Efficiency

When you use Google products, the servers in our data centers do the work for you — around the clock and around the world. Our servers support many products at a time. That's “the cloud.” By keeping our servers busy, we can do more with less — more searches, more Gmail, and more YouTube videos with fewer servers and less energy. We’ve worked hard to minimize the environmental impact of these services so that when you use our products, you’re also being good to the environment.

Helping businesses save energy in the cloud

The cloud supports many products at a time, so it can more efficiently distribute resources among many users. That means we can do more with less energy — and businesses can too. In 2013, Lawrence Berkeley National Laboratory published research indicating that moving all office workers in the United States to the cloud could reduce the energy used by information technology by up to 87%.

Related specifically to Google products, a case study of the U.S. General Services

Administration (GSA) showed that by switching to Google Apps, they were able to reduce office computing costs, energy use, and carbon emissions by 65-90%. Additionally, our study has shown that businesses that use Gmail have decreased the environmental impact of their email service by up to 98% compared to those that run email on local servers.
Because of our energy efficiency efforts, our cloud is better for the environment. This means businesses that use our cloud-based products are greener too.

How we do it

Our data centers use much less energy than the typical data center. We raise the temperature to 80°F, use outside air for cooling, and build custom servers. We also share detailed performance data to help move the entire industry forward.

Measuring and improving our energy use

We're focused on reducing our energy use while serving the explosive growth of the internet. Most data centers use almost as much non-computing or "overhead" energy (like cooling and power conversion) as they do to power their servers. At Google we've reduced this overhead to only 11%. That way, most of the energy we use powers the machines directly serving Google searches and products. We take detailed measurements to continually push toward doing more with less — serving more users while wasting less energy.

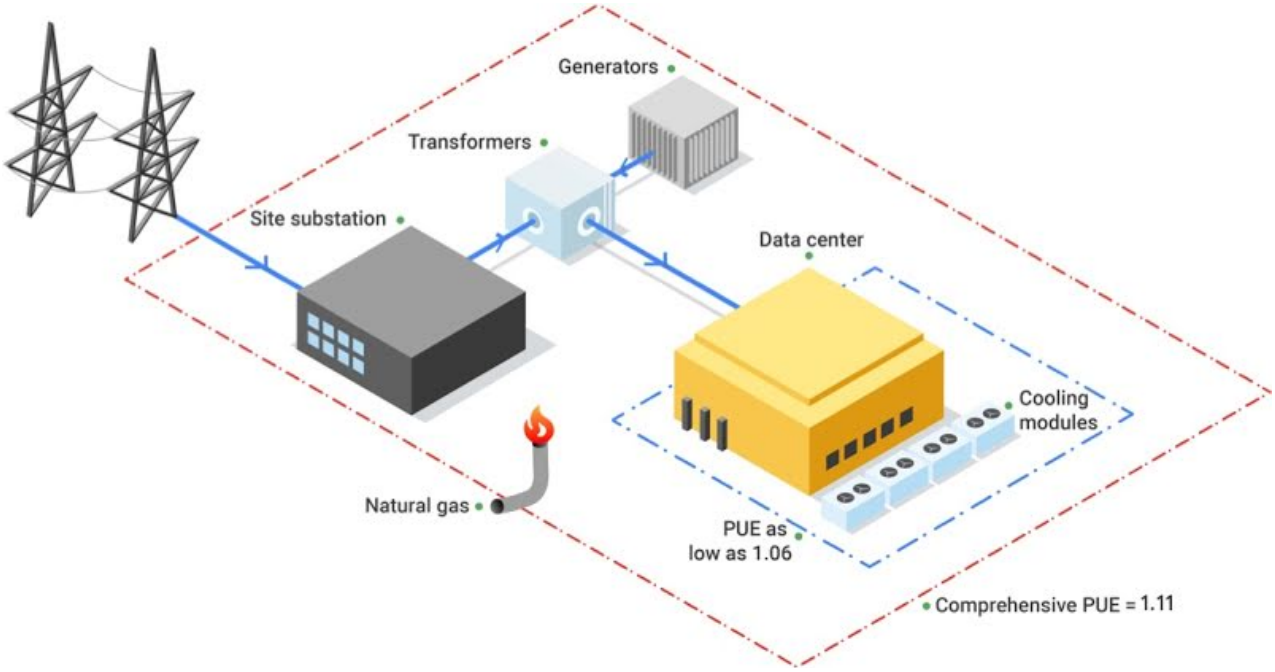


Figure 1: Google Data Center PUE measurement boundaries. The average PUE for all Google Data Centers is 1.11, although we could boast a PUE as low as 1.06 when using narrower boundaries.

We take the most comprehensive approach to measuring Power Usage Effectiveness (PUE)

Our calculations include the performance of our entire fleet of data centers around the world — not just our newest and best facilities. We also continuously measure throughout the year — not just during cooler seasons.

Additionally, we include all sources of overhead in our efficiency metric. We could report much

lower numbers if we took the loosest interpretation of the Green Grid's PUE measurement standards. In fact, our best site could boast a PUE of less than 1.06 if we used an interpretation commonly used in the industry. However, we're sticking to a higher standard because we believe it's better to measure and optimize everything on our site, not just part of it. Therefore, we report a comprehensive trailing twelve-month (TTM) PUE of 1.11 across all our large-scale data centers (once they reach stable operations), in all seasons, including all sources of overhead.

Google Data Center PUE performance

Our fleet-wide PUE has dropped significantly since we first started reporting our numbers in 2008. The TTM energy-weighted average PUE for all Google data centers is 1.11, making our data centers among the most efficient in the world.

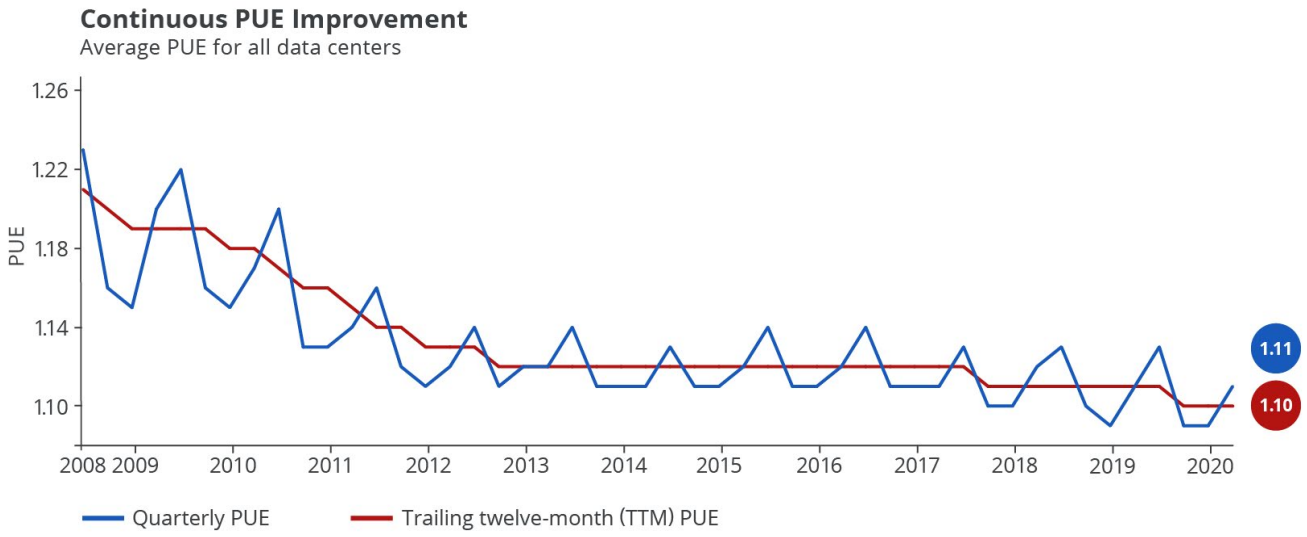


Figure 2: PUE data for all large-scale Google Data Centers

Yearly performance report

2020 2019 2018 2017 2016 2015 2014 2013

2012 2011 2010 2009 2008

QTR 01 QTR 02

Fleet wide PUE	**Quarterly PUE**	**Trailing twelve-month (TTM) PUE**
Fleet	1.09	1.10

Campuses	**Quarterly PUE**	**Trailing twelve-month (TTM) PUE**
Douglas County, Georgia	1.09	1.11
Lenoir, North Carolina	1.08	1.10
Berkeley County, South Carolina	1.09	1.11
Council Bluffs, Iowa	1.10	1.11
Council Bluffs, Iowa (2nd facility)	1.08	1.09
Mayes County, Oklahoma	1.10	1.11
The Dalles, Oregon	1.11	1.11
The Dalles, Oregon (2nd facility)	1.08	1.07
Dublin, Ireland	1.09	1.11

Campuses	Quarterly PUE	Trailing twelve-month (TTM) PUE
St. Ghislain, Belgium	1.08	1.08
Eemshaven, Netherlands	1.09	1.09
Hamina, Finland	1.09	1.09
Changua County, Taiwan	1.11	1.13
Singapore	1.14	1.15
Quilicura, Chile	1.09	1.09

For Q1 2020, TTM PUE was 1.10, and quarterly PUE was 1.09.

For individual campuses, our lowest TTM PUE was 1.07 in Oregon. Our lowest quarterly PUE was 1.08 in North Carolina, Iowa, Oregon, and Belgium.

Our highest TTM PUE was 1.15 in Singapore. Our highest quarterly PUE was 1.14 in Singapore.

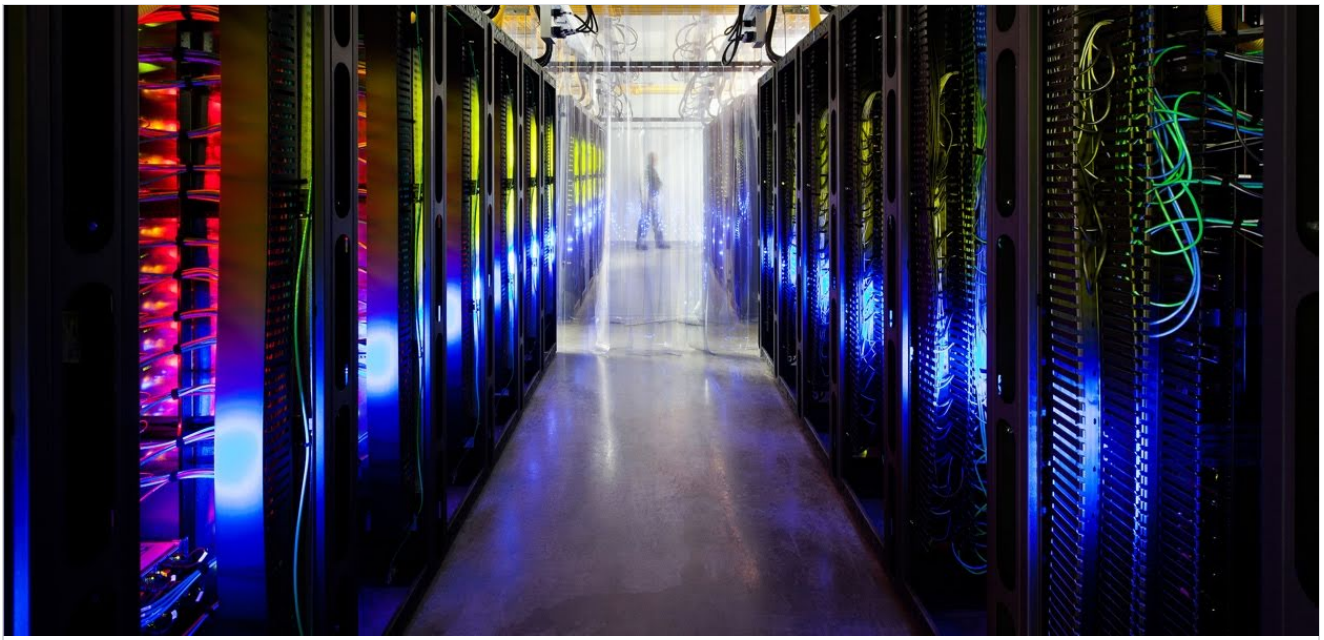
Measurement FAQ

What's the average PUE of other data centers?

Why does our data vary?

How do we get our PUE data?

What do we include in our calculations?



Power Usage Effectiveness (PUE)

The data center industry uses the measurement PUE, or power usage effectiveness, to measure efficiency. 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.

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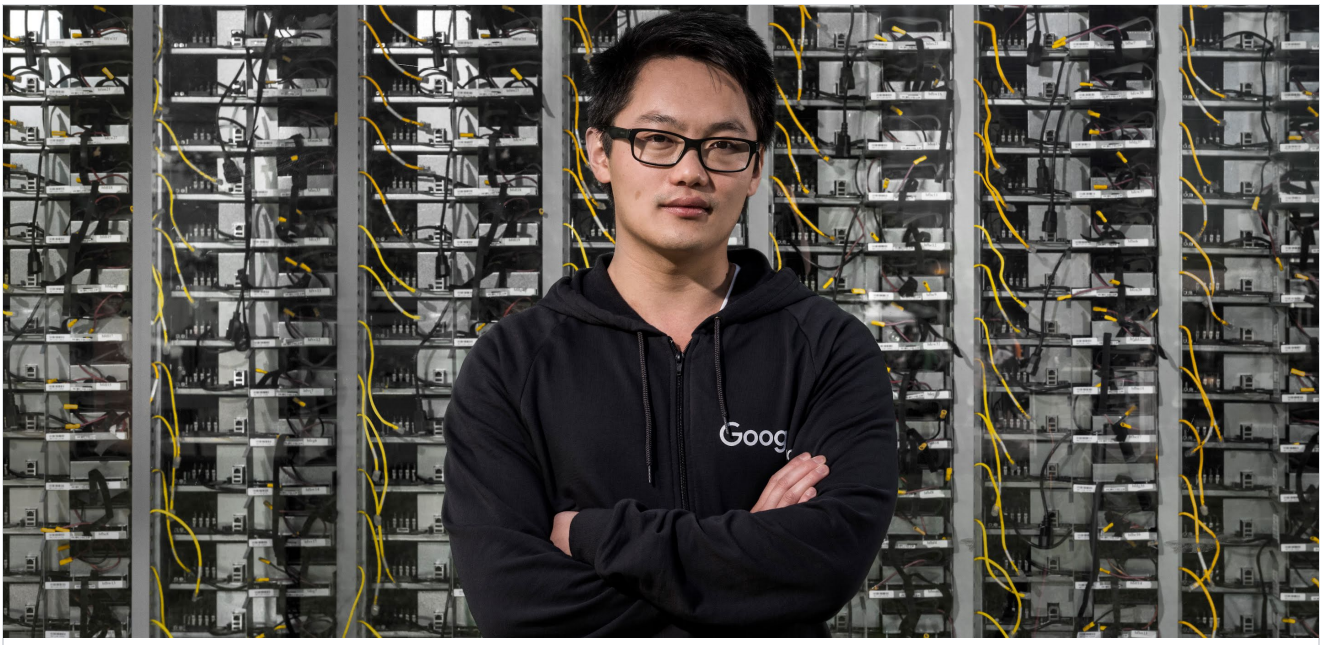

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Data centers and machine learning

The virtual world is built on physical infrastructure, and all those racks of humming servers use vast amounts of energy. Together, all existing data centers use roughly 2% of the world's electricity; if left unchecked, this energy demand could grow as rapidly as internet use. So making data centers run as efficiently as possible is a very big deal — and that's what we set out to do.

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