

## **Stanford expert says Internet's backbone can readily be made more sustainable**

EurekaAlert!

Most big data centers, the global backbone of the Internet, could slash their greenhouse gas emissions by 88 percent by switching to efficient, off-the-shelf equipment and improving energy management, according to new research.

The carbon emissions generated by a search on Google or a post on Facebook are related mostly to three things: the computing efficiency of IT (information technology) data center equipment, like servers, storage and network switches; the amount of electricity a data center's building uses for things other than computing, primarily cooling; and how much of the center's electricity comes from renewable or low-carbon sources.

Adding renewable power to the mix can help reduce a data center's overall emissions by 98 percent when combined with other strategies, but renewables are not the first choice for reducing emissions, the analysis shows.

"Of these three, improving the efficiency of the IT devices is overwhelmingly the most important," said Jonathan Koomey, a co-author of the study, "Characteristics of Low-Carbon Data Centers," published online June 25 in Nature Climate Change.

It's about the processors

The processors in most server farms perform computations at just 3 percent to 5 percent of their maximum capacity. Server virtualization, consolidation and better software can increase utilization to greater than 30 percent, and in some cases to be as high as 80 percent, said Koomey, a research fellow at Stanford University's Steyer-Taylor Center for Energy Policy and Finance, citing a recent account by Google.

Big, outward-facing companies whose business primarily is cloud computing have solved the sustainability problem for data centers. In addition to Google and Facebook, companies like Amazon, eBay and Expedia have instituted most or all of the changes, motivated by cost, publicity and pressure from environmental organizations. eBay even discloses its data center efficiency publicly at [dse.ebay.com](http://dse.ebay.com).

"These companies were hearing a lot of noise from Greenpeace and others. Apple went 100 percent renewable so they didn't have to hear about it, and with their high margins, they could afford to do that," said Koomey. "Electricity is a major cost for these companies, and in many of the countries where they operate, carbon emissions have a cost, or soon will."

Other ways to avoid wasting electricity include faster computers that pay for themselves fairly quickly and using flash memory on the motherboard instead of hard disks.

Not following best practices are innumerable companies and institutions that are not primarily cloud-computing entities and are more inward-facing. Examples include the major media companies, airlines, government, universities and others supplying the vast data that feed the Googles and Expedias of the world.

Nowhere near what's possible

"Pretty much every organization whose main job is not computing has done a poor job of improving efficiency," said Eric Masanet of Northwestern University's McCormick School of Engineering and a co-author of the paper. "Some have made progress, but nowhere near what's possible. Most can't even tell you how many servers they have, let alone the servers' utilization."

Department heads at such organizations typically want to keep control of their servers rather than centralize, which eliminates most potential optimization. And the managers who order and operate the equipment are often not accountable for energy costs or efficiency – a major institutional barrier to sustainable computing.

"The utilities and IT departments have separate budgets, and neither operates with the goal of saving the company money overall," said Koomey. "The IT people don't care about putting in an efficient server, because they don't pay the electric bill. Once you fix the institutional problems, then the company can move quickly, because the needed equipment is off-the-shelf and the energy management practices are well understood."

This principal-agent problem applies elsewhere in energy, too. "Who designs and builds your cable box? The cable company. Who pays the electric bill? You do," said Koomey. "So, you end up with a cat warmer on your shelf."

Koomey noted that the computing efficiency problem is sometimes exaggerated. Data centers consume about 1.5 percent of the world's electricity and are responsible for about 0.5 percent of carbon emissions. And the Internet overall is reducing greenhouse gas emissions because it distributes goods digitally that once were delivered physically, like books, music, publications and mail.

Easy reductions

Still, emissions and power use are growing and can be slashed pretty easily. After IT equipment, the second major way to reduce greenhouse gas emissions associated with data centers is to improve the efficiency of the buildings that support them. A key measurement of efficiency is the ratio of electricity used to perform computations to the amount of power consumed for secondary support, like cooling and monitoring systems. Typically that ratio is about 1 kilowatt-hour for computing to 0.8 kWh for the facility.

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"State-of-the-art data centers have reduced the ratio to about 1 to 0.1 kWh," said study co-author Arman Shehabi of Lawrence Berkeley National Laboratory's Environmental Energy Technologies Division. "They locate server farms in cool climates like the U.S. Northwest, Sweden and Iceland. They purchase processors that are less sensitive to heat. And they use efficient cooling equipment and air-flow management."

Of the potential 88 percent reduction in greenhouse gas emissions, though, IT device efficiency accounts for about 80 percent and facility energy management for only about 8 percent. Once those two areas are maximized, sourcing electricity from renewables like wind and solar power, plus green handling of retired equipment, can get a typical data center's emissions down 98 percent.

Policymakers and environmental organizations, however, tend to focus on the third option - renewable energy, which the study finds to be a misplaced priority.

"For data centers, as for all uses of energy, efficiency is always the first thing to do. It's cheapest and allows you to get more mileage out of your equipment," said Northwestern's Masanet.

"Most centers get their electricity from the local utility, rather than generate it themselves," he said. "So, high-energy data centers that pay their utilities a premium for renewable power unnecessarily tie up low-carbon electrons that might otherwise be used to reduce emissions from other customers."

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