernizing their operating systems, enhancing product longevity, and reducing the amount of potential devices that may end up as e-waste.

For eligible devices from any brand at the end of their useful life, we offer free recycling in every country where we ship consumer hardware devices.[175]

Working with suppliers

Manufacturing waste

In 2023, we achieved **UL 2799 validation** for waste diversion at all final assembly manufacturing sites for our consumer hardware products.[176] Of these sites, 75% achieved either Zero Waste to Landfill Gold classification (representing a 95%–99% landfill diversion rate) or Zero Waste to Landfill Platinum classification (representing a 100% landfill diversion rate). We'll continue pursuing UL 2799 validation for waste diversion at our consumer hardware final assembly manufacturing sites, including for new sites as they're added in the future.

Safer chemistry

We're working to eliminate antimicrobials and use safer flame retardants and solvents across our consumer hardware products. We're collaborating across the industry to raise awareness of safer flame retardant options available to the electronics sector. We've partnered with ChemFORWARD, a trusted nonprofit with chemical hazard data, on an approach to assess chemical safety that goes above existing regulatory and industry norms. We've performed safer chemistry evaluations for materials used in our products, and we're expanding this work to drive industry progress beyond the standard management of regulated chemicals.

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 the manufacturing process. In 2023, we introduced new hazard-based requirements, including mandatory hazard ratings and restrictions for certain solvents and flame retardants. 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.

In 2024, we, along with other companies, provided seed funding for the Safer Chemistry Impact Fund, which aims to advance science-based, data-driven solutions to systematically eliminate hazardous chemicals and replace them with verified, safer alternatives.

RESOURCES

- Accelerating the Circular Economy through Commercial Deconstruction and Reuse
- Closing the Plastics Circularity Gap
- Electronics Hibernation: Understanding Barriers to Consumer Participation in Electronics Recycling Services
- How Android Enterprise Can Help Businesses Reduce E-Waste

Nature and biodiversity

We strive to restore and enhance nature and biodiversity through our campuses and technology

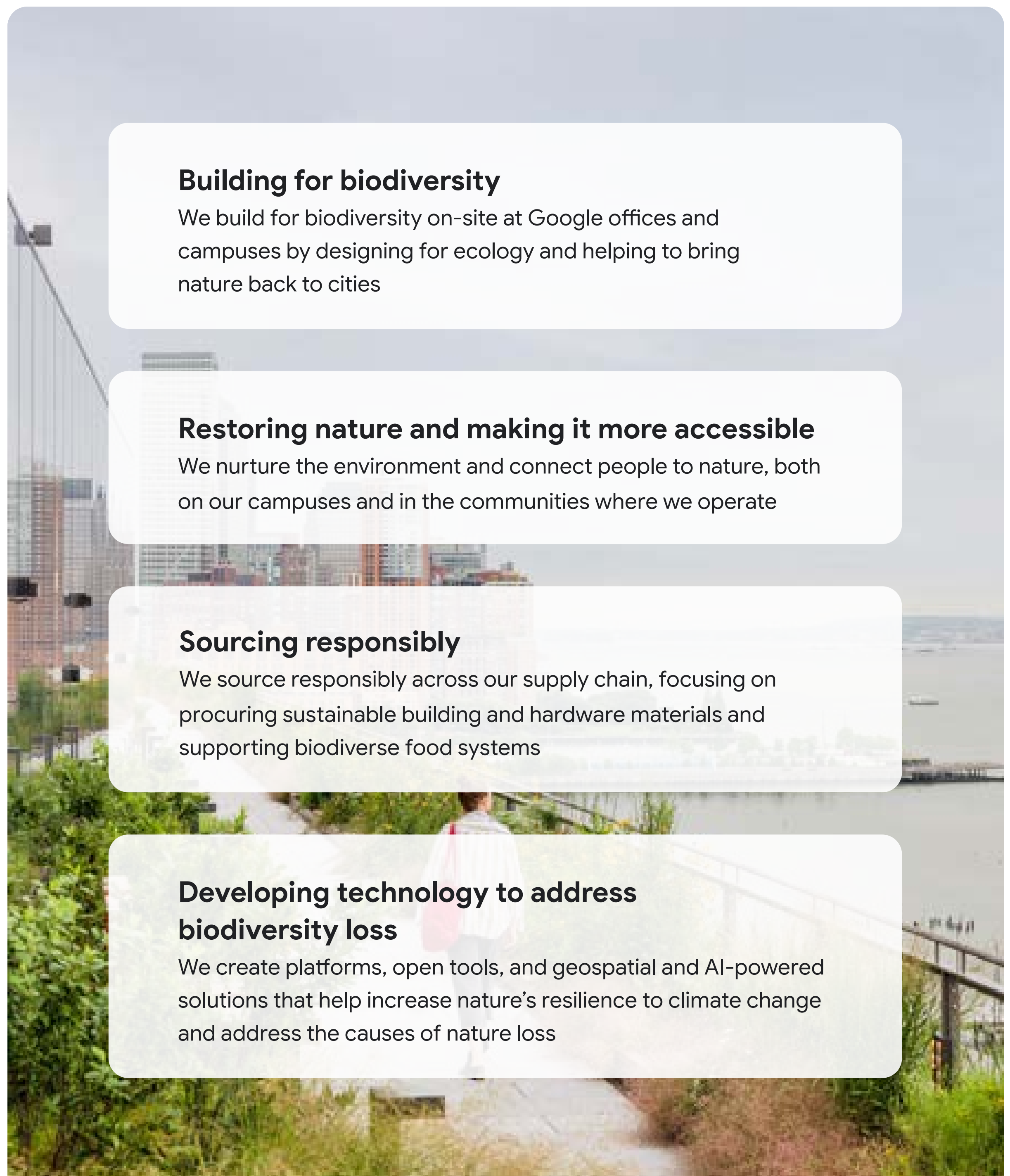
Our approach to nature and biodiversity

Preserving nature is critical for supporting biodiverse ecosystems and healthy communities, as well as for mitigating and adapting to climate change.

We strive to restore and enhance nature and biodiversity through a four-pillar approach that starts with designing our offices and campuses for ecology and actively managing our sites to maintain healthy ecosystems. This includes everything from developing guidelines for urban nature, to increasing habitat creation, restoration, and monitoring.

We also focus on restoring nature and making it more accessible in the communities where we operate, sourcing responsibly, and developing breakthrough technologies to address nature and biodiversity loss and assist various conservation initiatives (see Figure 28).

FIGURE 28 **Our four-pillar approach to nature conservation and biodiversity enhancement**



Building for biodiversity
We build for biodiversity on-site at Google offices and campuses by designing for ecology and helping to bring nature back to cities

Restoring nature and making it more accessible
We nurture the environment and connect people to nature, both on our campuses and in the communities where we operate

Sourcing responsibly
We source responsibly across our supply chain, focusing on procuring sustainable building and hardware materials and supporting biodiverse food systems

Developing technology to address biodiversity loss
We create platforms, open tools, and geospatial and AI-powered solutions that help increase nature's resilience to climate change and address the causes of nature loss

2023 highlights

- **Habitat creation and restoration:** As of the end of 2023, we created or restored approximately 67 acres of habitat and planted roughly 4,500 native trees on Google's campuses and the surrounding urban landscape, primarily in the San Francisco Bay Area.
- **Pollinator habitat:** From 2021 to 2023, we created 20 acres of new habitat on our California campuses designed to support monarch butterflies and other pollinators.
- **FSC-certified lumber:** Approximately 99% of the new lumber used for our Gradient Canopy building (both temporary and permanently installed) was procured from responsibly managed forests certified by the FSC.[177]

Global challenges

- **Local context, global scale:** Navigating the local complexities of biodiversity and ecosystem health while scaling global solutions requires careful consideration and nuanced approaches.
- **Accounting for benefits of nature:** Ecosystems are complex and support multiple services. Designing for specific outcomes can lead to unexpected tradeoffs or missed opportunities for biodiversity benefits.
- **Metrics and measurement:** As the global consensus on nature-related metrics continues to evolve, organizations are working to ensure their metrics are transparent and impactful. Ecosystems are living, dynamic systems—presenting unique challenges for measurement and ongoing stewardship needs.
- **Urban nature:** Building nature in urban settings requires close coordination with capital planning, design, and maintenance teams.

Building for biodiversity

We're helping to bring nature back into the built environment—for example, by restoring critical habitats like oak woodlands and willow groves across our San Francisco Bay Area campuses.

Developing guidelines for urban nature

Our campus biodiversity efforts are underpinned by our Urban Nature Design Guide that establishes criteria for ecologically designed landscapes. We made this guide freely available for landscape managers and the public.

Our ecology team also issues internal guidelines on topics such as pollinator habitat design, drought-tolerant native landscaping, and native landscape maintenance to translate ecological science into action.

To make the nature-friendly urban design approach broadly accessible, we helped support the Making Nature's City Toolkit, developed by the San Francisco Estuary Institute and the International Union for Conservation of Nature.

We've also published our research on balancing nature with urban density in an open-access academic paper—aiming to provide others with replicable tools and techniques for integrating nature into cities.

Creating and restoring habitat

We're expanding native, biodiverse habitats on our development sites through both large- and small-scale efforts that prioritize local species. As of the end of 2023, we created or restored approximately 67 acres of habitat and planted roughly 4,500 native trees on Google's campuses and the surrounding urban landscape, primarily in the San Francisco Bay Area.

We made progress on monarch butterfly habitat creation: from 2021 to 2023, we created 20 acres of new habitat on our California campuses designed to support monarch butterflies and other pollinators, aligned with Google's 2021 **monarch butterfly pledge**. We're already seeing benefits, with about 10 times more monarch caterpillars at our new habitat sites, compared to control sites on our campus without new monarch-friendly plants. Our efforts to support pollinator habitats earned us the 2023 Monarch Sustainer of the Year award from Pollinator Partnership.

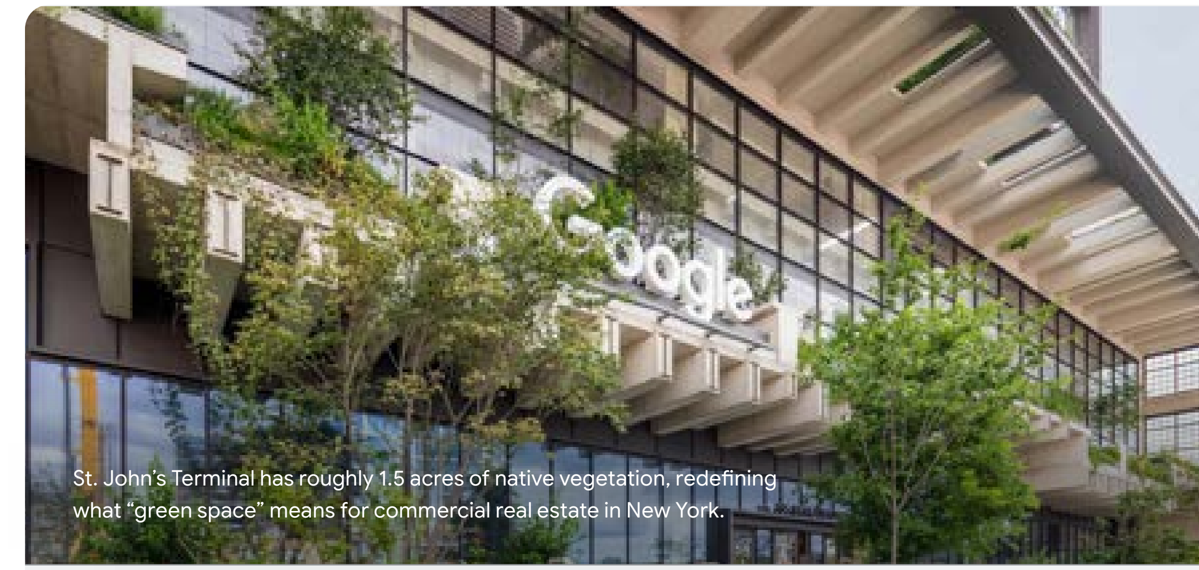
In 2023, we also completed a native habitat restoration project along the West Channel near our Sunnyvale, California, campus. This project restored 4.3 acres of aquatic, wetland, and riparian habitat and is expected to benefit local and migratory water birds. Additionally, the project provides flood protection for adjacent neighborhoods in Sunnyvale via a combination of floodwalls and flood control levees.

Managing and monitoring habitat

Once we've installed native landscaping, we manage our sites to ensure we're maintaining habitat quality—including assessing our sites as part of ongoing maintenance, prioritizing wildlife-friendly management practices, and refreshing planting areas. At our Bay View campus in Mountain View, California, we've worked to protect nesting cliff swallows, and we've piloted a rodenticide-free pest management approach. In 2023, we documented more than 10 species at our Bay View campus that we've avoided exposing to rodenticides as a result of this effort—including gray foxes, black-tailed jack rabbits, and red-tailed hawks.

We also monitor our sites for plant health and wildlife biodiversity. In addition to monitoring bird biodiversity in New York City, we monitored birds during the fall and winter of 2023 at our Bay View campus in California and identified more than 60 bird species using the open water, wetland, oak woodland, and grassland habitats—including several species where we've documented evidence of breeding on-site. Earlier projects are also showing success, such as the Charleston Retention Basin, where oak woodland, willow groves, and wetlands have filled into the basin since our initial planting in 2016.

We incorporated bird-friendly design elements in all of our San Francisco Bay Area ground-up construction office projects completed in 2023. We're monitoring key buildings to evaluate the effectiveness of our design approach in preventing collisions.



St. John's Terminal has roughly 1.5 acres of native vegetation, redefining what "green space" means for commercial real estate in New York.

SPOTLIGHT

Nurturing biodiversity in the heart of New York

Google's St. John's Terminal building in New York City, which opened in February 2024, incorporates extensive exterior green spaces.

Altogether there are roughly 1.5 acres of native vegetation at street level, in railbed gardens, and on terraces. These green spaces are helping to restore the site's native ecology within a modern urban context. Over 95% of the exterior plants installed at St. John's Terminal are native to New York State, and over 85% are native to New York City.

The native vegetation at St. John's Terminal is designed to create biodiverse habitat that supports a variety of local bird and insect species, with terrace and ground-floor plantings intended to support nesting, foraging, and migration habitat for multiple bird species. The site also features nest boxes—often missing from city centers—intended to attract birds that nest in tree cavities.

We're monitoring the bird species that arrive at the building and, working with NYC Audubon from July through November 2023, we've documented around 40 bird species using the habitat created at St. John's Terminal—including several species never before documented on a green roof. One observed species, the Blackpoll Warbler, is a long-distance migrant, which our expert partners say used the building to fuel up ahead of its transatlantic trip to South America.

Restoring nature and making it more accessible

To complement our on-campus biodiversity efforts, we're supporting ecological restoration efforts beyond our campuses to deliver benefits for communities and ecosystems.

As examples, we've supported the restoration and enhancement of over 750 acres of monarch butterfly habitat across California—achieving Google's 2021 monarch butterfly pledge, and we've partnered with Southeastern Grasslands Institute to restore approximately 100 acres of native prairie ecosystem near our data center in Clarksville, Tennessee.

Many of our water replenishment projects also deliver co-benefits for nature and biodiversity. For example, in 2023 we supported the acquisition of a 20-acre parcel of land in California's Central Valley that will enable floodplain reconnection and the restoration of native riparian forest habitat along the Tuolumne River. We're also advancing wetland restoration efforts with a project in Belgium's Sint-Onolfspolder nature reserve via a partnership with Natuurpunt's Wetlands4Cities initiative, and in Japan through a partnership with Ramsar Network Japan. For more details, see the Water stewardship section.

Connecting people with nature

We engage with local communities and lead programming that extends the benefits of nature to all. In partnership with the Santa Clara Valley Audubon Society, the City of Mountain View, and other organizations, in 2023 we continued hosting "Egret Office Hours" at the **Shorebird Way rookery** to provide members of the public with the opportunity to learn about local birds and witness moments throughout the egret breeding cycle.

In 2023, we completed the first sections of the **Moffett Park Green Link** at our Sunnyvale, California, campus—a publicly accessible landscape network that connects to regional walking and cycling corridors. Some of the key components of the Green Link include the restoration of native plant and tree species, as well as landscapes designed to reduce demand on local stormwater management infrastructure.

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

Sourcing responsibly

We're focused on sourcing responsibly across our supply chain, aiming to minimize negative impact on global biodiversity by procuring sustainable building and hardware materials and supporting biodiverse food systems.

For new campus developments, we've used timber certified by the Forest Stewardship Council (FSC)—the world's leading forest certification system for sustainable wood building materials.

Approximately 99% of the new lumber used for our Gradient Canopy building (both temporary and permanently installed) was procured from responsibly managed forests certified by the FSC.[178] And at our new San Bruno campus, the mass timber structures of the building are built with sustainably sourced FSC MIX-certified timber materials.

In partnership with our food vendors, we leverage procurement practices and menu design to replace monocrop commodities with climate-resilient and agrobiodiverse crops to ensure our food operations contribute positively to global agricultural biodiversity. For example, our culinary teams select specific regionally biodiverse beans, grains, and legumes to add to menus across the globe.

Developing technology to address biodiversity loss

We build tools and technology that enable partners, NGOs, governments, and academics around the world to help address nature and biodiversity loss.

The public's increased search interest in "wildlife"—which saw a 138% increase over the past two years[179] and reached an all-time high in 2023[180]—likely indicates a growing desire to understand and support conservation efforts.

As concerns for wildlife escalate, innovative technological tools empower us to observe animal populations and habitats with unprecedented detail, providing essential insights for protection and conservation.

Below are just a few examples:

- **Giant kelp monitoring:** Giant kelp forests, crucial to Australia's Great Southern Reef ecosystem, are disappearing rapidly due to climate change. That's why we've partnered with leading scientific and conservation organizations to use AI-powered tools to map the remaining kelp forests, identify heat-resistant kelp varieties for restoration efforts, and raise awareness of this critical environmental issue.
- **EEAGER:** The elusive beaver, a keystone species and wetland architect, is finally shedding some of its secrecy thanks to EEAGER—an image-recognition machine learning model pinpointing telltale dam complexes amidst vast landscapes, saving conservationists countless hours in their quest to understand this industrious engineer and protect their habitat.
- **Eyes on Recovery:** Australia's devastating bushfires were a stark reminder of the fragile balance of nature. AI-powered cameras are capturing the astonishing resilience of wildlife, revealing signs of recovery and offering conservationists a powerful new tool to track wildlife over time.
- **Biodiversity on Britain's railway:** The humble dormouse, nestled along Britain's sprawling railway network, is finding new hope as AI models illuminate their secret lives and guide efforts to protect them from dwindling numbers.
- **Blue carbon:** Similar to forests on land, seagrass can take carbon dioxide out of the atmosphere as it grows—storing it through a process called carbon sequestration. We're working with partners to explore novel AI applications to measure the capacity of seagrass ecosystems to absorb and sequester carbon.

RESOURCES

- The Biological Deserts Fallacy
- Biophilia beyond the Building
- Denser and Greener Cities
- Map of Life Indicators Adopted in UN Biodiversity Framework

Appendix

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 technology's potential 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. 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 wearable devices, Google Nest home products, and Pixel devices. Our Google Cloud offerings 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.

To learn more, see our data center locations and our office locations.

Sustainability governance

Alphabet's Board of Directors has delegated to its Audit and Compliance Committee the primary responsibility for the oversight of many of the risks facing our businesses.

The Audit and Compliance Committee 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 SVP of 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.

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, the team assesses environmental risks as part of the company's overall risk management framework. The risks and opportunities identified through this process 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. Google continues to build on qualitative and quantitative risk assessments to identify climate-related risks and opportunities and understand their associated impact.

We've increased our efforts to align our climate risk assessment process more closely with the recommendations of the Task Force on Climate-Related Financial Disclosures (TCFD), leveraging the TCFD categories of risks and opportunities and conducting climate scenario analyses. In an effort to drive completeness and consistency when reviewing these categories, we adopted our ERM rating scales (i.e., impact, frequency, likelihood, control effectiveness) to identify and prioritize areas of focus.

Beginning in 2022, climate-related risks and opportunities were analyzed across three time horizons—short term (through 2030), medium term (through 2040), and long term (through 2050)—for financial, operational, legal, and strategic risks. 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, see 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 that may present opportunities for water stewardship action and risk mitigation. Indicators from available risk assessment tools, including WRI Aqueduct Water Risk Atlas 3.0 and 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.

In 2023, we launched our data center water risk framework that allows us to evaluate the health of a local community's watershed and establish a data-driven approach to advancing responsible water use across our data center portfolio. We use our decision-making tool to evaluate the environmental responsibility of using water for cooling at new or expanding data centers. This context-based water risk and impact methodology generates more granular insights than can be provided by other water-risk screening tools. It provides us with a 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.

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.

To safeguard the health of local waterways, we comply with all local environmental regulations at our Google-owned and -operated data centers and further stipulate that suppliers "[treat all wastewater] as required prior to discharge or disposal." We conduct regular supplier audits to monitor adherence to our code of conduct. Additionally, we've engaged our suppliers through the CDP Supply Chain Water Security questionnaire, inviting them to disclose their water management efforts.

Stakeholder engagement and partnership

We recognize that achieving our own sustainability goals and addressing the urgency of climate change and sustainability requires engagement, collaboration, and partnership across a diverse set of stakeholders.

That's why we actively engage with a wide range of stakeholders—including employees, suppliers, NGOs, policymakers, customers, startups, researchers, academics, investors, 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 progress against key targets, and it 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.

See below for more information on how we engage with some specific stakeholder groups.

Employees

Sustainability is part of Google's culture, with passionate employees actively driving environmental initiatives through dedicated groups and engagement opportunities.

For example, employees can join global and local internal community groups focused on sustainability. One collection of sustainability-related internal community interest groups had 22 chapters across 15 countries as of the end of 2023—focused on organizing local sustainability activities and raising awareness about environmental topics for interested Googlers.

Another sustainability-related internal community group has more than 3,700 members globally. This community group hosts weekly climate talks featuring internal and external speakers and biannual events highlighting sustainability-related 20% opportunities—whereby Google employees are allowed to use 20% of their work time to explore innovative ideas beyond their current roles. This enables engineers with a diverse range of technical skill sets to be deployed into addressing climate and sustainability challenges, which is critical to unlocking innovation and solutions.

Our Cool Roofs initiative, which you can learn more about in the Our products section, is a successful example of an effort that originated as a 20% project.

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

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.

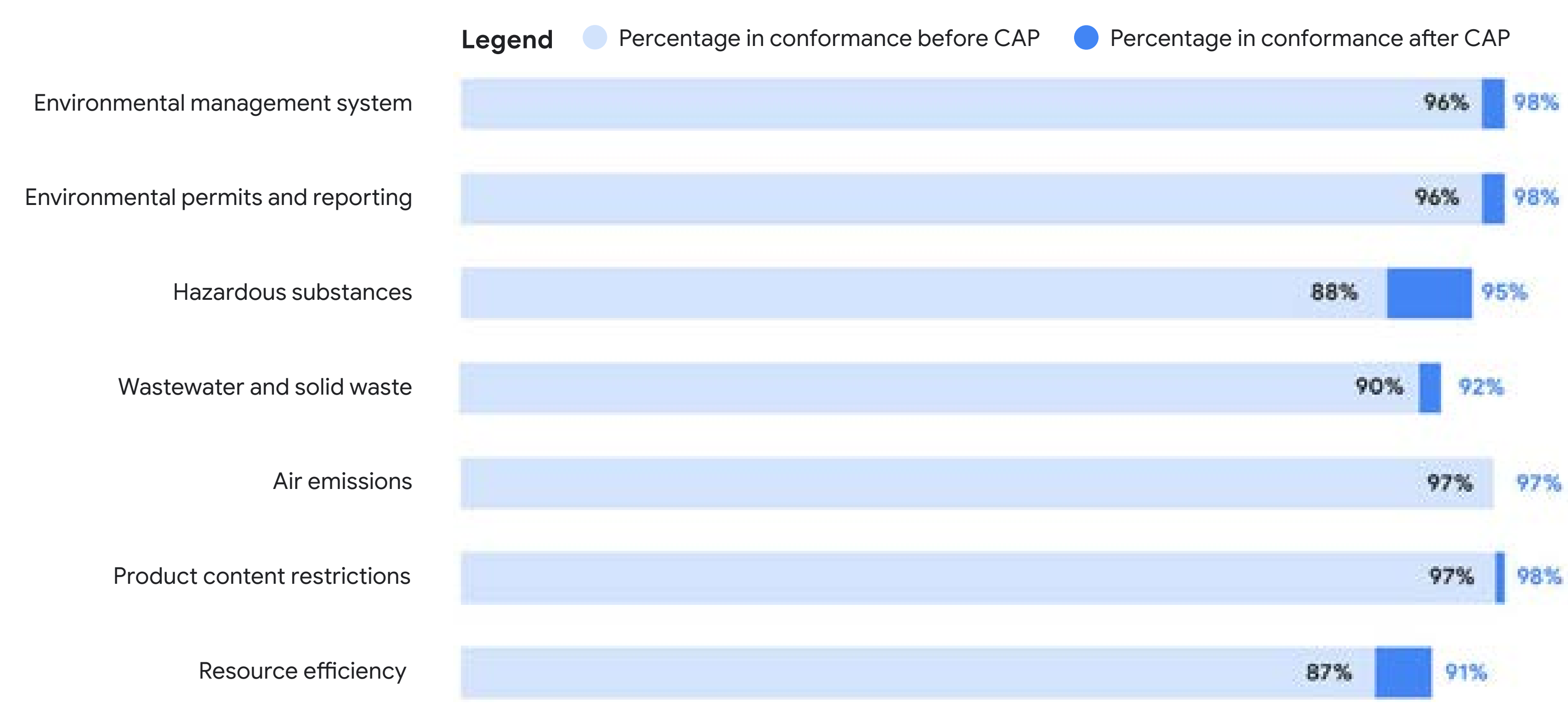
Google's Supplier Code of Conduct includes requirements that enable us to ensure that those we partner with are responsible environmental stewards. Along with having suppliers evaluate their operations, we perform our own ongoing due diligence and audits to verify compliance and to understand our supply 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 2023, we audited a subset of our suppliers to verify compliance for various environmental criteria (see Figure 29):

FIGURE 29 **2023 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 (CAP) process was completed.



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. See Figure 30 for our key positions on sustainability policy issues and Figure 31 for a detailed list of our sustainability policy engagements in 2023.

FIGURE 30 **Our sustainability policy positions**

Climate	Carbon-free energy	Accelerating climate-action with AI	Device repairability
See Our position on climate policy	See A policy roadmap for 24/7 carbon-free energy	See Accelerating climate action with AI	See Google & repairability

FIGURE 31 **Google's policy engagements in 2023**

Global and cross-cutting initiatives

Advanced clean electricity technologies	Google published a paper that highlights the importance of quickly commercializing advanced clean electricity technologies alongside the rapid growth of solar and wind. The paper outlines how corporate clean energy buyers can drive this progress by supporting favorable policies, signing long-term purchase agreements, and providing early-stage project funding.
Accelerating climate action with AI	We released a report with Boston Consulting Group which discusses AI's potential to mitigate global GHG emissions and provides recommendations for how policymakers can enable deployment of AI for climate.
UNFCCC 28th Conference of the Parties (COP-28)	Google participated in COP-28, hosted by the United Arab Emirates government and the United Nations. Our delegation—including Ruth Porat (President & Chief Investment Officer; Chief Financial Officer), Kate Brandt (Chief Sustainability Officer), Yossi Matias (VP of Engineering & Research), along with a number of senior subject-matter experts—participated in nearly 200 engagements on the ground throughout the conference with public sector leaders from across the globe, advocating for greater climate ambition and showcasing the role AI can play in enabling mitigation and adaptation.
United Nations General Assembly (UNGA)	Google participated in the 2023 UNGA meetings in New York City, which marked the halfway point on the 15-year timeline to achieve the 17 UN SDGs. At UNGA, we showcased the role that AI and digital technology can play in helping partners achieve and track progress toward the SDGs.
Tripling global renewable energy capacity	We joined a letter calling for a global target to triple renewable energy capacity by 2030, which governments recognized in the COP-28 decision. We also joined a letter highlighting the role of corporate clean energy buyers in supporting this objective.
Founding sponsor of Catalyze program	We announced our role as a founding sponsor of the Schneider Electric Catalyze program, which aims to increase renewable energy access across the global semiconductor and IT value chains through supplier education and combined purchasing power.

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 Environmental Protection Agency to discuss the role of digital technology and AI in accelerating climate mitigation and adaptation.
FTC Green Guides	In response to the FTC's request for public comment on the Green Guides update, we filed comments encouraging the FTC to prioritize true and fair representations in environmental marketing claims—with scientific integrity and technical accuracy acting as a north star.
Federal Energy Regulatory Commission (FERC) Generator Interconnection final rule	In 2022, Google filed comments (initial and reply) on FERC's "Improvements to Generator Interconnection Procedures and Agreements (Interconnection) Notice of Proposed Rulemaking." FERC's final rule, issued in June 2023, acknowledged Google input, including it as a basis for their actions on issues around transparency and study delays.
Western energy market expansion	In September 2023, Google submitted comments to FERC supporting California Independent System Operator's (CAISO) proposal to expand its energy market across the Western Interconnect—an important step toward a western Regional Transmission Organization. FERC accepted CAISO's proposal in late December, citing our comments in their final order.
FERC transmission expansion and cost management	In March 2023, Google submitted comments to FERC regarding the cost of transmission projects, a significant challenge for our portfolio. Our comments advocated for policies that balance strong oversight of transmission project spending with the need for timely grid expansion.
Engagement with coalitions and sustainability initiatives	
Electricity customer coalitions	We collaborated with partners across tech and traditional commercial and industrial sectors to drive customer-centric campaigns like the Electricity Customer Alliance (ECA) and Western Freedom. This effort included ECA's first-ever FERC filing in March 2023, which brought together state officials, trade associations, and think tanks to highlight the importance of transmission infrastructure for meeting load growth, economic development, and corporate sustainability goals.
U.S. state engagement	
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 and the National Association of State Energy Officials to discuss how Google's 24/7 CFE goal can be a supportive framework to drive cost-effective grid decarbonization.
Right to Repair	We affirmed our support for the "Right to Repair" movement, advocating for legislation like the proposed bill introduced in Oregon and publishing a white paper outlining our approach to repair issues. This paper provides a set of principles for policymakers to consider when creating regulations.
Climate-related disclosures	We shared our public support for California's climate-related disclosure legislation (SB-253 and SB-261). These bills would require disclosure of Scope 1, 2, and 3 emissions by large U.S. companies doing business in the state, along with climate-related financial risk reports.

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 standardized energy and sustainability reporting framework for data centers and establish measures to encourage greater reuse of waste heat.
Renewable Energy Directive	Google worked through DIGITALEUROPE and RE-Source to advocate for the inclusion of time-stamping for Guarantees of Origin in the EU Renewable Energy Directive—enabling hourly CFE matching and greater transparency of clean energy claims.
European electricity market redesign	We shared views on the future of European electricity market design in response to an EU consultation, advocating for measures that support corporate clean energy procurement and drive European grid decarbonization. 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.
EU 2040 climate targets	In response to the EU Commission's consultation on the EU's 2040 climate targets, we reaffirmed our support of EU climate leadership. Our submission outlines how technology can drive climate action and shares policy recommendations for achieving climate neutrality by 2050.
Google Climate Summits in Brussels, Germany, France, Sweden, and Switzerland	Across five different events throughout the year, we hosted hundreds of leaders—including policymakers, members of Parliament, journalists, and decision-makers from business, NGOs, and academia—for a series of discussions focused on the role of technology and AI in addressing the climate crisis.
DIGITALEUROPE report on energy digitalization	We contributed to a report by our trade association, DIGITALEUROPE, highlighting how digital technology can accelerate energy sector decarbonization. The report features three Google case studies (data center cooling, Nest, and Google/ENGIE on wind energy deployment) and has been shared with EU policymakers and the International Energy Agency (IEA).
Germany data center energy efficiency	We worked constructively with the German government on their Energy Efficiency Bill. Our technical deep dives into waste heat recovery at our data centers—a key feature of our first Google-owned Germany data center in Hanau—informed these discussions.
Implement Consulting regional reports	In 2022, we commissioned Implement Consulting Group's Digital Decarbonisation report, which demonstrated that digital solutions are essential to achieve 20–25% of the GHG reductions needed for a net-zero EU economy. In 2023, we expanded this study with country-specific reports for Sweden, Germany, Belgium and Denmark—outlining how targeted digital solutions can accelerate climate action in each country.

Engagement with coalitions and sustainability initiatives	
RE-Source Platform	In 2023, we worked with RE-Source to advocate for a stronger role for corporate clean energy buyers within Europe's evolving Electricity Market Design. These efforts led to the adoption of new measures promoting PPAs and improving renewable energy access for smaller buyers.
European Green Digital Coalition	We helped develop a methodology for measuring the net environmental impact of information communication technology (ICT) solutions. We also participated in EGDC-led panel discussions at COP-28 and the GeSI Digital with Purpose Summit.
Sustainability partnership with European Aviation Safety Agency	We announced a partnership with the EU Aviation Safety Agency (EASA) to develop standardized aviation emissions estimates. This will provide travelers consistent and reliable flight emissions estimates available through airline partners.
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.

Asia Pacific

ASEAN electricity grid regionalization paper	The Asia Clean Energy Coalition (ACEC), of which Google is a founding member, launched a paper, supported by Google, advocating for accelerated regional grid integration within ASEAN. This paper highlights the economic, energy security, and clean energy benefits of regional electricity markets.
Asia-Pacific Economic Cooperation (APEC)	We participated in the APEC Economic Leaders Week in San Francisco, California, to showcase the role of AI and digital technology in accelerating climate action in the Asia-Pacific region. We also participated in the APEC Energy Ministerial in Seattle, Washington, to discuss the role of corporate clean energy purchasing in helping accelerate grid decarbonization and meeting APEC member state climate goals.
Temasek Ecosperity and Asia Tech x Singapore (ATxSG) Summit	We engaged policymakers and private sector stakeholders in conversations about the critical role of data, digital infrastructure, and green computing in sustainability. These discussions centered on the nexus between technology and sustainability, as global demands on computing power and AI increase globally.
Asia Action Summit	We sponsored and co-hosted a closed-door roundtable with Climate Group on democratizing access to high-quality granular energy data to advance power system decarbonization. Moderated by the IEA, this event brought together key stakeholders—including energy producers, consumers, data providers, researchers, and governments—to discuss opportunities in the Asia-Pacific region and develop a call-to-action for policymakers to facilitate greater access to energy data.
ASEAN Energy Business Forum (AEBF)	We participated in AEBF and worked closely with the Asia Clean Energy Coalition (ACEC) to organize a session on accelerating power grid interconnectivity, as well as expressed support for strengthening the current Memorandum of Understanding on the ASEAN Power Grid.
Singapore International Energy Week (SIEW)	Our participation in SIEW's Energy Insights panel and TechTable session highlighted our energy thought leadership and commitment to achieving 24/7 CFE in the Asia-Pacific region.

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. See Figure 32 for an overview of our participation in these groups, and consult our CDP Climate Change Response for additional details.

We're members of the U.S. Chamber of Commerce, Business Roundtable, and other business trade associations where we're engaged in climate and energy policy issues. For example, we're founding members of the Chamber's Task Force on Climate Actions, and we've engaged within the Task Force since its inception to support constructive engagement by the Chamber on climate policy to create a low-carbon economy. We also participate in staff-level discussions on the Business Roundtable's Energy and Environment committee.

We respect the independence and agency of trade associations and third parties to shape their own policy agendas, events, and advocacy positions. Our sponsorship or collaboration with a third-party organization doesn't mean that we endorse the organization's entire agenda, its events or advocacy positions, or the views of its leaders or members. We assess the alignment of our trade association participation with the goals of the Paris Agreement, and engage within organizations to support advocacy for climate policies needed to limit warming to 1.5°C and create a prosperous and competitive low-carbon economy. We're in dialogue with our trade associations to encourage alignment between our core public policy objectives and their policy advocacy activities, including on climate change.

FIGURE 32 **Select list of Google's participation in sustainability-focused trade associations, memberships, and groups**

- Advanced Energy Buyers Group
- Advanced Energy United
- Advanced Power Alliance
- Alliance to Save Energy
- American Clean Power Association
- American Council on Renewable Energy
- Americans for a Clean Energy Grid
- Asia Clean Energy Coalition
- Business Alliance to Scale Climate Solutions
- Business Environment Leadership Council of the Center for Climate and Energy Solutions
- Cambridge Institute for Sustainability Leadership
- Carolinas Clean Energy Business Association
- Clean Air Task Force
- Clean Energy Buyers Alliance
- Clean Energy Demand Initiative
- Clean Grid Alliance
- Conservation Voters of South Carolina
- Corporate Eco Forum
- Data Center Coalition
- DIGITALEUROPE
- Energy Alabama
- Energy Storage Association
- Energy Systems Integration Group
- Energy Tag
- Eurelectric
- Fusion Industry Association
- GeSI
- Japan Climate Leaders Partnership
- Keystone Energy Board
- Long Duration Energy Storage Council
- Marktoffensive Erneuerbare Energien
- North Carolina Sustainable Energy Association
- Peak Load Management Alliance
- Princeton ZERO Lab
- RE100
- Renewable Northwest
- RE-Source Platform
- Resources for the Future
- Solar Energy Industries Association
- SolarPower Europe
- Trellis Network
- U.S. EPA Green Power Partnership
- Utah Clean Energy
- We Are Still In
- WindEurope


A green wall at our inaugural Google European Sustainability Summit in Brussels.

Partners

Google partners with many organizations to accelerate progress toward shared sustainability goals. Examples of some key partnerships are listed below (see Figure 33).

FIGURE 33

Key partnerships

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.
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. In 2023, the program was expanded into eThekwini, South Africa with grant support from Google.org. C40 is a strategic partner of Google's Environmental Insights Explorer.
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	In addition to reporting our carbon footprint to CDP since 2009, Google partnered with CDP to host its annual conference, host a hack-a-thon, and launch CDP scores in Google Finance, making corporate carbon disclosure information more widely available.
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. In 2022, Google.org provided a $1 million grant to the Clean Energy Buyers Institute to support CEBA's international expansion.
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 AI's role 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 their satellite data analysis, map leaks from oil and gas infrastructure around the globe, and put methane insights into the hands of scientists and decision-makers.
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.
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 EU, harnessing the emission-reducing potential of digital solutions for all other sectors, and supporting green and digital transformations in the EU.
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 toward net-zero emissions by no later than 2050. In 2023, Google co-hosted Solutions House during Climate Week NYC with ERI and Futerra to engage innovators and solutionists around climate action.
Frontier	In 2022, Google committed $200 million to Frontier, an advance market commitment that will accelerate the development of carbon removal technologies by guaranteeing future demand. As one of its founding members, we're helping to guide overall strategy and governance.
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. Today, 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 capacity globally by 2030 and have supported efforts to encourage high-impact corporate clean energy purchasing as a key strategy to accelerate progress toward this goal.
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 with data and insights from EIE.
International Energy Agency (IEA)	We've partnered with the IEA on multiple energy-related projects. In 2022, we sponsored research by the IEA on advancing decarbonization through clean electricity procurement and we launched a Search feature based on IEA data designed to inform people about the energy crisis in Europe and provide energy-saving tips. In 2023, we again leveraged IEA data for new Search features on electric vehicles and home heating. In February 2024, Google participated in the IEA Ministerial Meeting and 50th Anniversary in Paris, France.
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.
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 their technical teams and exploring ways to convene businesses. In 2022, to activate industry-wide change, Google provided anchor funding to kickstart the ReFED Catalytic Grant Fund, which selected as grantees 10 organizations working to accelerate and scale food waste solutions.
The Nature Conservancy (TNC)	Google has supported TNC on watershed projects in Chile and the United States. Separately, Google.org supported a three-phased approach to catalyze active reforestation of kelp at impactful scales. Google.org also provided a grant to TNC to develop a machine-learning-powered timber-tracing API to stop deforestation in the Amazon at scale. A team of Google engineers worked full-time for six months with TNC to develop this product as part of the Google.org Fellowship Program.
Net Zero Innovation Hub for Data Centers	In 2023, Danfoss, Google, Microsoft, and Schneider Electric—together with the Danish Data Center Industry—launched the Net Zero Innovation Hub for Data Centers, a pan-European consortium located in Denmark designed for cross-industry collaboration on decarbonizing the data center industry and ensuring grid stabilization.
Net Zero Public Data Utility (NZPDU)	Together with Insomniac Design and CyBourn, Google supported the design and build of the NZPDU proof of concept, which is based on recommendations from the Climate Data Steering Committee. Hosted on Google Cloud and launched in 2023 at COP28, the NZDPU proof of concept aims to be a freely available, global repository of company-level climate transition-related data, allowing users to easily access and interpret a core set of data that's crucial to realizing the net-zero transition.
United Nations Food and Agriculture Organization (UN FAO)	Since 2015, Google and the UN FAO have partnered on the monitoring of forests, natural resources, livelihoods, and the environment.
United Nations Environment Program (UNEP)	In collaboration with UNEP and the European Commission Joint Research Centre, Google launched the Freshwater Ecosystems Explorer—a platform that enables all countries to freely measure and monitor freshwater resources (toward Sustainable Development Goal 6.6.1), as well as when and where surface water is changing.
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, influencing consumer behavior change, and supporting regenerative agriculture.
World Economic Forum (WEF)	Google partners with WEF on various initiatives, including: the First Movers Coalition, which Google joined at WEF's annual meeting in 2022; Google's Chief Sustainability Officer participates in WEF's Chief Sustainability Leaders Community and is a co-chair of WEF's Global Future Council on the Future of Net Zero Living; Google is an active member of WEF's Tech for Climate Adaptation initiative, which launched the report Innovation and Adaptation in the Climate Crisis in 2023; Google is a member of WEF's Alliance for Clean Air; and, Google.org is a member of WEF's Giving to Amplify Earth Action (GAEA) initiative that convenes public, private, and philanthropic partnerships for climate and nature.
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.

Multi-sector products

While many of our products focus on reducing emissions within their respective sectors, others offer a more holistic approach. These solutions empower our customers and partners to make climate-conscious decisions that support both adaptation and mitigation across various industries.

Google Cloud

Google Cloud offers organizations 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.

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 (a geospatial solutions company), 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. This effort includes helping companies like Unilever build a more holistic view of the forests, water cycles, and biodiversity that intersect its supply chain. And Regrow—a technology company that helps its customers measure, manage, and reduce on-farm emissions—is using Earth Engine and advanced machine learning models to monitor 1.2 billion acres of land globally.

Grow
We help organizations use AI to find new growth opportunities and markets in the low-carbon transition. For example, we launched SpatiaFi with our Cloud partner Climate Engine to help the banking sector harness the power of geospatial analytics to support climate finance.

Build
We help developers reduce the carbon footprint of their cloud-based applications. We've created a suite of products in our 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 and Active Assist). We've also put together the Go Green Software guide, which provides a comprehensive overview of how to build software that uses energy more efficiently.

Google Earth

Google Earth has democratized geospatial information for a wide range of users. It renders a 3D representation of Earth by superimposing satellite images, aerial photography, and GIS data onto a digital globe, allowing people to explore our planet from endless vantage points.

Businesses utilize its layers to analyze potential renewable energy sites and optimize logistics, while governments rely on it for urban planning and emergency response. Researchers track deforestation patterns, explore ocean depths, and visualize complex scientific models. Citizens use Google Earth to travel the world virtually, discover local landmarks, and gain a new perspective on our planet. Its vast collection of images and data paints a comprehensive picture of the Earth's surface and its history.

Timelapse in Google Earth is a global, zoomable video that provides a clear picture of Earth's dynamic change since 1984, illustrating the planet's transformation. Timelapse shows climate change in action, as well as beautiful natural phenomena that unfold over decades. Timelapse is being used in partnership with other technologies and programs to empower everyone to take climate action across our planet's cities, oceans, and forests.

Google Earth can even illuminate potential solutions to ecological problems—revealing suitable terrain for solar arrays, providing context for conservation efforts, and facilitating discussions about responsible development. Its insights empower decision-makers to create more sustainable strategies for the future.

Google Earth Engine

Launched in 2010, scientists, researchers, and developers have been using Google Earth Engine—Google's planetary-scale platform for Earth science data and analysis—to detect changes, map trends, and quantify differences on the Earth's surface.

The tool offers over 1,000 Earth observation datasets with powerful cloud computing to show timely, accurate, high-resolution insights about the state of the world's habitats and ecosystems—and how they're changing over time. In 2023, over 100,000 users regularly used Google Earth Engine's data analytics and computing for research and educational purposes. In 2022, Google Earth Engine partnered with Google Cloud Platform to enable commercial use, giving businesses and governments worldwide access to up-to-date insights on how our planet is changing.

Google Earth Engine empowers a wide range of stakeholders with sustainability insights. Powered by Google Earth Engine, the United Nations FAO supports countries with forest monitoring to reduce deforestation-related emissions. OpenET uses Google Earth Engine to power science-based evapotranspiration (ET) models that provide vital agricultural water usage data in the western United States, aiding efficient water management. MapBiomas contributes to Brazilian conservation with detailed land-use mapping powered by Google Earth Engine, and the UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) uses the platform to monitor ecological integrity and assist nations with biodiversity planning. Google Earth Engine's unique ability to process massive geospatial datasets at scale provides these organizations with the insights needed to drive environmental impact.


A view of our planet from Google Earth ©2020 Landsat / Copernicus

Ecosystems for collaboration

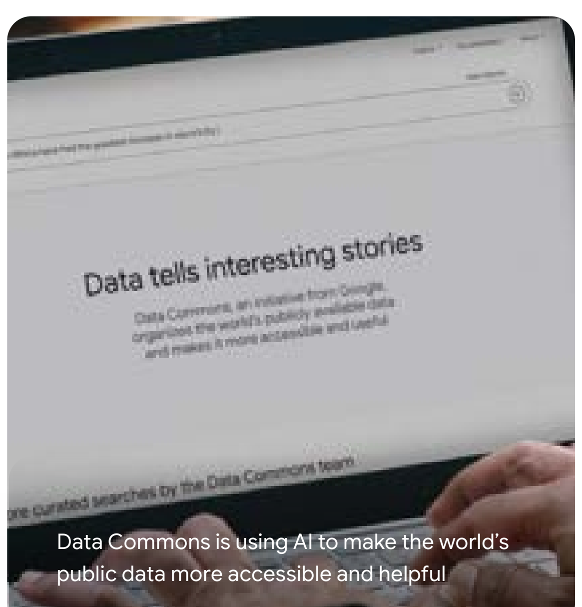
Data Commons

Every moment, all around the world, governments, organizations, and many others are generating data on topics as widely varied as temperature, agricultural production, or groundwater levels.

This sustainability data, even if publicly available, is fragmented across thousands of silos, in many formats and schemas, and across a multitude of databases rendering it difficult to access and use.

In 2017, we started the Data Commons project, which aggregates data from a wide range of publicly available sources, like from governments and nonprofits, into a unified database to make it more accessible and useful.

Data Commons was developed by Google to organize sustainability data from hundreds of publicly available sources—from the United Nations' Intergovernmental Panel on Climate Change (IPCC) to the Brazilian Institute of Geography and Statistics to the U.S. Department of Commerce—and makes this data available to policymakers, researchers, nonprofit organizations, journalists, students, and anyone trying to better understand societal issues and find solutions.



Data Commons is using AI to make the world's public data more accessible and helpful

Today, Data Commons is one of the world's largest public knowledge graphs on sustainability and includes data about climate, health, food, crops, shelter, emissions, and more. Our APIs are open and free to anyone to build new tools. For enterprise customers, this data is available via Data Commons on the BigQuery Analytics Hub, via Python Collaborative Notebooks, and even via embeddable widgets you can include on your article or webpage.

The ability to analyze a multitude of publicly available datasets with Data Commons has allowed it to be used to monitor and address a variety of sustainability challenges, including helping track progress toward the UN Sustainable Development Goals, understanding the state of climate progress at COP-28, and exploring how farming regions will be impacted by climate change.

Last year, Data Commons started harnessing the power of AI—specifically large language models—to create a natural language interface that allows people to ask questions like, "Which countries in Africa have had the greatest increase in electrification?," "What are the greenhouse gas emissions from these places?," and "How do these places compare with the United States and Germany?"

By investing early in technologies aimed at tackling sustainability challenges like climate change through initiatives such as Google for Startups and Startups for Sustainable Development, we have the potential to move the needle on sustainability and positively impact our planet.

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 build a more circular economy.

Google for Startups Accelerators are 10-week programs designed to bring the best of Google's programs, products, people, and technology to Seed to Series A technology startups. In addition to mentorship and technical project support, Google for Startups Accelerator programming focuses on product design, customer acquisition, and leadership development for participating founders.

- **Google for Startups Accelerator: Climate Change:** Since launching the program in 2021, we've hosted six climate accelerators across five continents, which have collectively supported 68 startups that report they've raised over $800 million in funding. The first two cohorts included 21 climate-focused startups in North America. In 2023, in addition to hosting another North American accelerator, we expanded this program to Europe, in partnership with Google Cloud, as well as to Latin America and the Middle East and Africa.
- **Google for Startups Accelerator: Circular Economy:** This program focuses on supporting startups in North America and the Asia-Pacific region working on challenges related to advancing a more circular economy—from food waste to fashion, recycling, and reuse—via advanced technologies including AI. In 2023, we supported startups through a 10-week curriculum complete with guidance from Google and industry leader mentors. These 11 participating startups report they've raised over $46 million in funding.

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.

The program now supports more than 500 startups in over 70 countries, working with a network of over 180 partner organizations.


Googlers working and collaborating in an office in New York City.

Google.org grantees

Google.org— Google's philanthropy—supports nonprofits, civic entities, and other organizations that address humanitarian issues worldwide. We empower these organizations with a unique blend of funding, in-kind donations, and technical expertise from Google employees—supporting scalable, data-driven solutions to global challenges with the potential to produce meaningful change.

Helping to pilot and scale AI solutions for sustainability

A key focus of Google.org is supporting efforts to accelerate climate action. We do this by leveraging technology and data, especially AI and machine learning, to support the creation of free, open-sourced tools and datasets for the global community. In 2023, we granted more than $67 million to social impact organizations for projects that leverage AI to build a more sustainable world, including through two open-call funding programs launched in 2022—the Google.org Impact Challenge on Climate Innovation and AI for the Global Goals.

The Google.org Impact Challenge on Climate Innovation provided $30 million to support breakthrough projects that use information, innovation, and AI to accelerate climate action. Selected organizations received funding to scale their activities, along with access to Google's technical expertise to help them maximize their impact. Over 800 organizations applied to the program, and we were impressed with the quality and ambition of ideas submitted. Climate adaptation was the most represented submission topic, matching an urgency to support those most affected by climate change, while nearly half of the submissions directly targeted impacts in the Global South.

In 2023, as part of this program, Google.org provided $5 million to World Wildlife Fund (WWF) to support ManglarIA—"AI for Mangroves." Through this project, WWF is using AI to analyze data about mangrove forests in Mexico. This work will provide conservationists around the world with the tools and information they need to conserve and restore these vital ecosystems in a changing climate. The Woodwell Climate Research Center was another program recipient, receiving $5 million in 2023 to develop a near real-time tracking system for Arctic permafrost thaw with the Permafrost Discovery Gateway. This project will help researchers, nonprofits, and others forecast seasonal permafrost thaw and estimate associated carbon release. Additionally, some Google employees will provide full-time pro-bono support for six months through the Google.org Fellowship Program, working alongside the Woodwell team to help build scalable machine learning workflows and data tools.

Technology will be a vital tool to help meet global goals like the Global Methane Pledge, which aims to reduce methane emissions by 30% by 2030. In 2023, Google.org provided more than $8 million to organizations working on methane mitigation solutions through expanded support of the Global Methane Hub.

- As part of the Google.org Impact Challenge on Climate Innovation, $5 million will support the development of WasteMAP—a platform consolidating satellite information on landfill methane emissions. WasteMAP will empower local governments and nonprofits to pinpoint methane sources, allowing them to take action and mitigate emissions before they become hazardous.
- To expand our support of methane reduction beyond the Google.org Impact Challenge, $3.25 million will support the UNEP International Methane Emissions Observatory to develop a new AI-based system for detecting methane emissions. This system will automatically detect, alert, and notify governments and corporations about their methane emissions, empowering them to take action.

In 2023, Google.org announced the 15 projects selected for the AI for the Global Goals program, a $25 million commitment to support innovative AI-driven approaches that accelerate progress on the UN SDGs. Among the 15 supported organizations, three projects accelerated environmental progress specifically. This effort includes DHI A/S, which received $2 million to develop machine learning models to accurately monitor wetlands globally, in partnership with UNEP.

Beyond our work with the Google.org Impact Challenge on Climate Innovation and AI for the Global Goals, we provided an additional $30 million in 2023 to other AI-based sustainability and climate action projects.

Supporting grassroots innovation

As of 2022, Google.org provided more than $9 million in funding to the Windward Fund to launch the Environmental Justice Data Fund (EJDF). This fund seeks to address the disproportionate climate and environmental impact on frontline communities that have been historically underserved. Announced in 2023 at COP-28, Google.org expanded its funding for the EJDF by more than $3.5 million. This additional support is dedicated to addressing air quality, water quality, and environmental hazards faced by frontline communities.

The Asia-Pacific region—particularly its low-lying and small island countries—is exceptionally vulnerable to climate change. Local organizations are at the forefront of developing sustainable practices and combating impacts, such as heat waves, rising sea levels, and biodiversity loss. Google.org's support for the Asia Venture Philanthropy Network's (AVPN) APAC Sustainability Seed Fund began in 2022 with a $3 million grant to support 13 local organizations focused on underserved communities in the region. In 2023, we expanded this support with an additional $5 million grant for the APAC Sustainability Seed Fund 2.0. This work is also supported by the Asian Development Bank (ADB), which acts as the strategy and outreach partner for the fund.

Calling on others

Google.org actively champions increased corporate philanthropy for innovation in the nonprofit and social impact sectors, and we'll continue encouraging other private actors to join these efforts. Our open-call programs clearly demonstrate strong interest from the social impact and social enterprise sectors to use AI to tackle the climate crisis. Corporate philanthropy has the opportunity to play an important role in catalyzing innovation and impact by providing the risk capital and non-financial resources that organizations need for bold experimentation. That's why we partnered with the WEF's Giving to Amplify Earth Action initiative and joined a community of like-minded corporate philanthropies and leading foundations to help launch the Corporate Philanthropy Challenge for People and Planet, with the shared goal of mobilizing $1 billion in catalytic capital for climate and nature solutions by 2030.


The Google.org Impact Challenge on Climate Innovation supports breakthrough projects that use data and technology to accelerate climate action.

Environmental data

Report scope

The reporting period for our environmental data covers our fiscal year January 1, 2023, through December 31, 2023. Most of our environmental data covers Alphabet Inc. and its subsidiaries. All reported data is global and annual unless otherwise specified.

Data measurement and uncertainty

All reported values represent the best data available at 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 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.

Recalculation of previous environmental metrics

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 target. Updates may include structural changes, calculation methodology updates, the inclusion of additional activity data, improvements in the accuracy of emission factors or activity data, and the correction of errors. 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.

In line with our recalculation policy, in 2023 we recalculated certain previously reported metrics, including our GHG emissions for our 2019 base year and interim years presented where the impact was deemed significant. See our Environmental data table endnotes for more information on which metrics and years were recalculated. The changes primarily included:

- We recalculated Scope 1 and Scope 2 (market-based) emissions to include fugitive emissions from refrigerant leakage.
- Scope 3 emissions:
  - We revised our methodology to calculate emissions related to our consumer devices manufacturing, as we migrated from a spend-based methodology to a Life Cycle Assessment-based methodology.
  - We made improvements to the quality of data used in estimating our emissions associated with manufacturing our equipment used in our technical infrastructure, that include supplier-specific data; as well as the LCAs and LCA emission factors used to calculate emissions related to data center construction.
  - We included two additional Scope 3 categories to our GHG emissions inventory—Category 3 and Category 5—and added these two categories to our reported historical inventories.
  - To enhance transparency, we now present "Category 1: Purchased goods and services" separately in our Environmental data tables. In previous years, emissions generated from manufacturing consumer devices were presented in "Category 2: Capital goods" while emissions from our food program were presented in "Other categories." Now, both are included in Category 1.
  - In addition, we began calculating emissions generated from remaining goods and services purchased for our operations, and have included these emissions in the newly presented Category 1.

We continually review emissions calculation methodologies and are committed to implementing best practices.

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 data tables. Ernst & Young LLP reviewed these metrics within the Schedules of Select Environmental Indicators for the fiscal year ended December 31, 2023 and the Schedule of Base Year GHG Emissions (including Recalculation) for the fiscal year ended December 31, 2019. For more details, see our 2024 (FY2023) Independent Accountants' Review Report.

Methodology

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 data tables. These metrics have been rounded as described below. Due to rounding, some of our reported values for prior years don't directly match the related Independent Accountants' Review Reports from those years.

Greenhouse gas emissions

GHG emissions reporting standards

GHG emissions are calculated according to the Greenhouse Gas Protocol standards and guidance developed by the WRI and the WBCSD, including A Corporate Accounting and Reporting Standard (Revised Edition), Scope 2 Guidance, and Technical Guidance for Calculating Scope 3 Emissions (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. We define operational control as having the authority to introduce and implement operational policies over an asset, and we report all energy and emissions for Alphabet Inc. and its subsidiaries' data centers, offices, and other assets under our operational control ("Global Facilities").

Our Scope 1 and Scope 2 emissions include four of the seven GHGs addressed by the Kyoto Protocol—carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and hydrofluorocarbons (HFCs). Other GHGs, including perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3), aren't included in our inventory, as they're not emitted as a result of our operations. We report emissions both in the unit of metric tons per gas (i.e., tCO_2, tCH_4, tN_2O, and tHFCs) 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 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).

We source the global warming potentials (GWP) for each GHG from the IPCC Fourth Assessment Report, Appendix A: Global Warming Potentials (AR4), and IPCC Fifth Assessment Report (AR5) in select instances.

Scope 1 GHG emissions

Scope 1 GHG emissions are direct emissions from sources such as company vehicles or generators at our offices and data centers. They represent direct emissions from owned Global Facilities, 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 square footage of Global Facilities 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 taking an average of GWP values from known refrigerants within our portfolio and leakage rates at Global Facilities.

The emission factors used to calculate Scope 1 emissions include the 2017 WRI/WBCSD GHG Protocol Emission Factors from Cross Sector Tools, the 2023 EPA Center for Corporate Climate Leadership GHG Emission Factors Hub, 2023 Climate Registry Default Emission Factors, and the 2023 Department for Environment, Food and Rural Affairs (DEFRA) UK Government GHG Conversion Factors.

Scope 2 GHG emissions

Scope 2 GHG emissions are indirect emissions from: purchased electricity; natural gas use and refrigerant leakage in our leased offices; purchased steam, hot water, and chilled water from district energy systems. 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, namely our renewable energy purchases via contractual mechanisms like 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 square footage of Global Facilities 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 2017 WRI/WBCSD GHG Protocol Emission Factors from Cross Sector Tools, the 2023 EPA Center for Corporate Climate Leadership GHG Emission Factors Hub, the 2023 DEFRA UK Government GHG Conversion Factors, the 2023 IEA Emission Factors, the 2024 EPA eGRID Emission Factors, and the 2023 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. 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 GHG emissions

Scope 3 GHG emissions are indirect emissions from other sources in our value chain, such as our suppliers, the use of our consumer devices, and business travel. In 2023, we included two additional Scope 3 categories to our GHG emissions inventory—Category 3 and Category 5—and added these categories to our reported historical inventories. We calculate our Scope 3 GHG emissions using the Greenhouse Gas Protocol's Technical Guidance for Calculating Scope 3 Emissions (version 1.0), in 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, including teleworking
- Category 11: Use of sold products
- Category 12: End-of-life treatment of sold products

None of the Scope 3 categories have associated biogenic CO_2 emissions. For all reported Scope 3 categories, we report emissions according to their minimum boundaries listed by the Greenhouse Gas Protocol. For certain categories, we've also included activities which the Greenhouse Gas Protocol deems optional.

In our Environmental data tables, we present certain emissions from Category 2, Category 11, and Category 12 as an aggregated subtotal—"Other categories"—for business reasons, as described further below.

"Category 1: Purchased goods and services" includes upstream emissions generated from manufacturing consumer devices, our food program, and additional goods and services purchased for our operations. We use the hybrid method, as defined by the Greenhouse Gas Protocol. To calculate full supply chain emissions generated from manufacturing consumer devices, we perform third-party-verified Life Cycle Assessments (LCAs) in accordance with ISO 14040 and ISO 14044. To calculate emissions generated from our food program, we use LCA emission factors from WRI and annual procurement volumes from our offices. Where actual procurement volume data isn't available, we extrapolate calculated emissions to our other offices using building admittances. To calculate emissions generated from the remaining goods and services purchased for our operations we estimate supplier emissions using spend data and industry-average GHG intensities by commodity type.

"Category 2: Capital goods" includes upstream emissions generated from goods and services we purchase for our operations, including manufacturing and assembly of servers and networking equipment used in our technical infrastructure, as well as emissions from materials used in the construction of data centers and offices. We use the hybrid method, as defined by the Greenhouse Gas Protocol. For manufacturing and assembly of servers and networking equipment used in our technical infrastructure, we collect supplier GHG emissions data from our contract manufacturers, component suppliers, and fabless suppliers through the CDP Supply Chain Program. These suppliers represent our key "Tier 1" manufacturing suppliers with whom we have a direct relationship. Per GHG Protocol, a "Tier 1" supplier provides or sells goods or services directly to a company, while a "Tier 2" supplier provides or sells goods or services to the company's "Tier 1" supplier. Where actual supplier emissions data isn't available, we estimate supplier emissions using spend data, U.S. Environmentally-Extended Input-Output industry-average GHG intensities by commodity type, or other supplier GHG data. We calculate data center construction emissions by using an LCA analysis to derive construction emissions data and then applying this to our construction activity. In our Environmental data tables, we present emissions beyond our "Tier 1" manufacturing suppliers in "Other categories."

"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, calculated using the market-based Scope 2 total. We use the average-data method, as defined by the Greenhouse Gas Protocol. We calculate upstream emissions from purchased fuel, steam, heating, and cooling and emissions from transmission and distribution of steam, heating, and cooling, using 2023 DEFRA UK Government GHG Conversion Factors. We calculate emissions from upstream electricity by country using the 2023 IEA Emission Factors. We calculate emissions from electricity transmission and distribution losses using the 2023 IEA Emission Factors and, for the United States, the 2024 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).

"Category 4: Upstream transportation and distribution" includes emissions generated primarily from transportation and warehousing of our consumer products and data center equipment. We calculate this category's emissions to also include the optional activities of (1) upstream emissions of transportation, and (2) transportation of data center equipment to decommission locations (which is an optional activity under Category 5). We use a combination of the fuel-based, distance-based, and site-specific methods, as defined by the Greenhouse Gas Protocol. For transportation emissions, we collect data from our logistics providers. These WTW GHG emissions are calculated based on fuel use or weight-distance data and routing associated with a shipment. Where actual logistics provider emissions data isn't available, we estimate WTW emissions using weight and distance data by shipment collected from our providers, using emission factors from the 2023 Global Logistics Emissions Council (GLEC) framework 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 collect energy and refrigerant leakage data directly from the warehouses and calculate emissions using LCA electricity and fuel emission factors from the Sphera Professional database 2023 and refrigerant emission factors from the 2023 EPA Center for Corporate Climate Leadership GHG Emission Factors Hub. Where actual warehouse energy data isn't available, we estimate the energy using the 2018 Commercial Buildings Energy Consumption Survey (CBECS) data and the warehouse square footage allocated to Alphabet. Where actual warehouse refrigerant leakage data isn't available, we estimate refrigerant leakage based on the average leakage rate from available data.

"Category 5: Waste generated in operations" includes emissions from solid waste generated at our offices and data centers that 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 Greenhouse Gas Protocol. 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 2023 EPA Center for Corporate Climate Leadership GHG Emission Factors Hub for U.S. activity and the 2023 DEFRA UK Government GHG Conversion Factors for non-U.S. activity.

"Category 6: Business travel" includes emissions from business-related air, rail, bus, personal vehicle, taxi, rideshare, shuttle, and rental car travel, including emissions from relocation travel. We use a combination of the distance-, fuel-, and spend-based calculation methods, as defined by the Greenhouse Gas Protocol. We collect all travel data through either our online booking system or a third-party travel agency. We calculate emissions from air, rail, taxi, rideshare, non-U.S. personal vehicle, and non-U.S. shuttle travel using 2023 DEFRA UK Government GHG Conversion Factors. We calculate emissions from car rental, U.S. personal vehicle, and U.S. shuttle travel using emission factors from the 2023 EPA Center for Corporate Climate Leadership GHG Emission Factors Hub.

"Category 7: Employee commuting, including teleworking" 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 calculate this category's emissions to also include the optional activity of teleworking. We use the distance-based method, as defined by the Greenhouse Gas Protocol. We survey our employees to determine typical commuting and teleworking 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 2021 Fact Book and the U.S. Department of Transportation's 2022 National Household Travel Survey. We calculate employee commuting emissions using mode-specific emission factors from the 2023 EPA Center for Corporate Climate Leadership GHG Emission Factors Hub. We account for the home energy emissions generated by our full-time employees working remotely by applying the estimation methodology outlined in EcoAct's 2020 Homeworking Emissions white paper to our annual average teleworking workforce.

"Category 11: Use of sold products" includes downstream emissions generated by Google's flagship consumer devices sold in the reporting period. 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. We calculate emissions from these activities using laboratory power draw measurements, data on use patterns, common industry assumptions on product lifetimes, and LCA electricity emission factors from the 2023 Sphera LCA for Experts database. In our Environmental data tables, we present emissions from use of sold products in "Other categories."

"Category 12: End-of-life treatment of sold products" includes downstream emissions associated with the end-of-life treatment of Google's flagship consumer devices sold in the reporting period. We use the average-data method, as defined by the Greenhouse Gas Protocol. We calculate end-of-life emissions through our LCA process, using emission factors from the 2023 Sphera LCA for Experts database. Our annual assessments continue to identify this category to be one that doesn't have significant life-cycle impact. We continue to develop programs to extend the life of our sold products and also to ensure efficient management of end-of-life materials. In our Environmental data tables, we present emissions from end-of-life treatment of sold products in "Other categories."

Biogenic emissions

In accordance with the Greenhouse Gas Protocol, we report biogenic emissions separately from other Scope 1 GHG emissions. Our biogenic CO_2 emissions are generated from our operated vehicles and generators that consume biofuels. We calculate biogenic emissions using emission factors from the 2023 EPA Center for Corporate Climate Leadership GHG Emission Factors Hub.

Other carbon and energy metrics

We calculate our **carbon intensity metrics** as defined by GRI Disclosure 305-4a-c. Carbon intensity metrics are based on gross 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 MWh of energy consumed values to the nearest ten thousandth.

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 renewable sources. 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 company square footage and internally developed intensity factors based on data from the reporting period.

We calculate **electricity purchased from renewable sources (%)** on a calendar-year basis for our global operations by dividing the megawatt-hours of renewable electricity procured (i.e., through PPA contracts, on-site renewable energy generation, and renewable energy in the electric grids where our facilities are located) by the total megawatt-hours of electricity consumed. This metric includes all renewable energy purchased, regardless of the market in which we consumed the renewable energy. To achieve our 100% renewable energy match goal, we first consider both our on-site renewable energy 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 energy through PPAs and utility renewable energy tariffs. We have a few facilities located in geographies where we're not currently able to source large volumes of renewable energy, so we make up for this by procuring surplus renewable energy 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.

We calculate **Google CFE** as a percentage that measures the degree to which our electricity consumption on a given regional grid is matched with CFE on an hourly basis. This is calculated using both CFE under contract by Google (Contracted CFE) as well as CFE coming from the overall grid mix (Grid CFE). **Grid CFE** refers to the percentage of carbon-free energy sources consumed within a Regional Grid. Grid CFE is applied to Google's load for any hour where Google's Contracted CFE is less than the load. Grid CFE values are calculated by a third party, Electricity Maps.

We calculate **Contracted CFE** as a percentage of our load that's matched with CFE on an hourly basis due entirely to the CFE that we purchase, and without consideration of the CFE already on the grids where we operate. If Google's total Contracted CFE exceeds our load in a given hour and region, the contracted CFE consumed by Google is capped at the load; 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 over and 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 load in a given market that's matched with CFE from the grid after the application of Contracted CFE. For hours when Contracted CFE equals or exceeds our load, Consumed Grid CFE is equal to zero. If our Contracted CFE is less than our load in an hour, then the Consumed Grid CFE is calculated by applying the hourly Grid CFE percentage to the remaining load, and then dividing that product by the total load in that hour.

For more details on how we calculate **carbon-free energy** percentages, please see 24/7 Carbon-Free Energy: Methodologies and Metrics.

Water metrics

Global operational water
We report all operational water metrics for Alphabet Inc. and its subsidiaries' data centers, offices, and other assets under our operational control. Our reported water metrics exclude seawater. We round water metrics to the nearest hundred thousand gallons and report them in million 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.

Water discharge is based on actual metered or invoiced data when it's available. Where actual potable water discharge isn't available, we apply an industry-standard 90% discharge flow factor to a facility's water withdrawal to estimate water discharge. For irrigation water, we apply a 0% discharge flow factor to a facility's water withdrawal to estimate water discharge. We apply this estimation process to all offices and to potable and irrigation water withdrawal at data centers used for domestic purposes (i.e., water not used for IT cooling) where actual discharge data isn't available.

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, who 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.

Waste metrics

We report all waste metrics for Alphabet Inc. and its subsidiaries' data centers, offices, and other assets under our operational control.

We calculate **waste generated** by quantifying solid waste generated at our offices and data centers 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). The waste diversion rate for data centers includes Google-owned and -operated data centers and Google-owned warehouses. We round reported waste diversion metrics to the nearest one percent.

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. The information in this report may contain projections, future estimates, plans, expectations, goals, and other forward-looking statements. Forward-looking statements are based on current expectations and assumptions that are subject to certain risks and uncertainties, which could cause our actual results to differ materially from those reflected in the forward-looking statements. 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. Except as required by law, we undertake no obligation to correct, revise, or update any information included in this report.

Targets data table

This table summarizes our targets and progress as of December 31, 2023, compared to the prior year. See the Environmental data tables that follow for more details.

	Topic	Target	Unit	2022	2023	Target year	Learn more
Net-zero carbon	**Achieve net-zero emissions across all of our operations and value chain by 2030**						
	Carbon-free energy	Run on 24/7 carbon-free energy on every grid where we operate by 2030	% global average carbon-free energy	64%	64%	2030	See page 35
	Carbon reduction	Reduce 50% of our combined Scope 1, 2 (market-based), and 3 absolute emissions (compared to our 2019 base year) by 2030[181]	% reduction since 2019	30% increase	48% increase	2030	See page 31
Water stewardship	**Replenish more water than we consume and help improve water quality and ecosystem health in the communities where we operate**						
	Water replenishment	Replenish 120% of the freshwater volume we consume, on average, across our offices and data centers by 2030	% freshwater replenished	6%	18%	2030	See page 46
Circular economy	**Maximize the reuse of finite resources across our operations, products, and supply chains**						
	Data centers	Achieve Zero Waste to Landfill for our global data center operations	% of data centers at Zero Waste to Landfill[182]	See page 53	29%[183]	N/A	See page 53
	Offices	Divert all food waste from landfill by 2025	% food waste diverted	85%	82%	2025	See page 52
	Consumer hardware devices	Use recycled or renewable material in at least 50% of plastic used across our consumer hardware product portfolio by 2025	% recycled/ renewable material	41%	34%	2025	See page 54
		Make product packaging 100% plastic-free by 2025	% plastic-free packaging	96%	99%	2025	See page 55

Environmental data tables

GHG EMISSIONS

Emissions inventory	Unit	2019[1]	2020	2021	2022	2023	
Scope 1[2]	**tCO_2e**	**81,900**	**55,800**	**64,100**	**91,200**	**79,400**	✓
Scope 2 (location-based)	tCO_2e	5,116,900	5,865,100	6,576,200	8,045,400	9,252,900	✓
Impact of PPAs and market-based emissions factors[3]	tCO_2e	-4,281,400	-4,953,700	-4,753,100	-5,553,200	-5,829,500	✓
Scope 2 (market-based)[4]	**tCO_2e**	**835,500**	**911,400**	**1,823,100**	**2,492,200**	**3,423,400**	✓
Scope 3 (Category 1: Purchased goods and services)[5]	tCO_2e	2,676,000	2,249,000	2,828,000	3,762,000	4,038,000	
Scope 3 (Category 2: Capital goods)[6]	tCO_2e	2,378,000	1,886,000	1,983,000	1,645,000	1,605,000	
Scope 3 (Category 3: Fuel- and energy-related activities not included in Scope 1 or Scope 2)[7]	tCO_2e	381,000	462,000	686,000	916,000	1,186,000	
Scope 3 (Category 4: Upstream transportation and distribution)[8]	tCO_2e	508,000	464,000	484,000	556,000	584,000	
Scope 3 (Category 5: Waste generated in operations)[9]	tCO_2e	11,000	8,000	9,000	9,000	10,000	
Scope 3 (Category 6: Business travel)[10]	tCO_2e	369,000	97,000	26,000	211,000	283,000	✓
Scope 3 (Category 7: Employee commuting)[11]	tCO_2e	173,000	116,000	111,000	151,000	113,000	✓
Scope 3 (Other categories)[12, 13]	tCO_2e	2,258,000	2,318,000	2,761,000	2,784,000	2,993,000	
Scope 3 (total)[14]	**tCO_2e**	**8,754,000**	**7,600,000**	**8,888,000**	**10,034,000**	**10,812,000**	
Total emissions: Scope 1, 2 (market-based), and 3 (total)[15]	**tCO_2e**	**9,671,400**	**8,567,200**	**10,775,200**	**12,617,400**	**14,314,800**	
Biogenic emissions	tCO_2	21,900	5,400	3,800	17,900	18,700	✓

Assured for 2023 ✓

1 We recalculated select metrics related to our 2019 base year emissions, including Scope 1 emissions and Scope 2 market-based emissions, and obtained limited third-party assurance from an independent auditor for those select metrics. For more details, see our 2024 (FY2023) Independent Accountants' Review Report and the endnotes below.
2 2019-2021 Scope 1 and 2019 Scope 2 market-based emissions were recalculated primarily due to changes to the reporting boundary to include fugitive emissions from refrigerant leakage.
3 Due to recalculations, the following GHG emissions metrics were adjusted: 2019 Impact of PPAs and market-based emissions factors; 2019-2022 Scope 3 (total) emissions, 2019-2022 Total emissions; and all 2019-2021 Carbon intensity metrics.
4 See endnote 2 above.
5 To enhance transparency, we now present Category 1: Purchased goods and services emissions separately. In previous years, emissions generated from manufacturing consumer devices were presented in Category 2: Capital goods while emissions from our food program were presented in "Other categories." Now, both are included in Category 1.
6 2019-2022 Scope 3 (Category 2: Capital goods) emissions were recalculated primarily due to methodology updates for data center construction emissions to use LCAs and LCA emission factors.
7 In 2023, we expanded our Scope 3 reporting boundary to include two additional emissions categories and recalculated 2019-2022 to include this additional Scope 3 activity in our reported historical inventories: Category 3: Fuel- and energy-related activities and Category 5: Waste generated in operations.
8 2019-2020 Scope 3 (Category 4: Upstream transportation and distribution) emissions were recalculated primarily due to improvements in data accuracy.
9 See endnote 7 above.
10 2020 Scope 3 (Category 6: Business travel) emissions were recalculated primarily due to improvements in data accuracy.
11 2020 Scope 3 (Category 7: Employee commuting, including teleworking) emissions were recalculated primarily due to refinements to our calculation methodology.
12 We present certain Scope 3 emissions from Category 2, Category 11, and Category 12 as an aggregated subtotal "Other categories" for business reasons, as described further in the Methodology section.
13 2019-2022 Scope 3 (Other categories) emissions were recalculated primarily due to improvements to the quality of data used in estimating our emissions beyond our "Tier 1" manufacturing suppliers of our equipment used in our technical infrastructure, which include supplier-specific data.
14 See endnote 3 above.
15 See endnote 3 above.

GHG EMISSIONS

Carbon intensity[1]	Unit	2019	2020	2021	2022	2023	
Carbon intensity per unit of revenue	tCO_2e/million USD ($)	5.67	5.30	7.33	9.13	11.40	✓
Carbon intensity per FTE employee	tCO_2e/FTE	8.48	7.62	13.00	14.76	19.02	✓
Carbon intensity per megawatt-hour of energy consumed	tCO_2e/MWh	0.0717	0.0624	0.1012	0.1155	0.1352	✓

GHG EMISSIONS

		2023					
GHG emissions by type	**Unit**	**Scope 1**		**Scope 2 (market-based)**		**Scope 2 (location-based)**	
CO_2	tCO_2e	54,800	✓	3,388,000	✓	9,183,600	✓
CH_4	tCO_2e	200	✓	4,800	✓	16,900	✓
N_2O	tCO_2e	200	✓	11,300	✓	33,100	✓
HFCs	tCO_2e	24,200	✓	19,300	✓	19,300	✓
Total	**tCO_2e**	**79,400**	✓	**3,423,400**	✓	**9,252,900**	✓
CO_2	tCO_2	54,800	✓	3,388,000	✓	9,183,600	✓
CH_4	tCH_4	6	✓	200	✓	700	✓
N_2O	tN_2O	1	✓	38	✓	100	✓
HFCs	tHFCs	15	✓	13	✓	13	✓
GHG emissions by region	**Unit**	**Scope 1**		**Scope 2 (market-based)**		**Scope 2 (location-based)**	
North America	tCO_2e	54,600	✓	1,855,700	✓	6,864,600	✓
Europe, Middle East, & Africa	tCO_2e	11,300	✓	59,900	✓	752,400	✓
Latin America	tCO_2e	1,200	✓	16,200	✓	142,000	✓
Asia Pacific	tCO_2e	12,300	✓	1,491,600	✓	1,493,900	✓
Global total	**tCO_2e**	**79,400**	✓	**3,423,400**	✓	**9,252,900**	✓

ENERGY

		2023			
Electricity and renewable energy by region	**Unit**	**Total electricity**		**Total renewable energy allocated[2]**	
North America	MWh	18,535,300	✓	11,875,400	✓
Europe, Middle East, & Africa	MWh	3,547,200	✓	3,456,200	✓
Latin America	MWh	424,900	✓	336,200	✓
Asia Pacific	MWh	2,799,600	✓	4,100	✓
Global total	**MWh**	**25,307,000**	✓	**15,671,900**	✓

ENERGY

Energy consumption[3]	Unit	2019	2020	2021	2022	2023	
Fuel	MWh	366,400	181,800	205,200	374,800	301,200	✓
Purchased electricity[4]	MWh	12,226,200	15,125,700	18,238,400	21,685,300	25,252,600	✓
Purchased heat[5]	MWh	150,500	124,900	119,300	219,100	278,500	✓
Purchased steam	MWh	17,600	17,600	22,600	23,500	14,500	✓
Purchased cooling	MWh	34,900	34,800	45,600	54,800	53,000	✓
On-site renewable electricity	MWh	6,300	7,200	8,800	9,600	10,700	✓
Total energy consumption	**MWh**	**12,801,900**	**15,492,000**	**18,639,900**	**22,367,100**	**25,910,500**	✓

Electricity consumption	Unit	2019	2020	2021	2022	2023	
Total electricity consumption[6]	**MWh**	**12,237,200**	**15,138,500**	**18,287,100**	**21,776,200**	**25,307,000**	✓

ENERGY

		2023			
Energy consumption	**Unit**	**Renewable sources**	**Non-renewable sources**	**Total**	
Fuel	MWh	68,300	232,900	301,200	✓
Purchased electricity[7]	MWh	15,672,000	9,580,600	25,252,600	✓
Purchased heat[8]	MWh	0	278,500	278,500	✓
Purchased steam	MWh	0	14,500	14,500	✓
Purchased cooling	MWh	0	53,000	53,000	✓
On-site renewable electricity	MWh	10,700	0	10,700	✓
Total energy consumption	**MWh**	**15,750,900**	**10,159,600**	**25,910,500**	✓

RENEWABLE ENERGY

Energy consumption	Unit	2019	2020	2021	2022	2023	
Renewable energy contracts (cumulative)	MW	5,400	5,700	7,200	11,600	14,900[9]	
Renewable electricity (PPAs)	MWh	9,715,000	12,069,200	14,109,400	16,693,600	19,089,200	✓
Renewable electricity (on-site)	MWh	6,300	7,200	8,800	9,600	10,700	✓
Renewable electricity (grid)	MWh	2,515,900	3,062,100	4,168,900	5,073,000	6,207,100	✓
Total renewable electricity purchased	**MWh**	**12,237,200**	**15,138,500**	**18,287,100**	**21,776,200**	**25,307,000**	✓
Electricity purchased from renewable sources	**%**	**100**	**100**	**100**	**100**	**100**	✓

1 Due to recalculations, the following GHG emissions metrics were adjusted: 2019 Impact of PPAs and market-based emissions factors; 2019-2022 Scope 3 (total) emissions; 2019-2022 Total emissions; and all 2019-2021 Carbon intensity metrics.

2 "Total renewable energy 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.

3 The following Energy consumption metrics were recalculated primarily due to changes to the reporting boundary with the inclusion of additional activity: 2019-2022 Purchased steam and 2019-2022 Purchased cooling. Due to recalculation, 2019-2022 Total energy consumption was adjusted.

4 "Purchased electricity" is electricity sourced from an electrical grid and purchased from a local electric utility company. This metric differs slightly from "Total electricity consumption," which includes both purchased and self-generated electricity.

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

6 See endnote 4 above.

7 See endnote 4 above.

8 See endnote 5 above.

9 This figure represents primarily PPAs, and includes some generation capacity from targeted renewable energy investments where we also receive EACs.

Assured for 2023 ✓

CARBON-FREE ENERGY (CFE)

Global average CFE	Unit	2019	2020	2021	2022	2023
CFE across Google data centers (hourly)	%	61	67	66	64	64
CFE across Google offices (hourly)	%	-	-	-	54[1]	56
CFE across Google data centers and offices (hourly)	**%**	**-**	**-**	**-**	**64**	**64**

Regional average CFE across Google data centers	Unit	2019	2020	2021	2022	2023[2]
North America - East[3]	%	-	-	-	-	47
North America - Central[4]	%	-	-	-	-	91
North America - West[5]	%	-	-	-	-	63
Europe, Middle East, & Africa	%	-	-	-	-	83
Latin America	%	-	-	-	-	91
Asia Pacific	%	-	-	-	-	12
Global CFE across Google data centers	**%**	**-**	**-**	**-**	**-**	**64**

DATA CENTER GRID REGION CFE

			2023			
Country	Regional grid[6]	Unit	Google CFE	Contracted CFE	Consumed Grid CFE	Grid CFE %
Australia	Australian Energy Market Operator (AEMO), New South Wales (NSW)	%	33	0	33	33
Australia	Australian Energy Market Operator (AEMO), Victoria	%	40	0	40	40
Belgium	Elia	%	82	35	47	74
Brazil	Operador Nacional do Sistema Elétrico (ONS)	%	90	0	90	90
Canada	Hydro-Québec	%	100	0	100	100
Canada	The Independent Electricity System Operator (IESO)	%	87	0	87	87
Chile	Sistema Interconectado Central	%	91	75	16	61
Denmark	Energinet	%	92	43	49	86
Finland	Fingrid	%	98	77	21	92
France	Réseau de Transport d'Électricité (RTE)	%	94	0	94	94
Germany	Germany	%	90	73	17	64
Great Britain	National Grid ESO	%	92	76	16	65
Hong Kong	CLP Power Hong Kong Limited (CLP Power)	%	28	0	28	28
India	Northern India Regional Grid	%	29	0	29	29
India	Western India Regional Grid	%	14	0	14	14

DATA CENTER GRID REGION CFE

			2023			
Country	Regional grid[7]	Unit	Google CFE	Contracted CFE	Consumed Grid CFE	Grid CFE %
Indonesia	Perusahaan Listrik Negara (PLN)	%	13	0	13	13
Ireland	EirGrid	%	43	0	43	43
Israel	Israel Electric Corporation (IEC)	%	5	0	5	5
Italy	Terna	%	52	0	52	52
Japan	Kansai Electric Power Company (KEPCO)	%	30	0	30	30
Japan	TEPCO Power Grid (TEPCO)	%	16	0	16	16
Netherlands	Tennet	%	80	61	19	58
Poland	Polskie Sieci Elektroenergetyczne (PSE)	%	31	0	31	31
Qatar	Kahramaa	%	0	0	0	0
Saudi Arabia	National Grid SA	%	0	0	0	0
Singapore	Energy Market Authority of Singapore	%	4	0	4	4
South Africa	Eskom	%	16	0	16	16
South Korea	Korea Power Exchange (KPX)	%	35	0	35	35
Spain	Red Eléctrica	%	76	0	76	76
Switzerland	Swissgrid	%	92	0	92	92
Taiwan	Taiwan Power Company	%	18	1	17	18
United States	Bonneville Power Administration (BPA)	%	84	0	84	84
United States	California Independent System Operator (CAISO)	%	55	0	55	55
United States	Duke Energy Carolinas (DUKE)	%	63	11	52	59
United States	Electric Reliability Council of Texas (ERCOT)	%	79	61	18	41
United States	Midcontinent Independent System Operator (MISO)	%	95	93	2	34
United States	NV Energy (NVE)	%	26	0	26	26
United States	PacifiCorp East (PACE)	%	29	0	29	29
United States	PJM Interconnection (PJM)	%	52	19	33	41
United States	Salt River Project (SRP)	%	48	0	48	48
United States	South Carolina Public Service Authority (Santee Cooper)	%	29	6	23	24
United States	Southern Company (SOCO)	%	42	17	25	30
United States	Southwest Power Pool (SPP)	%	87	80	7	47
United States	Tennessee Valley Authority (TVA)	%	65	24	41	53

1 2022 CFE across Google offices (hourly) was recalculated due to methodology updates.

2 2023 is the first year we're disclosing Regional average CFE across Google data centers. Data for prior years is not disclosed.

3 The eastern North America regional CFE percentage includes the following grid regions: DUKE, IESO, Hydro-Québec, PJM, Santee Cooper, SOCO, and TVA.

4 The central North America regional CFE percentage includes the following grid regions: ERCOT, MISO, and SPP.

5 The western North America regional CFE percentage includes the following grid regions: SRP, BPA, CAISO, NVE and PACE.

6 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 ISO or RTO 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.

7 See endnote 6 above.

DATA CENTER ENERGY EFFICIENCY (PUE)[1,2]

Country	Location	Unit	2019	2020	2021	2022	2023
Belgium	St. Ghislain	PUE	1.09	1.08	1.08	1.09	1.09
Chile	Quilicura	PUE	1.09	1.08	1.09	1.09	1.09
Denmark	Fredericia	PUE	-	-	-	1.12	1.10
Finland	Hamina	PUE	1.09	1.09	1.09	1.09	1.09
Ireland	Dublin	PUE	1.12	1.09	1.09	1.09	1.08
Netherlands	Eemshaven	PUE	1.09	1.09	1.08	1.07	1.08
Singapore	1st facility	PUE	1.15	1.14	1.13	1.13	1.13
Singapore	2nd facility	PUE	-	-	-	1.21	1.19
Taiwan	Changhua County	PUE	1.13	1.13	1.12	1.12	1.12
United States	Berkeley County, South Carolina	PUE	1.11	1.11	1.10	1.10	1.10
United States	Council Bluffs, Iowa (1st facility)	PUE	1.12	1.11	1.12	1.12	1.11
United States	Council Bluffs, Iowa (2nd facility)	PUE	1.09	1.09	1.09	1.08	1.08
United States	The Dalles, Oregon (1st facility)	PUE	1.11	1.10	1.11	1.10	1.10
United States	The Dalles, Oregon (2nd facility)	PUE	1.07	1.07	1.06	1.07	1.07
United States	Douglas County, Georgia	PUE	1.12	1.10	1.09	1.09	1.09
United States	Henderson, Nevada	PUE	-	-	-	1.11	1.08
United States	Jackson County, Alabama	PUE	-	-	1.13	1.12	1.10
United States	Lenoir, North Carolina	PUE	1.10	1.09	1.09	1.09	1.09
United States	Loudoun County, Virginia (1st facility)	PUE	-	-	1.10	1.09	1.08
United States	Loudoun County, Virginia (2nd facility)	PUE	-	-	1.13	1.09	1.08
United States	Mayes County, Oklahoma	PUE	1.10	1.12	1.10	1.10	1.10
United States	Midlothian, Texas	PUE	-	-	-	1.16	1.13
United States	Montgomery County, Tennessee	PUE	-	-	1.10	1.11	1.10
United States	New Albany, Ohio	PUE	-	-	-	1.14	1.10
United States	Papillion, Nebraska	PUE	-	-	-	1.13	1.09
United States	Storey County, Nevada	PUE	-	-	-	-	1.19
Average annual fleet-wide PUE across Google-owned and -operated data center campuses		**PUE**	**1.10**	**1.10**	**1.10**	**1.10**	**1.10**

WASTE

Waste generation	Unit	2019	2020	2021	2022	2023
Waste generated	Metric tons	48,100	28,900	28,200	38,200	41,100

Waste diversion	Unit	2019	2020	2021	2022	2023
Data center waste diversion rate	%	90	81	78	86	78[3]
Office waste diversion rate	%	71	71	64	75	77[4]
Total waste diversion rate	**%**	**77**	**77**	**77**	**84**	**78**

Data center hardware refurbishment and reuse	Unit	2019	2020	2021	2022	2023
Refurbished inventory used for server deployment, maintenance, and upgrades	%	-	10	13	21	29
Components resold into the secondary market	Million components	10.0	8.2	4.9	5.0	7.0

WATER

Global operational water	Unit	2019	2020	2021	2022	2023
Water consumption	Million gallons	3,412.4	3,748.9	4,561.8	5,564.7	6,352.0 ✓
Water discharge	Million gallons	1,748.3	1,939.8	1,734.8	2,034.9	2,301.3 ✓
Water withdrawal	Million gallons	5,160.7	5,688.7	6,296.6	7,599.6	8,653.3 ✓

Freshwater withdrawal by water scarcity	Unit	2019	2020	2021	2022	2023[5]
Low water scarcity	%	-	-	-	-	69
Medium water scarcity	%	-	-	-	-	16
High water scarcity	%	-	-	-	-	15

Water replenishment	Unit	2019	2020	2021	2022[6]	2023
Water replenished	Million gallons	-	-	-	271.0	1,035.9
Contracted water replenishment capacity	Million gallons	-	-	-	1,317.2	2,815.3

Assured for 2023 ✓

1 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.

2 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.

3 In 2023, we adjusted our methodology for calculating waste generation and diversion for our data centers—for more details, see Reducing data center waste in the Circular economy section. These changes are reflected in our reported total "Waste generated," "Data center waste diversion rate," and "Total waste diversion rate" for 2023, but not for prior years.

4 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 total "Waste generated," "Office waste diversion rate," and "Total waste diversion rate" for 2023, but not for prior years.

5 2023 is the first year we're disclosing Freshwater withdrawal by water scarcity (per our updated framework). Data for prior years is not disclosed.

6 2022 was the first year of implementation of our water replenishment program.

WATER USE BY DATA CENTER LOCATION		2023			Golf course equivalents (estimated)[1]
Location	Unit	Withdrawal	Discharge	Consumption	
Ashburn, VA	Million gallons	57.9 ✓	3.3 ✓	54.6 ✓	<1
Potable water		57.9			
Berkeley County, SC	Million gallons	847.2 ✓	83.8 ✓	763.4 ✓	5.1
Potable water		847.2			
Council Bluffs, IA	Million gallons	1,334.9 ✓	354.8 ✓	980.1 ✓	6.5
Potable water		1,334.9			
The Dalles, OR	Million gallons	383.7 ✓	81.3 ✓	302.4 ✓	2.0
Potable water		383.7			
Douglas County, GA	Million gallons	418.8 ✓	73.2 ✓	345.6 ✓	2.3
Potable water		34.5			
Reclaimed wastewater[2]		384.3			
Dublin, Ireland[3]	Million gallons	0.6 ✓	0.5 ✓	0.1 ✓	<1
Potable water		0.6			
Eemshaven, Netherlands	Million gallons	296.4 ✓	64.4 ✓	232.0 ✓	1.5
Potable water		2.1			
Non-potable water[4]		294.3			
Frankfurt, Germany	Million gallons	2.2 ✓	1.8 ✓	0.4 ✓	<1
Potable water		2.2			
Fredericia, Denmark	Million gallons	27.0 ✓	6.3 ✓	20.7 ✓	<1
Potable water		27.0			
Hamina, Finland	Million gallons	3.0 ✓	2.7 ✓	0.3 ✓	<1
Potable water		3.0			
Henderson, NV	Million gallons	273.8 ✓	115.0 ✓	158.8 ✓	1.1
Potable water		273.8			
Inzai, Japan	Million gallons	11.2 ✓	4.4 ✓	6.8 ✓	<1
Potable water		11.2			
Jackson County, AL	Million gallons	159.8 ✓	17.6 ✓	142.2 ✓	<1
Potable water		159.8			
Lancaster, OH	Million gallons	15.4 ✓	7.7 ✓	7.7 ✓	<1
Potable water		15.4			
Leesburg, VA	Million gallons	246.8 ✓	73.6 ✓	173.2 ✓	1.2
Potable water		246.8			
Lenoir, NC	Million gallons	358.1 ✓	21.3 ✓	336.8 ✓	2.2
Potable water		358.1			

WATER USE BY DATA CENTER LOCATION		2023			Golf course equivalents (estimated)[5]
Location	Unit	Withdrawal	Discharge	Consumption	
Lockbourne, OH	Million gallons	31.8 ✓	8.5 ✓	23.3 ✓	<1
Potable water		31.8			
Mayes County, OK	Million gallons	1,037.1 ✓	222.0 ✓	815.1 ✓	5.4
Potable water		1,037.1			
Middenmeer, Netherlands	Million gallons	7.1 ✓	2.1 ✓	5.0 ✓	<1
Potable water		7.1			
Midlothian, TX	Million gallons	164.3 ✓	28.5 ✓	135.8 ✓	<1
Potable water		164.3			
Montgomery County, TN	Million gallons	342.0 ✓	53.4 ✓	288.6 ✓	1.9
Potable water		342.0			
Montreal, Canada[6]	Million gallons	0.04 ✓	0.03 ✓	0.01 ✓	<1
Potable water		0.04			
New Albany, OH	Million gallons	152.0 ✓	24.9 ✓	127.1 ✓	<1
Potable water		152.0			
Papillion, NE	Million gallons	164.2 ✓	29.5 ✓	134.7 ✓	<1
Potable water		164.2			
Quilicura, Chile	Million gallons	190.7 ✓	85.5 ✓	105.2 ✓	<1
Potable water		190.7			
St. Ghislain, Belgium	Million gallons	348.9 ✓	104.7 ✓	244.2 ✓	1.6
Potable water		22.3			
Non-potable water[7]		326.6			
Sterling, VA	Million gallons	81.0 ✓	25.4 ✓	55.6 ✓	<1
Potable water		81.0			
Storey County, NV[8]	Million gallons	1.9 ✓	1.7 ✓	0.2 ✓	<1
Potable water		1.9			
Sydney, Australia[9]	Million gallons	0.9 ✓	0.8 ✓	0.1 ✓	<1
Potable water		0.9			
Other data center locations	Million gallons	698.5 ✓	57.9 ✓	640.6 ✓	4.3
Potable water		31.1			
Non-potable water		296.6			
Reclaimed wastewater		370.8			
Data centers total	**Million gallons**	**7,657.2** ✓	**1,556.6** ✓	**6,100.6** ✓	**40.7**
Potable water		5,984.6			
Non-potable water		917.5			
Reclaimed wastewater		755.1			

1 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.
2 Treated wastewater from the Sweetwater Creek Sidestream Reuse Facility.
3 Air-cooled facility; no water used for cooling.
4 Industrial water supplied by North Water.
5 See endnote 1 above.
6 See endnote 3 above.
7 Water drawn from the Nimy-Blaton-Peronnes shipping canal and treated on-site.
8 See endnote 3 above.
9 See endnote 3 above.

Assured for 2023 ✓

Certifications

CERTIFICATION	DETAILS
ISO 50001: Energy management	In 2023, we maintained our ISO 50001 certification for all Google-owned and -operated data centers in Europe that met our operational threshold for power usage. 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 an ISO 14001 certification for our mobile phones, computer, and tablet consumer hardware in the United States.
Climate Neutral Data Centre Pact (CNDCP)	As of 2021, Google is a signatory of the Climate Neutral Data Centre Pact, a pledge of data centers in Europe to achieve climate neutrality by 2030. The Pact sets targets in five areas: energy efficiency, renewables, water, circular economy, and heat recovery. In 2023, we successfully completed third-party verification that our five Google-owned and -operated data centers in the EU met the five pact targets in line with the Self-Regulatory Initiative.
EU Code of Conduct on Data Centre Energy Efficiency	In 2023, our five Google-owned and -operated data centers in the EU became "Participants" in the EU Code of Conduct on Data Centre Energy Efficiency.
Leadership in Energy and Environmental Design (LEED)	As of the end of 2023, over 300 Google office facilities have achieved LEED certification, including 71 with a Platinum rating and 165 with a Gold rating. In 2023 alone, we achieved LEED certification for 16 Google office facilities, including six with a Platinum rating and six with a Gold rating. For a list of some of Google's LEED-certified projects, see the U.S. Green Building Council's project library.
International Living Future Institute (ILFI)	In 2023, one Google building achieved ILFI certification: our Gradient Canopy building in Mountain View, California, achieved ILFI's LBC Materials Petal certification—the largest new construction project to date to attain this certification.
Green Business Certification Inc. (GBCI) TRUE Zero Waste	In 2023, we achieved TRUE Zero Waste certification for 14 buildings across nine campuses, including Platinum-level certification for seven buildings in Dublin, Ireland, and precertification for seven other buildings around the world. As of early 2024, we achieved TRUE precertification across 18 of our office campuses in Mountain View, California, which comprise more than 100 buildings. As of early 2024, we have the largest TRUE precertified portfolio in the world.

Recognitions

Below is a selection of sustainability-related recognitions received in 2023. While most focus on environmental topics exclusively, some also recognize broader achievements.

- CDP Climate Change A List (A score)
- CDP Supplier Engagement Leader (included)
- Dow Jones Sustainability North America Index (included)
- Dow Jones Sustainability World Index (included)
- EPA Green Power Partnership National Top 100 Partner Rankings (ranked #2)
- Gartner Sustainability Assessment ("strong" 5/5 score)
- Sustainability Magazine Top 10: Sustainable Data Centre Companies (ranked #1)
- Technology Magazine Top 10 Big Tech Companies Creating a More Sustainable World (ranked #1)
- TIME World's Best Companies of 2023 (ranked #3 overall)

Endnotes

1 This calculation is based on internal data, as of May 2024.
2 "The Carbon Footprint of Machine Learning Training Will Plateau, Then Shrink," Computer, vol. 55, July 2022.
3 According to Google's own analysis of our more efficient servers, power infrastructure, and cooling systems, compared with data center industry averages based on 2023 data. Uptime Institute's annual data center survey from 2023 noted that the primary contributor to the flatlining of the industry average PUE is a richer geographical mix of surveyed data centers, with an increasing number of data centers in the Asia, Middle East, Africa, and Latin America regions. Facilities in these regions tend to be smaller in capacity and located in warmer climates—both factors which typically require greater energy consumption.
4 According to the Uptime Institute's 2023 Global Data Center Survey, the global average PUE of respondents' data centers was around 1.58. The Institute noted that the primary contributor to the flatlining of the industry average PUE is a richer geographical mix of surveyed data centers, with an increasing number of data centers in the Asia, Middle East, Africa, and Latin America regions. Facilities in these regions tend to be smaller in capacity and located in warmer climates—both factors which typically require greater energy consumption.
5 "Reduce Carbon and Costs with the Power of AI," Boston Consulting Group, January 2021.
6 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. We then input the estimated prevented emissions into the EPA's Greenhouse Gas Equivalencies Calculator to calculate equivalent cars off the road for a year. The cumulative figure covers estimated emissions prevented after fuel-efficient routing was launched, from October 2021 through December 2023, while the annual figure covers estimated emissions prevented from January 2023 through December 2023. 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.
7 The estimated population covered is based on the forecasted flood risk area, using the WorldPop Global Project Population dataset.
8 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 2022 and 2023. 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, and it is not yet adjusted for local fleet mix. 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.
9 Alphabet's percentage of electricity purchased from renewable sources methodology is a custom calculation and is based on a global approach. Percentage of renewable energy is calculated on a calendar-year basis, dividing the volume of renewable electricity (in megawatt-hours) procured for our global operations (i.e., renewable energy procured through our PPA contracts, on-site renewable energy generation, and renewable energy in the electric grids where our facilities are located) by the total volume of electricity consumed by our global operations. The numerator includes all renewable energy procured, regardless of the market in which the renewable energy was consumed. Additional details on Alphabet's criteria and methodology can be found in the "Achieving Our 100% Renewable Energy Purchasing Goal and Going Beyond" disclosure.
10 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 ISO or RTO 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.
11 The total GW figure represents primarily PPAs, and includes some generation capacity from targeted renewable energy investments where we also receive EACs. Actual generation capacity may vary from the signed amounts based on changes during construction or project terminations.
12 The Google Renewable Energy Addendum applies to the electricity consumed by suppliers in the manufacturing of Google technical infrastructure and consumer hardware products.
13 We contracted a third-party to estimate replenishment benefits using the Volumetric Water Benefit Accounting (VWBA) methodology (Reig et al., 2019).
14 Based on total weight of new Google Pixel and Fitbit 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.
15 Based on total weight of new Google Pixel 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.
16 Unique, signed-in Google users that were provided information to make a more sustainable choice by at least one sustainable product feature.
17 See endnote 7 above.
18 See endnote 6 above.
19 See endnote 10 above.
20 See endnote 9 above.
21 See endnote 11 above.
22 See endnote 15 above.
23 Having previously used "before" and "by" interchangeably, we've refined the language of our carbon reduction target to "by" 2030 to enhance clarity and improve consistency with our targets. This adjustment, made in consultation with the Exponential Roadmap Initiative, doesn't alter our ambition, target strategy, or approach to our emissions reduction efforts.
24 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. For more details, see Reducing data center waste in the Circular economy section.
25 In 2023, we adjusted our methodology for calculating waste generated and diversion for our data centers—for more details, see Reducing data center waste in the Circular economy section. These changes are reflected for 2023, but not for prior years. 2022 performance (38%) is based on our previous methodology and is not comparable year-over-year. Had we not made these methodology changes, we estimate that our reported 2023 percentage of data centers to reach Zero Waste to Landfill would have been 43%, or a 5% increase compared to our reported 2022 percentage.
26 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.
27 Based on total plastic weight of Google Pixel, Nest, and Chromecast products manufactured in 2022. 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.
28 See endnote 14 above.
29 See endnote 14 above.
30 Google Trends provides access to a largely unfiltered sample of actual search requests made to Google, allowing us to display interest in a particular topic from around the globe or down to city-level geography. Google Trends is anonymized (no one is personally identified), categorized (determining the topic for a search query) and aggregated (grouped together).
31 Based on Google Trends data, when comparing global Google Search interest from 2004 through 2023.
32 This is based on a 1% sample of all signed-in users who were active on Google Search in the United States over the course of a year (May 1, 2023 to April 30, 2024). This calculation only included users that are active more than one day over the course of the year. Topics related to sustainability include climate change, sustainable food choices, sustainable consumer goods, sustainable transport and travel, electric vehicles, sustainable energy, home energy efficiency and electrification, recycling and waste management, and others.
33 Based on Google Trends data, when comparing U.S. Google Search interest in this disaster type from 2004 through April 2024.
34 Based on global Google Trends data from 2023.
35 See endnote 34 above.
36 Based on Google Trends data of global search interest between January 2004–April 2024.
37 Based on Google Trends data, when comparing global Google Search interest from 2004 through April 2024.
38 Based on Google Trends, when comparing U.S. Google Search interest from 2004 through 2023.
39 See endnote 34 above.
40 See endnote 5 above.
41 According to the Emissions Database for Global Atmospheric Research's 2023 "GHG emissions of all world countries" report, 2022 GHG emissions for the European Union's 27 Member States were approximately 7% of global 2022 GHG emissions, falling within the 5–10% range estimated by Boston Consulting Group.
42 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 the number of contrails produced in flights where pilots used predictions to avoid contrails, to the number of contrails created in flights where pilots didn't use contrail predictions. For more details, see the Project Contrails website.
43 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 2023.

44 "Data Centres and Data Transmission Networks," IEA, July 2023, accessed May 2024. This metric covers global final electricity demand. Although this statistic is based on a 2022 dataset, we believe this is the best and most applicable proxy for comparison to Google's 2023 data center energy consumption. More recent statistics include activity like cryptocurrency mining, which is not relevant to Google.

45 The IEA estimates that global data center electricity consumption is 240–340 TWh, or around 1–1.3% of global final electricity demand (roughly 25,000 TWh). In 2023, Google's data centers consumed over 24 TWh of electricity, translating to 7-10% of the estimated 240–340 TWh consumed by data centers globally, and less than 0.1% of the estimated 25,000 TWh of total global electricity demand. See endnote 44 for more information on the IEA statistic.

46 "Aligning Artificial Intelligence with Climate Change Mitigation," *Nature Climate Change*, June 2022. We believe this continues to be an appropriate proxy for 2023 activity.

47 See endnote 44 above.

48 See endnote 9 above.

49 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.

50 See endnote 3 above.

51 See endnote 2 above.

52 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.

53 "Gemini 1.5: Unlocking Multimodal Understanding Across Millions of Tokens of Context," Google, 2024.

54 "TPU v4: An Optically Reconfigurable Supercomputer for Machine Learning with Hardware Support for Embeddings," In Proceedings of the 50th Annual International Symposium on Computer Architecture, June 2023.

55 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.

56 This calculation is based on internal data, as of March 31, 2024.

57 See endnote 49 above.

58 See endnote 4 above.

59 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.

60 See endnote 24 above.

61 See endnote 16 above.

62 See endnote 31 above.

63 This sector categorization—energy; transportation; buildings; forests, land use, and agriculture; and industrial—references the work of leading climate expert organizations, including the IPCC's Clsimate Change 2023 Synthesis Report, Project Drawdown's Drawdown Foundations, and the U.S. EPA's Sources of Greenhouse Gas Emissions.

64 According to the IPCC's Climate Change 2023 Synthesis Report, the energy sector (34%) and transport (15%) accounted for a combined 49%—or roughly half—of global emissions in 2019.

65 See endnote 8 above.

66 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.

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

68 See endnote 6 above.

69 See endnote 43 above.

70 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.

71 "Sixth Assessment Report: Chapter 9: Buildings," IPCC, 2022.

72 See endnote 43 above.

73 See endnote 70 above.

74 "Solar PV," IEA, July 2023, accessed May 2024.

75 See endnote 66 above.

76 Tapestry refined the baseline GraphCast models, outperforming HRES by 15.1% with a 96-hour lead time, and by 18.4% with a 120-hour (5-day) lead-time (both location and wind weighted). HRES is the weather model of the ECMWF (European Centre for Medium-Range Weather Forecasts) and is considered the state-of-the art model for weather predictions. Testing was performed by generating the forecasts for 2021 and comparing the accuracy with GraphCast predictions. Note that these results are shown for pressure level PL1000, where a majority of the wind farms are located.

77 "Sixth Assessment Report: Chapter 10: Transport," IPCC, 2022.

78 See endnote 6 above.

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

80 See endnote 8 above.

81 "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).

82 See endnote 42 above.

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

84 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, see the Project Contrails website.

85 "Global Forest Resources Assessment 2020 - Key Findings," Food and Agriculture Organization of the United Nations, 2020.

86 "Land Area - Hungary," The World Bank Data, accessed May 2024.

87 "Feeding the Future Global Population," *Nature Communications*, January 2024.

88 "2023 Was the World's Warmest Year on Record, by Far," NOAA, January 2024.

89 See endnote 34 above.

90 "NASA Clocks July 2023 as Hottest Month on Record Ever Since 1880," NASA, August 2023.

91 See endnote 7 above.

92 "Spreading Like Wildfire: the Rising Threat of Extraordinary Landscape Fires," UNEP, February 2022.

93 See endnote 31 above.

94 "Canada's Record-Breaking Wildfires in 2023: A Fiery Wake-up Call," Natural Resources Canada, May 2024, accessed May 2024.

95 "Is climate change increasing the risk of disasters?," WWF, April 2024.

96 See endnote 7 above.

97 See endnote 7 above.

98 "Climate Change Impacts on Air Quality," U.S. Environmental Protection Agency, April 2024, accessed May 2024.

99 Includes only Google-owned and -operated data center locations. Some of our locations have more than one data center campus.

100 See endnote 11 above.

101 See endnote 9 above.

102 See endnote 23 above.

103 Although 2020 was the most recent emissions inventory available at the time the target was set, 2020 was deemed to not be representative of a typical year, because operations were impacted by the COVID-19 pandemic. The next most recent year with representative data, 2019, was selected as the base year.

104 See endnote 9 above.

105 These emissions savings represent the cumulative impact of PPAs and market-based emissions factors from 2012 to 2023 (i.e., the difference between our Scope 2 location-based emissions, which don't take into account our CFE procurement, and our Scope 2 market-based emissions). For the amounts from each year, see the Environmental data table in the Appendix for 2019-2023, the 2019 Google Environmental Report data table for 2013-2018, and the 2018 Google Environmental Report data table for 2012.

106 "Greenhouse Gas Equivalencies Calculator," U.S. Environmental Protection Agency, March 2024, accessed May 2024.

107 See endnote 3 above.

108 According to Google's platform-neutral measurement for CPU resources analyzed over a five-year period from 2018–2023.

109 See endnote 4 above.

110 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).

111 For example, research by Princeton University, TU Berlin, and the International Energy Agency has shown that local and hourly carbon-free energy matching goals have a greater impact on grid-level decarbonization than the prevailing approach of 100% annual renewable energy matching.

112 Carbon-free energy is any type of electricity generation that doesn't directly emit carbon dioxide, including (but not limited to) solar, wind, geothermal, hydropower, and nuclear. Sustainable biomass and carbon capture and storage (CCS) are special cases considered on a case-by-case basis, but are often also considered carbon-free energy sources.

113 For more details about our energy policy and ecosystem advocacy work, see the Public policy and advocacy section in the Appendix.

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

115 See endnote 11 above.

116 Solar panels equivalency based on "How Much Power is 1 Gigawatt?," Office of Energy Efficiency and Renewable Energy, August 2023, accessed May 2024.

117 This estimated spend is based on contracts signed to purchase clean energy for our operations, and includes some targeted renewable energy investments where we also receive EACs. Actual spend may vary from these estimates based on changes in renewable electricity output from operational projects, the number of contracts signed, project terminations, and energy market prices

118 See endnote 11 above.
119 Contracted CFE (%) represents the percentage of our load that's matched with hourly electricity generation from clean energy projects contracted by Google, without consideration of the CFE already on the grids where we operate. For more details, see the Other carbon and energy metrics section in the Appendix.
120 Grid CFE (%) refers to the percentage of carbon-free energy sources consumed within a Regional Grid. Grid CFE is applied to Google's load for any hour where Google's Contracted CFE is less than the load. These values are calculated by a third party.
121 See endnote 10 above.
122 Our CFE percentage measures the degree to which our electricity consumption on a given regional grid is matched with CFE on an hourly basis. This is calculated using both CFE under contract by Google as well as CFE coming from the overall grid mix. CFE coming from the overall grid mix is based on data obtained from a third party. For more information, see our 2021 white paper, "24/7 Carbon-Free Energy: Methodologies and Metrics."
123 The central North America regional CFE percentage includes the following grid regions: ERCOT, MISO, and SPP.
124 Regional Google CFE across Google data centers refers to the percentage of carbon-free energy sources consumed by Google's data centers within a given global region, following the same approach for calculating Google CFE (%) metrics. For more details, see the Other carbon and energy metrics section in the Appendix.
125 The eastern North America regional CFE percentage includes the following grid regions: DUKE, IESO, Hydro-Québec, PJM, Santee Cooper, SOCO, and TVA.
126 Contracted CFE (%) represents the percentage of our load that's matched with hourly electricity generation from clean energy projects contracted by Google, without consideration of the CFE already on the grids where we operate. For more details, see the Other carbon and energy metrics section in the Appendix.
127 Consumed Grid CFE (%) measures the percentage of our load in a given market that's matched with CFE from the grid after the application of contracted CFE. For more details, see the Other carbon and energy metrics section in the Appendix.
128 Residual grid mix removes from the grid electricity mix the proportion of renewable energy contracted to other parties that have claims to that electricity through EACs, and avoids double-counting.
129 2022 CFE across Google offices (hourly) was recalculated due to methodology updates.
130 This estimate is based on anticipated contracted energy from the projects that were terminated and then applied based on our CFE methodology.
131 "How the Tech Sector Can Drive Renewable Energy Opportunities in APAC," ENGIE Impact, accessed May 2024.
132 Per CDP's guidance documents, reported targets are considered "structured" if they include the scope(s) of emissions covered, the reduction percentage from the base year, the total base year emissions, the target year, and the target status.
133 See endnote 12 above.
134 This third-party estimate is based on a 2022 whole-building life cycle assessment, which includes requirements based on the LEED v4 Building Life Cycle Impact Reduction credit requirements, as well as full cradle-to-grave life cycle stages over a 75-year analysis period. The analysis includes the foundation, structure, enclosure, and interior materials.
135 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. This 100% recycled content claim excludes Pixel 5a.
136 Based on data collected from shuttle commuting trips in the San Francisco Bay Area, as compared to a scenario in which these employees had each used a private, fuel-based car for commuting. Assumptions include average Googler commute distance, miles per gallon assumptions from the Bureau of Transportation, and emissions per gallon of fuel assumptions from the Greenhouse Gas Protocol. Equivalency estimate is based on workdays in the year, using data from "Greenhouse Gas Equivalencies Calculator," U.S. Environmental Protection Agency, March 2024, accessed May 2024.
137 "Climate Change 2022: Mitigation of Climate Change Summary for Policymakers," IPCC, 2022.
138 In 2007, we set a goal to achieve operational carbon neutrality, and we met this goal every year from 2007 to 2022 via three steps. First, we worked to reduce our total energy consumption by pursuing energy efficiency initiatives. Next, we matched 100% of the global electricity consumption of our operations with purchases of renewable energy. Finally, we purchased high-quality carbon avoidance credits to address any remaining emissions, for example through the capture and destruction of highly potent greenhouse gasses like methane. Going forward, we continue to support a range of efforts to curb highly potent greenhouse gasses, for example through our work on MethaneSAT and grants to key organizations working on methane mitigation solutions. For more details, see Methane leaks in the Our products section and the Google.org grantees section in the Appendix.
139 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.
140 See endnote 13 above.
141 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.
142 See endnote 59 above.
143 See endnote 141 above.
144 Expected stormwater collection is calculated based on the roof areas and estimated peak flow rates into the stormwater cistern, weather data for expected rainfall, and expected use for non-potable water demands. The estimated reduction in municipal water use is calculated based on expected stormwater captured and reused onsite compared to total expected site water consumption per year.
145 See endnote 13 above.
146 See endnote 13 above.
147 See endnote 13 above.
148 Freshwater consumption from Other Bets is excluded from our water replenishment target. Non-Google businesses under Alphabet Inc. are referred to collectively as Other Bets, and Other Bets operate as independent companies.
149 See endnote 31 above.
150 See endnote 31 above.
151 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.
152 This figure represents the cumulative hardware components resold from 2015 to 2023. For the amounts from each year, see the Environmental data table in the Appendix for 2019-2023 and the 2019 Google Environmental Report data table for 2015-2018.
153 Updates for at least seven years from when the device first became available on the Google Store in the U.S. See g.co/pixel/updates for details.
154 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.
155 See endnote 151 above.
156 See endnote 31 above.
157 See endnote 152 above.
158 Our consumer hardware products include Pixel, Nest, Chromecast, and Fitbit devices.
159 UL110 and IEEE 1680.1 are multi-attribute, consensus-based sustainability standards for mobile phones and for computers and displays, respectively. Google uses a third party to validate conformance and independently certify to these standards. See UL Spot Database.
160 Doesn't include third-party products such as the Nest x Yale Lock.
161 For products launched in 2020 and 2021: Nest, Pixel, and Chromecast devices are made with recycled plastic ranging between 9% and 68% based on weight of plastic used in each respective product launched during this timeframe. The following items are excluded: 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. For products launched in 2022 and 2023: Pixel, Nest, and Chromecast devices are made with recycled materials ranging between 10% and 60% based on respective product weights.
162 For products launched in 2023: Fitbit devices are made with recycled materials of at least 5% based on product weight.
163 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.
164 Based on total plastic weight of Google Pixel, Nest, and Chromecast products manufactured in 2022. 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.
165 Based on total weight of new Google Pixel and Fitbit products launched and manufactured in 2023, including U.S. configuration of in-box accessories.
166 See endnote 163 above.
167 See endnote 164 above.
168 See endnote 163 above.
169 See endnote 14 above.
170 See endnote 15 above.
171 Based on packaging comparisons of Pixel 8 and Pixel 8 Pro phones vs. a first generation Pixel phone. Based on total weight of new Google Pixel 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.
172 See endnote 14 above.
173 See endnote 14 above.
174 See endnote 153 above.
175 Learn more about Google's recycling program on our site.
176 This includes all final assembly manufacturing sites globally for Google consumer hardware products with at least one year of data. Learn more about the UL 2799 Zero Waste to Landfill validation.
177 The percentage of FSC-certified wood used at Gradient Canopy is calculated based on material costs for new wood purchased for this project during construction.
178 See endnote 177 above.
179 Based on Google Trends data, when comparing global Google Search interest in 2022–2023 to 2020–2021.
180 See endnote 31 above.
181 See endnote 23 above.
182 See endnote 24 above.
183 See endnote 25 above.

Glossary

AI: artificial intelligence

CDP: Formerly known as the Carbon Disclosure Project

CFE: carbon-free energy

CO_2e: carbon dioxide equivalent

CPU: central processing unit

EAC: energy attribute certificate

EIE: Environmental Insights Explorer

EPA: U.S. Environmental Protection Agency

EV: electric vehicle

ft: foot

FSC: Forest Stewardship Council

GHG: greenhouse gas

GPU: graphics processing unit

GT: gigaton

GW: gigawatt

GWP: global warming potential

IEA: International Energy Agency

IPCC: Intergovernmental Panel on Climate Change

ISO: International Organization for Standardization

kWh: kilowatt-hour

LBC: Living Building Challenge

LCA: life cycle assessment

LEED: Leadership in Energy and Environmental Design

m: meter

ML: machine learning

MW: megawatt

MWh: megawatt-hour

NGO: non-governmental organization

PPA: power purchase agreement

PUE: power usage effectiveness

SDGs: Sustainable Development Goals

tCO_2e: metric tons of carbon dioxide equivalent

TPU: Tensor Processing Unit

TWh: terawatt-hour

WBCSD: World Business Council for Sustainable Development

WRI: World Resources Institute

UNEP: United Nations Environment Programme

UNFCC: United Nations Framework Convention on Climate Change

X: Alphabet's "moonshot factory"

Photo details

On the cover:
Google Earth image of Nome, Alaska.

What's inside (page 1):
Interior of Google's Bay View office. Photo credit: Iwan Baan.

Introduction (page 2):
Golden Hills wind farm in California (43 MW for Google)

A letter from our Chief Sustainability Officer and our Senior Vice President of Learning and Sustainability (page 3):
Photo of Kate Brandt by Vaughn Ridley/Sportsfile for Web Summit via Getty Images

AI for sustainability (page 9):
EDF's new satellite, MethaneSAT, will map, measure, and track methane from oil and gas with unprecedented precision, offering a comprehensive view of methane emissions. Photo credit: MethaneSAT LLC.

Our products (page 14):
By building AI models on the emissions profile of different vehicle types, fuel-efficient routing in Google Maps analyzes traffic, terrain, and the vehicle's engine to find the most efficient route.

Mitigation (page 16):
The Environmental Insights Explorer estimates the technical solar potential of all buildings in a region based on total sunshine exposure, weather patterns, and roof dimensions.

Adaptation and resilience (page 23):
Governments, aid organizations, and individuals can use Flood Hub to take timely action and prepare for riverine floods, seeing locally relevant flood data and forecasts up to 7 days in advance.

Our operations (page 27):
Our Bay View campus, as seen from across its stormwater retention pond. Photo credit: Iwan Baan.

Net-zero carbon (page 29):
El Romero solar farm in Chile (80 MW for Google)

Water stewardship (page 42):
A rainwater retention pond outside our data center in Berkeley County, South Carolina.

Circular economy (page 49):
The restored glue-laminated wooden interior of our Spruce Goose hangar, with the sculpture nicknamed the "Ghost of the Goose" in view. Photo credit: Connie Zhou.

Nature and biodiversity (page 56):
The design of the Charleston Retention Basin on our Mountain View Campus allows visitors to experience, learn about, and enjoy the expanded riparian habitat.

Appendix (page 60):
Norther Offshore wind farm in Belgium (92 MW for Google)

Google

Environmental Report

2024

Want to learn more about our latest efforts?

To stay up to date on our news and progress, see our Sustainability blog.

Publication date: July 2024