Google

Environmental Report

2019

Google Environmental Report 2019

Our approach

Designing efficient data centers

Advancing carbon-free energy

Creating sustainable workplaces

Building better devices and services

Empowering users with technology

Appendix

Environmental sustainability at Google

At Google, we believe that technology can be used to help address the biggest issues facing humanity. Climate change is a pressing global issue that poses an imminent threat to our planet. In 2018 alone, we experienced unprecedented heat waves, wildfires, and flooding in California, along with many other extreme weather events around the world. It's clear that immediate action must be taken on a global scale if the impacts of climate change are to be mitigated and, ideally, reversed.

Google has a longstanding commitment to climate action and environmental stewardship. Sustainability has been a core value since Google's founding, and we strive to build sustainability into everything we do. In 2018, we achieved twelve consecutive years of carbon neutrality and, for the second year in a row, matched 100% of the electricity consumption of our global operations with renewable energy. We also announced our long-term goal to power our operations with carbon-free energy, 24x7, 365 days a year.

We're exploring the role of artificial intelligence in helping us achieve even greater energy efficiency gains in our data centers, and we're prioritizing the use of healthy materials with safe chemistry across Google's built spaces. Beyond Google's operations, we're expanding access to the benefits of technology through energy-saving initiatives like the Nest Power Project. We're also working closely with partners to develop tools for policymakers, planners, and researchers that will enable better-informed decisions and actions, like the Environmental Insights Explorer, which provides city-level carbon emissions data.

In the years to come, we'll focus on how Google can accelerate the transition toward carbon-free energy and a circular economy, empower everyone with technology that enables sustainable action, and benefit the communities where we operate.

Google remains steadfast in its commitment to sustainability, and we will continue to look for collaborative partnerships and innovative opportunities to help create a clean and healthy planet for everyone.

Ruth Porat
Senior Vice President and
Chief Financial Officer

Urs Hölzle
Senior Vice President of
Technical Infrastructure

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."[1] We believe in technology's potential to have a positive impact on the world. We also believe we're just scratching the surface. Our vision is to remain a place of incredible creativity and innovation that uses our technical expertise to tackle big problems.

We generate revenues primarily by delivering both performance advertising and brand advertising. Google's core products—Android, Chrome, Gmail, Google Drive, Google Maps, Google Play, Search, and YouTube—each have more than 1 billion monthly active users.

We also offer a broad collection of cloud-based products and services, including G Suite business productivity apps like Docs, Drive, and Calendar and satellite mapping and analysis platforms like Google Earth and Google Earth Engine. In recent years we've expanded into consumer electronics with products including Chromecast, Google Home, Google Nest Hub, Google Pixel, and Google Pixelbook.

We're a wholly owned subsidiary of Alphabet Inc., which had $136.8 billion in total revenues in 2018 and 98,771 full-time employees as of December 31, 2018.[2]

Google's global headquarters are located in Mountain View, California, United States. We also have significant operations in Sunnyvale as well as operations in other cities throughout the San Francisco Bay Area, including San Francisco, San Bruno, and Palo Alto. In this report the term "Bay Area headquarters" refers to our operations in both Mountain View and Sunnyvale. We own and lease office and building space, as well as research and development sites, across more than 150 cities, primarily in North America, Europe, South America, and Asia, and we own and operate 15 data centers across four continents.

About this report

The annual data in this report covers our 2018 fiscal year (January 1 to December 31, 2018). The spotlights may also include data and stories from prior years to provide context, as well as some of our progress in 2019. Unless otherwise specified, all environmental performance data included in this report applies to Google LLC. The primary exception is our greenhouse gas (GHG) emissions and energy use data, which covers the combined operations of Google and our Other Bets and has been third-party verified.

For more information about our environmental sustainability initiatives, including case studies, white papers, and blogs, please see our Sustainability website. Google's "Our Commitments" website highlights our work across five areas: Protecting Users, Expanding Opportunity, Including All Voices, Responding to Crises, and Advancing Sustainability. Our Commitments Reports database includes all our public reports on these topics, and our environmental-focused reports can be found in our Sustainability Reports database. Additional information about our commitment to corporate responsibility can be found in the resources below:

LEARN MORE

About Google: Our Commitments

Accessibility

AI for Social Good

Alphabet's 2019 CDP Climate Change Report

Commitments Reports Database

Crisis Response

Diversity & Inclusion

Digital Wellbeing

Economic Impact

Google for Education

Google for Nonprofits

Google.org

Google Transparency Report

Grow with Google

Investor Relations: Sustainability and Related Information

Privacy & Security

Responsible AI

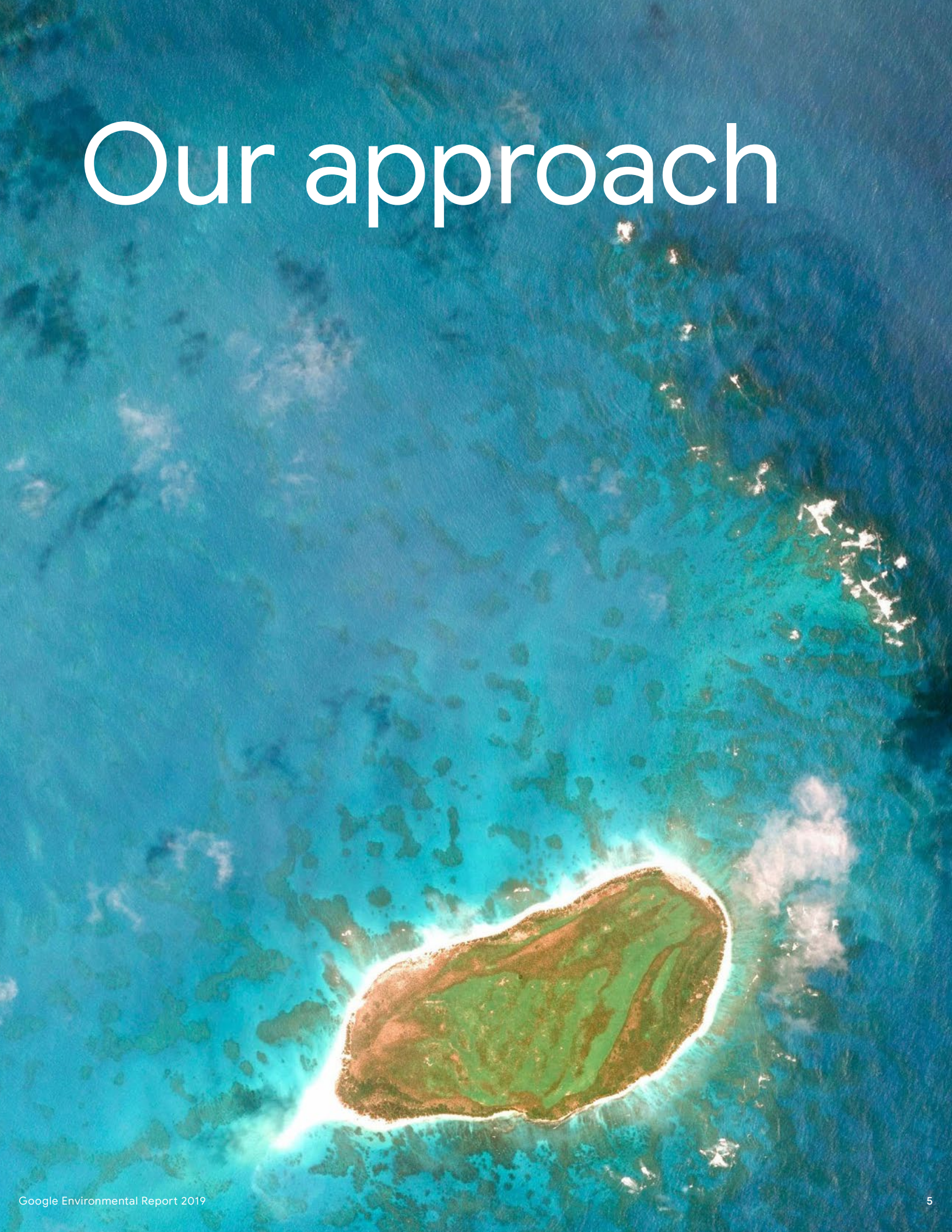
Responsible Supply Chain

Sustainability

Sustainability Reports Database

The Keyword blog

Our approach



The Googleplex in Mountain View, California

Mission and values

Our mission is to organize the world's information and make it universally accessible and useful. Fulfilling this mission, and bringing the benefits of information not just to the more than 3 billion people who are already online but to the next 4 billion, requires us to use resources ever more efficiently.[3]

The path to a cleaner, healthier future begins with the small decisions we make each day. That's why we strive to build sustainability into everything we do. We're raising the bar in making smart use of Earth's resources, expecting the highest ethical standards throughout our supply chain, and creating products with people and the planet in mind. We're also constantly looking for ways to have a positive environmental impact and be even more responsible in our use of energy, water, and other natural resources—and we want to help others to do the same.

This ambition is reflected across our value chain. Our data centers lead the industry in energy efficiency—they're twice as efficient as the industry average for enterprise data centers. We've been carbon neutral since 2007, and now for the second year in a row, we've matched 100% of the electricity our operations use with renewables. This same ethos carries over to our workplaces, with over 1.2 million square meters (13 million square feet) of Leadership in Energy and Environmental Design (LEED) certified offices, and to our products. Whether

By the end of 2018, Nest thermostats had helped customers cumulatively save more than

29 billion

kWh of energy.

someone is using Google at home or as part of an organization running Google Cloud or G Suite, all of the products in our Cloud are carbon neutral. As we continue to grow, we're on a journey to make our Made by Google consumer electronics products work for people and the planet.

Our tools are built to help everyone reduce their environmental impact, understand the planet, and take sustainable action. By mapping the world's forests and fisheries, our technology is making it easier for policymakers, researchers, and nonprofits to monitor the pulse of the planet. We're also making it easier for everyone to take sustainable action by providing more than 1 billion kilometers (km) (621 million miles) of alternative transit options through Google Maps every day and by helping people reduce their home energy consumption with Nest thermostats, which have helped customers cumulatively save more than 29 billion kilowatt-hours (kWh) of energy.

Addressing a global challenge

Humanity is consuming natural resources at an astonishing rate. During the 20th century, global raw material use rose at about twice the rate of population growth.[4] Every year humanity consumes far more than what the planet can naturally replenish. In 2018, global demand for resources was 1.7 times what the Earth's ecosystems can regenerate in a year.[5]

These statistics highlight the need to rethink the "take-make-waste" economic model that human societies have followed since the Industrial Revolution, in which we take a natural resource, make a product from it or burn it for fuel, and eventually send what remains to the landfill as waste. The consequences of this model have created some of the most significant challenges of our time, including climate change, extreme weather events, and plastic pollution, among others.

Climate change is one of the most significant global challenges of our time, and continued greenhouse gas emissions pose an existential threat to humanity. The science behind this is clear, and recent reports have stressed the urgency of the issue. In 2018, the Intergovernmental Panel on Climate Change released a special report addressing the need for rapid transition and widespread action in the next 12 years if we are to limit global warming to the 1.5 degree Celsius warming scenario.[6] Given this pressing time horizon, it's now more important than ever for governments, businesses, and individuals around the world to take immediate and ambitious action on climate at a global scale. We believe that Google's scale, resources, and technological expertise can help the world meet its energy and resource needs in a responsible way that drives innovation and growth.

Google's data center in Eemshaven, Netherlands

Taking action

With millions more people coming online every month, the demand for computing power continues to skyrocket and data center capacity continues to expand to meet this need. But despite this growth, the total amount of electricity used by U.S. data centers has remained constant. Annual consumption increased by 90% from 2000 to 2005, but only by 4% from 2010 to 2014, largely due to data centers' ability to improve their efficiency as they scale.[7] As the use of mobile devices increases and more IT users transition to public clouds, we believe our industry can and must do better than just holding the line on energy use. We can actually lower it, serving more users while using fewer resources.

Google's energy consumption drives our biggest impact on the environment. Internally, we're focused on tackling it through a threefold strategy for carbon neutrality. Beyond Google, we've long been a vocal advocate for greening electrical grids worldwide. We support strong clean-energy and climate-change policies committed to adding clean power to the grid, and we're partnering with governments and nongovernmental organizations to use Google technology to model the effects of climate change on both a global and a local level.

Our sustainability goals, like committing to match the electricity use for our operations with 100% renewable energy, not only are good for the environment but also make good business sense. By purchasing electricity from renewable sources like wind and solar, we can set a long-term fixed price for power. This allows us to gain access to an increasingly cost-competitive source of electricity, and it helps us save money in the long run. By the end of 2018, we had contracts to purchase more than 3.75 gigawatts (GW) of output from renewable energy projects. These contracts have led to nearly $5 billion in new capital investment in projects around the world.[8]

We're also working to incorporate a climate-resilience strategy into our operations that will enable our business and the communities we're part of to thrive despite the effects of climate change. The key principles that serve as the foundation for our strategy are focused on a people-centric framework that's robust, integrated, diverse, and designed with unique locations, scalability, and longevity in mind.[9] This framework was used to conduct a climate exposure and vulnerability analysis that enabled us to assess the future resilience of our current locations and evaluate the climate resilience of new developments. Beyond our operations, Google's AI for Social Good program and Crisis Response platforms are using our technology to enhance flood forecasting models that provide predictions to inform individuals in affected areas so that they can better prepare and stay safe.

Charleston Retention Basin on the edge of Google's campus in Mountain View, California

Our goal is to maximize the reuse of finite resources across our operations, products, and supply chains and enable others to do the same.

Water is another top priority. The United Nations predicts that by 2025, two-thirds of the world's population could live in water-stressed conditions, and with the existing climate change scenario, almost half the world's population will be living in areas of high water stress by 2030.[10] As a global company headquartered in drought-prone California, we've established a set of water principles to guide our approach to water use and ensure business continuity, especially in the places where we have the greatest potential risk. Under these principles, we're working to utilize water efficiently, exploring ways to incorporate circularity, and engaging in partnerships that use Google technology to raise awareness of water-related risks and opportunities and to create platforms that help everyone study and understand global water challenges. Examples of sustainable water management practices can be seen in our data centers, where we keep working to find innovative cooling options where possible, like the use of seawater in Finland, industrial canal water in Belgium, and air cooling in Ireland. Through Google.org, we've awarded millions of dollars in grants to promising water-conservation solutions.[11]

We see the circular economy as a complex yet inspiring information challenge that, once unlocked, will lead to a world of abundance where human, environmental, and economic systems can thrive. That's why we're leveraging our scale, resources, technological expertise, and close partnerships with organizations like the Ellen MacArthur Foundation, as well as with other leading companies, to accelerate the transition to a circular economy and help the world meet its resource needs.

Ultimately, our goal is to maximize the reuse of finite resources across our operations, products, and supply chains and enable others to do the same. We're applying our circular economy principles to design out waste, keep products and materials in use, and promote healthy materials and safe chemistry. We strive to embed these principles across our infrastructure, operations, and products, from how we manage servers in our data centers to how we design our consumer electronics to the materials we select to build and furnish our offices. As we work toward this goal, we'll continue exploring the role of technology and artificial intelligence (AI) in accelerating our transition to becoming a circular Google that contributes to a sustainable world.

Setting our priorities

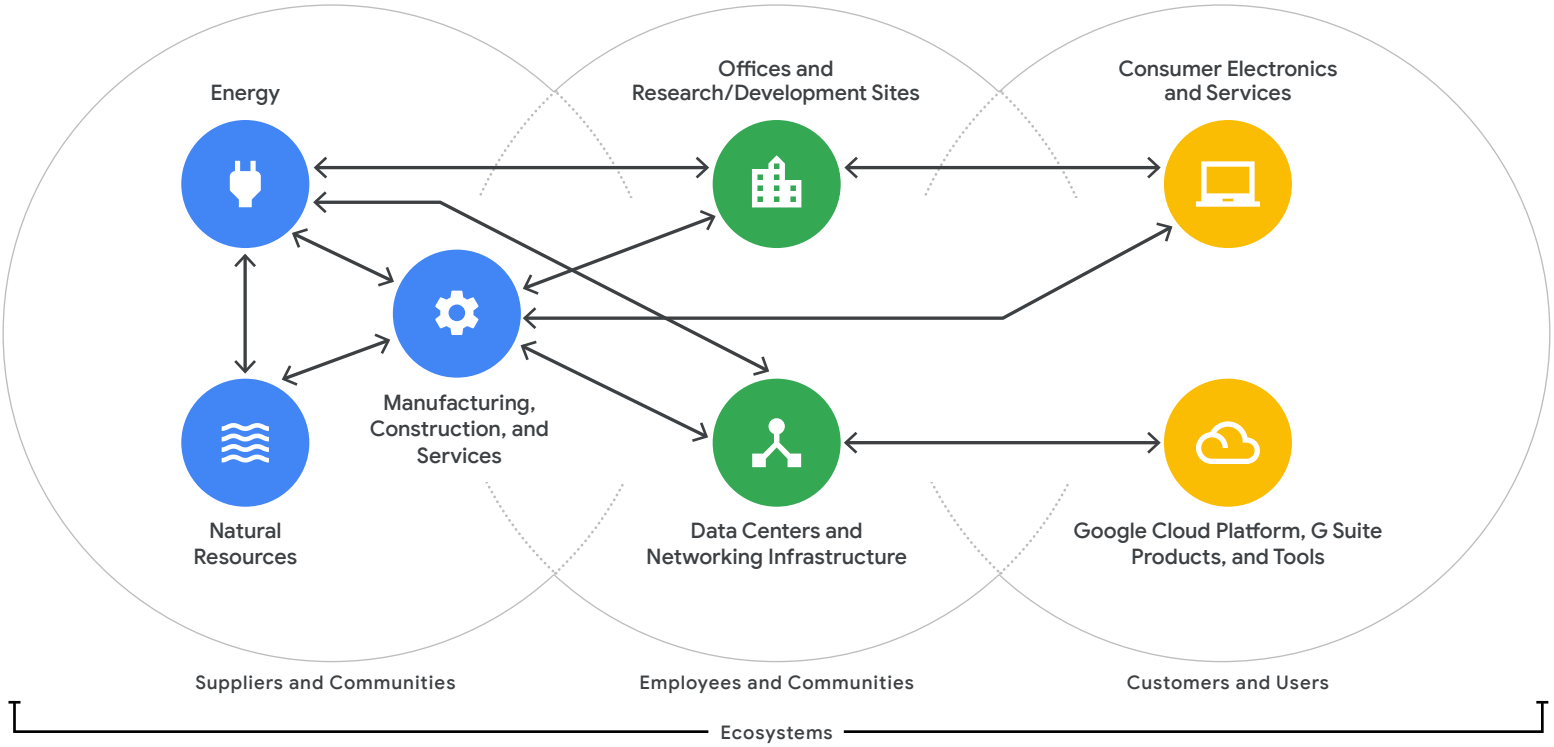
Google uses energy, natural resources, and products and services from our suppliers to build our workplaces, data centers, networking infrastructure, and consumer electronics. The software products and services that our customers and users rely on are powered by our data centers and networking infrastructure (see Figure 1). We're driving positive environmental impact throughout our value chain in five key ways: by designing efficient data centers, advancing carbon-free energy, creating sustainable workplaces, building better devices and services, and empowering users with technology.

In 2018, we undertook an assessment to identify and prioritize content for our environmental report that considered Google's impact on sustainability, the importance of environmental sustainability issues to our business strategy, and the perspectives of a diverse range of stakeholders outside of Google. The issue areas that were found to be of greatest relevance include our data centers, workplaces, users, water stewardship, circular economy strategy, and supply chain. Cutting across these priorities is the importance of engaging in public policy—at local, state, federal, and international levels—to support the success of sustainable business models.

As per recommendations from the Financial Stability Board's Task Force on Climate-related Financial Disclosures, we have reported our exposure to climate-related risks over multiple time horizons in Alphabet's 2019 CDP Climate Change Report.

Figure 1

GOOGLE VALUE CHAIN



Looking toward future opportunities

We believe global businesses like Google should lead the way in improving people's lives, while reducing or even eliminating our dependence on raw materials and fossil fuels. And we believe this can be done in a way that makes business sense, providing economic returns alongside societal benefits and positive environmental impacts.

Planning for the future, we've established a five-year strategy that will enable us to continue building sustainability into everything we do (see Figure 2). Our strategy focuses on three key pillars: to accelerate the transition to carbon-free energy and a circular economy, to empower users with technology, and to benefit the people and places where we operate. We're continuing to work to decouple our business growth from the growth of material use and carbon intensity. This includes enhancing our net positive impact through initiatives that help our users reduce carbon emissions, save energy, and use resources more sustainably. We also want to ensure that Google products, tools, and platforms inform or enable sustainability, and that we're implementing practices to add value to our communities within and outside of Google.

Creating Google tools that help people measure the planet's health and take action is a key part of our long-term strategy. Applications of machine learning (ML) and AI are increasingly enabling not only Google but also scientists and practitioners to create sustainable solutions and to turn data into insights and knowledge needed to guide better decision-making. We're excited to continue exploring how these technologies and applications can be used to create a more sustainable future for generations to come—and we're committed to using these technologies in a responsible way.[12]

Figure 2

FIVE-YEAR SUSTAINABILITY STRATEGY OVERVIEW

We strive to build sustainability into everything we do

Accelerate carbon-free and circular

Decouple business growth from growth of carbon intensity and material use

Empower with technology

Google products, tools, and platforms inform or enable sustainability

Benefit people and places

Share benefits with communities where we operate

Performance highlights and targets

The following section includes highlights of the environmental initiatives discussed in this report. It provides a snapshot of our performance as of the end of 2018 and our targets going forward—demonstrating how we're strengthening our business by reducing the environmental impact of our operations and working to empower people everywhere to live more sustainably.

For a more complete overview of our performance over time, see the environmental data table on page 59.

Designing efficient data centers

Energy

2x
as energy efficient

On average, a Google data center is twice as energy efficient as a typical enterprise data center.
Page 19

7x
computing power

Compared with five years ago, we now deliver around seven times as much computing power with the same amount of electrical power.
Page 19

1.11
PUE

The average annual power usage effectiveness (PUE) for our global fleet of data centers was 1.11, compared with the industry average of 1.67—meaning that Google data centers use about six times less overhead energy.
Page 20

Certifications

ISO 50001
certification

We maintained ISO 50001 (energy management) certification for 12 of our 15 Google-owned and -operated data centers globally, which together represented 91% of our IT energy use.
Page 21

Emissions

0
net carbon emissions

Whether someone is using Google at home or as part of an organization running Google Cloud or G Suite, all of the products in our Cloud are carbon neutral.
Page 22

98%
emissions reduction

A business using Gmail can reduce the GHG emissions impact of its email service by up to 98% compared with running email on on-premises servers.
Page 22

Waste

19%
of components refurbished

In 2018, 19% of components used for server upgrades were refurbished inventory.
Page 21

3.5 million
components resold

In 2018, we wiped clean and resold nearly 3.5 million components into the secondary market for reuse by other organizations.
Page 21

Waste (continued)

87%
waste diverted

We diverted 87% of waste from our global data center operations away from landfills.
Page 21

2018 performance highlights

Advancing carbon-free energy

Energy

3.75 GW
of renewable energy

Google is the world's largest corporate purchaser of renewable energy. We've signed 34 agreements totaling more than 3.75 GW of renewable energy.
Page 25

100%
renewable energy

In 2018, we matched 100% of the electricity consumption of our operations with purchases of renewable energy for the second consecutive year.
Page 25

26 million MWh of
renewable energy

To date, we've purchased a total of nearly 26 million MWh of renewable energy.
Page 25

$2.5 billion in
equity commitments

Since 2010, we've committed to invest nearly $2.5 billion in renewable energy projects with a total combined capacity of 3.7 GW.
Page 29

GHG emissions

86% decrease in
carbon intensity

Since 2011, our carbon intensity per unit of revenue decreased by 86%.
Page 32

52% decrease in
cumulative GHG emissions

Since 2011, we've reduced our cumulative Scope 1 and 2 GHG emissions by 52% by procuring renewable energy.
Page 30

12 years
of carbon neutrality

Google has been carbon neutral since 2007. Because of our renewable energy and carbon offset programs, our net operational carbon emissions during this period were zero.
Page 33

40
carbon offset projects

Since 2007, we've partnered with more than 40 carbon offset projects to offset more than 19 million metric tons of carbon dioxide equivalent (tCO_2e).
Page 34

Creating sustainable workplaces

Certifications

13 million square feet
LEED-certified

Over 1.2 million square meters (13 million square feet) of Google office facilities have achieved LEED certification.
Page 37

28%
LEED Platinum

28% of our LEED-certified square footage has achieved a Platinum rating and 57% a Gold rating.
Page 37

Waste

76%
landfill diversion

In 2018, we reached a 76% landfill diversion rate for our offices globally.
Page 39

6.6 million pounds
of food waste prevented

Since 2014, Google has prevented over 3 million kilograms (6.6 million pounds) of waste in our cafés globally by tracking pre-consumer food waste.
Page 40

Water

11 million
gallons avoided

By the end of 2018, we achieved a 3% reduction in potable water intensity at our Bay Area headquarters—equivalent to avoiding the use of over 42 million liters (11 million gallons) of potable water.
Page 39

Transportation

40,000
tCO_2e savings

By using Google shuttles in the Bay Area, we saved 40,000 tCO_2e emissions—equivalent to taking 8,760 cars off the road every work day.
Page 40

2018 performance highlights

Building better devices and services

Energy

29 billion kWh of energy savings

Nest thermostats have helped customers cumulatively save more than 29 billion kWh of energy—enough to power all of San Francisco's electricity consumption for five years.
Page 49

12 billion kWh of energy savings

In 2018 alone, Nest thermostats helped customers save nearly 12 billion kWh of energy—more energy than Google used in 2018.
Page 46

10%–15% energy savings

On average, Nest thermostats have proven energy savings of 10%–12% for heating and 15% for cooling, which means they pay for themselves in under two years.
Page 49

Materials

20%–75% recycled plastic

Products like the Nest Thermostat E, Google Home, and Chromecast all contain parts with 20%–75% post-consumer recycled plastic content.
Page 46

GHG emissions

40% emissions reduction per unit

From 2017 to 2018, we reduced carbon emissions for product shipments by 40% per unit, on average.
Page 46

Community

1 million Nest thermostats

The Nest Power Project aims to bring 1 million energy- and money-saving Nest thermostats to families in need by 2023.
Page 50

Empowering users with technology

Enabling technologies

1 billion kilometers of transit results

Google Maps provides more than 1 billion kilometers' (621 million miles') worth of transit results per day, helping limit carbon emissions by giving people access to mass transit options, bike routes, and traffic information.
Page 53

107 million mapped rooftops

Since 2015, Project Sunroof has mapped more than 107 million rooftops in 21,500 cities across Argentina, Australia, Canada, France, Germany, Italy, the Netherlands, the United Kingdom, and the United States.
Page 55

475 million air quality measurements

By the end of 2018, Project Air View had captured more than 475 million cumulative air quality measurements in 62 cities worldwide.
Page 56

5 pilot cities

In 2018, the Environmental Insights Explorer launched in partnership with five pilot cities: Buenos Aires, Argentina; Melbourne, Australia; Victoria, Canada; and Mountain View and Pittsburgh, USA.
Page 55

Enabling technologies (continued)

20 petabytes of freely available geospatial data

Earth Engine has enabled tens of thousands of active users around the world to easily analyze 20 petabytes of geospatial information, resulting in a deeper understanding of the planet.
Page 53

Progress against targets

Target	Deadline	2018 progress	Status
Designing efficient data centers			
Energy			
Maintain or improve quarterly PUE at each Google data center, year over year.	Annual	The average annual PUE for our global fleet of data centers was 1.11. Our fleet-wide PUE has stayed at or below 1.12 since 2013. **Page 20**	●
Waste			
Achieve Zero Waste to Landfill for our global data center operations.	None	Our global landfill diversion rate for data center operations was 87% in 2018. **Page 21**	○
Certifications			
Maintain ISO 50001 energy management system certification for all Google-owned data centers that meet certain operational milestones.	Annual	We maintained ISO 50001 certification for 12 of our 15 operating data centers, which together represented 91% of our IT energy use. **Page 21**	○
Advancing carbon-free energy			
Energy			
Match 100% of the electricity consumption of our operations with renewable energy purchases.	2018	Our wind and solar deals produced enough renewable energy to match 100% of the electricity consumption of our data centers and offices for the second consecutive year. **Page 25**	●
Triple our purchases of renewable energy from 1.1 GW to 3.4 GW by 2025.	2025	On July 27, 2015, as part of the American Business Act on Climate Pledge, Google committed to tripling our purchases of renewable energy from 1.1 GW to 3.4 GW by 2025. By the end of 2018, we've signed 34 agreements totaling more than 3.75 GW of renewable energy, exceeding our target seven years early. **Page 25**	●
GHG emissions			
Maintain carbon neutrality for our operations.	Annual	We purchased enough renewable energy and high-quality carbon offsets to bring our net operational carbon emissions to zero. Google has been carbon neutral since 2007—for twelve consecutive years. **Page 33**	●

● Achieved ◒ On track ○ Ongoing ⊘ Missed

Progress against targets

Target	Deadline	2018 progress	Status
Creating sustainable workplaces			
Certifications			
Pursue third-party green or healthy-building certifications for office projects, such as LEED, WELL Building Standard, and Living Building Challenge.	Annual	Over 1.2 million square meters (13 million square feet) of Google office facilities have achieved LEED certification, with 28% achieving a Platinum rating and 57% a Gold rating. **Page 37**	○
GHG emissions			
Reduce metric tons of carbon dioxide equivalent emissions per full-time employee (FTE) 50% by 2025 at Google's office in New York City.	2025	By the end of 2018, we had met our target ahead of schedule—reducing emissions by 54% per FTE. **Page 37**	●
Reduce single-occupancy vehicle commuting at our Bay Area headquarters to 45% of those commuting on any given day.	None	For our Bay Area headquarters, we're on track to meeting this commuting goal. **Page 40**	◒
Provide electric vehicle charging stations for 10% of total parking spaces at our Bay Area headquarters.	None	We have achieved a design standard of approximately 10% of parking spaces for new construction and tenant improvement projects at our Bay Area headquarters. **Page 40**	◒
Waste			
Reduce landfill waste per Googler at our Bay Area headquarters by 10% in 2018, compared with a three-year average baseline (2014–2016).	2018	We achieved a 15% reduction in landfill waste per Googler at our Bay Area headquarters. **Page 39**	●
Water			
Reduce potable water intensity at our Bay Area headquarters by 5% by the end of 2019, against a 2017 baseline.	2019	In 2018, we achieved a 3% reduction in our Bay Area potable water intensity. **Page 39**	◒
Building better devices and services			
GHG emissions			
100% of device orders shipping to and from Google customers will be carbon neutral by 2020.	2020	This target was set in 2019. **Page 44**	◒
100% of flagship consumer hardware products launching in 2020 and beyond will have published product environmental reports.	2020	This target was set in 2019. **Page 46**	◒
Materials			
100% of Made by Google products launching in 2022 and every year after will include recycled materials.	2022	This target was set in 2019. **Page 44**	◒
Community			
By 2023, Google Nest will install 1 million energy- and money-saving thermostats in homes that need them most.	2023	This target was set in 2019. **Page 50**	◒

● Achieved ◒ On track ○ Ongoing ⊘ Missed

Designing efficient data centers

DATA CENTERS: BY THE NUMBERS

2x
as energy efficient
On average, a Google data center is twice as energy efficient as a typical enterprise data center.[14]

1.11 PUE
In 2018, the average annual PUE for our global fleet of data centers was 1.11, compared with the industry average of 1.67—meaning that Google data centers use about six times less overhead energy.

7x
computing power
Compared with five years ago, we now deliver around seven times as much computing power with the same amount of electrical power.

87%
waste diverted
In 2018, we diverted 87% of waste from our global data center operations away from landfills.

Overview

Google's data centers are the heart of our company, powering products like Search, Gmail, and YouTube for billions of people around the world, 24x7. We own and operate 15 data centers[13] on four continents and continue to add new sites to better serve our customers. Each data center is a large campus where the vast majority of our facilities, servers, networking equipment, and cooling systems are designed from the ground up for maximum efficiency and minimal environmental impact.

For more than a decade, we've worked to make Google data centers some of the most efficient in the world, improving their environmental performance even as demand for our products has dramatically risen. We've done this by designing, building, and operating each one to maximize efficient use of energy, water, and materials.

To reduce energy use, we strive to build the world's most energy-efficient computing network by squeezing more out of every watt of power we consume. First, we outfit each data center with high-performance servers that we've custom designed to use as little energy as possible. We improve facility energy use by installing smart temperature and lighting controls and redesigning how power is distributed to reduce energy loss. We employ advanced cooling techniques, relying primarily on energy-efficient evaporative cooling, and use nonpotable water at some sites. Finally, we're applying machine learning to drive energy efficiency even further.

Our efforts have paid off: On average, a Google data center is twice as energy efficient as a typical enterprise data center.[15] Compared with five years ago, we now deliver around seven times as much computing power with the same amount of electrical power. Much of this improvement has come from new innovations with accelerators, such as our Tensor Processing Units (TPUs)—highly efficient computer chips we designed specifically for machine learning applications.

In 2018, the average annual power usage effectiveness (PUE)[16] for our global fleet of data centers was 1.11, compared with the industry average of 1.67[17]—meaning that Google data centers use about six times less overhead energy (11%) for every unit of IT equipment energy (see Figure 3). We aim to maintain or improve our quarterly PUE at each Google data center, year over year. Our fleet-wide PUE has stayed at or below 1.12 since 2013 (see Figure 4).

Generating electricity requires water, so the less energy we use to power our data centers, the less water we use as well. The source of energy matters too: Wind and solar energy require considerably less water to produce than do coal and nuclear energy. In 2018, matching our data center electricity consumption with renewable energy reduced embedded water use by 88% on average compared with buying grid power.

Figure 3

OVERHEAD ENERGY USE IN GOOGLE DATA CENTERS

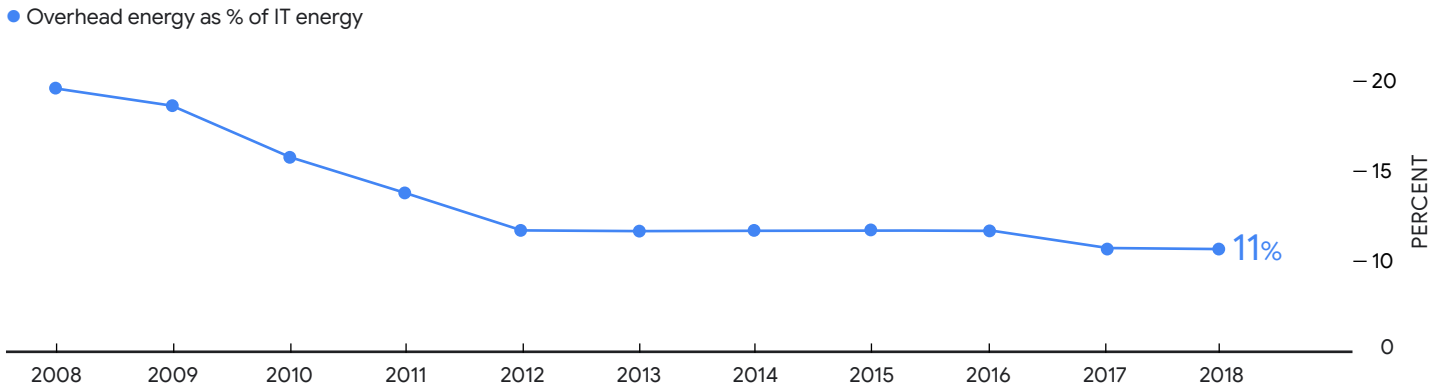
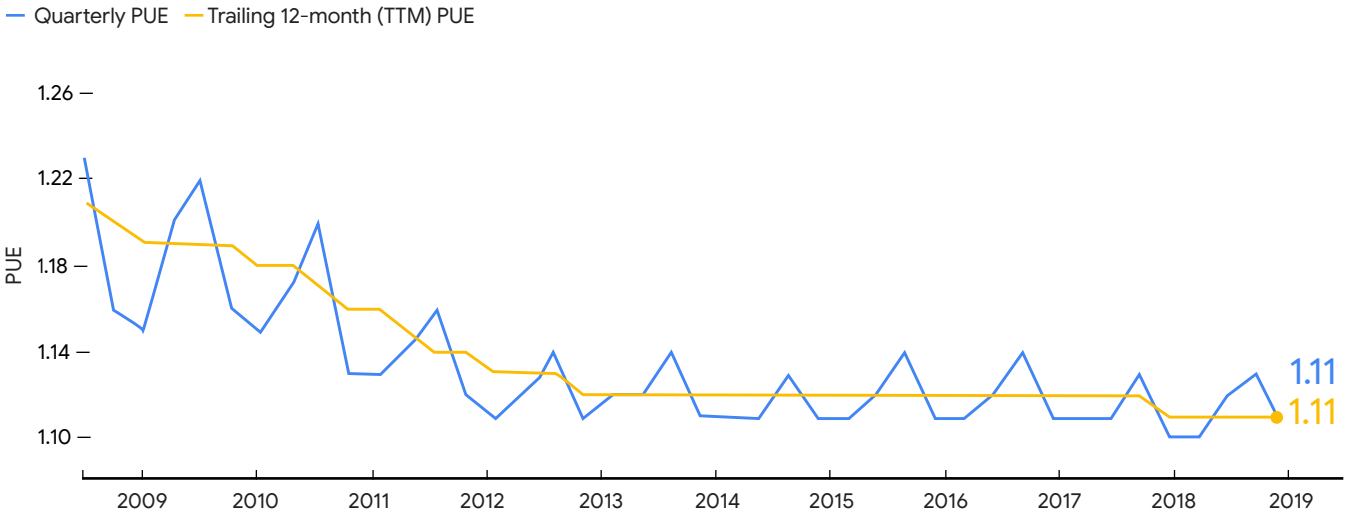
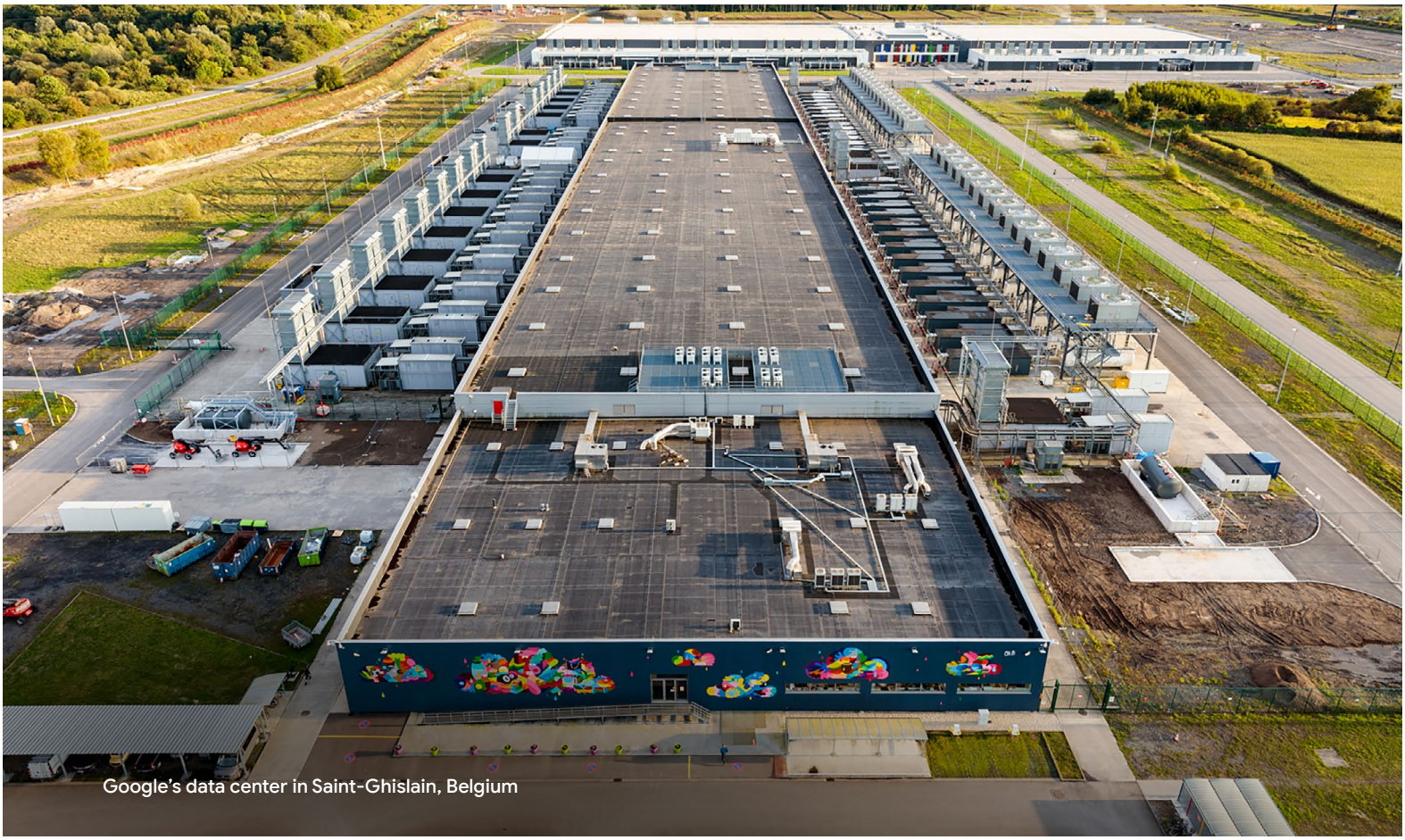


Figure 4

AVERAGE PUE FOR ALL DATA CENTERS





Google's data center in Saint-Ghislain, Belgium

In 2013, we became the first company in North America—and the only major internet company—to achieve a multi-site energy management system certification to ISO 50001, a voluntary third-party standard. Our energy management system intends to cover all of our owned data centers globally once they meet certain operational milestones. In 2018, we maintained ISO 50001 certification for 12 of our 15 Google-owned and -operated data centers, which together represented 91% of our IT energy use.[18]

We're also working to design out waste, embedding circular economy principles into our server management by reusing materials multiple times. In 2018, 19% of components used for machine upgrades were refurbished inventory. When we can't find a new use for our equipment, we completely erase any components that stored data and then resell them. In 2018, we resold nearly 3.5 million units into the secondary market for reuse by other organizations.

We're committed to achieving Zero Waste to Landfill[19] for our global data center operations by reducing the amount of waste we generate and finding better disposal options. In 2018, we diverted 87% of waste from our global data center operations away from landfills.

In addition to driving efficiency in our data center operations, we also consider supply chain impacts. Through the efforts of our Responsible Supply Chain program, we collaborate with stakeholders across our supply chain to uphold our high standards for protecting workers and the environment.

From 2007 to 2017, Google's data center investments in Europe supported economic activity with

€490

million per year in GDP.

Our Supplier Code of Conduct builds upon Google's core values and beliefs and incorporates key elements from the Google Code of Conduct and international human rights, safety, and environmental standards.

Google has saved more than $1 billion through our energy-efficiency initiatives and hundreds of millions more through resource efficiency. By sharing our best practices and supporting research and collaboration, we hope to help other companies realize their own savings and promote ever-greater data center sustainability worldwide.

Google's investment in digital infrastructure, such as data centers, also supports sustainable growth and creates economic opportunity. In 2016, Google's U.S. data centers generated $1.3 billion in economic activity, $750 million in labor income, and 11,000 jobs.[20] From 2007 to 2017, Google's data center investments in Europe supported economic activity with €490 million per year in gross domestic product (GDP) and 6,600 full-time equivalent (FTE) jobs per year, on average.[21]

Carbon-neutral cloud services

Google Cloud Platform and G Suite products like Gmail, Docs, and Drive are enabling millions of businesses to shift computing needs from self-managed data centers or colocation facilities to Google Cloud's highly efficient, renewable energy–based computing infrastructure. Businesses that switch to cloud-based products like G Suite have reported reductions in IT energy use and carbon emissions up to 87%,[22] and a business using Gmail can reduce the GHG emissions impact of its email service by up to 98%, compared with running email via on-premises servers.[23] Individual users also benefit, since providing an active user one month of Google services creates fewer GHG emissions than driving a car one mile.[24] Whether someone is using Google at home or as part of an organization running Google Cloud or G Suite, all of the products in our Cloud are carbon neutral.

LEARN MORE

2016 case study: Circular Economy at Work in Google Data Centers

2018 spotlight: Once Is Never Enough

2018 spotlight: Putting Down Local Roots Where Google's European Data Centers Are Growing

2018 spotlight: Belgian site becomes first Google data center to add on-site solar

2018 blog: Engineered for renewal: Google Cloud, Etsy and sustainability

2018 report: European Data Centers: Economic Impact and Community Benefit

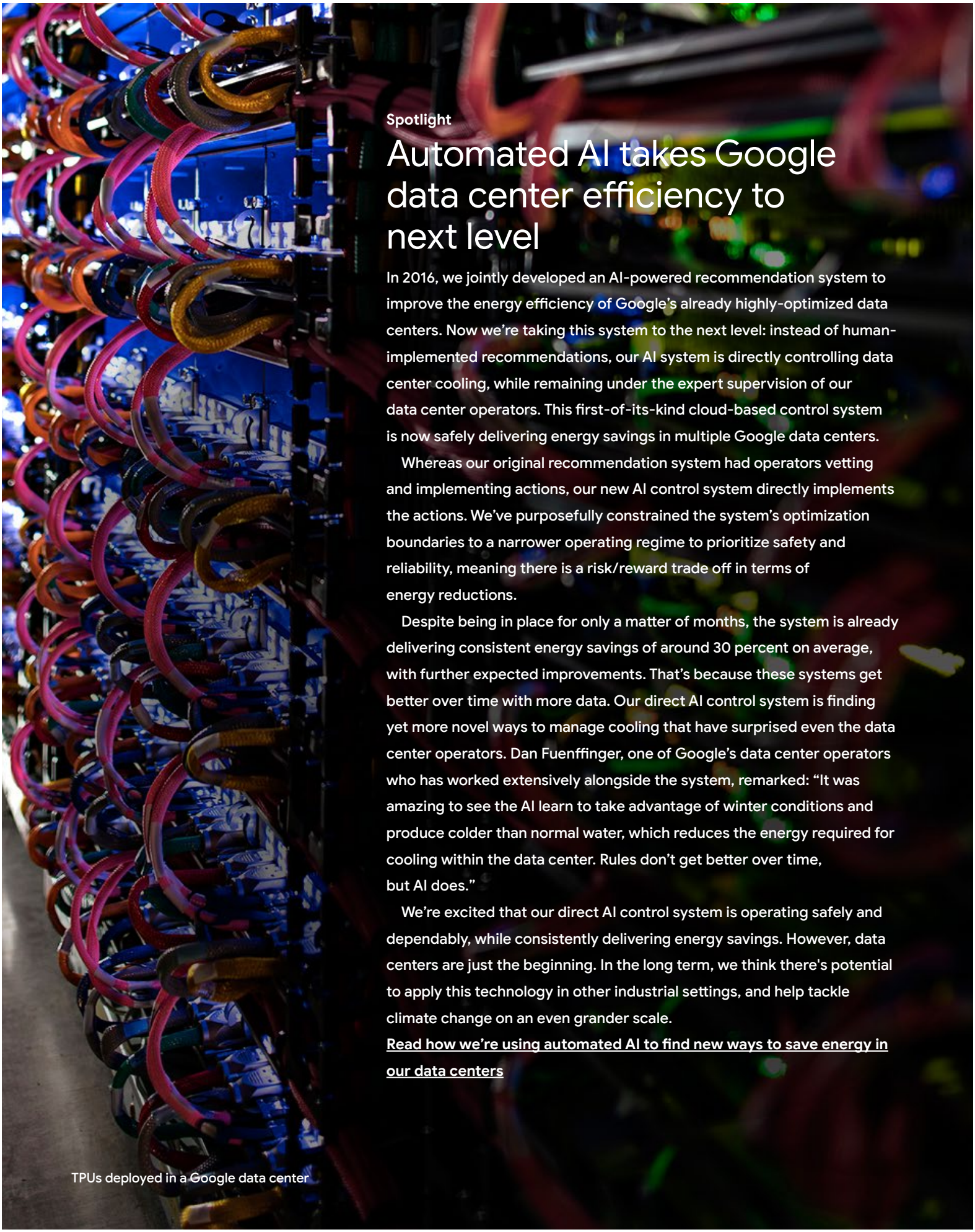
2018 report: U.S. Data Centers: Economic Impact and Community Benefit

Website: Google Data Centers: Efficiency: How We Do It

Website: Google Cloud Sustainability

Website: Google Cloud Renewable Energy

Website: Responsible Supply Chain



Spotlight

Automated AI takes Google data center efficiency to next level

In 2016, we jointly developed an AI-powered recommendation system to improve the energy efficiency of Google's already highly-optimized data centers. Now we're taking this system to the next level: instead of human-implemented recommendations, our AI system is directly controlling data center cooling, while remaining under the expert supervision of our data center operators. This first-of-its-kind cloud-based control system is now safely delivering energy savings in multiple Google data centers.

Whereas our original recommendation system had operators vetting and implementing actions, our new AI control system directly implements the actions. We've purposefully constrained the system's optimization boundaries to a narrower operating regime to prioritize safety and reliability, meaning there is a risk/reward trade off in terms of energy reductions.

Despite being in place for only a matter of months, the system is already delivering consistent energy savings of around 30 percent on average, with further expected improvements. That's because these systems get better over time with more data. Our direct AI control system is finding yet more novel ways to manage cooling that have surprised even the data center operators. Dan Fuenffinger, one of Google's data center operators who has worked extensively alongside the system, remarked: "It was amazing to see the AI learn to take advantage of winter conditions and produce colder than normal water, which reduces the energy required for cooling within the data center. Rules don't get better over time, but AI does."

We're excited that our direct AI control system is operating safely and dependably, while consistently delivering energy savings. However, data centers are just the beginning. In the long term, we think there's potential to apply this technology in other industrial settings, and help tackle climate change on an even grander scale.

Read how we're using automated AI to find new ways to save energy in our data centers

TPUs deployed in a Google data center

Advancing carbon-free energy

CARBON-FREE ENERGY: BY THE NUMBERS

3.75 GW
of renewable energy
Google is the world's largest corporate purchaser of renewable energy. We've signed 34 agreements totaling more than 3.75 GW of renewable energy.

100%
renewable energy
In 2018, we matched 100% of the electricity consumption of our operations with purchases of renewable energy for the second consecutive year.

12 years
of carbon neutrality
Google has been carbon neutral since 2007. Because of our renewable energy and carbon offset programs, our net operational carbon emissions during this period were zero.

$2.5 billion
in investment commitments
Since 2010, we've committed to invest nearly $2.5 billion in renewable energy projects with a total combined capacity of 3.7 GW.

Overview

Running our business requires us to use a lot of electricity to power our data centers, offices, and other infrastructure. And combating climate change requires the world to transition to a clean energy economy. So we've made it a top priority to become more energy efficient and to match every unit of energy we consume at our facilities around the world with an equivalent unit of energy from renewable sources, such as wind and solar. Our support for clean energy goes hand in hand with reducing our carbon footprint. By improving the efficiency of our operations and buying both renewable power and high-quality carbon offsets, we've been carbon neutral since 2007.

Google is the world's largest corporate purchaser of renewable energy.[25] Since 2010, we've signed 34 agreements to purchase a total of more than 3.75 GW of renewable energy that is new to the grid (see Figure 5).[26] On July 27, 2015, as part of the American Business Act on Climate Pledge, Google committed to tripling our purchases of renewable energy from 1.1 GW to 3.4 GW by 2025. We surpassed this in 2018, exceeding our target seven years early.

In 2012, we set a long-term goal to purchase enough renewable energy to match all the electricity we consume globally on an annual basis. In 2017, we achieved it for the first time: Google's total purchase of energy from sources like wind and solar matched the amount of electricity used by our operations around the world, including our offices and data centers. And in 2018, we again matched 100% of our annual electricity consumption with purchases of renewable energy (see Figure 6). This amounted to more than 10 million megawatt-hours (MWh) of energy—more electricity than is used annually by the state of Hawaii.[27] To date, we've purchased a total of nearly 26 million MWh of renewable energy.

We're the first company of our size to achieve 100% renewable energy two years running.[28] While we're still drawing power from the grid, some of which is from fossil fuel resources, we're purchasing enough renewable energy to match every MWh of electricity our data center and office operations consume.

Our long-term goal is to source carbon-free energy to match our electricity consumption *in all places, at all times*. This means realizing a future where each Google facility is always matched—around the clock—with local carbon-free power. Our ultimate vision is to create a world where everyone has access to clean energy; this includes not only Google, but our suppliers and their communities.

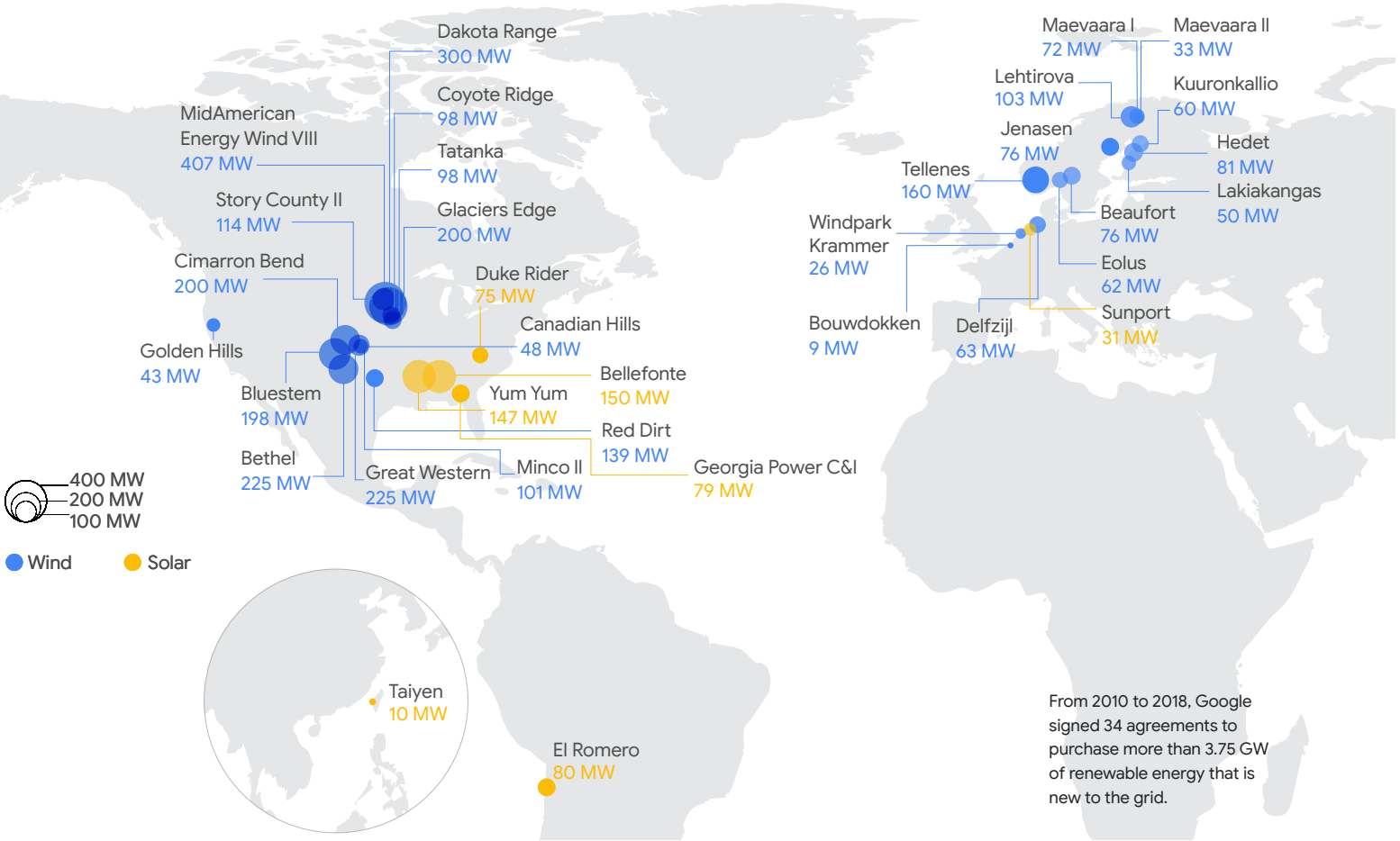


Figure 5

RENEWABLE ENERGY FOR GOOGLE'S OPERATIONS

Reaching 100% renewable energy

We achieved our 100% renewable energy target much faster and at much greater scale than we thought possible when we set this goal seven years ago. We met it primarily by buying renewable electricity directly from new wind and solar farms via long-term power purchase agreements (PPAs) on the grids where we have operations, as well as by buying renewable power through utilities via renewable energy purchasing models that we helped create. In addition, a portion of our utility energy purchases include renewable sources as part of the utility's grid mix.[29] With our PPAs, we're purchasing physical renewable energy, which includes the electrons bundled with renewable energy certificates (RECs).

By pioneering new energy purchasing models that others can follow, we've helped drive wide-scale adoption of clean energy. For example, we joined forces with Walmart, Target, and Johnson & Johnson in Georgia to help build a state-approved program that allows companies to buy renewable energy directly through the state's largest utility. The program is the first of its kind in Georgia and has paved the way for construction of two solar energy projects with a total capacity of 177 megawatts (MW).

Also in the Southeast region of the United States, we worked with the Tennessee Valley Authority (TVA) to sign a utility-based agreement where Google will purchase the output of several new solar farms, totaling 413 MW of power from 1.6 million solar panels— equivalent to the combined size of 65,000 home rooftop solar systems. Thanks to the abundant solar power generated by these new farms, electricity consumed by our new data centers under construction in Tennessee and Alabama will be matched with 100% renewable energy from day one.

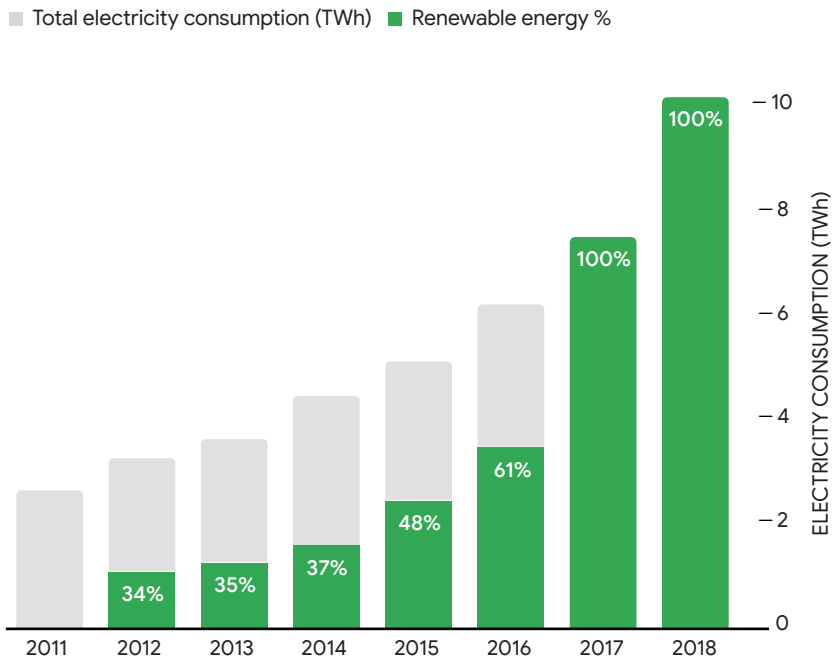
Our efforts to expand carbon-free energy in 2018 also took us to Europe, where we announced agreements in Finland to purchase additional renewable electricity from three new wind farms totaling 190 MW—our first such deals in the country.

Our renewable energy initiatives earned Google two 2018 Green Power Leadership Awards: one in International Market Development from the Center for Resource Solutions and one in Excellence in Green Power Use from the U.S. Environmental Protection Agency.

DeepMind and Google recently started using machine learning (ML) to make wind power more predictable and valuable. We used ML to optimize 700 MW of wind power capacity in the Central United States that is part of our global fleet of renewable energy projects. By predicting wind power output 36 hours ahead of actual generation, our model recommends how

Figure 6

RENEWABLE ENERGY PURCHASING COMPARED WITH TOTAL ELECTRICITY USE



Minco II wind farm in Oklahoma
(101 MW for Google)

to make optimal hourly delivery commitments to the power grid a full day in advance. This is important because energy sources that can be scheduled (i.e., can deliver a set amount of electricity at a set time) are often more valuable to the grid. To date, ML has boosted the value of our wind energy by roughly 20%, compared to the baseline scenario of no time-based commitments to the grid.

We're also helping to green the power grid through our advocacy of clean energy policies and our support for renewable energy procurement programs. For example, we worked with business and government stakeholders in Taiwan to share our experience with the benefits of corporate renewable energy purchasing and to support the creation of new purchasing channels for companies. We were pleased to see that Taiwan passed a law in January 2017 to allow end-users to directly purchase renewable energy for their operations. In 2018, we signed our inaugural renewable energy deal in Asia, the first such corporate power purchase agreement in Taiwan. We will purchase the output of a 10 MW solar array (which is part of a larger solar farm) in Tainan City, Taiwan. It will deploy 40,000 solar panels across commercial fishing ponds, maximizing land-use efficiency and benefiting local aquaculture workers. This will boost the carbon-free profile of our local data center.

To date, Google's renewable energy purchasing contracts have led to nearly

$5 billion

in new capital investment in renewable energy projects around the world.

Along with being the world's largest corporate purchaser of renewable energy, Google is also one of the world's largest corporate investors in renewable energy. Since 2010, we've committed to invest nearly $2.5 billion in large-scale renewable energy projects and residential solar rooftop funds with a total combined capacity of 3.7 GW.[30] These targeted investments go beyond our own operational footprint, enabling renewable energy deployment at a larger scale while generating attractive risk-adjusted returns.

The cost of renewable power has dropped precipitously, while its scale has grown dramatically. Since 2009, levelized costs for utility-scale wind and solar energy have decreased by 69% and 88%, respectively.[31] In 2015, wind and solar energy became the world's largest source of newly installed power capacity,[32] and in 2018, 65% of net new power capacity globally came from renewable energy.[33] Renewables have become a mainstream source of affordable electricity for millions of people.

Increasing the share of renewables on the grid will produce many positive impacts. For example, doubling renewables by 2030 is expected to increase global GDP by as much as 1.1%, improve global welfare by 3.7%, and employ more than 24 million people in the renewable energy sector.[34] To date, Google's renewable energy purchasing contracts have led to nearly $5 billion in new capital investment in renewable energy projects around the world.[35] At Google, we'll continue doing our best to help accelerate the transition to clean energy and a more prosperous future.

LEARN MORE

2016 white paper: Achieving Our 100% Renewable Energy Purchasing Goal and Going Beyond

2016 spotlight: Greening the Grid: How Google Buys Renewable Energy

2018 blog post: Meeting Our Match: Buying 100 Percent Renewable Energy

2018 spotlight: Unlocking Access to Corporate Renewable Energy Purchasing in Taiwan

2018 blog post: A new partnership to drive renewable energy growth in the U.S.

2018 blog post: New wind in Finland: Scaling renewable energy as we grow

2018 blog post: The Internet is 24x7. Carbon-free Energy Should be Too

2018 white paper: Moving Toward 24x7 Carbon-Free Energy at Google Data Centers

2019 blog post: Why we're putting 1.6 million solar panels in Tennessee and Alabama

2019 blog post: Let the sunshine in: opening the market for more renewable energy in Asia

2019 blog post: Machine learning can boost the value of wind energy

Our carbon footprint

We began calculating our annual carbon footprint in 2006. Every year since 2009, we've publicly reported the results to CDP, a global organization that asks companies to disclose information on their GHG emissions performance and management. Our report received an A score from CDP for the past five years, and for the past four years, we earned a spot on CDP's Climate A List, which recognizes top reporting companies.

In 2018, our gross Scope 1 and 2 GHG emissions were 4.4 million metric tons of carbon dioxide equivalent (tCO_2e), but because of our renewable energy purchases, our net GHG emissions were reduced by 3.7 million tons to 750 thousand tCO_2e (see Figures 7 and 8). Due to growth in our business, our operational emissions increased 30% over the past year.[36] After accounting for our carbon offset purchases, our net operational carbon emissions were zero.

Since 2011, our renewable energy purchasing has resulted in emissions savings of nearly 11 million tCO_2e—a cumulative 52% reduction in our Scope 1 and 2 emissions over this period (see Figure 9). This is equivalent to taking nearly 2.3 million cars off the road for a year, or the carbon sequestered by more than 12.5 million acres of U.S. forests in a year.[37] In 2018, our operational GHG emissions were 83% lower due to our renewable energy procurement (see Figure 9).

Figure 7

GHG EMISSIONS WITHOUT RENEWABLE ENERGY PURCHASES

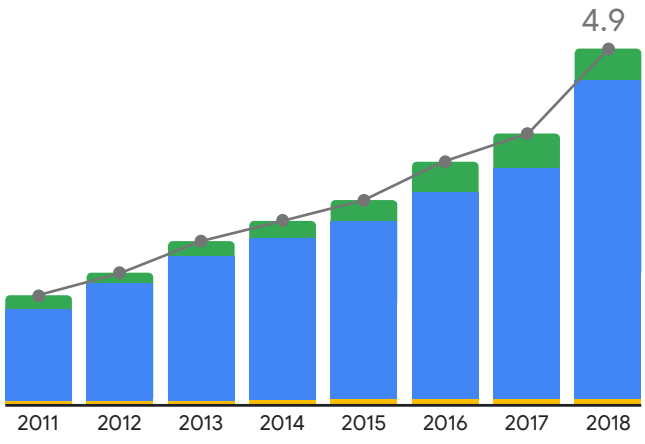
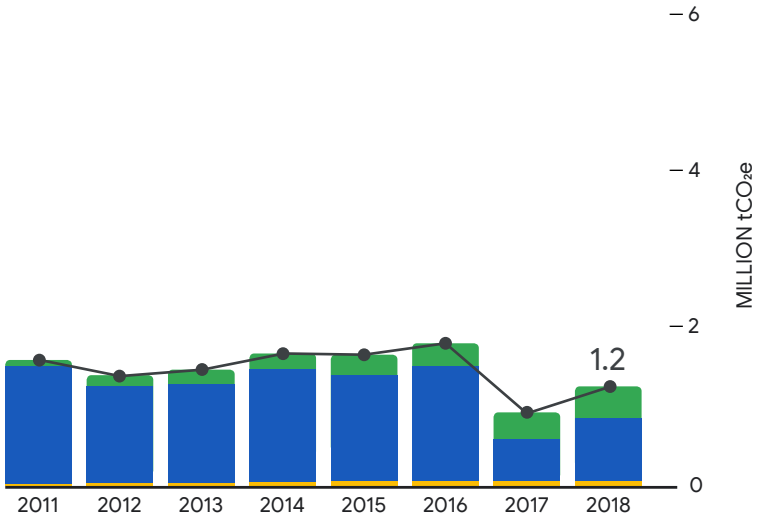


Figure 8

GHG EMISSIONS WITH RENEWABLE ENERGY PURCHASES



Scope 1 Scope 2 (location) Scope 2 (market) Scope 3 (business travel and commuting)[38]

Total location-based GHG emissions Total market-based GHG emissions

Figure 9

IMPACT OF RENEWABLE ENERGY PURCHASES ON GHG EMISSIONS

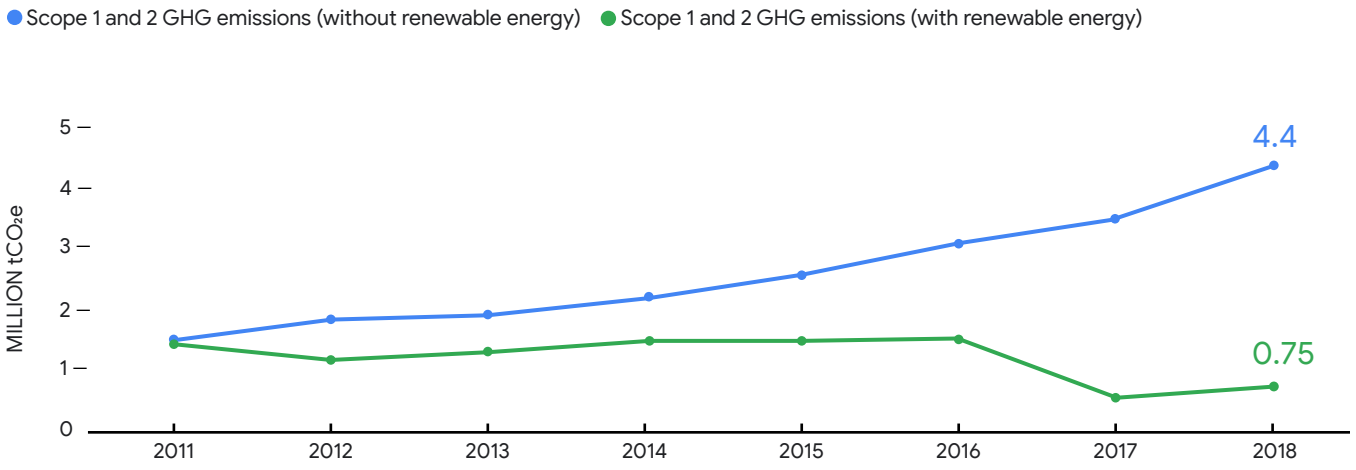


Figure 10

CARBON INTENSITY PER UNIT OF REVENUE

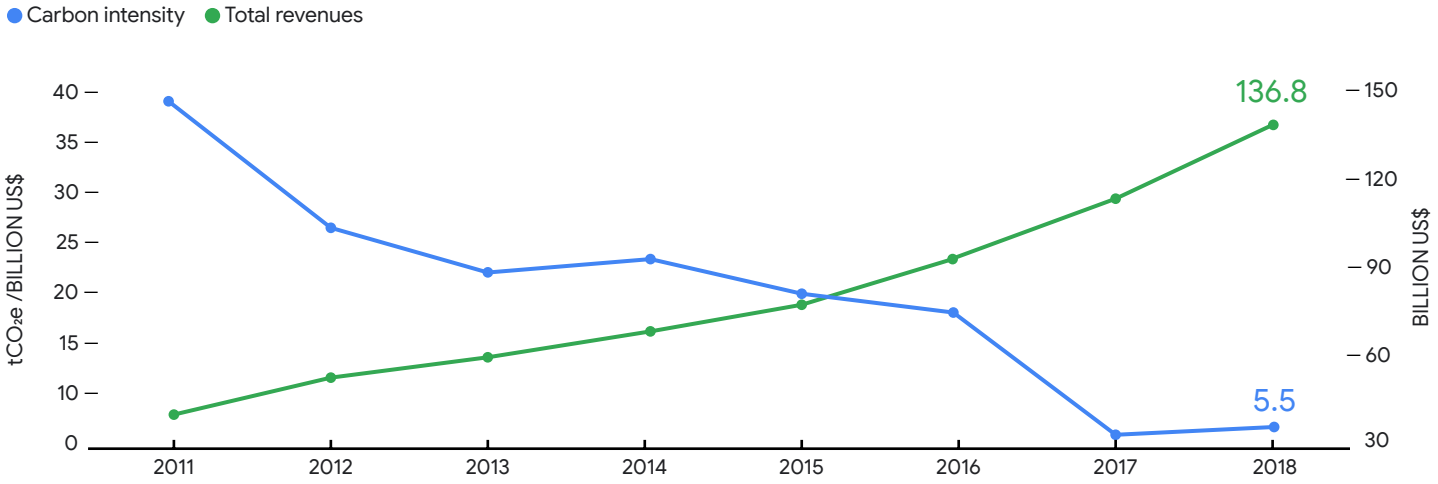
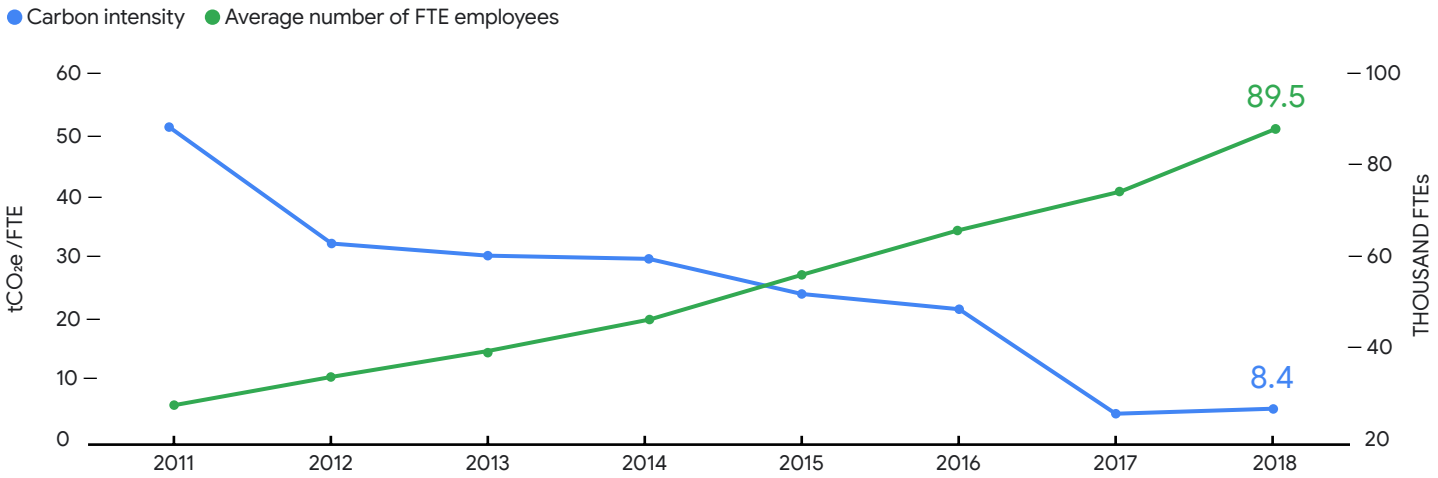


Figure 11

CARBON INTENSITY PER FTE EMPLOYEE



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

To align with industry best practices for Scope 3 reporting, in 2018, we extended our boundaries to include manufacturing emissions beyond Tier 1 suppliers (full upstream to the point of extraction), use of sold products, end-of-life treatment of sold products, and emissions associated with food from our corporate offices. We continue to improve the level of certainty we have in calculating our Scope 3 emissions and to work to reduce them. For example, our vision is for all our suppliers' sites to source 100% renewable energy in every region where our products are made.

Because of our emissions-reduction efforts, our carbon intensity has steadily decreased even as our company has grown and our energy use has correspondingly increased. Since 2011, our carbon intensity per unit of revenue decreased by 86% (see Figure 10), our carbon intensity[39] per FTE employee decreased by 84% (see Figure 11), and our carbon intensity for electricity used at our data centers dropped by 91%. This means we're delivering our products and services with reduced carbon impacts, even before using carbon offsets to reach neutrality.

Wells capture methane gas at Oneida-Herkimer Regional Landfill in New York.

Twelve years of carbon neutrality

In 2007, Google committed to being carbon neutral, and we've met this goal every year since then. We reach carbon neutrality via three steps. First, we work to reduce our total energy consumption by pursuing aggressive energy-efficiency initiatives. Second, we match 100% of the electricity consumption of our operations with purchases of renewable energy. Third, we buy carbon offsets for any remaining emissions we haven't yet eliminated.[40]

When we committed to carbon neutrality, we saw carbon offsets as an interim solution. As we work to reduce our emissions, our need for carbon offsets will continue to decrease. We reduce our Scope 1 and 2 emissions by improving energy efficiency and procuring renewable energy. We reduce our operational Scope 3 emissions by minimizing the need for business travel through encouraging use of video conferencing tools like Google Hangouts for meetings, and facilitating employees to use sustainable commuting options for employees, such as public transit, shuttles, carpooling, or electric vehicles.

When we do purchase carbon offsets, we follow stringent principles. We invest in high-quality, third-party-verified offsets, including landfill gas projects and animal waste management systems. All our offsets are additional, meaning that the projects reduce GHG emissions that wouldn't

We will continue to work toward **net zero** carbon in the decade to come and to increase the net positive impact of our products.

be reduced through other incentives. We also ensure that the projects we invest in are permanent sources of carbon reduction or sequestration, rather than temporary solutions. Finally, whenever possible, we invest for the long term, which offers owners and developers the financial stability they need to continue operating.

Google has been carbon neutral for twelve years, and in that time, we've partnered with more than 40 carbon offset projects to offset more than 19 million tCO_2e.[41] One of Google's long-standing project partners is Oneida-Herkimer Solid Waste Management Authority, a landfill gas project in upstate New York, United States. By enabling us to reduce our carbon footprint while reducing local air pollution, improving waste management, and increasing local revenue streams, each of these collaborations is a win for both Google and our communities.

Our commitment to reduce GHG emissions goes beyond our operational boundaries; some of our products enable users to reduce their own GHG emissions. For example, Google Maps and Waze Carpool help commuters reduce emissions by making transit and carpooling information more accessible. Nest thermostats help people reduce home energy consumption by controlling heating and cooling. And Project Sunroof helps users estimate potential solar energy production if they were to install rooftop solar. We will continue to work toward net zero carbon in the decade to come and to increase the net positive impact of our products.

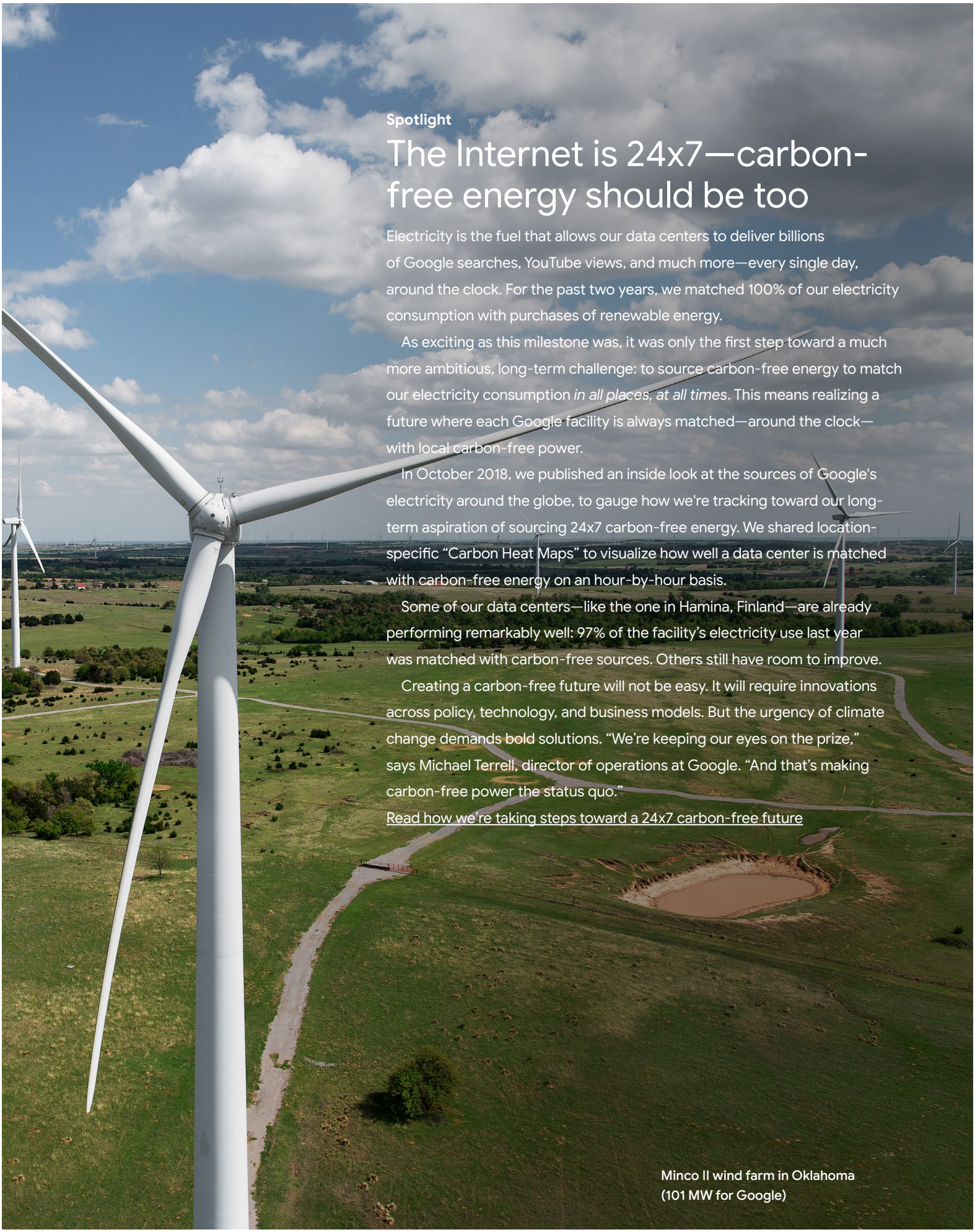
LEARN MORE

2011 white paper: Google's Carbon Offsets: Collaboration and Due Diligence

2017 white paper: 10 Years of Carbon Neutrality

2017 spotlight: Capturing Value from Waste in Upstate New York

Website: Responsible Supply Chain



Spotlight

The Internet is 24x7—carbon-free energy should be too

Electricity is the fuel that allows our data centers to deliver billions of Google searches, YouTube views, and much more—every single day, around the clock. For the past two years, we matched 100% of our electricity consumption with purchases of renewable energy.

As exciting as this milestone was, it was only the first step toward a much more ambitious, long-term challenge: to source carbon-free energy to match our electricity consumption *in all places, at all times*. This means realizing a future where each Google facility is always matched—around the clock—with local carbon-free power.

In October 2018, we published an inside look at the sources of Google's electricity around the globe, to gauge how we're tracking toward our long-term aspiration of sourcing 24x7 carbon-free energy. We shared location-specific "Carbon Heat Maps" to visualize how well a data center is matched with carbon-free energy on an hour-by-hour basis.

Some of our data centers—like the one in Hamina, Finland—are already performing remarkably well: 97% of the facility's electricity use last year was matched with carbon-free sources. Others still have room to improve.

Creating a carbon-free future will not be easy. It will require innovations across policy, technology, and business models. But the urgency of climate change demands bold solutions. "We're keeping our eyes on the prize," says Michael Terrell, director of operations at Google. "And that's making carbon-free power the status quo."

Read how we're taking steps toward a 24x7 carbon-free future

Minco II wind farm in Oklahoma
(101 MW for Google)

Creating sustainable workplaces

SUSTAINABLE WORKPLACES: BY THE NUMBERS

13 million
square feet LEED-certified
By the end of 2018, over 1.2 million square meters (13 million square feet) of Google office facilities had achieved LEED certification.

76%
landfill diversion
In 2018, we reached a 76% landfill diversion rate for our offices globally.

6.6 million
pounds of food waste prevented
Since 2014, Google has prevented over 3 million kilograms (6.6 million pounds) of pre-consumer food waste in our cafés globally.

40,000
tCO_2e savings
By using Google shuttles in the Bay Area in 2018, we saved 40,000 tCO_2e emissions—equivalent to taking 8,760 cars off the road every work day.

Overview

Americans spend roughly 90% of their time indoors, and much of that time is spent at work.[42] At Google, just as we focus on people when it comes to designing our products, we also focus on people when creating healthy and sustainable workplaces—from our Bay Area headquarters to our offices in more than 150 cities spanning over 50 countries around the world. To do so, we look for innovative ideas that deliver measurable results and can be implemented at scale.

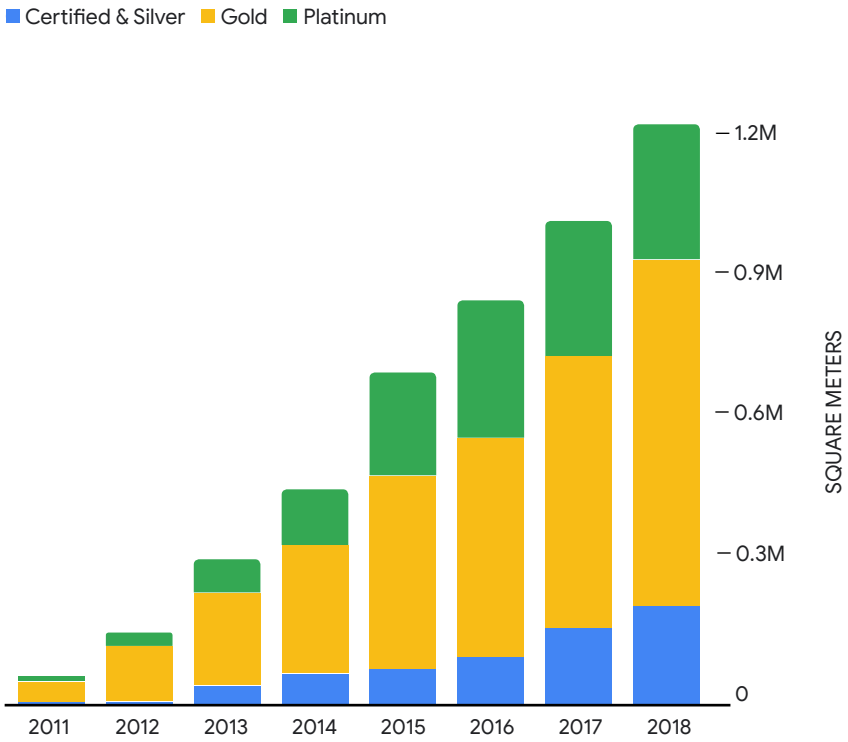
We start by applying industry-leading green building standards wherever possible. Our ongoing goal is to pursue third-party green or healthy-building certifications for our office projects, such as LEED, WELL Building Standard, and Living Building Challenge. By the end of 2018, over 1.2 million square meters (13 million square feet) of Google office facilities had achieved LEED certification, with 28% of our LEED-certified square footage achieving a Platinum rating and 57% a Gold rating (see Figure 12).

As part of our carbon neutral strategy, we continually pursue energy efficiency initiatives to reduce our energy consumption. In 2011, our Google office in New York City committed to the NYC Carbon Challenge—a voluntary, public-private partnership with the mayor's office in which organizations strive for a 30% reduction in GHG emissions per FTE by 2030. After meeting the 30% reduction goal early, we committed to a 50% reduction goal by 2025.[43] By the end of 2018, we had already met our target seven years ahead of schedule—reducing GHG emissions by 54% per FTE at our New York City office—primarily due to various energy efficiency and emissions reductions projects.

We also have a strong focus on the impacts associated with material selection, production, transportation, use, serviceability, and recycling of the products used for our spaces. We work to ensure that these products are safe for humans and the environment throughout their life cycles. We believe an industry-wide transition to safe chemistry and healthy materials is on the horizon. But making safe chemistry and healthy materials the new norm will require collective action across sectors, increased access to high-quality data that assesses chemical hazards, demand signals (from buyers like Google) to material and product manufacturers, and advancements in recycling technology and infrastructure.

Figure 12

CUMULATIVE LEED-CERTIFIED OFFICE SPACE



Considering local environments

We take a science- and community-driven approach to managing our campuses, with the aim of having a positive impact in the places where we operate and of designing and building our offices with local environments, ecology, and animal habitats in mind. One example is the thriving egret rookery in the middle of our Mountain View, California, campus. Since 2013, the Santa Clara Valley Audubon Society (SCVAS) and Google have worked together to provide conservation guidance and educational programming for the nesting area. Conservation efforts include limiting vehicular traffic during the breeding season, establishing a protocol for collecting and caring for injured and orphaned egrets, and installing signage. Additionally, the SCVAS organizes “Egret Office Hours,” attracting hundreds of Googlers, community members, North Bayshore company employees, nature enthusiasts, school groups, and others to learn about the rookery.

Another example is our science-based Design Guidelines for Bay Area landscaping projects. By the end of 2018, we had implemented our Habitat Design Guidelines on over 100 acres across our Bay Area headquarters. Areas once defined by lawn and hedges now host vibrant colonies of California wildflowers teeming with native bees and butterflies. These areas are studied and monitored to help inform future design decisions.

Google's offices are designed with people and the planet in mind.

Sustainability in our offices

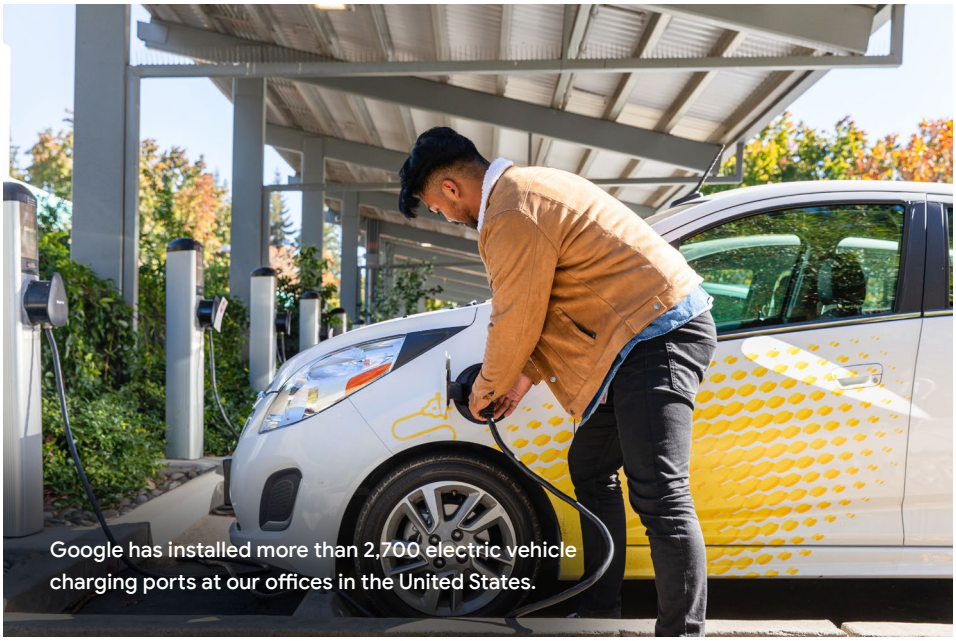
We reduce our water footprint by installing water-saving technologies and using reclaimed water wherever possible. In 2018, we set a target to reduce potable water intensity at our Bay Area headquarters by 5% by 2019. We're on track to meet this target: By the end of 2018, we achieved a 3% reduction in potable water intensity—equivalent to avoiding the use of over 42 million liters (11 million gallons) of potable water. Our current approach to global goal setting focuses on the highest-impact opportunities. We're now targeting our work at Google offices in highly water-stressed locations and in offices that are supported by recycling and composting infrastructure.

We implement strategies to minimize contamination in our office waste streams and identify diversion pathways that keep the waste we do generate out of landfills. In 2018, we reached 76% landfill diversion for our offices globally, and we surpassed our target to reduce landfill waste per Googler by 10% at our Bay Area headquarters—achieving a 15% reduction in landfill waste per Googler by the end of 2018. We also tracked waste generation for global offices that represent 53% of Google's total headcount.

Our cafés and Food Spots offer nutritious, responsibly sourced meals, snacks, and beverages.[44] We make thoughtful choices in the products we buy and the suppliers we buy them from. Our sustainability priorities include food waste prevention, sustainable hydration initiatives that encourage the use of reusable vessels for drinking water, and the promotion of balanced,

plant-forward offerings—all of which help reduce our environmental impact and support human health and well-being. We constantly come up with inventive solutions to repurpose food and look to compost and donate leftovers wherever we're legally able to do so, but we've learned that the best way to reduce food waste is to prevent it in the first place by tracking data and making adjustments. In 2018, this sort of data-driven optimization helped Google prevent more than 1 million kilograms (2.25 million pounds) of pre-consumer food waste in our cafés around the world, totaling over 3 million kilograms (6.6 million pounds) of food waste prevented since 2014. Also, by the end of 2018, 12 of our top 25 office sites were on track to reduce single-use beverages per seated headcount by 20% relative to a 2017 baseline.

Our Transportation team plans, implements, and operates mobility solutions to support Google's global growth. We set ambitious goals for helping Googlers transition to shuttles, carpooling, public transit, biking, and walking. There are also a growing number of electric vehicles in our Google-owned and -operated commuter program fleet, with the majority of the nonelectric vehicles using renewable diesel. In 2018, our Bay Area headquarters remained on track to meet our long-term goal of reducing single-occupancy vehicle commuting to 45%. We also have a target to provide electric vehicle charging stations for 10% of total parking spaces at our Bay Area headquarters. To date, we're on track to incorporate this design standard for new construction and tenant improvement projects and we've installed more than 2,700 electric vehicle charging ports at our offices in the United States. In 2018, our Google shuttle buses in the Bay Area produced



Google has installed more than 2,700 electric vehicle charging ports at our offices in the United States.

savings of more than 40,000 tCO_2e emissions—the equivalent of avoiding more than 165 million vehicle kilometers (102 million vehicle miles) per year or taking 8,760 cars off the road every work day.

Because sustainability is part of our culture, we give our employees opportunities to engage on environmental issues and put their passions into practice at work. Our Bay Area headquarters and many of our global offices host annual events to celebrate Earth Day and World Environment Day, where we share how Googlers can be sustainable on campus, at home, and in their communities. We also host an annual employee recognition program to recognize Googlers around the world who are driving sustainability across the company. The award winners are selected by members of our executive leadership team and are invited to attend an internal awards ceremony. Throughout the year we also invite thought leaders and experts to speak on the latest trends, achievements, and challenges related to sustainability, some of which are posted on the Talks at Google YouTube channel.

Our employees constantly reinvigorate our determination to build a better future. As we continue to explore sustainability strategies, we're committed to sharing what we learn with other companies to help foster the growth of more productive, environmentally friendly businesses.

LEARN MORE

2018 case study: The Role of Safe Chemistry and Healthy Materials in Unlocking the Circular Economy

2018 case study: Seeding Resilience with Ecology

2018 spotlight: Ecologically focused landscapes are coming to life on Google campuses

2018 blog post: Every summer, Google's campus is for the birds

YouTube channel: Talks at Google

Googlers explore different booths at Google Environment Day.

Spotlight

The journey toward healthier materials

If you want to construct a building that's healthier for people and the planet, the solution seems simple: Choose healthy materials made from safe chemistry. But, if you don't have information to understand what's healthier, where do you start?

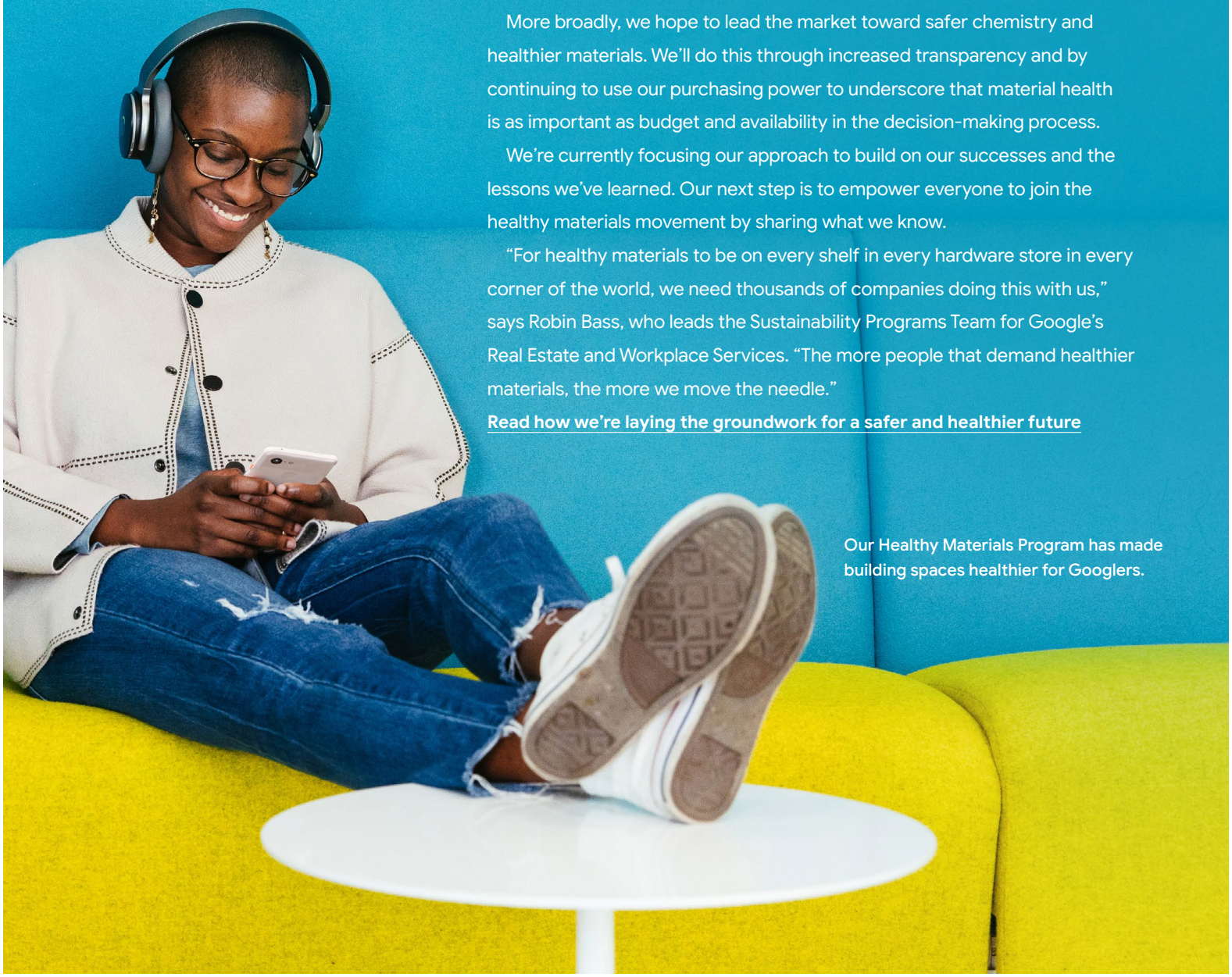
That's the challenge we took on several years ago with the launch of our Healthy Materials Program. A natural extension of Google's belief in using data to shed light and inform decision-making, the program is intended to fill the information gap between common building materials and the safety of the chemicals used to make them.

More broadly, we hope to lead the market toward safer chemistry and healthier materials. We'll do this through increased transparency and by continuing to use our purchasing power to underscore that material health is as important as budget and availability in the decision-making process.

We're currently focusing our approach to build on our successes and the lessons we've learned. Our next step is to empower everyone to join the healthy materials movement by sharing what we know.

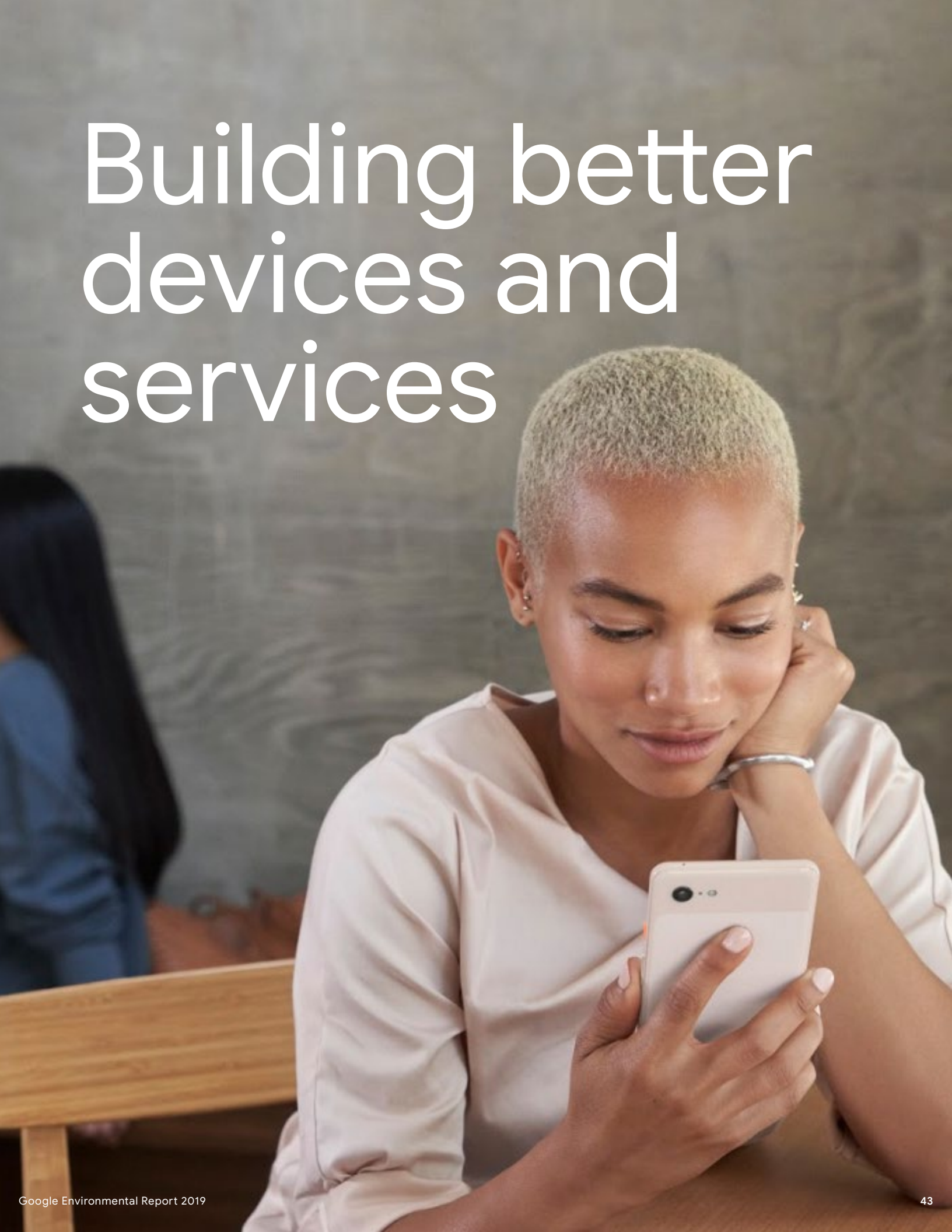
"For healthy materials to be on every shelf in every hardware store in every corner of the world, we need thousands of companies doing this with us," says Robin Bass, who leads the Sustainability Programs Team for Google's Real Estate and Workplace Services. "The more people that demand healthier materials, the more we move the needle."

Read how we're laying the groundwork for a safer and healthier future



Our Healthy Materials Program has made building spaces healthier for Googlers.

Building better devices and services



DEVICES AND SERVICES: BY THE NUMBERS

29 billion
kWh of energy savings
Nest thermostats have helped customers cumulatively save more than 29 billion kWh of energy—nearly three times as much energy as Google used in 2018.

10%–15%
energy savings
On average, Nest thermostats have proven energy savings of 10%–12% for heating and 15% for cooling, which means they pay for themselves in under two years.

20%–75%
recycled plastic
Products like the Nest Thermostat E, Google Home, and Chromecast all contain parts with 20%–75% post-consumer recycled plastic content.

1 million
Nest thermostats
The Nest Power Project aims to bring 1 million energy- and money-saving Nest thermostats to families in need by 2023.

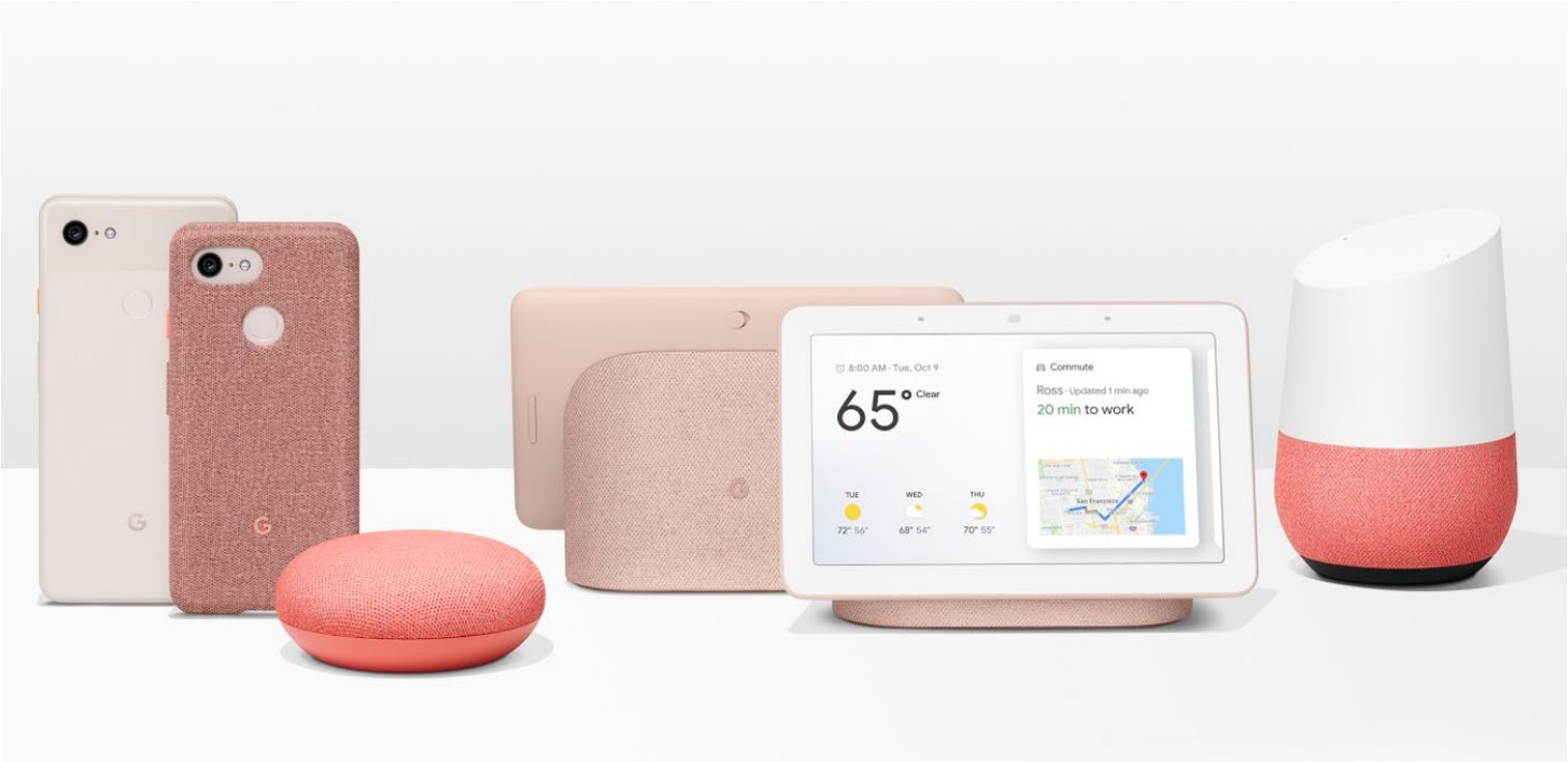
Overview

At Google, we strive to build sustainability into everything we do. And, now that our business includes building consumer hardware, our commitment remains the same. Our ambition is that every product we build will leave people, the planet, and our communities better than we found them. We're at the start of a journey of reimagining how even better devices and consumer hardware experiences are created.

Although we've been making some consumer devices for a while, Google's consumer hardware product area was formed just over three years ago. We're working to integrate sustainability into our products, operations, and communities—making it not just an aspect of how we do business but the centerpiece of it. This is an ongoing endeavor that involves designing in sustainability from the start and embedding it into the entire product development process and across our operations, all while creating the products our customers want.

To help us get a step closer to reaching our goals, in 2019 we shared a set of sustainability commitments for hardware devices and services. By 2020, 100% of all shipments going to or from customers will be carbon neutral. By 2022, 100% of Made by Google products will include recycled materials, with a drive to maximize recycled content whenever possible. And we're committed to making technology that puts people first and expands access to the benefits of technology.

Looking ahead, we know there's more work to be done. We'll continue working to design energy-efficient products. We'll continue working to extend the useful life of our products by making them more serviceable. And we'll continue ensuring that our products are accessible for as many people as possible. We're excited about the direction we're headed.



Some of Google's consumer hardware products: Pixel 3 XL, Pixel 3, Google Home Mini, Google Nest Hub, and Google Home

Consumer devices

Over the past few years, we've been steadily growing our family of great consumer hardware products. We see tremendous potential for devices to be helpful, make your life easier, and get better over time by combining the best of Google's AI, software, and hardware. This is reflected in our latest generation of hardware products like Pixel 3 phones and the Google Nest Hub smart display. Creating beautiful products that people rely on every day is a journey that we're investing in for the long run, and one we want to do in a sustainable way.

In 2018, we launched a suite of new products, including the Pixel 3 and Pixel 3 XL phones, Google Pixel Slate, Google Nest Hub, Google Clips, Google Nest Hello Doorbell, Google Nest Temperature Sensor, Nest x Yale Lock, Titan Security Key, and Chromecast. Other products we offer include Google Home, Google Home Max, Google Home Mini, and Google Pixelbook. We hold ourselves to the highest environmental standards and strive to ensure that Google products are designed, manufactured, and disposed of in a sustainable way. This applies to how we think about materials, manufacturing processes, energy efficiency, and packaging.

We're laying the foundation for what we believe will be a way of doing business that commits to building better products and services. Google has a company-level goal to increase the sustainability and circularity of our consumer electronic products, operations, and communities. We've made good progress so far, and we have great momentum.

In 2018 alone, Nest thermostats helped customers save nearly

12 billion

kWh of energy—more energy than Google used this year.

For most devices, in 2018 we began publishing product environmental reports, which help people understand the sustainability attributes of our products. Each product environmental report provides an overview of that device's environmental impact in areas such as material composition, life cycle GHG emissions, and energy efficiency. Starting in 2020, we'll publish product environmental reports for all of the flagship products we launch.

We consider sustainability throughout the entire life cycle of a device, including its production, transportation, use, and end of life. Our product life cycle assessments give us insight into our largest opportunities for reducing the environmental impact of a given product. For example, GHG emissions from shipping are an important contributor to the environmental impact of our products. From 2017 to 2018, we reduced carbon emissions for product shipments by 40% per unit, on average, by shifting many devices from air to ocean shipping.

We want to ensure that the materials and substances used for our products are safe for people and the environment, can be reused to create future products, and retain economic value. One of the keys to unlocking the circular economy is safer chemistry from the start, so in 2017, we published our Restricted Substances Specification to ensure the use of safer materials across our products.

We support greener electronics standards and certifications, including UL 110, IEEE 1680.1, and the Electronic Product Environmental Assessment Tool (EPEAT).[45] We strive for the highest rating available for applicable products within available product categories. We've achieved EPEAT Gold registration for all current models of the Pixel 3 phone.[46]

We also strive to make our products as energy-efficient as possible. For example, the 2018 Google Pixelbook incorporates power-management software to reduce energy consumption during use. This allowed it to attain ENERGY STAR® certification, which means it has energy performance among the top 25% of similar products of its type. And in 2018 alone, Nest thermostats helped customers save nearly 12 billion kWh of energy—more energy than Google used in 2018.

To accelerate the transition to a circular economy, it's critical to create demand for recycled materials. To date, we've shipped millions of devices made with post-consumer recycled plastic. Products like the Nest Thermostat E, Google Home, and Chromecast all contain parts with 20%–75% post-consumer recycled plastic content.

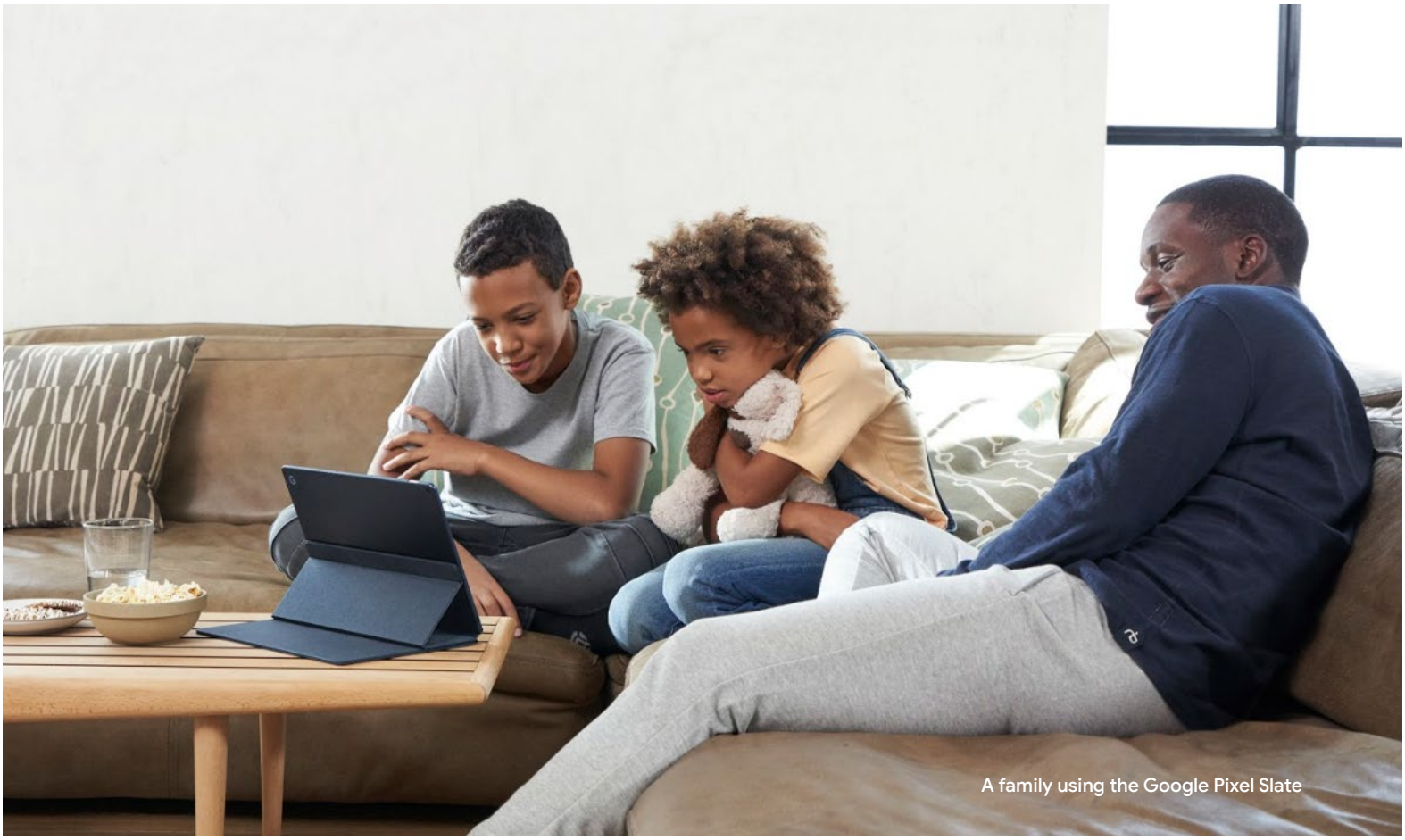
New plastic made from fossil fuels is the industry standard for consumer electronics, and incorporating recycled plastic involves surmounting a number of challenges. It requires building new processes and approaches while ensuring that materials meet our rigorous quality and technical specifications, costs are viable, and products are delivered on time. To meet these requirements, we spent years building partnerships with top-tier raw materials suppliers willing to invest in producing high-quality materials and innovation. Going forward, we're committed to expanding the use of sustainable materials across our portfolio of products.

We're also making it easier for people to give their old devices a second life. Customers can responsibly recycle devices for free—whether made by Google or not—via our take-back program for all products, available in 16 countries, and via our U.S. Pixel trade-in program, through which customers can earn credit toward a new Pixel purchase.

Our commitments go beyond the consumer electronic products we make. We're committed to minimizing our environmental impact as well as improving the lives of people who make our products. We require the highest ethical standards throughout our supply chain and are working to drive positive impacts in the communities in which we operate. Our Supplier Code of Conduct articulates our expectations for suppliers and is based on the Google Code of Conduct and on international human rights, safety, and environmental standards.

Building on the progress we've already made, in 2019, we shared our inaugural public commitments for consumer hardware. First, we aim to design products and services for circularity and to reuse materials at their highest

The Nest Learning Thermostat in a home



A family using the Google Pixel Slate

environmental and social value. Many of our Nest products already include significant levels of post-consumer recycled plastic. Starting in 2022, 100% of Made by Google products will include recycled materials, and we'll strive to maximize recycled content wherever possible. By decreasing our use of new materials, we'll reduce our waste per device while signaling our demand for a more circular economy.

Second, we aim to be the neighbor everyone wants in the communities in which we operate. By 2020, 100% of all shipping of device orders going to or from customers will be carbon neutral. To achieve carbon neutrality for shipping, we have a two-step approach: The first step is carbon reduction. Our goal is to work with shipping partners to reduce shipping emissions; we've already successfully driven a shift from air to ocean in many cases, and we'll continue to look for solutions like this. For the emissions that remain, our second step will be to purchase high-quality carbon offsets. Shipping devices to consumers falls outside the scope of Google's operations, and thus goes above and beyond our long-standing commitment to carbon neutrality.

Finally, we're committed to make technology that puts people first and to expand access to the benefits of technology. One way we do this is through energy partnerships.

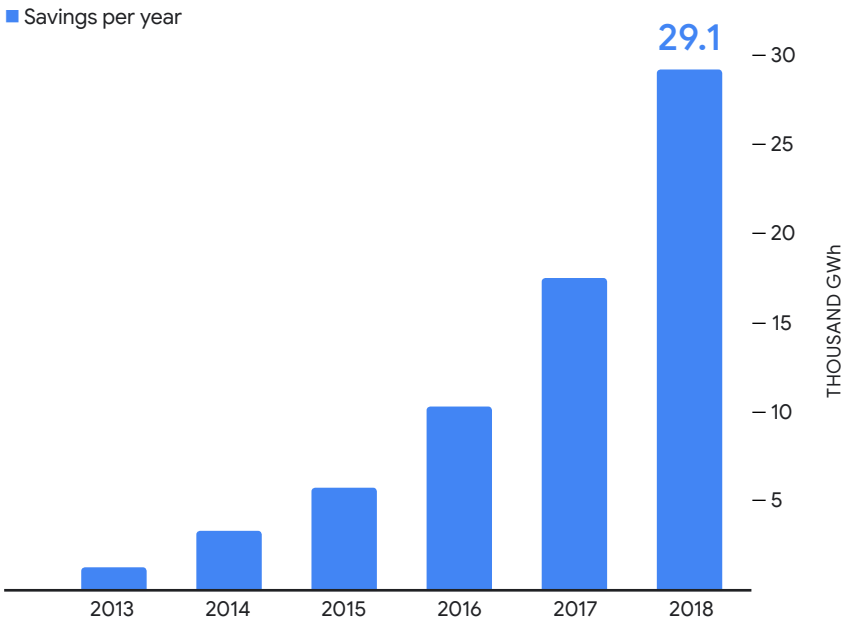
Energy partnerships

Our products enable customers to be more thoughtful about their individual environmental impact. Connected homes can help streamline consumers' daily decisions about resource consumption, making sustainable choices easier for busy households. For example, smart thermostats can play a critical role in addressing climate change by automatically saving energy and helping consumers be more aware of their energy usage. These savings benefit customers, as well as the utilities generating and delivering the energy, while reducing energy use and GHG emissions.

The Nest thermostat controls residential heating and cooling systems—which make up around half of a home's energy consumption—and uses AI and ML to reduce energy consumption and achieve collective savings as it learns how and when to keep users comfortable while at the same time optimizing for energy efficiency. On average, Nest thermostats have proven energy savings of 10%–12% for heating and 15% for cooling,[47] which means they pay for themselves in under two years as a result of those savings.[48] In February 2017, the Nest Learning Thermostat became the first thermostat to achieve ENERGY STAR® certification by the EPA.[49] And by the end of 2018, Nest thermostats had helped customers cumulatively save more than 29 billion kWh of energy (see Figure 13), based on average savings studies—enough energy to power all of San Francisco's electricity consumption for five years and nearly three times as much energy as Google used in 2018. That's

Figure 13

CUMULATIVE HOUSEHOLD ENERGY SAVED BY NEST THERMOSTAT USERS



equivalent to avoiding 9.6 million tCO_2e emissions—or taking more than 2 million cars off the road for a year.[50]

We help consumers save energy and money by forming partnerships with a variety of energy companies and service providers across North America. We've partnered with nearly 100 companies to offer Nest thermostat and demand response programs.

Nest's Rush Hour Rewards program works in partnership with utilities to reduce energy use during times of peak demand through harnessing the power of consumer engagement—acting as a leader in demand response programs for energy customers. For example, during the 2017 solar eclipse, Nest launched a special Rush Hour program with an opt-in feature that allowed Nest thermostats to automatically pre-cool customers' homes, reducing demand on the grid at a time when solar energy production dropped by thousands of megawatts. More than 750,000 Nest thermostats worked together across the United States to reduce demand by 700 MW.[51] In 2018, Nest and partners also pioneered residential gas demand response programs. In a world of gas shortages and increasing weather variability, these programs are proving their capability to manage demand spikes and increase system flexibility.

We also work with energy, government, nonprofit, and manufacturer partners to expand access to the benefits of technology through income-qualified programs. Today, nearly one in four U.S. families struggle with a high energy burden, with up to 20%–50% of income going to energy bills.[52] In 2018, we launched the Nest Power Project, which aims to install 1 million energy- and money-saving Nest thermostats in homes that need them most over the next five years. We're proud to help our partners meet their efficiency and customer participation goals and are excited about our collective impact on consumers as well as the environment.

LEARN MORE

2015 white paper: Energy Savings from the Nest Learning Thermostat

2018 report: Circular Consumer Electronics: An Initial Exploration

2018 reports: Product Environmental reports

2018 report: Responsible Supply Chain Report

Guidelines: Alphabet's Conflict Minerals Policy and Report

Guidelines: Google Supplier Code of Conduct

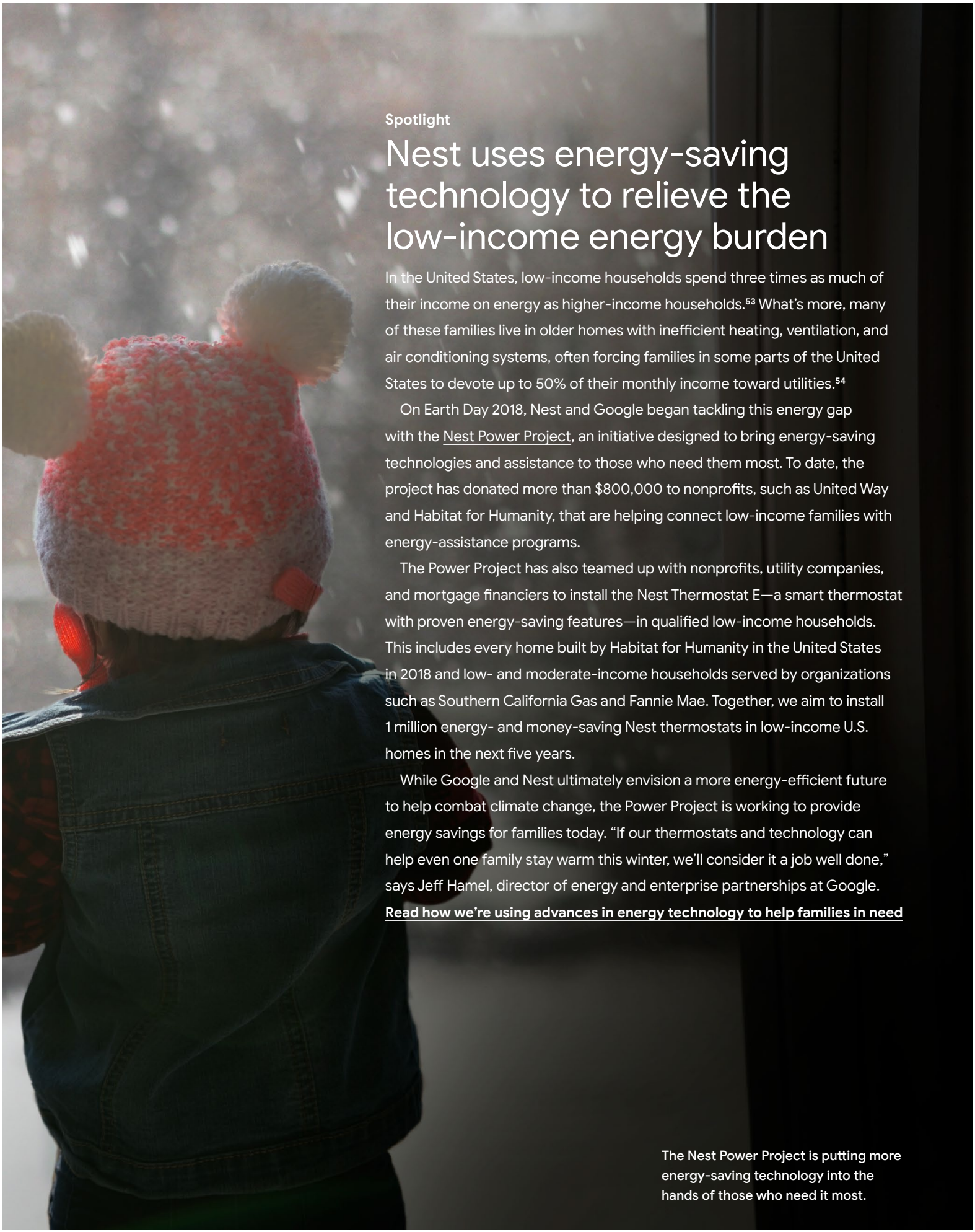
Guidelines: Policy Against Modern Slavery and 2018 Modern Slavery Statement

Guidelines: Restricted Substances Specification

Website: Google Store Sustainability

Website: Nest Power Project

Website: Responsible Supply Chain



Spotlight

Nest uses energy-saving technology to relieve the low-income energy burden

In the United States, low-income households spend three times as much of their income on energy as higher-income households.[53] What's more, many of these families live in older homes with inefficient heating, ventilation, and air conditioning systems, often forcing families in some parts of the United States to devote up to 50% of their monthly income toward utilities.[54]

On Earth Day 2018, Nest and Google began tackling this energy gap with the Nest Power Project, an initiative designed to bring energy-saving technologies and assistance to those who need them most. To date, the project has donated more than $800,000 to nonprofits, such as United Way and Habitat for Humanity, that are helping connect low-income families with energy-assistance programs.

The Power Project has also teamed up with nonprofits, utility companies, and mortgage financiers to install the Nest Thermostat E—a smart thermostat with proven energy-saving features—in qualified low-income households. This includes every home built by Habitat for Humanity in the United States in 2018 and low- and moderate-income households served by organizations such as Southern California Gas and Fannie Mae. Together, we aim to install 1 million energy- and money-saving Nest thermostats in low-income U.S. homes in the next five years.

While Google and Nest ultimately envision a more energy-efficient future to help combat climate change, the Power Project is working to provide energy savings for families today. "If our thermostats and technology can help even one family stay warm this winter, we'll consider it a job well done," says Jeff Hamel, director of energy and enterprise partnerships at Google.

Read how we're using advances in energy technology to help families in need

The Nest Power Project is putting more energy-saving technology into the hands of those who need it most.

Empowering users with technology

TECHNOLOGY: BY THE NUMBERS

20 petabytes
of freely available geospatial data

Earth Engine has enabled tens of thousands of active users around the world to easily analyze 20 petabytes of freely available geospatial information, resulting in a deeper understanding of the planet.

1 billion
kilometers of transit results

Google Maps provides more than 1 billion kilometers' (621 million miles') worth of transit results per day, helping limit carbon emissions by giving people access to mass transit options, bike routes, and traffic information.

5
pilot cities

In 2018, the Environmental Insights Explorer launched in partnership with five pilot cities: Buenos Aires, Argentina; Melbourne, Australia; Victoria, Canada; and Mountain View and Pittsburgh, USA.

107 million
rooftops mapped

Since 2015, Project Sunroof has mapped more than 107 million rooftops across 21,500 cities.

Overview

A global challenge requires a global response. We want to leverage our scale, resources, and technological expertise to meet the vast challenge posed by climate change and work to empower everyone—businesses, governments, nonprofit organizations, communities, and individuals—to use Google technology to help create a more sustainable and resource-efficient world.

Google Earth is used globally by millions to explore and understand our ever-changing planet. While Google Earth is for exploration and raising awareness, Google Earth Engine is focused on planetary-scale geospatial analysis, giving researchers access to Google's massive cloud and computational capabilities. It includes 20 petabytes of freely available geospatial data, which are used by tens of thousands of active users around the world to create new knowledge that's fundamentally changing what we know about Earth's natural resources and how to manage them.

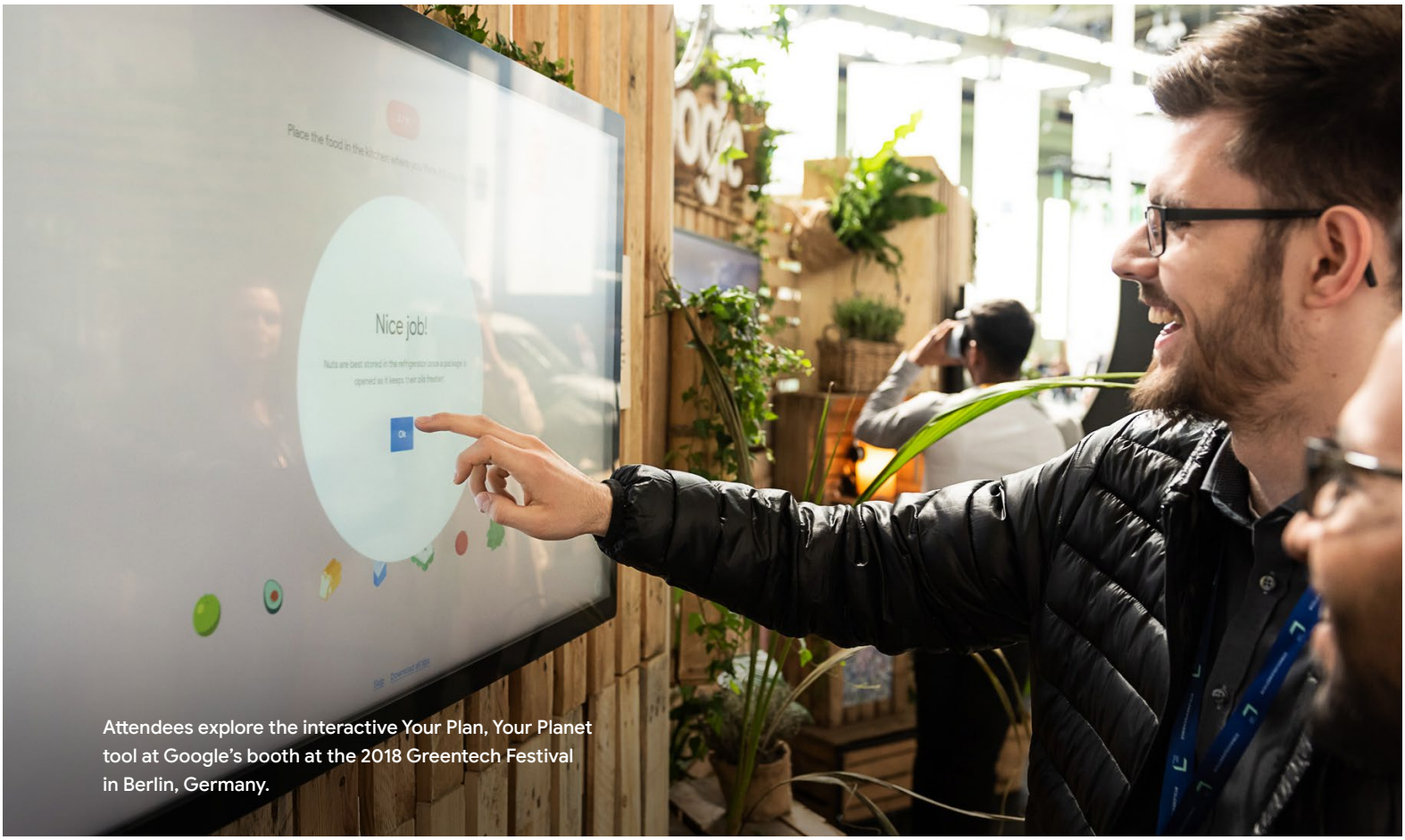
Google Maps provides more than 1 billion kilometers' (621 million miles') worth of transit results per day, helping limit carbon emissions by giving people access to mass transit options, bike routes, and traffic information. In 2018, Google Maps added new features that enable users to search for information about electric vehicle charging stations around the world and to see nearby Lime scooters, pedal bikes, and e-bikes as alternative transportation options right from the app.

Waze Carpool is also tackling the issue of too many cars on the road by encouraging Waze users to commute together, saving time and money, while reducing the strain on transportation infrastructure and the environment. By the end of 2018, Waze Carpool was available nationally throughout Israel, Brazil, and the United States.

Using technology for good

In 2018, Google AI announced its AI for Social Good program, which applies core Google research and engineering efforts to projects that help address social, humanitarian, and environmental challenges. Additionally, the program provides tools and resources through initiatives like the Google AI Impact Challenge, which was an open call for nonprofits, academics, and social enterprises from around the world to submit proposals on how they could use AI to help address some of the world's greatest problems.

In 2018, as part of Google's AI for Social Good program and Crisis Response efforts, Google announced a flood-forecasting initiative pilot in Patna, India. To help keep people safe during floods, Google is using AI to create better forecasting models that predict when and where floods will occur. The predictions are made using a combination of ML, satellite imagery, and



Attendees explore the interactive Your Plan, Your Planet tool at Google's booth at the 2018 Greentech Festival in Berlin, Germany.

physics-based simulations. The predictions are then shared with affected individuals via Google Search, Google Maps, and Google Public Alerts.

AI can also aid in wildlife conservation. In 2018, as part of Google's AI for Social Good program, we announced the work of Google AI researchers who teamed up with the National Oceanic and Atmospheric Administration to identify if humpback whales are present in more than 170,000 hours' worth of underwater audio recordings. This is part of a larger effort to help scientists better understand and protect whales—and hopefully in the future, other animal species as well.

Using TensorFlow, Google's open source ML platform, we're enabling thousands of companies, nonprofits, researchers, developers, and students to apply ML to better predict extreme weather events, help farmers glean insights into their herd's health and efficiency improvements for their farms, and prevent illegal deforestation in the Amazon.

In 2018, Google teamed up with the California Academy of Sciences to launch Your Plan, Your Planet, an interactive tool to help people understand their environmental impact as it relates to food, energy, and water, while demonstrating simple, science-based ways to improve it.

Rooftop solar provides renewable energy to a community in Manchester, England. Project Sunroof expanded coverage to the United Kingdom in 2018.

Tools for everyone

We also put Google technology to work helping others study and respond to environmental challenges. Our Geo team works with numerous research and nonprofit organizations to map the world's forests, fisheries, watersheds, and air quality—and even to create a global database of power plants. We then work on getting that information into the hands of decision-makers.

In 2018, we launched the Environmental Insights Explorer (EIE), an online tool created in collaboration with the Global Covenant of Mayors for Climate & Energy and in partnership with five pilot cities: Buenos Aires, Argentina; Melbourne, Australia; Victoria, Canada; Mountain View, California, USA; and Pittsburgh, Pennsylvania, USA. By analyzing Google's comprehensive global mapping data together with standard GHG emission factors, EIE estimates city-scale building and transportation carbon emissions data, as well as renewable energy potential, leading to more globally consistent baselines from which cities can measure, plan, act upon, and track progress toward emissions reductions.

Project Sunroof is an online tool that helps users explore whether they should go solar by analyzing high-resolution aerial mapping and 3D modeling of residential roofs to sun positions, historical weather patterns, shadows cast by nearby objects, and typical electricity consumption. In 2018, Project Sunroof expanded coverage into new markets around the world, including Argentina, Australia, Canada, France, Italy, the Netherlands, Puerto Rico, and

the United Kingdom. Collectively, Project Sunroof has mapped more than 107 million rooftops across 21,500 cities since 2015. Policymakers are also using Sunroof data to make bold renewable energy commitments. For example, the City of San José, California used the data for a city-wide solar assessment to set a 1 GW solar energy target as part of its Smart City Action Plan. In addition to city climate plans, Sunroof data is being used by some of the world's largest utilities, such as Engie and E.ON, to provide customers with the option to power their homes with solar energy.

Project Air View measures air quality data using Google Street View cars equipped with air quality sensors. In 2018, Project Air View increased its air quality mapping efforts, expanding beyond the United States to map air quality in Copenhagen, Denmark, and London, United Kingdom. We announced plans to further expand coverage to more cities around the world by equipping 50 Street View vehicles with Aclima's mobile air sensors. By the end of 2018, Project Air View had captured more than 475 million cumulative air quality measurements in 62 cities worldwide.

Through Google Earth Timelapse, a global, zoomable video that lets us see how the world has changed over recent decades, we can watch as cities grow, forests disappear, glaciers recede, and lakes dry up. We can also help monitor and promote sustainable resource management with tools like Global Fishing Watch (GFW), which monitors the planet's fisheries by tracking the locations and behaviors of commercial fishing fleets, powered by Google Cloud Platforms' machine learning algorithms. In 2018, GFW published 13 papers in top-tier journals and successfully drove new commitments and programs with governments from Canada, Indonesia, Japan, and Peru. Ultimately, our vision is to continue leveraging our mapping, cloud, and ML technologies to create a living, breathing dashboard of our planet that can help inform everyday decisions for individuals, organizations, and nations.

LEARN MORE

2017 report: Cities in the Circular Economy: The Role of Digital Technology

2018 spotlight: Transparency unleashed: How Global Fishing Watch is transforming fishery management

2018 blog: A tale of a whale song

2018 blog: AI for Social Good

2018 blog: Get charged up with Google Maps

2018 blog: How we explored the whole wide world with Google Earth in the past year

2018 blog: Fighting fire with machine learning: two students use TensorFlow to predict wildfires

2018 blog: The fight against illegal deforestation with TensorFlow

2018 blog: Air View is ready to expand to more places around the globe

2018 blog: Your Plan, Your Planet: How to reduce your environmental footprint

Spotlight

The more you know: Turning environmental insights into action

To date, more than 10,000 cities worldwide have committed to reducing their carbon footprints by 80% within the next 30 years. But, unlike large cities like New York and Berlin, which have access to huge carbon data sets, many small and midsize cities lack the resources to gather comprehensive data on building and transportation emissions. This makes it hard to set firm carbon commitments of their own.

The Environmental Insights Explorer (EIE), an online tool created by Google in collaboration with the Global Covenant of Mayors for Climate & Energy, is designed to provide carbon emissions insights to cities of all sizes—and ultimately accelerate the transition to a low-carbon future.

Developed by the Google Earth Outreach team, EIE analyzes data from Google Maps and Google's other climate-related projects, like Project Sunroof, to surface insights across four categories: building emissions, transportation emissions, solar energy potential, and climate projections. EIE pairs this information with third-party data and standard GHG emissions factors, deriving carbon estimates and reduction potential for cities around the world.

Although EIE is starting with a handful of cities initially, Google eventually plans to make these insights available to thousands of towns, cities, and regions across the globe. "Imagine what we could accomplish if every city in the world were engaged in the fight against climate change," says Rebecca Moore, leader of the Earth Outreach team. "What would the world look like?"

Read how Environmental Insights Explorer is bringing insights to cities

The Environmental Insights Explorer tool provides city-level carbon emissions data.

Appendix

Environmental data

The following table provides an overview of our performance over time and includes environmental data for our global operations, including our data centers, offices, and other facilities.

Data for GHG emissions and energy use covers Alphabet Inc. and all of its subsidiaries, including Google LLC. The exceptions are the figures for data center energy efficiency and renewable energy, which cover Google only. All other data applies only to Google and is global unless otherwise specified.

We obtain third-party assurance by an independent, accredited verifier for our Scope 1 and 2 emissions and part of our Scope 3 emissions. Our electricity use is also part of our Scope 2 verification.

For more information on our energy use and GHG emissions data and initiatives, see Alphabet's 2019 CDP Climate Change Report.

		Fiscal year[55]					
Key performance indicator	**Unit**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Greenhouse gas emissions[56]							
Scope 1*,†	tCO_2e	41,373	51,802	66,991	66,218	66,549	63,521
Scope 2 (market-based)*,†,[57]	tCO_2e	1,245,254	1,460,762	1,384,427	1,518,643	509,334	684,236
Scope 2 (location-based)*,†	tCO_2e	1,831,142	2,198,821	2,450,438	2,902,554	3,301,392	4,344,686
Scope 3 (total)*,†	tCO_2e	479,389	980,783	1,234,683	1,292,267	2,719,024	14,279,467[58]
Scope 3 (business travel and commuting)*,†,[59]	tCO_2e	190,575	239,771	297,789	314,027	356,060	463,467
Scope 3 (other)*,†	tCO_2e	288,814	741,012	936,894	978,240	2,362,964	13,816,000
Total	tCO_2e	1,766,016	2,493,347	2,686,101	2,877,128	3,294,907	15,027,224[60]
Total operational (Scope 1, 2 [market-based], and 3 [business travel and commuting])	tCO_2e	1,477,202	1,752,335	1,749,207	1,898,889	931,943	1,211,224
Emissions neutralized by carbon offset projects	tCO_2e	–1,766,016	–2,493,347	–2,686,101	–1,898,889	–931,943	–1,211,224
Net operational carbon emissions[61]	tCO_2e	0	0	0	0	0	0
Carbon intensity[62]							
Carbon intensity per unit of revenue	tCO_2e/million US$	23.2	22.9	19.4	17.6	5.19	5.47
Carbon intensity per full-time equivalent (FTE) employee	tCO_2e/FTE	31.9	31.0	25.0	23.4	7.6	8.36
Carbon intensity per megawatt-hour (MWh) of electricity consumed at data centers	tCO_2e/MWh	0.325	0.316	0.242	0.227	0.0485	0.0495

Environmental data

Key performance indicator	Unit	Fiscal year 2013	2014	2015	2016	2017	2018
Energy use							
Total energy consumption[63]	MWh	3,970,438	4,702,387	5,533,433	6,513,719	8,029,409	10,572,485
Electricity consumption*	MWh	3,712,865	4,434,390	5,221,476	6,209,191	7,609,088	10,104,295
U.S.	MWh	2,562,688	2,985,108	3,779,280	4,522,314	5,533,782	7,085,620
International	MWh	1,150,177	1,449,282	1,442,196	1,686,877	2,075,306	3,018,675
Data center energy efficiency							
Trailing 12-month (TTM) power usage effectiveness (PUE)[64]	TTM PUE	1.12	1.12	1.12	1.12	1.11	1.11
Data center sites included in ISO 50001 certificate	#	9	9	12	12	12	12
% of IT energy use represented by data centers included in ISO 50001 certificate	%	–	–	–	98	96	91
Renewable energy							
Total cumulative renewable energy contracts, in megawatts (MW)	MW	634	1,147	2,121	2,611	2,960	3,837
Total renewable electricity purchased	MWh	869,636	1,056,433	2,075,139	3,516,849	7,609,089	10,104,295
Renewable electricity (PPAs and on-site)	MWh	869,636	1,056,433	2,075,139	2,817,913	6,244,788	8,246,508
Renewable electricity (grid)	MWh	-	-	-	698,936	1,364,301	1,857,787
% of total electricity obtained from renewable sources[65]	%	35	37	48	61[66]	100	100
Waste generation							
Total waste generated annually	Metric tons (t)	–	–	50,050	43,058	53,363	57,113
Waste diversion							
Total annual landfill diversion rate[67]	%	–	–	–	81	83	80
Annual landfill diversion rate for data centers	%	–	–	84	86	91	87
Annual landfill diversion rate for offices	%	–	–	78	78	78	76
Cumulative pre-consumer food waste prevented in cafés	Kilograms	–	–	269,292	980,291	1,990,868	3,019,252
Hardware refurbishment and reuse							
Components used for machine upgrades that were refurbished inventory[68]	%	–	–	52	22	11	19
Components resold into the secondary market	#	–	–	2,000,000	2,100,000	2,114,567	3,478,048
Water consumption							
Total annual water consumption[69]	Million gallons	–	–	–	2,500	3,071	4,170

Environmental data

Key performance indicator	Unit	Fiscal year 2013	2014	2015	2016	2017	2018
Sustainable workplaces							
Offices							
Cumulative LEED-certified office space, in square meters (m^2)	m^2	313,209	462,395	711,626	865,494	1,034,876	1,239,898
Gold	%	63	59	58	54	56	57
Platinum	%	23	26	31	34	28	28
Commuting							
Cumulative electric vehicle (EV) charging ports installed at Google offices in the United States[70]	Ports	601	988	1,382	1,646	2,077	2,722
Estimated annual emissions avoided due to employee EV commuting in the United States	tCO_2e	483	929	1,489	2,142	2,891	4,103
Total annual employee shuttle commuting trips in the Bay Area	Total trips	2,500,000	3,000,000	3,500,000	3,750,000	3,800,000	4,000,000
Peak daily employee shuttle riders in the Bay Area	Unique riders	6,000	7,500	8,500	9,000	10,000	11,000
Annual emissions avoided due to employee shuttle trips in the Bay Area	tCO_2e	10,065	18,856	28,901	33,656	33,241	40,309
Equity investments in renewable energy projects[71]							
Cumulative commitments, in gigawatts (GW)[72]	GW	2.4	2.7	3.7	3.7	3.7	3.7
Empowering users with technology							
Cumulative household energy saved by Nest Thermostat users, in gigawatt-hours (GWh)	GWh	1,146	2,895	5,717	10,270	17,480	29,142
Cumulative rooftops mapped for solar potential by Project Sunroof	Million	–	–	43	60	67	107
Cumulative cities covered globally by Project Sunroof	#	–	–	–	7,300	8,900	21,500
Cumulative air quality measurements captured by Project Air View	#	–	13,771,873	37,867,975	121,663,079	281,744,820	475,325,437
Cumulative cities covered globally by Project Air View	#	–	–	10	27	41	62

* Indicates verified data. Scope 1, 2, and part of Scope 3 emissions are verified by an independent, accredited verifier. Our electricity use is also part of our Scope 2 verification.

† Scope 1 emissions are direct emissions from sources we own or control, such as company vehicles or generators at Google's offices and data centers.

Scope 2 emissions are indirect emissions from the production of electricity we purchase to run our operations. The location-based category reflects the average carbon intensity of the grids where our operations are located and thus where our energy consumption occurs. The market-based category incorporates our procurement choices, i.e., our renewable energy purchases via contractual mechanisms like PPAs.

Scope 3 emissions are indirect emissions from other sources in our value chain, such as business travel or our suppliers.

Endnotes

1. Read our 2004 Founders' Initial Public Offering Letter at https://abc.xyz/investor/founders-letters/2004/ipo-letter.html.
2. Alphabet, Inc., Form 10-K for the fiscal year ended December 31, 2018, https://abc.xyz/investor/static/pdf/20180204_alphabet_10K.pdf.

Our approach

3. "Internet Users by Region and Country, 2010–2016," International Telecommunication Union, accessed 2018, http://www.itu.int/en/ITU-D/Statistics/Pages/stat/treemap.aspx.
4. Mathy Stanislaus, "A Virtuous Circle," *The Environmental Forum*, September/October 2016, https://www.epa.gov/sites/production/files/2016-08/documents/stainislaus_a_virtuous_circle_2016_final.pdf.
5. "Earth Overshoot Day," Global Footprint Network, accessed 2019, https://www.footprintnetwork.org/2018/06/13/earth-overshoot-day-2018-is-august-1-the-earliest-date-since-ecological-overshoot-started-in-the-early-1970s.
6. Valérie Masson-Delmotte et al., eds., *Summary for Policymakers. Global Warming of 1.5°C: An IPCC Special Report on the Impacts of Global Warming of 1.5°C above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty, Intergovernmental Panel on Climate Change*, October 2018, https://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf.
7. Arman Shehabi et al., *United States Data Center Energy Usage Report*, Lawrence Berkeley National Laboratory, June 2016, https://eta.lbl.gov/publications/united-states-data-center-energy.
8. Estimates of project-level capital investment are sourced from Google's renewable energy project partners.
9. Alicia Seiger, Kate Brandt, and Kate Randolph, "Connecting Climate Resilience to the Bottom Line," *Stanford Social Innovation Review*, May 1, 2017, https://ssir.org/articles/entry/connecting_climate_resilience_to_the_bottom_line.
10. "International Decade for Action 'Water for Life' 2005–2015," United Nations Department of Economic and Social Affairs, accessed 2016, http://www.un.org/waterforlifedecade/scarcity.shtml.
11. Jacquelline Fuller, "Water Organizations Using Tech to Make an Impact," *The Keyword* (blog), March 22, 2016, https://www.blog.google/outreach-initiatives/google-org/world-water-day.
12. Read about Google's AI principles at https://www.blog.google/technology/ai/ai-principles.

Designing efficient data centers

13. At the end of 2018, we had 15 operational campuses across 19 data center locations. Some of our locations have more than one data center campus and others were not yet operational during 2018.
14. According to Google's own analysis of our more efficient servers, power infrastructure, and cooling systems, compared with data center industry averages.
15. See note 14 above.
16. PUE is a standard industry ratio that compares the amount of noncomputing 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.
17. According to the Uptime Institute's 2019 Data Center Industry Survey, the global average PUE of respondents' largest data centers was around 1.67.
18. This slight decline from 2017 is partly due to new sites not yet included in our energy management system and partly due to a change in how we calculate this number.
19. At Google, Zero Waste to Landfill means that when waste leaves our operating data centers, none of it goes to a landfill—100% is diverted to more sustainable pathways, with no more than 10% going to a waste-to-energy facility, unless waste to energy can be proved more valuable than alternative diversion paths. Our approach is based on UL's Environmental Claim Validation Procedure for Zero Waste to Landfill. Some waste cannot be diverted away from landfill for regulatory reasons.
20. *Google Data Centers: Economic Impact and Community Benefit*, April 2018, Oxford Economics, https://static.googleusercontent.com/media/www.google.com/en//about/datacenters/usstory/full-report/full-report.pdf.
21. Bruno Basalisco et al., *European Data Centres: How Google's Digital Infrastructure Investment Is Supporting Sustainable Growth in Europe*, Copenhagen Economics, February 2018, https://static.googleusercontent.com/media/www.google.com/en//about/datacenters/eustory/report/Google_EU-DCs_Report.pdf.
22. Eric Masanet et al., *The Energy Efficiency Potential of Cloud-Based Software: A U.S. Case Study*, Lawrence Berkeley National Laboratory, June 2013, https://www.osti.gov/biblio/1171159.
23. The annual carbon footprint of a Gmail user is about 1/80th that of a small business with locally hosted email servers. Larger organizations show smaller, though still impressive, efficiency gains. "Google's Green Computing: Efficiency at Scale," Google, 2011, https://static.googleusercontent.com/media/www.google.com/en//green/pdfs/google-green-computing.pdf.
24. Google emits less than 8 grams of carbon dioxide equivalent per day to serve an active Google user—defined as someone who performs 25 searches and watches 60 minutes of YouTube a day, has a Gmail account, and uses our other key services.

Advancing carbon-free energy

25. Bloomberg New Energy Finance database for wind and solar energy PPAs, as of December 31, 2018, considering both renewable energy capacity in MW as well as capacity factors. Google's resource mix primarily includes wind, which has a higher capacity factor than solar, thus we continue to have the largest procurement of renewables on an absolute energy basis.
26. For updates on Google's renewable energy purchases, visit http://sustainability.google.
27. "State Electricity Profiles: Data for 2017," U.S. Energy Information Administration, accessed 2019, https://www.eia.gov/electricity/state.
28. Bloomberg New Energy Finance database for wind and solar energy PPAs, as of December 31, 2018. Google is the largest organization, in terms of electricity consumption, to achieve 100% renewable energy.
29. WRI's market-based Scope 2 methodology requires the use of residual grid mixes, which represent the mix of resources generating electricity in a region after accounting for those designated for specific customers via contractual instruments like PPAs.
30. Reflects capital committed by Google. Does not reflect capital deployed or returned, or investment interests that may have been divested.
31. *Lazard's Levelized Cost of Energy Analysis—Version 12.0*, Lazard, November 2018, https://www.lazard.com/media/450784/lazards-levelized-cost-of-energy-version-120-vfinal.pdf.
32. *Medium-Term Renewable Energy Market Report 2016*, International Energy Agency, October 25, 2016, https://www.iea.org/Textbase/npsum/MTrenew2016sum.pdf.

33. *Renewables 2019 Global Status Report*, REN21, June 2019, http://www.ren21.net/gsr-2019.
34. *Renewable Energy Benefits: Measuring the Economics*, International Renewable Energy Agency, 2016, http://www.irena.org/DocumentDownloads/Publications/IRENA_Measuring-the-Economics_2016.pdf.
35. See note 8 above.
36. Our operational emissions include our Scope 1, Scope 2 (market-based), and Scope 3 (business travel and employee commuting).
37. "Greenhouse Gas Equivalencies Calculator," U.S. Environmental Protection Agency, accessed 2019, https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.
38. See note 36 above.
39. Carbon intensity figures are based on our combined Scope 1 and market-based Scope 2 emissions, with the exception of electricity consumption intensity, which is calculated using only market-based Scope 2 at the data centers.
40. A carbon offset is an investment in an activity that reduces carbon emissions. The reduction in carbon emissions is represented by a carbon credit. The credit, usually verified by a third party, signifies that GHG emissions are lower than they would have been had no one invested in the offset. One credit equals 1 metric ton (1,000 kilograms or 2,204 pounds) of carbon dioxide equivalent (CO_2e) prevented from being released into the atmosphere.
41. CO_2e is a quantity that describes, for a given mixture and amount of GHG, the amount of CO_2 that would have the same global warming potential (GWP), i.e., the ability of a gas to trap heat in the atmosphere when measured over a specified timescale (generally, 100 years). Some GHGs are more potent than others, as measured by their GWP. Carbon dioxide is the baseline and thus has a GWP of 1.

Creating sustainable workplaces

42. Neil E. Klepeis et al, "The National Human Activity Pattern Survey: A Resource for Assessing Exposure to Environmental Pollutants," *Journal of Exposure Analysis and Environmental Epidemiology*, 2001, http://www.readcube.com/articles/10.1038/sj.jea.7500165.
43. This target applies to Scope 1 and 2 emissions from our Google-occupied building spaces in New York City, NY, USA.
44. "Food Spots" is an umbrella term covering Google's MicroKitchens, Hubs, and Hydration Stations.

Building better devices and services

45. 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.
46. "EPEAT Registry," Green Electronics Council, accessed 2019, https://epeat.sourcemap.com.
47. *Energy Savings from the Nest Learning Thermostat: Energy Bill Analysis Results*, February 2015, Nest Labs, http://downloads.nest.com/press/documents/energy-savings-white-paper.pdf.
48. Independent studies showed that Nest saved people an average of 10% to 12% on heating and 15% on cooling. Based on 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.
49. Mary Farrell, "Nest Becomes First Smart Thermostat to Get Energy Star," *Consumer Reports*, March 2, 2017, https://www.consumerreports.org/thermostats/nest-awarded-first-energy-star-for-smart-thermostats.
50. "Greenhouse Gas Equivalencies Calculator," U.S. Environmental Protection Agency, accessed 2019, https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.
51. "Solar Eclipse Rush Hour," Google Nest Help, accessed 2019, https://support.google.com/googlenest/answer/9249049.
52. "Energy Savings are for Everyone" Nest Power Project, accessed 2019, https://nestpowerproject.withgoogle.com.
53. Ariel Drehobl and Lauren Ross, *Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low-Income and Underserved Communities*, American Council for an Energy-Efficient Economy, April 20, 2016, https://aceee.org/sites/default/files/publications/researchreports/u1602.pdf.
54. Adam Chandler, "Where the Poor Spend More Than 10 Percent of Their Income on Energy," *The Atlantic*, June 8, 2016, https://www.theatlantic.com/business/archive/2016/06/energy-poverty-low-income-households/486197.

Appendix

55. Alphabet's fiscal year runs from January 1 to December 31. Unless otherwise specified, reported data is global.
56. GHG emissions are calculated according to WRI's Greenhouse Gas Protocol. For more information on our methodology, see Alphabet's 2019 CDP Climate Change Report.
57. Since 2010, we've procured renewable energy for our operations, and in 2012, we began publishing how this reduces our overall carbon footprint. Up until 2015, there was no guidance from WRI on how to account for these emissions reductions, so we developed our own methodology, whereby on an annual basis we assigned renewable electricity procured against electricity consumed (in MWh) in the closest data center to the renewable energy project. In 2015, WRI released new guidance for market-based Scope 2 accounting, which we adopted, starting with 2015 data. Our pre-2015 methodology differs from WRI's in the use of residual mixes, which avoid double-counting of claimed renewable energy attributes.
58. In 2018, to align with industry best practices for Scope 3 reporting, we extended our reporting boundaries to include emissions associated with food from our corporate offices, hardware manufacturing emissions beyond Tier 1 suppliers (full upstream to the point of extraction), use of sold products, and end-of-life treatment of sold products. Google's hardware includes data center servers, networking equipment and consumer hardware products. These extended categories will be reported annually going forward.
59. In 2016, we adopted the industry practice of including only operational emissions in our carbon neutrality commitment. Our 2016 operational emissions include Scope 1, Scope 2 (market-based), and Scope 3 (business travel and employee commuting). For more information, see our 2017 white paper *10 Years of Carbon Neutrality*.
60. See note 58 above.
61. See note 59 above.
62. See note 39 above.
63. Total energy consumption represents total Scope 2 electricity consumption plus total Scope 1 fuel use.
64. Power usage effectiveness (PUE) is an industry-recognized ratio to measure data center efficiency. For more information on our PUE and how we calculate it, see "Efficiency: How We Do It" on our website.
65. Percentage of renewable energy is calculated on a calendar-year basis, comparing the volume of renewable electricity (in MWh) purchased for our operations (i.e., renewable energy procured through our PPA contracts, on-site renewable energy generation, and residual renewable electricity delivered directly through the grid) with the total volume of electricity consumed by our operations.

66. To align with the method outlined in note 65 above, starting in 2016, we adapted our methodology for calculating total electricity obtained from renewable sources. Prior to 2016, we were not accounting for the residual renewable electricity purchased through grid electricity.
67. Waste diverted to a more sustainable pathway than landfill or incineration without energy recovery.
68. Decommissioning activity decreased in 2017 and 2018 because most of the decommissioning returns in this period were from an older generation of technology, which did not qualify for redeployment.
69. Includes all water (both recycled and potable) consumed at offices and data centers.
70. Number of ports for ChargePoint stations in the United States only, which represent the majority of our electric vehicle charging ports in the United States. Emissions avoided are estimated using data from these ports only.
71. In addition to our renewable energy contracts, Google also invests in renewable energy projects around the world that have an attractive risk-adjusted financial return. These projects are not used to offset our carbon footprint.
72. See note 30 above.

Google

Google Environmental Report 2019
September 2019

On the cover:
A row of servers in a Google data center

Our approach:
Google Earth image of Hawaii, United States
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Designing efficient data centers:
Servers in a Google data center

Advancing carbon-free energy:
El Romero solar farm in Chile (80 MW for Google)

Creating sustainable workplaces:
Inside a Google office in Sunnyvale, California

Building better devices and services:
A woman using a Google Pixel 3 XL

Empowering users with technology:
Google Earth image of Paris, France
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