Big data centers, big problems:

The surging environmental and consumer costs of AI, crypto and big data

Environment America Research & Policy Center

U.S. PIRG Education Fund

Frontier Group

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Written by:

Quentin Good, Frontier Group
Johanna Neumann, Environment America Research & Policy Center
Abe Scarr, U.S. PIRG Education Fund
R.J. Cross, U.S. PIRG Education Fund

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Executive summary

Electricity demand in the U.S. is growing faster than at any point since the 1990s, breaking a decades-long trend of flat or falling growth rates, and analysts predict high electricity demand growth will continue through 2035. [1]

Energy use for computing — including highly energy-intensive computing activities such as artificial intelligence (AI) — is projected to be second only to electrification of vehicles as a source of increased electricity demand over the next 10 years.[2] Energy demand from the physical data centers where such computing takes place has caused some utilities to delay the retirement of fossil fuel power plants and led to proposals to resurrect some retired fossil fuel and nuclear power plants solely to serve data centers, slowing America's progress toward a clean energy system with less impact on the climate.

Is a dramatic surge in electricity demand and increased use of dirty and dangerous forms of energy inevitable? The answer is no.

Further delays in phasing out fossil fuel power plants due to increasing electricity demand from U.S. data centers can be prevented. Policymakers must take action to limit the unnecessary expansion of computing energy use, improve the efficiency of data centers, and accelerate the adoption of clean, renewable energy to meet increased demand.

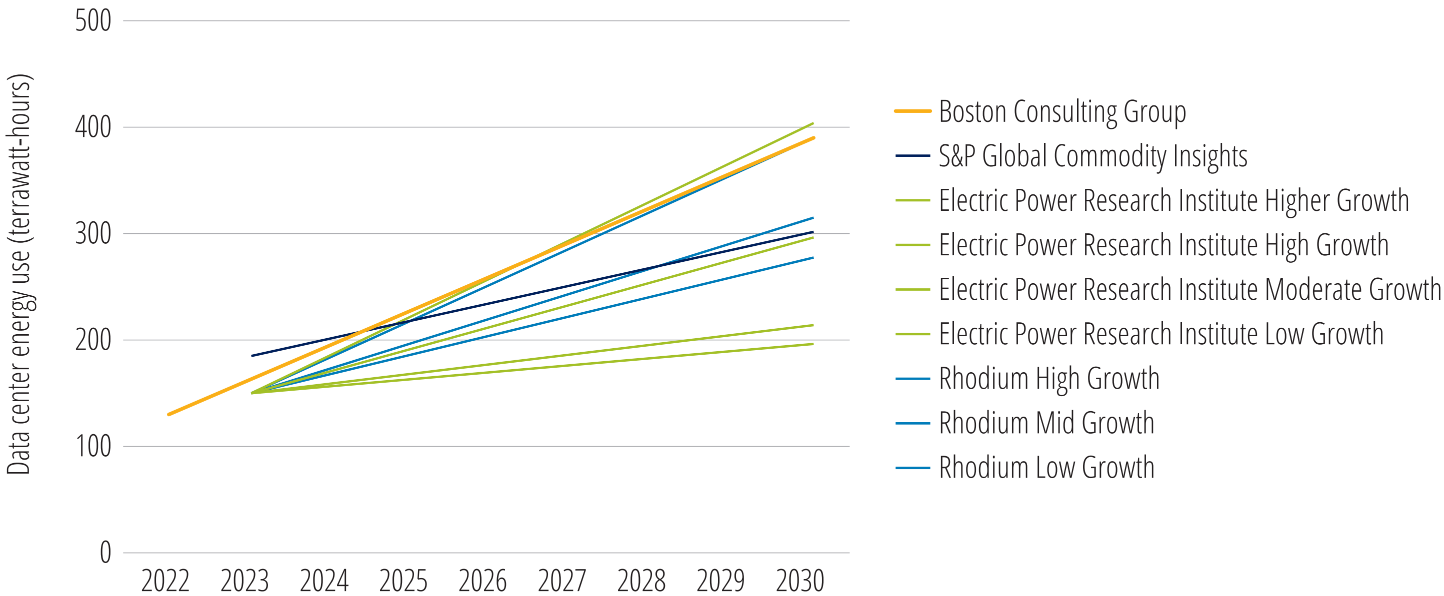
Energy use for computing is increasing dramatically, but projections of future demand are highly uncertain and depend on policy.

- **Forecasts of future electricity demand from data centers project significant growth through 2030 and beyond**, but vary widely and are highly uncertain, with many analysts considering a wide range of possible outcomes. One report by the Electric Power Research Institute (EPRI), for example, predicts data center electricity demand could grow by as little as 29% by 2030 from 2023 levels, or a potentially massive 166% increase.[3]

Rising computing demand is already delaying America's transition to clean energy.

- **Much of the increased demand for energy from data centers is attributable to new energy-intensive computing practices such as artificial intelligence (AI) and cryptocurrency mining.** Some of this demand is unnecessary. Bitcoin, one of the most popular cryptocurrencies, is mined by using computing power to solve cryptographic puzzles. Globally, Bitcoin consumed 121.13 Terawatt hours (TWh) of electricity in 2023, which is more than the entire state of Michigan produced that year.[5]
- **High demand for electricity from U.S. data centers has delayed the planned closures of fossil fuel power plants.** Frontier Group identified at least 17 fossil fuel generating units at seven power plants totaling 9,100 megawatts (MW) of capacity whose closures have been delayed or are at risk of being delayed, many of which can be linked to rising electricity demand from data centers.[6]
- **Utilities are also emphasizing concerns about computing energy demand to propose investments in new fossil fuel power plants** — plants that are not compatible with battling climate change. Frontier Group identified at least 10,808 MW of new fossil-fuel generation being planned to meet projected demand, including, in many cases, from data centers.[7]

Figure ES-1: Comparison of industry forecasts for data center electricity demand[4]



Data centers have other impacts on communities.

- **Data centers consume millions of gallons of water every day** both on-site for cooling and off-site for electricity generation. Just one data center can consume as much as 5 million gallons of water daily.[8]
- **Data centers are loud.** Residents living near cryptocurrency mines have reported noise as high as 91 decibels, which is nearly as loud as a chainsaw.[9] Exposure to noise can cause health problems. For example, ever since a loud cryptocurrency mine was built near residents in Granbury, Texas, citizens have reported a variety of ailments — from hearing loss and migraines to vertigo and nausea.[10]
- **The cost of investments in new generating capacity could be passed off to taxpayers and utility customers if demand for electricity is overestimated**. Concerns among regulators and utility customers are well-founded: Data centers have been cited as a root cause of an expected 20% increase in the price of electricity in 2025 in the Mid-Atlantic region.[11]

Rising electricity demand from computing is not inevitable. Common-sense limits on the most wasteful and unnecessary activities (such as some forms of cryptocurrency mining), requiring data centers to be more efficient and efforts to power data centers with renewable energy can reduce the impacts of energy use for computing.

Specifically:

- Policymakers should limit the unnecessary growth of data centers and other computing facilities. States should consider moratoria on particularly energy-intensive practices such as "proof of work" crypto mining. [12]
- Policymakers should eliminate subsidies that incentivize data center expansion. The public should not be called upon to pay for the expansion of facilities that impose environmental, quality of life and economic costs.
- Local and state governments should require data centers to report on energy and water use and

meet comprehensive energy efficiency standards. Additional transparency measures should also help communities understand when permits are applied for and approved, who is leasing the land and what their plans are.

- Public utility commissions should insist that utilities take steps to reduce the impacts of data center energy use such as implementing demand-response programs and directing utilities to avoid investments in new fossil fuel infrastructure to meet new demand.
- Governments should require data centers to power routine operations with virtually all renewable energy. Investments in new fossil fuel power plants may delay the transition to clean, renewable energy; nuclear power also poses unacceptable risks to the public and the environment.
- Public utility commissions should enact ratepayer protections such as requiring long-term service for large load customers, charging exit fees for reduced or terminated service and requiring data centers to pay for the full cost of service.
- Decision-makers should accelerate clean renewable energy production and reduce interconnection queues.

Introduction

In the early 1970s, electric utilities gazed into their forecasting crystal balls and saw a future of ever-increasing demand for power.

In 1974, the North American Electric Reliability Council (NERC), relying on projections and data from individual utilities, projected that U.S. electricity demand would increase by 7.5% annually through 1983.[13] By 1983, they believed, Americans would be consuming roughly twice as much power as they had a decade earlier.

That level of growth was not necessarily a crazy idea. Between 1951 and 1973, U.S. electricity demand rose by an average of 7.8% annually.[14]

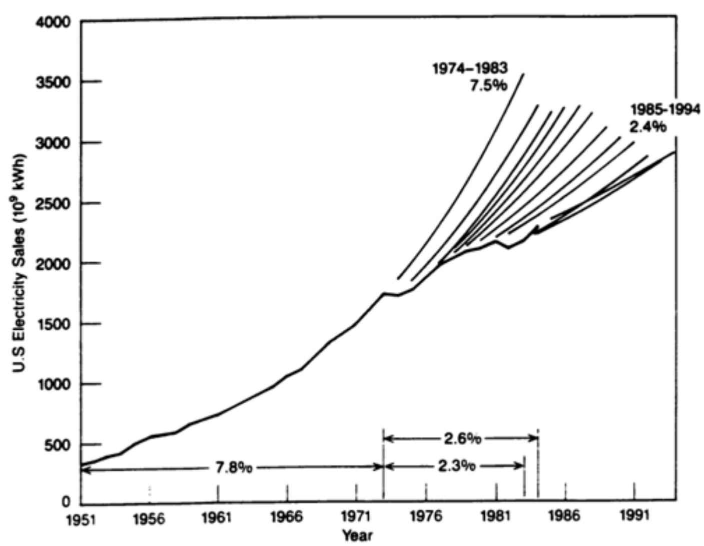
But in the 1970s and 1980s, forecasts of rapid electricity demand growth proved to be overly "rosy" and "optimistic."[15] When all was said and done, electricity demand increased by just 2.3% annually from 1974 to 1983.[16] The level of growth in demand in the postwar decades, it turned out, couldn't continue forever.

The fallout from these missed projections was severe. The anticipation of continued load growth at those levels led utilities to plan investments in new power plants they thought would be needed — many of them nuclear plants. As the costs of nuclear power rose and electricity demand failed to materialize, many of those projects were canceled. Any plant that wasn't canceled became a financial albatross around the neck of utilities. For example, Washington Public Power Supply (WPSS) earned the derisive moniker "Whoops" after it borrowed more than $8 billion to invest in five nuclear plants, but quickly abandoned the first two completed plants and defaulted on $2 billion in bonds.[18]

Today, America may be standing on the precipice of a new era of electricity demand growth. Much of that growth is expected to result from converting technology and systems that had previously been powered by fossil fuels, such as cars, home heating systems, and industrial facilities, to electricity — an important step in reducing America's impact on the global climate.

However, expectations of demand growth are increasingly coming from a new source: computers. Cloud data centers that Americans rely on in our

Figure 1: **The "NERC Fan"**



The infamous "NERC fan" shows annual projections for future electricity demand alongside actual electricity demand. The slope of each successive projection is less steeply curved than the previous projection.[17]

daily lives, along with energy-hungry new forms of computing like generative artificial intelligence (GenAI), cryptocurrency mining and big-data analytics, are consuming more energy than ever.

Utilities across the country are forecasting sudden and dramatic increases in electricity use from computing — forecasts that are being used to justify investments in infrastructure and fossil fuel-fired power plants that are the source of utility profits.

So, are we headed toward a future of rapid electricity demand growth like the 1950s and 1960s or a future of more modest growth with less strain on the grid and less impact on the climate? **The choice is up to us.**

Just as conservation and investments in energy efficiency helped limit the growth of electricity demand after the 1970s, strong energy efficiency standards, coupled with common-sense decision-making about which energy-intensive forms of computing generate societal benefits, can moderate growth of demand for electricity from computing. Fundamentally, America has the capacity to choose whether rapid growth of energy use for technologies such as GenAI and crypto mining are worth the pollution, disruption and costs they impose.

In this white paper, we review why computing energy use is an issue now, how demand is forecast to change in the years to come, and what tools are available to ensure that rising energy use for computing doesn't divert the nation from progress toward a future of clean, safe, renewable energy.

What are data centers?

A data center is like a warehouse, but instead of physical goods entering and leaving the building, it's data. Inside, the building is filled with stacks of servers. Data centers typically contain tens to hundreds of thousands of servers — computers with specialized processors for large-scale computing.[19] These servers process digital traffic, performing computing tasks as varied as retrieving data, streaming videos or writing AI poetry. The servers and the systems that keep them cool require resources including power and water.

In addition to the CPU (central processing unit), special processors called GPUs (graphics processing units) greatly accelerate advanced computing applications like machine learning, cryptocurrency mining, graphics processing and video rendering.[20] Google has developed another type of specialized processor called a TPU (tensor processing unit) to accelerate neural network machine learning and big data analytics.[21]

Data center servers and the processors they contain produce a lot of heat.[22] To ensure no lapses in the services they provide or the loss of valuable equipment, data centers deploy environmental controls and backup power systems, each of which also has impacts on energy use and emissions.[23]

Data centers are typically separated into three categories: enterprise data centers, cloud data centers, and managed data centers/co-location facilities.[24] One highly specialized type of computing facility, a cryptocurrency mine, is not always referred to as a data center. However, this paper includes discussions of cryptocurrency mines because the facilities contain similar IT infrastructure and are similarly resource intensive.

Enterprise (on-premises) data centers: Some companies choose to set up and independently operate data centers at their own facilities. This strategy provides more control over information security and simplifies compliance with data privacy regulations.[25] Until recently, this was the dominant model for data centers.

Public cloud data centers: Cloud computing companies including Amazon, Google and Meta build data centers to house resources that are shared by multiple customers. The largest of these data centers, known as "hyperscale" data centers, can house and process much more data than conventional data centers.

In addition to running the largest data centers, cloud providers also set up smaller edge data centers located close to customers to improve the overall performance of data-intensive tasks that require low latency — meaning the operation needs to happen quickly — including big data analytics, GenAI and streaming services.[26]

Managed data centers and colocation facilities: Like cloud data centers, managed data centers and colocation facilities serve multiple clients. At managed data centers, clients lease dedicated servers, storage and hardware, and the facility is monitored and managed for the client (to prevent overheating, outages, etc.).

Clients at colocation facilities own the IT infrastructure they use and lease the space to host it. Most colocation facilities offer management and monitoring services for clients, but some leave the responsibility to the clients leasing the space. Colocation facilities are well suited for data storage and disaster recovery technology for small and midsize businesses.[27]

Cryptocurrency mines: These data centers house IT infrastructure that is similar to the other types of data centers, but their function is unique. A cryptocurrency mine helps facilitate transactions of cryptocurrency by solving complex puzzles with computers: an energy-intensive process. Only the owners of the cryptocurrency mine use the facility.

U.S. data centers are expanding

The number of data centers in the U.S. is growing rapidly. EPRI estimates that the U.S. was home to nearly 2,700 data centers (excluding cryptocurrency mines) in January 2021. As of March 2024, just three years later, that number had roughly doubled.[28] Globally, hyperscaler capacity is expected to double in the next four years.[29]

Growth in the number of U.S. data centers has been mostly concentrated in a few regions, meaning the impacts on the grid have been highly localized. "Data Center Alley," a data center hub in Loudon County, Virginia, for example, has the highest concentration of data centers in the U.S., and is second globally only to the greater Beijing area, which it is expected to overtake in the next decade.[30]

Data center siting depends on multiple factors including the proximity of customers (for low latency functions) and the proximity of electricity generation (i.e., the ability to procure sufficient power). Tax breaks being offered by 22 states may also incentivize concentrated data center growth in particular states.[31]

Table 1: 2023 U.S. data center electricity consumption for 15 states[35]

State	2023 Load, MWh/y	% of Total State Electricity Consumed	% of National Data Center Load
Virginia	33,851,122	25.59%	22.25%
North Dakota	3,915,720	15.42%	2.57%
Nebraska	3,959,520	11.70%	2.60%
Iowa	6,193,320	11.43%	4.07%
Oregon	6,413,663	11.39%	4.22%
Wyoming	1,857,120	11.26%	1.22%
Nevada	3,416,707	8.69%	2.25%
Utah	2,562,037	7.68%	1.68%
Arizona	6,253,268	7.43%	4.11%
Washington	5,171,612	5.69%	3.40%
Illinois	7,450,176	5.48%	4.90%
New Jersey	4,038,360	5.42%	2.65%
Texas	21,813,159	4.59%	14.34%
Georgia	6,175,391	4.26%	4.06%
Montana	578,160	3.71%	0.38%

Data center demand growth is concentrated in specific areas of the country

While electricity demand for data centers has been growing nationally, aggregate national statistics conceal the uneven growth in energy use, with some regions experiencing dramatic increases in consumption and others little at all.

As noted earlier, data center development has thus far been concentrated in specific parts of the country. According to EPRI, "[f]ifteen states accounted for an estimated 80% of the national data center [electricity] load in 2023."[32] As a percentage of the state's total electricity consumption, Virginia (25.59%), North Dakota (15.42%), Nebraska (11.70%), Iowa (11.43%) and Oregon (11.39%) used the most electricity for data centers in 2023.[33]

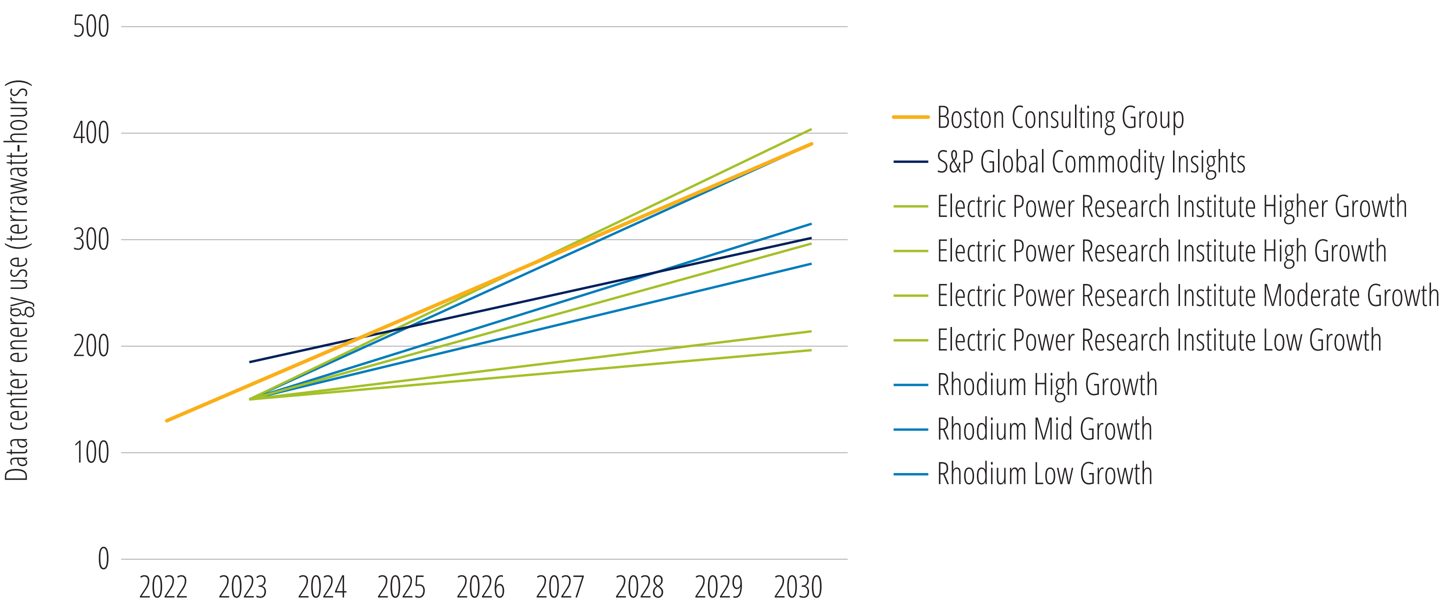
Nationwide, EPRI estimates data centers consumed almost 4% of electricity generation, but in Virginia, they estimate data centers gobbled up more than 25% of the state's electricity in 2023.[34] By contrast, in at least 14 states, data centers accounted for less than 1% of electricity demand.

Data centers are energy-intensive

Modern data centers require huge amounts of electricity, more than 1 gigawatt (GW) to power the largest hyperscaler projects.[36] The energy used by some data centers is comparable to powering 80,000 homes, about the number of houses in Montgomery, Alabama.[37] As data centers grow and multi-building campuses are built, electricity consumption can skyrocket. Reuters reported that, according to earnings calls in 2024, one new modern data center could require enough electricity to power 750,000 homes.[38]

Not all data centers are built alike, however. The electricity use from a data center is affected by many factors including its size, location, equipment, configuration and the types of computing it performs.[39] Three types of hardware account for most energy use at a typical data center: IT equipment (40% to 50%), cooling systems (30% to 40%) and auxiliary hardware (10% to 30%). The efficiency of these various systems also affects the overall efficiency of the data center.[40]

Figure 2: Comparison of industry forecasts for data center electricity demand[49]



Models for future U.S. data center electricity demand express a wide range of projections, reflecting high uncertainty industry-wide.

At the national level, estimates for how much power data centers have consumed historically, and projections of future use, vary widely. This is in part due to companies' unwillingness to share this information publicly. Most analyses depend on bottom-up approaches to estimate electricity use, meaning analysts calculate the electricity used by data centers using mathematical equations accounting for size, types of servers, etc. Setting aside high levels of uncertainty, the most conservative estimates still suggest that data centers use a significant and growing percentage of total U.S. electricity consumption.

Boston Consulting Group (BCG) estimates that U.S. data center electricity consumption in 2022 was about 130 terawatt-hours (TWh) (about 2.5% of total U.S. electricity consumption).[41] BCG projects that U.S. data center electricity consumption will triple from 2022 levels to about 390 TWh by 2030.[42]

S&P Global Commodity Insights (S&P) estimates the electricity demand from U.S. data centers was 185 TWh in 2023 (4.5% of the U.S. total) and will increase to 302 TWh by 2030 (and 385 TWh by 2035).[43]

The Electric Power Research Institute (EPRI) estimates that in 2023 electricity consumption from U.S. data centers was about 150 TWh (4% of total U.S. electricity consumption), which is the average annual consumption of 14 million households.[44] EPRI projects that U.S. data center electricity demand will increase to between 196.3 TWh and 403.9 TWh by 2030, and comprise 5% to 11% of total electricity consumption in the U.S. by 2030.[45]

Rhodium Group (Rhodium) projects that electricity use from U.S. data centers could increase by between 85% to 160% compared with 2023 levels by 2030, and between 140% and 260% by 2035.[46] Rhodium's methodology does not provide a baseline estimate for U.S. data center electricity use. However, assuming EPRI's estimate of 150 TWh for 2023, Rhodium's projections for U.S. data center power use would indicate an increase to between 278 TWh and 390 TWh by 2030.

Globally, the International Energy Agency (IEA) projects data center energy usage stood at around 460 TWh in 2022 and could increase to between 620 TWh and 1,050 TWh in 2026.[47]

Total U.S. data center electricity consumption appears poised to continue increasing. However, the projected rates of change in U.S. data center electricity use vary widely — anywhere from a 29% increase to a massive 166% increase from 2023 levels by 2030.[48]

New technologies are driving increased data center energy use

The rise in computing energy use is being driven both by increasing data use generally and by technologies that are particularly data- and energy-intensive: specifically, AI and cryptocurrency mining.

In 2024, AI applications made up 10% to 20% of data center power use.[50] While AI has existed in various forms for decades, the recent rise of generative artificial intelligence (GenAI) has spurred a flurry of competition among tech companies to develop new GenAI models and advance other types of AI, such as AI-assisted decision-making tools. Generating a text response using GenAI uses far more energy than using a traditional search engine. In addition to concerns about the electricity usage of AI, it has the potential to cause great harm if left unchecked. Investments in AI could also lead to an economic bubble if companies are unable to find ways to monetize the technology.

Cryptocurrency mining can also be extremely energy-intensive, straining the grid while generating negligible benefits to society. Some crypto mines use a method called "proof of work" to verify transactions and mine coins. Proof of work uses huge amounts of electricity in the process of solving cryptographic puzzles using computing power. The global electricity consumption of Bitcoin mining in 2023 was 121.13 TWh, more than the entire state of Michigan produced the same year.[51]

GenAI is resource-intensive

AI has taken many forms — from computers that can beat world champion chess players to spam filtering tools. However, none has captured the public's imagination like GenAI.

After ChatGPT was released to the public by OpenAI in November 2022, the model reached 100 million active users within two months, setting the record for the fastest-growing consumer application in history.[52] Since then, GenAI models — systems that create new outputs like text, image, video or audio in response to prompts — have continued to gain popularity with applications in education, business and entertainment, setting in motion a technological arms race to build competing models. Google, Microsoft, Meta, Apple and Adobe are some of the companies pouring significant resources into developing GenAI models and embedding them into their already-existing products. Some are designed to be workplace productivity assistants that help with tasks such as editing text and writing summaries of long documents, while others are primarily used for entertainment. Several smaller firms offer more specialized GenAI services, such as ElevenLabs, which creates voice clones that can be trained to sound like a particular person — an application that has prompted alarm from privacy and consumer rights advocates.[53]

The generative models underpinning GenAI applications have only become possible in recent years thanks to more powerful computing hardware including special processors like GPUs, access to unprecedented amounts of data (largely collected from the internet) and cheap data storage enabling the creation of large data sets for use in training.

GenAI models use electricity both in the development and training phase and in deployment to businesses and consumers. Model development and training are estimated to comprise 40% of the energy footprint of AI, while use and inference make up 60%.[54]

Training GenAI models uses a lot of electricity

Before an AI model becomes available to use, it must be trained with large amounts of data. Put simply, the more neural networks and the more parameters a model has, the more computational power it takes to run.

The initial training of OpenAI's GPT-3 is estimated to have consumed 1,300 MWh of power — enough electricity to power more than 120 households for a year.[55] While that training regimen might not seem too alarming by itself, GPT-3 is just one of many GenAI models, and models are retrained after deployment. The number of AI models that are being trained, and how large the models are (i.e., how many neural networks and parameters the model has), remains a mystery. As one researcher explained, "With ChatGPT we don't know how big it is, we don't know how many parameters the underlying model has, we don't know where it's running … It could be three raccoons in a trench coat because you just don't know what's under the hood."[56]

With the ongoing growth and popularity of GenAI, more and more models are expected to be trained and retrained over the next five years.[57]

Deploying GenAI uses a lot of electricity

Once a GenAI has been trained, it can be deployed for use by businesses or consumers. The most popular GenAI systems are widely used in more resource-intensive tasks. An average of 34 million images are generated by GenAI daily and 15.47 billion total images were generated from 2022 to August 2023.[58] ChatGPT reached over 200 million weekly active users in November 2024.[59] According to McKinsey & Company's annual survey of AI use in businesses, generative AI use nearly doubled in less than a year. In early 2024, 65% of businesses surveyed reported regularly using GenAI, most often for marketing and sales.[60]

The energy use from all that generative computing is significant. Sajjad Moazeni, a University of Washington professor, estimated that in one day ChatGPT uses as much power as 33,000 homes do in a year.[61] The use of GenAI is significantly more energy-intensive than standard computing functions such as traditional search engines. Early text applications of ChatGPT were estimated to require 10 times the amount of electricity to respond to user queries than a traditional Google search.[62]

Energy use also varies by the type of output. Generating images — an increasingly common use of AI — requires significantly more power than text-based applications. One study finds that while text generation consumes an average of 0.047 kWh per 1,000 queries, image generation consumes an average of 2.907 kWh (62 times more).[63] To put that electricity use into perspective, on average, generating just eight images using GenAI uses as much power as charging a typical smartphone. Some AI models produce multiple images per prompt, and users often use multiple prompts before they arrive at an image they like.

In addition to new applications, GenAI is also being fused with pre-existing services, from search engines to fast food menus, making it difficult to avoid and increasing the energy use from GenAI.

Cryptocurrency mining wastes electricity

Another new and energy-intensive computing activity, cryptocurrency mining, has grown rapidly over the last several years. Preliminary estimates by the Energy Information Administration (EIA) suggest that electricity use for cryptocurrency mining represents between 0.6% to 2.3% of annual U.S. electricity consumption.[64]

To understand why cryptocurrency mining wastes electricity, some background is needed. The "blockchain" is a distributed ledger that keeps track of crypto transactions. Some cryptocurrencies, including Bitcoin, use a decentralized method to verify transactions called “proof of work.” Proof of work rewards participants with cryptocurrency when they add a block to the blockchain and verify a transaction by solving cryptographic puzzles using computing power.

To date, proof of work has required increasing amounts of electricity and become less energy efficient over time.[65] In 2023 alone, Bitcoin mining consumed 121.13 TWh of electricity globally.[66]

The electricity use of cryptocurrency mines is influenced by cryptocurrency markets, which are notoriously volatile. When the price of a cryptocurrency is high, miners have an incentive to run the cryptocurrency mine around the clock to earn as much crypto as possible. If the price is low, however, keeping the servers running is less advantageous, and may even result in losses.

Crypto data centers don’t need to run 24/7/365; they can choose when to run servers or shut them down. Because of this “flexible load,” cryptocurrency advocates and industry insiders argue that cryptocurrency mining can help mitigate power shortages and catalyze renewable energy growth. [67] In Texas, where cryptocurrency mining is rapidly expanding, the Electric Reliability Council of Texas (ERCOT) pays crypto companies to shut down during periods of extreme temperatures through “demand response” programs.[68] In August 2023, the grid operator paid crypto mining company Riot $31.7 million dollars to shut down during a heat wave.[69]

However crypto advocates spin it, cryptocurrency mining represents a significant new load that isn’t needed. In addition, the cryptocurrency mining industry is far from transparent about its electricity consumption. In 2024, the U.S. Energy Information Administration (EIA) attempted to collect data regarding its electricity use; the industry responded with a lawsuit. [70]

Proof of work isn’t the only way to mine cryptocurrency. Some cryptocurrencies like Ethereum use a different mechanism called “proof of stake” that is far less energy intensive. In 2023, Ethereum mining consumed 5.85 MWh globally for mining, just 0.0048% the amount used for Bitcoin mining.[71] While this is in part due to volume, proof of stake doesn’t require lots of computing power by design like proof of work; instead of solving cryptographic puzzles, miners are randomly selected to add a block to the chain based on their “stake” in the cryptocurrency.

Data centers strain the grid but can reduce their impact

Data centers can satisfy their demand for electricity in several ways — by drawing it from the grid, generating it themselves, or improving their efficiency to reduce the amount of power they need in the first place. Many data center owners attempt to address the environmental impact of their data use by purchasing renewably generated power or renewable electricity certificates (RECs). While beneficial, these methods don't always alleviate the climate impacts or the strain on the electrical grid created by data centers.

Data centers impose a heavy burden on the grid

One way that data centers power their operations is by hooking up to the grid. The sudden increase in demand for electricity from a data center can strain the grid and increase the use of fossil fuel-fired generation.

In every state, utilities have an "obligation to serve" all customers in their service territory, both existing and new.[72] Whether the customer is a single household or a large-load customer such as a data center, the utility must provide them with service. Under current law, utilities cannot simply deny service to a new entity, no matter how disruptive or unexpected new load may be. Utilities may require upgrades prior to providing service to a new large load customer, but they cannot deny the customer service outright and must make the needed investments. While this policy is important for providing access to electricity for all Americans, it may no longer make sense to apply it to large load customers like data centers.

Given that just one large data center uses massive amounts of power, when multiple data centers open in a particular region the utility or grid operator may need to invest in new generating capacity and transmission and distribution infrastructure to be able to reliably serve new data centers along with its other pre-existing customers. If one large customer, such as a data center, or a data center complex, is deemed to be the cause of new load that requires such investments, the companies moving in should pay their fair share rather than leave utility customers and taxpayers paying the bill.

As discussed further below, the demand from data centers being added to the grid is already prompting U.S. utilities to keep fossil fuel-powered plants open longer than planned and invest in new fossil fuel plants and transmission and distribution infrastructure, sometimes even at the expense of ratepayers in neighboring states.[73]

Data centers can purchase "green" energy

Data centers and their customers appear to be increasingly eager to utilize "carbon-free" energy so they can meet their own energy goals. Some hyperscalers source renewable energy through corporate procurement strategies such as unbundled RECs and power purchase agreements.[74] In 2023, for example, Amazon signed agreements with more than 100 solar and wind projects globally, including a 500 MW project in Texas and a 170 MW project in Maryland.[75]

Corporate procurement creates demand for clean energy and can therefore incentivize investments in clean energy production. However, it isn't a sufficient solution. Even if a company matches its annual electricity use with purchases of renewable energy certificates, they may still end up relying on fossil fuels during the hours when contracted clean energy sources can't generate enough power to meet data center needs.[76] Furthermore, that energy may be wasteful for certain applications, and leads to competition for existing clean energy resources, increasing scarcity and prices for all consumers. These strategies also do not offset the localized impacts of fossil fuel power production and consumption.

Data centers can produce power on-site

Another way data centers can reduce strain on the grid is to produce power on-site. Data centers can build new power generation on-site and connect it directly to the facility to create a "microgrid." Some companies buy or own pre-existing generating resources and build a data center nearby, while others purchase existing data centers and build new power generation on-site. In Pennsylvania, for example, crypto mining data centers have popped up to take advantage of coal waste[77] and low-producing fracking wells.[78]

On-site generation doesn't need to be dirty or dangerous. To serve data centers, one startup company is building three dedicated solar projects in Illinois, adding 9.24 MW in load, and has a pipeline of solar projects that will add a total of 100 MW in capacity.[79]

Renewable on-site generation creates new clean energy generating capacity to meet demand for data centers rather than pulling any existing resources from the grid. While producing new clean energy on-site will help reduce data centers' impact, many hyperscalers use so much energy that it may not be possible to power the facility entirely with on-site clean energy sources.

Will data center expansion launch a "nuclear renaissance"?

The tech industry's insatiable demand for energy has led many to consider a form of electricity production that has been out of favor for decades due to cost, security, environmental and safety concerns: nuclear power. In 2024, several deals were announced between tech firms and nuclear plant operators to secure power from new or existing nuclear plants. Diverting existing nuclear power to data centers raises concerns about how that power might be replaced on the grid, while building new nuclear plants to serve data centers will be expensive and take many years — if new nuclear plants are even completed at all.

In May 2024, Amazon Web Services acquired a data center campus in Pennsylvania owned by Talen Energy, which operates the adjacent Susquehanna nuclear power plant. Talen had agreed to sell Amazon up to 960 MW of power from the plant, whose two reactors have a combined capacity of 2,475 MW.[80] However, the Federal Energy Regulatory Commission (FERC) rejected PJM Interconnection's[81] amended interconnection service agreement, putting the deal on ice, as of the time of the publication of this report.[82]

In September 2024, Constellation Energy announced plans to reopen Unit 1 at Pennsylvania's Three Mile Island nuclear plant as part of a deal to supply energy from the plant to Microsoft for its data center operations.[83] The plant had closed in 2019, but Constellation hopes to receive an operating license from the U.S. Nuclear Regulatory Commission (NRC) for the closed reactor in late 2027 and resume generating power in 2028.[84]

The following month, Google announced an agreement to purchase power from proposed new small modular reactors (SMRs) to be built by Kairos Power, and Amazon announced a $500 million investment in X-energy, another SMR company, and a deal to deploy four X-energy reactors in Washington state.[85] Both deals anticipate generating power from the reactors by the early 2030s, despite the lack of actual license approvals and the fact that these designs have never been built.[86]

Despite the announcements, a tech-driven nuclear renaissance is not inevitable, nor is it desirable.

The cost of restarting shuttered nuclear reactors such as Three Mile Island is uncertain, but it will be expensive. Constellation expects the Three Mile Island restart will cost at least $1.6 billion, but nuclear projects in the United States and elsewhere in the world have a long track record of severe cost overruns.[87] The cost of restarting Michigan's Palisades nuclear plant, which was closed in 2022, for example, may be significantly higher than expected following the discovery of greater-than-expected levels of cracking in the plant's steam generator tubes.[88]

SMR technology is even more uncertain. There are currently no SMRs in operation in the United States and only three are in operation worldwide, in China and Russia.[89] Only one SMR design, by the company NuScale, has been certified by the U.S. Nuclear Regulatory Commission,[90] but a deal to build NuScale SMRs in the western U.S. was canceled in late 2023 due to rising costs.[91]

The environmental and safety impacts of SMRs are also uncertain. A 2022 analysis by researchers at Stanford University and the University of British Columbia estimated that SMRs could increase the amount of nuclear waste needing to be stored or managed by a factor of between two and thirty compared with conventional reactors.[92] A 2022 study prepared by the U.S. Department of Energy estimated that X-energy's SMR design could produce 12 times as much spent nuclear fuel by volume as a traditional reactor.[93]

Nuclear waste is stored on-site at nuclear reactors because the U.S. does not have a federal repository. So, in effect, every SMR would create a nuclear waste dump in the host community.

Redirecting power from existing nuclear plants to serve data centers could raise electricity costs for consumers and harm grid reliability, while creating, in the words of one analyst, a "massive hole" in electricity supplies that may be filled, at least in the short run, by fossil fuel-fired power.[94] Utility companies Exelon and American Electric Power have argued that the Talen Energy-Amazon deal could shift $140 million in grid costs to customers per year in the PJM grid region.[95]

The existence of federal (and in some places, state) subsidies is one of the factors driving the revived interest in nuclear power. Constellation Energy is expected to seek a $1.6 billion federal loan guarantee for the Three Mile Island restart.[96] Kairos Power will receive up to $303 million toward the construction of a demonstration SMR[97], while X-energy has received more than $300 million in federal funds according to the organization Good Jobs First.[98] The Inflation Reduction Act also includes tax credits for production of electricity from existing nuclear plants (such as Susquehanna in Pennsylvania) and new "advanced nuclear" reactors that would receive even more money in subsidies over time.[99]

A "nuclear renaissance" is by no means guaranteed, hinging on unproven technologies and the expensive and uncertain process of refurbishing shuttered reactors. Failure to meet the industry's ambitious nuclear goals could commit the world to additional years' worth of fossil fuel pollution, while wasting taxpayer and ratepayer money. Successfully building out substantial nuclear generation would create a different set of problems, tying the nation ever more closely to nuclear power, a form of energy with inherent health and safety risks and a history of exorbitant costs.

Rather than make a risky bet on nuclear power solely to meet the speculative needs of one industry, tech companies and public officials should instead invest in quick and cost-effective solutions such as improved energy efficiency, renewable energy and on-site energy storage.

Data centers can improve their efficiency, but gains have slowed in recent years

Given the massive amounts of electricity data centers use, increasing the efficiency of IT equipment and cooling systems will be critical to prevent data centers from slowing progress toward a future powered by clean, renewable energy. In the past, the increased uses of computing resources have largely been offset by increased efficiency in hardware and cooling systems, keeping increases in energy use for computing from spiraling out of control. One key element of the efficiency improvements has been server virtualization (which reduces the amount of server power required for each computation).[100] However, virtualization of current AI models is not currently possible, restricting access to this efficient option. Recent increases in electricity demand for computing reflect the fact that efficiency gains aren't keeping pace with rising demand for AI.

Data centers can improve their energy efficiency in multiple ways: They can purchase more energy-efficient servers and IT equipment, improve the optimization of software and code running on the servers and/or reduce the share of energy that goes to non-IT related functions such as cooling.

Power usage effectiveness (PUE), the ratio between the total energy consumption of a facility and the energy consumed by the IT equipment within it, is often referred to as a measure of data center efficiency.[101]

$$PUE = \frac{\text{Total Electricity Used by the Data Center}}{\text{Electricity Used by Infrastructure}}$$

But PUE only tells part of the story. PUE measures the efficiency of cooling systems, lights and other non-IT equipment relative to the amount of power consumed by IT equipment.[102] A PUE of 2 means that the amount of energy used by IT equipment is equal to the amount used by non-IT equipment. A PUE of 1 means the data center doesn't use any energy for non-IT equipment. A PUE greater than 2 indicates the data center uses more electricity for non-IT equipment than it does for computing.

In the past, efficiency gains for non-IT equipment have largely offset the increase in energy use from data center expansion, but PUE gains have slowed in the past few years. According to EPRI, the average annual PUE in data centers decreased from 2.5 to 1.58 between 2007 and 2018, meaning the non-IT equipment came to account for a smaller share of overall facility energy use. Since 2018, however, PUE has remained mostly flat at around 1.6 PUE.[103]

Efficiency improvements for the non-IT share of data center energy use are still possible. IT equipment produces significant amounts of heat, and cooling can account for 40% of data centers' energy demand according to IEA.[104]

The National Renewable Energy Laboratory (NREL) is working with multiple universities to research advanced cooling technologies and system configurations. At NREL's South Table Mountain Campus in Colorado, 97% of waste heat from the Eagle supercomputer is captured and integrated with the main thermal system of the building and is even used to melt ice outside during the winter. Thanks to this efficient system, running Eagle requires only 2 MW of power.[105]

PUE is not, however, a sufficient metric for understanding data centers' energy efficiency because it doesn't account for the efficiency of the IT equipment itself, nor the software or code being used. Although it represents two-thirds of a data center's energy use, the efficiency of IT equipment has not been a focus for efficiency improvements. Fortunately, opportunities for improving the energy efficiency of computing equipment are being increasingly considered.

Some ways to increase the efficiency of IT equipment are by separating critical and noncritical loads, powering down noncritical racks when possible, and not connecting noncritical loads to uninterruptable power supplies.

Improving the energy efficiency of IT equipment largely comes down to upgrading to newer, more efficient equipment. The U.S. government's Energy Star rating recognizes the most efficient data center equipment, including efficient servers, uninterruptible power supplies, storage and network equipment. Energy Star-rated servers use 30% less electricity and could save an average of over 650 kWh per year. With hundreds of Energy Star-rated servers available in the U.S., including dozens of servers with four or more processor slots, data centers have lots of options for upgrading to more efficient equipment for a variety of computing functions.[106]

To grant an Energy Star rating for servers, the agency uses a metric developed by Standard Performance Evaluation Corporation (SPEC) and the U.S. Environmental Protection Agency called Server Efficiency Rating Tool (SERT). The rating tests a variety of computing functions in three categories: CPU workloads (weighted 65%), storage worklet (weighted 5%) and memory (weighted 30%).[107]

Performance per watt is another potentially useful measure of energy efficiency of server racks. In the simplest terms, performance per watt measures how many operations a server system can run per unit of energy.[108] Data centers may use multiple kinds of server systems with varying efficiency, and efficiency might also be affected by other factors like configuration (i.e., the number of servers per rack, the number of racks, and the spacing relative to cooling systems).

While multiple metrics exist that can help evaluate data center efficiency, each should be taken with a grain of salt and considered in conjunction with others. For example, improving the efficiency of AI processing chips may improve the work per watt servers can perform, but could also result in more electricity use overall because of the sheer number of operations they perform.

To reduce future demand for electricity from data centers and avoid slowing down the transition to 100% clean energy, data centers need to become more energy efficient. To do so, data centers should plan for efficiency in both their cooling systems and in their IT equipment and optimize software and code for peak efficiency.

Although energy efficiency is a commonsense measure that prevents waste, increasing energy efficiency alone will not necessarily reduce overall energy use from data centers. As data centers become more efficient, they are likely to continue using the maximum amount of power available to them.

Data center expansion is already delaying the transition to clean energy

The recent expansion of data centers — and forecasts of future growth — is leading utilities around the country to slow down the closure of old fossil fuel power plants and even propose the addition of new gas-fired power plants, putting America's transition to carbon-free renewable energy at risk.

Keeping old fossil-fuel plants open into the 2030s and 2040s and building new fossil fuel generation is incompatible with meeting climate protection targets.

Utilities have delayed the closure of fossil fuel plants

At least 17 fossil fuel generating units at seven power plants totaling 9,100 MW of capacity across the country have had proposals to delay their closures due to concerns from utilities and grid operators about increasing electricity demand or the need for investments in transmission and distribution infrastructure. And given the projected growth of U.S. electricity demand, many more coal- and gas-fired plants around the country will be at risk of delayed closures around the country in the coming years, especially where new data center projects are planned.

Nearly half (45%) of new data center electricity demand through 2035 is expected to be in northern Virginia, where Data Center Alley is located.[110] PJM Interconnection, the grid operator in the region, concluded that local reliability issues require it to delay the planned retirement of Brandon Shores coal-fired power plant, the biggest climate polluter in Maryland, by about five years. [111] PJM also requested that the utility Talen Energy keep two units at Herbert A. Wagner gas and oil power plant open roughly three years longer than originally planned.[112]

Dominion Energy, a utility serving Virginia and South Carolina, proposed delaying the closure of Clover coal-fired plant in Virginia until 2040 in an updated Integrated Resource Plan (IRP) in May 2024.[113] Dominion's energy manager of media relations, Aaron Ruby, explained, "To reliably serve our customers and keep the lights on 24/7, we'll need to preserve most of our existing power stations until at least the late 2030s, including Clover. It's all about reliability and serving our customers."[114]

Ohio-based utility FirstEnergy Corp. had planned to significantly scale-down operations at two high-polluting plants, Harrison Power Station and Fort Martin, to reduce the company's emissions by nearly a third in the next six years. Following increases in projected electricity demand, however, the utility announced it is abandoning the 2030 goal to significantly cut greenhouse gas emissions because, it argues, the two plants are crucial to maintaining grid reliability.[115] The Harrison power plant was the eighth-largest climate polluter in the U.S. in 2022.[116]

Table 2: Fossil fuel-fired power plants at risk of delayed closures[109]

Power Plant	Unit	Source	State	Nameplate Capacity, MW
Herbert Wagner	3	Gas	MD	359.0
Herbert Wagner	4	Gas	MD	415.0
Brandon Shores	1	Coal	MD	685.1
Brandon Shores	2	Coal	MD	685.1
Clover	1	Coal	VA	424.0
Clover	2	Coal	VA	424.0
Harrison	1	Coal	WV	684.0
Harrison	2	Coal	WV	684.0
Harrison	3	Coal	WV	684.0
Fort Martin	1	Coal	WV	576.0
Fort Martin	2	Coal	WV	576.0
Scherer	3	Coal	GA	891.0
E C Gaston	1	Coal and gas	AL	272.0
E C Gaston	2	Coal and gas	AL	272.0
E C Gaston	3	Coal and gas	AL	272.0
E C Gaston	4	Coal and gas	AL	952.0
E C Gaston	Unit A	Coal and gas	AL	244.8
Total				**9,100.0**

In the Southeast, utility Georgia Power's updated 2023 IRP considers a plan to continue operating Plant Scherer Unit 3 and Plant Gaston Units 1-4 and Unit A through 2035 to meet the utility's capacity needs. The company cites an influx of businesses including "manufacturers, the ET [electric transportation] industry, data centers, and other businesses. The size of many of these projects far exceeds historical annual norms, with some individual projects surpassing 1,000 MW."[117]

Table 3: New fossil fuel generation being planned or proposed[118]

Utility	New fossil fuel capacity planned or proposed, MW
Dominion Energy	1,447
Duke Energy	3,145
Georgia Power	1,400
Nebraska Public Power District	636
Arizona Public Service	600
Excel Energy	1,575
Constellation Energy	300
NIPSCO	1,705
Total	**10,808**

Utilities are planning new fossil fuel plants and infrastructure

While some utilities are keeping old fossil fuel power plants online to serve data center demand, others, from Virginia to Arizona, are proposing new gas-fired power plants. We identified at least 10,808 MW of new fossil-fuel generation being considered to meet increasing demand.

In Dominion's 2023 Integrated Resource Plan, every build plan adds at least 1,447 MW of gas-fired generation to support system reliability.[119] To meet anticipated demand from data centers, grid operator PJM Interconnection is planning a $5.2 billion project to build hundreds of miles of interstate transmission lines connecting to coal plants that were scheduled to be retired.[120]

In January 2024, Duke Energy issued a supplement to its 2023 Carolinas Resource Plan that outlined the need for 3,145 MW of new fossil fuel generation.[121] Furthermore, the company notes that new sources of demand include "data centers and advanced cloud computing and blockchain operations, with many of these projects being very high load factor customers with 24x7x365 operations that will require substantial generation and constant energy delivery to ensure reliable service."[122]

Georgia Power also plans to add 1.4 GW of gas generation to meet electricity demand.[123] Across the Southeast, gas-fired power plants have been proposed by by Dominion Energy, Duke Energy, and Georgia Power.[124]

In Indiana, Northern Indiana Public Service Co (NIPSCO) is preparing plans to add 1,705 MW of new gas generation if data center load increases.[125] Nebraska Public Power District is planning an additional 636 MW of gas capacity by 2027 to serve increased demand from agriculture, industrial users and data centers.[126] And, anticipating new data centers to require 12,997 MWh of generation from 2023 to 2028, Arizona Public Service plans to add 600 MW of gas generating capacity.[127] In Texas, Constellation Energy is planning a new 300 MW unit at Wolf Hollow II to burn gas.[128]

Crypto mining is burning fuel directly

As mentioned previously, crypto mines can be built almost anywhere cheap sources of energy exist, such as fracking wells and coal waste sites. They sometimes also burn gas directly.

In 2021, ExxonMobil launched a project to sell gas to mine cryptocurrency in North Dakota's Bakken oil fields, and it is considering doing the same in Alaska.[129] ConocoPhillips is also selling off flare gas — methane gas that is a byproduct from drilling for oil and can be burned for energy — to crypto mines in North Dakota.[130]

Data centers impose other burdens on communities

From water use and noise pollution to imposing costs on ratepayers, data centers have profound impacts on communities besides their electricity consumption.

Data centers are water-intensive

Data centers not only require lots of electricity, but they also consume large amounts of water, which could be a problem in water-scarce regions.[131] Data centers withdraw and/or consume millions of gallons of water daily for on-site cooling systems and the electricity being generated to power them.[132] Furthermore, due to a lack of transparency, facility-specific data for water usage is difficult to find, leaving communities in the dark about the possible impacts.

Largely due to the growth in data centers, Google and Microsoft's data center water usage increased by 20% and 34%, respectively, from 2021 to 2022.[133] And because data centers are regionally concentrated, the water resources required can have a big local impact. In The Dalles, Oregon, where Google's data centers now consume more than a quarter of the city's water, the company's water use nearly tripled in the five years prior to 2022[134]

In 2022, Google, Microsoft and Meta were responsible for the withdrawal of an estimated 396 billion gallons of water.[135] A significant amount of that water was consumed (not returned to the supply source) in the process through evaporative cooling. Researchers estimate that training ChatGPT-3 can consume 180,000 gallons of water (not including water used for power generation off-site), and the model needs to continue to "drink" a 16-ounce bottle of water for every 10 to 50 responses.[136]

In 2023, a typical data center was estimated to use 1 million to 5 million gallons of water daily.[137] And even before the recent data center explosion, the water footprint of data centers was garnering attention. Virginia Tech researchers estimated that the national water footprint of data centers in 2018 was 513 million cubic meters, equivalent to just over 135.5 billion gallons, about a quarter of which is used on-site. The study also found that data centers "disproportionately utilize water resources from watersheds experiencing greater water scarcity than average."[138]

More efficient cooling systems and strategic siting of data centers would directly reduce water consumption for cooling. In addition, improved efficiency of data center IT infrastructure would indirectly reduce water consumption by reducing the water used for electricity generation.

Data centers are very loud

Data centers and the backup diesel generators they run can make a lot of noise, creating not just an annoyance for the people and animals living nearby, but also a serious health concern. Servers, cooling systems and generators can all create noise pollution.

Although individual servers produce minimal noise, hundreds of servers can together emit noise up to 96 decibels inside data center buildings. Cooling systems are especially audible outside the data center where nearby communities are exposed to noise pollution from the facility.[139]

Some data centers can emit from 70 to 90 decibels for those within earshot, potentially harming health.[140] Citizens in Granbury, Texas, have reported ailments — from hearing loss and migraines to vertigo and nausea — ever since a loud cryptocurrency mine was built near residents.[141] Residents living near the mine have recorded noise as high as 91 decibels, which is nearly as loud as a chainsaw.[142] One local doctor states that high cortisol and blood sugar from stress caused by the noise could be causing the symptoms.[143]

Liquid cooling and soundproofing can help reduce the noise pollution from data centers, making them better neighbors. In addition, the emergence of efficient, clean energy storage can help replace the need for backup generators.

Data centers can increase utility prices for consumers

When large load customers come into a service territory, utilities and grid operators may need to add generating, transmission and distribution infrastructure to be able to serve all customers reliably. If investments are needed because of one customer, utility regulators typically attempt to allocate the costs to upgrade the grid to that customer. However, new load can still lead to higher utility prices for ratepayers. In addition, loopholes in some states allow large customers to avoid paying very significant interconnection costs, socializing those costs among other ratepayers. When demand increases very rapidly in a very short time (i.e., when a new data center is built), the need for investments in transmission and interconnection and delays in interconnection queues will constrain supply in the short term, raising prices for all ratepayers.

In PJM's territory, where Data Center Alley is located, additional costs for expanded investments in the grid will likely be passed on to utility customers. Maryland People's Counsel David Lapp anticipates annual utility bills for Baltimore-area households will increase by $192. In Maryland, Ohio, Pennsylvania, New Jersey and West Virginia, rates could increase by as much as 20% by spring 2025.[144]

As large load customers, data centers don't always pay their fair share. Utilities have commonly used "economic development rates" (EDRs) to attract and retain large customers.[145] Utilities are now striking up discounted rate deals for data centers. For example, Dominion Energy agreed to a deal with Google to pay less than half of what residential customers pay per kilowatt hour.[146]

Taxpayers subsidize data centers in many states

Taxpayers subsidize data centers through economic development incentives to attract data centers, intended to attract businesses that are supposed to create jobs and support economic activity. Data center subsidies — in many shapes and sizes — are already in place in 22 states, further imposing the burden of data center energy use onto taxpayers.[147]

The organization Good Jobs First reports that from mid-2019 to July 2023, Illinois granted $468 million worth of tax breaks to data centers; then in 2024, the annual cost of tax breaks for data centers in Illinois ballooned to $370 million.[148] The nonprofit also reports that Texas lost $80 million in 2022 and $290 million in 2023 to its "Data Center Program Exemption."[149] Further, it claims data center subsidies cost the Washoe County School District in Nevada $22 million in FY 2023, more than it spent on its education transportation budget (money that could be spent on things that benefit students' health, like electric buses).[150]

These subsidies may not have any impact on the likelihood of a company following through on a data center project because many projects would likely go through regardless. What is certain is that such policies benefit some of the most profitable companies in the world while creating major costs and electrical grid strain for the communities where data centers are built.

Are AI and cryptocurrency "worth it"?

The tremendous impacts of data centers — including more fossil fuel use, carbon pollution, water consumption and impacts on local communities — beg the question: Are AI and cryptocurrency worth the environmental impacts and economic costs to taxpayers and ratepayers? While computing plays an important and beneficial role in people's lives — and technological advances such as AI hold great promise — some of the most energy-intensive forms of computing energy use produce limited, or at least debatable, social value.

AI can be transformative — and harmful

AI encompasses a number of technologies with potential to profoundly reshape society for the better. For example, two researchers working with Google's DeepMind received the Nobel Prize for Chemistry in 2024 for their work on AlphaFold, an AI model that predicts the 3D structure of proteins from their amino acid sequences, which could significantly accelerate drug discovery and disease research.[151]

However, the power of AI can also be very harmful. The technology is being made available broadly to the public without sufficient safeguards, regulatory standards or space for anyone besides the tech developers themselves to ask if a particular application of AI is "worth it." Those companies' primary goal is profit, not broader societal benefit. And the American public is not necessarily satisfied with the current breakneck pace; over half of Americans polled in 2023 were more concerned about AI than excited by it, a jump of 15% in just two years.[152]

Many current examples demonstrate that AI systems produce biased results. For example, one company developed an algorithm that was intended to help healthcare providers prioritize high-risk patients for preventive care, but a racial bias in the design of the algorithm resulted in Black patients receiving less than half the preventive care as white patients.[153]

GenAI is another example of a technologically impressive development with considerable tradeoffs. GenAI is an inherently surveillance-based and extractive technology. These applications require large amounts of data, and constantly need new data, which will need to be obtained through increasingly predatory methods.

While ChatGPT can be used for entertainment and has some useful applications such as line editing text, it has also been described as a "bullshit generator" designed to produce plausible statements rather than the factual truths, rendering it unsuitable for pursuits such as education and healthcare. [154]

The release of GenAI systems to the broader public has introduced a variety of serious problems and risks. GenAI has made it easy to generate nonconsensual sexual imagery, leading to what *The New York Times* called "an epidemic" of deepfake nude images of teen girls being used to harass and humiliate them in middle and high schools across the country.[155] Voice cloning AI has made it easier for fraudsters to generate deepfake voices capable of impersonating anyone with enough voice data available online.[156] Finally, the ability of anyone to generate text on a massive scale for little cost has degraded the quality of information available online significantly. "AI slop" refers to the massive quantity of AI generated content that is flooding many corners of the internet.[157]

These GenAI systems were released without public debate or regulatory discussion. They were released without providing tools to help manage the fallout: Schools have been left to grapple with what ChatGPT meant for homework and cheating, and there still exist no surefire tools for determining what images and video online are AI-generated. Once a GenAI system has made harmful content, there's nothing that the company can do to stop the dissemination of it.

The future of AI is unclear. Some suggest that models become less reliable as they get bigger,and AI companies could run out of human-written data to train models sometime between 2026 and 2032.[158, 159] The rush into funding GenAI tools has also sparked discussion about the possibility of an AI bubble, as it's not yet obvious how much the amount of investment flowing into AI — including the construction of data centers — will pay off, as there is currently no sustainable business model in place. As the head of stock research at Goldman Sachs recently said about the current wave of GenAI investment: "Overbuilding things the world doesn't have use for, or is not ready for, typically ends badly."[160]

Perhaps most concerningly, industry leaders — including those at OpenAI and Google — have warned that AI has the capacity to pose an existential risk to humanity, on par with threats such as nuclear war and pandemics.[161]

Cryptocurrency is volatile and often used for consumer scams and criminal money laundering

Cryptocurrency is also problematic beyond its wasteful energy use. It is a volatile and risky investment that is difficult to exchange for goods and services or other currencies.

Firstly, the banks that cryptocurrencies so proudly subvert are merely replaced with online exchanges that are rife with consumer scams, criminal money laundering and poor customer service.[162]

Crypto is harmful in part because it exists outside of most of the financial consumer protections the nation has developed specifically to protect consumers, such as insurance from the Federal Deposit Insurance Corporation (FDIC). In 2022, the FDIC released an advisory to insured banks regarding the risks of dealing with crypto.[163]

The spectacular crash of FTX in November 2022 is a prime example of the risks of cryptocurrency. John Ray III, the lawyer who helped clean up the Enron scandal in 2001, said of the situation, "Never in my career have I seen such a complete failure of corporate controls and such a complete absence of trustworthy financial information as occurred here."[164]

The crypto industry continues to fight against stronger regulations and oversight on both sides of the aisle. For example, following a surge in cryptocurrency lobbying in 2023, Congress blocked SEC guidance that would have required companies to record their client's crypto assets *as* assets and liabilities in their accounting due to the "increased risk of financial loss."[165]

Recommendations

Though the ultimate future of advanced computing such as AI is unknown, the rapid expansion of data center energy use is causing serious problems in the here and now — including delaying America's transition to clean, renewable energy.

Fortunately, policymakers have options rto protect the environment and reduce the impacts on the electrical grid, while supporting a more robust societal debate about the role and uses of tools such as AI.

Limit the growth of the least valuable forms of computing energy use

U.S. data centers are expanding and delaying the transition to clean renewable energy, but at least some of that growth is unnecessary — especially growth to serve energy-intensive forms of cryptocurrency mining, and perhaps AI applications that produce negligible societal benefits. Even if all U.S. data centers are powered with renewable energy, some of the "work" data centers do isn't a wise use of the energy harnessed from utility-scale solar arrays, wind farms and expanded transmission lines, all of which have a cost to consumers and the environment. Government and society need to consider what level of data center growth is beneficial, and limit forms that do not meet that standard.

In 2022, for example, after Bitcoin miners flocked to New York from China, the state imposed a moratorium (two years) on proof of work cryptocurrency mining, a move that will ease the strain on the grid.[166] States across the country should adopt similar policies.

Don't let data centers derail the renewable energy transition

Rising energy demand for data centers cannot be permitted to stall the nation's progress toward a zero-carbon future. Reviving mothballed coal and nuclear power plants is short-sighted, expensive, bad for the environment and bad for consumers — at a time when cleaner and safer energy sources like wind, solar and geothermal are more affordable.

Thirteen states have adopted enforceable targets to transition to 100% clean or carbon-free electricity.[167] Other states in the Northeast, mid-Atlantic and western U.S. have adopted carbon cap-and-trade programs that set limits on greenhouse gas pollution from power plants. States should adopt similar policies, especially amid growing electricity demand from data centers. Similarly, state Public Utility Commissions should ensure that the needs of consumers and the environment are accounted for in decisions related to utilities' resource planning for the future. This includes a full assessment of the costs and risks to the environment — and ratepayers — of resuscitating existing nuclear plants or building new ones.

End public subsidies for data centers

Part of the reason that data centers are concentrated in certain regions around the country is that many states are providing various types of subsides to attract data centers. These subsidies attract energy hogs and risk causing more pollution from burning fossil fuels, straining water supplies and increasing electricity costs for ratepayers.

At the time of this writing, tax incentives for data centers exist in 22 states. These subsidies can also exacerbate the regional challenges utilities and grid operators face in meeting increased power demand. State governments should eliminate these unnecessary subsidies as soon as possible.

State and local governments should end public subsidies for data centers and instead ensure that data center owners and operators pay their fair share for the impact they impose on the public and the environment.

Improve transparency into data center energy and water use

Increasing the transparency of the data center industry not only enables better policy making, but it also encourages companies to improve energy efficiency. Recent research highlights the need to eliminate gaps in the data necessary to deal with a potential AI boom, noting that "[e]nergy analysts are currently ill-equipped to provide robust answers to these questions due to critical data gaps and the fast-moving nature of AI technology."[168]

The dispute between the crypto industry and the EIA over the agency's attempt to collect data about crypto mines' energy use demonstrates that many actors in the industry won't take this step without strict requirements.

In Ireland, the Central Statistics Office collects data on metered electricity use by data centers, which enables the country to fully grasp the scope of current and past data center electricity consumption and address the challenges.[169] The U.S. is simply not tracking such data currently.

Data centers or utilities should publicly report data center energy and water usage to enable analysts to improve their forecasts and to make energy efficiency standards possible. In addition, companies should not be allowed to obfuscate their impacts through nondisclosure agreements with local governments, a practice that leaves the public in the dark about who is buying or building capacity and for what.

Create efficiency standards and incentives to improve efficiency for data centers

Under the Energy Act of 2020, the U.S. initiated the development of a metric for data center energy efficiency and a regular evaluation of federal agencies' data centers.[170] Having informative standard metrics for data center efficiency is an important step to enable governments to establish efficiency standards and to enable consumers and regulators to hold data center companies accountable for their climate impact.

Metrics such as PUE can be useful in driving efficiency gains. China and Germany have established minimum PUE targets for data centers.[171] A similar federal target or requirement in the U.S. could help drive data center operators to maximize efficiency.

Federal (and state) governments can also set efficiency standards for IT equipment or provide incentives for the purchase of efficient equipment. Energy Star-rated servers — those given an energy efficient rating by the U.S. Environmental Protection Agency or Department of Energy — consume 30% less electricity than standard models while maintaining higher productivity.[172] The agency also assigns the Energy Star rating to auxiliary equipment like network equipment and storage. Governments should create incentives to improve efficiency beyond the standard and incentivize (and eventually require) the use of IT equipment meeting Energy Star or other efficiency standards.

Setting efficiency standards alone will likely not reduce the impact on the grid because data centers are likely to use the maximum amount available to them. However, it will allow us to do more computing with the total amount of energy we are able to allocate to data centers.

Require or incentivize data center load flexibility

In the media and literature on this issue, data centers are often characterized as needing capacity 24/7/365. But data centers can and should be designed so that is not required. Data centers should be designed and operated to complement the electrical grid. They should use energy when it is abundant and curtail operations when power is scarce. This would limit their negative impact on the grid as well and reducing the economic and environmental costs of serving data centers' power needs. Similarly, co-locating renewable energy generation such as solar power and energy storage with data centers can reduce their impact on the grid and the need for on-site fossil fuel backup power. States and utilities should work with data centers to implement these forms of demand flexibility and do so in ways that do not create unjustified windfall profit opportunities for data center operators.[173]

Require data centers to build and/or use new sources of clean renewable energy, preferably on-site

As previously discussed, many data center developers are partnering with solar companies to create independent, flexible energy systems on-site.[174] Creating microgrids not only creates new clean energy generation, but it also reduces the need to withdraw metered electricity that can strain the grid and helps data centers keep the lights on reliably. Uninterruptible power supply (UPS) systems consist of generators and batteries that kick in in the case of a power outage.[175] Data centers should also reduce their impact by eliminating diesel fuel from emergency generator systems and using battery storage instead.

Governments should require companies to meet virtually all their energy needs through clean energy sources. In addition, to prevent data centers from taking away clean energy from the grid, governments should incentivize or require data centers to build new clean renewable energy generation, preferably on-site.

Reduce supply chain headwinds for new renewable energy projects

As previously discussed, much of the electricity used by data centers is unnecessary, such as electricity used to generate "AI slop" and electricity used for mining proof of work cryptocurrencies.[176] Additionally, electricity used for computing should be deployed as efficiently as possible. But if U.S. electricity demand continues to increase despite those efforts, decision-makers must ensure that new generation is powered by clean, renewable sources like solar, wind and geothermal.

Building new renewable energy generation is happening quickly but connecting that power to the grid with new transmission and distribution infrastructure is taking years. When a company wants to build a new solar farm or wind farm, it needs to be added to an "interconnection queue" with the regional grid operator. In recent years, these interconnection queues have been increasing nationally, slowing down the additions of new renewable electricity generation to the grid. In addition to interconnection challenges, Rhodium cites local opposition to the siting of renewable energy facilities, long permitting processes, and lack of equipment availability as barriers that are hampering deployment.[177]

To ensure that any new demand is met with 100% clean, renewable energy sources, governments should adopt policies that reduce these supply chain headwinds and accelerate the completion of new clean energy projects. Governments should require grid operators to conduct long-term planning for transmission and distribution and reduce permitting obstacles while ensuring safety and protecting the environment.

Conclusion

Much of the public conversation around data center energy use — even among environmentalists and conservationists — has focused on the question: How can we grow in the right way?[178] This framing assumes that data center growth is inevitable, necessary and universally beneficial if the demand is met with clean energy. But everything comes at a cost, even clean renewable energy. "The cloud" isn't an amorphous entity that takes up no space or resources. It manifests itself in the form of massive data center complexes that consume water and electricity every hour of the day, and perhaps next door, a power plant emitting greenhouse gases that jeopardize the transition to clean energy.

Much of this electricity demand is being driven by hype, bad policy and inefficient applications of AI and cryptocurrency technology. These new energy-intensive computing practices are not always a beneficial use of resources, even if the electricity data centers use comes from clean renewable sources. Furthermore, projections for future growth in the sector vary dramatically and are highly uncertain. The media hype and hasty reaction from the utilities (reopening retired fossil fuel and nuclear power plants, planning new fossil fuel infrastructure that may not be needed) seems haphazard.

This problem must be framed differently: Is growth for data centers necessary? How does it improve our lives? Can it be minimized? And finally, to the extent that it is necessary and beneficial, how can growth happen in a sustainable way?

Legislators should first limit the growth of data centers to prevent the electricity shortfalls being projected by utilities. To meet increased electricity demand to power beneficial uses of computing, lawmakers should focus on making data centers more efficient, increasing the transparency of data center resource use and accelerating clean renewable energy projects to meet the increased demand.

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