Accelerating Climate Action at Google and Beyond
A Progress Update

Google

Introduction

The United Nations' [Intergovernmental Panel on Climate Change](#) (IPCC) is unequivocal: climate change is an urgent threat to human well-being and the health of the planet. Decarbonizing the global economy is one of humanity's most urgent challenges, and this decade is critical for setting the world on a path to a sustainable future.

At Google, we believe we have a responsibility to protect our planet. Since our founding in 1998, we have worked to build sustainability into everything we do. We've set aspirational goals to minimize our own carbon footprint, and worked to maximize our contribution to global climate solutions.

In 2007, we were the first major company to become carbon neutral. Ten years later we became the first major company to match 100% of our annual electricity use with renewable energy—which we've continued to achieve for five consecutive years. Building on the lessons and achievements from our first two decades of progress, in 2020 we launched our [third decade of climate action](#)—our most ambitious yet.

We know that our responsibility begins with our own footprint. But no company, no matter how ambitious, can solve a challenge as big as climate change alone. One of the most powerful things we can do is build technology that allows us, our partners, and individuals around the world to take meaningful action. That's why our strategy focuses on three areas:

Leading at Google	Supporting Partners	Enabling Everyone
We always start with operating our business more sustainably, and sharing the innovations we create and the lessons we learn with others around the world.	Our impact is far greater when we collaborate and share technology, methods, and funding to help organizations everywhere transition to resilient, carbon-free systems.	Collectively, individual actions can make a big difference. We're continuously developing products and technology that empower everyone on their journey to a more sustainable life.

Google's mission is to organize the world's information and make it universally accessible and useful. By organizing information about our planet, and making it actionable through technology, we can help people make even more positive impact, together.

This paper offers an overview of our ambitions, an update on our efforts, and examples of how we are using technology to accelerate climate action.

Leading at Google

Last year we announced our goal of achieving net-zero emissions across our operations and value chain, including our consumer hardware products, by 2030.

We aim to reduce 50% of our combined scope 1,[1] scope 2,[2] and scope 3[3] absolute emissions (versus our 2019 baseline) before 2030, and plan to invest in nature-based and technology-based carbon removal solutions to neutralize our remaining emissions. We have submitted a formal commitment to the Science Based Targets initiative (SBTi) to seek their validation of our absolute emissions reduction target.

Google is working toward net-zero emissions in three main ways: advancing carbon-free energy across our global operations, reducing emissions within our value chain, and addressing our residual emissions with carbon removal and other solutions.

Advancing Carbon-Free Energy Across our Global Operations

For over a decade, Google has deployed clean energy projects at scale to reduce carbon emissions across our global operations.

These efforts start with our scope 1 emissions, including transitioning fossil fuel powered vehicles, heating and cooling systems, and kitchen equipment across our global offices to run on electricity. In parallel, in 2020 we set a new goal to address our scope 2 emissions by operating our data centers and office campuses on 24/7 carbon-free energy by 2030.

We are working to achieve these goals through three complementary approaches:

"The world is at a crossroads: we need to take rapid action today to create a sustainable and equitable future for all. **Google's industry-leading commitment to 24/7 carbon-free energy has created new momentum in the race to decarbonize global electricity grids**, and their partnership with UN-Energy and other leading organizations and governments on the 24/7 Carbon-Free Energy Compact has been critical in propelling us closer to a world where everyone, everywhere, can benefit from clean energy."

Damilola Ogunbiyi
CEO and Special Representative,
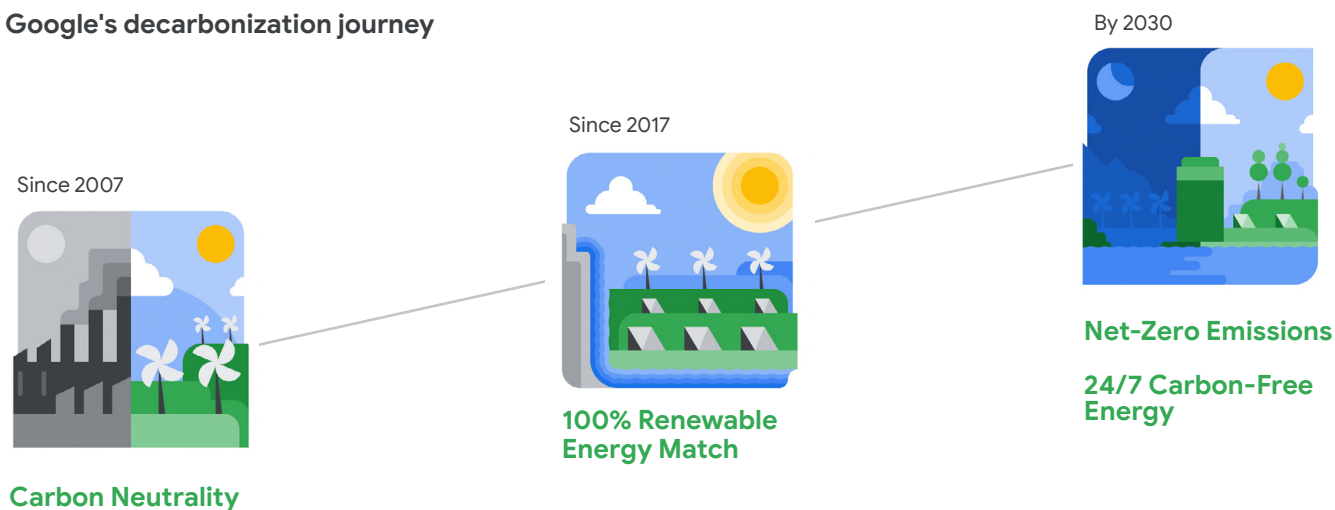UN Secretary-General for
Sustainable Energy for All

1. **Purchasing carbon-free energy**

   Over the past decade, Google purchased more renewable energy than any other company.[4] From 2010 to 2021, we signed more than sixty power purchase agreements totaling more than 7 gigawatts of renewable energy, and as of 2021, we have achieved five consecutive years of 100% renewable energy annual matching.[5] Over that same period, we also committed approximately $6 billion to purchase clean energy from wind and solar projects globally through 2040.[6]

   Even though Google purchases enough renewable energy to match our global electricity use on an annual basis, we operate in many places where solar and wind power are not readily available at all the times we need them. In these circumstances, we are forced to rely on the carbon-emitting energy sources that power local grids at any given moment in time.

   We knew we needed to go further and work to eliminate carbon from our electricity supply. That is why we set ourselves a new goal in 2020: to operate on carbon-free energy, 24 hours a day, 7 days a week, 365 days a year—all by 2030. We call it 24/7 carbon-free energy, and we aim to prove that it's possible for one

FIG. 1
Google's decarbonization journey

Since 2007

Carbon Neutrality

Since 2017

100% Renewable Energy Match

By 2030

**Net-Zero Emissions**

24/7 Carbon-Free Energy

of the world's largest companies to operate major facilities entirely on carbon-free energy, every hour of every day, in every region where we operate.

24/7 carbon-free energy is a complex and challenging goal: no company has achieved this before, and there is no playbook for doing so. But we are making steady progress. Five of our data centers are already operating at or near 90% carbon-free energy, and in 2021 we achieved approximately 66% round-the-clock carbon-free energy across all of our data centers, up from 61% in 2019. Most importantly, our 24/7 carbon-free energy procurement efforts are already catalyzing progress beyond our own operations, unlocking new investments in carbon-free energy generation, and creating new tools and approaches to procure clean energy around the clock.

FIG. 2
Carbon-free energy at Google Data Centers

In **2021**, Google reached approximately **66% carbon-free energy** globally on an **hourly basis**.

In the same year, **five of our data centers** operated **at or near 90%**.
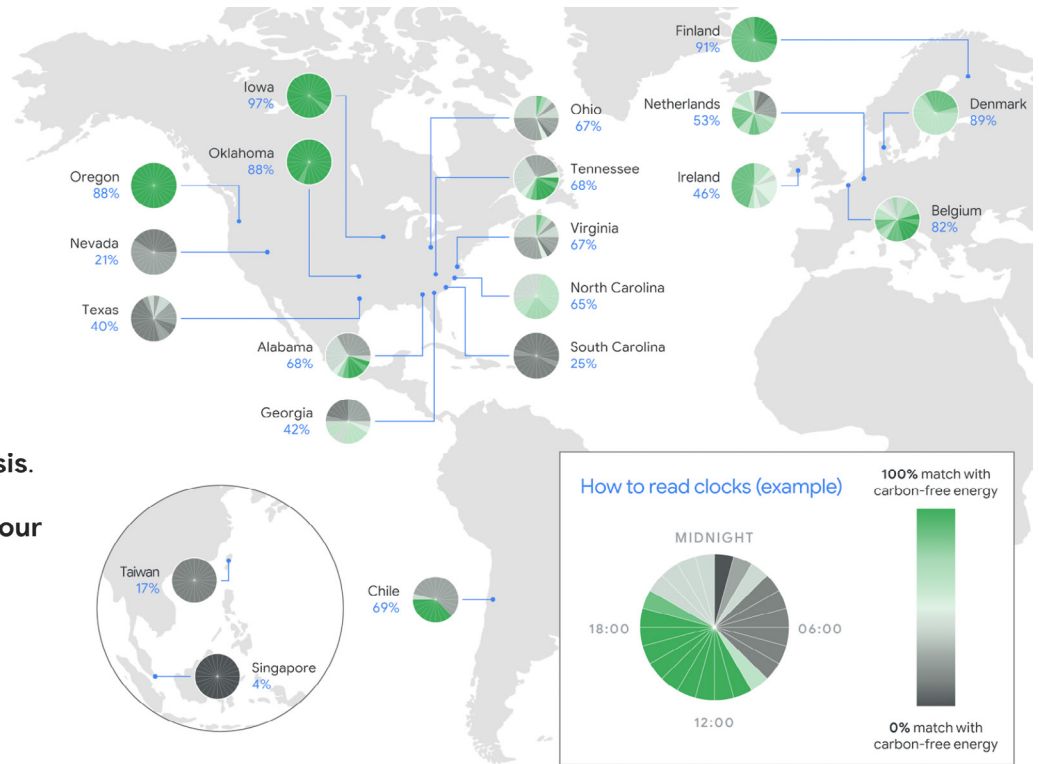
2. Accelerating new and improved technologies

Wind and solar power have played a critical role in enabling Google's clean energy progress, but meeting our 24/7 carbon-free energy goal—and maximizing our contribution to global decarbonization—will require expanding our technology toolkit. We are working on a wide range of projects to demonstrate, scale, and maximize the climate impact of carbon-free energy technologies. For example:

Optimizing generation from existing carbon-free energy technologies	We are deploying machine learning solutions to optimize wind power forecasting and project economics, in partnership with Engie. And to reduce the carbon footprint of our new Bay View and Charleston East campuses, we designed and installed 'Dragonscale,' a new solar roofing technology that helps us power our facilities through on-site generation.
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 carbon-free energy availability. This allows us to shift some of our data centers' computing tasks to the times of day when local solar and wind power are most plentiful, and to shift tasks geographically across data centers so that we can do more computing in regions where carbon-free energy is abundant.
Accelerating next generation energy sources	In 2021 we signed the first corporate agreement to develop a next-generation geothermal power project, and in 2021 we installed the first ever battery-based backup power system for a data center at our facility in St. Ghislain, Belgium. We have also contributed technological and financial support to the development of nuclear fusion technologies.
Improving energy data and clean energy tracking	Google is driving the development of advanced methods for tracking clean energy, including time-based energy attribute certificates (T-EACs). We are also working to improve the quality, consistency, and granularity of grid electricity data through active collaborations with EnergyTag, Electricity Maps, FlexiDAO, LF Energy, and LevelTen Energy.
Investing in new funding models for carbon-free solutions	In 2020, Alphabet (Google's parent company) issued $5.75 billion in sustainability bonds, the largest such bond issuance by any company in history at the time. Since then we have fully allocated these bonds, funding new initiatives to improve energy efficiency, expand clean energy, and more.

> "Multi-stakeholder collaboration will be critical to achieving net-zero global emissions, and companies have a vital role to play. **Google has raised the bar for corporate climate leadership, creating benefits for people and the planet** through their investments in clean energy and their partnerships with governments and civil society organizations around the world."

Antonia Gawel
Head of Climate Action,
World Economic Forum

3. **Transforming the energy system through partnerships and advocacy**

Our 24/7 carbon-free energy efforts are not just about decarbonizing our own energy use—they are also designed to maximize our contribution to the decarbonization of power grids worldwide.

Studies by researchers at Princeton University in the U.S. and the Technical University of Berlin in Europe have shown that aiming for 24/7 carbon-free energy increases the impact of corporate clean energy procurement on system-level decarbonization, as compared with 100% annual renewable energy matching. That is why we are encouraging others to join us on our journey to 24/7 carbon-free energy, and supporting their efforts to do so by sharing insights and lessons we are learning and new approaches we are developing.

We are pleased that many large electricity buyers have either announced 24/7 carbon-free energy goals or joined efforts to advance 24/7 carbon-free energy, including Microsoft and Iron Mountain and the governments of the U.S., Iceland, and Scotland. To build on this momentum, we partnered last year with the United Nations and Sustainable Energy for All to launch the 24/7 Carbon-Free Energy Compact, a fast-growing consortium of over 85 companies, governments, nonprofits, and other stakeholders working to expand 24/7 carbon-free energy worldwide. And this year we partnered with C40 to launch the 24/7 Carbon-Free Energy for Cities programme, which will support cities including Copenhagen, London, and Paris to develop and pilot scalable approaches to decarbonizing urban energy consumption.

Google partners with many other organizations to expand clean energy and accelerate climate progress. We helped create and scale the Clean Energy Buyers Association (CEBA) in the U.S. and the RE-Source Platform in Europe, consortia which have grown to include hundreds of energy buyers working together to break

down policy and market barriers to clean energy deployment and procurement. Most recently, we joined the Exponential Roadmap Initiative and the UN's Race to Zero Campaign, prominent multi-stakeholder partnerships aimed at accelerating emissions reductions to meet global climate goals.

Finally, we recognize that the clean energy transition requires strong actions from governments in addition to companies, and we call for ambitious public policies aimed at decarbonizing electricity grids worldwide. This year, we published a first-of-its-kind policy roadmap sharing our recommendations for energy policy and market reforms, informed by our experiences as a large energy user and clean energy buyer around the world.

Reducing Emissions Across our Value Chain

Scope 3 emissions are often the most difficult for companies to address. These emissions are typically distributed across a large number of entities and regions, and reducing them requires engagement and innovation across complex global networks of suppliers, customers, and users. We are fortunate to work with many suppliers who are leading the way on sustainability: in 2021 alone, our supply partners implemented over 700 initiatives to reduce emissions. We are working alongside these suppliers to develop solutions to reduce emissions, share relevant expertise, and build new data infrastructure to quantify and track emissions reductions across the supply chain.

Some examples of how Google is pursuing value chain emissions reductions include:

Supplier energy efficiency and carbon-free energy procurement	We work closely with many of our suppliers to track energy use, maximize energy efficiency, and expand carbon-free energy procurement. Since setting our net-zero emissions goal, we've engaged our key suppliers to develop roadmaps to reduce emissions across our supply chain.
Investing in carbon-free energy in key manufacturing regions	In 2020, we committed to enabling 5 gigawatts of new carbon-free energy through investments in our key manufacturing regions. Working with our suppliers, we aim to invest in clean energy projects that reduce emissions and serve manufacturing operations across our supply chain.
Recycled materials for consumer and data center hardware	The aluminum in the phone enclosures of Pixel 5, 6, 6 Pro, 7, and 7 Pro is made with 100% recycled content, reducing the carbon footprint of the aluminum portion of the enclosures by over 35% compared to 100% primary aluminum.[7] At our data centers, we are piloting the recovery and reuse of rare earth magnets and other hardware components, which recent studies have shown can significantly reduce emissions.
Consumer hardware efficiency, longevity, and recycling	We design our products to be energy efficient: for example, the 2022 Chromecast with Google TV (HD) reduces power draw by more than 40% compared to the 2018 Chromecast.[8] We also promote product longevity: Pixel 6 and later Pixel phones will get security updates for 5 years from when they first become available on the Google Store in the U.S.[9] For devices at the end of their service life, we offer free recycling in every country where we ship consumer hardware products, and in 2021 we invested in a research and pilot program aimed at increasing user participation in e-waste recycling.
Carbon-conscious construction materials	In Sunnyvale, we are building our first ground-up mass timber building, which is projected to have 96% fewer embodied carbon emissions than an equivalent steel and concrete structure, factoring in sequestration.[10] We are also salvaging and reusing building materials for some new building projects, and our 6 Pancras Square building in London was recently awarded the International Living Future Institute's first ever Zero Carbon Certification.
Operational waste mitigation	Google is working to achieve Zero Waste to Landfill for our global data center operations and across our final assembly consumer hardware manufacturing sites. We also aim to send zero food waste to landfills by 2025. Since 2014 we have diverted 10 million pounds of food from going into landfills, with a carbon impact equivalent to taking 5,000 cars off the road for a year.
Googler travel and commuting	We are creating hybrid events and virtual participation options to reduce our employees' travel, while encouraging them to travel by rail and public transit where possible. Our campuses have a total of 4,800 charging stations for electric vehicles, and many offer commuter shuttles to reduce individual vehicle trips.

"Halving greenhouse gas emissions by 2030, and ensuring the world is on track to reach net-zero emissions, is the challenge of our time. **Meeting this goal, even as demand for goods and services grows, requires climate solutions, emissions reduction, and carbon removals to be scaled up exponentially.**"

Johan Falk
Co-founder and Head,
Exponential Roadmap Initiative

Addressing our Residual Emissions

We aim to avoid or reduce greenhouse gas emissions as much as possible to reach our absolute emissions reduction target, but there are some emissions that cannot be abated immediately. We are taking multiple approaches to address these residual emissions:

1. **Investing in carbon dioxide removal**

   While permanent carbon removal solutions are not yet economically viable or deployed at scale, the IPCC stated earlier this year that "the deployment of carbon dioxide removals (CDR) to counterbalance hard-to-abate residual emissions is unavoidable if net-zero emissions are to be achieved." That is why we are supporting the development and commercialization of emerging carbon removal technologies as well as the development of initiatives to ensure the integrity and climate impact of the emerging CDR sector.

   We are championing two coalitions to advance science-based CDR:

   - The First Movers Coalition - Carbon Removal Sector, which aggregates the purchasing power of multiple committed buyers to create early markets for innovative clean technologies across eight hard-to-abate sectors, including CDR.

   - Frontier, which spurs the development of carbon removal technologies by guaranteeing future demand for them and facilitating purchasing from high-potential CDR companies.

2. **Bridging the gap with high-quality carbon credits**

   While CDR technologies are being proven and scaled over the short to medium term, we believe that avoided emissions credits can play a valuable role in keeping the world on track for a 1.5ºC future. Since 2007, when we became carbon neutral across our

operations, we have supported the capture and destruction of highly potent greenhouse gasses through the procurement of high-quality carbon credits.

The destruction of these gasses is an urgent priority. Methane is over 25 times more potent than carbon dioxide at trapping heat in the atmosphere, and its atmospheric concentration has more than doubled over the last two centuries, leading to roughly 25% of the anthropogenic global warming that the planet has experienced to date. And while methane is short-lived, breaking down after approximately 10 years in the atmosphere, the importance of the next two decades for mitigating climate change makes immediate methane destruction a critical near-term priority. We will continue to procure high-quality carbon credits to advance valuable methane and gas destruction projects as we work our way to achieving net-zero emissions by 2030.

Reducing emissions while growing the digital world

The World Economic Forum estimates that 70% of new value created in the global economy over the next decade will be based on digitally-enabled business models. With demand for digital services growing rapidly, our path to achieving net-zero emissions by 2030 will not be linear: it will require long-term investments, new systems and technologies, and major transformations to our operations. Some of our plans will take years to deliver their full results, particularly where they involve building new large-scale infrastructure with long lead times. As a result, we expect a rise in emissions before peaking and then dropping to our absolute emissions reduction target before 2030.

While rapid digitalization will make our own net-zero emissions goal more challenging to achieve, it is likely to be excellent news for the climate: according to one recent estimate, accelerating the use of digital technologies across a range of sectors and use cases could enable one-fifth of the emission cuts needed to reach global net-zero emissions by 2050.

3. Strengthening carbon markets

Carbon markets can be a valuable mechanism for businesses to counterbalance residual emissions, but only if there are strong standards and effective verification mechanisms to ensure that the offsets that businesses purchase lead to permanent emissions reductions. Google.org has contributed more than $6 million to strengthen carbon markets, digitize their infrastructure, and set standards for high-quality carbon credits:

FIG. 3
Strengthening carbon markets

Supply-side integrity

Establish 'floor standards' for carbon credit quality (Core Carbon Principles) and support their application through a single authority (the Integrity Council).

Market infrasctucture

Develop and mainstream digital standards, support tokenization of credits, and create an interoperable data warehouse that connects national and independent climate registries into a single global meta-registry.

Demand-side integrity

Establish rulebook for use of carbon credits and embed transparency protocols into existing reporting frameworks.

Grantee: Integrity Council for the Voluntary Carbon Market

Grantees: Gold Standard, RMI, & Climate Action Data Trust

Grantee: Voluntary Carbon Market Integrity Initiative

We will continue to evolve our approach to counterbalancing our residual emissions. Although shorter-permanence solutions have an important role to play in the near term, we will continue to invest in and shift our portfolio to CDR solutions as they become available at scale.

Supporting Partners

Google is fortunate to work with thousands of partners across nearly every sector of the economy and society, including companies, governments, cities, and nonprofits. Many of these partners are leaders in advancing climate mitigation and resilience. We are privileged to learn from these partners and share our technology, research, and insights to help them accelerate their positive impact.

> "Business innovation—especially innovation from the IT industry—**can unlock new systems and approaches that will help reduce global emissions at the pace and scale required to limit the worst impacts of climate change.** In the global race to zero emissions, we have no time to lose."
>
> **María Mendiluce**
> CEO, We Mean Business Coalition

Enabling Climate Change Mitigation with Technology

Mitigating climate change requires transformations in every region of the world and every sector of the economy. Google's technology and resources are contributing to emissions reduction far beyond our own operations.

1. **Helping cities and regions reduce their climate impact**

    Over half of the global population lives in cities, and urban areas account for over two-thirds of global energy consumption and around 70% of global carbon emissions. By 2030, we aim to help more than 500 cities and local governments reduce an aggregate of 1 gigaton (one billion tons) of carbon emissions annually.

    Our Environmental Insights Explorer (EIE) tool uses comprehensive data sources and modeling capabilities to help cities and regions measure emission sources, run analyses, and identify strategies to reduce emissions. EIE is used by leading city networks including the Global Covenant of Mayors for Climate & Energy (GCoM), C40 Cities Climate Leadership Group, and ICLEI-Local Governments for Sustainability, and major cities—including San José and Houston in the U.S.—have used it to shape their climate action plans. By the end of 2021, EIE covered nearly 42,000 cities and regions worldwide, and thousands of cities globally have signed up to view their data.

FIG. 4

EIE emissions measurements, Mountain View, CA (Full year 2021)

Transportation emissions
130,000
Total tCO2e/yr

Building emissions
326,000
Total tCO2e/yr

Rooftop solar potential
242,000
Total tCO2e/yr
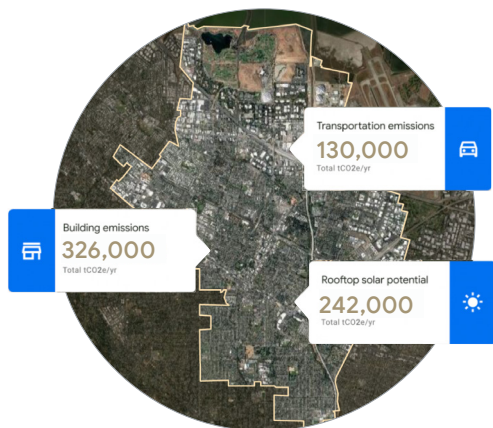
"Sustainable mobility and climate action planning on a local level require data on mobility patterns and transport emission sources. **Google EIE provides current and easily accessible data for thousands of cities worldwide, and can, in combination with local data sources, support and facilitate decision-making** for decarbonizing the transport sector and developing new sustainable mobility alternatives."

Wolfgang Teubner
Regional Director, ICLEI Europe

In 2021, we added new capabilities to EIE. We simplified the creation of greenhouse gas inventories compliant with the Greenhouse Gas Protocol for Cities, expanded EIE's building coverage to include over 13,000 cities and regions, and added job creation potential to EIE's solar power estimates—all with the goal of supporting cities' climate ambition and action.

Sidewalk Labs, an urban innovation unit within Google, is creating useful tools that enable cities to operate more efficiently. Sidewalk Labs' products aim to reduce emissions from energy, transport, and construction while increasing urban resilience and quality of life.

We also know that many cities suffer from urban road traffic, which wastes fuel and creates harmful air pollution. That's why we created Project 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 light changes to reduce stop-and-go traffic. This means drivers hit more green lights in a row and make fewer stops, but that some of these stops last slightly longer—an important feature to ensure the tool doesn't inadvertently encourage more driving. In our most recent tests in Hamburg, Germany, cars made over 25% fewer stops, resulting in approximately 10% fewer emissions at intersections where the technology was deployed. We are now bringing this technology to cities on four continents, including Rio de Janeiro, Bangalore, Seattle, Budapest, Manchester, and multiple cities in Israel.

Environmental Insights Explorer in Action

In Izmir, Turkey's third most populous city, transportation emissions accounted for almost 23% of total city emissions in 2018. Yet these emissions are difficult to monitor and track, often having to rely on fuel sales as a rough estimate. Moving forward, Izmir seeks to use EIE to assess the effectiveness of greenhouse gas emissions mitigation actions and apply them to policy and planning decision-making to align with the goals defined in the city's Sustainable Energy and Climate Action Plan.

2. Helping Google Cloud customers accelerate sustainable transformations

We are supporting our customers with cloud products and services that help them predict climate risk, increase visibility across their supply chain, and reduce their emissions.

We've created a group of products in our Carbon Sense Suite that enable our customers to accurately measure, report, and reduce their cloud-related carbon emissions, using tools like Carbon Footprint and Active Assist to optimize their cloud environment for lower emissions.

We also recognize that partnerships will be a key enabler for our customers to achieve their sustainability goals, and we are building our partner network across industries to scale the impact of our products. Since we announced the Google Cloud Ready - Sustainability designation to validate and promote sustainability solutions providers this summer, we've seen incredible momentum, with more than 20 partners achieving the designation. This will help companies get the support they need to process ESG data, reduce carbon emissions, increase value chain sustainability, identify climate risks, and improve operational resilience.

Google Cloud in Action

The Lufthansa Group partnered with Google Cloud to develop a platform that facilitates better planning and steering of the airline's daily flight operations. The efficiencies gained through the deployment of Google Cloud have led to measurable carbon emission reductions through more efficient aircraft deployment. Within eighteen months of working with Google Cloud on these initiatives, Lufthansa Group subsidiary Swiss International Air Lines has already cut carbon emissions by an estimated 7,400 tons per year—the equivalent of eighteen Boeing 777 roundtrip flights between Zurich and New York City.

Google

As many of our customers are adopting a hybrid and flexible work model, Google Workspace is enabling them to reduce employee commuting and business travel, increasing productivity while reducing energy use and emissions. And for our vehicle fleet customers, our Cloud Fleet Routing tool enables accurate fleet-wide routing plans, resulting in greater efficiency, fuel and cost savings, and lower greenhouse gas emissions.

Leveraging Data and Technology to Strengthen Resilience

Extreme weather events are already impacting every region in the world, and they are projected to increase in both frequency and severity while disproportionately affecting the most vulnerable communities worldwide. Technology can help communities better understand the risks they face and prepare for and respond to extreme events—both today and in the years to come. Google is advancing several multidisciplinary solutions to analyze climate risk and strengthen climate adaptation by improving disaster preparedness and emergency response:

1. **Improving emergency response in vulnerable communities**

   Leveraging our engineering capabilities and access to geospatial data, we are building tools to strengthen communities' response to extreme weather events, for example:

   - A forecasting initiative that provides flood alerts and information to at-risk communities via Search, Maps, and notifications. Forecasting systems are currently operational in regions of Asia and Latin America, covering over 360 million people. During Pakistan's severe 2022 flooding, we provided nationwide SOS alerts with links to the latest information from government authorities.

FIG. 5
Google flood forecasting alert
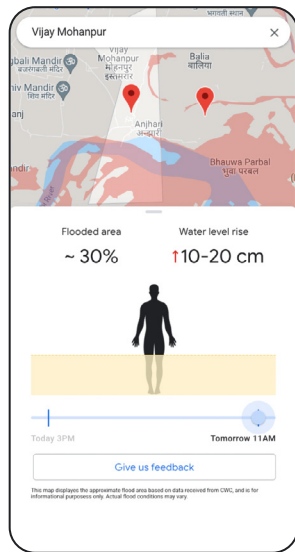
- A new feature within Search and Maps that uses machine learning to improve wildfire detection and response, alerting communities in the U.S. to nearby wildfires and providing them with high-quality information.

- Artificial intelligence tools, co-developed with the UN World Food Programme, that leverage satellite imagery to enable humanitarian aid organizations to conduct initial large-scale impact assessments of extreme weather events less than 72 hours from acquiring the imagery.

From fragmented databases to consolidated data insights

Quality environmental data is critical for researchers to understand climate change, and for decision makers to anticipate and respond to its impacts. But despite the importance of this data, much of it is fragmented and spread across a multitude of systems.

We applied our expertise in organizing information to create Data Commons, one of the world's largest knowledge graphs, including data for climate adaptation and mitigation. Spanning more than 100 sources of data covering climate, health, food, crops, shelter, emissions, and more, Data Commons is available for anyone to access using Google Search. Users can explore this data using our free dashboards and visualization tools, or build new tools using our open and free APIs.

Another powerful data tool we've developed is Google Earth Engine, which combines satellite imagery and geospatial datasets with planetary-scale analysis capabilities. Commercial and nonprofit researchers use Earth Engine to detect changes, map trends, and quantify climate impacts on the Earth's surface. For example, Unilever, in partnership with Google and NGIS, are harnessing the power of cloud computing, satellite imagery, and machine learning to build a more holistic view of the ecosystems that intersect its supply chain. Leveraging Google Cloud and Google Earth Engine, Unilever is raising sustainable sourcing standards for its suppliers and advancing progress toward its goal of ending deforestation and regenerating nature.

Earth Engine users can also use the Timelapse tool, which combines 24 million satellite photos from the past 37 years into an interactive 4D experience that enables them to visualize and share how our world is changing.

FIG. 6
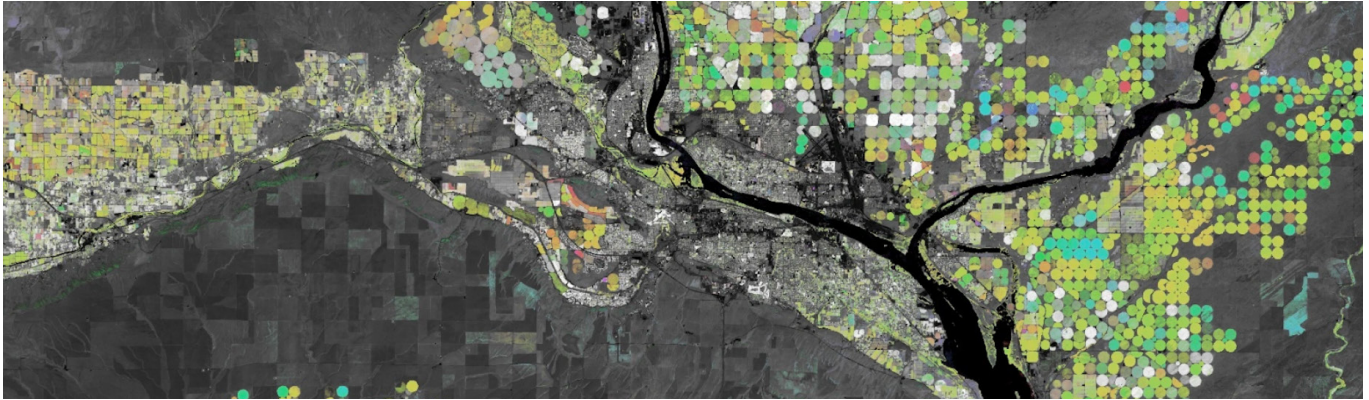
Google Earth Engine image showing seasonal agricultural peaks of soy and corn near the Columbia and Snake Rivers in Washington state

### 2. Increasing resilience across cities and regions

Many cities around the world experience higher temperatures and greater air pollution than their surrounding regions—a phenomenon known as the 'urban heat island effect.' By the end of 2022, we will have expanded our Environmental Insights Explorer's Tree Canopy Insights tool to more than 100 cities, to support them in using trees to lower temperatures while providing comfortable shade and contributing to cleaner air. We have also launched new air quality insights through Project Air View, which brings detailed air quality maps to scientists, policymakers, and communities around the world.

FIG. 7
Google Environmental Insights Explorer
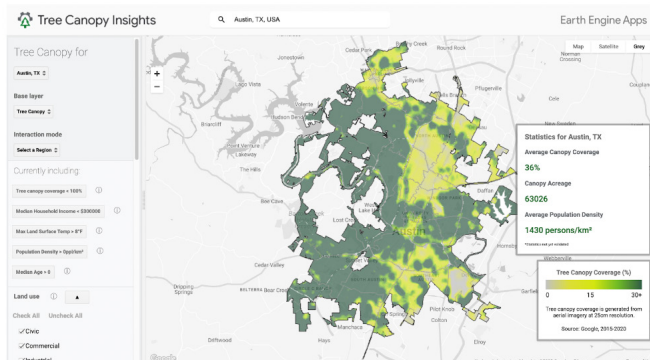
Tree Canopy Insights
Currently available in select U.S. cities
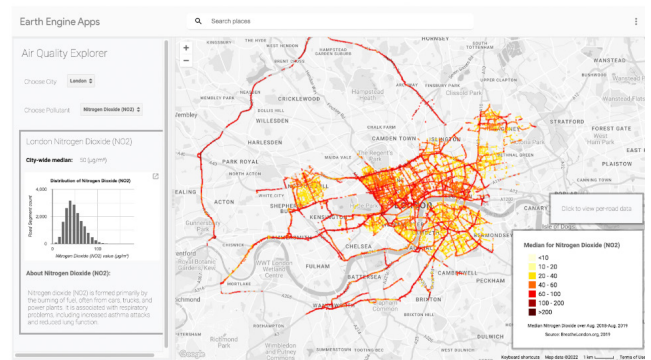
Air Quality Explorer
Available for Amsterdam, Copenhagen, and London

> "Reducing climate change requires all hands on deck, including governments, companies, civil society, and individuals. **It's great to see Google using its platforms to help connect us to the climate information we need to make better decisions.**"

Anthony Leiserowitz
Director, Yale Program on Climate Change Communication

Investing in Innovators to Scale Climate Action

Beyond our own tools and programs, Google also invests in promising initiatives that aim to create scalable, high-impact climate solutions.

Google.org, our charitable arm, is providing catalytic funding to innovative projects around the world:

- The Impact Challenge on Climate Innovation, a $30 million fund to support breakthrough projects that use data and technology to accelerate climate action. Selected organizations will receive up to $5 million in funding to scale their activities, along with access to Google's technical expertise and products to help them maximize their impact.

- AI for the Global Goals, a $25 million fund to support the development of new AI-driven approaches that accelerate progress on the UN Sustainable Development Goals (SDGs).

- A $10 million grant to ICLEI-Local Governments for Sustainability to fund ten nonprofit-led projects that advance sustainable cities.

- The Environmental Justice Data Fund, a $9 million fund managed by the Windward Fund that provides flexible funding to U.S.-based environmental justice organizations to collect data and build data analysis capacity that will enable communities to apply for infrastructure funding from the U.S. federal government.

Google

Google also initiated the Google for Startups Accelerator: Climate Change, a 10-week program for early-stage technology startups based in North America. The accelerator, which has graduated its first two cohorts, provides Google resources to climate change innovators working to scale their efforts and impact. Our recently launched Growth Academy: Sustainability is bringing a similar model to Europe, and our Startups for Sustainable Development program is supporting a global ecosystem of startups working to advance the UN SDGs, including SDG 13: Climate Action.[11]

Enabling Everyone

Individual consumption decisions are, collectively, a major driver of greenhouse gas emissions. They are also challenging to address, because they are dispersed across billions of households with a wide range of consumption patterns, options, and needs. While our responsibility always starts with our efforts to run our own business more sustainably, it extends to how we empower our users to live more sustainably and contribute to climate solutions.

Many of our billions of users are looking for ways to live more sustainably, and our goal is to make it easier for them to do so. In 2022, Google searches reached all-time highs for terms including "rooftop solar power," "solar energy," "electric bicycles," and "electric cars." When we empower users to make more sustainable choices, we often find that we are also helping them save time, money, and energy.

While a single individual's decisions may seem small, when billions of people have the tools to make more sustainable decisions, they add up to meaningful impacts on their communities and the entire planet. In early 2022, the IPCC Working Group III report stated that, with policy support, socio-cultural and behavior change could deliver a rapid 5% reduction in demand-side carbon emissions. This offers a significant opportunity to enable positive choices by Google users that reduce carbon emissions while improving their well-being.

Google is helping users contribute to climate action in several ways.

Supporting More Sustainable Transportation

Transportation relies more heavily on fossil fuels than any other sector, and for individuals in most high-income countries, changing transportation patterns is a high-impact way to reduce their individual footprint. Google has added new features across our products to encourage more sustainable transportation decisions.

> "Better use of data and digital tools can enable people to make easier and more informed choices that deliver big carbon reductions and align with their values. **The tools that Google are launching now across energy, travel, shopping, and finance will support greater awareness, easier comparison of products and services, and more flexible energy consumption**. Behavior change by even a portion of the population can trigger wider changes that make those choices increasingly affordable, normal, and easy for everyone."

Dr. Richard Carmichael
Co-Leader, Behaviour Change in Energy and Environment Policy Research Network
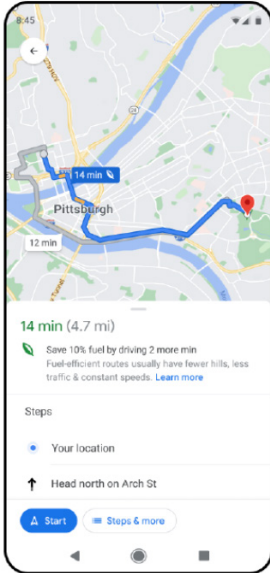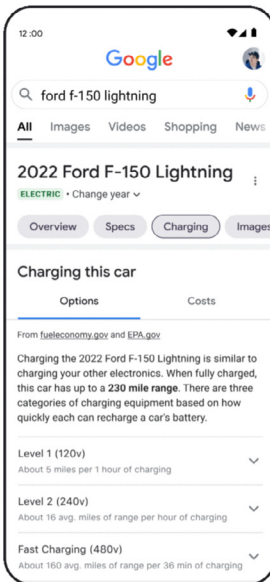
FIG. 8

**Google Maps
eco-friendly routing**

FIG. 9

**Google Search
vehicle comparison**

1. Google Maps

In 2021, we launched Google Maps eco-friendly routing to help users get to their destinations as quickly as possible while minimizing fuel or battery consumption. This new feature leverages Google's AI tools and insights from the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) and the European Environment Agency to optimize route choices. Eco-friendly routing is available across the U.S., Canada, and nearly forty European countries, and it is already estimated to have helped avoid more than half a million metric tons of carbon emissions—the equivalent of taking approximately 100,000 fuel-based cars off the road.[12]

Google Maps also offers alternatives to car transport by including public transit, walking, and cycling when people search. We also recently introduced more detailed cycling route information to give bikers additional information about their routes, and expanded bike and scooter share information to over 300 cities globally. Now, users can find nearby docking stations and see real-time vehicle availability in cities including Berlin, New York, São Paulo, and Taipei.

2. Google Search vehicle comparison

When our U.S. users search for vehicles, we offer useful information to help them understand the differences between electric- and gas-powered options. For those interested in electric vehicles, new features allow them to see useful information on their options, including charging needs, range estimates, and applicable financial incentives. We are working to expand these features internationally to enable more drivers to consider switching to electric vehicles.

Google

Helping People Support a Clean Energy Future at Home

Many Google users want to save energy and money by powering their homes with clean energy. We support those choices with:

1. **Nest thermostats**

   For over a decade, Nest thermostats have helped people save energy and money at home. On average, Nest thermostats have proven energy savings of 10%-12% for heating and 15% for cooling, which means they can pay for themselves in under two years.[13] The collective impact of these savings is significant: as of October 2022, Nest thermostats have helped customers cumulatively save more than 105 billion kWh of energy—more than double Portugal's electricity consumption in 2020.

   As of October 2022, anyone in the continental U.S. with a compatible Nest thermostat linked to a Google Account can join Nest Renew, which can help users support a clean energy future by automatically shifting their energy consumption to times of day when local grid electricity is cleaner or less expensive.[14] New features like Energy Shift gather local power grid emissions forecasts and identify opportunities where heating or cooling a home slightly earlier or later would mean taking advantage of cleaner energy. These small actions add up: we estimate that Energy Shift has already helped Nest Renew's early preview users collectively prioritize cleaner energy for over 20 million hours.

   For users who want to do more to support the growth of clean energy, Google offers a paid subscription option—Nest Renew Premium—which matches the fossil fuel electricity used in their homes with enough high-quality wind and solar renewable energy credits (RECs) to cover the average U.S. household. These RECs are generated from projects within Google's own carbon-free energy portfolio, starting with Bethel Wind in Castro County, Texas, and expanding to Roseland Solar in Falls County, Texas, in 2023.

2. Project Sunroof

[Project Sunroof](#) estimates the energy cost savings that installing rooftop solar panels could provide for users in the U.S., using Google Earth Engine imagery and local data on weather, electricity prices, and solar installation costs—including state and federal incentives. These estimates are available for over 170 million rooftops across 21,500 cities.

Enabling More Sustainable Travel Choices

Many of our users are searching for ways to lower the carbon footprint of their travel plans, and we are working to make it easier to make more sustainable choices:
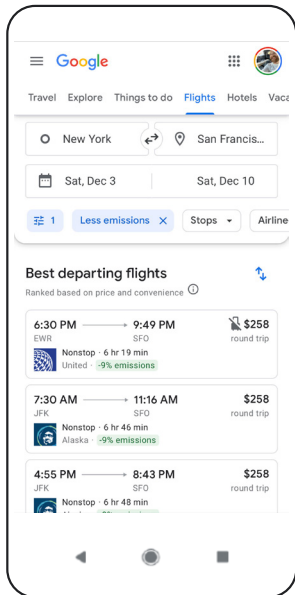
1. Flights

Users searching for flights now see [carbon emissions estimates](#) for nearly every flight, right next to price and duration. Lower-emissions flights are labeled with a green badge, and users can sort results by carbon impact. We also offer [public access](#) to the model we use to estimate per-flight emissions so that others in the travel and aviation industries can help their customers fly more sustainably.

2. Hotels

When our users search for travel accommodations, they now see information about hotels' sustainability efforts. For hotels that have been certified by independent bodies such as Green Key or EarthCheck, an eco-certified badge appears next to their name indicating that they meet or exceed high standards of sustainability.

As we work to provide products and services that enable our users to make sustainable choices and reduce their own carbon footprints, we aim to continue improving our ability to measure the individual and collective impact of these decisions. This is important not only for Google, but also for the growing number of companies offering solutions to help their customers reduce emissions.

**FIG. 10
Flights**

Looking Forward

Google is a global company, and we know that climate change affects every person and community around the world. It is both a complex challenge for which solutions are desperately needed and one of the greatest opportunities for innovation, creativity, and collaborative action in human history. As a technology company, Google works every day to harness the power of data and technology to solve difficult problems. We aim to leverage our tools and expertise, in collaboration with our partners, to enable powerful solutions to combat climate change.

We will continue to provide regular updates on our progress toward our climate goals and on the technologies and partnerships we are advancing to support a sustainable future.

Endnotes

1. Scope 1 emissions are direct emissions from sources we own or over which we have operational control (as defined by the Greenhouse Gas Protocol), such as company vehicles or generators at Google's offices and data centers.

2. Scope 2 emissions are indirect emissions from the production of electricity we purchase to run our operations and the production of space heating for our offices (as defined by the Greenhouse Gas Protocol).

3. Scope 3 emissions are indirect emissions from other sources in our value chain, such as business travel or our suppliers (as defined by the Greenhouse Gas Protocol). For a breakdown of emissions and calculation methodologies by Scope 3 category, see Alphabet's CDP Climate Change Response.

4. Based on our cumulative renewable electricity purchased in megawatt-hours (MWh) from 2012 to 2021, totaling more than 73 million MWh of renewable energy through PPAs, on-site generation, and from the electric grids where our facilities are located.

5. Alphabet's renewable energy methodology is a custom calculation and is based on a global approach. 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.

6. This estimated spend commitment is for clean energy purchased for our operations. It may fluctuate over time, based on the number of contracts signed and energy market prices.

7. 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.

8. Based on comparison of watts drawn in active and standby modes in 2022 Chromecast with Google TV (HD) as compared to the Chromecast in 2018.

9. See details on Pixel updates.

10. This analysis was based on whole building life cycle analysis (LCA) following the LEED v4 Building Life Cycle Impact Reduction requirements. The interior design was not factored into this LCA.

11. To get involved in these programs, please subscribe to Google for Startups's Newsletter, register your interest for the next cohort of our Accelerator, and find out more about past and upcoming Google.org Impact Challenges.

12. Google, with the help of the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) RouteE technology, started by analyzing the fuel consumption for all routes driven on Google Maps during the last year using a representative set of vehicle types. Then, using AI and Google Maps' record of available alternative routes at the relevant times, we identified and calculated the fuel usage of each of these viable alternative routes. This enabled us to pinpoint the most fuel-efficient route for any given journey made last year. Next, we removed any fuel-efficient alternative that noticeably increased drive time or did not provide meaningful fuel savings. And finally, to achieve the resulting one million metric tons of CO_2 calculation, we tallied the total fuel usage of the more fuel-efficient routes, subtracting this number from the fuel usage that actually occurred, and input this value into EPA's Greenhouse Gas Equivalencies Calculator.

13. Energy Savings from the Nest Learning Thermostat: Energy Bill Analysis Results, Nest Labs, February 2015. Independent studies showed that Nest saved people an average of 10% to 12% on heating and 15% on cooling. Using typical energy costs, we've estimated average savings of $131 to $145 a year. That means the Nest Learning Thermostat can pay for itself in under two years. Individual savings are not guaranteed.

14. See details on thermostat compatibility.

Google

Notes on Disclosure

Transparency

Transparency is one of our key priorities. We annually publish information on our approach to climate change and climate risk in Google's Environmental Report and Alphabet's CDP Climate Change reports. Data and transparency are important markers of the progress we are making to evaluate and address climate-related risks and opportunities facing our business. We also see the value of sharing best practices and lessons learned as we work to achieve ambitious climate goals. Over time, we expect to update our disclosures as our actions to combat the impacts of climate change evolve.

Climate Change Risk

In April 2021, we formally expressed our support for the Task Force on Climate-related Financial Disclosures (TCFD) reporting framework, including its seven principles for climate disclosures, as an important tool to allow stakeholders to understand how we manage risks and opportunities associated with climate change. In 2017, we conducted climate risk assessments for our physical assets that consider various time horizons. This process included a global assessment of the impact of sea level rise, flooding, drought, temperature, and water stress on our real estate operations. In 2020, we updated this assessment to include various climate scenario analyses to evaluate the potential impact on twenty-six priority office sites and twenty-three data center locations. In 2022, we are updating our climate risk assessment (including physical and transition risks) to align efforts with the company's overall enterprise risk management (ERM) process as we continue to align our disclosures and adopt the recommendations of the TCFD. Updates on our process will be shared in Google's future reporting.