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The World's Data Plan

As the world uses ever more data, it seems reasonable that this must require ever more energy. Not so, says a comprehensive new analysis.

Researchers have developed the most detailed model to date of global data center energy use. With this model, the team found that although demand for data has increased rapidly, massive efficiency gains by data centers have kept energy use roughly flat over the past decade. However, the researchers caution that the industry and government should not be lulled into complacency.

The research, which appears in the journal Science, was led by Eric Masanet, a faculty member in UC Santa Barbara's Bren School of Environmental Science & Management. Masanet, the holder of the Duncan and Suzanne Mellichamp Chair in Sustainability Science for Emerging Technologies, is formerly an associate professor at Northwestern University, where the work was conducted.

The comprehensive model provides a more nuanced view of data center energy use and its drivers, which will enable the researchers to make policy recommendations that can help society better manage this energy use in the future.

"While the historical efficiency progress made by data centers is remarkable, our findings do not mean that the IT industry and policymakers can rest on their laurels," said lead author Masanet. "We think there is enough remaining efficiency potential to last several more years. But ever-growing demand for data means that everyone — including policymakers, data center operators, equipment

manufacturers and data consumers — must intensify efforts to avoid a possible sharp rise in energy use later this decade.”

Filled with computing and networking equipment, data centers are central locations that collect, store and process data. As the world increasingly relies on data-intensive technologies, the energy use of data centers is a growing concern.

"Considering that data centers are energy-intensive enterprises in a rapidly evolving industry, we do need to analyze them rigorously,” said study coauthor Arman Shehabi, a research scientist at Lawrence Berkeley National Laboratory. “Less detailed analyses have predicted rapid growth in data center energy use, but without fully considering the historical efficiency progress made by the industry. When we include that missing piece, a different picture of our digital lifestyles emerges.”

To paint that more complete picture, the researchers integrated new data from numerous sources, including information on data center equipment stocks, efficiency trends and market structure. The resulting model enables a detailed analysis of the energy used by data center equipment (such as servers, storage devices and cooling systems), by type of data center (including cloud and hyperscale centers) and by world region.

The researchers concluded that recent efficiency gains made by data centers have likely been far greater than those observed in other major sectors of the global economy.

“Lack of data has hampered our understanding of global data center energy use trends for many years,” said coauthor Jonathan Koomey of Koomey Analytics. “Such knowledge gaps make business and policy planning incredibly difficult.”

Addressing these knowledge gaps was a major motivation for the research team’s work. “We wanted to give the data center industry, policymakers and the public a more accurate view of data center energy use,” said Masanet.

The researchers also translated their findings into three recommendations for policymakers that can help mitigate future growth in data center energy use:

1. Extend the life of current efficiency trends by strengthening IT energy standards such as ENERGY STAR, providing financial incentives, and

disseminating best energy efficiency practices;
2. Increase research and development investments in next generation computing, storage and heat removal technologies to mitigate future energy use, while incentivizing renewable energy procurement to mitigate carbon emissions in parallel;
3. Invest in data collection, modeling and monitoring activities to eliminate blind spots and enable more robust data center energy policy decisions.

“The reality is that more efforts are needed to better monitor energy use moving forward,” Masanet said, “which is why we’ve made our model and datasets publicly available.” By releasing the model, the team hopes to catalyze more research activity on this important topic.

The study, “Recalibrating global data center energy-use estimates,” was supported by the U.S. Department of Energy (award number DE-AC02-05CH11231) and by Leslie and Mac McQuown. The paper was a collaboration between researchers at Northwestern University, Lawrence Berkeley National Laboratory, Koomey Analytics, and UC Santa Barbara.

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