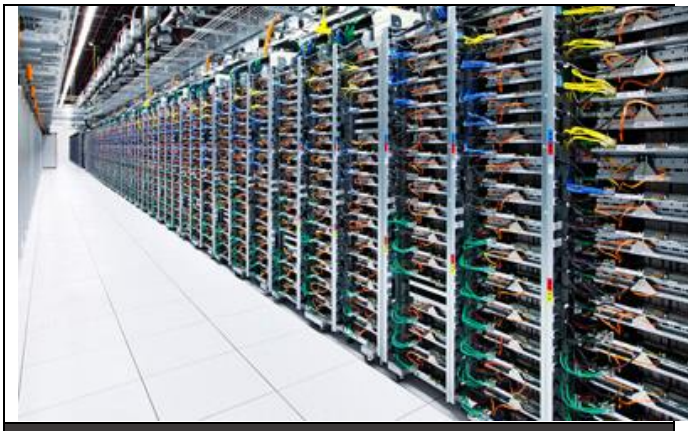
Global Energy Management System Implementation: Case Study

Global

Google

Capturing Energy Savings by Designing Efficient Data Centers



A row of server racks inside a Google data center

Business Case for Energy Management

Company profile: Google's 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 revenue primarily through online advertising. Google's core products—Search, Android, Maps, Chrome, YouTube, Google Play, and Gmail—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 including Google Pixel, Chromecast, and Google Home.

We're a wholly owned subsidiary of Alphabet, which also includes companies such as Access, Calico, CapitalG, GV, Nest, Verily, Waymo, and X. As of December 31, 2016, we had more than $90 billion in total revenues and 72,053 full-time employees. Our headquarters are in the United States and we own and operate 14 data centers (DCs) across four continents.

"Google has a long-standing commitment to the environment and energy efficiency. We used ISO 50001 as a framework to establish a more structured and formalized energy management system and achieve recognition for our efforts."

—Joe Kava, VP Google Data Centers

Case Study Snapshot	
Industry	Information Technology
Product/Service	Internet Software and Services
Location	Global
Energy Management System	ISO 50001
Energy Performance Improvement Period	2013 – 2016 (3 years)
Energy Performance Improvement (%) over improvement period	24% decrease in carbon intensity (tCO2e/million US$)
Total energy cost savings over improvement period	>US$1 billion to date (not just over 3 yrs)
Cost to implement EnMS	<USD$250,000
Payback period (years) on EnMS implementation	<1 year
Total Energy Savings over improvement period	-
Total CO_2-e emission reduction over improvement period	3.8 million tCO2e

Drivers: Google's 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 ever 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.

After all, the cheapest energy and water are what we don't use in the first place, and waste streams can offer 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.

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

Energy and greenhouse gas (GHG) management approach: Google's energy consumption is our biggest impact on the environment, and we've focused on tackling it through a threefold carbon neutrality strategy. First, we pursue aggressive energy efficiency initiatives. Second, we purchase significant amounts of renewable energy. Third, we buy carbon offsets for any remaining GHG emissions we haven't yet eliminated.

When we committed to carbon neutrality in 2007, we saw carbon offsets as an interim solution. As we continue to improve our energy efficiency and reach our target of operating with 100% renewable electricity, our need for carbon offsets will decrease. When we do purchase carbon offsets, we follow stringent principles.

Google has been carbon neutral for a decade now, and in that time, we've partnered with more than 40 carbon offset projects to offset more than 16 million tCO2e.

Google is the world's largest corporate purchaser of renewable energy. We've signed 20 agreements to purchase a total of 2.6 gigawatts (GW) of renewable energy that is new to the grid—generating emissions savings that are equivalent to taking more than 1.2 million cars off the road.

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

Business Benefits Achieved

2016 was a year of big milestones. We celebrated 10 years of carbon neutrality and announced that we would purchase enough renewable energy in 2017 to match 100 percent of our global consumption for operations.

DC energy management: Google's DCs are the heart of our company, powering products like Search, Gmail, and YouTube for billions of people around the world, 24/7. We own and operate 14 DCs on four continents and continue to add new sites to better serve our customers. Each DC 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 worked to make Google DCs some of the most efficient in the world, improving their environmental performance even as demand for our products has dramatically risen. We've done this by designing, building, and operating each one to maximize efficient use of energy, water, and materials.

To reduce energy use, we strive to build the world's most energy-efficient computing network by squeezing more out of every watt of power we consume. First, we outfit each DC with high-performance servers that we've custom designed to use as little energy as possible and keep them busy, so we can do more with less energy. 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. Finally, we apply machine learning to drive energy efficiency even further.

Our efforts have paid off: Google DCs use 50% less energy than typical DCs use. Compared with five years ago, we now deliver more than 3.5 times as much computing power with the same amount of electrical power. That means that even though we're sending more e-mails, watching more YouTube videos and saving more digital photos, we're using the same amount of energy.

Carbon neutrality: Google became carbon neutral in 2007, and since then, our carbon footprint has grown more slowly than our business—proof, 10 years later, that economic growth can be decoupled from environmental impact and resource use.

EnMS Development and Implementation

In 2013, Google became the first company in North America—and the only major internet company—to achieve a multi-site ISO 50001 certified energy management system (EnMS). At the end of 2016, our ISO 50001 certification covered 12 of our 14 Google-owned and -operated DCs globally, which together represented more than 98% of our IT energy use in 2016. It includes our global corporate headquarters as well as seven sites in the U.S., three in Europe, and two in Asia. In 2017, our two newest DCs (in Chile and the Netherlands) were audited and found to conform to Google's EnMS and the requirements of ISO 50001, so they will be added to our certificate in 2018.

Organizational: When the ISO 50001 standard came out, we saw the framework as an opportunity to establish a more structured and formalized EnMS and gain third-party recognition for our existing energy efficiency efforts. We established our EnMS at a corporate level and included in its scope our Google-owned and -operated DC sites, once they meet certain operational criteria, as they represent the vast majority of our energy consumption.

ISO 50001 is built around a "Plan-Do-Check-Act" concept. This concept ensures we have a strong energy policy, implement processes that strengthen our EnMS, build a sound auditing program that verifies our EnMS is effective, continually monitor, assess, and respond to our energy efficiency results, while always working on ways to make things even better.

"Based on the requirements in the standard, Google developed an EnMS that makes sense for our energy culture. This means continuously challenging energy performance goals, improving upon our energy-efficient data center designs and establishing progressive monitoring systems, to name a few."

—Joe Kava, VP Data Centers

It took us less than a year to establish our EnMS. When developing our EnMS, we took a lean approach to documentation. We built a streamlined system that consolidated ISO 50001 requirements into only five management system procedures, reducing the amount of time our employees need to spend on paperwork so they can spend more time researching and implementing energy efficiency initiatives.

We also streamlined our internal auditing. Because so much of our energy program is managed at our corporate headquarters, we created a targeted internal auditing program for our DCs. It limits the number of on-site audits conducted each year by utilizing a self-audit questionnaire at some selected sites. The audit topics are also focused to include only those relevant to data center activities.

Our VP of DC Operations is defined as 'Top Management' and has overall responsibility for ensuring that our EnMS is effective and continually improved. He's also responsible for appointing a Management Representative and an Energy Team. The Energy Team ensures that the key characteristics of DC operations that determine energy performance are monitored, measured, analyzed, and reported to Top Management at least annually. This team consists of key executives involved in DC operations in each of our regions. We also have an EnMS lead, who has primary responsibility for daily management of our EnMS program.

Energy review and planning: As part of our energy planning, we perform an annual review of all activities within the defined scope of the EnMS that can affect energy performance. We analyze our energy use and consumption by collecting utility-provided and Google-metered energy data and looking for patterns and deviations. We identify our significant energy uses (SEUs) and record and prioritize opportunities for improving energy performance. We also interview key staff across the company to identify opportunities to improve our EnMS.

Google uses the DC industry standard measurement, power usage effectiveness (PUE), as one measure of energy efficiency. PUE is the ratio of total facility energy to IT energy at a DC. 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 of the energy is used for computing. PUE data is available to DC staff in real time. Any abnormal deviations detected are investigated and appropriate remediation is taken if needed.

Our facility-wide energy performance indicator (EnPI) is PUE. We establish an initial PUE energy baseline using information from the energy review and changes in PUE continue to be measured against this established baseline. Our primary target is to maintain or improve quarterly PUE at each Google DC, year over year. Other opportunities for improving energy performance are also identified, prioritized, and evaluated, and associated action plans are developed.

Cost-benefit analysis: To set up our EnMS and obtain initial certification took about 500-750 work hours combined for personnel at our corporate headquarters. The key tasks led at the corporate level were creating the EnMS documentation, establishing and implementing an EnMS training and awareness plan, and preparing for and participating in internal and external audits. In addition, each certified DC required 2-30 work hours combined for onsite personnel to set up the EnMS locally and prepare for internal and external audits. We used an external consultant to help develop our system and conduct the internal audits, and used third-party auditors to conduct certification audits. All of our metering and monitoring systems were already in place and no additional software was needed.

To date, Google has saved more than US$1 billion through our energy-efficiency initiatives. Given our longstanding leadership in energy efficiency and GHG management, it's difficult to separate energy and GHG savings that resulted specifically from our ISO 50001 program or only during the 3 year performance period for this case study.

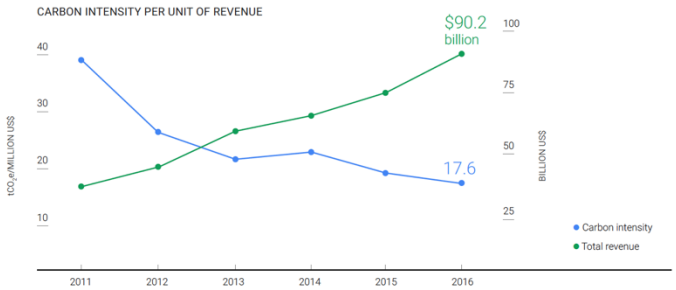
Our combined GHG savings over the 3 years since implementing our ISO 50001 program (2013-2016) were 3.8 million tCO2e. We can make a rough estimate of the potential financial value of these savings by applying an average price of carbon, using a public figure of e.g. $14/metric ton (price of carbon/metric ton at AB32 Auction in May 2014). If such a carbon price were established through future regulation, our GHG savings would equate to US$53 million.

Given the low cost of implementing our EnMS program and the large savings generated, under either scenario our payback period was far less than a year.

Approach used to determine whether energy performance improved: We assess quarterly PUE at each facility by comparing it to the PUE at that facility during the same quarter of the previous year, as PUE varies greatly by season.

In 2016, the average annual PUE for our global fleet of DCs was 1.12, compared with the industry average of 1.7—meaning that Google DCs use nearly six times less overhead energy for every unit of IT equipment energy. Our fleet-wide PUE has stayed constant at 1.12 for the past five years. This is an achievement given the significant expansion of our DC fleet, as when new facilities are brought online, it takes a while before they operate at optimal performance. Additionally, we're continually upgrading our DCs and as PUE is negatively impacted when retrofits are in progress, this makes our stable PUE even more impressive.

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. In 2016, our gross GHG emissions were 2.9 million metric tons of carbon dioxide equivalent (tCO2e), but because of our renewable energy and carbon offset programs, our net operational carbon emissions were zero.



Over the past five years, our carbon intensity per revenue and our carbon intensity per full-time equivalent employee both decreased by 55%, and our carbon intensity for electricity used at our DCs dropped by 59%. This means we're delivering our products and services with decreased carbon impacts, even before using carbon offsets to reach neutrality. Since implementing our ISO 50001 program in 2013, our carbon intensity metrics decreased by 24%, 27%, and 30%, respectively.

Approach used to validate results: We can only improve upon what we measure, so we regularly calculate comprehensive efficiency performance data for each facility. In fact, we were the first DC operator to disclose detailed energy efficiency data for all of our DCs in 2008, and we've continued to publish this every quarter since then. All of our DC PUE performance data is published on our website Efficiency: How we do it.

We began calculating our annual carbon footprint in 2006. Every year since 2009, we've publicly reported the results to CDP, a global organization that asks companies to disclose information on their GHG emission performance and management. For the past three years (2015-2017), we earned a spot on CDP's A List, which recognizes top reporting companies.

We conduct annual EnMS certification audits at our corporate headquarters as well as at a certain number of DCs, and conduct on-site internal audits at a sample of sites annually. We also conduct regular legal compliance audits at all our sites. Our EnMS certification audits have never identified any non-conformances, demonstrating that our program is comprehensive and effective.

Steps taken to maintain operational control and sustain energy performance improvement: The DC Energy Team and Facility Managers have identified and planned operations and maintenance (O&M) activities that are related to SEUs and opportunities for energy performance improvement. Various software tools are used to schedule and track preventive maintenance activities, as well as record compliance and conformance audit results and track the associated corrective and preventive actions. Other tools are used to track and monitor non-scheduled opportunities for energy performance improvement.

Development and use of professional expertise, training, and communications: To ensure workers are competent based on appropriate education, training, skills, and/or experience, we've identified qualifications for workers including those that control the SEUs and support the EnMS. As part of these qualifications, training has been identified in part based on the person's ability to affect energy use. Relevant staff develop and/or provide in-house training or approve outside training to meet these needs.

The EnMS Management Representative or delegate ensures workers are aware of the importance of conforming with the DC Energy Policy, procedures, and EnMS requirements, including their role, responsibilities, and impact with respect to energy use. The DC Energy Team or delegate communicates internally the importance of the EnMS and overall energy performance.

Google has a strong global culture of energy stewardship. All of our employees are encouraged to bring forward ideas for energy-efficiency and we have several mechanisms and channels for them to do so. Our DC employees actively initiate many ideas, all of which are evaluated for potential implementation. Energy management best practices and lessons learned are also shared across sites.

Tools & resources: In our ongoing pursuit of extreme efficiency, we recently hit upon a new tool to drive our energy use to unprecedented lows: machine learning. In a dynamic environment like a DC, it can be difficult for a human to see how all of the variables – IT load, outside air temperature, etc. – interact with each other. To address this, several years ago we began applying machine learning to optimize our DC operations. We partnered with our artificial intelligence company, DeepMind, to analyze the large amounts of data we gather in the course of our daily operations and build models to recognize patterns and "learn" from them, which enabled us to predict – and improve – DC performance. To learn more, see Machine learning finds new ways for our data centers to save energy.

Lessons Learned

Over time we've learned and innovated across energy-efficiency initiatives, renewable energy, and carbon offsets in ways we couldn't have imagined a decade ago. By sharing our best practices and supporting research and collaboration, we hope to help other companies realize their own savings and promote ever-greater DC sustainability worldwide.

We share best practices and lessons learned on Google's environment website, data centers website, in our Environmental Report, and via case studies and white papers. In 2009, we hosted our first data center efficiency summit, and we're a founding member of the Green Grid and part of the Open Compute Project.

Keys to Success

Enabling others to reduce energy use with the cloud: We believe that Google's scale, resources, and technological expertise can help the world meet its energy and resource needs in a way that drives innovation and growth while reducing GHG emissions. For example, Google Cloud Platform and G Suite applications like Gmail, Docs, and Drive are enabling millions of businesses to switch from locally hosted solutions to Google Cloud's highly efficient, renewable energy–based computing infrastructure. This infrastructure is so efficient that providing an active user one month of Google services creates about the same amount of GHG emissions as driving a car one mile. Businesses that switch to cloud-based products like G Suite have reported reductions in IT energy use and carbon emissions up to 85%, and 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.

As we continue our quest for energy efficiency, ISO 50001 is one of the many tools we use. We are participating on ISO 50001's technical committee, to ensure the standard continues to be a valuable tool for Google and others.