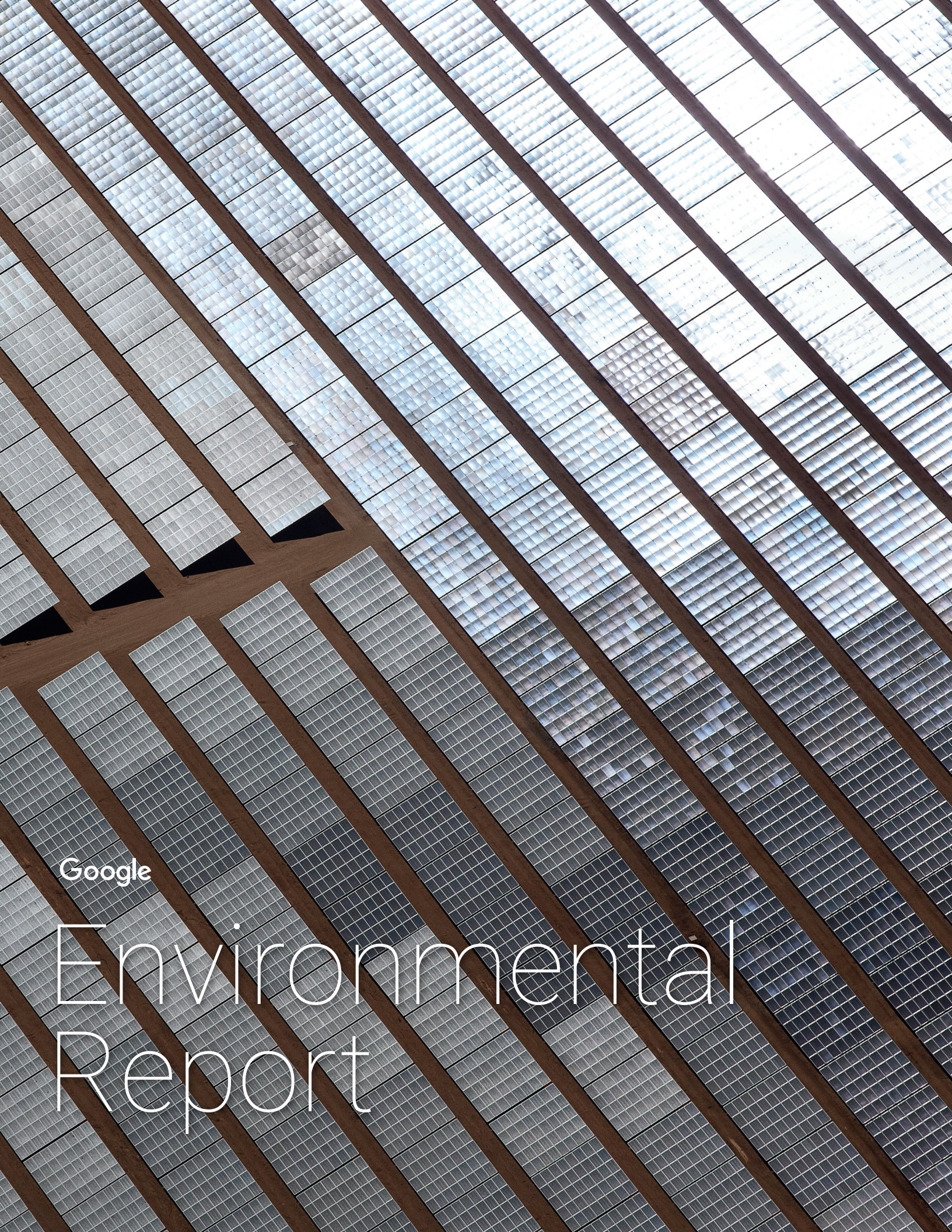


Google

Environmental Report

Google

Environmental sustainability at Google

At Google, our values reflect the fundamental importance of inclusion, openness, science, and commitment to the environment. Operating our business in an environmentally sustainable way has been a core value from the beginning.

Shortly after I joined the company, we moved to our Mountain View office in California ("Building Zero"). Our desks were made of repurposed materials—simple wooden planks on tripods. Larry and Sergey, Google's founders, made sure the paints and carpets were free of harmful chemicals. Through many other efforts over subsequent years, we improved Google's environmental performance as our company grew.

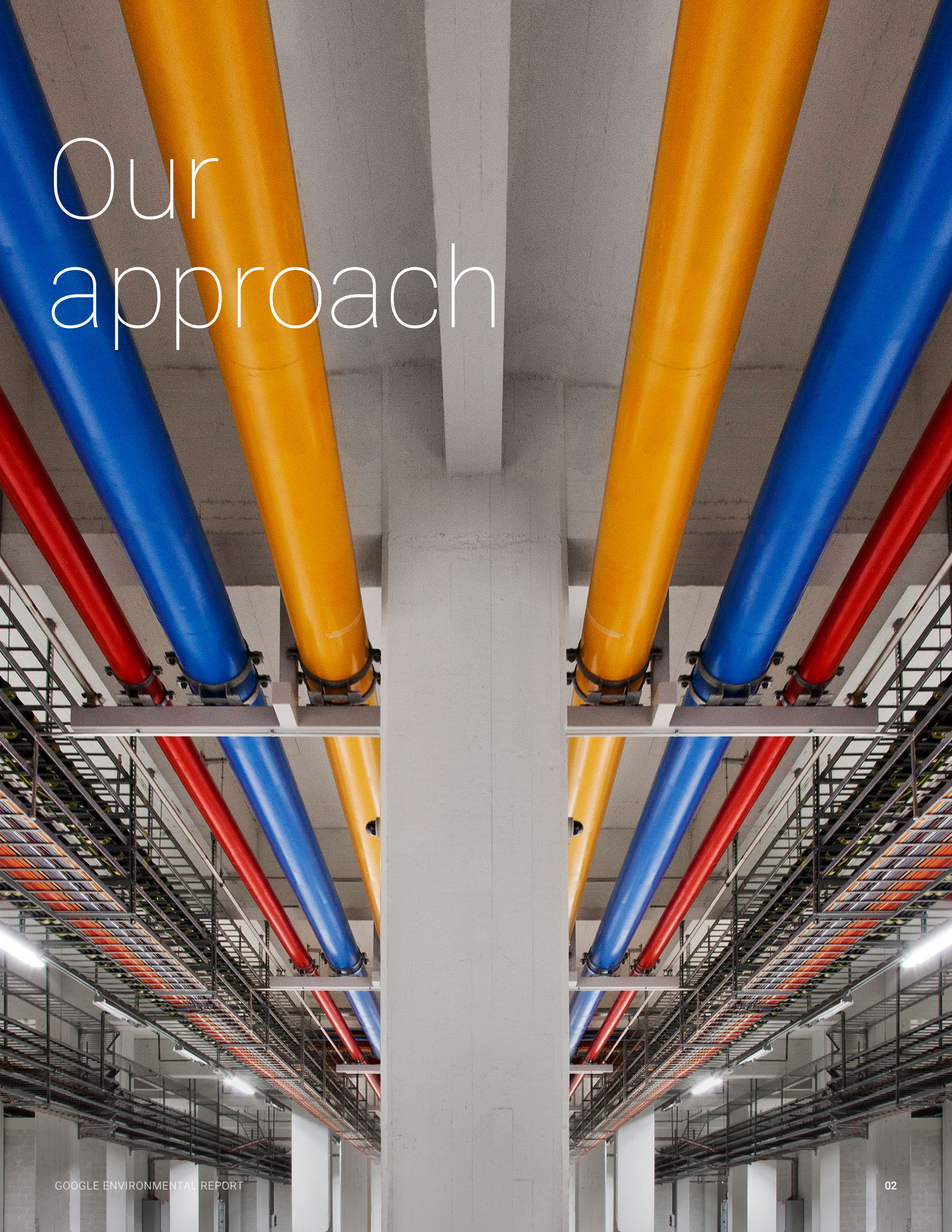
Eighteen years later, environmental sustainability is still our touchstone. We've been carbon neutral since 2007. Our Geo team is using machine learning and cloud computing to build a living, breathing dashboard for the planet. And in 2017 Google will reach 100% renewable energy for our global operations—a landmark moment for our company that also makes good business sense. Over the long term, we gain visibility into our electricity expenses and cost-competitive rates.

While we've reported our carbon footprint and published information on our sustainability programs for many years in white papers, blog posts, and on our website, we haven't put it all together until now. This report is a chance for us to reflect on what we've achieved so far, the lessons we've learned along the way, and the opportunities and challenges we see ahead. We hope you're as excited as we are to see all our work in one place.

We're more committed to the environment than ever and believe that businesses, governments, and citizens all have critical roles to play to ensure that we all have clean air, water, and soil, as well as healthy forests. Ultimately, we want Google to provide a platform for our users to change the world. We've only just begun.

Urs Hölzle
Senior Vice President of Technical Infrastructure
Google

Our approach



IN THIS SECTION

Mission and values

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

We meet the challenges posed by climate change and the need for resource efficiency by working to empower everyone—businesses, governments, nonprofit organizations, communities, and individuals—to use Google technology to create a more sustainable world. This philosophy started with Googley decisions like building server casings from reused Legos and grew to designing and building a global network of data centers that lead the industry in efficiency.

After all, the cheapest energy and water are what we don't use in the first place, and waste streams can present new sources of value. In a growing number of regions, renewable resources like wind and solar are now less expensive than standard grid power, helping us save money over the long term. We've been carbon neutral since 2007, and our carbon footprint has been growing more slowly than our business—proof that economic growth can be decoupled from environmental impact and resource use.

Addressing a global challenge

Humanity is using natural resources at an astonishing rate. During the 20th century, global raw material use rose at about twice the rate of population growth.[1] Each year, our economy consumes far more than what the planet can naturally replenish. Recent data shows that in 2015, global demand for resources was equivalent to 1.5 times what the Earth can support in one year.[2]

These statistics highlight the need to revisit the economic model we've followed since the Industrial Revolution, in which we take a natural resource, make a product or burn it for fuel, and eventually send it to the landfill as "waste." A major consequence of this model is climate change, one of the most significant challenges of our time, which requires urgent action from everyone—including businesses. We believe we can help the world meet its energy and resource needs in a way that drives innovation and growth while reducing greenhouse gas (GHG) emissions and the use of virgin materials and water.

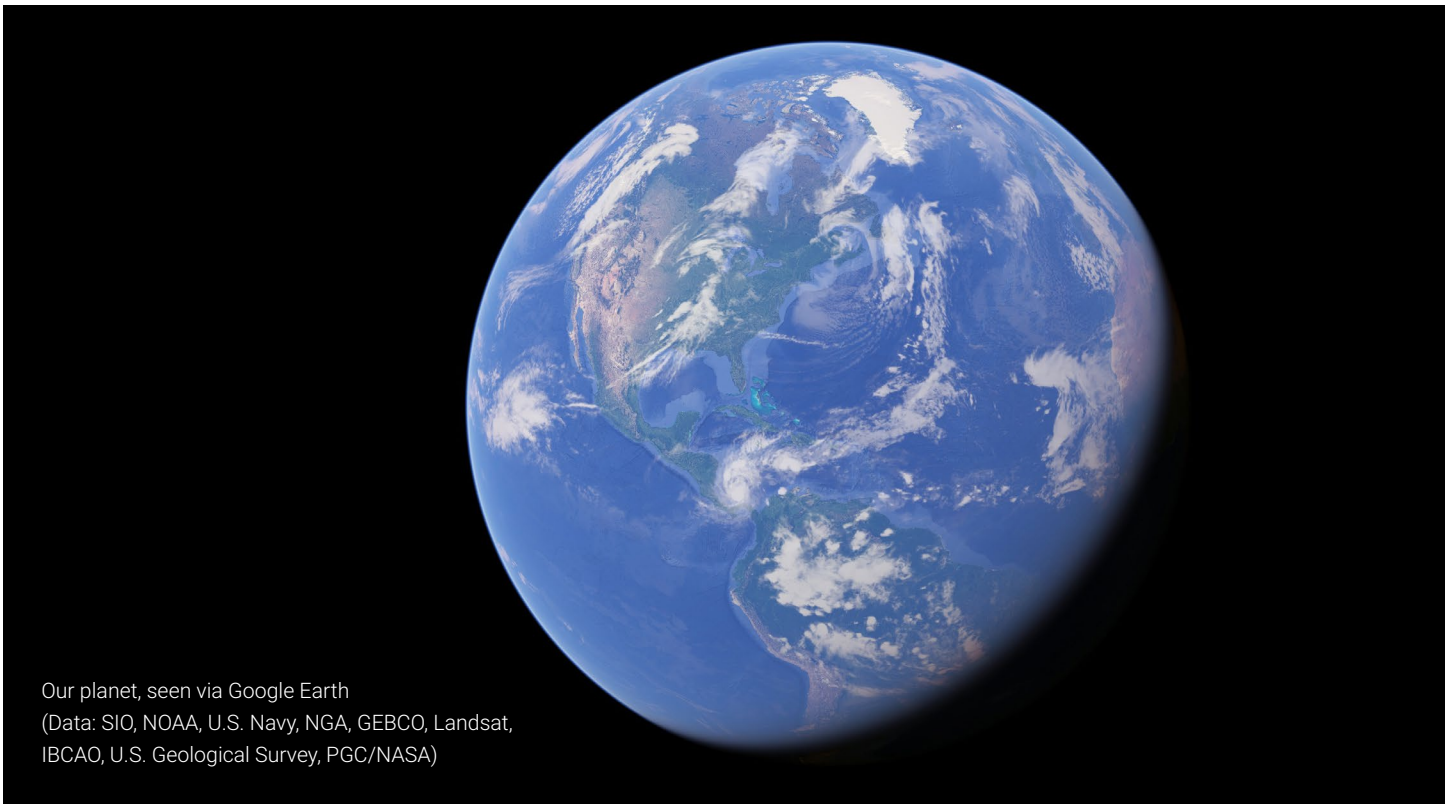
Taking action

With millions more people coming online every month and demand for computing skyrocketing, data center capacity continues to expand to meet this need. Despite this growth, total electricity used by U.S. data centers has flattened—annual data center electricity consumption increased by 90% from 2000 to 2005 but only 4% from 2010 to 2014—largely due to data centers' extraordinary ability to improve their efficiency as they scale.[3] As the use of mobile devices increases and more IT users transition to public clouds, we believe our industry can go beyond holding the line on energy use and actually lower it, serving more users while using fewer resources.

Google's energy consumption is our biggest impact on the environment, and we have focused on tackling it through a threefold strategy. First, we pursue aggressive efficiency initiatives. Second, we purchase significant amounts of renewable energy. Third, we buy carbon offsets for any remaining emissions we haven't yet eliminated. And we're excited to announce that we will reach 100% renewable energy for all our operations in 2017.

We also help millions of people conserve energy with Google Cloud. Research from the Lawrence Berkeley National Laboratory suggests that if all office workers in the United States moved their email and documents to the cloud, it would reduce IT energy use by up to 87%—enough to power the city of Los Angeles for one year.[4]

We've been a vocal advocate for greening electrical grids worldwide. We've supported strong clean energy and climate change policies. We've committed to invest $2.5 billion in solar and wind projects, adding clean power to the grid. And we're partnering with governments and non-governmental organizations to use Google technology and computing power to model the effects of climate change on both a global and a local level.



Our planet, seen via Google Earth
(Data: SIO, NOAA, U.S. Navy, NGA, GEBCO, Landsat, IBCAO, U.S. Geological Survey, PGC/NASA)

Water is another top priority. The United Nations predicts that by 2025, two-thirds of the world's population will live in water-stressed conditions.[5] As a global company headquartered in drought-prone California, we're working to efficiently utilize water, particularly in our data centers, where we regularly redesign and enhance our cooling technologies and utilize water from non-potable sources. We're also using Google technology to help researchers study global water challenges and awarding millions in grants to promising water conservation solutions.

Finally, we're changing how we think about waste. Humankind's current linear economy is based on a take-make-waste model: We take resources from the environment and make something, which quickly becomes waste. But natural resources are too valuable to go in a straight line to landfill. By repairing, reusing, and recycling products, we can recapture resources and use them again and again. We strive to embed these circular economy principles into everything Google does, from how we manage servers in our data centers to the materials we select to build and furnish our offices.

In fact, we recently announced that we're committed to achieving Zero Waste to Landfill for our global data center operations. Six of our operating data centers have already reached 100% landfill diversion, and we're looking further upstream to reduce waste. Zero Waste to Landfill is an important milestone in our journey to sustainably manage resources across Google. As a Global Partner of the Ellen MacArthur Foundation, we're also working together with other leading companies to accelerate the transition to a circular economy and help bring initiatives like these to scale.

Looking toward the future

We believe global businesses like Google should lead the way in improving people's lives while reducing or even eliminating dependence on virgin 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, most critically, positive environmental impacts.

Our end goal is a zero-carbon world where everyone everywhere has access to clean, carbon-free energy 24 hours a day, 365 days a year. This means empowering all energy users with cheap, clean options by continuing to drive down costs of existing renewable energy sources like wind and solar, and developing new policies, technologies, and tools that help users, businesses, and activists drive change.

We're helping people measure the planet with Google tools so that anyone can see the world change over recent decades, watching as cities grow, forests disappear, glaciers recede, and lakes dry up. We're also working with research and nonprofit organizations all over the world to monitor the Earth's vital signs.

Our vision is to use our mapping, cloud, and machine learning technologies to create a living, breathing dashboard of our planet that can help inform everyday decisions for individuals, organizations, and nations. This bright future, where everyone has access to information that is essential to creating environments optimized for human and ecosystem health, will be a win not only for the world today but for many generations to come.

Story County II wind farm in Iowa (114 MW for Google). Imagery and map data: Google

About Google

As our founders explained in their first letter to shareholders, Google's goal is to "develop services that significantly improve the lives of as many people as possible." We believe in the potential for technology to create a positive impact in the world. We also believe we are just beginning to scratch the surface. Google's vision is to remain a place of incredible creativity and innovation that uses our technical expertise to tackle big problems.

At Google, our innovations in search and advertising have made our website one of the most widely used and our brand one of the most recognized in the world. We generate revenues primarily through online advertising. Google's core products such as Search, Android, Maps, Chrome, YouTube, Google Play, Gmail, and Google Cloud Platform each have over 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 hardware solutions with products like Pixel, Chromecast, and Google Home.

We are a wholly owned subsidiary of Alphabet, which also includes such companies as Verily, Calico, X, Nest, GV, Google Capital, and Access/Google Fiber. As of December 31, 2015, we had almost $75 billion in total revenues and 61,814 full-time employees.

Google's headquarters are located in Mountain View, California, in the San Francisco Bay Area, United States. We own and lease additional office and building space, research and development labs, and sales and support offices across more than 150 cities primarily in North America, Europe, South America, and Asia, and we own and operate 13 data centers across four continents.

About this report

Most annual data in this report covers our 2015 fiscal year (January 1, 2015, to December 31, 2015). We've also included data and stories from prior years to provide context, as well as some of our year-to-date progress as of November 1, 2016. Unless otherwise specified, all environmental performance data included in this report applies to Google Inc. The primary exception is our GHG emissions and energy use data, which covers operations of Google together with our parent company, Alphabet Inc.

LEARN MORE

For more information about our environmental sustainability initiatives, including case studies, white papers, and blogs, please see our Google Environment website. Our investor relations website has more information on sustainability and corporate responsibility at Google.

El Romero solar farm in Chile
(80 MW for Google)

Performance highlights and targets

The following three pages summarize key highlights of our environmental initiatives discussed in this report. They provide a snapshot of our performance to date as well as our targets going forward. Together, they demonstrate 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 tables and charts on pages 64 to 67.

Performance highlights

Designing efficient data centers

ENERGY

50%
LESS ENERGY
On average, a Google data center uses 50% less energy than a typical data center.

1.12
PUE
In 2015, the average annual power usage effectiveness (PUE) for our global fleet of data centers was 1.12, compared with the industry average of 1.7—meaning our data centers use nearly six times less overhead energy.

3.5x
COMPUTING POWER
Compared with five years ago, we can now deliver more than 3.5 times as much computing power with the same amount of electrical power.

CERTIFICATIONS

14001 & 50001
ISO CERTIFICATIONS
12 out of 13 Google-owned and -operating data centers globally have achieved ISO 14001 (environmental management) and ISO 50001 (energy management) certifications.

WASTE

100%
LANDFILL DIVERSION
In total, six of our operating data centers have achieved 100% landfill diversion, and one of these has reached Zero Waste to Landfill.

86%
WASTE DIVERTED
In 2015, we diverted 84% of waste from our global data center operations away from landfills, and so far in 2016, we've diverted 86%.

19%
OF SERVERS REMANUFACTURED
In 2015, 19% of the servers Google deployed were remanufactured machines.

52%
OF COMPONENTS REFURBISHED
In 2015, 52% of the components we used for machine upgrades in our data centers were refurbished inventory.

Advancing renewable energy

ENERGY

100%
RENEWABLE ENERGY
We will achieve 100% renewable energy for our operations in 2017.

2.6 GW
OF RENEWABLE ENERGY
Google is the world's largest corporate purchaser of renewable energy. We've signed 20 agreements totaling 2.6 gigawatts (GW) of renewable energy—generating emissions savings equivalent to taking more than 1.2 million cars off the road.

842 MW
OF RENEWABLE ENERGY
In 2015, we nearly doubled our total purchases of renewable energy by entering into six new power purchase agreements (PPAs) totaling 842 megawatts (MW)—the largest aggregate purchase ever made by a non-utility.

$2.5 BILLION
IN EQUITY COMMITMENTS
We've committed to invest a total of $2.5 billion in renewable energy projects with a total combined capacity of 3.7 GW.

GHG EMISSIONS

0
NET EMISSIONS
Google has been carbon neutral since 2007.

50% DECREASE
IN CARBON INTENSITY
From 2009 to 2015, our carbon intensity per revenue (metric tonnes Scope 1 and 2 CO_2e/million US$) and per full-time equivalent employee both decreased by more than 50%.

Performance highlights

Creating sustainable workplaces

CERTIFICATIONS

9.2 MILLION
SQUARE FEET LEED CERTIFIED

To date, 854,000 square meters (9.2 million square feet) of Google office facilities have achieved Leadership in Energy and Environmental Design (LEED) certification.

31%
LEED PLATINUM

In 2015, 31% of our LEED-certified square footage achieved a Platinum rating and 58% received a Gold rating.

TRANSPORTATION

29,000 tCO_2e
SAVINGS

In 2015, use of Google shuttle buses and corporate electric vehicles in the Bay Area resulted in net annual savings of more than 29,000 metric tonnes of CO_2e (tCO_2e). That's like taking 5,700 cars off the road every day or avoiding 140 million vehicle kilometers (87 million vehicle miles) every year.

WATER

30% REDUCTION
IN POTABLE WATER USE

From 2013 to 2015, we reduced potable liters of water used per Googler by 30% at our Bay Area headquarters.

WASTE

86%
LANDFILL DIVERSION

In 2015, we reached an 86% landfill diversion rate in the Bay Area and 78% for our offices globally.

Empowering users with technology

ENABLING TECHNOLOGIES

1 BILLION
KILOMETERS

Google Maps provides more than 1 billion kilometers' worth of transit results per day.

100%
OF FORESTS MONITORED

Global Forest Watch, powered by Google Earth Engine, monitors 100% of the planet's tropical rainforests and provides timely and precise status information, including near-real-time alerts showing recent suspected tree cover loss.

>5,000
LEAKS DETECTED

Google Street View cars equipped with methane analyzers have driven more than 19,000 kilometers (12,000 miles) and detected more than 5,000 leaks from natural gas pipelines in 11 cities.

43 MILLION
ROOFTOPS MAPPED

To date, Project Sunroof has mapped over 43 million U.S. rooftops in 42 states. More than 2 million users have accessed the tool to make informed decisions about solar panel installation.

CLOUD-BASED PRODUCTS

65%–85%
ENERGY SAVINGS

Businesses that switch to G Suite products like Gmail, Calendar, Docs, Drive, and Hangouts have reduced energy use and carbon emissions by 65% to 85%.

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 local servers.

1 MONTH = 1 MILE

Providing an active user one month of Google services creates about the same amount of GHG emissions as driving a car one mile.

Targets

Designing efficient data centers

ENERGY

Maintain or improve quarterly PUE at each Google data center, year over year.

WASTE

Achieve Zero Waste to Landfill for our global data center operations.

CERTIFICATIONS

Maintain ISO 50001 energy management system certification for all Google-owned data centers that meet certain operational milestones.

Incorporate all Google-owned data centers into ISO 50001 energy management system certificate, once they exceed specified operational requirements.

Advancing renewable energy

ENERGY

Reach 100% renewable energy for our operations.

GHG EMISSIONS

Maintain carbon neutrality for our operations.

Creating sustainable workplaces

WATER

Reduce potable water consumption per Googler at our Bay Area headquarters by 40% by 2016, compared with 2013.

Set regional water-reduction targets for our offices in 2017.

WASTE

Reduce total waste per Googler at our Bay Area headquarters by 10% in 2016, compared with 2015.

Set regional waste-reduction targets for our offices in 2017.

CERTIFICATIONS

Pursue third-party green or healthy building certifications for office projects, such as LEED, WELL Building Standard, and Living Building Challenge.

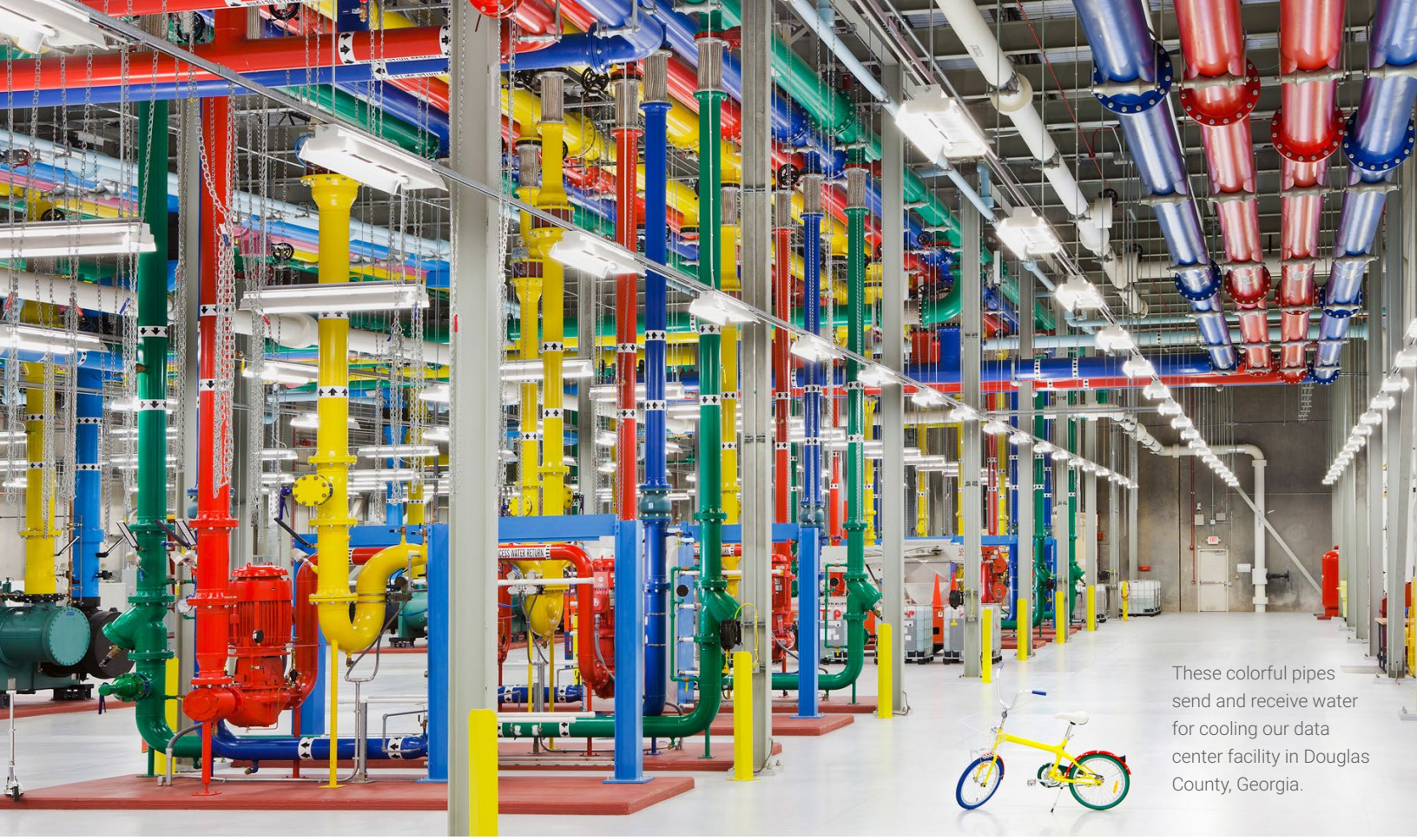
TRANSPORTATION

Reduce single-occupancy vehicle commuting at our Bay Area headquarters to 45%.

Provide electric vehicle charging stations for 10% of parking spaces at our Bay Area headquarters.

Designing efficient data centers

Google data center in The Dalles, Oregon



These colorful pipes send and receive water for cooling our data center facility in Douglas County, Georgia.

IN THIS SECTION

Google's data centers are the heart of our company, powering products like Search, Gmail, and YouTube for billions of people around the world, 24/7. We have 13 data centers on four continents and continue to add new sites. Each of our data centers is a large campus whose 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 pushed Google data centers to make them some of the most efficient in the world, improving their environmental performance even as demand for our products has dramatically risen. By designing, building, and operating each data center to maximize efficient use of energy, water, and materials, we're helping to reduce resource use.

Our data centers use 50% less energy than typical data centers.[6] To achieve this, we first 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 using non-potable water whenever possible. Finally, we apply machine learning to drive energy efficiency even further.

We're also working to design out waste from our data centers, embedding circular economy principles into our server management by reusing materials multiple times. We're committed to achieving Zero Waste to Landfill for our global data center operations by reducing the amount of waste we generate and finding better disposal options.

50%

ON AVERAGE, A GOOGLE DATA CENTER USES 50% LESS ENERGY THAN A TYPICAL DATA CENTER.

Building an energy-efficient computing network

We continuously strive to build the world's most energy-efficient computing network and to squeeze more out of every watt of power we consume. Compared with five years ago, we can now deliver more than 3.5 times as much computing power with the same amount of electrical power.

We've achieved energy savings in our data centers through two key strategies: efficient servers and efficient facilities. In addition to making our data centers more energy efficient, we also buy renewable energy for our operations (see pages 25 to 41).

Designing custom, high-efficiency servers

The core of our data centers are Google servers—high-performance computers running 24/7. Since 2001 we've been custom designing our own servers to use as little energy as possible by minimizing power loss and removing unnecessary components.

Up to a third of the energy consumed by a typical server is wasted before it gets to the computing components that actually run software products and services. We combat this by minimizing the number of times we convert power from one type of electrical current to another and using high-efficiency batteries that we keep as close as possible to the equipment they need to power. Only 10% to 15% of the electricity our servers use is lost during power conversion steps—about half the loss of a typical server. We estimate these efforts have resulted in annual savings of around 500 kilowatt-hours per server.

We also reduce server energy use by removing unnecessary parts like peripheral connectors and video cards, encouraging suppliers to produce energy-efficient components, and optimizing servers and racks so that internal fans spin only as fast as necessary to keep the machines cool enough to run. And by consolidating servers and keeping them busy, we can do more with fewer servers and less energy. Finally, we ensure that our servers use little energy while waiting for a task, when there's less computing work to be done.

LEARN MORE

Read our 2011 case study: "Google's Green Computing: Efficiency at Scale"

An employee in a server room at Google's data center in The Dalles, Oregon

TURNING UP THE HEAT

It's a myth that data centers need to be kept chilly in order for the equipment to run properly. By turning the thermostat up to 27 degrees Celsius (80 degrees Fahrenheit), we dial up our energy savings by reducing the need for energy-intensive air conditioning on the server floor.

Efficient facility operations

When we design a data center, we consider how best to work with the natural environment and conditions. There's no one-size-fits-all model—each data center is built for the highest operational performance and efficiency for its specific location.

When a data center is operating, we employ many different strategies to ensure we're running it as efficiently as possible. One key strategy is managing the temperature and airflow to help our equipment perform at its best while saving energy. To keep internal data center temperatures within an optimal range, we use thermal modeling to locate "hot spots" and better understand the airflow. Then we prevent hot air from mixing with cold by using simple, cost-effective tactics like sealing sheet metal and hanging plastic curtains.

We also take advantage of waste heat—at some sites, instead of releasing waste heat from the servers outside, we reuse it to heat up incoming fresh air for the office area. This reduces or eliminates the need for other heat sources, such as natural gas boilers.

LEARN MORE

Read our 2011 case study: "Google's Green Data Centers: Network POP Case Study"

SPOTLIGHT

From paper mill to data center in Finland

In Hamina, Finland, we turned an abandoned paper mill into a high-efficiency data center. This coastal site had its own power substation (something we would normally have to build) and a 450-meter (1,500-foot) underground tunnel that ran into the Baltic Sea, which the mill had used for cooling.

From this existing infrastructure we designed an innovative seawater cooling system, which was the first of its kind anywhere in the world. We pump cold seawater to our data center, transfer heat from our operations to the seawater through a heat exchanger, and then cool this water before returning it back to the sea. This approach provides all the cooling we need year-round—no mechanical chillers needed.

WHAT IS POWER USAGE EFFECTIVENESS?

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

Best-in-class power usage effectiveness

Most data centers use almost as much energy for non-computing purposes (like cooling and power conversion) as they do to power their servers. We've reduced this overhead to just 12%, meaning that most of the energy we use directly powers the machines that serve Google searches and other products.

We calculate this energy-efficiency performance using a measurement called power usage effectiveness (PUE). In fact, we were the first data center operator to disclose detailed energy-efficiency data for all of our data centers in 2008, and we've published this information every quarter since. We measure and monitor PUE vigilantly, including a comprehensive accounting of overhead energy sources, and ensure staff have access to real-time data to track—and thus improve—our facilities' energy performance.

Our PUE was 1.21 when we first started reporting this metric in 2008, and we've significantly lowered it since then. The average annual PUE for our global fleet of data centers was 1.12 in 2015, compared with the industry average of 1.7.[7] That means, compared with Google, the average data center uses nearly six times more overhead energy for every unit of IT equipment energy.

Our fleet-wide PUE dropped significantly from 2008 to 2012, showing an approximate 40% reduction in overhead energy use over that period, and it has remained constant at 1.12 for the past four years. The lowest quarterly PUE we attained in 2015 was 1.08, in Belgium.

We continually push to do more work with less energy, and our goal is to maintain or improve quarterly PUE at each of our data centers, year over year.

LEARN MORE

See our website to learn more about our PUE performance and how we measure it.

Using machine learning to drive PUE to new lows

A few years ago, our data centers had become so energy efficient we thought we couldn't do much more. Then one of our engineers had the idea to take a tool we use frequently and apply it in a new way.

From smartphone assistants to image recognition and translation, machine learning is already being deployed in lots of different Google products to help people in their daily lives. But this artificial intelligence can also help us tackle much bigger challenges in large-scale commercial and industrial systems, like data centers.

Data centers are highly dynamic environments, making it difficult for humans to see the complex interactions between all of the variables. Machine learning uses model simulations of the information that's gathered in a day—things like temperature, IT loads, and pump speeds—and suggests precise opportunities for optimizing operational performance.

DATA CENTER ENERGY MANAGEMENT POLICY

Google will lead the industry in the design, operation, and maintenance of economical, energy-efficient data centers. We will strive for continual improvement of data center energy performance by collecting, trending, analyzing, and ensuring the availability of energy consumption data; committing appropriate resources; and purchasing energy-efficient components for our systems.

We will maintain progressive energy conservation targets and will monitor our performance against these targets. We will comply with relevant energy use, consumption, and efficiency legal requirements and, as appropriate, we will implement other voluntary standards or best management practices.

In partnership with our colleagues at DeepMind, Google's data center team built models to recognize and "learn" from patterns in large amounts of operational data, which enabled us to predict—and improve—data center performance. After some trial and error, our models are now 99.6% accurate in predicting PUE, and we've been able to reduce the amount of energy used for data center cooling in test data centers by up to 40% (which equates to a 15% reduction in overall energy overhead after accounting for electrical losses and other non-cooling inefficiencies). This enabled one of our test data centers to bring its PUE to a new low and tie with the lowest PUE in the fleet—around 1.08.

This would be a huge improvement in any large-scale industrial environment. Given how efficient Google's data centers already were, it's a phenomenal step forward. As we roll out this system more broadly across our fleet, we're excited about its potential to push our PUE down to record-setting levels. And we'll continue sharing the lessons we learn along the way, so that other data center and industrial system operators—and ultimately the environment—can benefit from our work.

Certifiably smart energy management

In 2013, we became the first company in North America to achieve a multi-site ISO 50001 energy management system (EnMS) certification. Google is the only major Internet company to secure this voluntary third-party certificate, which covers all of our owned data centers globally once they meet certain operational milestones (it currently applies to 12 of our 13 operating data centers).

We keep working to improve our energy performance across our existing sites and to extend our EnMS to new facilities. Our EnMS certification audits have never identified any nonconformances, demonstrating that our program is comprehensive and effective.

We also maintain a corporate, multi-site ISO 14001 environmental management certification across our owned data centers, once they meet specified operational requirements.

Water evaporates from cooling towers at our data center in St Ghislain, Belgium.

Free cooling: An efficient way to beat the heat

The electricity that powers our servers ultimately turns into heat. The industry norm for data centers is to use air conditioning to cool things down, which requires 30% to 70% overhead energy use. While we still keep mechanical chillers on hand at most of our sites for when the temperature or humidity gets too high, we use these only when necessary. For the most part, we're able to rely on "free cooling"—utilizing local conditions by cooling with water or air rather than mechanical chillers. Most of our facilities, for instance, use highly energy-efficient evaporative cooling, which brings cold water in to cool the servers and then releases it through cooling towers as water vapor.

We're always looking for new approaches to cooling; we redesign our fundamental cooling technology on average every 12 to 18 months. Along the way, we've pioneered innovations in the use of non-potable water such as recycled wastewater, seawater, industrial canal water, reclaimed water, and rainwater.

For example, our Belgian data center uses industrial canal water for cooling. Some of the sludge that's removed from the water is used for cement manufacturing. We then return any water that hasn't evaporated to a local river, cleaner than we got it.

At our Taiwan data center, the process cooling water is connected to a thermal energy storage system that cools water at night when temperatures are lower, stores it in large insulated tanks, and then pumps the chilled water through the facility during the day.

We've also built a data center in Ireland that uses outside air from the chilly local climate to cool our servers instead of using water. We continue to investigate waterless cooling technologies.

Saving water by saving energy

Generating electricity requires water. So the less energy we use to power our data centers, the less water we use as well. This is called embedded or virtual water—water that's consumed by off-site sources for power production.

For every liter of water we use for cooling, we eliminate 2 liters of water used for energy production. This translates into saving large quantities of embedded water per year through our energy-efficiency measures alone.

The source of energy matters too. Coal and nuclear energy require considerably more water to produce than do wind and solar energy. In 2015, by powering our data centers with renewable energy, we reduced our embedded water use associated with data center power generation by approximately 40% on average.

We keep pipes like these at our Douglas County, Georgia, data center ready with highly pressurized water in case of a fire.

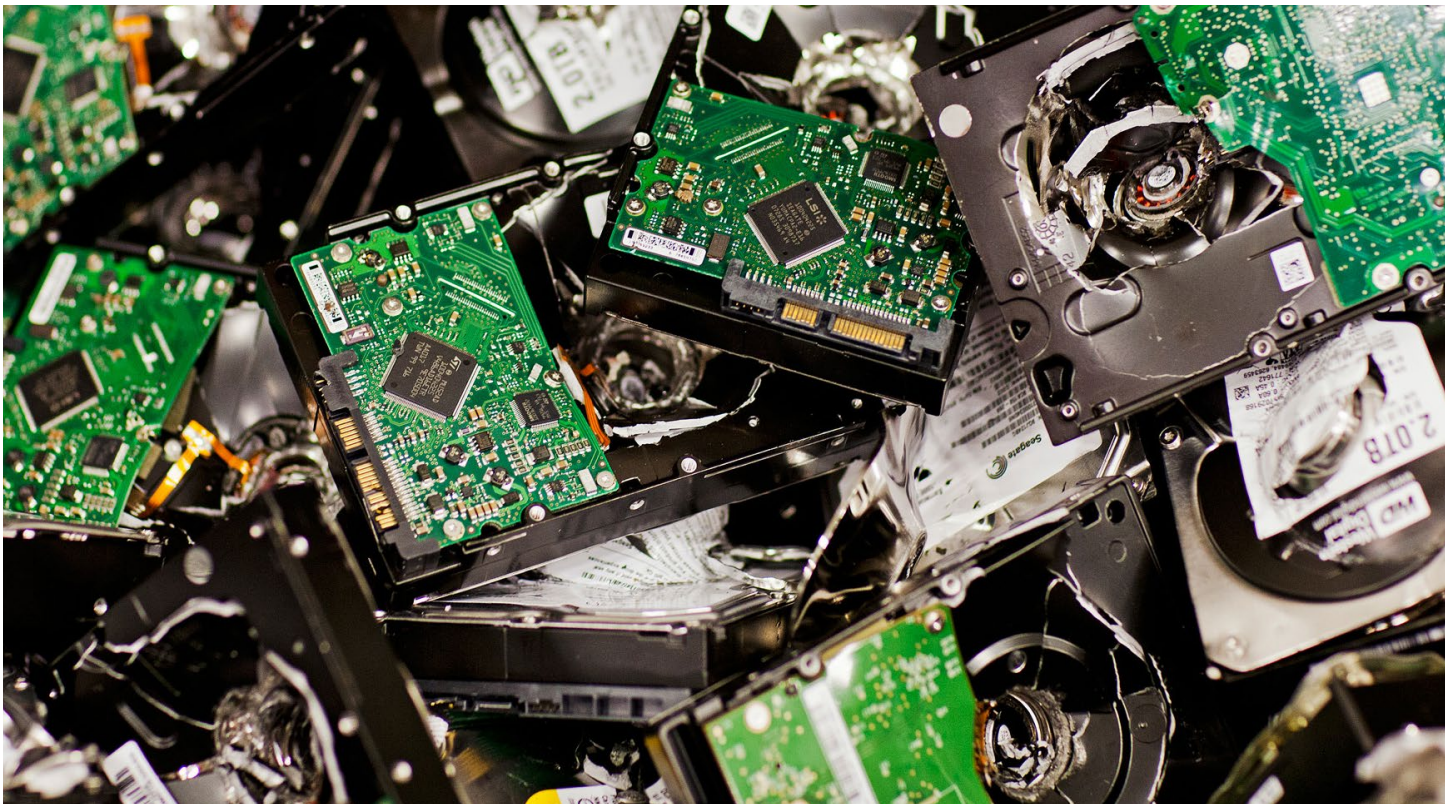
SPOTLIGHT

Flushing heat with wastewater in Georgia

When someone in Douglas County, Georgia, flushes a toilet, it helps cool our local data center and preserve drinking water for residents of this drought-prone region.

When we built our Georgia data center in 2007, we realized that the water we used didn't have to be clean enough to drink. So we approached the local water and sewer authority with a win-win proposal: Let our data center use recycled wastewater from its water treatment facility.

As a result, we built a side-stream treatment plant that intercepts up to 30% of the sewer authority's water and cleans it through sterilization, filtration, and chlorination. We then send this water to our data center for use in our cooling towers. Any water that isn't evaporated is then treated again and returned to the Chattahoochee River cleaner than when we received it.



84%

WASTE FROM OUR DATA CENTER OPERATIONS DIVERTED FROM LANDFILL GLOBALLY IN 2015.

The zero waste moonshot

In September 2016, we announced an ambitious new commitment to achieve Zero Waste to Landfill for our global data center operations. This is the kind of challenge that excites us, and we're approaching it on dual tracks: reducing the amount of waste we generate and finding better disposal options that divert as much waste as possible from landfills.

Our data center in Mayes County, Oklahoma, was the first to reach Zero Waste to Landfill. In total, six of our operating data centers—nearly half, including all of our operating sites in Europe and Asia—have achieved 100% landfill diversion, albeit five of those have a current waste-to-energy contribution of greater than 10%, meaning they haven't yet achieved Zero Waste to Landfill. As we continue to implement new diversion strategies and find new ways to design waste out altogether, this waste-to-energy percentage will decrease.

In 2015, we diverted 84% of waste from our global data center operations away from landfills, and so far in 2016, we've hit 86%. The last 10% to 20% of waste diversion is generally the hardest to solve, but it's also where we can be the most creative about new community partnerships and designing waste out of our systems. Zero Waste to Landfill is only the first step in our journey to weaving circular economy principles into our operations by efficiently managing resources throughout our data centers' entire lifecycles.

HOW DO WE DEFINE ZERO WASTE TO LANDFILL?

At Google, Zero Waste to Landfill[8] 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 a standard developed by UL Environment,[9] which helped us ensure that our waste-diversion guidelines and monitoring process were aligned.

Getting the most out of all our hardware

We're constantly maintaining and upgrading our servers to meet the ever-growing demand for Google products around the world. And before we buy new hardware equipment and materials, we look for ways to reuse what we already have. In 2015, 52% of the components we used to upgrade our machines 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 2015, we resold nearly 2 million units—primarily memory modules, hard drives, and networking gear—into the secondary market for reuse by other organizations.

The small percentage of hard drives and storage tapes that can't be reused or resold is crushed, shredded, combined with plastics and metals from other electronic waste, and then sent off to be recycled into new materials.

This regimen—maintaining, remanufacturing, reselling, and recycling hardware—not only saved energy, materials, and water by avoiding the need to manufacture new products, it also saved Google hundreds of millions of dollars in 2015 alone.

LEARN MORE

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

Driving our industry forward

Google has saved more than $1 billion through our energy-efficiency initiatives, and hundreds of millions more through resource efficiency. We've learned a lot along the way, and we make a point of sharing best practices through white papers and case studies. We also support research and industry collaboration to drive mutual progress. In 2009, we hosted our first data center efficiency summit, and we're a founding member of the Green Grid and a member of the Open Compute Project.

BY THE NUMBERS: HARDWARE REFURBISHMENT AND REUSE

From refurbishing to recycling, we diverted waste throughout our data centers in 2015, saving hundreds of millions of dollars in material costs.

19%
OF SERVERS
Google deployed were remanufactured machines.

52%
OF COMPONENTS
used for machine upgrades were refurbished inventory.

NEARLY 2 million
COMPONENTS
were wiped clean and resold into the secondary market.

100%
OF THE HARD DRIVES
and storage tapes that can't be resold are crushed and sent to our recycler.

SPOTLIGHT

Waste compactors do double duty in Oklahoma

In working to achieve Zero Waste to Landfill, our data center in Mayes County, Oklahoma, really crushed it by deploying compactors. Trash compactors divert waste more effectively; give us accurate weight data for tracking; decrease the number of pickups our vendor has to make (saving us both time and money); and reduce janitorial work by keeping the site cleaner overall.

Through our Data Center Mural Project, we partner with artists to reimagine the facades of our data centers. This mural on the side of our Mayes County, Oklahoma, data center features four collages of Google Maps satellite imagery, focusing on the types of infrastructure that enable the flow of goods, power, and information.

Advancing renewable energy

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

El Romero solar farm in Chile
(80 MW for Google)

IN THIS SECTION

Meeting the demand for Google products and running our business require us to consume energy—primarily electricity—to power our data centers, offices, and other infrastructure. Combating climate change requires the world to transition to a clean energy economy. That's why we've made it a top priority not only to become more energy efficient, but also to ensure the energy we purchase comes from clean sources, such as renewables.

Google is the largest corporate purchaser of renewable energy in the world.[10] To date, we've signed contracts to purchase 2.6 gigawatts (GW) of renewable energy, and we will reach 100% renewable energy for our operations in 2017—a major milestone. While we'll still be drawing power from the grid, some of which will be from fossil fuel resources, we'll be purchasing enough wind and solar energy to account for every megawatt-hour (MWh) of electricity our operations consume.

We're also looking beyond our business to drive wide-scale adoption of renewable energy. We're supporting new energy purchasing models that others can follow, such as our pioneering commitment to long-term contracts to buy renewable energy directly from developers (power purchase agreements, or PPAs) and our support of renewable energy purchasing programs with utilities. We're also helping to green the power grid through our advocacy of clean energy policies and our $2.5 billion in equity investment commitments for renewable energy projects.

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, Google has been carbon neutral since 2007.

Renewable energy is good for business

As a large consumer of energy, purchasing electricity has a significant impact on our bottom line. Entering into long-term renewable energy contracts makes sound business sense for two key reasons:

Price certainty: Because the fuel for renewable sources like wind and solar is essentially free, we know our renewable energy prices from the start of a contract and pay the same amount for electricity regardless of volatility in energy market prices. This gives us long-term visibility into our electricity expenses, which is valuable since electricity is a core part of our operating costs.

Cost competitiveness: We always try to buy renewable energy from the most cost-competitive sources within the grids where we operate. In a growing number of regions, electricity from renewable resources like wind and solar is now cheaper than grid power. Even in places where that's not currently the case, we expect that renewable energy contracts signed today will become more cost competitive over time, saving us money over the long term.

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

SPOTLIGHT

Economic benefits of the renewable energy industry

The renewable energy and energy-efficiency sectors are surging, creating hundreds of thousands of new jobs in the United States. Globally, the renewable energy sector employed 8.1 million people in 2015. In addition, large hydropower accounted for another 1.3 million jobs.[11]

Further, the renewable energy industry is now a crucial part of the U.S. economy. With investment commitments reaching over $44 billion last year, renewables have become a mainstream source of affordable electricity for millions of Americans.[12]

Renewables have also dropped precipitously in cost and in 2015 became the world's largest source of installed power capacity.[13, 14] Countries around the world remain committed to tackling climate change and investing in clean energy technologies.

Doubling the share of renewables by 2030 would bring a range of positive impacts, including an increase in global gross domestic product (GDP) of up to 1.1%, improvement of global welfare by 3.7%, and employment for over 24 million people in the renewable energy sector.[15]

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

Reaching 100% renewable energy

In 2012, we made a commitment to reach 100% renewable energy for our operations, and we've made great strides toward this goal. We've tackled it from many angles, including buying renewable electricity directly from wind and solar farms via PPAs and purchasing renewable power through utilities via renewable energy tariffs. Lastly, many utilities typically have renewable sources as part of their grid mix,[16] which means our regular energy purchases contain some renewable energy.

Our use of renewable energy has been growing rapidly. In 2015, we purchased enough renewable electricity to match 44% of our total annual electricity consumption, and in 2016, we increased this percentage to more than 50%. We're excited to announce that we will make a huge leap forward next year. Given our signed contracts for projects soon to come online, we will nearly double our annual purchases of renewable electricity in 2017, reaching 100% renewable energy for our global operations—including both our data centers and offices. We achieved this milestone much faster and at a much greater scale than we thought possible when we set this goal just a few years ago.

LEARN MORE

Read our 2016 white paper: "Getting to 100% Renewable Energy and Going Beyond"

100%

IN 2017, WE WILL REACH 100% RENEWABLE ENERGY FOR OUR GLOBAL OPERATIONS.

What do we mean by 100% renewable energy?

At Google, 100% renewable energy means that on an annual basis we purchase the same amount of renewable electricity (in MWh) as the electricity that our global operations consume. It doesn't mean we're getting all our energy directly from wind and solar farms, or that this renewable production matches our consumption every hour—we're still connected to the electricity grid and drawing power 24/7, even when wind and solar facilities in that grid may not be producing energy.

With today's technology, electrons generated in one spot can't be physically directed to a specific user on the grid, any more than a cup of water poured into a river could be directed to a particular stream. Once you put electricity on the grid, it becomes part of the shared energy pool within that grid system—which includes renewable and nonrenewable sources—and flows where physics dictates.

Why don't we just build renewable energy projects at our data center sites? This "behind the meter" approach doesn't usually make economic or practical sense for large facilities like data centers for three reasons:

Location mismatch: The places with the best renewable power potential generally aren't the same locations where a data center can most efficiently and reliably serve our users.

Intermittency: While our data centers operate 24/7, most renewable energy sources don't. Given the complexities and costs of large-scale energy storage today, it would not be practical to keep Google's products online 24/7 using renewable sources alone.

Space constraints: The large amount of renewables required to supply industrial loads would require a significant amount of suitable land, which isn't usually available on or near our data center sites.

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

New models for greening energy consumption

The most straightforward way for companies to access renewable energy is for utilities to offer a renewable power option to companies that request it. When we first decided to buy clean energy, our preference was to get it directly from our utility partners; however, many utilities have been slow to create renewable energy purchasing options for customers that want them.

Since we couldn't buy green power the easy way, we created workarounds and helped reinvent clean energy markets. We pioneered corporate PPAs—approaching renewable project developers and signing long-term contracts to buy energy from them directly. We also supported the creation of renewable energy tariffs, enabling customers to buy renewable energy directly from their utilities. By doing these at scale and making our methods publicly available, we've helped establish new models for green power purchasing that many other corporations have followed, accelerating the growth of clean energy.

WHAT ARE RECS AND GOOS?

RECs are U.S. market-based instruments used to track renewable electricity from the point of generation to the consumer. One REC represents the renewable attributes of one MWh of generation, and can be sold separately (unbundled) or together (bundled) with the underlying electricity. GoOs are a similar instrument used in Europe to label electricity from renewable sources.

Setting a high bar for every project

For each renewable energy deal that we evaluate, we look for three critical factors:

Additionality: To ensure that Google is the driver for bringing new clean energy onto the grid, we insist that all projects are "additional," which means two things. First, we seek to purchase energy only from newly constructed generation facilities or expansions of existing projects, rather than simply redirecting renewable energy outputs from pre-existing projects. Second, these facilities must produce renewables above and beyond what's required by existing regulation (such as a state renewable portfolio standard). By adhering to both of these additionality criteria, we're confident these projects are creating positive local and regional economic impacts as well as environmental impacts.

Physical energy bundled with its "renewable certification": We purchase both the physical electricity and its corresponding "bundled" certification of renewable energy—a Renewable Energy Certificate (REC) in the United States or a Guarantee of Origin (GoO) in Europe—which represents the "green-ness" of the power. By bundling physical energy with these certifications, we provide all or nearly all of a project's cash flow over time, whereas buying "unbundled" RECs or GoOs provides only a small portion of a project's cash flow. At today's prices, buying bundled RECs and energy provides revenue that is orders of magnitude larger than RECs alone, giving developers sufficient financing to build a project and helping to ensure additionality.

Proximity: Where possible, we seek renewable energy projects that will operate on the same grids as our data centers. This creates a stronger link between the renewable power we purchase and our data center electricity consumption. Purchasing fixed-price energy on the same grid also enables us to hedge our financial exposure to market price fluctuation. When we can't supply our data centers directly with renewable energy, we typically resell this electricity back onto the grid, "retiring" the green certificates. Reselling renewables back to the grids from which our data center buys electricity acts to hedge our financial exposure at that data center location.

The criteria above apply to projects that we contract for via PPAs or that are dedicated to us via renewable energy tariffs. They don't apply to renewable energy we purchase indirectly from utilities as part of their existing grid mix.

2.6 GW

WE'VE SIGNED 20 AGREEMENTS TO PURCHASE MORE THAN 2.6 GW OF RENEWABLE ENERGY—GENERATING EMISSIONS SAVINGS EQUIVALENT TO TAKING MORE THAN 1.2 MILLION CARS OFF THE ROAD.

PPAs: Partnering with developers to bring more clean energy online

Our core method of purchasing renewables has been PPAs: direct contracts with renewable energy developers in which we buy the bundled output (both the electricity and its RECs) of a wind or solar farm for an extended term of typically a decade or longer.

Although PPAs have been around for a while in the utility industry, they're a relatively new model for corporate renewable power purchasing. In 2010, we were one of the first non-energy companies to obtain permission from the Federal Energy Regulatory Commission (FERC) to participate in U.S. wholesale electricity markets. This gave us the authority to buy renewable energy directly from a project, then resell it back into the same grid where we operate a data center. We entered into our first PPA later that year.

This basic strategy—selling renewable energy in one location and consuming electricity at another, both on the same grid—helps us reach our renewable energy goals while gaining certainty in our financial planning.

PPAs have played a huge role in transforming the clean energy market. Many corporations have since applied this model. Between 2012 and 2015, corporate purchasing of wind and solar in the United States grew by more than 30 times, from less than 100 MW in 2012 to more than 3.2 GW in 2015.[17]

LEARN MORE

Read our 2013 white paper: "Google's Green PPAs: What, How, and Why"

Putting PPAs to work at Google

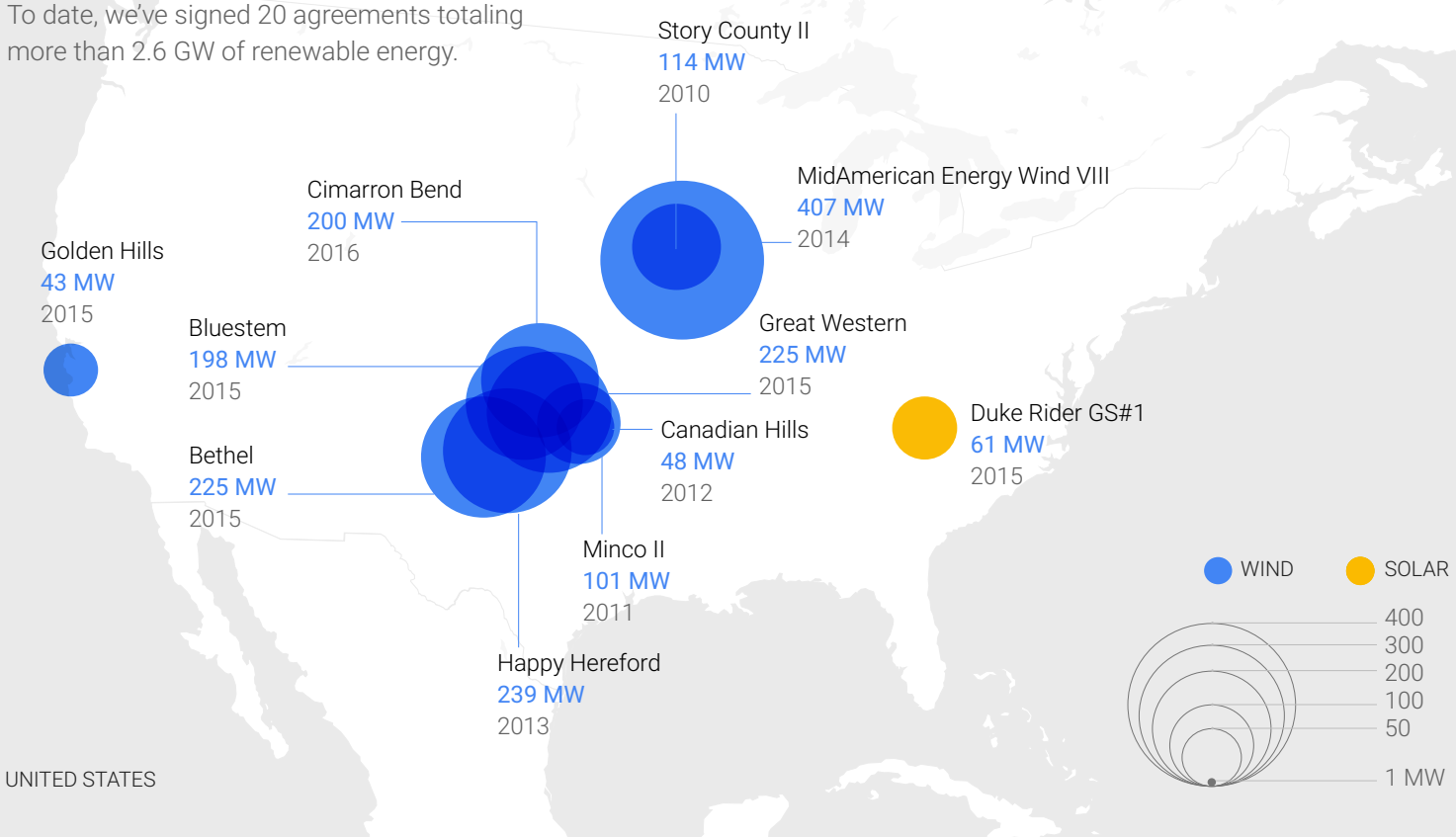
Google entered into our first PPA in 2010, with a 20-year agreement to purchase 114 MW of power from a wind project in Iowa. In the years since, we've crisscrossed the United States, Europe, and South America to sign 20 agreements totaling more than 2.6 GW of renewable energy.

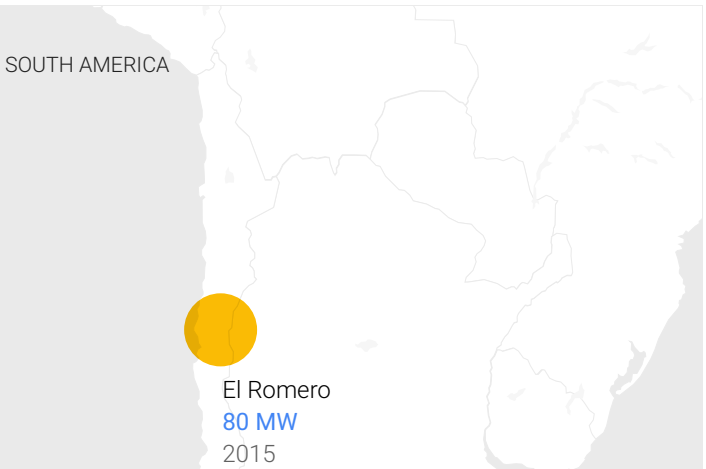
In 2015, we nearly doubled our total purchases of renewable energy with the largest aggregate purchase ever made by a non-utility—842 MW. This spanned six projects on three continents, including two wind farms in Sweden, a solar plant in Chile, and three wind farms in the United States.

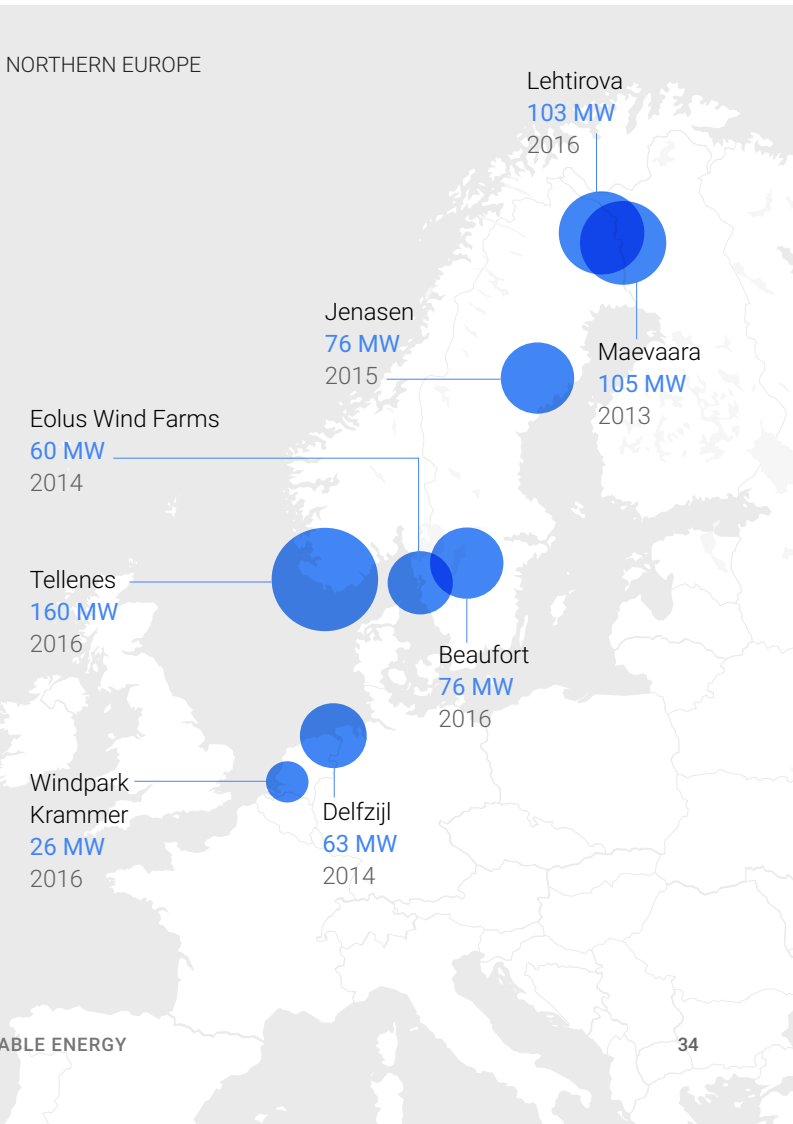
In 2016, our PPA efforts earned us a Green Power Leadership Award in Direct Project Engagement from the U.S. Environmental Protection Agency.

RENEWABLE ENERGY FOR GOOGLE'S OPERATIONS

To date, we've signed 20 agreements totaling more than 2.6 GW of renewable energy.







Renewable energy tariffs: Working with utilities to increase access to clean energy

While PPAs have had a big impact, they're not an ideal structure; they were a workaround created because many utilities have insufficient mechanisms and incentives for supplying renewable energy. That's why, in addition to pursuing PPAs, we also work directly with utility partners to find solutions that will make more renewable energy available to us and others.

This includes promoting renewable energy tariffs—a new class of rates that allows companies to buy large amounts of renewable power directly from their utilities. By tapping into utilities' strengths in power generation and delivery, renewable energy tariffs allow more companies to opt in to renewable energy, without having to do complex transactions like wholesale PPAs. Essentially, they enable a utility to dedicate electricity output of a newly constructed wind or solar facility to a customer such as Google.

In 2013, we began working with Duke Energy in North Carolina on one of the first renewable energy tariffs—the Green Source Rider program. Two years later, we signed on as the program's first customer with an agreement to purchase energy from a 61 MW solar project in North Carolina's Rutherford County.

By working with providers like Duke, we've helped pave the path to renewable energy for other large customers.

LEARN MORE

Read our 2013 white paper: "Expanding Renewable Energy Options for Companies Through Utility-Offered 'Renewable Energy Tariffs'"

El Romero solar farm in Chile (80 MW for Google)

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

Accelerating the transition to clean energy

Thanks in part to our work on renewable energy tariffs and PPAs and related efforts by our peers, the number of corporate renewable energy deals is soaring, and renewable energy tariffs will soon be available in eight U.S. states.[18] In 2015 alone, corporations purchased 3.2 GW of renewable energy in the United States and Mexico, nearly three times as much as in 2014.[19]

This has helped bring the cost of renewable power down tremendously and has helped scale up the market, creating hundreds of thousands of jobs across the United States. Over the past six years, solar and wind energy costs have decreased by 80% and 60%, respectively.[20] From 2012 to 2015, corporate renewable energy purchases grew 60% year over year.[21]

We're excited by the growth of the renewable energy industry and the increasing ability of customers to take control of their electricity consumption, but there's more work to be done. We continue to look for new ways to help utility business models become more customer-centric, so that cost-effective renewable energy is available to anyone who wants it.

Driving clean energy policies

To grow the clean energy industry and bring renewable energy solutions to scale for their customers, businesses need policies that confirm that long-term investments are sound. That's why Google has long been an advocate at the state, national, and international levels for strong clean energy and carbon policies.

In the United States, we support robust renewable energy portfolio standards at the state level, which are instrumental in bringing new renewable energy online. At the U.S. federal level, we joined with Amazon, Apple, and Microsoft to promote federal mechanisms to grow cleaner sources of electricity in the United States. We came together because our companies collectively operate 50 data centers in 12 states, and reliable, affordable, clean electricity is integral to the continued growth and operation of all of our businesses.

Internationally, we engaged with the European Commission on its review of pan-European renewable energy policy, which aims to improve access to renewable energy throughout the European Union. In Asia, we've provided seed funding to the Center for Resource Solutions (CRS) to begin laying the groundwork for renewable energy certification programs (similar to RECs and GoOs) across the region, starting in Taiwan. Our efforts in Asia earned us a Green Power Leadership Award in International Green Power Market Development from CRS.

At the global level, Google has long been an advocate for a comprehensive international agreement to address carbon emissions. We advocated for a strong and effective outcome at the 21st United Nations Conference of the Parties (COP21) climate change conference in Paris. Eric Schmidt, executive chairman of Alphabet, Google's parent company, published a blog post expressing the urgent need to reach an agreement to take action on climate change.

In addition to direct engagement and advocacy, we push for clean energy policies through industry partnerships and by participating in trade associations, standing alongside many of the world's most influential companies in working to tackle climate change.

In 2015, we signed the American Business Act on Climate Pledge, and we joined the RE100 campaign with other businesses committed to 100% renewable energy. Google is also a founding member of the U.S. Partnership for Renewable Energy Finance (PREF), and an active member of many other clean energy organizations, such as the American Council on Renewable Energy (ACORE) and the Renewable Energy Buyers Alliance (REBA).

SPOTLIGHT

Investing in a clean energy future

We believe in a clean energy future where anyone can choose renewable energy because it's sustainable, economical, and available.

To help make this vision a reality, Google has made commitments to invest nearly $2.5 billion since 2010 in innovative, large-scale renewable energy projects with a total combined capacity of 3.7 GW. This includes approximately $700 million in commitments in 2015 alone. These projects represent a broad portfolio of investments, including wind farms and new solar and energy transmission technologies, residential rooftop solar systems for homes, and an oil and gas field repurposed for renewable energy.

We're not using the electricity produced by these projects, nor are we using the projects to offset Google's operational carbon footprint. These targeted equity investments go beyond our own footprint and have transformative market potential. They are solutions that can scale to meet society's long-term energy needs.

For example, in 2015 we agreed to purchase a 12.5% stake in the 310 MW Lake Turkana Wind Power Project, Africa's largest wind farm. When complete, the project has the potential to supply power to more than 2 million homes in Northern Kenya.

Other Google investments have helped renewable energy technologies generate wider interest and go mainstream. For example, we began investing in residential solar companies in 2011, with a $280 million commitment to finance rooftop solar projects in partnership with SolarCity. As of 2015, three other investments have brought our total commitment to rooftop solar to more than $700 million. Our investments have played an influential role in the more than $10 billion that residential solar companies have raised to deploy solar on residential rooftops.[22]

El Romero solar farm in Chile
(80 MW for Google)

This family of deer have moved in next to our Council Bluffs, Iowa, data center.

50%

FROM 2009 TO 2015, OUR CARBON INTENSITY PER REVENUE AND PER FULL-TIME EQUIVALENT EMPLOYEE BOTH DECREASED BY MORE THAN 50%.

Our carbon footprint

We began calculating our annual carbon footprint in 2006. Each year since 2009, we've publicly reported it to CDP, a global organization that asks companies to disclose information on their greenhouse gas (GHG) emission performance and management. Our report received an "A" score from CDP for the past three years, and we earned a spot on CDP's A List—which recognizes top reporting companies—in both 2015 and 2016.

In 2015, our gross GHG emissions were 3 million metric tonnes of carbon dioxide equivalent (CO_2e), but because of our renewable energy and carbon offset programs, our net carbon emissions were zero. 100% of our Scope 1 and 2 emissions and part of our Scope 3 emissions are third-party verified by an independent and accredited verifier.

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. From 2009 to 2015, our carbon intensity per revenue (metric tonnes Scope 1 and 2 CO_2e/million US$) and per full-time equivalent employee (metric tonnes Scope 1 and 2 CO_2e/FTE) both decreased by more than 50%. At our data centers, our electricity intensity (metric tonnes Scope 2 CO_2e/MWh) also dropped more than 50% over the same period. This means that we're delivering our services and products with decreased carbon impacts, even before using carbon offsets to reach neutrality.

Carbon neutrality

In 2007, we 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 (see pages 12 to 24). Second, we purchase significant amounts of renewable energy. Third, we buy carbon offsets for any remaining emissions we haven't yet eliminated.

When we committed to carbon neutrality in 2007, we envisioned carbon offsets as an interim solution. As we continue to improve our energy efficiency and reach our target to operate with 100% renewable energy (for our Scope 2 emissions), our need for carbon offsets will decrease.

When we do purchase carbon offsets, we follow stringent principles. We invest in high-quality, third-party-verified offsets ranging from landfill gas projects to animal waste management systems. All our offsets are additional—meaning that the projects reduce GHG emissions that would not be reduced through other incentives. We also ensure that our offsets are permanent—meaning that the projects we invest in aren't temporary methods of carbon reduction or sequestration.

LEARN MORE

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

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

Our journey to net zero carbon

Google is committed to reducing our carbon emissions and helping to increase the world's supply of clean energy. Here are some of our notable milestones over the past decade.

2007

We committed to **carbon neutrality** and purchased enough carbon offsets to bring our net annual emissions to zero for the first time.

Our Bay Area headquarters became a proving ground for renewable energy with a **1.6 MW rooftop solar installation,** the largest corporate rooftop solar array at the time.

2010

We became one of the first non-utility corporations to receive **permission from the Federal Energy Regulatory Commission** (FERC) to buy energy directly from wind and solar providers.

With FERC authority in hand, we made our **first purchase of renewable energy** by signing a 20-year power purchase agreement (PPA) with the Story County II wind farm in Iowa.

In addition to purchasing renewable energy for our operations, we began contributing to growing the clean energy market by making our **first renewable energy equity investment** with a $39 million commitment to the 170 MW Peace Garden wind farm in North Dakota.

2012

With the momentum from our purchases, we set a **goal to reach 100% renewable energy** for our operations.

Our total cumulative commitments reached **$1 billion in renewable energy equity investments.**

2014

We surpassed a cumulative total of **1 GW of renewable energy purchased** for our operations.

2015

We nearly **doubled our renewable energy purchases** in a single year by entering into six new PPAs totaling 842 MW, the largest aggregate purchase of renewable energy ever by a non-utility, bringing our total contracts to more than **2 GW of renewable energy worldwide.**

Our total cumulative commitments reached **$2.5 billion in renewable energy equity investments.**

Further bolstering our commitment to operate with 100% renewable energy, we **signed the American Business Act on Climate Pledge** and joined the RE100 campaign.

2016

We joined with Amazon, Apple, and Microsoft to promote federal mechanisms to grow cleaner sources of electricity in the United States.

By November, we had signed a cumulative total of 20 PPAs for **more than 2.6 GW of renewable energy.**

By the end of the year, we will have been **carbon neutral for 10 consecutive years**.

2017

We will reach

100%

renewable energy for our global operations.

Creating sustainable workplaces

IN THIS SECTION

On average, people spend 90% of their time indoors. A lot of that time is spent at work. At our Bay Area, California, headquarters and in Google's offices in over 150 cities around the world, we try to help Googlers perform at their best by building workplaces that are healthier for people and for the environment. We also look to share the lessons we've learned and the tools we've used so that other businesses can apply the same techniques in their own offices.

We leverage third-party green building standards and, whenever possible, build and furnish our workspaces with nontoxic materials. These materials are safer for workers and building occupants and much easier to perpetually cycle, reducing the use of virgin materials.

We take a science- and community-driven approach to managing our campus landscapes, with the aim of strengthening the ecosystem while improving access to the outdoors for employees and community members.

Our green transportation fleet takes thousands of commuting Googlers out of cars. We look for opportunities to install renewable energy, such as solar panels and ground source heat pumps, at our offices. We reduce our water footprint by installing water-saving technologies and using reclaimed water when possible. We eliminate waste wherever we can and try to find diversion pathways that keep the waste we do generate out of landfills.

9.2 million

SQUARE FOOTAGE OF GOOGLE OFFICE FACILITIES THAT HAVE ACHIEVED LEED CERTIFICATION TO DATE—THE SIZE OF MORE THAN 16 GREAT PYRAMIDS OF GIZA.

Better buildings

We build new offices in accordance with Google's values of promoting sustainability and human health and happiness. To do this, we leverage global third-party rating systems like Leadership in Energy and Environmental Design (LEED), WELL Building Standard, and Living Building Challenge.

To date, more than 854,000 square meters (9.2 million square feet) of Google facilities have achieved LEED certification. In 2015, 31% of our LEED-certified square footage achieved a Platinum rating and 58% received a Gold rating. We've also had many firsts for their regions. For example, our Dublin office achieved Ireland's first Platinum certification, and our Buenos Aires office achieved Argentina's first LEED certification.

Many offices have also received other green building certifications. Our Sydney office is Green Star certified by the Green Building Council of Australia; our Zürich office got an "A" from the Minergie green building rating system in Switzerland; and many of our U.K. offices have achieved BREEAM ratings.

We also use data to limit the resources we consume. We collect energy, water, and waste data at Google offices all over the world, which helps us decide which projects to implement to improve our performance over time. We're always looking for simple solutions that we can scale globally.

Patio of the Googleplex headquarters in Mountain View, California

QUARTZ: INGREDIENTS FOR HEALTHY BUILDINGS

Most of us spend a lot of time in buildings, yet we know little about how the materials used in their construction could impact the environment and our long-term health. In 2015, in partnership with Flux, HBN, and thinkstep, Google launched Quartz, an open online database that offers baseline human and environmental health information for 100 common building products.

Creating healthier, happier workplaces

Since Google was founded, we have always been focused on creating physical work environments that support human and environmental health. In 2010, we started asking for transparency about the material content of building products that we purchased. We learned that supply chain transparency in the building industry was extremely challenging and that a surprising number of concerning substances are commonly used in building materials, such as formaldehyde and heavy metals. In 2012, Google gave a $3 million grant to the U.S. Green Building Council to improve human health and well-being by supporting more industry research and better standards around healthy materials.

To address this issue in our own operations, we worked with the Healthy Building Network (HBN) to develop Portico, an online tool that lets building project teams collaborate, research products, and choose healthy materials.

Portico leverages the power of data to enable real-time decisions about building materials that prioritize health outcomes. Its growing product library includes more than 2,500 products that satisfy our healthy material requirements. To date, we've used it on more than 195 Google office projects in 20 countries with over 1,500 project team members. Portico also creates a direct communications channel between project teams and the 5,000 participating manufacturers and their supply chains, saving time and money by making it easier to get information about products.

Portico Early Access Program

In October 2016, Google and HBN announced the next phase of Portico. Together with four new founding partners—Harvard University, the Durst Organization, Perkins+Will, and HomeFree Affordable Housing—we hope to launch Portico as a tool for the entire industry.

The ecosystem in our backyard

Our Bay Area headquarters have campuses on the edge of the San Francisco Bay, an area that includes an array of wildlife habitats alongside its thriving urban centers. We take a science- and community-driven approach to managing these landscapes.

Our vision for landscape resilience, developed in partnership with local environmental organizations and leading national ecologists, has three primary objectives: create more habitat for wildlife diversity; improve landscape resilience in the face of drought and rising sea levels; and improve human health by expanding access to nature.

We believe we've made a good start. By transitioning to native plants on campus, for instance, we've saved water, improved biodiversity by bringing species like Monarch butterflies and Anna's hummingbirds to our gardens, and provided new spaces for Googlers and community members to relax and recharge outdoors.

LEARN MORE

Read the 2015 report: "Vision for a Resilient Silicon Valley Landscape"

87 million

VEHICLE MILES AVOIDED DUE TO USE OF GOOGLE SHUTTLES AND CORPORATE ELECTRIC VEHICLES IN THE BAY AREA IN 2015, SAVING 29,000 METRIC TONNES OF CARBON DIOXIDE (CO_2E) EMISSIONS—EQUIVALENT TO TAKING 5,700 CARS OFF THE ROAD.

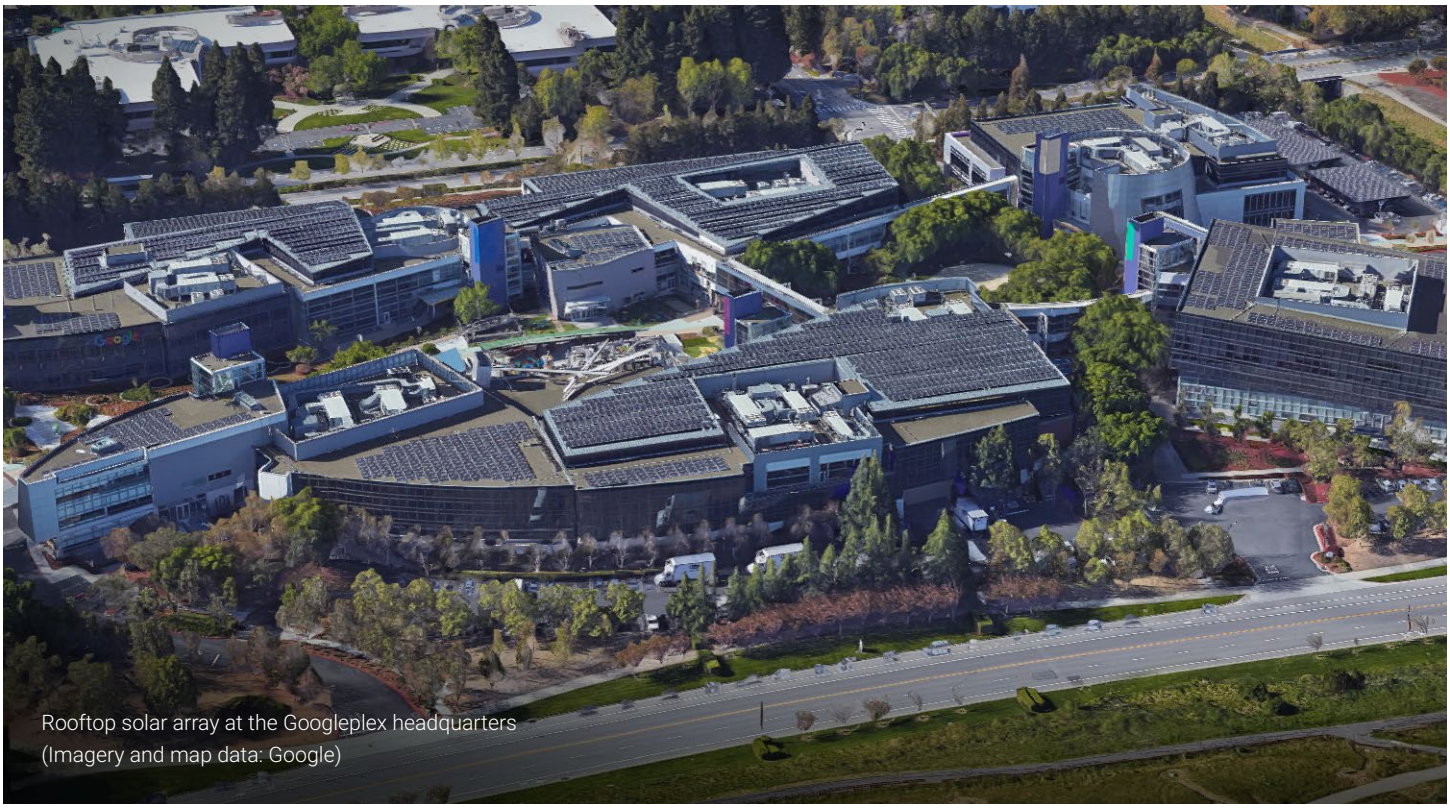
A greener way to get there

Our green transportation program for our Bay Area headquarters includes biodiesel shuttles and the largest corporate electric vehicle charging infrastructure in the United States. These investments support our commitment to reduce single-occupancy vehicle commuting at our headquarters to 45%—an unprecedented number for an American suburban office park—by transitioning more employees to shuttles, carpooling, public transit, biking, and walking. In 2015, use of Google shuttles and corporate electric vehicles in the Bay Area resulted in net annual savings of 29,000 metric tonnes of carbon dioxide (tCO_2e) emissions.

GBus program: On peak days to date, Google's GBuses shuttle more than 9,000 riders in the Bay Area each way. Our shuttles run on 5% biodiesel and use filtration systems that eliminate harmful emissions like nitrogen oxide.

Commuter e-Bike and GBike programs: In the Bay Area, 10% of Googlers bike to work. We help facilitate this by providing an electric pedal-assist bike, lock, and helmet to any Googler at our headquarters who wants to make biking his or her primary means of commuting. We also have hybrid bikes available for visiting employees and interns, and 1,500 community bikes stationed around our Bay Area campus for employees to travel between buildings.

Electric vehicle charging stations: To encourage Googlers to use electric vehicles, to date we've installed more than 1,600 charging ports globally at our offices and data centers, and we provide charging at no cost to our employees. Our goal is to provide charging for up to 10% of the parking spaces at our Bay Area headquarters.



Rooftop solar array at the Googleplex headquarters
(Imagery and map data: Google)

Renewable energy starts at home

Our commitment to operate with 100% renewable energy, discussed on pages 25 to 41, includes our offices.

In 2007, we became an early adopter of rooftop solar by installing a 1.6 megawatt (MW) solar array at our Bay Area headquarters. At the time, this was the largest corporate solar installation of its kind and was Google's first significant renewable energy project. The array has since grown to 1.9 MW, and in 2015 it generated 1.3 million kilowatt-hours (kWh) of electricity to power our offices.

We also operate highly efficient ground source heat pumps and solar water heaters at our offices in Mountain View, California; Hyderabad, India; and Tel Aviv, Israel. The solar water heater at our Mountain View office supplies 3.8 million liters (1 million gallons) of hot water per year.

In 2015, we signed a long-term agreement to buy 43 MW of local wind energy for our Bay Area headquarters. Our agreement helped to repower an iconic wind farm at California's Altamont Pass, which in the 1980s was the first test bed in the United States for large-scale wind power technology. The wind farm has been upgraded from legacy turbines to technology that's twice as efficient and up to 66% safer for birds, according to wildlife monitoring groups.[23]

Our Mountain View, California, campus conserves water by replacing turf with drought-tolerant plants.

167 million

COMBINED WATER SAVINGS IN LITERS AT OUR BAY AREA HEADQUARTERS IN 2013 AND 2014.

Conserving water in California and around the world

Water scarcity is both a local and a global issue. The United Nations predicts that by 2025, two-thirds of the world's population will live in water-stressed conditions.[24] Our home state of California is currently enduring its fifth year of record drought, prompting the state to set aggressive water usage limits for households and businesses. We're doing our part to conserve water in the Bay Area and at Google offices around the world.

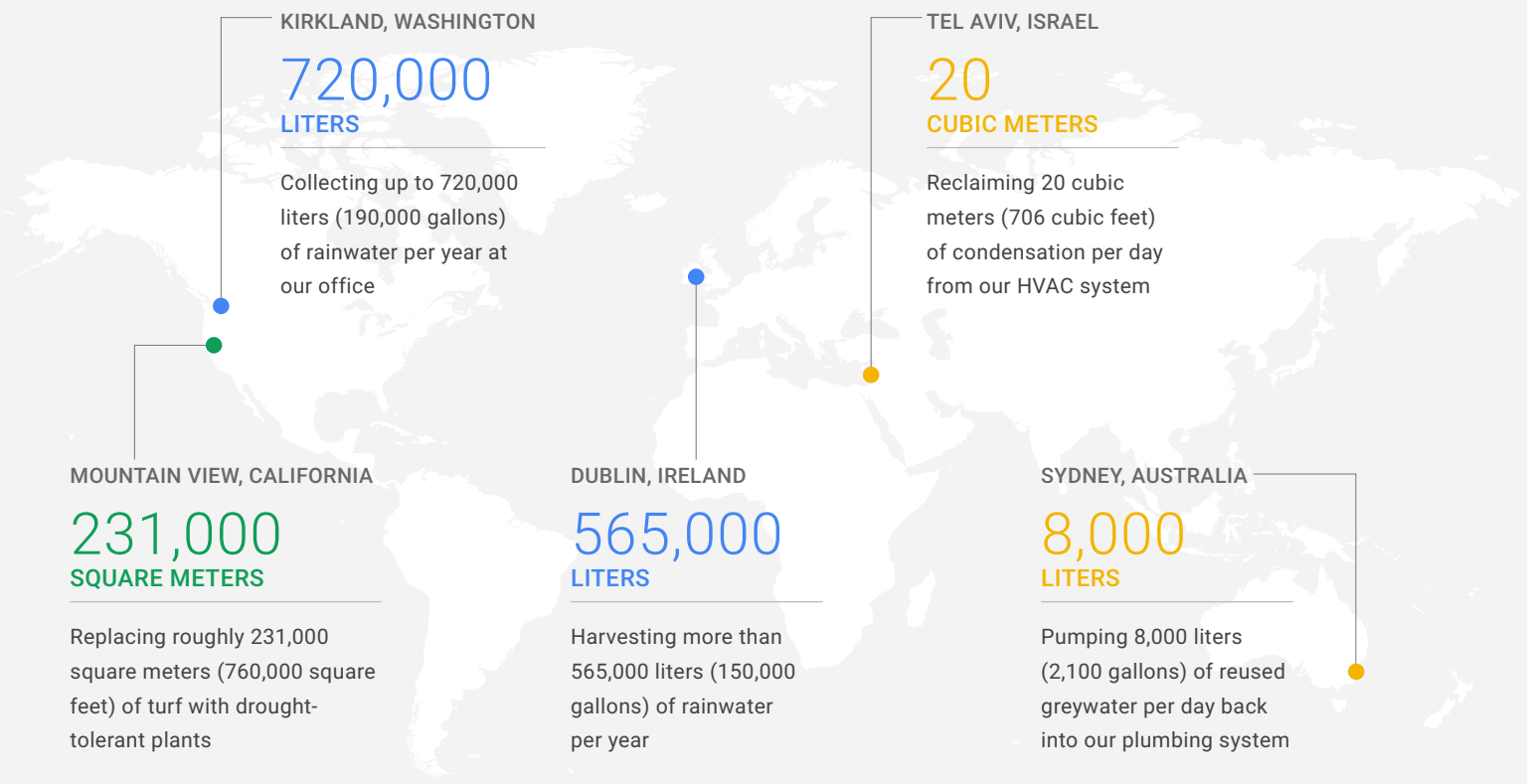
In 2012, 11 Google buildings at our Bay Area headquarters joined the California Best Buildings Challenge, which targeted a 20% reduction in energy, waste, and potable water use over a two-year period. We exceeded our water goal by 41%, saving roughly 167 million liters (44.2 million gallons) by using reclaimed water for irrigation, high-efficiency indoor water fixtures, café water audits, and staff conservation training. We also exceeded our targets in energy and waste, saving 22% and 36% respectively.

In 2014, we reduced annual potable water consumption across our Bay Area headquarters by about 91 million liters (24 million gallons) by, among other measures, switching our landscape irrigation systems to recycled municipal water and replacing approximately 231,000 square meters (760,000 square feet) of turf with drought-tolerant plants.

At our Bay Area headquarters, we reduced potable liters of water used per Googler by 30% from 2013 to 2015. Our goal for 2016 is to reduce our consumption of potable water by 40% per Bay Area Googler compared with 2013. In 2017, we plan to set regional water-reduction targets.

FIVE WAYS WE SAVE WATER AT OUR OFFICES

DROUGHT-TOLERANT PLANTS RAINWATER RECLAIMED AND REUSED



KIRKLAND, WASHINGTON

720,000

LITERS

Collecting up to 720,000 liters (190,000 gallons) of rainwater per year at our office

TEL AVIV, ISRAEL

20

CUBIC METERS

Reclaiming 20 cubic meters (706 cubic feet) of condensation per day from our HVAC system

MOUNTAIN VIEW, CALIFORNIA

231,000

SQUARE METERS

Replacing roughly 231,000 square meters (760,000 square feet) of turf with drought-tolerant plants

DUBLIN, IRELAND

565,000

LITERS

Harvesting more than 565,000 liters (150,000 gallons) of rainwater per year

SYDNEY, AUSTRALIA

8,000

LITERS

Pumping 8,000 liters (2,100 gallons) of reused greywater per day back into our plumbing system

86%

WASTE DIVERTED FROM LANDFILL IN OUR BAY AREA OPERATIONS IN 2015.

Designing out waste

The easiest way to get waste out of a system is to avoid creating it in the first place—and when you can't avoid creating it, finding ways to extract value from it.

In 2014, we started using LeanPath software, which tracks food waste produced in our cafés. Armed with this data, in the Bay Area alone we were able to prevent nearly 200,000 kilograms (440,540 pounds) of food from going to waste in 2015, and we've saved more than 475,000 kilograms (1 million pounds) so far in 2016. We also donate wherever possible and compost what is left. Finally, at some sites, such as our Zürich office, food waste is used by a third party to make natural biogas.

In 2015, we reached an 86% landfill diversion rate for total waste in the Bay Area and 78% globally. This year we hope to reduce total waste in our Bay Area operations by 10% per Googler compared with 2015. Our next step will be to set regional waste-reduction targets in 2017.

LEARN MORE

Read our 2016 report: "Google Bay Area Waste Case Study"

A composting partnership in Mountain View

At one time, all the compostable materials at our Bay Area headquarters ended up in the landfill. In 2009, we partnered with the city of Mountain View to pilot a composting program. We started with food scraps, compostable plastics, napkins, waxed cardboard, and other materials, and trained our staff and employees to sort waste properly and keep the contamination rate low.

The pilot worked so well that the city expanded the program to other local companies in 2012. Today it's available to all commercial customers in the area.

SPOTLIGHT

Putting imperfect produce to use

Google purchases healthy, nutritious fruits and vegetables that might otherwise go to waste because of stringent cosmetic requirements. Our imperfect produce initiative in our Bay Area headquarters has saved 150,000 kilograms (330,000 pounds) of produce, while making better use of the water, energy, and other natural resources that went into growing and transporting all that food.

Empowering users with technology

Our Geo team built Google Earth Engine,
a platform for Earth science data and analysis.

IN THIS SECTION

Global challenges require a truly global response. We meet the challenges posed by climate change and the need for resource efficiency by working to empower everyone—businesses, governments, nonprofit organizations, communities, and individuals—to use Google technology to create a more sustainable world.

Companies that use Google Cloud can take advantage of our efficient, renewable-energy-based computing infrastructure instead of building and managing their own. Google Cloud Platform and G Suite applications like Gmail, Docs, and Drive are shifting millions of businesses from locally hosted solutions to Google Cloud. And Google Maps helps limit carbon emissions by giving people access to mass transit options, bike routes, and traffic information.

The hardware we build is designed to meet the highest environmental standards. The 2016 Pixel phone is UL 110 Platinum certified for sustainability in categories like energy use, health and environment, and end-of-life management. We're also upcycling recycled plastic content in products like Google Home and Chromecast, and making it easy for customers to recycle their electronics for free via take-back programs.

We also use technology to help people study and respond to environmental challenges. Our Geo team is working with numerous research and environmental organizations to map the world's forests, oceans, watersheds, and air in real time. These tools and data can help scientists, environmental organizations, and communities develop more informed solutions to challenges like deforestation, overfishing, and air pollution.

SAVING ENERGY WITH GOOGLE CLOUD

Google Cloud Platform
Developers and businesses that build websites and apps on Google Cloud Platform are using the same energy-efficient infrastructure that powers Google services, so they don't have to build their own.

G Suite
By switching to G Suite products like Gmail, Calendar, Docs, Drive, and Hangouts, businesses have reduced energy use and carbon emissions by 65% to 85%.[27] A business using Gmail alone can reduce the greenhouse gas (GHG) emissions impact of its email service by up to 98% compared with running email on local servers.[28]

Efficiency in the cloud

The Google Cloud is built for efficiency. Our comprehensive Cloud portfolio—from infrastructure to apps to devices—helps enterprises innovate faster, scale smarter, and do more with data, all in the most efficient way possible.

Because the cloud supports many products at a time, it can more efficiently distribute resources among many users. That means we can do more with less energy—and other businesses can too. Research from the Lawrence Berkeley National Laboratory suggests that if all office workers in the United States moved their email and documents to the cloud, it would reduce IT energy use by up to 87%—enough to power the city of Los Angeles for one year.[25]

Beyond the general environmental benefits of cloud computing, the Google Cloud is particularly resource efficient. Providing an active user one month of Google services creates about the same amount of GHG emissions as driving a car one mile.[26]

LEARN MORE
See our 2011 case study: "Google's Green Computing: Efficiency at Scale"

Smarter transportation with Google Maps

Travelers or commuters wanting to reduce their personal carbon footprint (not to mention their waistline) can use Google Maps to get where they're going by walking, biking, or using public transportation.

According to the U.S. Department of Transportation, taking the bus reduces a person's GHG emissions by 33% per mile compared with driving alone in a car.[29] Subways and other heavy rail trips are even more efficient, reducing GHG emissions by 76% per passenger mile. And travelers can avoid vehicular emissions altogether by choosing the bike or walking icon in Maps and getting customized turn-by-turn directions incorporating bike and pedestrian routes.

Maps offers transit info for more than 6,000 public transit agencies and 3 million transit stations in 20,000 cities and towns in 64 countries—which adds up to more than 1 billion kilometers' (621 million miles) worth of transit results per day.

1 billion

TOTAL KILOMETERS' WORTH OF TRANSIT RESULTS PER DAY PROVIDED BY GOOGLE MAPS.

Driving sustainability in our consumer electronics

In addition to our Google Cloud products, we hold ourselves to the highest environmental standards for Google-branded consumer electronics. We strive to ensure that Google products are designed, packaged, and recycled in a sustainable way.

For example, the 2016 Pixel phone by Google obtained the UL 110 Platinum certification for sustainability in mobile phones—a standard that rates devices on 48 attributes across six categories, including energy use, health and environment, end-of-life management, and packaging.

The Pixel is easy to take apart for recycling, with screws that can be removed with ordinary tools, and comes in packaging that's 99% recyclable and made primarily with renewable, biobased fiber. Vegetable-based inks and water-based adhesives are used in the Pixel packaging. Moving forward, we intend to design all Google-branded phones to meet the UL 110 sustainability standard.

For our Chromecast and Google Home devices, we focused on upcycling recycled plastic. All the major hard plastic components in the latest Chromecast Ultra are made from 50% recycled plastic content, and those in the new Google Home are made from 20% recycled plastic. We intend to continue using recycled content wherever possible.

Device recycling

Many Google Store customers in the United States can recycle their used electronics for free via a mail-back program or use our recycling help page to find local e-waste drop-off sites. Google is a member of e-waste collection and take-back programs around the world that help us meet our e-waste obligations and support international recycling goals. This includes supporting recycling for consumer electronics, batteries, and packaging materials in Europe.

Monitoring the environment in real time

To get the attention of decision-makers, we're helping everyone visualize and measure the planet. With Google Earth, Street View, and Timelapse, people can see the world change over recent decades, watching as cities grow, forests disappear, glaciers recede, and lakes dry up. We also give nonprofits, educators, and other public benefit organizations access to our premier mapping tools.

But seeing is only half the battle. We're also working with research and environmental organizations all over the world to monitor the Earth's vital signs. We're building a living, breathing dashboard of our planet that can help inform everyday decisions for individuals, organizations, and nations.

Google Earth Engine is a Google-Cloud-powered, planetary-scale platform for Earth science data and analysis. This tool makes more than 40 years of the world's geospatial satellite imagery available online for free to scientists and researchers whose work is driving a deeper understanding of our planet.

GOOGLE.ORG WATER PROJECTS

Through our philanthropic arm, Google.org, we're investing in water-saving projects and technologies that have the potential to create lasting impact in communities around the world.

So far we've helped fund real-time water-monitoring technologies in East Africa; a data platform about the water crisis in Flint, Michigan; an entrepreneur-driven network of water purification systems in Cambodia; and technology to improve water and sanitation infrastructure for rural villages in India, among others.

LEARN MORE

Read about our $6.5 million in Google.org water projects

Google Earth Outreach helps nonprofit and public benefit organizations use Google's mapping, cloud, and machine learning capabilities to address some of the world's most pressing problems. We choose strategic initiatives based on where we believe Google's technology and scale can have the greatest impact. Equipped with hard data, organizations and decision-makers can analyze trends, examine their root causes, make informed decisions, and communicate this information to millions of people.

Keeping an eye on forests and waters

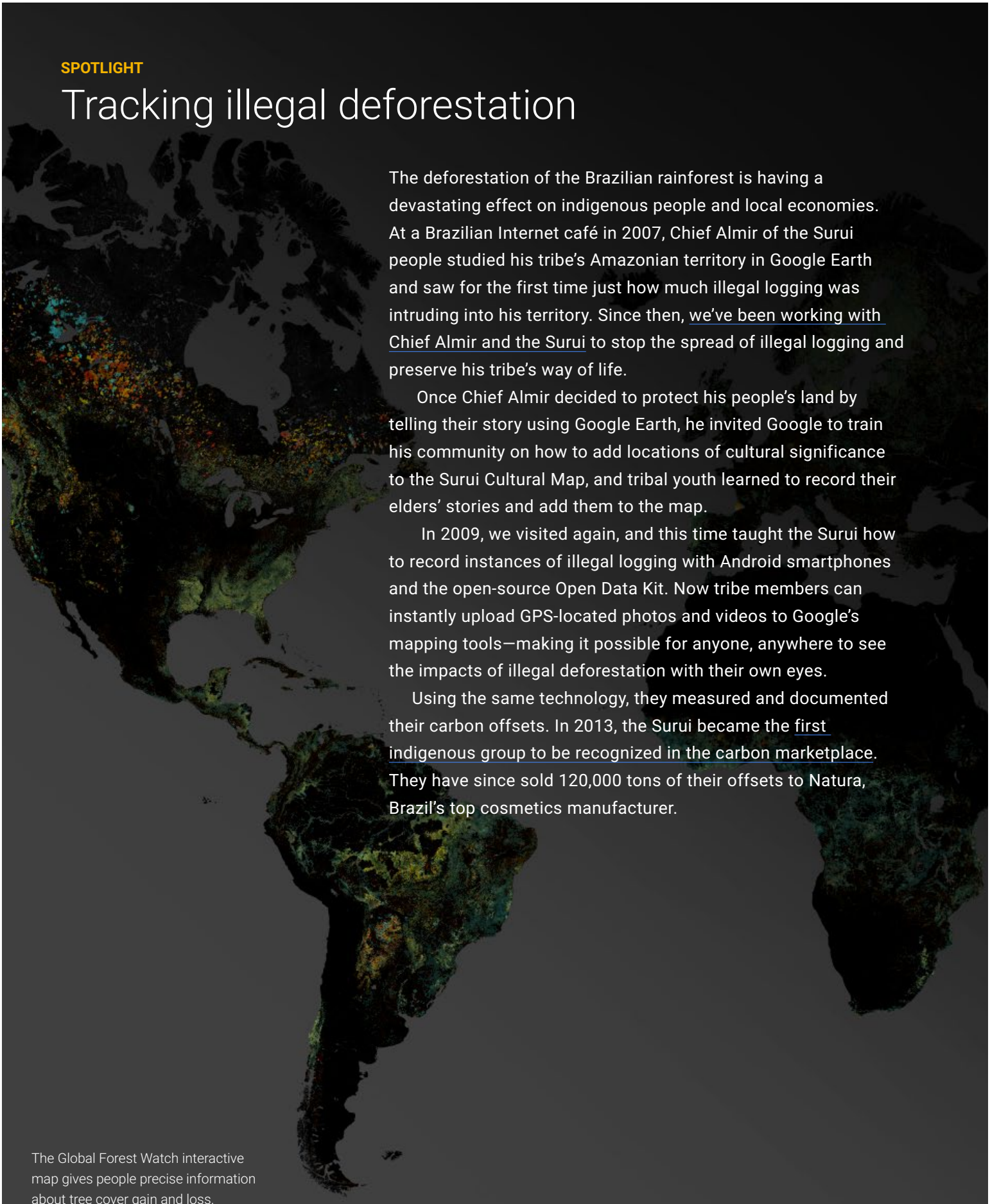
Forests are critical to the health of our planet and all its inhabitants. Using Google Earth Engine, we helped create the first-ever global high-resolution map of forests, which is the cornerstone of the World Resources Institute's (WRI) Global Forest Watch (GFW). The platform monitors 100% of the planet's tropical rainforests and provides the most timely and precise information about the status of forests worldwide, including near-real-time alerts showing recent suspected tree cover loss.

GFW has been used to inform and enforce forest-related legislation by governments in many countries, including the Philippines, Indonesia, Singapore, Peru, and the Democratic Republic of the Congo. For example, the Peruvian government's forestry department used GFW to identify roads transporting illegally harvested timber coming from the buffer zone of Cordillera Azul National Park.

With Google Timelapse, people can see changes in land use over recent decades.

SPOTLIGHT

Tracking illegal deforestation



The deforestation of the Brazilian rainforest is having a devastating effect on indigenous people and local economies. At a Brazilian Internet café in 2007, Chief Almir of the Surui people studied his tribe's Amazonian territory in Google Earth and saw for the first time just how much illegal logging was intruding into his territory. Since then, we've been working with Chief Almir and the Surui to stop the spread of illegal logging and preserve his tribe's way of life.

Once Chief Almir decided to protect his people's land by telling their story using Google Earth, he invited Google to train his community on how to add locations of cultural significance to the Surui Cultural Map, and tribal youth learned to record their elders' stories and add them to the map.

In 2009, we visited again, and this time taught the Surui how to record instances of illegal logging with Android smartphones and the open-source Open Data Kit. Now tribe members can instantly upload GPS-located photos and videos to Google's mapping tools—making it possible for anyone, anywhere to see the impacts of illegal deforestation with their own eyes.

Using the same technology, they measured and documented their carbon offsets. In 2013, the Surui became the first indigenous group to be recognized in the carbon marketplace. They have since sold 120,000 tons of their offsets to Natura, Brazil's top cosmetics manufacturer.

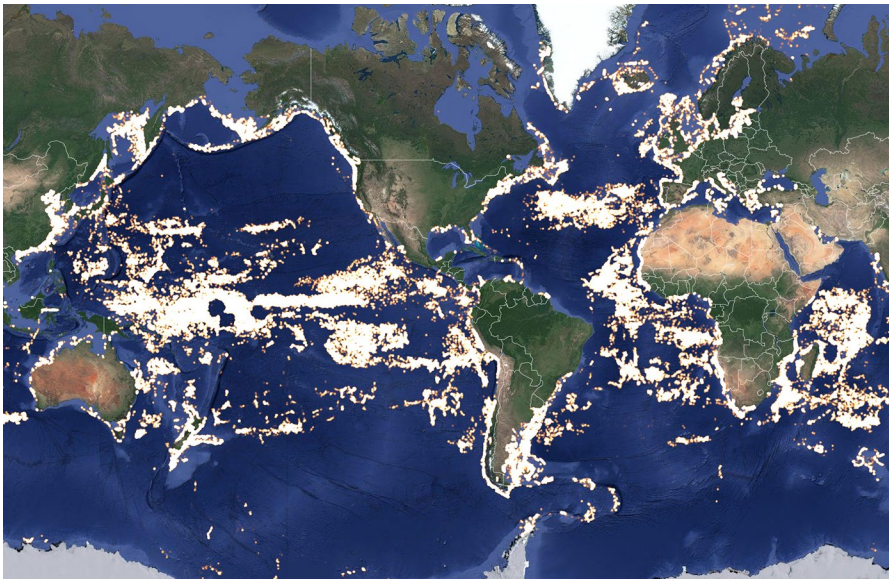
The Global Forest Watch interactive map gives people precise information about tree cover gain and loss.

We also partnered with the European Commission's Joint Research Centre (JRC) to develop new high-resolution global maps of the world's surface freshwater resources, showing both long-term trends and seasonal changes in the world's estuaries, deltas, seas, lakes, and rivers over the past 30 years. To build these maps, the JRC created algorithms to characterize water-covered land and applied them in Google Earth Engine. Requiring more than 600 million hours of computation over petabytes of satellite imagery data, this is the first time that the world's surface freshwater resources have been mapped so comprehensively.

Using satellite data to stop overfishing

Humans are over-harvesting the ocean. Some fish species are down to 10% of their former population sizes, even as humanity's need for sustainable protein continues to climb.

With Global Fishing Watch, a partnership with Oceana and SkyTruth, we're combining cloud computing and satellite data to create the first global view of commercial fishing activities.



Global Fishing Watch provides a global view of commercial fishing activities.

>5,000

METHANE LEAKS FROM NATURAL GAS PIPELINES DETECTED BY GOOGLE STREET VIEW CARS EQUIPPED WITH METHANE ANALYZERS IN 11 CITIES.

At any given moment, there are about 200,000 seagoing vessels publicly broadcasting their location through the Automatic Identification System. Global Fishing Watch uses machine learning to analyze more than 22 million points of this information per day to determine each ship's type (e.g., cargo, tug, sail, fishing) and the "fishing probability" at every point in each fishing vessel's route, then creates an animated heat map that anyone can view.

This platform, which wasn't even technically feasible a few years ago, is now poised to change the way agencies, governments, and citizens manage our endangered ocean resources.

Making the invisible visible with air mapping

Methane is a potent GHG that's a leading contributor to climate change. For the past few years, Google Earth Outreach and the Environmental Defense Fund have been working together to map methane leaks from the natural gas pipelines that run beneath our streets.

Street View cars equipped with methane analyzers have driven more than 19,000 kilometers (12,000 miles) and mapped more than 5,000 leaks in 11 cities. We found leaks ranging from an average of one leak per mile in Boston to one every 200 miles in Indianapolis. Utility companies armed with this data are prioritizing the replacement of old leaky gas pipelines with newer piping made of plastic.

We're also partnering with the air sensing company Aclima to measure pollutants like carbon dioxide, nitrogen dioxide, black carbon, and particulate matter in California communities, and pinpoint where the levels of these pollutants are highest. This data stored in the Google Cloud is enabling scientists to analyze how air patterns change over the course of a day, a month, or a year. We intend to provide air quality maps through Google Earth for individual and community use.

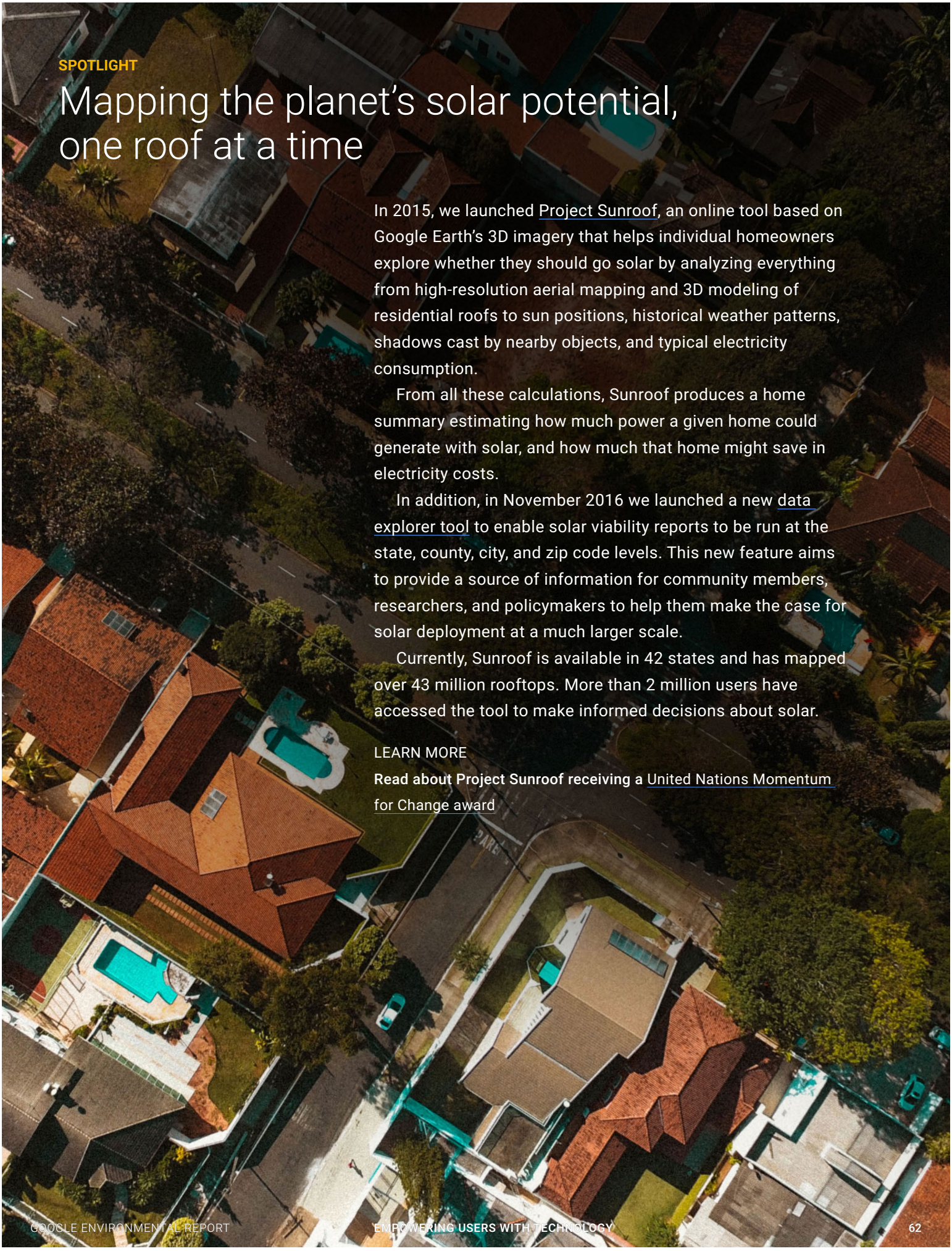
Understanding global power plants

Helping the world plan and move toward a zero-carbon economy requires lots of transparent, highly accurate data. But even the most basic information about major carbon sources and decarbonization plans is often incomplete or unavailable to the public, hindering research, development planning, and impact evaluation.

In partnership with WRI, we created Global Power Watch, the most comprehensive database of power plants in existence today. This freely available data provides accurate, timely information about power plants' location, production, impact, and risks.

SPOTLIGHT

Mapping the planet's solar potential, one roof at a time



In 2015, we launched Project Sunroof, an online tool based on Google Earth's 3D imagery that helps individual homeowners explore whether they should go solar by analyzing everything from 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.

From all these calculations, Sunroof produces a home summary estimating how much power a given home could generate with solar, and how much that home might save in electricity costs.

In addition, in November 2016 we launched a new data explorer tool to enable solar viability reports to be run at the state, county, city, and zip code levels. This new feature aims to provide a source of information for community members, researchers, and policymakers to help them make the case for solar deployment at a much larger scale.

Currently, Sunroof is available in 42 states and has mapped over 43 million rooftops. More than 2 million users have accessed the tool to make informed decisions about solar.

LEARN MORE

Read about Project Sunroof receiving a United Nations Momentum for Change award

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.

Greenhouse gas (GHG) emissions and energy use data applies to operations of Google Inc. together with our parent company, Alphabet Inc. The exceptions are data center energy efficiency and renewable energy figures, which apply to Google's operations only. All other data applies to Google's operations only. Unless otherwise specified, reported data is global.

For more information on our energy use and GHG emissions data and initiatives, see our annual CDP climate change report.

		FISCAL YEAR[30]				
KEY PERFORMANCE INDICATOR	UNIT	2011	2012	2013	2014	2015
GHG emissions[31]						
Scope 1*,†	Metric tonnes (t) CO_2e	29,563	37,187	41,373	51,802	66,991
Scope 2 (market-based)*,†,[32]		1,439,703	1,149,988	1,245,253	1,460,762	1,695,161
Scope 2 (location-based)*,†		1,439,703	1,654,645	1,831,142	2,198,821	2,694,531
Scope 3*,†		208,157	332,612	479,388	980,783	1,234,682
Total (Scope 1, 2 [market-based], and 3)		1,677,423	1,519,787	1,766,014	2,493,347	2,996,834
Emissions neutralized by carbon offset projects		−1,677,423	−1,519,787	−1,766,014	−2,493,347	−2,996,834
Net carbon emissions		0	0	0	0	0
Carbon intensity[33]	tCO_2e					
Carbon intensity per unit of revenue	tCO_2e/million US$	38.8	25.8	23.2	22.9	23.5 [34]
Carbon intensity per full-time equivalent employee (FTE)	tCO_2e/FTE	51.9	33.8	31.9	31.0	30.3
Carbon intensity per megawatt-hour (MWh) of electricity consumed at data centers	tCO_2e/MWh	0.552	0.337	0.325	0.316	0.242
Energy use						
Electricity*	MWh	2,675,898	3,324,818	3,712,865	4,434,390	5,743,793
U.S.		-	2,326,210	2,562,688	2,985,108	3,788,237
International		-	998,608	1,150,177	1,449,282	1,955,556
Data center energy efficiency						
12-month trailing power usage effectiveness (PUE)[35]	TTM PUE	1.14	1.12	1.12	1.12	1.12
Renewable energy						
Total cumulative renewable energy contracts	MW	215	263	634	1,147	2,121
% of total electricity obtained from renewable sources[36]	%	-	34	35	37	44

Environmental data

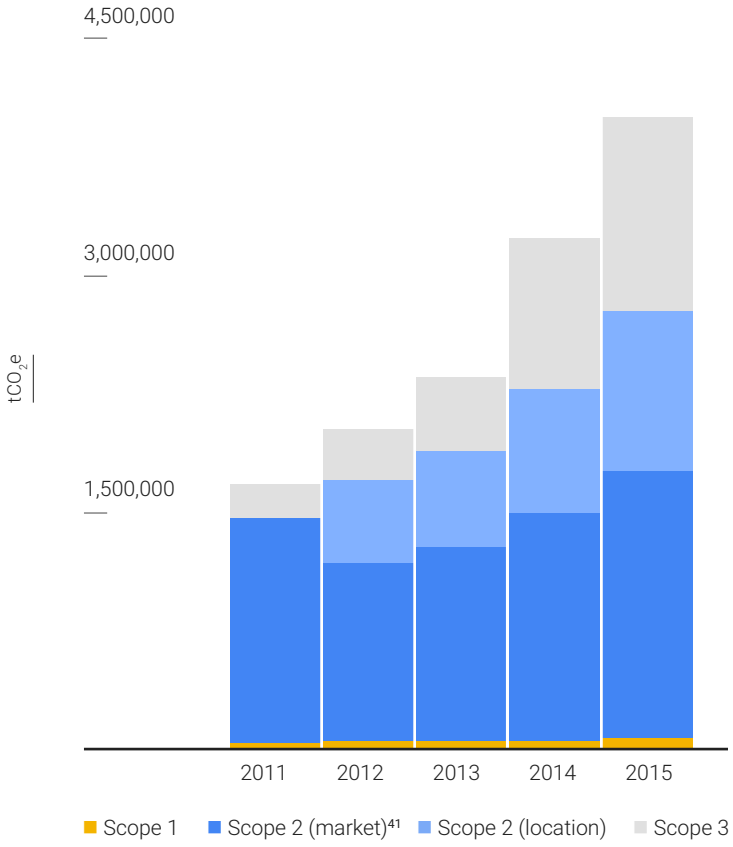
KEY PERFORMANCE INDICATOR	UNIT	FISCAL YEAR[37] 2011	2012	2013	2014	2015
Waste generation						
Total waste generated annually	Metric tonnes	-	-	-	-	50,050
Waste diversion						
Annual landfill diversion rate[38] for data centers	%	-	-	-	-	84
Annual landfill diversion rate for offices	%	-	-	-	-	78
Annual food waste prevented in cafés	Metric tonnes	-	-	-	-	200
Sustainable workplaces						
Offices						
Cumulative LEED-certified office space	Square meters	62,852	156,894	313,209	462,395	711,626
Platinum	%	17	19	23	26	31
Gold	%	69	75	63	59	58
Commuting						
Cumulative electric vehicle (EV) charging ports installed at Google offices in the U.S.[39]	Ports	147	415	601	988	1,382
Estimated annual emissions avoided due to employee EV commuting in the U.S.	tCO_2e	41	148	483	929	1,489
Total annual employee shuttle commuting trips in the Bay Area	Total trips	1,500,000	2,000,000	2,500,000	3,000,000	3,500,000
Peak daily employee shuttle riders in the Bay Area	Unique riders	4,000	5,000	6,000	7,500	8,500
Annual emissions avoided due to employee shuttle trips in the Bay Area	tCO_2e	4,527	7,858	10,065	18,856	28,901
Equity investments in renewable energy projects[40]						
Cumulative commitments	GW	1.8	1.9	2.4	2.7	3.7

* Indicates verified data. Scope 1, 2, and part of Scope 3 emissions are externally verified. Our electricity use is verified as part of our Scope 2 verification.

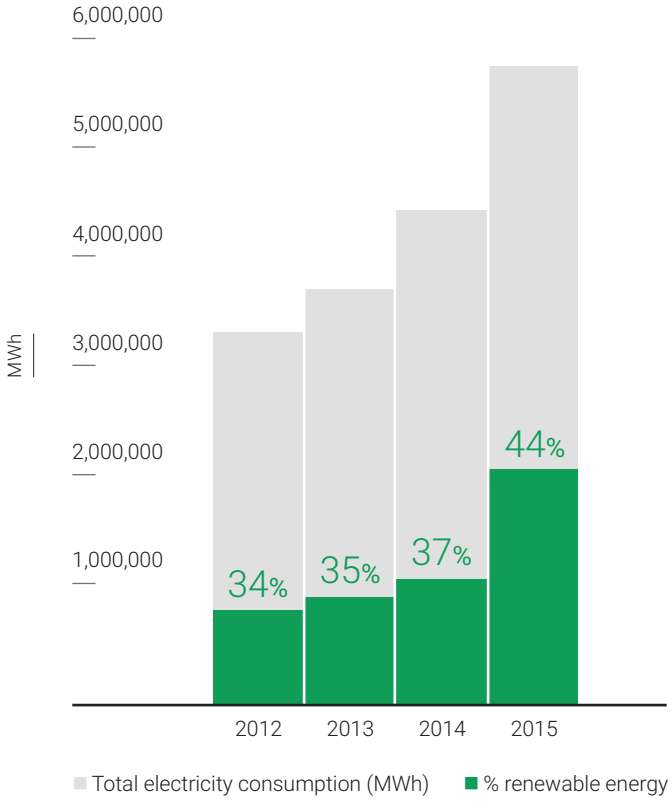
† Scope 1 emissions are direct emissions from sources we own or control, such as company vehicles or generators at Google's offices and data centers. Scope 2 emissions are indirect emissions from the production of electricity we purchase to run our operations. The location-based category reflects the 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.

Environmental data

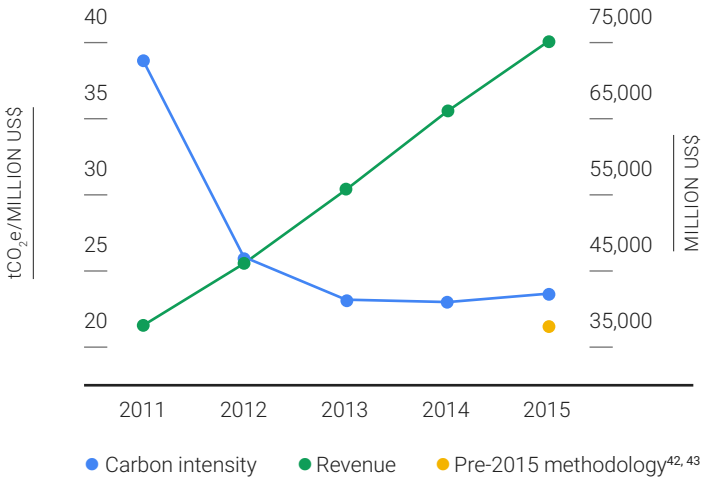
GREENHOUSE GAS EMISSIONS



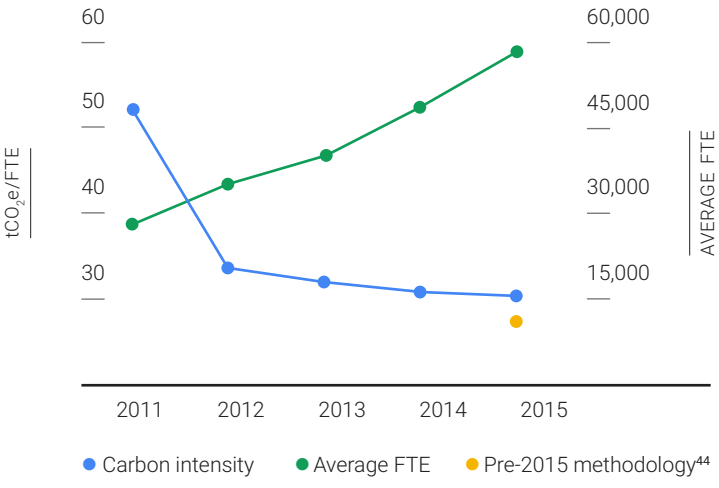
RENEWABLE ENERGY AS PERCENTAGE OF TOTAL ELECTRICITY USE



CARBON INTENSITY PER UNIT OF REVENUE

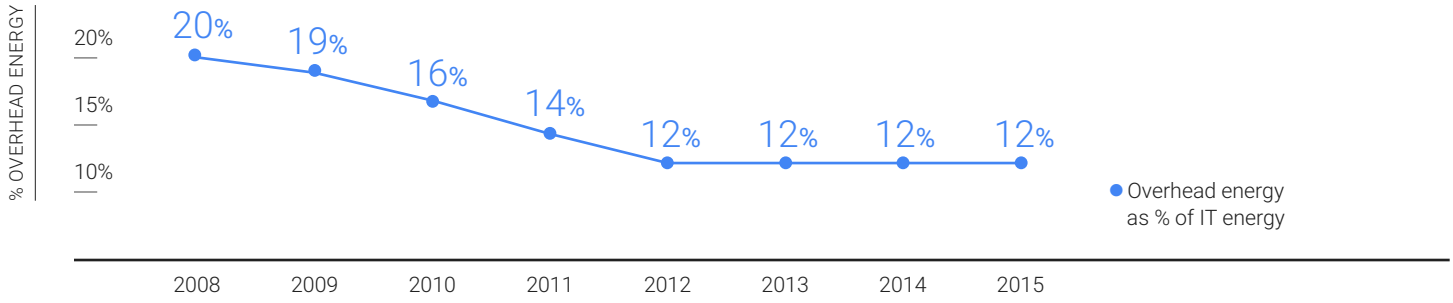


CARBON INTENSITY PER FULL-TIME EQUIVALENT EMPLOYEE (FTE)

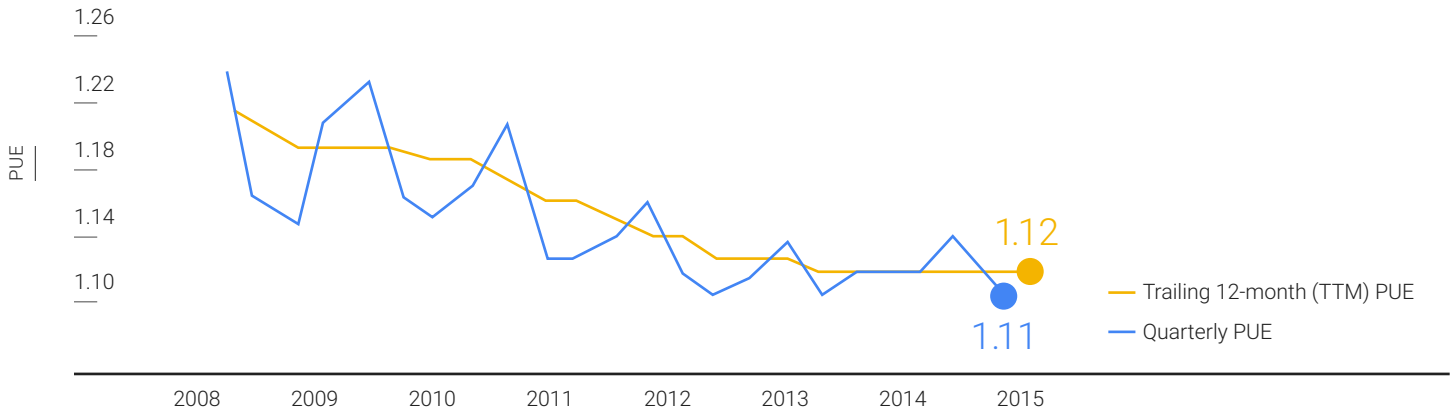


Environmental data

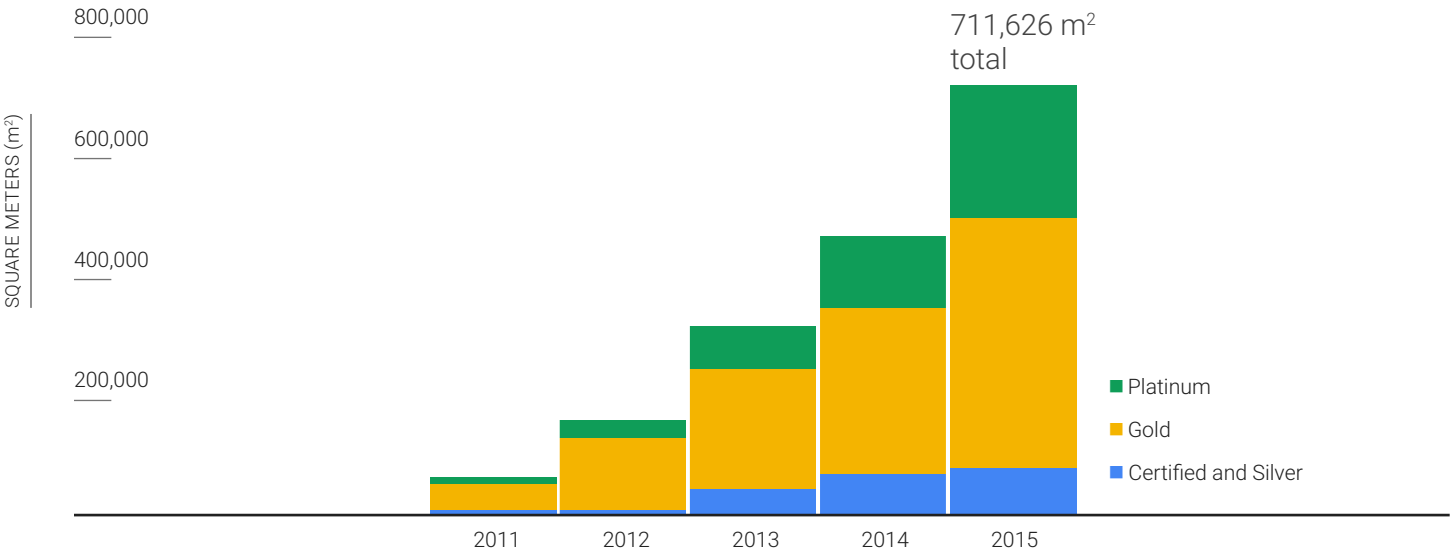
OVERHEAD ENERGY USE IN GOOGLE DATA CENTERS



AVERAGE POWER USAGE EFFECTIVENESS (PUE) FOR ALL DATA CENTERS



CUMULATIVE LEED-CERTIFIED OFFICE SPACE



Endnotes

OUR APPROACH

1. “A Virtuous Circle,” Mathy Stanislaus, Environmental Forum, September/October 2016.
2. "Earth Overshoot Day 2016," Global Footprint Network, retrieved November 2016, http://www.footprintnetwork.org/en/index.php/GFN/page/earth_overshoot_day/.
3. “United States Data Center Energy Usage Report,” U.S. Department of Energy, Lawrence Berkeley National Laboratory, 2016.
4. “The Energy Efficiency Potential of Cloud-Based Software: A U.S. Case Study,” Lawrence Berkeley National Laboratory, June 2013.
5. “International Decade for Action ‘Water for Life’ 2005–2015,” United Nations Department of Economic and Social Affairs, retrieved November 2016, http://www.un.org/waterforlifedecade/scarcity.shtml.

DESIGNING EFFICIENT DATA CENTERS

6. According to Google’s own analysis of our more efficient servers, power infrastructure, and cooling systems, compared with data center industry averages.
7. According to the Uptime Institute's “2014 Data Center Industry Survey,” the global average PUE of respondents' largest data centers was around 1.7.
8. "UL Zero Waste," UL, retrieved November 2016, http://industries.ul.com/environment/zero-waste.
9. Environmental Claim Validation Procedure (ECVP) for Zero Waste to Landfill, UL ECVP 2799.

ADVANCING RENEWABLE ENERGY

10. Bloomberg New Energy Finance database for wind and solar energy PPAs, as of November 2016.
11. “Renewable Energy and Jobs: Annual Review 2016,” International Renewable Energy Agency, 2016.
12. “Global Trends in Renewable Energy Investment 2016,” Bloomberg New Energy Finance, 2016.
13. “Lazard’s Levelized Cost of Energy Analysis—Version 9.0,” Lazard, November 2015.
14. “Medium-Term Renewable Energy Market Report 2016,” International Energy Agency, 2016.
15. “Renewable Energy Benefits: Measuring the Economics,” International Renewable Energy Agency, 2016.
16. 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.
17. “BRC Deal Tracker,” Business Renewables Center, 2016.
18. “Corporate Renewable Strategy Map,” Corporate Renewable Energy Buyers’ Principles, retrieved November 2016, http://buyersprinciples.org/corporate-re-strategy-map/.
19. See note 17 above.
20. See note 13 above.
21. See note 17 above.
22. “2013 Solar Annual and Q4 Funding and M&A Report,” Merck Capital Group, 2014.

CREATING SUSTAINABLE WORKPLACES

23. “Avian and Bat Monitoring Project, Vasco Winds LLC: Final Report, 2012–2015,” Ventus Environmental Solutions, prepared for NextEra Energy Resources, June 2016.
24. See note 5 above.

EMPOWERING USERS WITH TECHNOLOGY

25. See note 4 above.
26. Google emits about 8 grams of CO_2e 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.
27. “Google Apps: Energy Efficiency in the Cloud,” Google, 2012.
28. “Google’s Green Computing: Efficiency at Scale,” Google, 2011.
29. “Public Transportation’s Role in Responding to Climate Change,” Federal Transit Administration, U.S. Department of Transportation, January 2010.

Endnotes

APPENDIX

30. Alphabet's fiscal year runs from January 1 to December 31. Unless otherwise specified, reported data is global.
31. GHG emissions are calculated according to WRI's Greenhouse Gas Protocol. For more information on our methodology, see our CDP report.
32. 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 (in MWh) 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 claimed renewable energy attributes.
33. 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.
34. The primary reason for the 2015 increase in our carbon intensity per unit of revenue is the modification in our market-based Scope 2 accounting methodology as per WRI's new GHG Protocol Scope 2 Guidance. The new methodology requires the use of residual grid mixes, after accounting for all contractual instruments (such as PPAs). This change in methodology resulted in a slight increase in our 2015 market-based Scope 2 emissions, as compared with our 2014 market-based Scope 2 emissions (which we calculated using our own methodology). If we used the same market-based accounting methodology for our Scope 2 emissions in 2015 as in 2014, then this intensity figure would have decreased by 7% (21.3 tCO_2e/million US$) in 2015 as compared with 22.9 tCO_2e/million US$ in 2014).
35. 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 our website.
36. Percentage of renewable energy is calculated on a calendar-year basis, comparing the volume of renewable electricity (in MWh) purchased plus the residual renewable electricity in the grid with the total volume of electricity consumed by our operations.
37. See note 30 above.
38. Waste diverted to a more sustainable pathway than landfill or incineration without energy recovery.
39. 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.
40. In addition to our renewable energy contracts, Google also invests in renewable energy projects around the world that have an attractive financial return, which are not used to offset our carbon footprint.
41. See note 32 above.
42. See note 32 above.
43. See note 34 above.
44. See note 32 above.

Google

ON THE COVER:
El Romero solar farm in Chile (80 MW for Google)

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