U.S. House Committee on Energy and Commerce
Subcommittee on Energy, Climate, and Grid Security
"Powering AI: Examining America's Energy and Technology Future"
[June 4, 2024]

1. Report from The Honorable Tony Clark entitled "What Happens When A Nuclear Plant And A Data Center Shack Up?" April 2024, submitted by the Majority.
2. Letter to Chair Rodgers and Ranking Member Pallone from The Williams Companies, Inc., June 4, 2024, submitted by the Majority.
3. Article from the Financial Times entitled "AI's thirst for electricity risks slowing US coal phaseout" May 30, 2024, submitted by the Majority.
4. Article from Utility Dive entitled "Duke to offer expanded suite of clean energy options to Amazon, Google, other large customers" May 30, 2024, submitted by the Majority.
5. Letter to Chair Duncan and Ranking Member DeGette from the Digital Energy Council, June 4, 2024, submitted by the Majority.
6. Report from the EFI Foundation entitled "Managing Unprecedented Electricity Demand Growth on the Path to Net Zero Emissions" April 2024, submitted by the Majority.
7. EPRI White Paper entitled "Powering Intelligence: Analyzing Artificial Intelligence and Data Center Energy Consumption" 2024, submitted by the Majority.
8. Letter to the Energy and Commerce Committee from Neste, June 4, 2024, submitted by the Majority.
9. Letter to Chair Duncan and Ranking Member DeGette from Hugging Face, May 31, 2024, submitted by the Majority.
10. Letter to Chair Duncan and Ranking Member DeGette from TechNet, June 3, 2024, submitted by the Majority.
11. Article from the Wall Street Journal entitled "There's Not Enough Power for America's High-Tech Ambitions" May 12, 2024, submitted by the Majority.
12. Article from Utility Dive entitled "AEP Ohio proposes data center, crypto financial requirements amid 30 GW in service inquiries" May 15, 2024, submitted by the Majority.
13. Letter from American Clean Power, May 20, 2024, submitted by Rep. Peters.
14. Letter from the Clean Energy Buyers Association, May 20, 2024, submitted by Rep. Peters.
15. Letter from the Electricity Customer Alliance, May 20, 2024, submitted by Rep. Peters.
16. Letter from the Zero Emission Transportation Association, May 20, 2024, submitted by Rep. Peters.
17. Article from Latitude Media entitled "Microsoft says Georgia may be overestimating data center load growth" April 12, 2024, submitted by Rep. Barragan.
18. Letter from transformer coalition, April 22, 2024, submitted by Rep. Schrier.

APRIL 2024

WHAT HAPPENS WHEN A NUCLEAR PLANT AND A DATA CENTER SHACK UP?

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The runaway appetite of data centers for electricity, supercharged by the prospects for AI, is producing staggering forecasts for generation and transmission expansion. This comes alongside other new demand, such as the resurgence of onshore manufacturing and the electrification of heating and transport. At the same time, environmental policy is hastening the retirement of fossil-fueled power stations and the resources lining up to replace them are inadequate in capability, insufficient in number and stuck in lugubrious interconnection processes.

Considering the disquieting mathematics of expected supply to meet forecasted demand, policymakers need to take a hard look at data center interconnections. We cannot and should not use regulation to prevent the interconnection of data centers. But policymakers should examine how data centers are coming on-line. Most have connected in the traditional manner – as retail load, served off the distribution system. A more recent approach involves the colocation of data center campuses with dedicated generation "inside the fence."

Colocation models can involve the promise of developing new generation to supply an accompanying data center campus. This raises the interesting prospect of demand spurring innovation and investment in new purpose-built generation, such as small modular reactors or hydrogen fueled solutions, and for self-sufficient microgrids to support accelerating data center load. Exciting, no doubt, but still more theoretical than immediate reality.

What "colocation" means today - in the present time - is the development of data center campuses adjacent to existing plants, particularly existing nuclear power stations. The campus is designed to tap directly into the plant. This affords the data center a dedicated, time-matched source of zero-emission supply and service which, arguably, is more reliable than a grid-connected configuration.

So, what's not to like? Before examining that question, note that the model of colocated campuses at existing nuclear stations is happening in RTOs, and not at non-RTO facilities like Brown's Ferry, Vogtle or Turkey Point – even as Tennessee, Georgia and Florida themselves see notable data center load growth. Not a coincidence, we'd argue. Powerful economic incentives in RTO regions work to motivate data campuses to colocate with existing nuclear plants and skip the path of slow, messy and more expensive grid interconnection.

Policymakers and regulators in RTO regions must examine closely whether incentives inherent to organized markets are inviting a model of colocation that (i) results in unfair rate impacts to consumers, (ii) challenges reliable system operations, and (iii) promotes a "shell game" for marketing rights around zero-emission electricity.

THREE ECONOMIC INCENTIVES

The leading examples of data center/nuclear colocation involve plants participating in RTO markets and owned by non-utility merchants - operators not tied directly to retail customers and ones whose fortunes depend on RTO wholesale market prices. Until recently, these markets struggled to retain installed nuclear and insufficient market revenue resulted in several plants retiring. What a difference a couple of years makes. Palisades, which shuttered in Michigan just two years ago, is well on its way to an historic return. Talen emerged from bankruptcy just last year. And merchant operators Constellation and Vistra enjoy stock prices that are presently soaring. But it's not as if the RTOs important to these nuclear operators, like PJM, have fixed their markets to start paying these plants a living wage. For example, in 2023 average energy prices (LMP) in PJM decreased 61.2% from 2022. PJM's market monitor reports this was the largest annual price decrease ($49.06 per MWh) and the largest annual percentage price decrease since the creation of PJM markets in 1999.

So, while the RTO market is an important predicate to the recent success of these operators, something other than market performance (i.e, the price outcomes in these markets) is at work to explain their dramatic turnaround. This "something" can be understood by examining (i) federal and state clean energy subsidies and programs, (ii) their impact on both wholesale prices and retail prices in RTO regions, and (iii) how they combine to create powerful economic incentives which drive a merchant nuke to cohabitate with a data campus.

1. Volatile and Generally Suppressed Wholesale Market Prices

As mentioned, prices in RTO markets are broken. Average energy and capacity prices are artificially low due to the penetration (through subsidy and support) of zero-marginal cost resources. Allowing these price taking resources to participate in price formation suppresses clearing prices because their uneconomic entry effectively moves the supply curve to the left.

Merchant nukes live or die based on what the RTO's wholesale market pays them for energy, capacity and grid services. That is, unless they can find other, non-market sources of revenue. One such opportunity, a power purchase agreement (PPA), looks increasingly appealing to nuclear operators in RTO markets. Not only does a PPA offer the seller a higher average price than what the market would deliver, it offers a certain price - one not subject to the volatility of the RTO's wholesale electricity markets. Particularly for publicly traded operators, this certainty can be transparently communicated to investors whose valuation of the company's stock is otherwise discounted on account of uncertain price outcomes in RTO markets.

2. The Nuclear PTC Under the IRA and State Zero Emission Credits

Usually, however, the seller under a fixed-price PPA must worry that prices in the RTO's wholesale market might rise and its fixed-price PPA commitment becomes an out of the money liability. Not really a concern for operators in RTO markets as it turns out, because this risk is fully hedged by virtue of the nuclear PTC under the IRA and by retail ratepayers (in some jurisdictions) providing ZECs. But there's more! Not only is the downside risk to the nuclear plant now covered, the upside which can take the form of PPA revenues or RTO market revenues (realized by that portion of the plant which remains grid-connected) and which may exceed the returns necessary to maintain the financial health of the plant as a whole, can be retained usually without offsetting any of the value of the PTC or ZEC subsidy.

Okay, so low RTO wholesale market prices and the raft of recent legislative support enabling nuclear plant owners to lock in a floor price that creates the condition for nuclear PPAs. These two incentives explain why contracting outside the RTO's markets may be attractive to sellers of nuclear energy. These arrangements, however, can be done financially without actually pulling nuclear MWs and MWhs off the grid. In RTOs, where a nuclear plant and data center physically shack up, we're seeing a third incentive at work – this one motivating the behavior of the buyer.

3. Avoiding Costs - Some that were once Manifest in RTO Wholesale Markets but now Appear in Downstream Retail Markets

A customer that colocates avoids "wires charges" – the fixed costs of the poles, wires, transformers and substations that comprise the transmission and distribution network. These costs are increasing and the call for massive investment in grid infrastructure to support the energy transition, harden the grid from extreme weather, physical and cyber vulnerabilities and replace aged infrastructure, only promises further escalation.

Less obvious are other non-bypassable charges that show up in the retail bill. These charges support state programs whose costs in the past were relatively modest – such as low-income assistance or energy efficiency weatherization – but now represent a significant percentage of the cost of delivered energy because they serve to fund RECs, and ZECs and other subsidy programs for clean energy and advanced technologies. These charges are tied to the bill from the local distribution utility. So, avoiding this utility by colocating allows the customer to bypass supposedly non-bypassable charges.

Even less obvious is that, because the widely accepted "missing money" problem in RTO energy market is worsening (on account of the price suppression discussed above), costs that should be manifest in wholesale energy market prices, are being reconstituted (to some degree) by RTOs as transmission or capacity market costs or other operating charges that for various reasons are not captured in LMP. These charges collectively are significant and go by various names such as uplift, conservative operations, operating reserves, start-up, no-load and reliability must run costs.

And guess what? All these costs, along with a share of administrative costs to fund the RTO, NERC, FERC, etc., are also allocated by the RTO to the local distribution utility, and passed through in retail rates, alongside wires charges and other non-bypassable charges.

For states that have adopted full utility restructuring and retail open access, this presents an acute problem. When policies work to suppress wholesale electricity prices and correspondingly inflate retail costs for delivered electricity, there's simply not much left for retail suppliers to compete over or to motivate retail customers into switching suppliers. But what will excite a customer is a power supply arrangement that allows it to avoid altogether the retail utility and, in so doing, bypass this burgeoning bucket of supposedly non-bypassable charges.

So, it takes a unique confluence of incentives and unintended consequences to create conditions supporting inside-the-nuclear-fence load. Nuclear units that operate outside of RTOs and those that remain part of a regulatory framework where the investment is dedicated to franchised customers who in turn pay cost of service rates are unlikely candidates for colocation strategies. And beyond data centers, it takes imagination to envision other energy-intensive operations (such as electric arc furnaces or smelters) finding a way to colocate with existing nuclear facilities. So, while this phenomenon might have a limited runway, it would be a mistake for policymakers, regulators, and retail customers in RTO regions to dismiss it as no big deal. We see three areas that call for inquiry.

QUESTIONS ARISING FROM COLOCATION

1. **Economics and Fairness**

Once energy and capacity is dedicated to serve inside the fence load it's removed from the RTO's wholesale energy and capacity markets.[1] Losing these resources from the supply stack increases clearing prices for grid-connected customers. These supply and demand economics don't change when the data campus is connected to and served by the grid. But the traditional approach to load interconnection comes with greater transparency and established regulatory processes that permit policymakers, customers and other stakeholders to understand and debate the impact of these interconnections.

For example, in Virginia, the proposal to meet grid-connected data center growth through both new natural gas generation (such as Dominion's 1000MW Chesterfield County project) and new large transmission projects in the mid-Atlantic is spawning debate at PJM, in Richmond and at FERC. Here consumers, environmentalists and neighboring states are raising questions of burden and debate the allocation of these burdens, including costs that will fall outside of Virginia and on consumers in other PJM states.

The debate and processes that characterize traditional grid interconnection stand in marked contrast to the essentially unregulated connection of colocated load. This opacity impedes policymakers from weighing the public interest in say, the equity in having a specific data campus industrial rate schedule, or the pros and cons of tax or economic development incentives to attract data center investment, or possibly regulating energy efficiency standards or requirements for back-up generation required from data center customers.

But the real cost shift occasioned by colocation goes back to the wires and so-called "non-bypassable" charges discussed earlier. Let's illustrate using simple but representative rate estimates. Assume a typical rate on file for a utility to serve a grid-connected data center at retail in the mid-Atlantic is $0.08 per kWh. Average energy prices (LMP) in PJM in 2023 according to the IMM's State of the Market Report came in around $0.03 per kWh.

[1] In PJM, situations where the nuclear plant can assure that its inside the fence customer will be immediately curtailed if the plant goes off-line raises a question whether the inside the fence load is "consuming" capacity from the plant. This engenders debate over the metaphysical definition of capacity. PJM's position is that the plant cannot sell its full MW capacity value into PJM's auctions and must account for the portion that has already been "sold" bilaterally to the colocated load. Some operators disagree and would prefer to continue fully participating in PJM's capacity market as they have done historically, essentially asking the RTO to close its eyes to the huge data campus that has sprung up inside its fence.

Even accounting for historic LMP variability and the wholesale seller's lost revenue opportunities (as could be realized in the RTO's capacity and ancillary service markets) the chasm separating 8 cents from 3 cents shows how both nuclear seller and data campus buyer are driven to form a PPA priced somewhere in the middle.

Some significant portion of this 5-cent differential represents wires costs and other non-bypassable charges that are fixed and must therefore be shifted to grid-connected customers. This cost shift should be accepted, so the argument goes, because colocating means the data campus doesn't use the grid and thus, shouldn't have to pay for it.

Going off-grid does not justify avoiding most non-bypassable charges. Because retail electric rates serve as a convenient funding and collection mechanisms for programs that have no relationship to distribution and transmission itself, the non-bypassable charges resulting from these programs are distinct from actual "wires charges" and equity demands they be borne by all electricity consumers. But the case is also strong to charge actual "wires charges" to colocation customers. It's hardly the case that colocation occurs without impact to the grid – impact that causes expensive infrastructure additions. We'll turn to these impacts below – but for the moment, consider PJM's recently approved $5 billion grid expansion plan, much of it driven by data centers in Northern Virginia coming on-line in the traditional grid-connected configuration. Does anyone believe the transmission needs identified by PJM would go away or cost materially less if each of these data centers had found a way to colocate?

Colocation, simply stated, subsidizes the data campuses involved. The arrangement will create needs for new transmission and generation and other customers, including those competitor data centers interconnecting the old-fashioned way, will be stuck paying the full tab left behind by the cohabitating couple.

2. **Reliability**

The interstate transmission grid was planned and developed over the past century to support the delivery of fossil and nuclear plants to load centers. The retirement of fossil plants, and their replacement with renewable generation that performs differently and requires different support from the transmission network, present reliability challenges that NERC and system operators are voicing with increasing volume and alarm.

On the heels of fossil retirement, now comes data center colocation with existing nuclear. Of course, colocation doesn't result in the retiring of the nuclear plant. But from the perspective of the system operator, charged with maintaining operational security and resource adequacy, the effect isn't much different. When a nuke dedicates output to inside the fence load, it deprives the system operator of a resource it otherwise would rely on to serve grid customers, provide grid services to support delivery of electricity and serve as capacity to meet resource adequacy requirements.

It's not apparent sufficient efforts, such as rigorous load flow modeling, have been undertaken to study what happens to a transmission network when resources it was designed to deliver are physically disconnected from the network. But common sense says it will spur yet more demand for new transmission infrastructure to replace the inertia/frequency response, stability and voltage support the nuke previously provided.

And, of course, there's no escaping the need for simply more generation to replace what's lost due to the colocation arrangement. New demand, both grid-connected or inside the fence, will pressure existing infrastructure and create the need for new supply. But the trending towards colocation tells us that it's quicker and easier to build a data campus with inside the fence interconnection facilities to existing generation, than it is to build the new generation and transmission needed to support the data center if it were to interconnect in the more traditional manner. This raises obvious cost allocation and fairness questions.

3. **The Zero-Emission Shell Game**

Finally, colocation feeds the myth of the "sustainable" data center. Connecting a 500 MW data campus to siphon 500 MWs from an existing nuke isn't reducing system emissions or advancing decarbonization goals. It merely kicks the carbon can down the road.

Colocation may make data center owners and their users feel good about their individual carbon footprints. But their action has just made the carbon picture of the rest of the system worse, and the total system no better. And unless the capacity lost to the system from colocation is replaced with new nuclear or the almost unimaginable equivalent of wind/solar/storage and transmission (or some breakthrough new zero emission technology), then when all is said and done, interconnection of the data campus has increased carbon emissions.

WHAT SHOULD POLICYMAKERS DO?

Ideally, we would fix price formation in RTO markets to remove the incentives driving merchant nuclear owners toward colocation. This is a herculean task, complicated by steps already taken by policymakers at both state and federal levels providing powerful financial support and subsidy for zero-emission generation, distorting RTO markets and suppressing RTO revenues to all sellers.

Looking downstream from the RTO, colocation still involves a retail sale. State regulators therefore have some ability to regulate the terms and conditions of this sale. This creates the possibility to reimpose on the data center many of the non-bypassable charges that have been bypassed. State lawmakers would need to examine their individual regulatory regimes to determine how extensive such regulation could be and whether it would be sufficiently effective to avoid cross-subsidization or undue cost shifts between customers.

One action that would effectively deter colocation would be to eliminate the federal PTC and accelerate the expiry of state ZECs for any portion of nuclear capacity dedicated to inside the fence load. Through these support mechanisms, the public has already purchased the environmental attributes of the plant. It can be argued that once this plant is severed from the grid, and thus no longer "in the public service" so to speak, the burden of paying for zero-emissions should shift from the public to the inside the fence customer. Preserving these incentives for grid-connected nuclear generation and future colocation arrangements that couple new zero-emission resources with dedicated load would encourage an equitable and truly carbon progressive form of colocation.

CONCLUSION

Let's be clear, we can't afford to lose any nuclear plants due to suppressed RTO wholesale market prices. Neither are we casting stones. The firms entertaining these arrangements are making rational economic decisions based on the incentives imbedded in the regulatory and policy structures in which they operate. But asking tax and ratepayers to support these plants only to see them excuse themselves from the supply stack and, in so doing, leave a complicated mess of cost and reliability burdens at the feet of these same tax and ratepayers seems facially unfair. And that's before even considering the distortions arising from the convergence of different policies that unintentionally result in subsidies to data campuses and financial windfalls for merchant nukes.

The early naivete that led many to think costs to transition to a decarbonized grid would be modest, is giving way to a more sober appraisal informed by real world experience. With this context in mind, policymakers should scrutinize how data campus load is coming on-line. If affordability, reliability and fairness across customer classes are still duties of regulators and lawmakers – and they are – then the nuclear/data campus colocation arrangements presently underway in RTO regions should be sparking heated debate as to what's in the public interest.

WE MAKE CLEAN ENERGY HAPPEN®

June 4, 2024

The Honorable Cathy McMorris Rodgers, Chair
Committee on Energy & Commerce
United States House of Representatives
2125 Rayburn House Office Building
Washington, D.C. 20515

The Honorable Frank Pallone, Ranking Member
Committee on Energy & Commerce
United States House of Representatives
2125 Rayburn House Office Building
Washington, D.C. 20515

Dear Chair McMorris Rodgers and Ranking Member Pallone:

We commend House Energy and Commerce Committee Chair Cathy McMorris Rodgers and Energy, Climate, and Grid Security Subcommittee Chair Jeff Duncan for holding a hearing, "Powering AI: Examining America's Energy and Technology Future." As a trusted energy industry leader, Williams is committed to safely, reliably, and responsibly meeting the nation's growing energy demand. We use our 33,000-mile pipeline infrastructure to move a third of the nation's natural gas, each day, to where it is needed most, supplying the energy used to heat our homes, cook our food, and generate low-carbon electricity.

As you know, electricity demand is experiencing three times faster growth per year this decade than what we have seen in prior decades, driven by increasing electrification, the emergence of new, large-load data centers, and a growth in manufacturing. Data centers alone present a challenge, which is projected to add nearly 30 gigawatts (GW) of electric demand by 2030.[i] This increase in growth reflects a major opportunity for our country and underscores the need for more natural gas infrastructure to keep up with this growing demand. A comprehensive solution that includes holistic reforms to all federal infrastructure permitting will help America realize a lower-carbon future while still satisfying the country's energy needs.

Natural Gas = Reliable, Affordable, and Clean

As a country, we can proudly say that the United States is the leader in emissions reductions and clean energy innovations. Between 2005 and 2023, the technological advancements occurring as part of the "Shale Revolution" resulted in significant increases in natural gas production and significant decreases in carbon dioxide emissions. In fact, the shift to natural gas generated electricity reduced energy-related carbon dioxide emissions nationally by unprecedented levels. There were 860 million metric tons of emissions reductions in the U.S. electric power sector from 2005-2021. Sixty percent, or ~500 million metric tons, of this reduction was from coal-to-gas switching, a reduction equivalent to ~111 million gasoline-powered passenger vehicles taken off the road for one year.

U.S. energy-related carbon dioxide emissions decreased another 3 percent in 2023, with over 80 percent of those emissions reductions coming from the electric power sector's increased use of natural gas and solar.[ii]

When power grid regulators assign capacity factors to natural gas, they assign nearly 100 percent of nameplate capacity to dispatchable natural gas but only 10-30 percent to variable solar and wind.[iii]

And power grid regulators rely on natural gas capacity up to 3.5 times more, on average, than wind and solar capacity when planning for future demand needs.

To state the obvious, it will not be possible to increase reliance on intermittent wind and solar power without a solid foundation of dispatchable natural gas power.[iv]

When looking at carbon neutrality goals, especially those set by states, it is important to understand what it would take to reach 100 percent electrification through wind and solar generation only – and how much such an electrification pathway would cost citizens.

For example, The Climate Act requires New York to reduce economy wide GHG emissions 40 percent by 2030 and 85 percent by 2050 from 1990 levels.[v] To replace the energy supplied by natural gas to New York's homes and businesses in February 2023 alone, New York would need 285 times more utility scale solar installations than the state had in 2022 and enough solar panels to cover 549,000 football fields – and it would require $1 trillion in solar construction costs.

John Howard, long-time state employee who served in the Cuomo Administration and as the energy advisor for then-Assembly Energy Committee Chair, Paul Tonko, recently questioned New York Governor Kathy Hochul's Climate Plan due to its "near total lack of transparency on how much each of us will have to pay to finance [climate] mandates."[vi]

While wind and solar and other low-carbon sources have an important place in our energy mix, they are intermittent and cannot be implemented or accelerated, nor can electrification occur, without natural gas as a reliable complement. And natural gas cannot play this vital complementing role without supporting infrastructure.

Natural Gas Can Meet Soaring Energy Demands from Data Centers, AI

The electrification of heating, transport, data centers, and an AI-driven future will create growth in power demand not seen in the past two decades – three times faster growth per year this decade than the previous one. According to *The Wall Street Journal*, projections in power growth "come after efficiency gains kept electricity demand roughly flat over the past 15 years…"[vii] *The Washington Post* notes that a major factor behind the skyrocketing demand is the rapid innovation in artificial intelligence (AI), which is driving the construction of large warehouses of computing infrastructure that require exponentially more power than traditional data centers.[viii]

These data centers will drive strong regional growth in baseload and peak power demand, as they tend to operate around-the-clock, a tailwind for natural gas, wind, and solar demand. Energy expert Robert Bryce notes that "Microsoft's electricity use has tripled since 2018…now using more electricity than Iceland, a country that's renowned for its carbon-free power grid."

While there are already numerous data centers operating across the country, more are being planned, especially in Texas, on the East Coast, and the Northwest. These centers' power demand needs are projected to approach 46 GW by 2030, 2.3 times higher than in 2023 alone, requiring as much as 4 Bcf/d of incremental natural gas demand. To put that in context, Williams' Transco pipeline that extends along the East Coast from Texas to New York currently has 19.5 Bcf/d of delivery capacity.[ix]

The pipeline system is fully subscribed by our transportation customers, which is notable, particularly for a system of this size.

Expansion of infrastructure along our Transco system provides the ability to continue to meet peak demand of our customers and serve growth to fill the large power generation resource need with natural gas.

We are currently progressing seven growth projects along this system to bring delivery capacity to over 21.2 Bcf/d, representing approximately 20 percent of Lower 48 natural gas demand in 2022.

While there is a push to meet this growing demand with wind and solar, natural gas plays a crucial role in creating resilient data centers by providing a reliable source of baseload power and quick response backup power when needed, compared to solar and wind, which provide intermittent power.

Onshoring Manufacturing Requires Affordable, Reliable, Baseload Power

In recent years, there has been a significant shift for manufacturers to "onshore" or "reshore" plants, factories, and jobs back to the United States. The COVID-19 pandemic exposed our over-dependance on foreign supply chains and significant legislation urged companies to invest in onshoring their operations.

Federal incentives to boost funding for onshoring manufacturing projects include $15 billion from the Inflation Reduction Act (IRA), $50 billion from the CHIPS and Science Act, and $370 billion from the Infrastructure Investment and Jobs Act. A recent article in *Construction Dive* cites TSMC's $40 billion plan in Arizona, Micron's $100 billion investment in New York, and Texas Instruments' $11 billion semiconductor plant in Utah as "megaprojects" being built here in the U.S. to take advantage of tax incentives from these new laws.[x] The fastest growing manufacturing markets are in the Sun Belt, near large ports of entry or distribution – largely to accommodate growth in the electric vehicle industry and the semiconductor industry.[xi]

American-produced natural gas that can be safely and reliably transported from the wellhead to the manufacturing floor supports our competitiveness. As The Natural Gas Solution explains, "the price of energy – from the electricity needed to run a factory to the [gasoline] powering the delivery truck – impacts the final cost of every item you purchase."[xii]

Our country's plentiful supply of natural gas supports jobs and gives U.S. energy-intensive manufacturers an advantage over foreign competitors. In 2016, the National Association of Manufacturers (NAM) estimated that total natural gas demand is expected to increase by 40 percent over the next decade, with the manufacturing and power generations sectors driving that need.[xiii] That was before passage of the IRA, CHIPS and Science Act, and the Infrastructure Investment and Jobs Act – and well before recent talks about growing needs for data centers to support AI and technological growth.

Natural gas is also used for petrochemical manufacturing, which is necessary for plastics, fertilizers, synthetic fibers, cosmetics, and medicines. Last year, the American Chemistry Council reported that U.S. chemical industry investment linked to natural gas is over $200 billion, due to natural gas and its plentiful supplies and ability to support chemical manufacturers' emissions reductions efforts.[xiv]

Natural Gas Pipeline Capacity is Required for Power Needs
U.S. power demand expectations are repeatedly underestimated by forecasters. For example, since 2015, forecasts such as the U.S. Energy Information Administration (EIA) have repeatedly underestimated the year-ahead gas demand in the power sector by about 3 Bcf/d, on average. In 2022, forecasters dramatically missed annual demand by a whopping 24 percent.

Some of Williams' largest customers have made the following predictions about the continued and increased need for electricity:[xv]

- Georgia Power says its current load growth projections are 17 times higher than what was forecasted in 2022. This will require a mix of energy sources, including additional gas-powered generation.

- A report from Duke Energy indicates that North Carolina and South Carolina together are experiencing eight times the load growth they projected just two years ago. Said another way, for every power plant built over the last 60 years, Duke would need to build half of that again in the next decade to meet expected demand.

- Dominion Energy also is forecasting power load needs from new data centers to grow 2.5 times over the next ten years in Virginia, already home to more than 35 percent of all hyperscale data centers worldwide, including facilities owned by Amazon, Alphabet, and Microsoft.

When building out energy infrastructure, plans consider peak volumes, not averages. And peak natural gas infrastructure providers and customers must plan for increasing peak demand needs for those extreme weather days or seasonal demand peaks, rather than for annual average volumes. Peak natural gas demand is increasing due to AI- and EV-driven electricity demand and intermittent wind and solar capacity, which tends to increase the variability and peaks for natural gas demand. Demand for natural gas has steadily grown, with a 6 percent increase in annual natural gas demand and peak day demand from 2022 to 2023. In July 2023, a new peak day record was set at 53 Bcf/d.

Lack of Adequate Pipeline Capacity Creates Price and Emissions Spikes During Peak Demand
There is a need for incremental gas capacity, or volume above technically available capacity at existing interconnection points between two market areas. In other words, there is a need to create new interconnection points to meet growing demands for natural gas. As prices in pipeline-constrained markets, such as New England and Chicago, continue to spike each winter with high demand, Southwest Pennsylvania prices tend to be more moderate, due to better pipeline access to abundant natural gas supplies from Appalachian natural gas basins.[xvi]

Additionally, the lack of adequate natural gas infrastructure leads to the use of more carbon-intensive fuels on peak days of demand. For example, during Winter Storm Elliott, when natural gas was infrastructure-constrained and wind and solar could not keep up, significantly more carbon-intensive fuels were added to meet power generation needs, which corresponded to a 42 percent increase in carbon dioxide emissions, due to the burning of fuels that are 2.5 times more carbon-intensive than natural gas.[xvii]

There is a growing need for reliable natural gas infrastructure investment, as demand for gas continues to grow, but the infrastructure being built to deliver that gas has not grown as quickly.

Specifically, natural gas demand has grown 43 percent since 2013, while infrastructure to deliver natural gas has only increased 25 percent. And notably, storage delivery capacity has only grown 2 percent. A streamlined permitting process would allow for faster and more cost-effective development of infrastructure.

The Need to Modernize our Nation's Permitting System

Williams is encouraged by the leadership of this committee to further bipartisan interest in reforming permitting processes for our nation's energy infrastructure.

Permitting reform is vitally needed for natural gas pipelines. Although it only takes six-to-nine months to build a pipeline across multiple states, the regulatory process that precedes such a project currently takes about four years. Virtually every pipeline project encounters costly and time-consuming delays due to duplicative permitting processes, a lack of cooperation between agencies, and inadequate judicial review standards.

We appreciate that this Committee's leadership remains committed to pressing forward with more comprehensive reforms. To that end, Williams strongly supports the targeted improvements to the Natural Gas Act that were included in H.R. 1, the Lower Energy Costs Act, introduced by Rep. Steve Scalise (R-LA), which passed the House with bipartisan support on March 30, 2023, and the SPUR Act S. 1456 (SEC. 3004 and SEC. 3011) which was introduced in the Senate and referred to the ENR Committee. Under these changes:

- No longer can a state use the Clean Water Act Section 401 process to wield a one-state veto of a critical interstate infrastructure project. Instead, a state can raise concerns about a project's water quality impacts as a participating agency under the FERC-led NEPA process: the proper forum to address potential concerns.

- FERC is authorized, based on state and EPA input, to include, in any order or certificate for a project, those terms and conditions that FERC finds necessary to ensure the project's compliance with applicable water quality requirements – provided the finding is supported by clear and convincing evidence. This includes the ability to remedy a state's water quality concerns.

- Long-standing NEPA case law is preserved whereby the NEPA lead agency must give due consideration to input from states and other participating agencies (the "hard-look" requirement).

- To address the problem of endless and often frivolous lawsuits, Section 3011 of the SPUR Act (Judicial Review) requires a reviewing court to remand any federal or state agency denial of a permit for an interstate pipeline project if the permit denial is not supported by clear and convincing evidence.

The Lower Energy Cost Act will unlock the Nation's full energy potential by eliminating inefficient bottlenecks in federal permitting and approval procedures.

Williams is a Committed Partner in Our Nation's Leadership Toward a Lower-Carbon Future

With its abundant natural gas supplies, the United States is perfectly positioned to move to a lower-carbon future that meets growing energy demands from electrification, data centers, AI, and onshoring manufacturing. Reforms to federal permitting and review processes will help us realize this future.

Williams appreciates the bipartisan and committed efforts of this Committee to further these issues for the benefit of the American people. We stand ready to be a resource and constructive, solutions-oriented partner.

Sincerely,

THE WILLIAMS COMPANIES, INC.

T. Lane Wilson
Sr. Vice President and General Counsel

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[i] https://www.williams.com/2024/03/05/natural-gas-is-powering-ai-and-ev-innovation/
[ii] https://www.eia.gov/todayinenergy/detail.php?id=61928&src
[iii] Data source: IHS North America wind and utility-scale solar PV fundamental REC values, June 2022
[iv] S&P Global Commodity Insights © 2024. Based on estimated U.S. annual average capacity values through 2040 for PV solar and onshore wind assigned by power grid regulators to assess reliability for future demand needs. Natural gas reliability based on PJM's assigned capacity credit for combined cycle for 2025/2026.
[v] https://www.nyserda.ny.gov/Impact-Greenhouse-Gas-Emissions-Reduction
[vi] https://www.timesunion.com/opinion/article/commentary-what-exactly-energy-transition-19448746.php
[vii] https://www.wsj.com/business/energy-oil/data-centers-energy-georgia-development-7a5352e9?mod=Searchresults_pos1&page=1
[viii] https://www.washingtonpost.com/business/2024/03/07/ai-data-centers-power/
[ix] https://etfdb.com/energy-infrastructure-channel/williams-wmb-golden-age-natural-gas/
[x] https://www.constructiondive.com/news/manufacturing-construction-onshoring-ancillary-projects/699500/
[xi] https://www.cbre.com/insights/briefs/us-industrial-market-benefits-from-rise-in-onshore-manufacturing
[xii] https://naturalgassolution.org/natural-gas-makes-u-s-manufacturing-competitive/
[xiii] https://nam.org/wp-content/uploads/2019/05/NAM_NG_Report_042816.pdf
[xiv] US Chemical Industry Investment Linked to Shale Gas Tops $200 Billion - American Chemistry Council
[xv] https://www.williams.com/2024/03/05/natural-gas-is-powering-ai-and-ev-innovation/
[xvi] Source: S&P Global Commodity Insights © 2024 Algonquin city-gates was used as the proxy for New England. Chicago city-gates as the proxy for Chicago. EGT South was used as the proxy for SW PA
[xvii] Williams Winter Storm Elliott Case Study

WE MAKE CLEAN ENERGY HAPPEN®

The need for reliability

Carbon neutrality goals call for ambitious renewables buildout

What it would take to electrify the NY res/com sector with solar on a peak day of demand

solar panels to cover

549K

football fields

which is

285x

more than NY state has today[1]

and would require

$1T

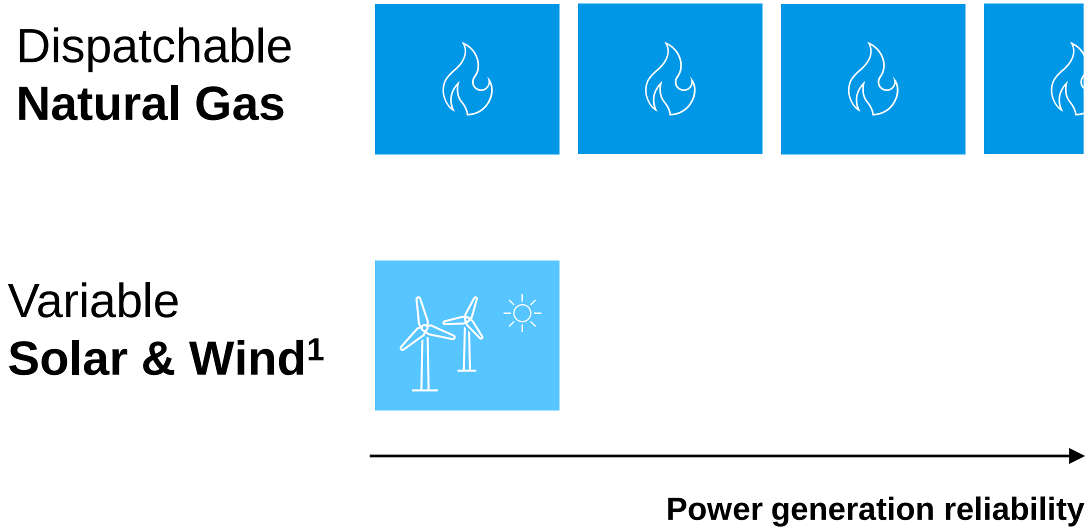
in solar construction cost

excl. transmission & distribution costs

Sources: Williams' analysis utilizing data from S&P Global Platts, US Energy Information Administration, Environmental Protection Agency and National Renewable Energy Laboratory. [1]To replace the natural gas Btus that NY state's residential/commercial customers used on 02/3/2023, it would take 285x more utility scale solar installations than the state had in 2022.

Dispatchable natural gas more reliable than intermittent renewables

Power grid regulators rely on natural gas capacity **up to 3.5x more**[1] on average than wind and solar capacity when planning for future demand needs



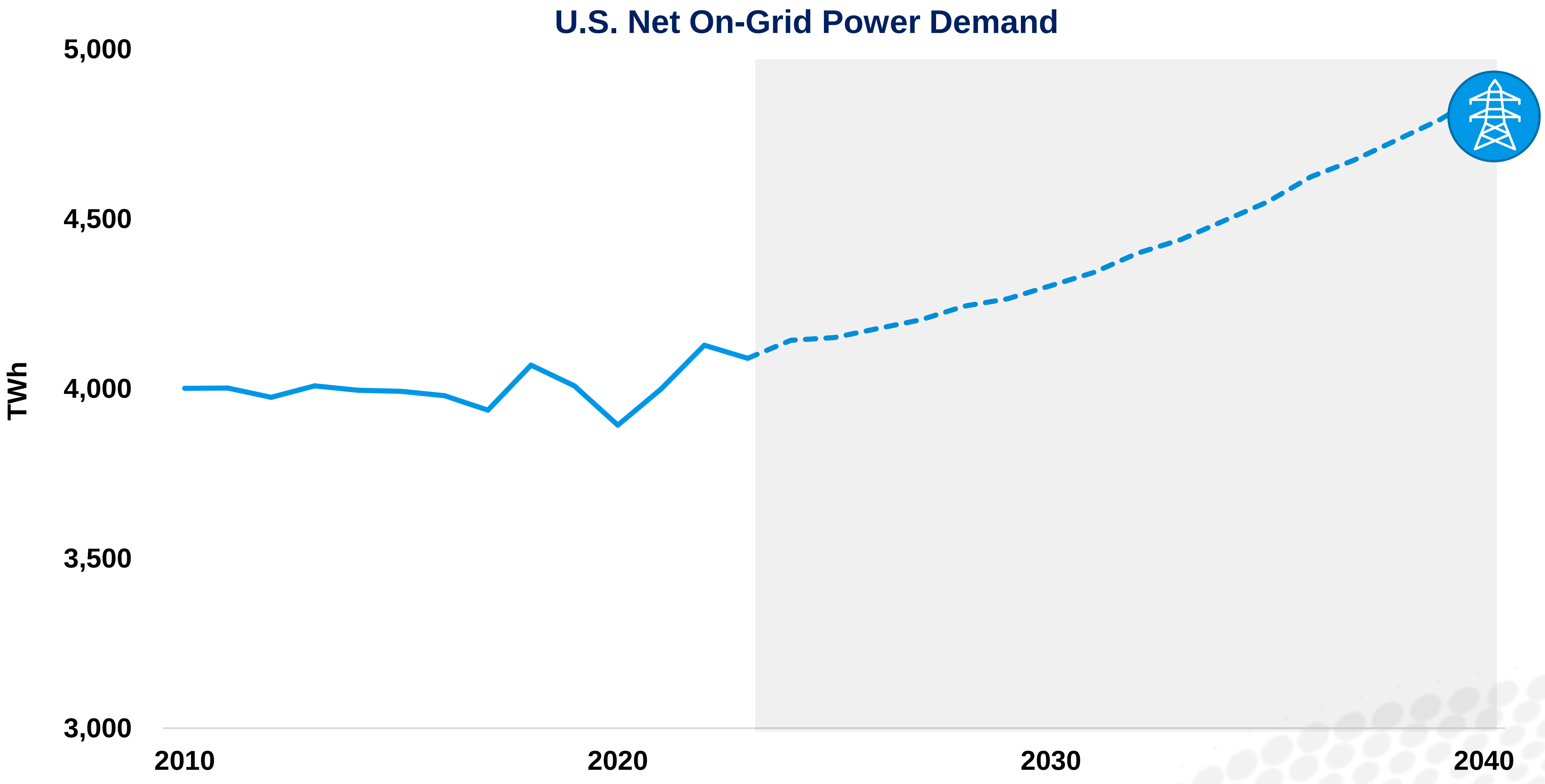
Natural gas capacity is quickly dispatchable and will be relied upon to backstop renewables during days of peak demand

Renewables have much lower reliability metrics due to the intermittent nature of wind and solar

Source: S&P Global Commodity Insights © 2024. [1]Based on estimated U.S. annual average capacity values through 2040 for PV solar and onshore wind assigned by power grid regulators to assess reliability for future demand needs. Natural gas reliability based on PJM's assigned capacity credit for combined cycle for 2025/2026.

Growing electricity demand requires additional backup generation

Electrification of heating and transport, data centers and AI-driven future will create growth in power demand not seen in past two decades



Electricity demand experiencing

▲ 3x

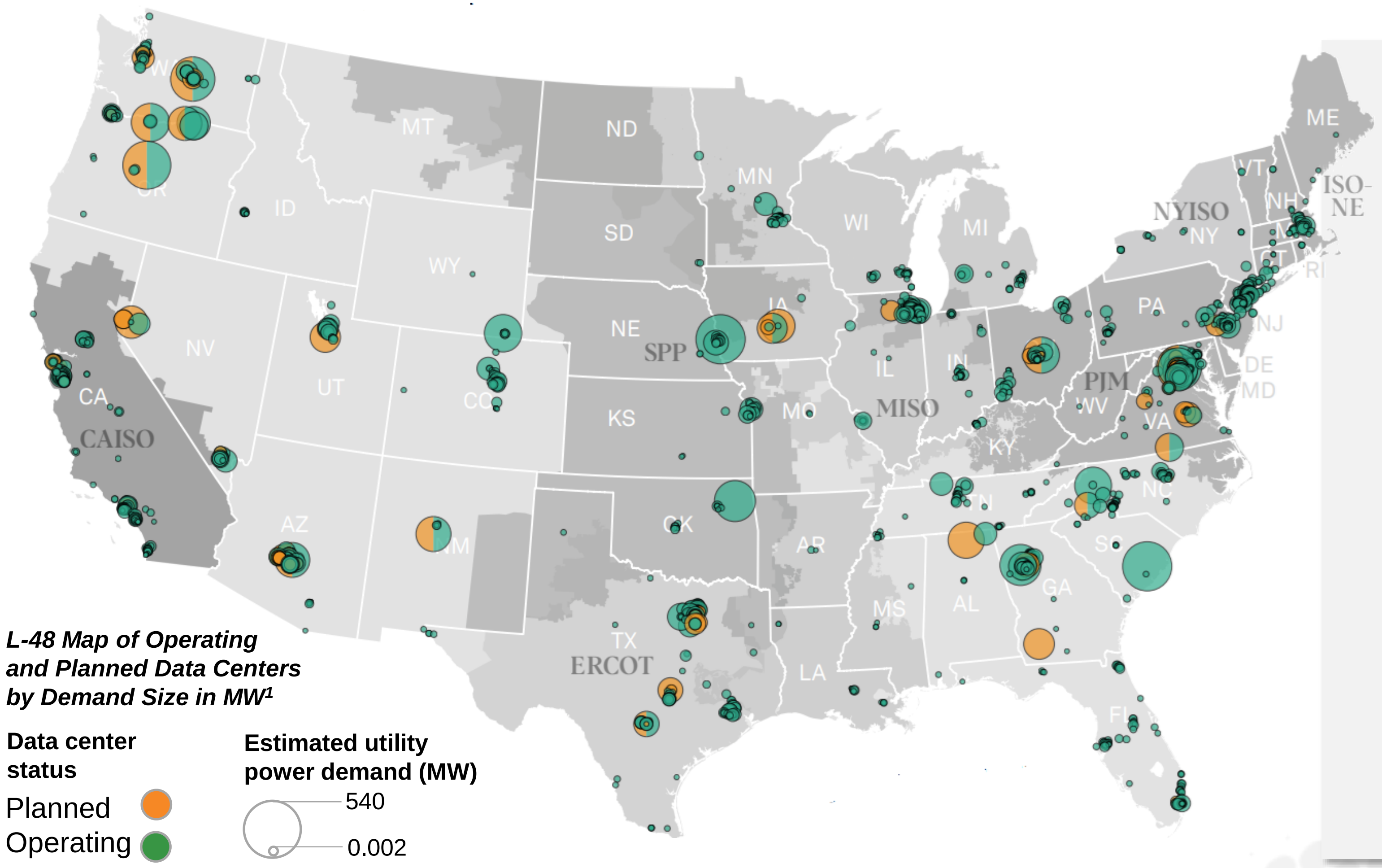
faster growth per year

this decade vs. prior decade driven by EV growth and emergence of large load data centers

Source: S&P Global Commodity Insights © 2024.

AI is expected to drive more power demand from data centers

Data centers will drive strong regional growth in baseload and peak power demand as they tend to operate around-the-clock, a tailwind for natural gas and renewables demand



L-48 Map of Operating and Planned Data Centers by Demand Size in MW[1]

Power demand needs from US data centers are projected to approach 46 GW by 2030,

2.3x

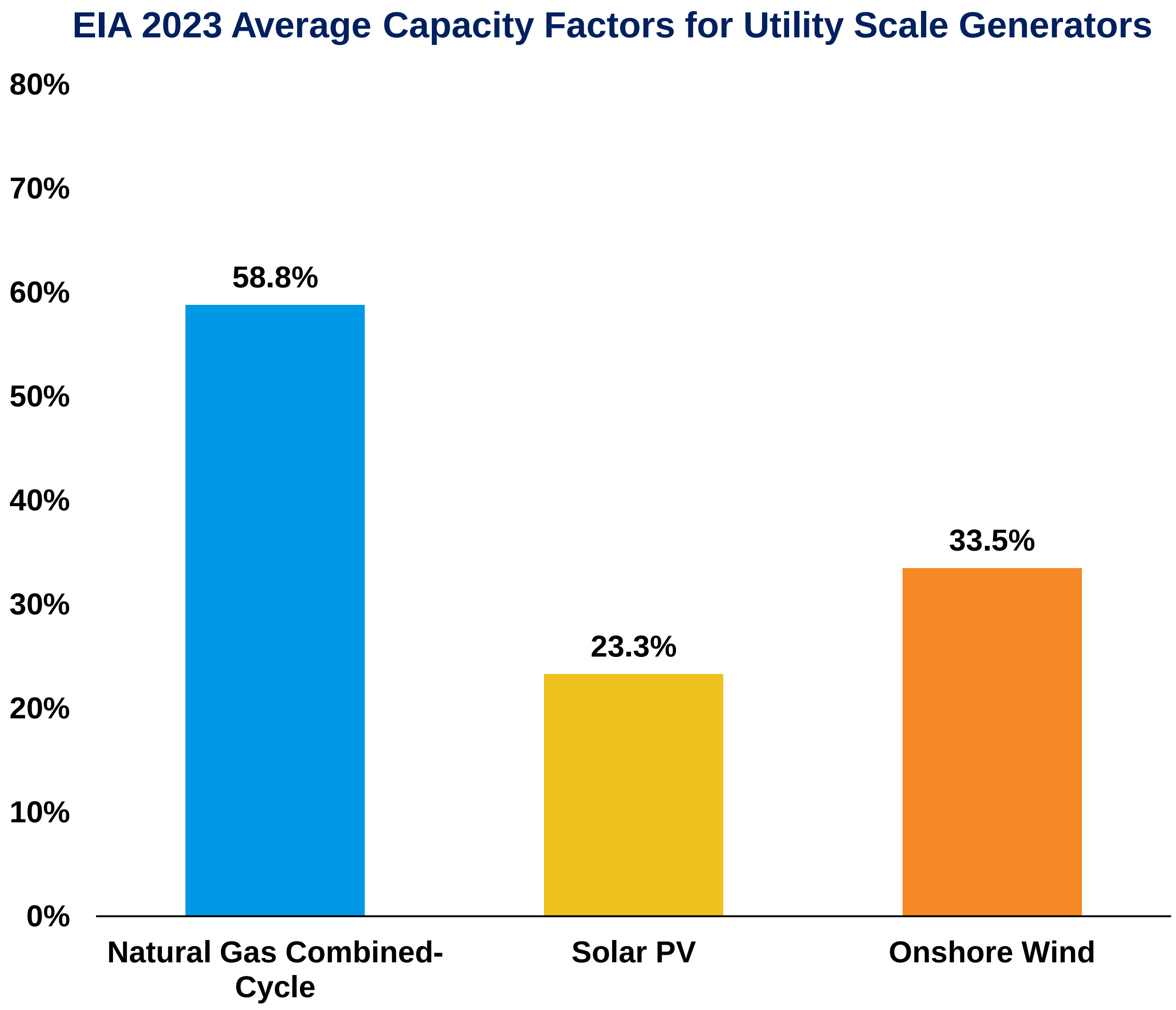
higher than in 2023[2], requiring as much as

4 Bcf/d

of incremental natural gas demand[3]

Sources: [1]As of Oct. 1, 2023. Power demand is based on total uninterruptible power supply data where known. If only net uninterruptible power supply power is known, figure was multiplied by 1.5 to account for estimated additional cooling power. If datacenter power supply was not available, it was estimated from total square footage. Data centers without square footage or power consumption figures were omitted from the analysis. Map image credit: Ciaralou Agpalo Palicpic. [2]Data center forecast is S&P Global Commodity Insights © 2024. [3]Williams Market Intelligence assumes all incremental demand US power demand from data centers is met by natural gas

Utilization rates for solar and wind power are comparatively lower than those of natural gas power sources



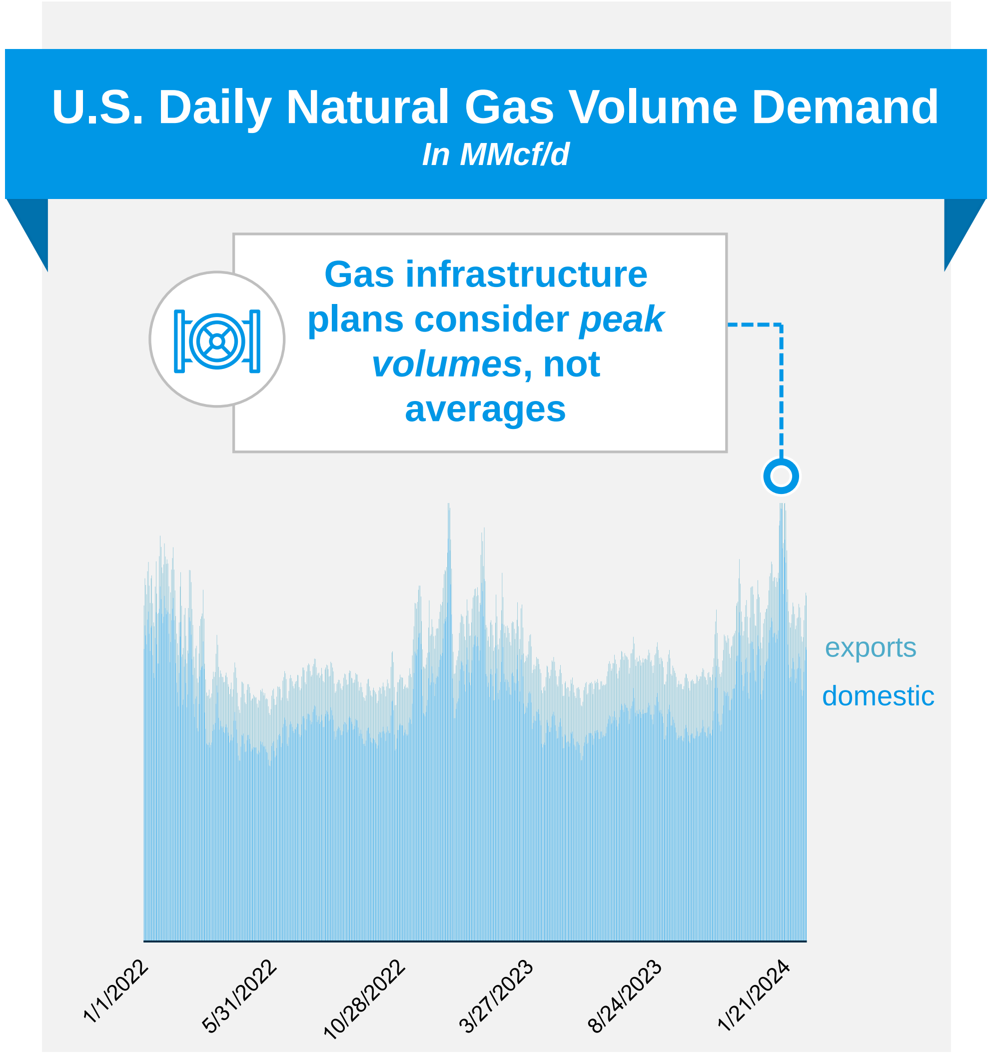
Source: U.S. Energy Information Administration (EIA)

The need for

reliability

- A power plant's **nameplate capacity** indicates its theoretical maximum electricity output
- A power plant's **capacity factor** is the ratio of the average output of a facility to its theoretical maximum output
- The capacity factor is not about how much energy a power plant can potentially generate, but **how consistently it produces energy over a period**
- A power plant with **100% capacity factor** means the power plant is producing electricity at its full potential all the time; however, this is **not operationally possible**
- The **lower the capacity factor, the less electricity that is generated**
- Because **solar and wind are variable** and reliant on weather conditions, the average energy produced over time is quite less than dispatchable natural gas

Natural gas pipeline capacity required to handle peak volume demand



Gas pipeline capacity required
for peak demand needs

Natural gas infrastructure providers and customers must plan for increasing **peak demand needs** for those extreme weather days or seasonal demand peaks rather than for lower annual average volumes

Peak natural gas demand is increasing due to AI- and EV-driven electricity demand growth, increasing intermittent renewables capacity and strong LNG export demand which tend to increase the variability and peaks for natural gas demand

Source: S&P Global Commodity Insights © 2024

US power demand expectations are repeatedly underestimated by forecasters

The need for reliability

Our natural gas pipeline contracted capacity is critical to ensure electric grid reliability on peak days

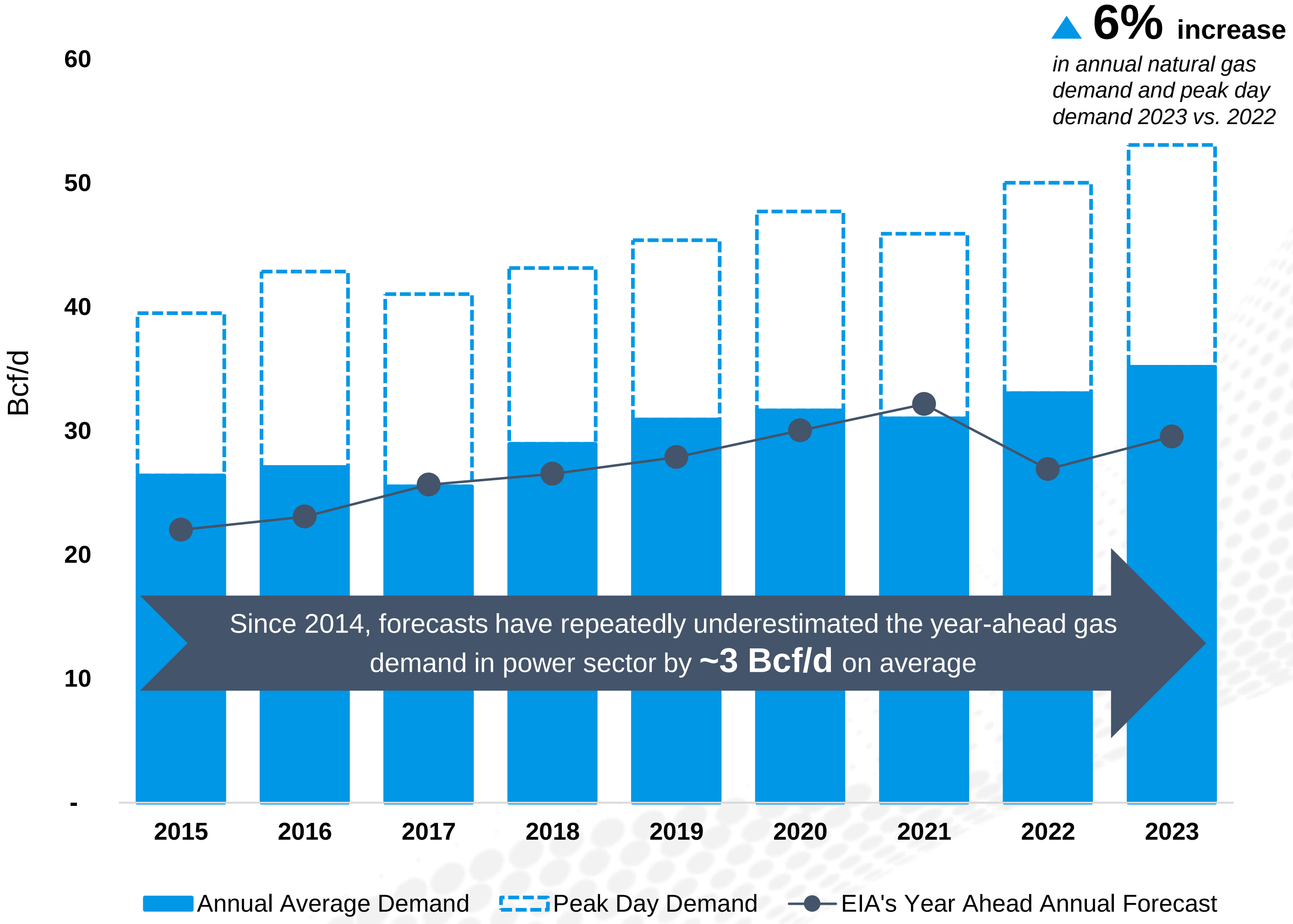
Growing demand for natural gas
Annual demand for natural gas has steadily grown ~4% CAGR since 2015

Setting new peak day records
Hit record day demand for natural gas in July 2023 of 53 Bcf/d

Forecasters underestimating the need for gas
Year ahead forecasts historically underestimate gas demand and dramatically missed 2022 annual demand by 24%

Accurate planning is vital to ensure sufficient transmission will be available when and where it is needed.

US Natural Gas Demand for Power



Source: S&P Global Commodity Insights © 2024 and U.S. Energy Information Administration (EIA).

Power utility customers recognizing need for more natural gas

GEORGIA POWER

By the '30-'31 winter season, will need to produce **17x more energy** than it originally planned; will meet the new demand with a mix of energy sources, including new gas and oil burning at Plant Yates and new agreements to buy more gas-powered energy

DUKE ENERGY

Energy demands 8x greater than predicted two years ago, driving move to **add additional hydrogen-capable natural gas generation**; expects to have 6,800 megawatts of combined-cycle natural gas capacity by 2035

DOMINION ENERGY

Predicted in 2023 forecast for PJM an increase in peak and energy load growth over next decade driven primarily by data centers; laid out five possible scenarios for meeting its customers' needs, all of which call for **new natural gas generation**

Sources: Georgia Power 2023 Integrated Resource Plan Update, October 2023. Duke Energy Carolinas Resource Plan Update, January 2024. Dominion Energy Virginia Electric and Power Company's Report 2023 Integrated Resource Plan, May 2023.

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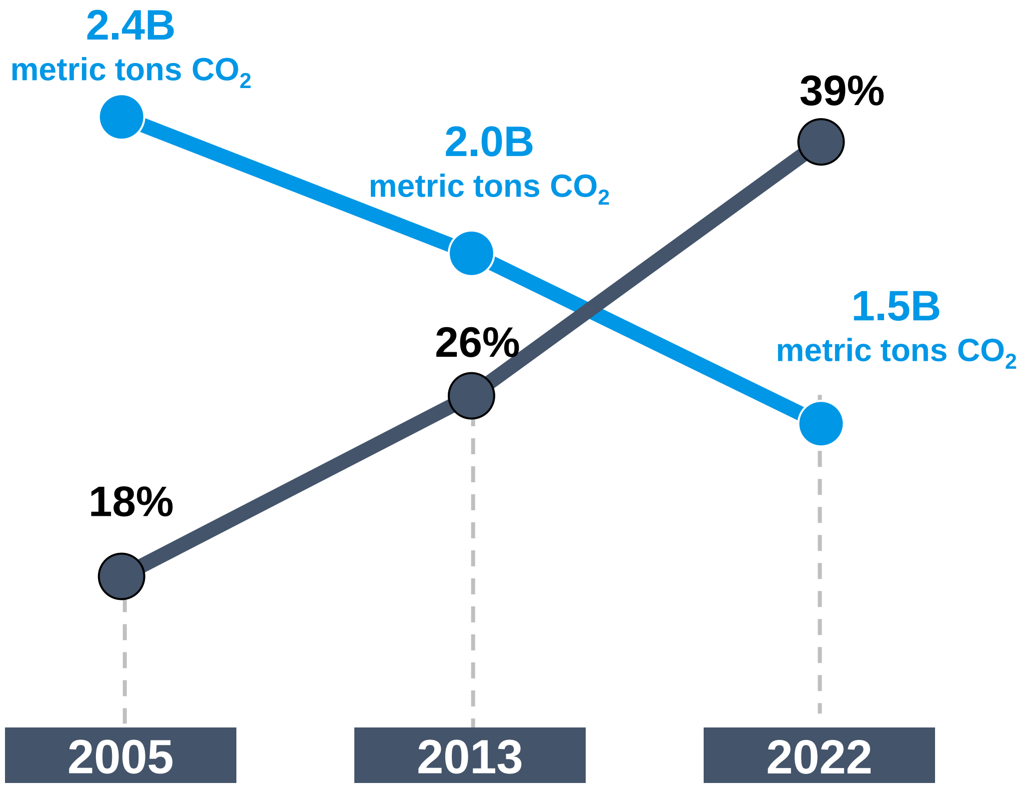
Natural gas is a tool to reduce emissions

U.S. CO_2 emissions declined with increased natural gas generation

U.S. Electric Power Sector: CO_2 Emissions vs. Natural Gas Market Share



Natural gas increased to **39% from 18%** market share

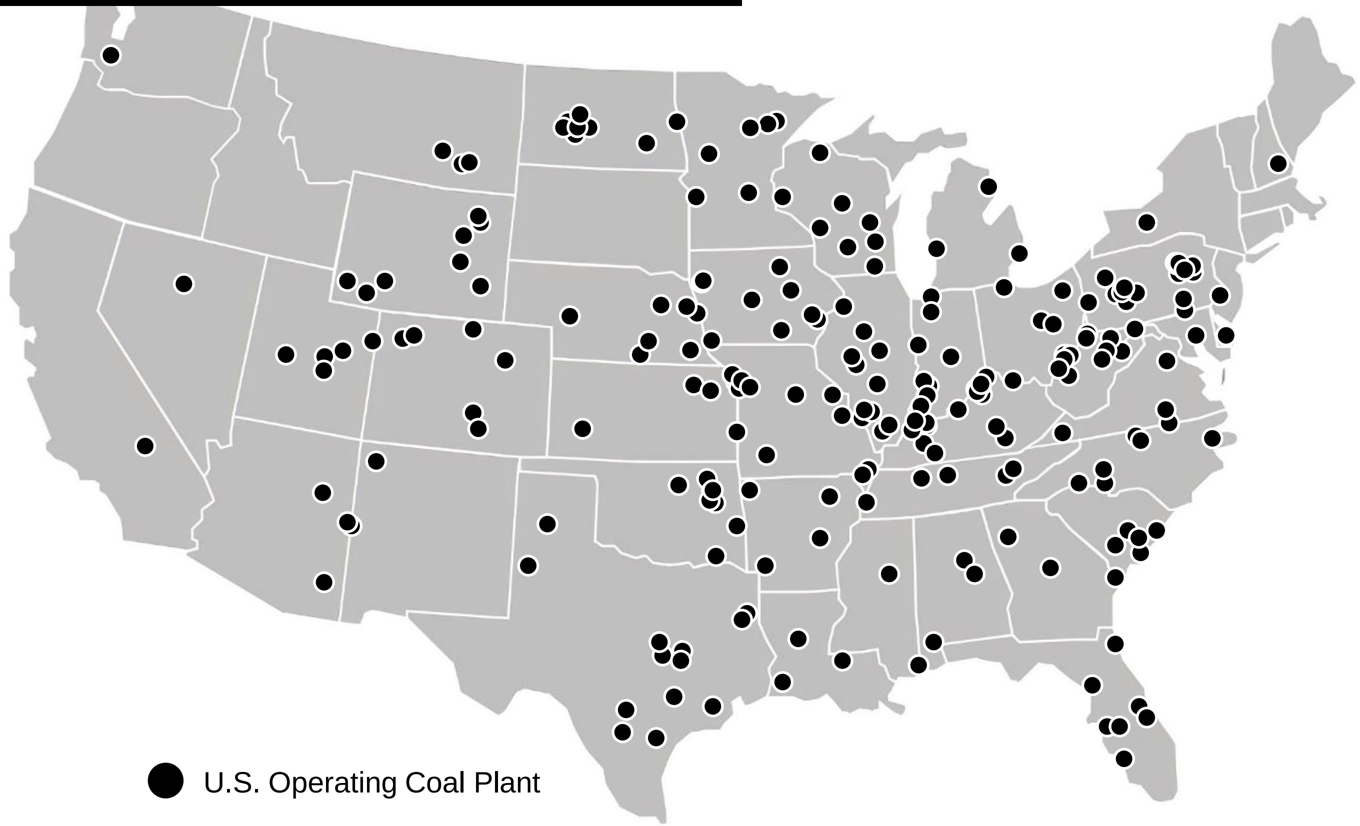
Shift to natural gas directly responsible for reducing ~500 MM metric tons of CO_2 or ~**60%** of the total reduction

Equivalent to the CO_2 emissions saved by running **2x as many wind turbines** as the U.S. has today

Sources: U.S. Energy Information Administration (EIA), January 2024; Environmental Protection Agency (EPA) Greenhouse Gas Equivalencies Calculator.

Continued opportunity to reduce CO_2 emissions by replacing coal with gas

There are 217 operating coal plants in the U.S. today



U.S. Operating Coal Plant

Replacing existing U.S. coal plants with natural gas-fired generation could:

Cut CO_2 power emissions by **27%**

Equivalent to

Removing **~80% of the cars** off the road today

Sources: Operating coal plant data sourced from Wood Mackenzie North America Power Service Tool. The data and information provided by Wood Mackenzie should not be interpreted as advice and you should not rely on it for any purpose. You may not copy or use this data and information except as expressly permitted by Wood Mackenzie in writing. To the fullest extent permitted by law, Wood Mackenzie accepts no responsibility for your use of this data and information. Coal and natural gas plants emissions rates and heat rate assumptions per U.S. Energy Information Administration (EIA); Metric tons of CO_2 emitted by a typical passenger vehicle per year per Environmental Protection Agency (EPA). As of January 2024.

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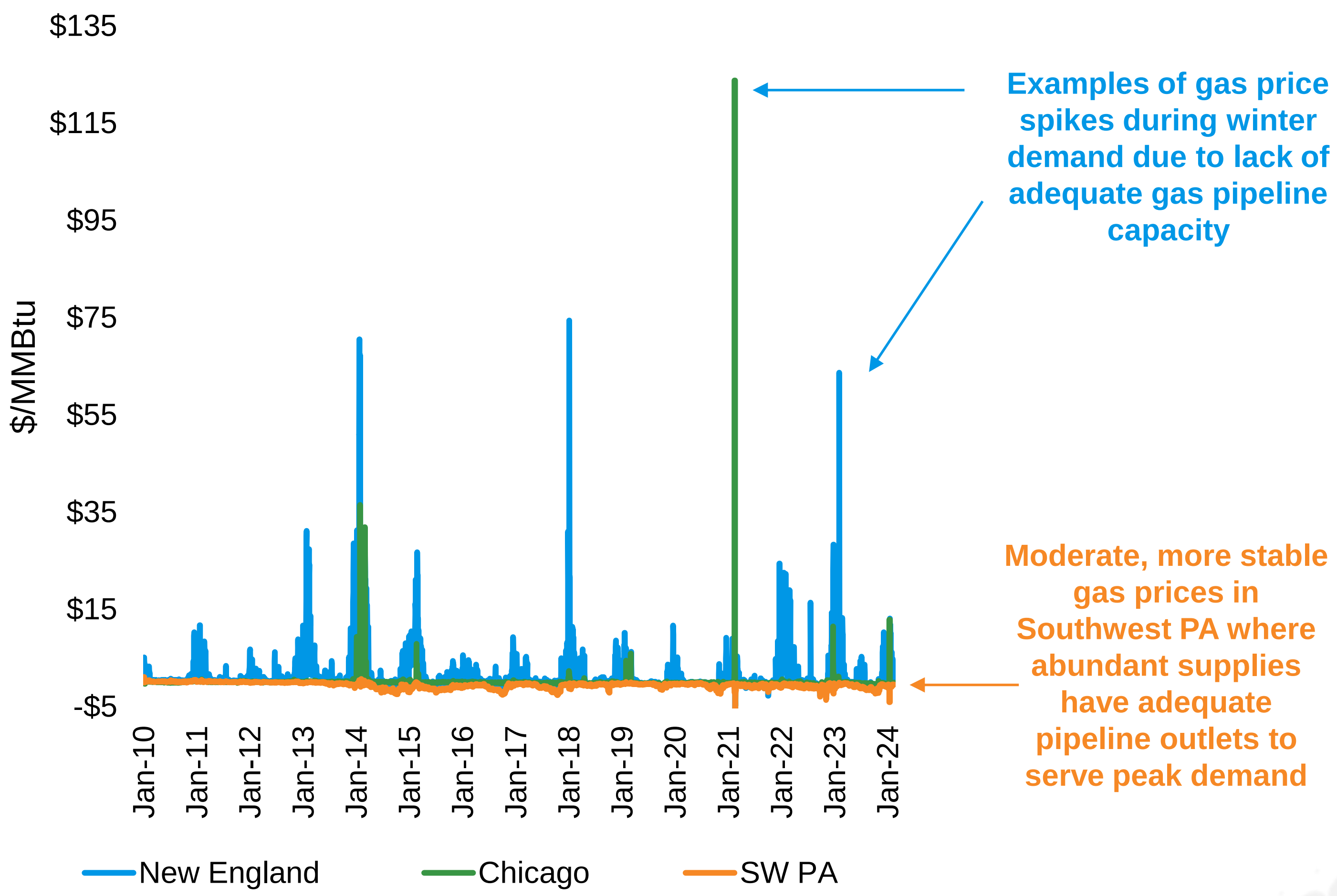
Lack of adequate natural gas pipeline capacity creates price and emissions spikes during days of peak demand

Lack of adequate natural gas pipeline capacity creates price spikes during days of peak demand

Historical Natural Gas Price Basis to Henry Hub- Northeast Region



The need for **incremental gas capacity**

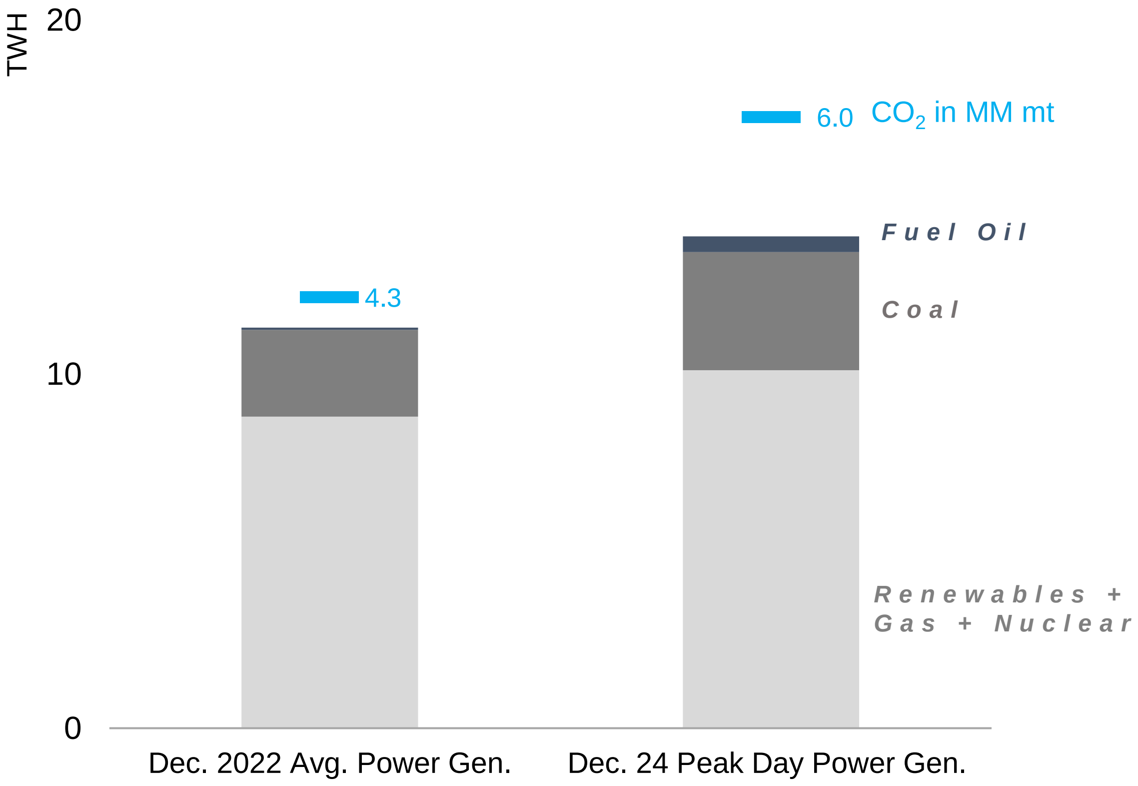
As prices in pipeline constrained markets, such as New England and Chicago, continue to spike each winter with high demand, SW Pennsylvania prices tend to be more moderate due to better pipeline access to gas abundant supplies

Source: S&P Global Commodity Insights © 2024 Algonquin city-gates was used as the proxy for New England. Chicago city-gates as the proxy for Chicago. EGT South was used as the proxy for SW PA

Lack of adequate natural gas infrastructure leads to use of more carbon-intensive fuels on peak days of demand

Spotlight: Winter Storm Elliot

L-48 Dec. '22 Average Daily Power Generation vs. Peak Day Power Generation (Dec. 24, '22) by Fuel Type with Associated CO_2 Power Emissions



Gas pipelines needed to **reduce emissions**

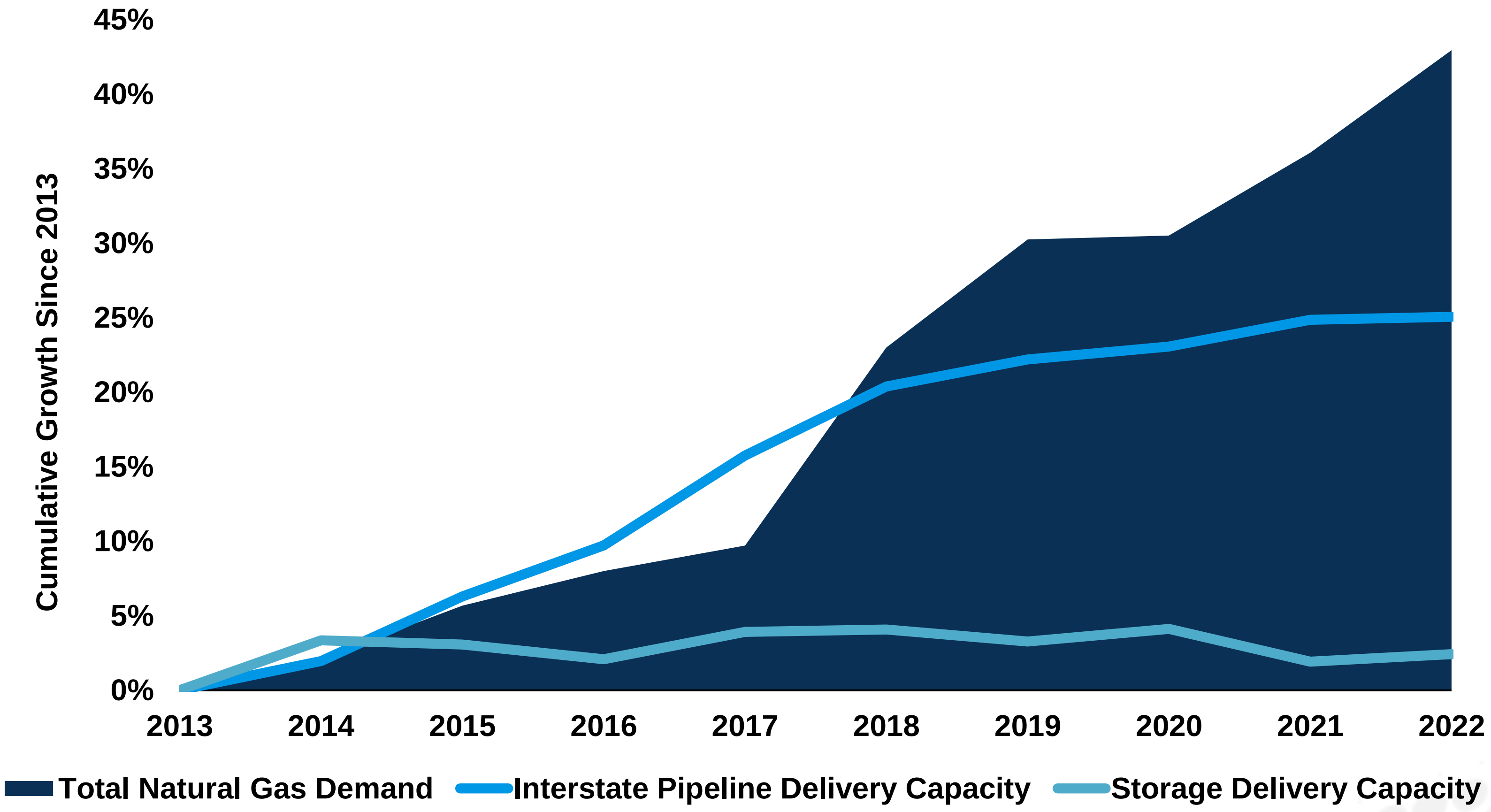
51% **more coal + fuel oil generation on peak day of demand vs. average generation**

42% **increase in CO_2 emissions due to burning more fuels that are ~2.5x more carbon-intensive than gas when gas is constrained, and renewables can't keep up on peak days of demand**

Source: U.S. Energy Information Administration. Williams' Winter Storm Elliot Case Study

There is a growing need for reliable infrastructure investment

Cumulative Percentage Growth in L-48 Natural Gas Demand versus Growth in Interstate Natural Gas Pipeline Capacity and Natural Gas Storage Delivery, 2013-2022



Since 2013 demand for gas has grown by

▲ **43%**

while infrastructure to deliver gas has increased by

▲ **25%**

and storage delivery capacity has grown only

▲ **2%**

Source: U.S. Energy Information Administration (EIA).

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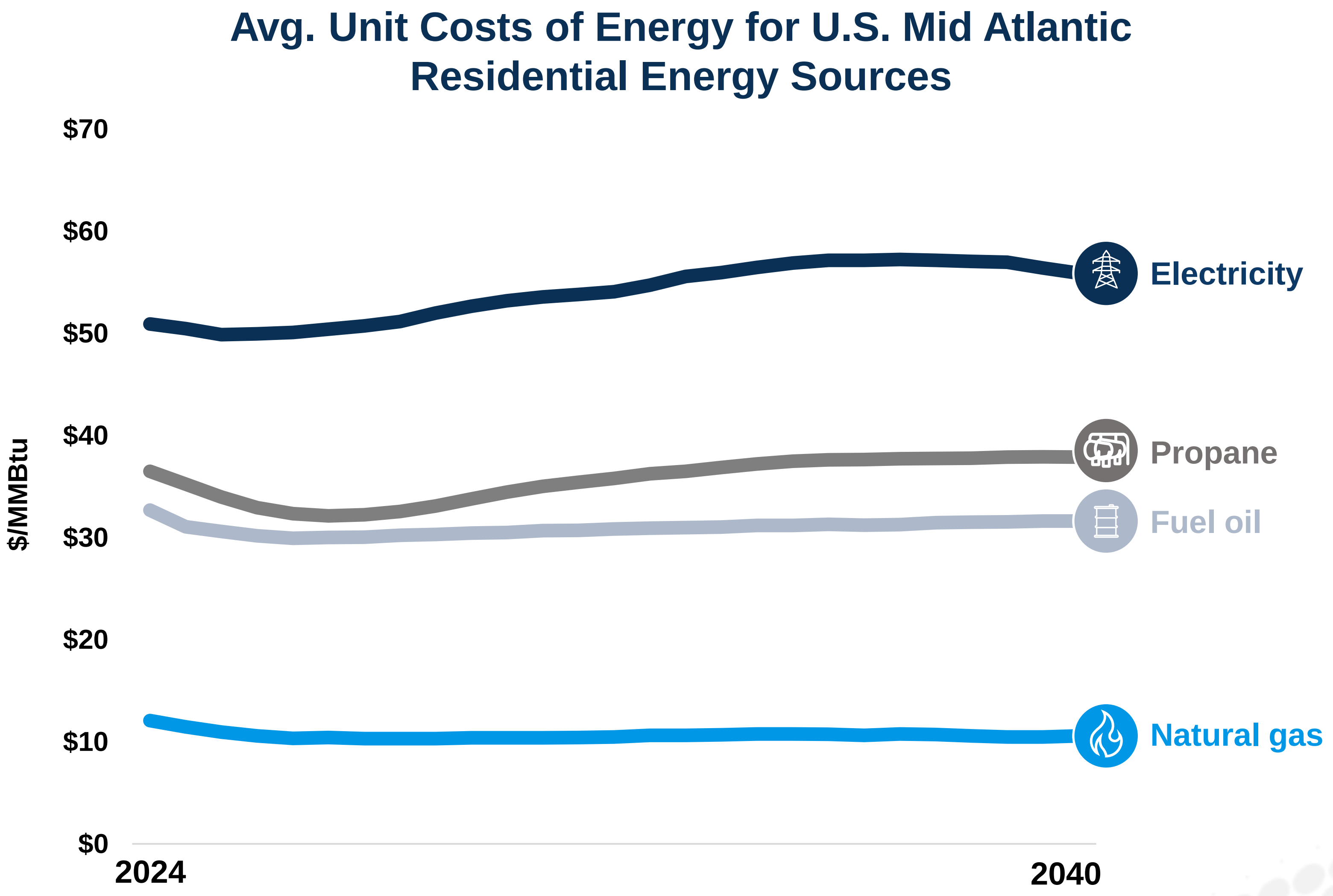
Natural gas is the most affordable decarbonizing solution

Natural gas is the cheapest fuel for residential consumers



Residential natural gas bills are

4x

less expensive

than electric bills **today** and will remain the most affordable solution for residential customers for the **next 20 years**

Source: U.S. Energy Information Administration (EIA), Annual Energy Outlook, 2023.

Natural gas is the cheapest fuel for residential consumers

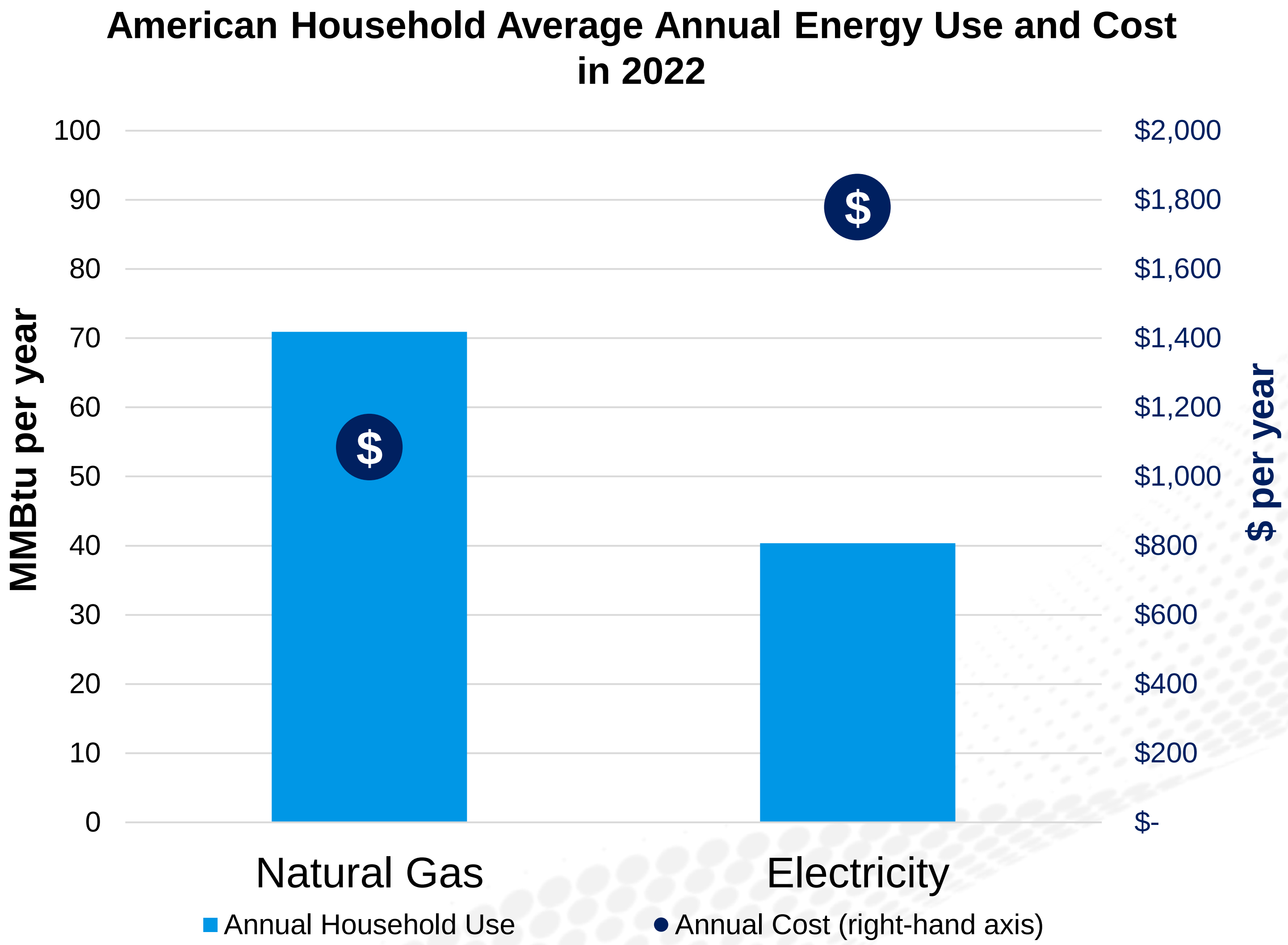
Natural gas makes up

65%

of the average American household energy usage but only makes up

40%

of the household energy bill



Source: U.S. Energy Information Administration (EIA)

Natural gas affordability in the home

It costs **$1.40** to cook one egg every day for a year using a gas stove, versus **$4.25** using an electric stove

It costs **$0.15** to take the average shower utilizing a natural gas water heater, with an electric water heater it costs about **$0.40**

The average U.S. household utilizing gas for home heating this winter will spend **$600**, where homes using electricity for heat will pay **$1,080**

It costs **$0.15** to dry one load of laundry in a gas dryer, compared to **$0.45** in an electric dryer

Sources: U.S. Energy Information Administration (EIA) Electric Power Monthly January 2023; EIA Residential Natural Gas Prices January 2023; DOE Estimating Appliance and Home Electronic Energy Use; ENERGY STAR Market & Industry Scoping Report Residential Clothes Dryers; EIA Short-Term Energy Outlook. Note: Cost values rounded

Natural gas meets the trifecta for energy solutions

CLEAN

45%

less carbon dioxide emissions than coal[1]

U.S. CO_2 emissions decline with increased coal-to-natural gas switching in the power sector

RELIABLE

3.5x

more reliable than renewables as assigned by power grid regulators[2]

Natural gas is a flexible and dispatchable energy source, making it ideal for the power sector

AFFORDABLE

4x

cheaper than electricity[3]

Natural gas remains the cheapest fuel for residential consumers

Sources: [1]Energy Information Administration (EIA) Carbon Dioxide Emissions Coefficients by Fuel; [2]S&P Global Commodity Insights © 2024. Based on U.S. annual average capacity values through 2040 assigned by power grid regulators to assess reliability for future demand needs. Onshore wind and PV solar; [3]U.S. Energy Information Administration (EIA), Annual Energy Outlook, 2023. Avg. Unit Costs of Energy for U.S. Mid Atlantic Residential Energy Sources

Natural gas is a tool to solve energy challenges

RELIABLE

Natural gas is an available backup and easily dispatchable

AFFORDABLE

Natural gas remains cheapest energy source for residential consumers

EMISSIONS REDUCTION

Continued opportunity to reduce emissions using natural gas to replace dirtier fuels like coal

ABUNDANT

Vast resource of gas supplies to serve demand domestically and abroad creating energy security for the U.S.

Natural gas is an immediate and scalable climate solution that works towards reducing global emissions while providing affordable and reliable energy.

Energy Source Energy sector

AI's thirst for electricity risks slowing US coal phaseout

But analysts cautioned against equating reports of coal plant retirement delays to higher generation

© Bloomberg

Amanda Chu 6 HOURS AGO

This article is an onsite version of our Energy Source newsletter. Premium subscribers can sign up here to get the newsletter delivered every Tuesday and Thursday. Standard subscribers can upgrade to Premium here, or explore all FT newsletters

Good morning and welcome back to Energy Source, coming to you from New York.

ExxonMobil easily rebuffed an attempted shareholder revolt against its board of directors yesterday, with investors overwhelmingly voting to re-elect all 12 members. The attempted revolt was in protest over the oil major's lawsuit against two climate-focused investors.

"Today our investors sent a powerful message that rules and value-creation matter," Exxon said in a statement following the results. "We expect the activist crowd will try and claim victory on today's vote, but common sense should tell you otherwise in light of the large margin of the loss."

Meanwhile, the wave of consolidation continues to wash across the US oil patch. ConocoPhillips, one of the world's biggest independent oil and gas producers, agreed to buy rival Marathon Oil in an all-stock deal yesterday that values the Houston-based company at $22.5bn, a merger first reported by the FT.

Today's newsletter looks at the US power sector. Plans to retire ageing coal plants are getting pushed back as power demand is expected to surge across the country.

Thanks for reading,

Amanda

AI's thirst for electricity means running US coal plants for longer

The US is delaying shutdowns of its ageing coal fleet amid expectations of soaring power demand from artificial intelligence and concerns over grid reliability.

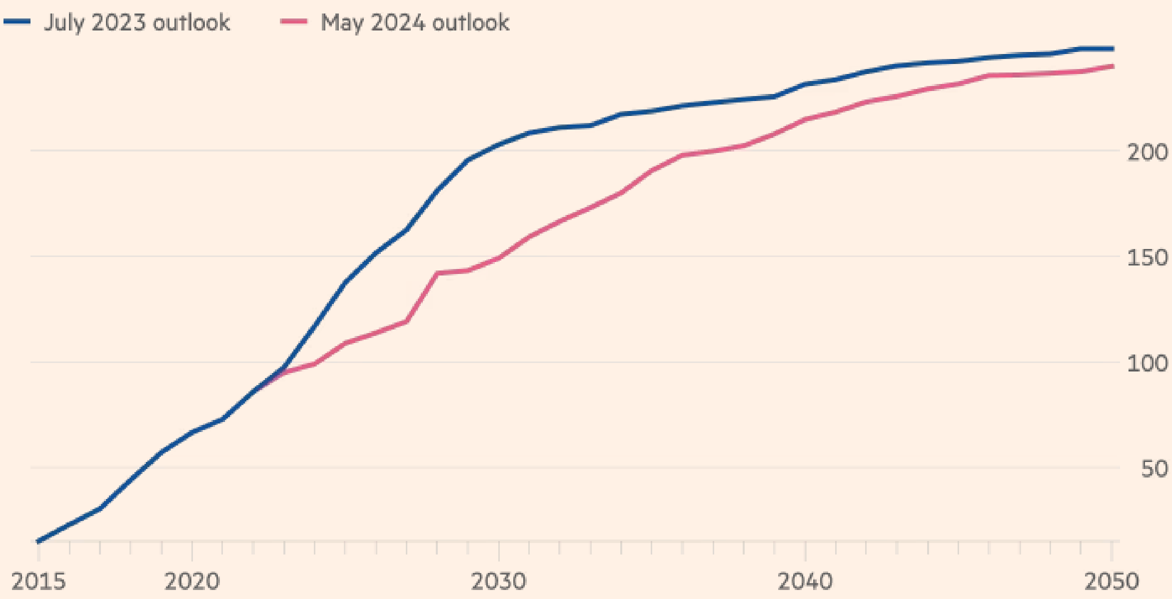
Last Thursday, US utility Alliant Energy said it was pushing back plans to convert its coal plant in Wisconsin to gas from 2025 to 2028. The announcement marks the latest in a series of coal plant retirement delays this year, including grid operator PJM's request to keep Talen Energy's Maryland coal units running for longer, and FirstEnergy's decision to forgo its 2030 target to phase out coal, citing the need to keep two plants running due to "resource adequacy concerns".

The retirement delays have driven analysts to lower forecasts for coal's phaseout. S&P Global Commodity Insights estimates 54GW of US coal capacity will retire by the end of the decade, a 40 per cent downward revision from its forecast last year. The consultancy expects coal shutdowns to average 7.5GW per year over the next decade, down from an average of 10GW annually from the previous decade.

"The existing fleet is struggling to meet the demands of all this power growth," said Brent Bilsland, chief executive of Hallador Energy, which operates a 1GW coal plant in Indiana.

US coal is slowing down its decline

Cumulative US coal capacity retired since 2015 (GW)*



*Only includes retirements in lower 48 states
Source: S&P Global Commodity Insights
© FT

The slowdown in retirements highlights a confrontation emerging between US electricity-intensive initiatives to lead in AI and manufacturing and the country's decarbonisation targets.

Grid Strategies, a consultancy, forecasts US electricity demand growth of 4.7 per cent over the next five years, nearly doubling its projection from a year earlier. A study released yesterday by the Electric Power Research Institute found that data centres will make up 9 per cent of US power demand by 2030, more than double current levels.

Meanwhile, a shortage of power equipment, lack of transmission and the bureaucratic hurdles for grid connection are creating multiyear wait times for renewable projects to come online to replace existing fossil capacity.

"It's going to take a lot of thermal generation to meet this growing demand. I don't know how we're going to do that and then also increase our clean energy percentages at the same time," said Patrick Finn, a senior analyst at Wood Mackenzie.

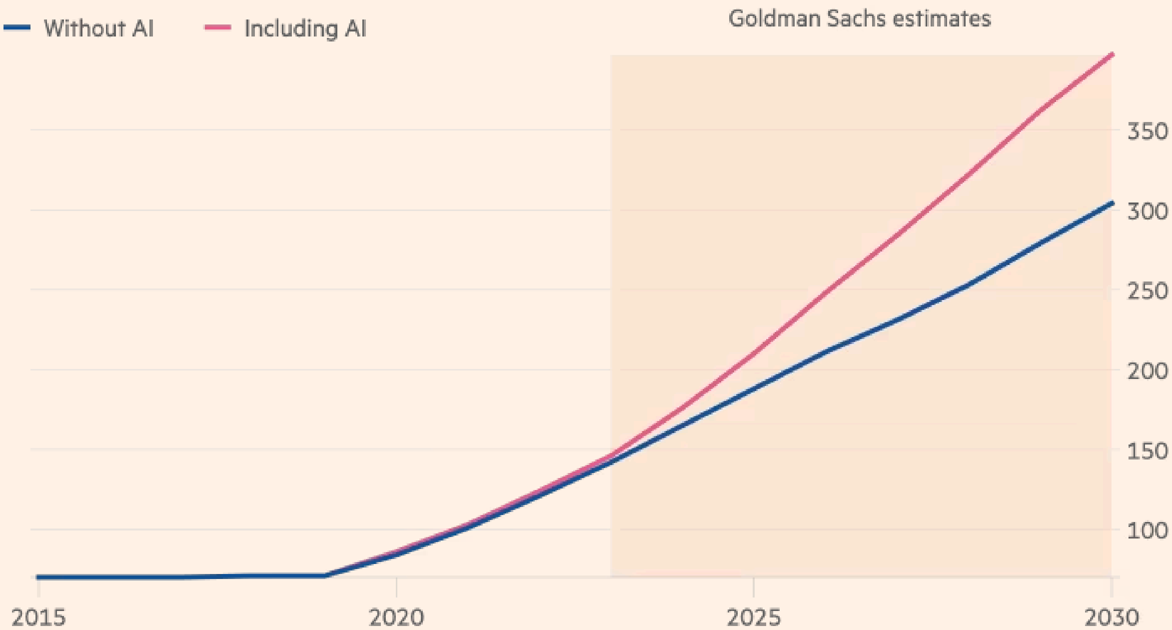
The delays are evidence to critics of the Biden administration's energy strategy that the US Environmental Protection Agency's guidelines to phase out unabated coal plants starting in 2032 are premature and will only exacerbate the reliability problems.

"We have a perfect reliability storm that's brewing," said Bill Scherman, partner at Vinson & Elkins. Randall Atkins, the former chair of the now-defunct National Coal Council and chief of Ramaco Resources, called the Biden administration's policies "shortsighted" and warned they risked creating a shortfall in reliable power to manage the intermittent nature of renewables.

"If EPA's [greenhouse gas] standards drive dispatchable coal and natural gas resources to retire before enough replacement capacity is built with the attributes the system needs, reliability will be compromised," said a Midcontinent Independent System Operator spokesperson. The grid operator recorded 3.2GW of coal plant retirement delays this year.

US power demand from data centres expected to surge

Annual power demand from data centres (TWh)



Source: Masanet et al. (2020), Cisco, IEA, Goldman Sachs Research

Members of the coal industry hope that a Donald Trump victory in November and successful court challenges to the EPA rules will create a more favourable environment for coal generation.

"We think that another [Trump] administration could bring forth sensical environmental regulations and make sure we take advantage of all of our domestic resources," said Michelle Bloodworth, head of America's Power, a coal industry association, which filed a motion last week to stop the EPA rules.

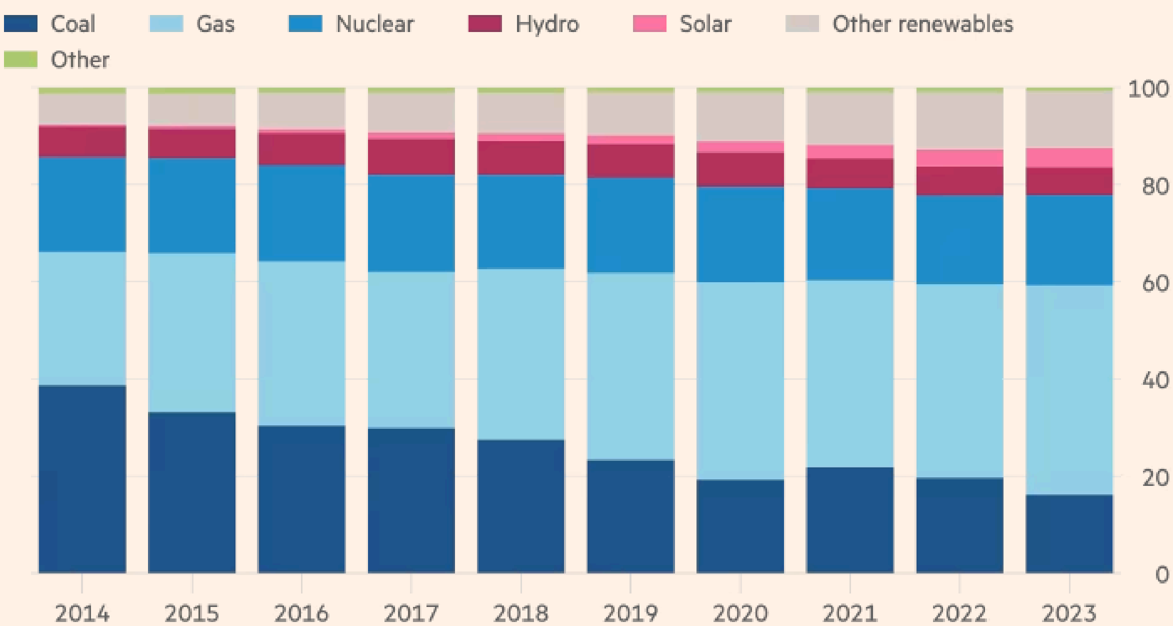
An EPA spokesperson said the power plant rules are on "firm legal ground" and that cumulative impact analyses of the rules show the sector can meet electricity demand while maintaining reliability and affordability and reducing pollution.

The Biden administration has set a target to reach a carbon-free power sector by 2035. US power generation from coal, the most polluting source of fuel, has fallen dramatically over the past decade as cheap gas from the shale revolution became the more economical choice and ageing coal plants went offline.

Last year, coal made up 16 per cent of the country's electricity supply, down from nearly 40 per cent in 2014, according to the US Energy Information Administration.

Coal's share of power mix continues to fall

Share of US utility-scale electricity generation by year and fuel



Source: US Energy Information Administration

Environmental campaigners warned that delays to retirements should not be a long-term solution to addressing growing power demand and pushed back against industry claims that EPA rules set unrealistic timelines for phaseout.

"A number of these coal plants that have retirement dates at the moment in the late 2030s or 2040s are going to have to actually come to the table and think about how do we meet energy load growth in a cost-effective manner that also accounts for and recognises the environmental and public health costs of these facilities," said Amanda Levin, director of policy analysis at the Natural Resources Defense Council, an environmental advocacy group.

Seth Feaster, a data analyst at the Institute for Energy Economics and Financial Analysis, told Energy Source that a slowdown in coal retirements did not change the trajectory for coal.

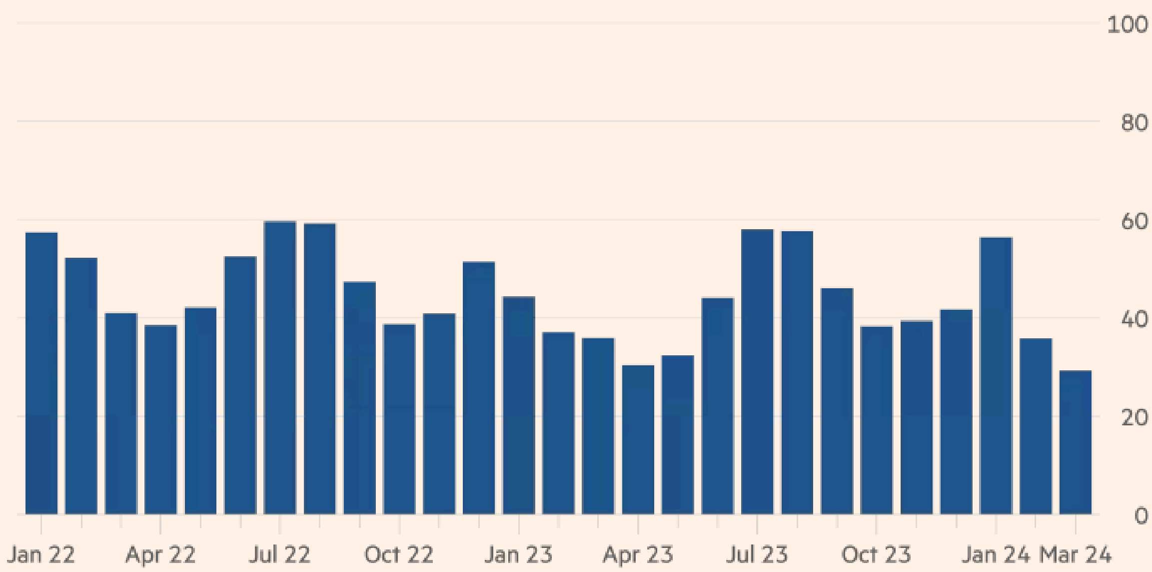
US coal generation is predicted to fall another 4 per cent this year as plant utilisation rates remain low, according to the EIA. Data from Argus Media shows that coal prices in the Powder River Basin, the source of most US production, are down 5 per cent year over year.

While roughly 70GW of the country's coal generation capacity has no retirement date, IEEFA estimates the bulk of the plants are too old to consider installing carbon capture systems to comply with EPA rules and were already facing the question of retirement.

"EPA rules are really, in many ways, simply putting down on paper a reality that was already out there on the ground," Feaster said.

US coal plants are operating at low utilization rates

Monthly capacity factor*



*Capacity factor measures how often a plant is running at maximum capacity
Source: US Energy Information Administration
© FT

Job moves

- Climate scientist **Susan Avery** is retiring from the board of **ExxonMobil**, the company announced at its annual meeting yesterday. Avery served as chair of the oil major's environment, safety and public policy committee since 2021.

- **Enverus**, a US energy consultancy, promoted **Manu Nikhanj** to chief executive, succeeding **Jeff Hughes**, who will serve as executive chair.

- **Brice Morlot** will join **BW Energy**, an oil and gas company, as chief financial officer, succeeding **Knut Sæthre**. Morlot joins from **Assala Energy**.

- **Petrobras** has elected **Magda Chambriard** as its new chief executive officer after the Brazilian government fired **Jean Paul Prates**.

- **Ipieca**, an oil and gas industry association focused on environmental and social issues, appointed **Paul Krishna** as chair. Krishna previously worked for 30 years at **ExxonMobil**.

Power Points

- How Joe Biden's climate push fell flat with Gen Z voters

- BHP's £39bn pursuit of Anglo American collapses

- Ex-Pioneer CEO says he was 'scapegoated' in Opec collusion case

Energy Source is written and edited by Jamie Smyth, Myles McCormick, Amanda Chu, Tom Wilson and Malcolm Moore, with support from the FT's global team of reporters. Reach us at energy.source@ft.com and follow us on X at @FTEnergy. Catch up on past editions of the newsletter here.

UTILITY DIVE

DIVE BRIEF

Duke to offer expanded suite of clean energy options to Amazon, Google, other large customers

The proposed framework includes "innovative financing" to support emerging technologies like advanced nuclear and long-duration storage in the Carolinas.

Published May 30, 2024

Ethan Howland
Senior Reporter

Duke Energy is developing a framework for offering clean energy in the Carolinas to large commercial and industrial customers such as Amazon, Google, Microsoft and Nucor, the companies said May 29, 2024. *halbergman via Getty Images*

Dive Brief:

- Duke Energy is developing a framework for offering clean energy to large commercial and industrial customers in the Carolinas, with an initial focus on Amazon, Google, Microsoft and Nucor, the companies said Wednesday.

- The planned Accelerating Clean Energy tariffs will include financing options that could be used to support emerging technologies such as long-duration energy storage and advanced nuclear power as well as "mega" projects, Lon Huber, senior vice president for pricing and customer solutions, said Thursday in an interview.

- Duke expects to begin filing new tariffs with utility regulators in North Carolina and South Carolina within a month or two, but the process will occur in stages, Huber said. The clean energy tariffs will be available to Duke's C&I customers.

Dive Insight:

The C&I class makes up about 35% of Duke's overall load in the Carolinas, but it is expected to grow in the next five years as technology companies and manufacturers expand their operations, according to Huber.

The Accelerating Clean Energy program will offer C&I companies a suite of clean energy options to pick from to meet their clean energy goals without increasing costs for other customers, he said. A company would have an individual "lean transition tariff" that could cover, for example, demand response, onsite generation and 24/7 clean energy, according to Huber.

The planned program is multifaceted "because it has to be comprehensive … because there's no silver bullet on clean energy yet, so you need to have a bunch of different technologies that work in harmony to get to deep decarbonisation," Huber said. "It takes 'all of the above' to do this both at a system level but also individualized for a customer."

The plan includes the potential for various financing options that could enable emerging technology, such as a premium for a resource's attributes, help with cost overrun protection and low-cost financing, according to Huber.

"It creates and formalizes a new pillar of support for emerging clean tech and large mega projects, and this is something that really hasn't been standardized or done on any scale before," he said. "We'll be working it out with these partners, with regulators and other stakeholders on what's the best way to structure a tariff to help capture the variety of different ways a large customer can support these types of emerging or big clean energy projects."

The companies signing initial memorandums of understanding with Duke have a range of clean energy goals.

Google, for example, aims to run its operations on clean electricity every hour of the day by 2030. "Through collaboration with Duke Energy, the Clean Transition Tariff creates a pathway for us and our peers to bring new, innovative solutions to the forefront faster," Briana Kobor, Google's head of energy market innovation, said in a statement.

It's good that large customers are pushing for increased clean energy options beyond "business as usual" utility supply, but there may be smaller C&I customers and residential customers that would also want clean power beyond what Duke already offers, according to Nick Jimenez, senior attorney at the Southern Environmental Law Center.

Also, the plans by the large customers like Google to acquire clean energy for their facilities may call into question Duke's recent proposal to add about 2 GW of gas-fired generation to meet rising loads, Jimenez said Thursday.

"If there's a tariff coming that allows all of these large corporate entities that have significant climate goals to procure new clean generation for themselves, then we shouldn't be building gas plants to also meet that load," he said.

DIGITAL ENERGY COUNCIL

June 4, 2024

The Honorable Jeff Duncan
Chair
Energy and Commerce Subcommittee on Energy, Climate, & Grid Security
2229 Rayburn House Office Building
Washington, DC 20515

The Honorable Diana DeGette
Ranking Member
Energy and Commerce Subcommittee on Energy, Climate, & Grid Security
2111 Rayburn House Office Building
Washington, DC 20515

Chair Duncan and Ranking Member DeGette,

The Digital Energy Council (DEC) appreciates the opportunity to submit this Statement for the Record to the House Energy and Commerce Subcommittee on Energy, Climate, and Grid Security.

About the Digital Energy Council
The Digital Energy Council (DEC) is a non-profit advocacy organization with members working at the forefront of the energy, digital asset mining, and high-performance computing data center industries. Our members support energy security and resilience through the adoption of modern grid solutions and new technologies. DEC was founded to shape the future of energy use and inform policymakers about the important cross-section between the energy industry and the digital energy applications driving a new economy. As society becomes increasingly digital, the energy sector must evolve to keep pace. It is essential for the energy ecosystem to embrace new technologies and adapt to meet growing demand.

How the growing demand for electricity will have serious economic and national security consequences for our nation.
The biggest source of new electricity demand is expected to come from data centers that enable cloud computing, digital asset mining, and artificial intelligence (AI)[1]. As we continue to assess the need for grid upgrades and new generation to meet growing demand for electricity, it is just as important to assess some of the unique characteristics of certain new load. NERC's 2024 Summer Reliability Assessment emphasized the role of "Evolving Demand-Side Management Programs" for resources adequacy and load balancing. These programs leverage the load shedding capabilities of large, flexible load data centers, which act as "short-notice resources" to support wind and solar energy adjustments and during periods of stress[2].

[1] Analysis and Forecast to 2026, IEA.
[2] 2024 Summer Reliability Assessment, NERC.

The increasing electricity demand from data centers, including AI and digital asset mining, will drive innovation, improve efficiency, and facilitate the transition to cleaner energy sources. If done right, incorporating new loads for digital applications can bring additional investment to the table in a manner that compliments the needs of our aging energy infrastructure, without compromising our goal of ensuring the United States remains the leader in developing new digital technologies, like AI. Here are key points to consider:

Grid Stabilization and Demand Response:
Digital asset mining data centers, which offer flexible load, serve as an important grid stabilizing tool, as they can quickly turn off and revert power back to the grid at a moment's notice. This takes stress off the grid during peak times, also known as demand response or curtailment. Congress has long acknowledged the potential benefits for demand response, including in Section 1252(f) of the Energy Policy Act of 2005 (EPACT) by encouraging "the deployment of such technology and devices that enable electricity customers to participate in such pricing and demand response systems shall be facilitated, and unnecessary barriers to demand response participation in energy, capacity and ancillary service markets shall be eliminated."[3] And in a 2006 Department of Energy (DOE) report required by Section 1252(d) of EPACT, DOE acknowledged the reliability benefits of demand response to "the operational security and adequacy savings that result because demand response lowers the likelihood and consequences of forced outages that impose financial costs and inconvenience on customers."[4]

The unique characteristics of flexible load data centers along with their widespread deployment make them one of the most savvy methods of demand response on the market. While demand response has been a discussion point for nearly 20 years, digital asset mining operations offer demand response capabilities and offer a new, precise, and highly flexible solution that has been deployed with private capital at scale.

Data Centers and Sustainable Energy Practices:
Data centers, as significant consumers of electricity, have a pivotal role in energy grid development. Leading tech companies are increasingly committing to renewable energy sources to power their data centers, driving demand for clean energy projects. By signing power purchase agreements (PPAs) with renewable energy providers, data centers can support the financial viability of new wind, solar, and other renewable energy projects. With advanced energy management systems, data centers can adjust their power consumption in response to grid signals, helping to stabilize the grid during periods of fluctuating supply and demand. Pending thorough assessment by grid operators, this could also provide an opportunity for renewable power sources to play a larger role in capacity markets.

Investment in Energy Infrastructure:

[3] Energy Policy Act of 2005.
[4] Benefits of Demand Response in electricity Markers and Recommendations for Achieving Them, DOE.

During the rapid expansion of sectors like AI, data storage, cloud computing, and digital asset mining there has been significant investment to upgrade electric infrastructure, like transmission, and procure energy resources. It is critically important that we continue this investment to maintain American leadership and protect these industries, and protect against offshoring to countries that do not share American values and also utilize much higher emitting energy sources. One of the biggest challenges the energy industry currently has is building transmission, particularly interregional transmission. Permitting reform would expedite the development of new and upgraded transmission that is essential for continued advancement of our digital economy.

Promotion of Energy Efficiency and Storage:
The competitive nature of AI, digital asset mining, and cloud computing data centers incentivizes continuous improvement in energy efficiency. Innovations in cooling systems, power management, and hardware efficiency developed in these sectors can spill over into broader industrial and commercial applications, leading to widespread energy savings. The demands of these energy-intensive sectors are driving advancements in energy storage and management technologies. Improved battery storage systems and advanced energy management solutions developed to support data centers and mining operations can be deployed to enhance grid reliability and facilitate the integration of intermittent renewable energy sources.

Support for Decentralized Energy Systems and Economies:
These sectors can also support the growth of decentralized energy systems, such as microgrids and distributed generation. By co-locating data centers with renewable energy sources or deploying digital asset mining operations in areas with abundant renewable resources, we can enhance energy resilience, increase capacity factors, and reduce transmission losses. The expansion of AI, digital asset mining, and data centers contributes to economic growth and job creation in the energy sector. This includes roles in engineering, construction, maintenance, and cybersecurity, fostering a skilled workforce equipped to support a modernized grid.

Conclusion
The United States has an opportunity to lead in the development and deployment of data centers, digital asset mining, and AI as both a technology and energy tool. Policymakers must act now to ensure that digital energy infrastructure can continue to operate in the United States with sensible and certain regulation.

We appreciate the opportunity to submit this Statement for the Record and look forward to serving as a resource for these important and complex issue areas.

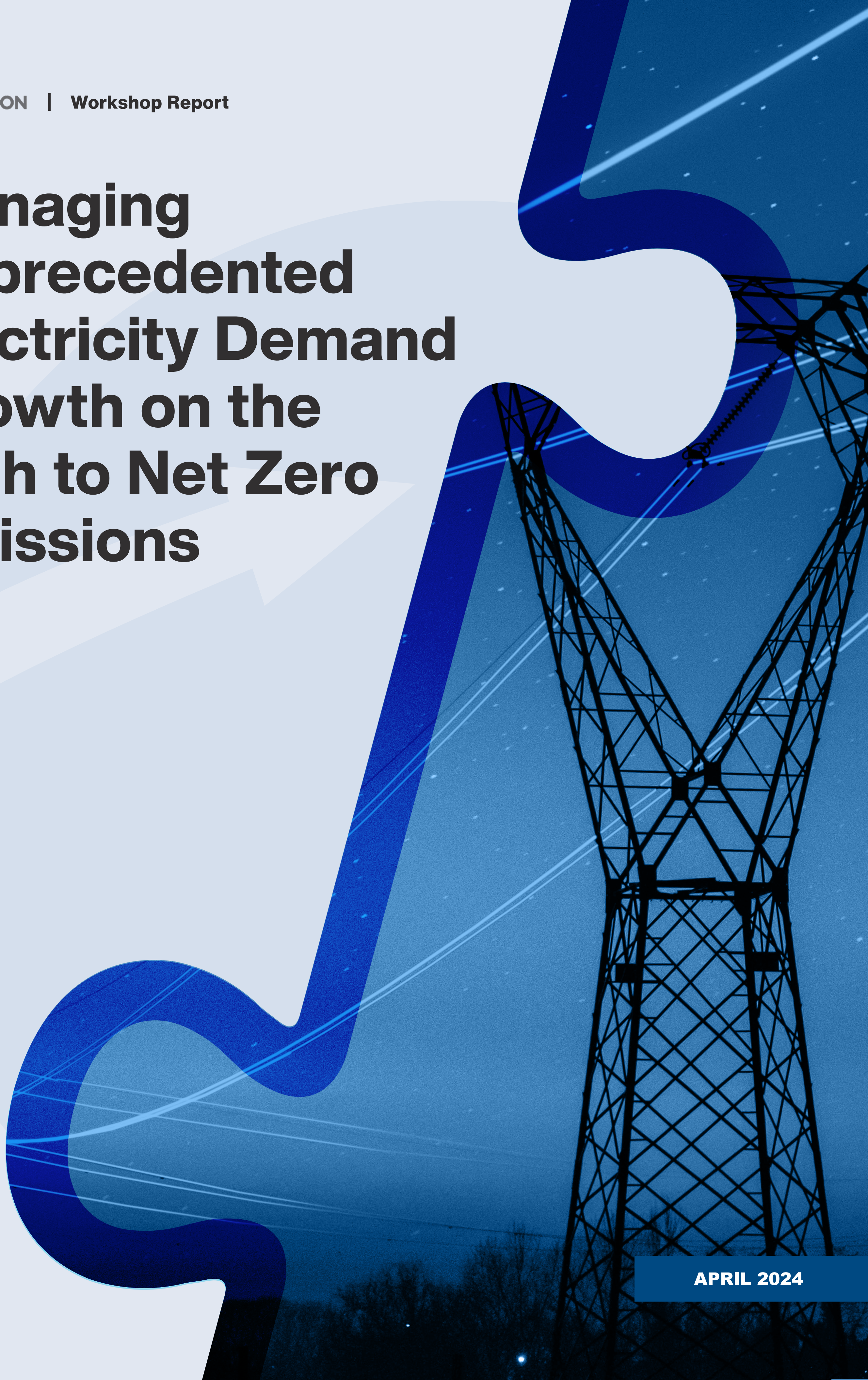
Best Regards,

Tom Mapes

Founder and President

EFI FOUNDATION | Workshop Report

Managing Unprecedented Electricity Demand Growth on the Path to Net Zero Emissions



APRIL 2024

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Report Sponsors

The EFI Foundation would like to thank Arizona Public Service (APS), Duke Energy, and GE Vernova for sponsoring this work. All content in this report is independent of their sponsorship.

Suggested Citation: EFI Foundation. “Managing Unprecedented Electricity Demand Growth on the Path to Net Zero Emissions.” April 2024.

www.efifoundation.org

The EFI Foundation advances technically grounded solutions to climate change through evidence-based analysis, thought leadership, and coalition-building. Under the leadership of Ernest J. Moniz, the 13th U.S. Secretary of Energy, the EFI Foundation conducts rigorous research to accelerate the transition to a low-carbon economy through innovation in technology, policy, and business models. EFI Foundation maintains editorial independence from its public and private sponsors.

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Summary

As the United States works to address the climate crisis, the urgent push for decarbonization stands in stark contrast to the immediate challenges of managing near-term electricity load growth. Recent incentives to re-shore clean energy supply chains in legislation like the Inflation Reduction Act (IRA), the Infrastructure Investment and Jobs Act (IIJA) and the CHIPS and Science Act have prompted some of these new load demands, many of which will require firm power 24/7. Data center proliferation is also a major driver of near-term load growth, and the rapid expansion of AI is exacerbating their load requirements. In the mid- to long-term, increased electrification of end uses, such as vehicles, heat pumps and some industrial processes, compound the issue. To capitalize on these economic development opportunities, states and regions are seeking creative solutions to deal with load growth such as building out grid infrastructure and investing in projects that accelerate clean energy innovations.

The load growth dilemma is intensifying the strain on existing infrastructure, and addressing it requires inventive solutions and strategic foresight. Many utilities have dramatically increased their projected electricity load growth and have proposed meeting this in the near term by increasing their use of existing and/or new thermal plants. The tension between economic development and the associated increased electricity load and declared utility decarbonization targets in the 2030-time frame has stimulated important discussions.

On Feb. 12, 2024, the EFI Foundation hosted a group of nearly 30 senior-level experts from utilities, system operators, industry, and nongovernmental organizations, as well as former policymakers and regulators, consumers, and equipment (e.g., turbine) manufacturers to discuss the implications of recent public announcements of unprecedented load growth across many regions of the country.[1,2,3]

Several challenges were identified at the workshop that will need to be addressed in an era of dramatic acceleration in load growth. They are as follows.

1. Load growth is not uniform across the country and regionality impacts the tools available to address it. Regional differences in resource availability, including the appropriate geology for carbon storage and access to water resources, as well as the availability of generation resources like wind and solar means that strategies for addressing load growth must be tailored to regional resources, infrastructure needs, and limitations, particularly in the near term.

2. Load growth is likely to further accelerate. Data centers dominate the headlines today, but new manufacturing combined with electrification of transportation, space heating, and industry will place even greater strain on the grid in the coming decades.

3. Ensuring reliability and resiliency is paramount. While grid-enhancing technologies and storage solutions may lessen near-term load growth challenges, new gas-fired generation capacity will come online to provide firm power. As a result, power sector emissions may rise in the short term, while

generation and transmission with longer lead times will address emissions in the longer term.

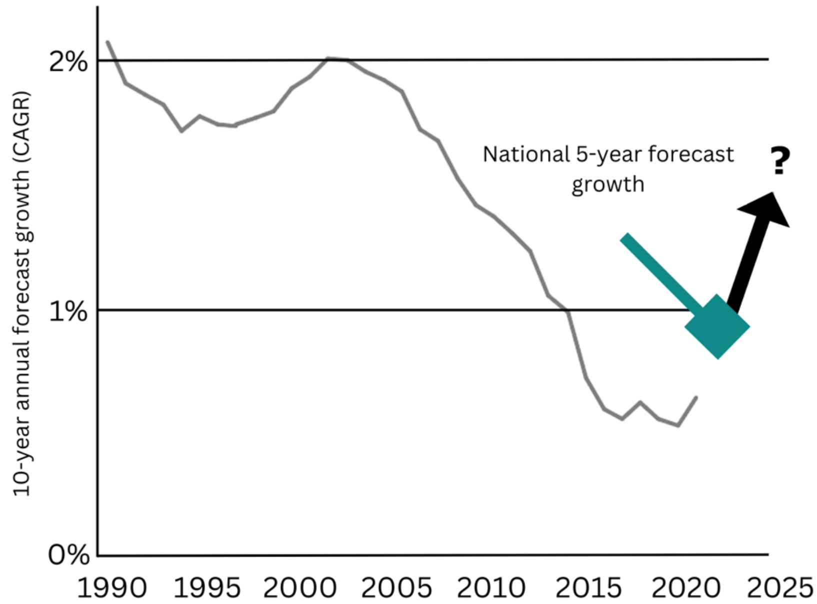
4. Policies need to be harmonized. New proposals seek to limit power sector emissions in the wake of recent policies promoting electrification. These proposals may constrain the sector's ability to meet increasing load demands. If the U.S. continues to encourage electrification, complementary policies will be needed to expedite grid modernization.
5. Very large, unexpected loads like gigawatt-sized data center campuses could require utilities to rethink their five-year plans. Longer term, grid managers may also need to create the frameworks and the associated regulatory structures to enable more proactive infrastructure buildout.
6. Though the threat of litigation has long been considered a serious impediment to building out new infrastructure, it has increased in prevalence and now seems to pervade the entire political spectrum.

Introduction

The economywide transition to net zero emissions will rely heavily on successfully decarbonizing the power sector. For years, relatively flat power demand provided grid operators a clear and certain view of the scale of clean energy resources needed to reach zero carbon emissions. Now, driven in part by massive incentives in domestic manufacturing; trends in electrification of transportation, buildings, and industry; clean energy targets across the economy; and new investments in data centers and artificial intelligence, the pace of electricity load growth could nearly double or even triple over the next five years (Figure 1).[4,a] These load growth trends have potentially paradigm-shifting implications for the power sector, affecting system-wide reliability in the near-term and changing the course of deep decarbonization in the mid-term.

[a] Electricity load is the amount of power required to meet the demands of all customers on the grid. For example, a new data center may require 750 megawatts (MW) of power capacity. Once it is connected to the grid, the data center adds 750 MW of load. Grid managers are now facing the challenge of serving an unexpected growth in new load.

Figure 1. North American Electric Reliability Corporation's 10-year load growth forecast trend



For the last decade, grid planners have forecast only 0.5% annual electricity load growth, as reported by the North American Electric Reliability Corporation. However, in 2023, that forecast changed to 0.9%, as indicated by the blue box in the graph. Regional utility profile filings have revealed that electricity load will likely increase even more than that. Adapted from: North American Electric Reliability Corporation, Long-Term Reliability Assessment, December 2022, p. 20, Supplemental Table F, https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_LTRA_2022.pdf.

Held under Chatham House Rule[b], the private EFI Foundation Load Growth Workshop was designed to elicit stakeholder discussion of both the opportunities and challenges of these recent trends, addressing the following questions:

- What is contributing to the potentially paradigm-shifting changes in near- and midterm load growth forecasts?
- What are the immediate needs for meeting electricity demand in the next one to five years, and how can stakeholders stay on track to decarbonize the sector by midcentury?
- How can longer-term planning and coordination efficiently enable the transition to a reliable, carbon-free electricity grid by midcentury?

The workshop discussion made clear that stakeholders are grappling with a new reality. Previously unforeseen load growth presents challenges with respect to continuing coal plant retirements, integrating renewables, and maintaining reliability. However, on the path to long-term climate goals, utilities, system operators, and policymakers also have

[b]Unattributed quotes throughout the report originate from the workshop discussion.

an opportunity to proactively collaborate and plan for a future that supports technologies that are clean, reliable, and affordable.

Four major themes emerged during the conversation:

1. **Recent projections are likely underestimating actual load growth.** Participants agreed that the projection that the pace of electricity load growth will double in five years is likely an underestimate as more utilities update their load growth forecasts.[5] This reinforces the idea that the era of flat demand is truly over for the near- and mid-term.
2. **Region-specific approaches are necessary for managing near-term load growth.** Regions across the U.S. are experiencing different paces of load growth and have varying options for its management. It is clear that reliable and affordable electricity cannot be compromised as cities, states, and regions work to meet climate goals. However, few existing technologies can provide cleaner, reliable, and affordable electricity. To meet near-term demand, natural gas generation with lower carbon intensity is an option consistent with various federal policies including the Inflation Reduction Act's (IRA) methane emissions fee. Grid-enhancing technologies, demand-side management, transmission and distribution system investments, and energy storage can also help. In parallel, continued investment in research, development, and demonstration projects is crucial to commercializing and deploying advanced clean energy technologies like CCS, clean hydrogen, small modular reactors, and long-duration energy storage.
3. **Stakeholder alignment is critical to meet the dual challenges of load growth: manage reliability and plan for deep decarbonization.** While the issue of certainty was discussed along many dimensions, what is clear is that the key stakeholders that collectively manage significant new loads must be aligned for the necessary investments in generation, transmission and distribution, and other resources that help manage the system. For example, how can policymakers and regulators unlock large amounts of private capital for projects? New large loads need to be developed in close coordination with grid planners and operators.
4. **Stakeholders are seeking flexibility to manage load growth uncertainty.** Investors, grid managers, and end users are all seeking certainty: Will new demand materialize to justify investments in generation and transmission infrastructure, and will it do so on the anticipated timeline? If electricity prices rise (which some stakeholders expect), will that reduce future load growth in turn? Increased transparency and collaboration can reduce uncertainty. Durable policies are also critical for investors to feel confident deploying large amounts of capital to projects.

Given the cross-cutting nature of many of the topics, some themes recur throughout this workshop report as they did in the conversation. Such cross-cutting themes demonstrate that these issues—along with many others—must be considered holistically by decision-makers.

1 Recent projections are likely underestimating actual load growth.

“[F]ive years ago, we had relatively flat growth in the industrial sector. … Certainly, data centers were growing, but not quite the pace that they are suddenly now, so I think this is just a challenge to change to a new era.”

“10 years ago, everybody thought a 25 [megawatt, MW] load was big. These [loads today] are huge—725 MW.”[c]

Until recently, demand in the electricity sector was relatively stable. In recent years, however, investment in large sources of new load—manufacturing facilities and data centers—has reached $630 billion.[6] This rapid growth is driven, in part, by recent legislation: the Infrastructure Investment and Jobs Act (IIJA), the Inflation Reduction Act (IRA), and the CHIPS and Science Act (Figure 2).[7] While recent projections from utilities, RTOs, analysts, and others are being revised upwards to account for these investments, workshop participants agreed that the projections are lagging economic development indicators.

Figure 2. Regional growth drivers

	Data centers	Industrial facilities	Hydrogen plants	Electrification
ERCOT	●	●		
PJM	●			
Duke Energy	●	●		
Georgia Power	●	●		
NYISO	●	●	●	●
Arizona Public Service	●	●		
CAISO				●
Portland General Electric	●	●		

In recent years, grid planners’ load forecasts pointed to economic growth, population growth, temperature patterns, and electrification as driving electricity demand. However, in seven of the eight load forecasts above, data centers (including for cryptocurrency and artificial intelligence) and industrial facilities (mainly battery and automotive, but also hydrogen plants) are the key drivers of this sudden surge in load growth expectations. Adapted from: John D. Wilson and Zach Zimmerman, Grid Strategies: The Era of Flat Power Demand is Over, December 2023, https://gridstrategiesllc.com/wp-content/uploads/2023/12/National-Load-Growth-Report-2023.pdf.

[c] As mentioned, quotes from workshop participants are unattributed as the workshop was held under Chatham House Rule.

Affordable and reliable electricity is non-negotiable on the road to net zero. One participant summed up comments from the group in saying, "Our first and foremost responsibility is reliability—to keep the lights on." As electricity demand grows from rapid electrification, manufacturing, and proliferating data centers that require more energy, electricity generation and transmission capacity must be adequate to meet demand. That capacity must also be able to integrate clean energy sources, or decarbonization goals in this sector will be undermined.

At present, data centers account for 2.5% of U.S. electricity consumption but are expected to reach 7.5% to 10% of the nation's electricity demand by 2030.[8] At the same time, demand for cloud computing services is surging, and the COVID-19 pandemic has accelerated the shift toward centralized data storage.[9]

Together, these estimates suggest a potential undercount of three to five gigawatts (GW) in national forecasts through 2028, although participants emphasized that projection is likely still too low.[6] Concerns about undercounting are warranted: a single data center coming on line in the Southeast in 2027, for example, will require 950 MW of capacity.[10] The developers expect it to take two to four years to reach full capacity and anticipate demand will peak somewhere between 70% and 90% of capacity, which enables a reserve margin to account for weather variation and unexpected demand.[10] As data centers of this magnitude proliferate, advanced, proactive planning by system operators and utilities to meet the increased demand is critical. Figure 3 provides an overview of the projected load growth from a regional transmission organization (RTO), PJM Interconnection, that exemplifies the change in projections in as little as one year.[11]

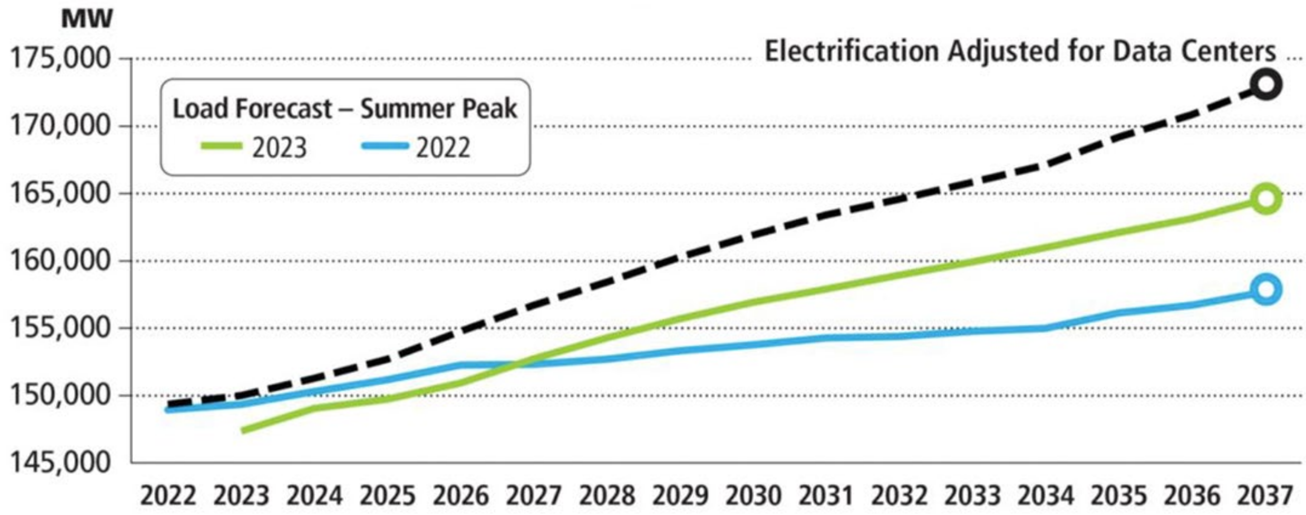
In the short term, increasing electricity demand is driven by new large loads, including data centers and manufacturing facilities. In the long term, electrification and electric vehicles are expected to contribute larger shares of the overall load demand.

"It's not only adding generation for load growth; it's adding generation to get out of that coal."

Amid this growth in demand, utility companies are continuing their decade-long efforts to reduce the use of coal, which further increases the need for new electricity generation. Participants emphasized a need for "new, firm, reliable power on a short timeline to serve new large loads." However, one individual noted the "need to find a way of doing that that doesn't make us go backward on our climate commitments."

Meeting unexpected near-term load growth may necessitate expediting the construction of rapidly deployable plants like natural gas combustion turbines or the increased use of existing thermal power plants (e.g., extending the operational life of coal-fired plants or maximizing the usage of natural gas plants). These measures present potential conflicts to pursuing decarbonization goals while adhering to environmental regulations and meeting electricity demand.

Figure 3. PJM's projected load growth



PJM's load forecast has been reviewed twice in recent years to account for future expected load growth, including from data centers. In the latest projection, for instance, the 2028 forecast increased from 152.7 GW to 155.7 GW in the past year, a 2% increase. PJM is a regional transmission organization (RTO) that has about 50 participating electric distribution utilities operating in 13 states from New Jersey to Illinois and the District of Columbia. Source: PJM, Energy Transition in PJM: Resource Retirements, Replacements, and Risks, February 2023, https://www.pjm.com/-/media/library/reports-notices/special-reports/2023/energy-transition-in-pjm-resource-retirements-replacements-and-risks.ashx.

2 Region-specific approaches are necessary for managing near-term load growth.

"At the end of the day, we're utility customers and our operations are dependent on the grids where we are located. … I can't be in [one state] and switch to someone else's grid to get electricity."

"I'd love to have a large clean energy resource that I could bring on line by 2030. It doesn't exist right now."

The levels of load growth that were discussed will depend on building new generation in many regions of the country. Workshop participants pointed to the importance of considering regional differences in electricity demand, resource availability, and policy landscapes. Regionality was, in fact, the most discussed topic of the workshop as it is inextricably linked with every other issue in the load growth conundrum.[d]

Load growth, in particular, has remained relatively consistent in some parts of the country while changing quickly in others. To the extent that neighboring regions have excess generation, enhancing interregional transmission can play a role in addressing

[d] In our thematic coding of the workshop themes, regionality was the most frequent code, including the words "region," "regionality," and the names of individual regions such as "MISO" (Midcontinent Independent System Operator) and "the Southwest."

this challenge. For example, much of the nation's anticipated industrial load growth is occurring in three regions: the Southwest, particularly Arizona and Nevada; the Midwest, concentrated in Michigan and Indiana; and the Southeast in Georgia and the Carolinas. One participant said that Arizona alone is expecting at least 40% load growth over the next five years.[e,1,12]

Among the technologies for addressing load growth today, it is particularly difficult to find ones that are readily available, reliable, and clean, with large capacity. Participants observed that natural gas partially fills such a gap because of its reliability and affordability but does not provide the emissions reduction benefits of emerging clean energy technologies.[f] Natural gas usage has markedly increased as coal usage has decreased (Figure 4), in part because it has become cost-competitive due to policy and technological advancements.[13] Addressing upstream and point-source methane emissions will help decrease the greenhouse gas emissions from natural gas and increase its acceptability.

Many utility representatives expressed concerns that recent policy proposals may constrain their ability to meet increasing load demands. For instance, EPA's proposed greenhouse gas rules could decrease utilities' flexibility in technology selection; and many utilities indicated they would need to limit their natural gas plants' capacity factors to meet the requirements.[14] The challenge will be how to design policies and regulations that drive toward a cleaner grid while still ensuring affordability, reliability, and resilience even as electricity load growth far exceeds recent expectations.

Although the average capacity factor of natural gas combined-cycle power plants in the United States is 64%,[15] materially increasing this number to meet additional load is not seen as feasible for some utilities: "Just not enough," one participant said, "it's not efficient for the plants to run much higher than they're already running."

In addition to running current plants at higher capacities where possible, utilities confirmed they were planning to bring more natural gas on line to meet the growing load and that additional natural gas capacity will be hydrogen- and carbon-capture-and-storage-ready, with a tendency to favor carbon sequestration over hydrogen. As one participant noted, "We're not committing to one or the other by any specific point in time, but if we had to bet on one, we're betting on carbon [sequestration] in the time frame we're looking at."

When participants considered additional strategies for managing load growth, the themes that emerged ranged from regulatory and infrastructure challenges to opportunities for technological innovation to unlock new options. Technologies with longer deployment lead times that were discussed included carbon capture and storage

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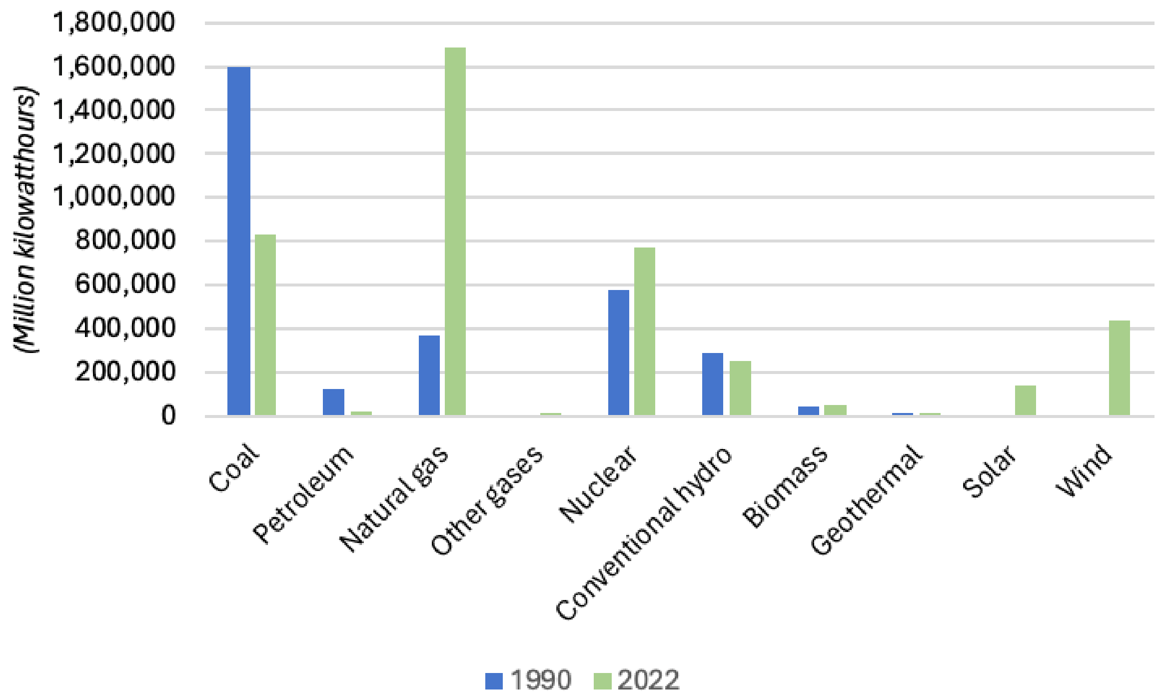
[e] Though data centers account for the largest share of expected load growth overall, that growth is more evenly dispersed around the country. Data center growth is highest in the PJM region, which covers much of the mid-Atlantic, including Virginia, where data centers and cloud markets are expected to concentrate. PJM recently updated its load forecast and tripled its estimated growth expectations over the next decade from the previous year (see endnotes 4 and 29) to accommodate the expected increase in data centers, particularly those that support generative AI, which is especially energy-intensive. Increased electrification of transportation and industry was another reason for the PJM update.

[f] Natural gas was the fifth most frequent topic of discussion, with 42 mentions, accounting for 11% of all coded segments.

(CCS), small modular reactors (SMR) and advanced nuclear reactors, nuclear fusion, hydrogen, and long-duration energy storage.

Figure 4. U.S. annual electricity generation by source



Comparing trends from 1990-2022, 78.4% of U.S. power generation in 2022 was from natural gas and zero-carbon sources, a substantial increase over the last three decades. Zero-carbon sources accounted for 39.6% of U.S. power generation in 2022. "Other gases" refers to blast furnace gas and other manufactured and waste gases derived from fossil fuels. Through 2010, this includes propane gas. "Biomass" includes wood and wood-derived fuels, along with municipal solid waste from biogenic sources, landfill gas, sludge waste, agricultural byproducts, and other biomass. Through 2000, this includes non-renewable waste, as well. "Solar" includes generation from solar thermal and photovoltaic energy at utility-scale facilities. It does not include small-scale photovoltaic generation. Data from: U.S. Energy Information Administration (EIA), Monthly Energy Review, Table A2: Approximate Heat Content of Petroleum Production, Imports, and Exports, January 2024, https://www.eia.gov/totalenergy/data/monthly/pdf/sec12_3.pdf.

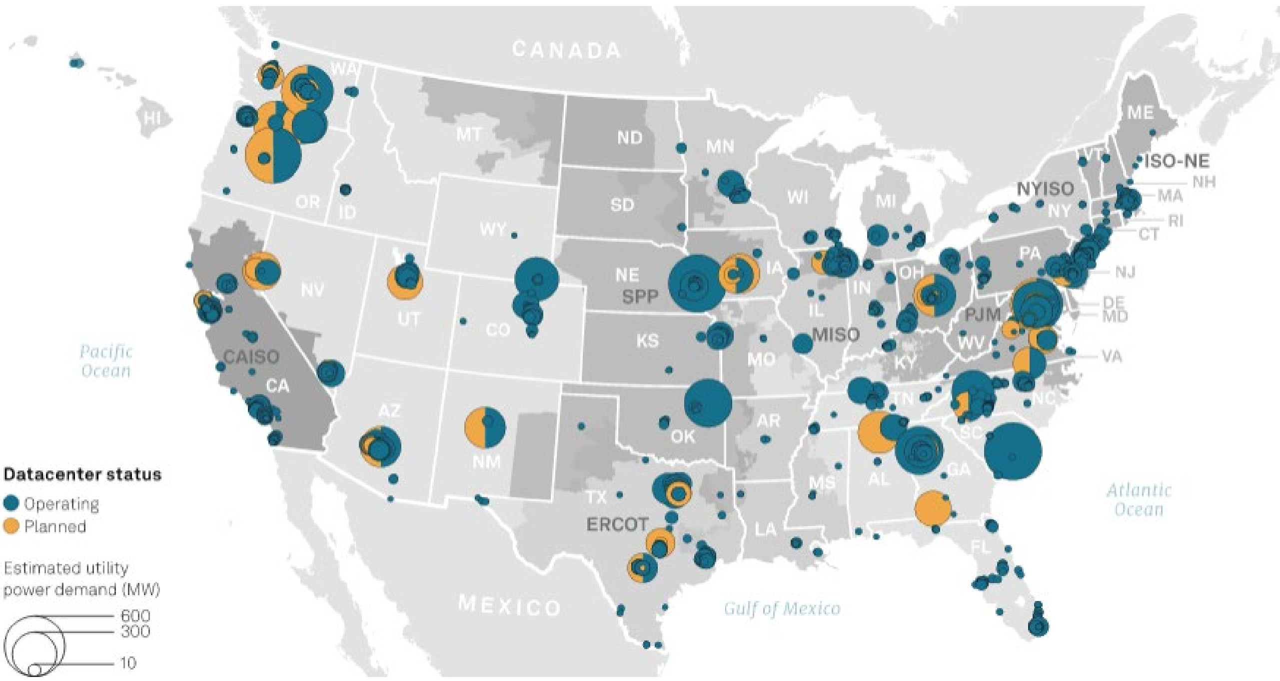
Regulatory

Federal and sub-national policymaking impacts utilities' ability to meet load growth demands, sometimes in unanticipated ways. Each region is also subject to its own regulatory structures that complicate utilities' ability to meet load growth with clean electricity. For example, New York state's ozone peaker rule requires 1,500 MW of combustion turbines, or peakers, to shut down by 2025.[16] However, because of predicted summer shortfalls, one participant noted that 600 MW of peaker capacity is being retained for "a period of two years, possibly extended up to four years."

Infrastructure

Increased transmission capacity will be an important complement to building new generation and deploying other strategies for modernizing the grid (e.g., grid-enhancing technologies, innovative market designs). Where and how new infrastructure is built remains an open question (Figure 5).[17]

Figure 5. Estimated data center growth by grid region



This figure illustrates the estimated growth in data center capacity across various regions, highlighting the need for corresponding infrastructure development to meet growing load demand. Source: S&P Global, POWER OF AI: Wild predictions of power demand from AI put industry on edge, October 2023, https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/electric-power/101623-power-of-ai-wild-predictions-of-power-demand-from-ai-put-industry-on-edge.

At present, some stakeholders noted that the United States lacks sufficient large, interregional transmission lines to move electricity from regions with excess generation to those with the fastest load growth – to the extent that excess generation exists as coal retirements continue. In addition, local and regional transmission investments are needed to continue integrating renewable energy as well as new sources of electricity demand. Not only is it expensive to add new transmission lines, it also is slow. “When you start to think about even bringing transmission lines across areas, places that shouldn’t be—you would think—all that controversial just take a tremendous amount of time,” one participant said.

“Inadequate transmission capacity/linkages across the country” also prevents utilities from maximizing output from existing generation. Some solutions to address this in the short run are to make use of grid-enhancing technologies like dynamic line ratings and advanced power controls, both of which are expected to be included in an upcoming rule from the Federal Energy Regulatory Commission (FERC) regarding transmission.[18] Some participants agreed that focusing on transmission is a way to help support near-term load growth while addressing generation that is currently curtailed.

Pipelines, underground storage (e.g., salt domes), and other infrastructure requirements also limit the technologies available for electricity production in each region. For instance, some parts of the Southeast have ample access to CO_2 storage, but not in the Carolinas, where “there’s no pipelines, no places to store it” near the load.[22]

Participants observed that the threat of litigation is a serious impediment to building out new infrastructure and that “it really seems to be moving across the entire political spectrum,” impacting states like Ohio and Illinois, which have not been resistant to such industrial activity in the past. Given “all the opportunities for lawsuits to really slow that down,” the workshop emphasized the need for efficient and effective permitting regimes and stakeholder engagement that enables rather than frustrates infrastructure development.

CCS

Workshop participants touched on the status of CCS in the power sector and what is needed to move the technology forward. They expect that some natural gas power plants could be retrofitted to incorporate CCS, while new natural gas units already are considering CCS (and/or hydrogen) in the initial planning stage. Participants also reinforced the importance of the infrastructure theme above, noting that the development of supporting infrastructure (e.g., CO_2 pipelines and storage sites) will be central to enabling CCS deployment. Policies to accelerate supporting infrastructure buildout and foster community acceptance were also cited as essential for CCS development.

Nuclear (SMRs, advanced reactors, and fusion)

Nuclear power is seen as a promising option for addressing load growth because of its high capacity factor, zero emissions generation, and potential to contribute to a balanced energy mix.[19] SMR deployment, however, is still a few years away. “Nobody wants to go first. How do you de-risk and enable SMRs?” asked one participant.

Certainty of fuel supply will play a role in reducing risks. According to another participant, “We need a lot of policy changes and a lot of streamlining to get SMRs on quicker and faster; our resource plan is showing the quickest is 2035.”

Collaboration among the U.S. Department of Energy, SMR developers, utilities, and regulators was mentioned as a pathway to reduce risks and streamline SMR uptake. The EFI Foundation’s concept for a “cost stabilization facility” was discussed as a potential solution to manage risk between the government and private sector that could help move initial projects forward.[20] Specifically, a consortium of buyers would all commit to buying the same design – enabling a nuclear manufacturer to build an “order book” – and then public-private cost sharing could commence if project costs exceeded the negotiated threshold.

Nuclear fusion is making remarkable progress, with over $6B of private funding invested in an array of different fusion technologies.[21] If demonstrated in a commercial pilot project, fusion would present a major long term opportunity for carbon-free firm power that can be sited with great flexibility.

Hydrogen

Clean hydrogen could play a role in addressing load growth, particularly in hydrogen-capable natural gas combustion turbines that can ultimately operate with pure hydrogen. The major question that was posed by participants was whether those turbines would ever actually use a meaningful amount of hydrogen. Building electrolyzers on-site for green hydrogen production was discussed as a strategy to minimize hydrogen transportation costs. Some regions of the country are seen as more suitable for hydrogen storage because of existing geological formations (e.g., salt caverns, aquifers, and depleted hydrocarbon reservoirs).[22]

Long-duration storage

In a power system with a large penetration of solar and wind, energy storage helps to manage load growth effectively, ensure reliability, and meet peak demand, especially during winter mornings.[23] Participants highlighted that, ideally, energy storage would need to evolve to long-duration, on the order of two days, rather than the current duration of about four hours. While energy storage today is dominated by pumped hydropower and lithium-ion batteries, new energy storage solutions like thermal storage and iron-air batteries potentially offer cost-competitive multiday storage.[24,25] Technology development, deployment, and diffusion, however, is a near-to-mid-term challenge.

3 Stakeholder alignment is critical to meet the dual challenges of load growth: manage reliability and plan for deep decarbonization.

Stakeholder collaboration was highlighted as crucial for the successful transition to a clean energy future. The workshop underscored the importance of involving a broad spectrum of stakeholders, including utilities, governments, communities, and businesses in the planning and implementation of strategies related to load growth. This could be helpful for reducing uncertainty and identifying innovative solutions to challenges. Further, to coordinate effectively, stakeholders must understand one another's decision-making processes and incentives along with the downstream impacts of major decisions.

Supply-side and demand-side coordination was viewed as critical. Very large, unexpected loads like GW-sized data center campuses require utilities to rethink their five-year plans. When grid operators (RTOs and utilities) were asked if they felt "confident that you're seeing those requests for service as quickly as you need to," the response in the room was a resounding "No, not at all." This can be a particular challenge for RTOs/ISOs, which are increasingly serving large customers that have not historically participated in transmission planning processes, and the time scale of imagining new capabilities may be mismatched to the capability of providing the infrastructure. Without close coordination, grid operators lack the certainty to do the proactive planning necessary to address increasing load requests.

Data centers and utilities, in particular, have a dynamic relationship because they are each other's customers in the electricity and data markets. As one participant noted, "When you are beholden to the grid you are on, you work with utilities as best you can to try to influence their decisions. … I can't go to a utility and say I need like nine SMRs."

Such "influence" translates into looking for innovative ways to partner with utilities to bring more clean electricity generation to the grid and support policy efforts that will enable the energy transition. For instance, utilities can use AI and drones to inspect transmission lines; data centers can use AI to assist in permitting applications to accelerate the process by minimizing back-and-forth; and project developers and utilities can partner on on-site selection for large loads.[26,27] Large load customers, transmission operators, system operators, and planners can also collaborate on long-term load forecasts beyond five years.

Large customers, like data centers and manufacturing plants, are increasingly pressuring utilities to match clean energy supply with load at an hourly level. Simultaneously, utilities are adapting to a new paradigm in which both supply and demand are more flexible. Utilities can develop creative ways to help customers keep their climate commitments such as "creative rate designs" to shift flexible loads (e.g., electric vehicle charging and data center computing) to off-peak periods: "Planning for peaks is going to be really critical, as well as finding those opportunities for demand response and flexibility." In turn, customers can help utilities minimize reliability challenges by making available backup generators and energy storage currently used for redundancy.

4 Stakeholders are seeking flexibility to manage load growth uncertainty.

Workshop participants from a variety of perspectives—end users, utilities, RTOs, and former regulators—all noted the importance of increasing certainty (or decreasing uncertainty) for decision making, albeit from different, sometimes competing perspectives. As one participant observed, "They're looking for certainty of the load to show up, and I'm looking for certainty that generation is there." Another commented, "It's very difficult to get the regulator to say 'Yes, I want you to go ahead and build that 500-KV backbone across your entire state' without already knowing where the load is coming from."

Customers want guarantees that their electricity will be provided from clean, affordable, and reliable resources; utilities want to know they will "get cost recovery, whether it's through the regulatory commission or through the wholesale market structure"; and regulators want more assurances about how much load will materialize in order to assess whether infrastructure is needed.

To address uncertainty, participants also highlighted the need for flexibility, particularly for regulatory approaches, market and technological innovation, demand-side management, and policy development. As one example, a participant highlighted that in joint comments with other independent system operators (ISOs) on the U.S. Environmental Protection Agency's (EPA) proposed greenhouse gas rule for power plants, ISOs (and RTOs) advocated for a "safety valve" to address reliability if needed. There was also a call for flexibility in policymaking to avoid premature retirement of existing resources before replacements are ready, ensuring system reliability.

The discussion strongly suggested the need for systems that can adapt to varying levels of demand. It also pointed to responsive demand as an increasingly important tool for balancing the grid. Some new loads may offer flexibility (e.g., cryptocurrency mining, electric vehicle charging) with appropriate incentives and pricing structures, while others may be less flexible. This differentiation underscores the importance of incorporating the right incentives along with flexibility in planning and operational strategies to accommodate varying types of loads and their impacts on peak demand and system reliability. Increasing transparency and collaboration between stakeholders through proactive engagement and information sharing can help unlock demand flexibility and other solutions.

Participants described four contexts in which certainty is particularly important:

Grid management

The discussion highlighted the need for regulatory bodies to provide certainty, or at least predictability, for grid management and planning. Interconnection queues, for instance, have long been blamed for transmission backups. However, one participant cited an informal poll of ISOs and RTOs nationwide that showed "close to 300,000 MW of projects that signed interconnection agreements," suggesting "it is more about a construction backlog than an interconnection queue backlog."[g, 28, 29, 30, 31, 32, 33, 34] A 2023 analysis from S&P Global reports a smaller figure: 178,000 MW.[35] It is difficult to determine how much of the interconnection queue is speculative until queue reforms are complete, but regardless of the exact magnitude, such figures point to a major shift in hurdles to deploying clean energy.

The lack of capacity may also cause grid managers to rethink plans for decommissioning existing assets or shifting to cleaner forms of electricity generation. For example, one participant mentioned a Panasonic factory being built in Kansas that will require 200 MW to 250 MW of power to operate.[36] "That company is going to come on line and coal-fired power plants [will] not be retired to serve [the load] to build new electric vehicle batteries. And it just becomes this need for new firm, reliable power on a short timeline to serve new large loads." As timelines for interconnecting new generation

[g] Data based on an informal poll conducted among ISOs and RTOs that publicly display such information on their websites. For instance, the following is potential new generation projected to meet commercial operation in 2025 for specific regions: ERCOT estimates 78,277 MW; PJM estimates 81,852 MW; SPP estimates 22,651 MW; ISO-NE estimates 9,887 MW; NYISO estimates 4,840 MW; CAISO estimates 2,293 MW; and MISO estimates 51,858 MW for summer peak demand and 51,997 for winter peak demand.

lengthen, it is likely that baseload thermal resources will remain on line to meet short-term needs for new load.

Transmission planning

Decisions about where to site new transmission lines depend in part on projections of where new electricity generation and load will occur. Planners must balance the risk of overbuilding in areas where load and/or generation do not materialize with the risk of expensive incremental upgrades if the system does have sufficient capacity to serve new load and/or generation.

Further, planners must secure consensus for new transmission capacity among myriad regional stakeholders, and they must reach consensus not only on where new transmission lines are needed, but also on who will pay for them. Increasing transparency and collaboration—and the associated reduction of uncertainty—in transmission planning can enable a more proactive approach to connect expected generation and load over the next 20-plus years in the most efficient way possible at both the local and regional levels.[37]

Supply chains

Robust and resilient supply chains are critical to enabling utilities to "systematically prioritize and systematize their interconnection," as one participant noted. Recent supply chain constraints on transformers, aluminum, and copper have led to higher costs and delays, often measured in years.[38]

Complicating the issue further, while securing domestic supplies can help alleviate some supply chain constraints, it also introduces additional load on the grid as new domestic production facilities come online. Utilities and end users are often "competing for very similar components," resulting in an increased risk of project delays.

Investment

High costs, interconnection challenges, and the risk of litigation add significant uncertainty to investment decisions. For example, one participant noted that they may have "tens of millions of dollars at risk" because they're "looking for 100,000 feet of copper or aluminum."

Further, new generators seeking to connect to the grid are often required to pay for significant transmission upgrades to do so.[39] As a result, otherwise economical projects become too expensive and are canceled.[40] Large sources of new load, like data centers, are increasingly facing multiyear delays in gaining electricity access due to transmission constraints. Across project types, the ever-increasing risk of litigation creates uncertainty about whether a project will ever go on line, threatening investors' ability to recoup their capital, let alone earn a competitive return.[41]

Clear, transparent, and accurate market signals are necessary to stimulate the investment and technological advancement needed to meet load additions. As load increases and coal-fired generation retires, several participants said they expect prices to start rising. Whether or not those price increases cause a boomerang effect in shifting load back down remains to be seen.

Conclusion and next steps

"I think there's an opportunity to take some lessons learned in the next few years that we can then carry forward to the next 25 years."

The EFI Foundation Load Growth Workshop conversation highlighted the multifaceted nature of the energy transition, emphasizing the need for coordinated and creative approaches to decarbonization and electrification. The rapid shift in load growth projections will require greater flexibility and agility by grid managers to meet demand, especially in the near term. We are already seeing extension of existing fossil generation assets, otherwise planned for closure, online for longer periods of time as well as rapid deployment of new single-cycle natural gas power plants to augment currently planned increased deployment of renewable generation projects. Such a strategy, however, will result in higher than projected emissions in the near term, which will need to be reconciled with longer-term goals, shared by both grid managers and customers, to transition to clean electricity generation.

The workshop highlighted the need for decision-makers to prioritize investments in infrastructure, leverage technological innovations, advocate for supportive policies, engage with a wide range of stakeholders, and develop strategies that are responsive to regional dynamics. By embracing these recommendations, the energy sector can navigate the challenges of the transition and move closer to achieving a sustainable, resilient, and equitable energy future for all.

In addition to the primary themes emerging from the workshop, several other issues arose that warrant further research and discussion.

1. **Innovative business models, policies, and regulations will be needed to accelerate the deployment of clean energy resources onto the grid.** In the near-term, regulatory models could provide greater financial certainty for proactive investments in clean generation and associated infrastructure, whether through rate basing or assurances that resources will be deployed. Longer-term, grid managers could explore adjustments to traditional cost-of-service regulatory models to ones that reward outcomes like reliability, affordability, and decarbonization.
2. **Policymakers and regulators could consider creative measures to deploy readily available technologies that maximize the effectiveness of the grid.** Workshop participants highlighted the need for grid-enhancing technologies to upgrade transmission infrastructure, but changes to incentives may be necessary to drive adoption. For example, near-term investments in dynamic line ratings and virtual power plants can provide a complement to longer-lead infrastructure investments in new generation and transmission.
3. **RTOs/ISOs and state regulators may need to establish new safe harbor protections to facilitate needed investments in new generation, life extension of existing assets, and customer-led behind-the-meter solutions.** With electricity growth increasing rapidly, there is space for creative problem-

solving, including additional exploration of alternative pathways to improve and optimize load capacity, such as energy conservation and supporting edge-of-grid technologies and localized (behind-the-meter) generation and storage.[42]

4. **Hyper-scale data centers present fundamentally different challenges relative to traditional sources of large load, both because of the speed with which they're coming online and the sheer capacity required.** Further, centers could potentially also offer significant load flexibility.[43] As such, utilities, regulators, and data center customers will benefit from exploring new and creative tariff structures.
5. **The primary responsibility of service providers includes ensuring reliability and affordability of electricity supply.** This commitment is especially vital in underserved communities.[44] Underserved communities often incur greater electricity costs; increasing loads threaten to exacerbate that tendency.[45] As one participant observed, "I think that's just an interesting dynamic that individual regions are bearing costs that are associated with national prerogatives." More strategies need to be developed to meet increasing demand with cleaner electricity sources while also prioritizing equitable access to reliable and affordable electricity for all.
6. **Though many large customers (end users) are committed to decarbonizing, there is a need for "carbon-managed" electricity sources, not just "carbon-free."** For example, natural gas with CCS is considered carbon-managed but not carbon-free, which investors indicated would not count toward their decarbonization goals. As one participant said, "You can't lump in gas with capture with solar… You just can't get away with it in the investor community." What is unclear at present is how the investor community will incorporate carbon-managed electricity, carbon-free electricity, and carbon offsets in their climate calculus for achieving their environmental, social and governance (ESG) goals. Further exploration is needed to develop agreed-upon, transparent methodologies for calculating emissions to ensure steps forward in the energy transition align with the diverse goals and expectations of stakeholders.
7. **Addressing the water-energy nexus presents a significant challenge for stakeholders, as some major electricity consumers and generators have substantial water needs.** Water could become a limiting factor for clean hydrogen production, data center expansion, and hydropower generation. As climate change alters precipitation patterns, exacerbates droughts, and influences water availability, the issue of water use has become a central concern in the deployment of certain clean energy technologies. Stakeholders may want to develop strategies tailored to regional conditions, taking into account future climate scenarios, local water resources, and energy requirements to ensure both resilience and sustainability in the era of climate change.
8. **Innovative zero GHG emission technologies, including enhanced geothermal, fusion, SMRs, and long-duration storage, are unlikely to be on a deployment timescale that can meet near-term load growth needs.** Accelerated innovation efforts, including new risk-sharing mechanisms to enable

increased investments, could help shorten deployment timelines. Load growth can spur innovation into technology areas that are not currently available for meeting near-term load, especially with zero-carbon firm power.

Access to adequate data and information is crucial and permeates all the areas listed above, allowing stakeholders to formulate effective strategies and allocate resources efficiently to manage load growth and enhance grid reliability. Examples of data that could be collected and made available are real-time data on consumer electricity usage; EV charging demand, locations, and times, along with EV battery storage capacities and usage patterns; cross-sector (industrial, commercial, residential, transportation) electricity usage data that comprehensively allow energy management strategies; efficiency improvements; and holistic approaches to reducing carbon footprints. Comprehensive data collection and sharing also enhance certainty by enabling investors and technology solution providers to make well-informed decisions and accurately assess risks.

Moving forward, stakeholders will face the delicate challenge of keeping the lights on day in and day out while simultaneously navigating profound shifts in the demands placed on the grid. As a result, long-term planning will only increase in value.

Planning, regulatory, and financing processes must evolve to enable proactive investments for the future while providing flexibility to accommodate near-term fluctuations. Planning will be an effective tool, however, only if it is based on realistic projections of future grid needs and represents a consensus view regarding what investments are needed and who will pay for them.

To that end, a growing chorus of perspectives (e.g., host communities, data center operators) must engage in planning efforts—and be equipped to engage effectively—to build the consensus necessary to meet the goals of reliable, resilient, affordable, and clean power today and in the decades to come.

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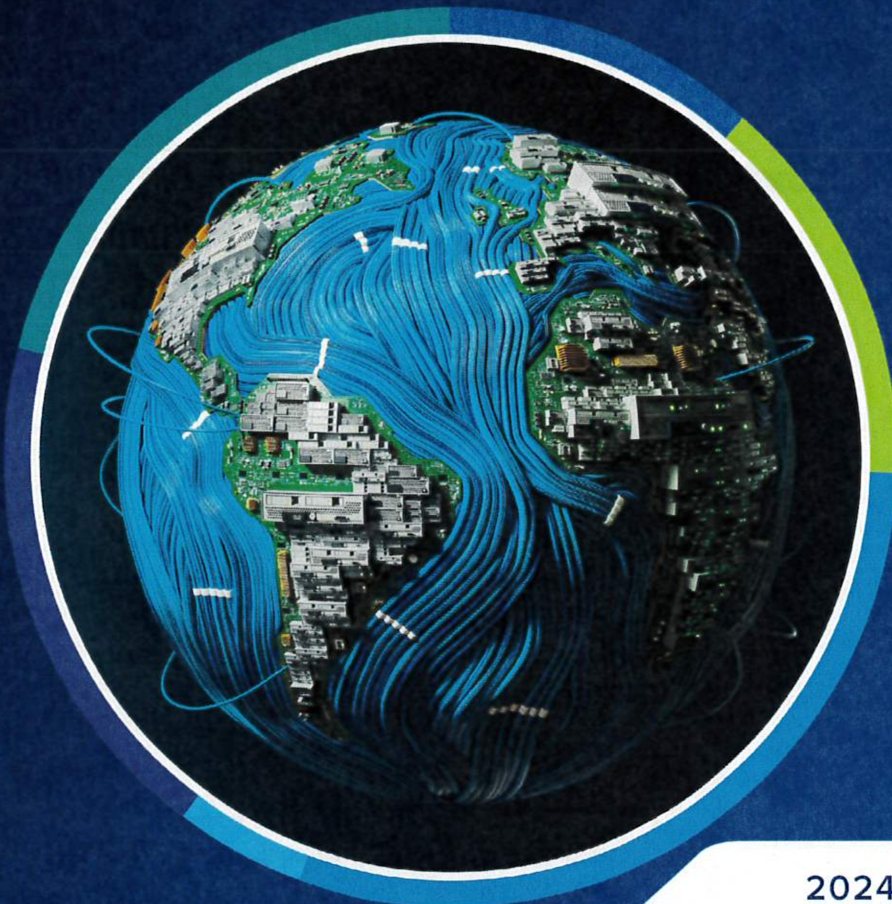


2024 White Paper

Powering Intelligence

Analyzing Artificial Intelligence and Data Center Energy Consumption

EXECUTIVE SUMMARY

Key Messages

- In the United States, powering data centers, providing clean energy for manufacturing, supporting industrial onshoring, and electrifying transportation are driving renewed electric load growth. Clusters of new, large point loads are testing the ability of electric companies to keep pace.
- Data centers are one of the fastest growing industries worldwide. Between 2017 and 2021, electricity used by Meta, Amazon, Microsoft, and Google—the main providers of commercially available cloud computing and digital services—more than doubled.
- A fundamental uncertainty in projecting data center load growth comes from the broad emergence of artificial intelligence (AI) technologies in business and daily life—punctuated by the explosion into public consciousness of generative AI models, such as OpenAI's ChatGPT, released in November 2022. While AI applications are estimated to use only 10%–20% of data center electricity today, that percentage is growing rapidly.
- AI models are typically much more energy-intensive than the data retrieval, streaming, and communications applications that drove data center growth over the past two decades. At 2.9 watt-hours per ChatGPT request, AI queries are estimated to require 10x the electricity of traditional Google queries, which use about 0.3 watt-hours each; and emerging, computation-intensive capabilities such as image, audio, and video generation have no precedent.
- To provide an early assessment of potential data center load growth at the national level, EPRI has developed low, moderate, high, and higher growth scenarios for data center loads from 2023 to 2030. Data centers grow to consume 4.6% to 9.1% of U.S. electricity generation annually by 2030 versus an estimated 4% today.
- While the national-level growth estimates are significant, it is even more striking to consider the geographic concentration of the industry and the local challenges this growth can create. Today, fifteen states account for 80% of the national data center load, with data centers estimated to comprise a quarter of Virginia's electric load in 2023. Concentration of demand is also evident globally, with data centers projected to make up almost one-third of Ireland's total electricity demand by 2026.
- With the shift to cloud computing and AI, new data centers are growing in size. It is not unusual to see new centers being built with capacities from 100 to 1000 megawatts—roughly equivalent to the load from 80,000 to 800,000 homes. Connection lead times of one to two years, demands for highly reliable power, and requests for power from new, non-emitting generation sources can create local and regional electric supply challenges.
- EPRI highlights three essential strategies to support rapid data center expansion:
    1. Data center ***efficiency improvements and increased flexibility***.
    2. ***Close coordination between data center developers and electric companies*** regarding data center power needs, timing, and flexibility, as well as electric supplies and delivery constraints.
    3. ***Better modeling tools*** to plan the 5–10+ year grid investments needed to anticipate and accommodate data center growth without negatively impacting other customers and to identify strategies for maintaining grid reliability with these large, novel demands.

TABLE OF CONTENTS

Potential Impacts of Artificial Intelligence on Data Center Load Growth

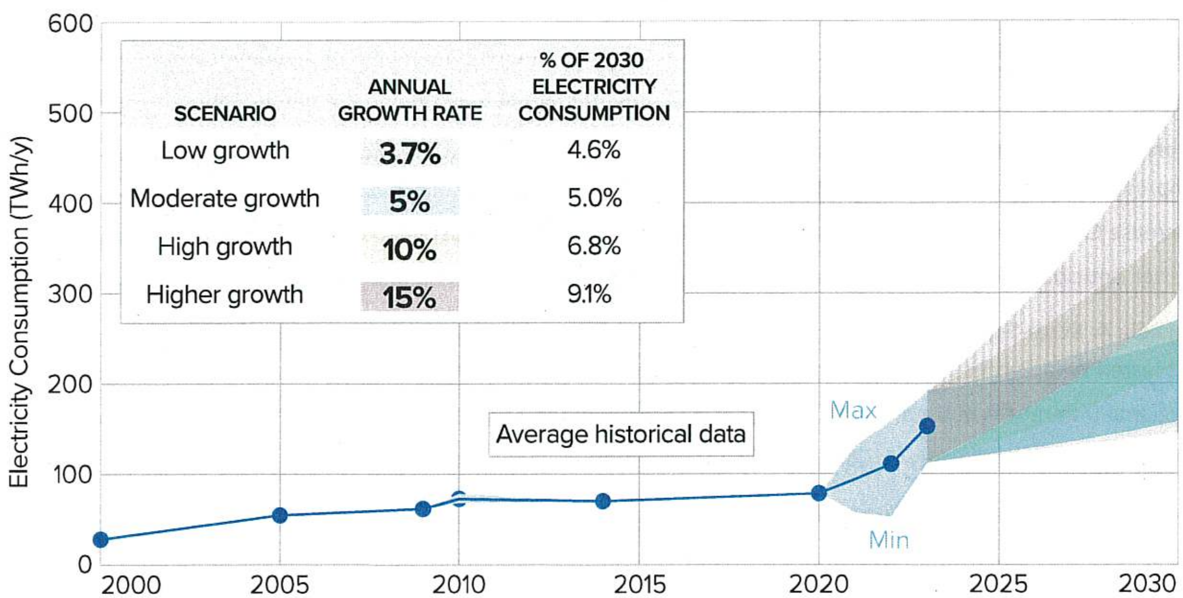
Data center operation is one of the fastest growing industries worldwide. The International Energy Agency recently projected that global data center electricity demand will more than double by 2026. In the United States, the national outlook could resemble the global outlook, but is highly uncertain.

One key uncertainty that could change the trajectory of data center load growth is the use of generative AI models. Both public and corporate imaginations were triggered by the release of OpenAI's ChatGPT on November 30, 2022. Evidence about how widely these tools will be used and how much they will change computational needs is just starting to emerge. These early applications were estimated to require about ten times the electricity—from 0.3 watt-hours for a traditional Google search to 2.9 watt-hours for a ChatGPT query—to respond to user queries. Creation of original music, photos, and videos based upon user prompts and other emerging AI applications could require much more power. With 5.3 billion global internet users, widespread adoption of these tools could potentially lead to a step change in power requirements. On the other hand, history has shown that demand for increased processing has largely been offset by data center efficiency gains.

EPRI U.S. Data Center Load Projections

Drawing on public information about existing data centers, public estimates of industry growth, and recent electricity demand forecasts by industry experts, EPRI prepared four scenarios of potential electricity consumption in U.S. data centers during the period from 2023 to 2030 (**Figure ES-1**). The blue line in the figure, running from 2000 to 2020, traces historical data center electricity consumption estimates. From 2000 to 2010, data center load grew as centers expanded across the country to support the emerging internet. From 2010 to 2017, despite continued growth in computing demands and data storage this load growth flattened due to efficiency gains and the replacement of small, relatively inefficient corporate data centers with large, cloud computing facilities. In recent years, load growth has likely accelerated, driven by emerging AI applications and COVID-era increases in demand for services like streaming and video conferencing. The light blue area highlights uncertainty in a range of data center electricity consumption estimates for 2021 to 2023. Colored bands show the four projections, which combine estimates of increased data processing needs with assumptions about efficiency gains. The widths of these bands carry forward the uncertainty about the 2023 starting load level:

- ***Low growth****—3.7% annual load growth based on a Statista projection of data center financial growth issued prior to the release of ChatGPT.*



SCENARIO	ANNUAL GROWTH RATE	% OF 2030 ELECTRICITY CONSUMPTION
Low growth	3.7%	4.6%
Moderate growth	5%	5.0%
High growth	10%	6.8%
Higher growth	15%	9.1%

Figure ES-1*. Projections of potential electricity consumption by U.S. data centers: 2023–2030 . % of 2030 electricity consumption projections assume that all other (non-data center) load increases at 1% annually.*

- ***Moderate growth****—5% annual load growth based on an expert assessment commissioned by EPRI.*
- ***High growth****—10% annual load growth consistent with both a McKinsey estimate and another expert assessment commissioned by EPRI in summer 2023.*
- ***Higher growth****—15% annual growth based upon a commissioned expert assessment consistent with rapid expansion of AI applications and limited efficiency gains.*

The estimates of data centers' share of total U.S. electricity consumption in 2030—9.1%, 6.8%, 5.0%, and 4.6%—assume that all other loads increase at 1% per year. Data centers accounted for about 4% of the total load in 2023 (average estimate).

Data Center Power Demands Are Concentrated in a Few Regions

Fifteen states accounted for an estimated 80% of the national data center load in 2023. Ranked from highest to lowest, they are Virginia, Texas, California, Illinois, Oregon, Arizona, Iowa, Georgia, Washington, Pennsylvania, New York, New Jersey, Nebraska, North Dakota, and Nevada. Concentration of demand is also evident globally, with the International Energy Agency recently projecting that data centers in Ireland could account for almost one-third of Ireland's total electricity demand by 2026.

The map in **Figure ES-2** shows the effect in 2030 of applying the annual U.S. data center growth rates (averaged across the four scenarios) to project state-level loads against a backdrop of 1% annual growth in other loads. With evenly spread growth, the data center share of load in Virginia increases to almost 50% in the higher growth scenario and to 36% when averaged across the four scenarios. The shares in other states vary widely with five other states projected to approach 20% or more of electricity demand under these simplified assumptions. In reality, load growth is unlikely to be spread evenly. Data centers favor sites where internet connections are strong; where electricity prices, land costs, and disruptive events are low; where skilled labor is available; near population centers and users; and where the centers can develop backup power to ensure power supply (usually natural gas or diesel generators). The additional

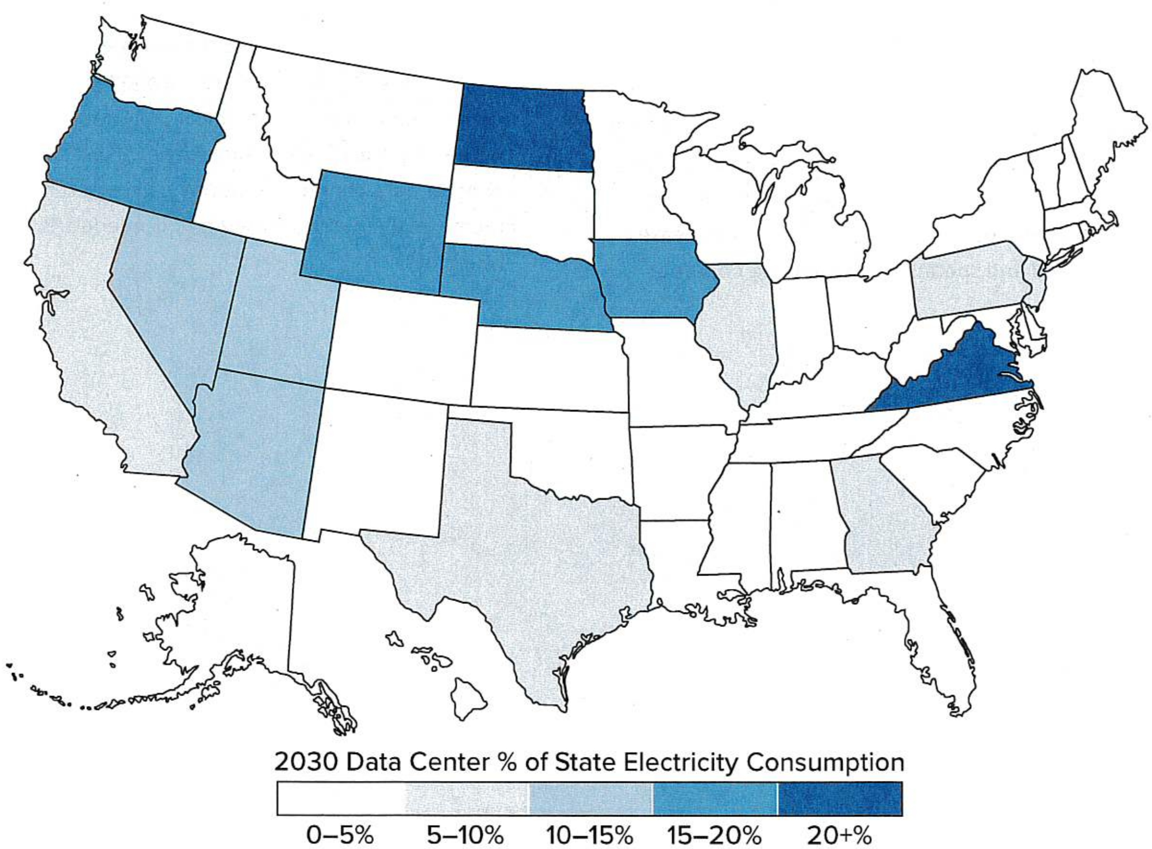


Figure ES-2. *2030 projected data center share of electricity consumption (assumes average of the four growth scenarios and that non-data center loads grow at 1% annually) [4, 8, 9]* requirement of some developers for new, clean electricity generation sources adds to the challenge of developing and delivering this new generation.

A Roadmap to Support Rapid Data Center Expansion

The most serious challenges to data center expansion are local and regional and result from the scale of the centers themselves and mismatches in infrastructure timing. A typical new data center of 100 to 1000 megawatts represents a load equal to that of a new neighborhood of 80,000 to 800,000 average homes. While neighborhoods require many years to plan and build, data centers can be developed and connected to the internet in one to two years. New transmission, in contrast, takes four or more years to plan, permit, and construct. And developing and connecting new generation can also take years.

EPRI highlights three essential strategies to support rapid data center expansion. These strategies emphasize increased collaboration between data center developers and electric companies.

1. ***Improve data center operational efficiency and flexibility***. Although gains in data center operational efficiency have plateaued in recent years, there are clear opportunities for further improvement, including more efficient IT hardware; lower electricity use for cooling, lighting, and security; and more efficient AI development and deployment strategies. Efforts to increase both temporal and spatial (i.e., spreading compute geographically) flexibility are critical to helping accommodate these new loads.
2. ***Increase collaboration between data center developers and electric companies***. Developing a deeper understanding of data center power needs, timing, and potential flexibilities—while assessing how they match available electric supplies and delivery constraints—can create workable solutions for all. Enabled by technology and supporting policies, data center backup generators, powered by clean fuels, could support a more reliable grid while reducing the cost of data center operation. Shifting the data center-grid relationship from the current "passive load" model to a collaborative "shared energy economy"—with grid resources powering data centers and data center backup resources contributing to grid reliability and flexibility—could not only help electric companies contend with the explosive growth of AI but also contribute to affordability and reliability for all electricity users.
3. ***Improve point load forecasting to better anticipate future point load growth and modeling of transient system behavior to maintain reliability***. Forecasts need to make better projections describing new point load locations, magnitudes, and timing alongside better techniques for making decisions—to build or not build long lead-time infrastructure—while facing the economic, regulatory, and political uncertainty associated with siting these large point loads. Also, real-time modeling of data center operational characteristics in an increasingly inverter-based grid is needed to maintain reliability.

INTRODUCTION

Research Questions

As the number and size of data centers expand to support continued growth in data processing, internet traffic, and rapid expansion in artificial intelligence (AI) applications, some critical questions emerge:

- How rapidly can we expect data centers to expand, and how does the rapid growth in AI change their power demands?
- What is the impact of these developments on electric load and resource adequacy?
- What implications do these trends have for future electricity infrastructure planning?
- How can the data center and electric utility industries work together to support rapid data center expansion?

Data Centers in the United States

As of March 2024, there were approximately 10,655 data centers globally; half of them, 5,381, were in the United States. Just over three years ago, in January 2021, there were approximately 8,000 data centers, with about one-third of them in the United States [1].

The construction of new data centers is accelerating at a rapid pace, largely driven by demand for AI-powered tasks such as speech recognition, tailored diagnostics, logistics, internet of things (IoT), and generative AI. The expansion of interest in generative AI is particularly notable due to the overnight popularity of ChatGPT, released on November 30, 2022, marking the public-facing start of a technology race.

Data centers vary significantly in design and purpose and are generally grouped into two categories, small or large scale. *Small-scale data centers*, representing about 10% of U.S. data center load [2], typically cater to localized operations and service small businesses, government facilities, or specific departmental needs within larger corporations. They include server rooms/closets embedded in buildings and "edge data centers," which are strategically located on the outer edges of networks to bring computing capabilities closer to users who are geographically distant from large cloud data centers [3]. Though the electricity demands of each installation are relatively modest—500 kilowatts (kW) to 2 megawatts (MW)—they account for roughly half of all servers [3]. Market research analysts have projected the global edge data center market to grow at a compound annual growth rate (CAGR) of 22.1% to 2030 [4], highlighting the rising importance of small-scale and edge data centers in digital infrastructure.

Large-scale commercial data centers are designed to serve extensive operations and often serve multiple businesses or even entire industries. These data centers seek proximity to customers and a skilled workforce and can benefit from lower land costs, property taxes, labor rates, energy prices, and risk of severe weather or seismic activity [5]. **Figures 1–3** show maps of various large-scale facility types, which include:

- Enterprise data centers, which are owned and operated by single companies for their exclusive computing and networking use. These account for about 20–30% of total load [2, 6].
- Co-location centers, where several businesses may rent space to house their servers and other hardware with shared energy and cooling infrastructure.
- Hyperscale data centers, which are capable of rapidly scaling up their operations to meet the vast computing needs of cloud giants like Amazon AWS, Google Cloud, and Microsoft Azure. Given their large scale and recent emergence, they are often at the forefront of electricity consumption and efficiency innovations. Hyperscale and co-location centers together account for the lion's share of U.S. data center load—about 60%–70% [7].

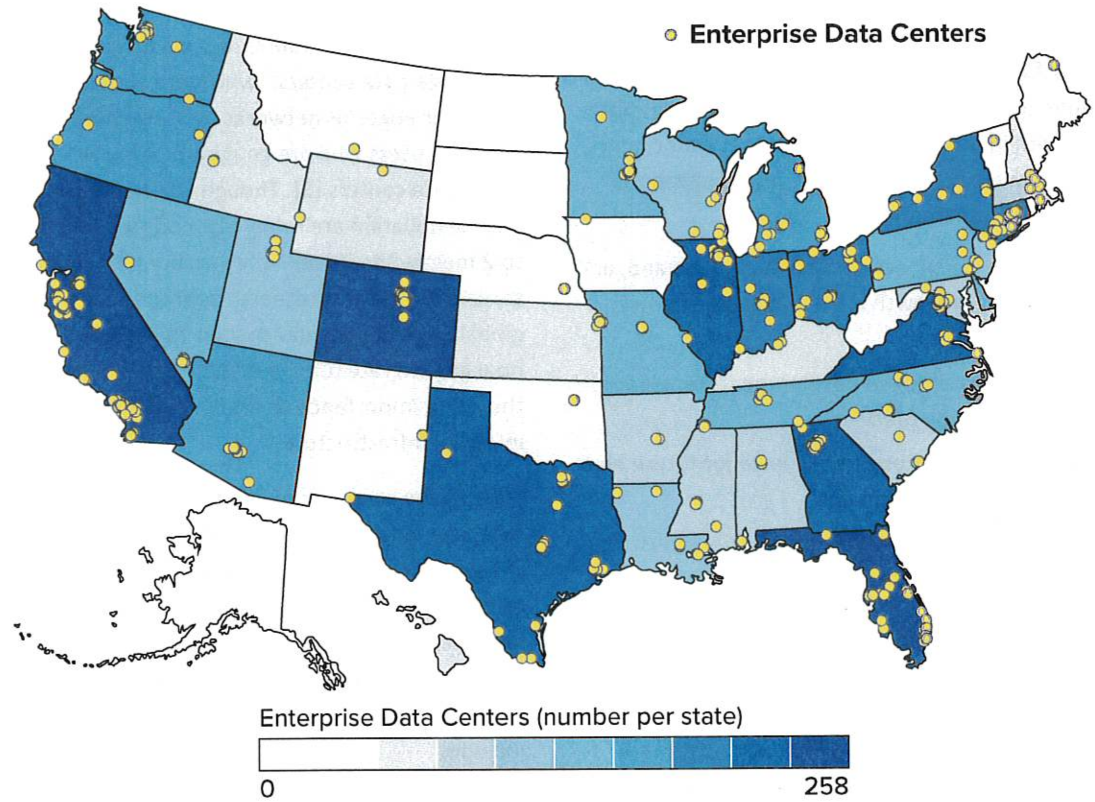


Figure 1. U.S. enterprise data center distribution as of 2022 [4, 8, 9]

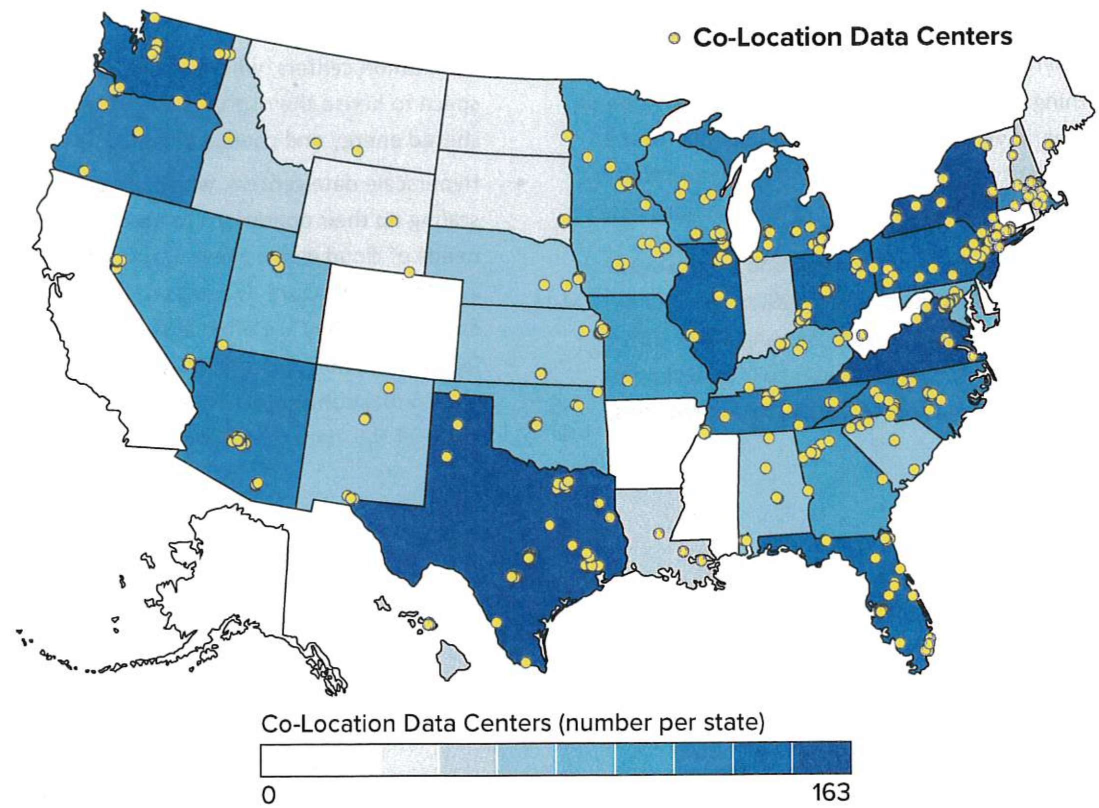


Figure 2. U.S. co-location data center distribution as of 2022 [4, 8, 9]

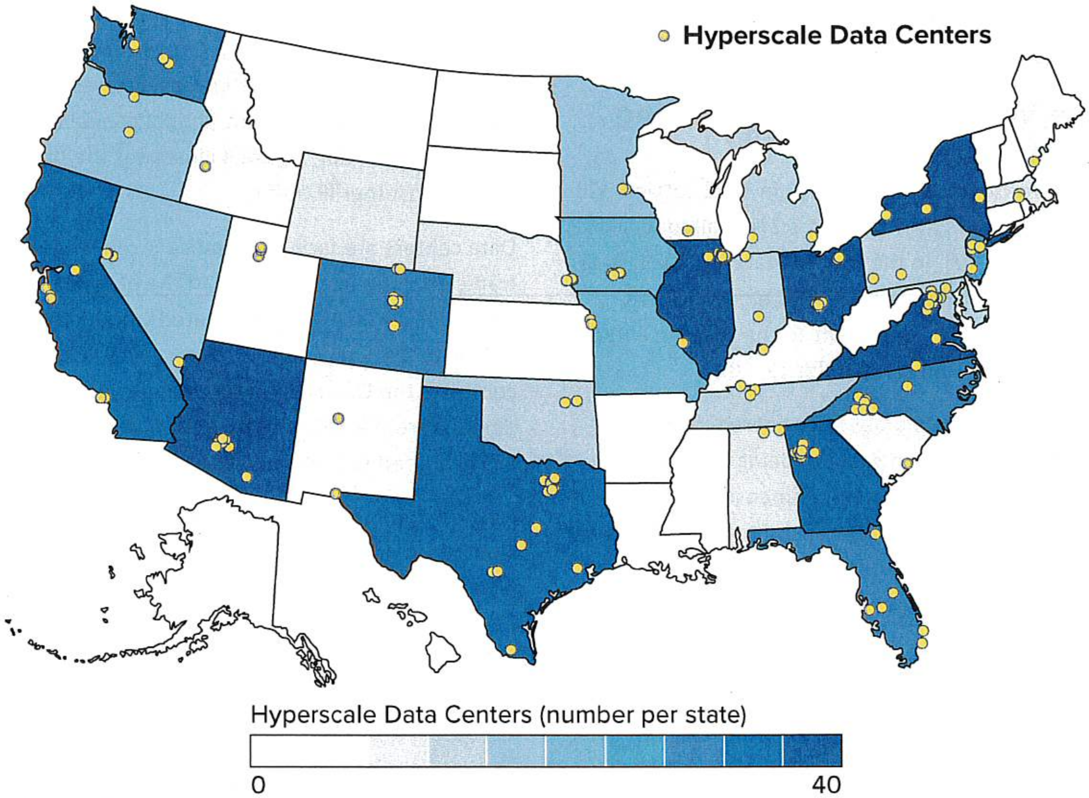


Figure 3. U.S. hyperscale data center distribution as of 2022 [4, 8, 9]

Data Centers' Primary Electricity-Consuming Hardware and Equipment

The electricity needs of data centers are determined primarily by the three constituent hardware categories. Each category's proportion of energy consumption can vary depending on the data center's age, configuration, type, and function [10, 11, 12, 13]. The three main categories and their energy consumption [2, 13, 14] are:

- IT equipment, typically composing 40%–50% of data center energy consumption, encompasses the following foundational hardware units:
  - Servers, which are the workhorses, responsible for data processing and computational tasks
  - Storage systems, which include both traditional hard disk drives (HDDs) and the faster, more energy-efficient solid-state drives (SSDs), crucial for data retention
  - Network infrastructure, which comprises switches, routers, and other components, ensuring seamless data transfer and connectivity
- Cooling systems, typically composing 30%–40% of data center energy consumption, are critical to maintaining an optimal temperature within data centers to prevent hardware malfunction and ensure longevity. While data centers historically used traditional HVAC, advanced cooling technologies in data centers have transitioned towards systems that are specialized for data center use. Please refer to the section **Energy Efficiency and Load Management** below for more details.
- Auxiliary components, typically composing 10%–30% of data center energy consumption, are used for various operational needs and include uninterruptible power supplies, security systems, and lighting.

Assessing data center energy efficiency is crucial to gauging how effectively they use electricity. These assessments help to identify trends, drive improvements, and set benchmarks for electricity usage; and play a key role in operational strategy [15, 16].

AI AND DATA CENTER POWER CONSUMPTION INSIGHTS

Immense Volumes of Data are Being Processed Daily

Data centers' worldwide electricity use in 2022 totaled 300 million megawatt-hours (MMWh), or 1.2% of all load, a 45% increase from 2015 [17]. In the United States in 2023, data centers accounted for about 4% of total electricity consumption or 150 MMWh, equivalent to the average annual consumption of 14 million households [9, 18].

Since 2017, *annual* data volumes have soared, tripling to around 4,750 exabytes (an exabyte being a billion gigabytes) by 2022, showcasing the immense volume of information being processed and transmitted globally every day [19]. In 2022, the *daily* generation of data—including captured, copied, or consumed—reached approximately 13 exabytes, a surge partly attributable to the burgeoning impact of AI models [17]. Concurrently, in 2022, global data transmission network energy use was reported to be around 260–360 MMWh, roughly equal to data center power use [17, 20]. **Figure 4** illustrates the dramatic rise in global consumer IP traffic.

Data centers are facing a significant challenge with internet traffic growing nearly 12-fold in the past decade, a trend paralleled by increasing AI-related workload demands [19]. The historical precedent is showcased in **Figure 5**, which contrasts the U.S. data storage supply versus estimated demand from 2009 to 2020, underscoring a growing deficit and the need to address these trends [22].

Despite the immense growth in network traffic and data generation, load growth has been much slower due to efficiency gains and consolidation.

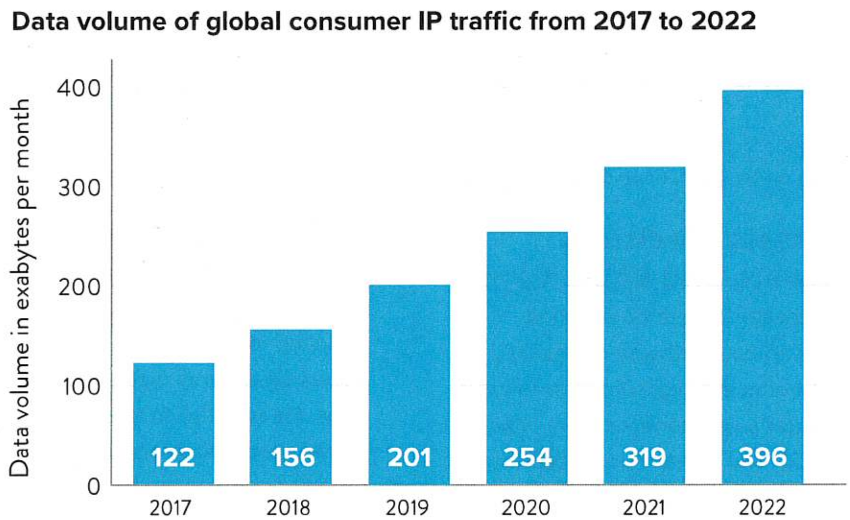


Figure 4. Trends in global consumer IP traffic, 2017–2022 [21]

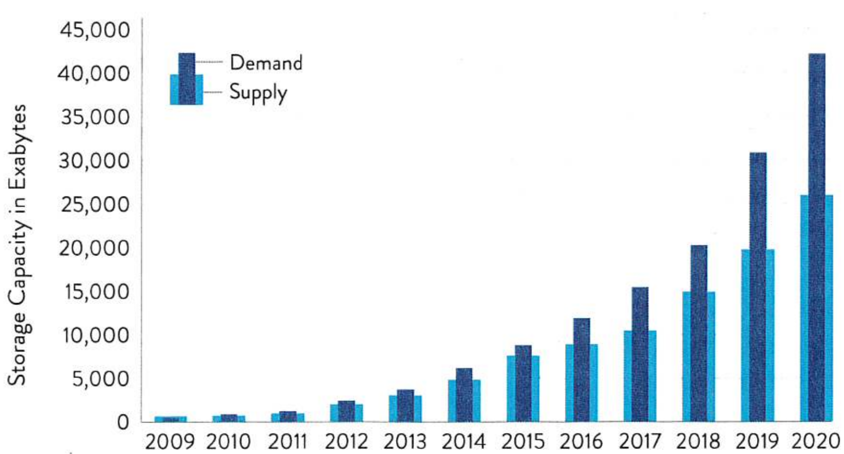


Figure 5. U.S. data storage supply vs. demand, 2009–2020 [22, 23]

History of Energy Efficiency in the Data Center Industry

Over the last 25 years, U.S. data center load growth, as shown in **Figure 6**, has experienced three phases:

1. Energy consumption grew in the early 2000s driven by the rapid expansion of internet infrastructure and the dot-com boom [24].
2. From 2010–2020, electricity consumption stabilized as data center expansion was offset by equally rapid improvements in energy efficiency achieved both through improvements at individual facilities and through the transition from small data centers to more efficient cloud facilities [25, 26].
3. Recent load growth in data centers is driven mainly by the expanding demand for cloud services, big data analytics, and AI technologies—which require significant computational resources—and a slowing of efficiency gains [27].

Efficiency gains in individual data centers have been led by advancements in server efficiency, which have been significant, leading to reduced power consumption per unit of computing power [28]. Power and cooling equipment, required to operate the IT components, has also improved its efficiency. Power Usage Effectiveness (PUE) and Data Center Infrastructure Efficiency (DCIE), key efficiency metrics in the data center industry, are defined in the box on the next page. **Figure 7** shows the U.S. PUE declined from 2007 to 2022, illustrating notable efficiency gains in

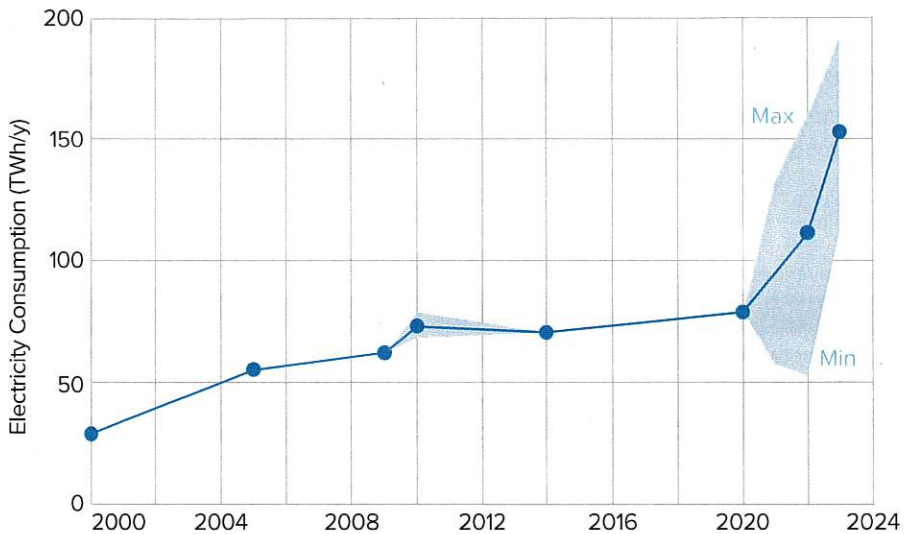


Figure 6. U.S. data center load growth from 2000 to 2023. The graph's light blue area indicates the uncertainty range based on two datasets estimating recent-to-current data center loads [4, 8, 9]

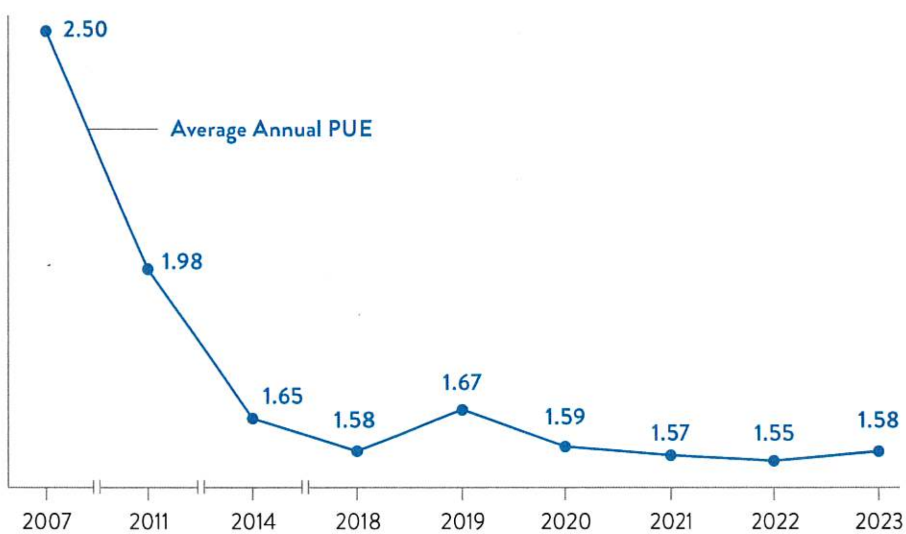


Figure 7. Average annual PUE in data centers, 2007–2023 [26, 29]

non-compute power demands [26, 29]. The recent stabilization at an average PUE of 1.6 suggests slowed progress in energy-saving strategies amidst the recent, rapid buildout [29]. With increased cooling needs of GPUs, advanced technologies (as discussed later in the report) could restart the downward drive in cooling and ancillary equipment power needs, with projected PUEs in advanced facilities potentially approaching 1.2.

DEFINITIONS OF KEY EFFICIENCY METRICS FOR DATA CENTERS

Power Usage Effectiveness (PUE)—A metric that quantifies a data center's energy efficiency by dividing the total energy usage by the energy consumed by the IT equipment alone. A lower PUE indicates higher efficiency, with 1.0 implying that all energy use is for computation.

Data Center Infrastructure Efficiency (DCIE)—A measure of a data center's energy efficiency calculated as the percentage of energy used directly by IT equipment out of the total energy consumption. Higher DCIE values signify greater efficiency in non-computational functions.

Uneven Geographic Distribution Creates Imbalance in Data Center Load

The geographic distribution of data centers is notably uneven, creating economic opportunity but also localized grid stress. For example, in 2022, data centers accounted for 1.2% of worldwide electricity, but 20% of electricity consumption in Ireland [30]. Similarly, the United States shows uneven growth in data center investments, reflecting a diverse landscape of regional opportunities and challenges. Data centers consume more power in Virginia, for instance, than in any other state. [9, 17]

Fifteen states accounted in 2023 for 80% of the national data center load. Ranked from highest to lowest in estimated load, each presents both opportunities and challenges as shown in **Table 1**.

Table 1. Opportunities and challenges for states ranked in the Top 15 for data center growth [29, 31, 32, 33, 34, 35, 36, 37]

STATE	OPPORTUNITIES	CHALLENGES
Virginia	Unparalleled network infrastructure; proximity to federal government agencies	Community pushback; regulatory scrutiny, particularly concerning environmental impact; transmission
Texas	Business-friendly; ample land availability	Electric grid reliability and pace of expansion
California	Robust technological ecosystem	High real estate and power costs; stringent environmental regulations
Illinois	Strategic location; significant tax incentives; nuclear generation and increasing renewable energy investments to address sustainability	Transmission constraints and rapidity of development
Oregon	Low electricity rates, low carbon emissions, moderate climate, tax incentives, and skilled workforce	Complex environmental regulations; demand for green energy solutions, and pace of growth
Arizona	Solar electricity, low risk of natural disasters; recent market growth	Water scarcity; need for sustainable cooling solutions
Iowa	Low electric rates; renewable energy availability	Geographic limitation (distant from major U.S. data hubs)
Georgia	Availability of land and power; friendly business environment	Balancing rapid expansion with local resource impacts
Washington	Abundant renewable energy resources	High energy costs; strict regulatory measures
Pennsylvania	Strategic location near major East Coast markets; relatively low energy costs	Aging infrastructure
New York	Hub for financial services; high connectivity demand	Space limitations; high energy costs
New Jersey	Close to major metropolitan areas; robust fiber-optic infrastructure ; transmission capacity from recent build out	High property and energy costs
Nebraska	Low energy costs; generous tax incentives	Remote location might limit connectivity options
North Dakota	Significant tax incentives; low cost of operations	Limited connectivity; need for more robust infrastructure
Nevada	Tax abatements; low electricity prices	Water scarcity; need for sustainable cooling solutions

Table 2 presents estimates of data center consumption in 2023, 2030, and the projected consumption as a percentage of state electricity demand (%EC) for the 15 states. For detailed graphs of each state's projections as well as a table showing 44 states that are pertinent to the U.S. data center market, see **Appendix A**.

Table 2. Current and projected load growth in Top 15 states [4, 8, 9]

FORECASTED SCENARIOS: PROJECTIONS OF DATA CENTER ELECTRICITY CONSUMPTION IN TOP 15 STATES (2023—2030)										
	2023 Load		Low-growth scenario (3.71%)		Moderate-growth scenario (5%)		High-growth scenario (10%)		Higher-growth scenario (15%)	
STATE	MWh/y	% of Total State Electricity Consumed (%EC)	MWh/y	% of Total State Electricity Consumed (%EC)	MWh/y	% of Total State Electricity Consumed (%EC)	MWh/y	% of Total State Electricity Consumed (%EC)	MWh/y	% of Total State Electricity Consumed (%EC)
Virginia	33,851,122	25.59%	43,683,508	29.28%	47,631,928	31.10%	65,966,260	38.47%	89,880,357	46.00%
Texas	21,813,159	4.59%	28,149,002	5.47%	30,693,306	5.94%	42,507,676	8.04%	57,917,564	10.64%
California	9,331,619	3.70%	12,042,078	4.43%	13,130,525	4.81%	18,184,686	6.54%	24,777,000	8.70%
Illinois	7,450,176	5.48%	9,614,151	6.53%	10,483,145	7.08%	14,518,285	9.54%	19,781,455	12.56%
Oregon	6,413,663	11.39%	8,276,574	13.39%	9,024,668	14.43%	12,498,415	18.93%	17,029,342	24.14%
Arizona	6,253,268	7.43%	8,069,590	8.81%	8,798,975	9.53%	12,185,850	12.73%	16,603,465	16.58%
Iowa	4,828,440	11.43%	6,230,907	13.44%	6,794,100	14.48%	9,409,263	18.99%	12,820,310	24.21%
Georgia	6,175,391	4.26%	7,969,093	5.08%	8,689,396	5.51%	12,034,090	7.48%	16,396,690	9.92%
Washington	5,171,612	5.69%	6,673,757	6.77%	7,276,977	7.34%	10,078,009	9.88%	13,731,490	13.00%
Pennsylvania	3,594,038	3.16%	4,637,961	3.78%	5,057,172	4.11%	7,003,763	5.61%	9,542,768	7.49%
New York	4,067,385	2.84%	5,248,796	3.40%	5,723,219	3.69%	7,926,182	5.05%	10,799,583	6.75%
New Jersey	3,723,199	5.42%	4,804,638	6.46%	5,238,914	7.00%	7,255,461	9.44%	9,885,711	12.44%
Nebraska	2,896,295	11.70%	3,737,552	13.75%	4,075,378	14.81%	5,644,059	19.41%	7,690,145	24.71%
North Dakota	2,975,815	15.42%	3,840,169	18.00%	4,187,271	19.31%	5,799,022	24.89%	7,901,284	31.11%
Nevada	3,416,707	8.69%	4,409,122	10.28%	4,807,649	11.10%	6,658,195	14.75%	9,071,924	19.07%

The four load growth projection scenarios reflect national-level estimates of data center growth applied to state-level estimates of current demand. This analytical approach is explained in more detail in the section **Forecasting Data Center Load Growth to 2030.*

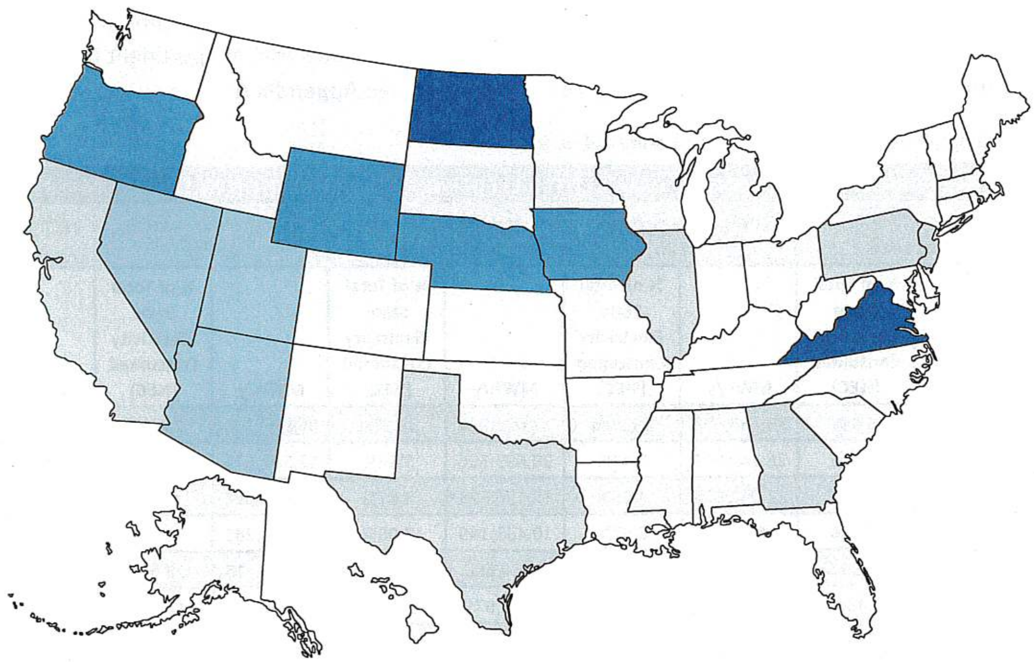


Figure 8. 2030 projected data center share of electricity consumption (assumes average of the four growth scenarios and that non-data center loads grow at 1% annually) [4, 8, 9]

The map in **Figure 8** depicts the projected data center share of state electricity demand in 2030, calculated by applying the annual U.S. data center growth rates (averaged across the four scenarios) to project state-level data center loads and assuming other loads grow at 1% annually. (The scenarios are explained in the section **Forecasting Data Center Load Growth to 2030**.) The potential for a rapidly rising share of data center power demand in many states accentuates the need for customized energy strategies that align with the specific demands and infrastructure capabilities of each state's grid. State-level projections also underscore the critical need for innovation in energy management and the optimization of localized infrastructure to accommodate the rising energy demands associated with expanding data center workloads.

AI Implications for Power Consumption

In the latter half of the 20th century, AI applications typically involved rule-based strategies and small machine-learning models that used very little electricity. However, as the 21st century unfolded, AI systems witnessed exponential growth in their complexity and computational requirements [38, 39]. On a global level, the United States has been leading in the development of prominent AI systems, with the creation of 16 such systems since 2022, compared to the United Kingdom's eight and China's three [39].

Key AI-related technological drivers contributing to escalating data center electricity demands include:[1]

- The exponential growth of data generation: The dramatic rise in global consumer IP traffic represents a reflection of the "big data" wave, part of which has resulted from feeding AI models with diverse and large datasets [9, 10, 40, 41]. The surge in data availability not only fuels the sophistication and accuracy of AI algorithms but also underscores the symbiotic relationship between increasing internet usage and AI advancement. Of course, this has required expanded storage, increased processing capabilities, and escalating electricity demands [21].
- The increasing complexity of AI models: Initially constituted as rule-based entities functioning through coded

1 While cryptocurrency mining, with its distinct computational processes and energy patterns for blockchain transaction verification and cryptocurrency generation, also impacts energy loads, it is excluded from this study to maintain focus on traditional data center operations and AI-driven computations. In 2022, global crypto mining was estimated to have consumed around 110 million MWh, accounting for 0.4% of annual global electricity demand, around one-third the usage of traditional data centers [17]. A separate assessment is warranted to understand the potential power needs and flexibility of cryptocurrency power demands.

instructions, AI models have undergone a monumental transformation, becoming increasingly complex and capable over time [42], in turn increasing their computational demands. As an illustration of the staggering increase in computation demand, note that in 1957, the Perceptron Mark I, the first real-world implementation of a one-layer neural network that could classify images, utilized 695,000 floating-point operations per second (FLOPS)—an assessment of AI complexity and computation intensity. In 2020, however, GPT-3 required a staggering 3.14×10^{23} FLOPS, an increase of 18 orders of magnitude, and at present each subsequent AI model is requiring even greater amounts.

- The continuous operational demands of a digital ecosystem: In the modern era, data centers function ceaselessly to uphold the demands of a globalized society that thrives on connectivity. Data centers facilitate uninterrupted services, ensuring 24/7 availability in various sectors including business, e-commerce, and entertainment. Maintaining constant uptime requires robust backup power solutions.

Energy contributions of AI annual workloads are categorized into three major areas [7, 18, 39, 43, 44]:

- Model development (10% of the energy footprint): Models are developed and fine-tuned before training.
- Model training (30% of the energy footprint): Algorithms learn by processing a vast array of data to make predictions or decisions without exact input-response relations preprogrammed, which requires substantial computation efforts and high energy expenditure for extended periods.
- Use/inference (60% of the energy footprint): Includes the deployment and utilization of developed AI models in real-world applications and requires computational resources for interpreting new data and generating outcomes or predictions based on pre-trained models.

For detailed information on AI model types, specific models and their descriptions, and the electricity consumption of each, see **Appendix B**.

Chat GPT and Other Large Language Models (LLMs)

Over the last year, the surge in popularity of generative AI sparked by the public release of Open AI's ChatGPT has created new concerns about AI's potential impact on future computing energy needs. **Figure 9** shows the increase in web traffic—starting from zero—for prominent generative AI platforms including ChatGPT, which is illustrated by the dark blue line [45].

ChatGPT garnered 100 million global users in only two months, which was rapidly followed by tech giants like Microsoft, Alphabet, Meta, and Bing launching their own large-language model chatbots. From a power usage perspective, these LLMs create a new frontier with ultimate impact to be determined, in part, by how widely the 5.3 billion internet users adopt the new features being rolled out. [46, 47].

For example, Google plans to implement LLMs to boost its search engine's ability to recognize and respond to user queries in a more conversational and natural style [48]. At

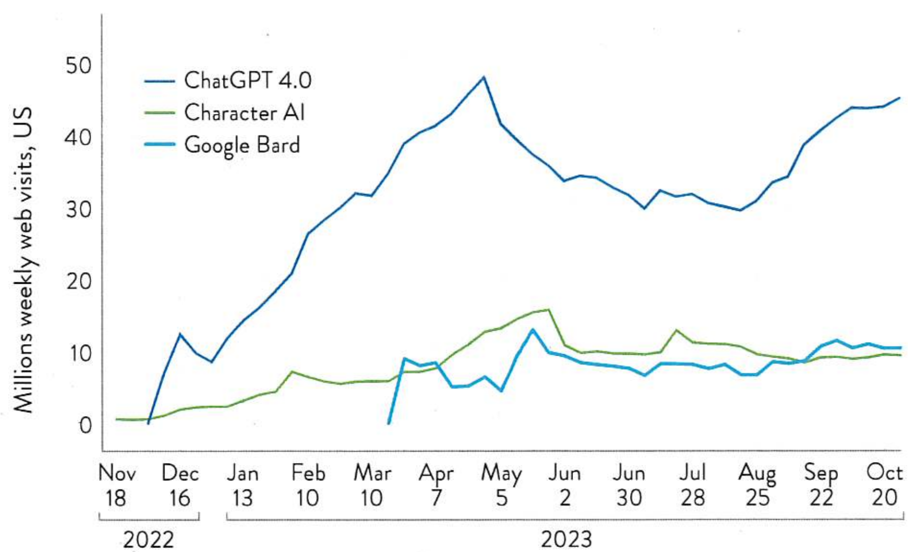


Figure 9. U.S. web traffic trends to AI platforms, 2022–2023 [45]

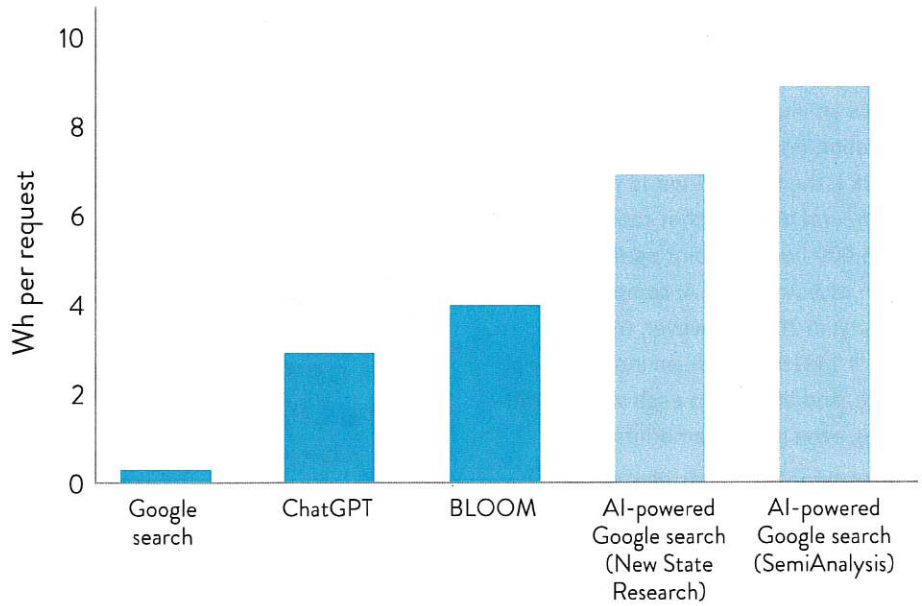


Figure 10. Electricity consumption per request [47]

2.9 watt-hours (Wh) per ChatGPT request, AI queries are estimated to require 10 times the electricity of traditional Google queries, which use about 0.3 Wh each [47]. Implementing LLMs in every Google search could necessitate 80 gigawatt-hours (GWh) daily or 29.2 terawatt-hours (TWh) yearly electricity consumption, according to SemiAnalysis [34]. New Street Research's similar analysis suggests the need for around 400,000 servers, consuming 62.4 GWh daily or 22.8 TWh yearly [47]. As shown in **Figure 10**, the BLOOM model's electricity usage averages 3.96 Wh per request, while ChatGPT's is slightly lower at 2.9 Wh per request; however, if Google integrated similar AI into its searches, the electricity per search could increase to between 6.9–8.9 Wh [47].

The explosive growth in investments aimed at building and deploying new AI capabilities are raising concerns over the overall electricity consumption and environmental impact of AI and data centers and the ability of the United States to maintain its leadership position.

FORECASTING DATA CENTER LOAD GROWTH TO 2030

Four Scenarios Based on Historical Data, Expert Insights, and Current Trends

Drawing on public information about existing data centers, public estimates of industry growth, and recent electricity demand forecasts by industry experts, EPRI prepared four projections—using low (3.7%), moderate (5%), high (10%), and higher (15%) growth scenarios described in **Table 3** below—of potential electricity consumption in U.S. data centers from 2023 to 2030. See **Figure 11** for a graph of the projections. These projections are based on a bounding analysis of various data sources surveyed as of November 2023 [1, 2, 4, 8, 14]. The analysis reflects historical trends for the AI industry, internet traffic, demand for storage, coupled with the computational intensity and prevalence of AI models. All of these factors are uncertain, including the development of business models and updates for LLMs, rate of increase in mature applications, and efficiency gains in computational and non-computational aspects of data centers.

The graph's blue line depicts average historical data center electricity consumption. The light blue area indicates the uncertainty in recent historical projections of data center power use, and the colored swaths show the four projection scenarios [4, 8].

Under the 15% higher growth scenario, EPRI's projections show data center electricity usage rising to an average of 403.9 TWh/year. Under the 10% high growth scenario, data center energy usage rises to a mid-range of 296.4 TWh/yr. Using the moderate growth 5% scenario, the projection predicts a mid-range of 214.0 TWh/yr. Under the 3.7% low growth scenario, the graph shows the projection at a mid-range of 196.3 TWh/yr. The mid-range estimates of data centers' share of total U.S. electricity consumption in 2030—9.1%, 6.8%, 5.0%, and 4.6%—assume that other loads grow at 1% annually. An examination of regional variations is found in **Appendix A**.

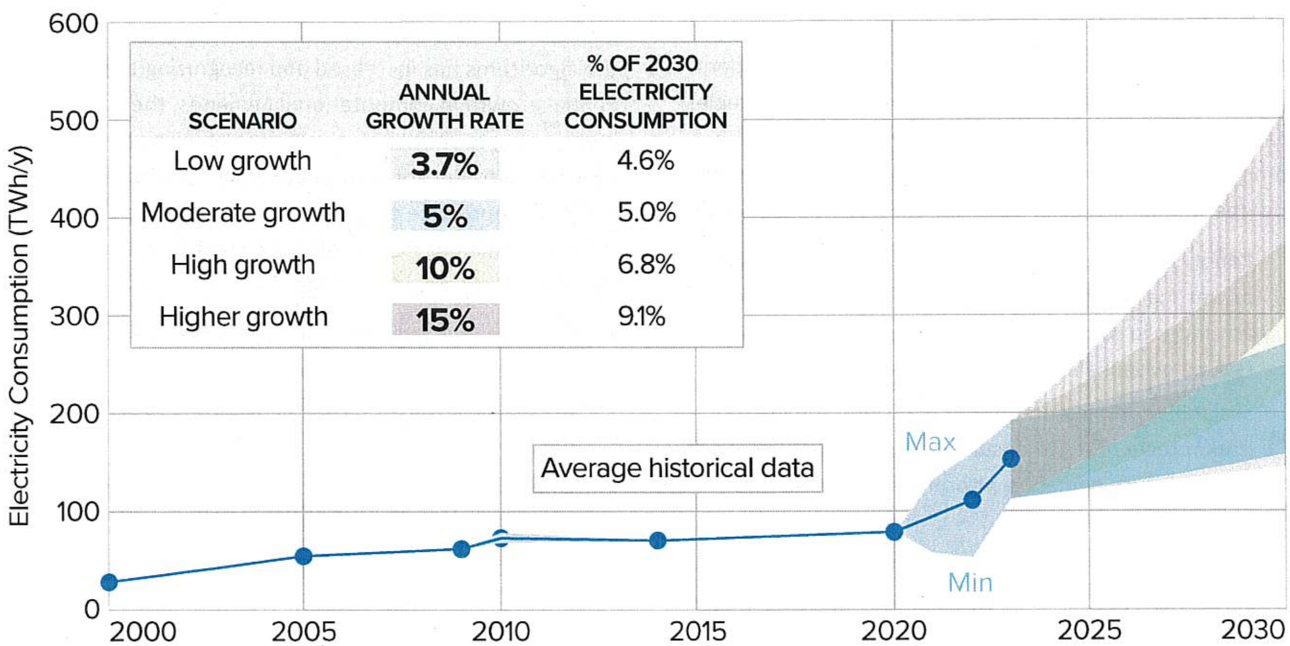


Figure 11. Projections of potential power consumption in U.S. data centers scenarios, 2023–2030 [1, 2, 4, 8, 14]

Table 3. Forecasted load projections: Parameters of power consumption in each of the four U.S. data center scenarios, 2022-2030 [4, 8, 9]

COMPOSITION OF GROWTH SCENARIOS (2023—2030)				
GROWTH SCENARIO	CAGR (%)	AVERAGE 2023 DATA CENTER LOAD (MWH)	AVERAGE PROJECTED LOAD, 2030 (MWH)	CHANGE IN GROWTH (Δ)
Higher Growth	15%	152,120,846	403,906,136	166%
High Growth	10%	152,120,846	296,440,493	95%
Moderate Growth	5%	152,120,846	214,049,306	41%
Low Growth	3.7%	152,120,846	196,305,818	29%

Each growth scenario's characteristics are described in **Table 3**. The load projections combine estimates of today's data center power usage with assessments of potential future technological advances and computational demands. It is essential to understand that while these scenarios are based upon the latest available data and subject-matter expert (SME) insights, the factors affecting them—such as consumer demand, technological advancements, operational efficiencies, and evolving industry standards—are changing almost daily.

ENERGY EFFICIENCY, LOAD MANAGEMENT AND CLEAN ELECTRICITY SUPPLY

With the escalating demands of AI and data center operations, there is a critical need for new, innovative strategies that leverage advances in hardware, system monitoring, computational algorithms, clean electricity procurement, and operational flexibility [49]. Key considerations include:

- Energy efficiency: Adopt advanced cooling solutions, power management systems, and leverage efficiency advances in computational and supporting hardware to reduce overall electricity consumption.
- Scalability: Implement modular designs and virtualization techniques to ensure that infrastructure can handle future demands without disproportionate increases in energy use.
- Carbon-free energy (CFE) use: Transition to carbon-free electricity sources for data center operations and low-carbon technologies for backup power to support data center expansion without increasing carbon emissions and make energy costs more certain.
- Monitoring and analytics: Utilize real-time monitoring tools to track electricity consumption, detect inefficiencies, and optimize operations.
- Research and development (R&D): Invest in innovations that drive both performance and sustainability, such as green energy sources or AI-driven optimization of work load to meet latency, grid, environmental, and other objectives.

The remainder of this section discusses in more detail strategies that cover energy-efficient algorithms, hardware, and cooling technologies; scalability and renewable energy use; and monitoring, analytics, and R&D.

Energy-Efficient Training Algorithms

The initial phases of AI algorithm development have been heavily focused on enhancing accuracy and augmenting performance capabilities. However, as the performance of the algorithms has increased and recognizing the exponential growth in computational demands, the paradigm is beginning to shift to also value the efficiency of model development. Recent studies document applications where a slight compromise on model accuracy has yielded substantial reductions in electricity consumption [7, 18, 43, 50]. The techniques utilized include:

- Pruning: This technique aims to reduce or eliminate unnecessary elements in neural networks, thereby maintaining robust performance while reducing computational complexity [43, 51].
- Quantization: This method reduces the numerical precision of computations, effectively conserving electricity without compromising significantly on accuracy [14, 51].
- Knowledge distillation: This approach involves developing a smaller, more manageable model that mirrors the functionalities of a larger, more intricate structure, reducing computational requirements [14, 51].

Energy-Efficient Hardware

Computational hardware is becoming more efficient, venturing beyond general-purpose central processing units (CPUs) to embrace an array of specialized hardware. These hardware variants are customized for specific tasks, streamlining power usage, and enhancing overall efficiency. This specialized hardware includes:

- Tensor processing units (TPUs): Specifically designed to expedite machine learning (ML) tasks, these units provide pronounced performance and energy efficiency enhancements [11, 18]. For example, Google's Cloud TPUv4 showed not only a 10-times leap forward in ML system performance over TPUv3, but it also boosted energy efficiency by 2–3% compared to contemporary ML data structures and algorithms [52].
- Field-programmable gate arrays (FPGAs): Recognized for their versatility as non-hard etched processors, FPGAs can be reprogrammed for specific tasks, providing improved performance and lower per-unit energy consumption [11, 28]. Though savings are task-dependent, FPGAs have shown reductions in memory and bandwidth usage as much as 75% when compared to traditional CPUs and graphics processing units (GPUs) [28, 53, 54].
- Power capping: Some processing chips, such as GPUs, can operate at reduced power levels. For example they can reduce direct power consumption by 10% while also reducing cooling needs.

Energy-Efficient Cooling Technologies

Heat is a byproduct of computation, and traditional cooling methods are energy-intensive, composing around 35% of data center electricity use. However, innovative solutions are emerging, some of which include:

- Liquid cooling: Utilizing liquids to absorb and dissipate heat can use less electricity than traditional air-cooling systems [18, 50]. A recent study, which examined the shift from 100% air cooling to a combination of 25% air cooling and 75% liquid cooling, highlighted the efficiency gains—leading to a notable decrease in PUE—from transitioning to hybrid cooling systems in data centers. The study observed a 27% reduction in facility power consumption and a 15.5% decrease in overall energy usage across the data center site [55]. **Table 4** shows an overview of various innovative cooling ttechnologies currently being adopted or considered in data centers, highlighting vendor-reported technology-readiness level (TRL) and energy-saving estimates [56, 57, 58, 59, 60, 61].
- Economizer use: An economizer can evaluate outside temperature and humidity, and use exterior air to help cool data center infrastructure when appropriate, minimizing reliance on mechanical cooling methods and leading to significant electricity savings [18, 62]. A 2015 study found that air-side economizers yielded cooling coil load savings of 76–99% in comparison to conventional cooling systems in data centers; and the total cooling energy savings of the economizers ranged from 47.5%–67.2% [62].

Table 4. Emerging cooling technologies with vendor-reported TRLs and energy savings [56, 57, 58, 59, 60, 61]

EMERGING COOLING TECHNOLOGIES		
TECHNOLOGY	**TECHNOLOGY-READINESS LEVEL (TRL)**	**CLAIMED EFFICIENCY DIFFERENTIAL (%)**
Air-Assisted Liquid Cooling	9	This technology offers up to a 50% reduction in energy usage compared to traditional air cooling, with the potential to reach a PUE of less than 1.1 [56].
Immersion Cooling	8	Immersion cooling promises substantial energy savings from 50–95% compared to traditional air-cooling methods [57, 58].
Microconvective Liquid Cooling	6	This emerging technology proposes an 18% energy saving and a PUE of 1.02, alongside a 90% reduction in water usage compared to other liquid systems, indicating its potential for more sustainable operation [59].
Radiative Cooling	6	This solution offers 50–70% energy savings, with the benefits of zero water use and low maintenance [60].
Two-Phase Liquid Immersion Cooling	7	This technology claims a 41% energy saving compared to air cooling, noting its water conservation and space-saving benefits [61].

- Heat reuse: Heat generated by computation can be used for various applications such as heating adjacent buildings, particularly in cold climates, thereby reducing overall energy usage [18, 42, 63]. Since 2016, Amazon's 1.1 million-square-foot Doppler building has been estimated to recover 3200 MWh of excess heat from a nearby data center; this is projected to continue over the next 25 years. This heat, which would otherwise have been wasted and would have required cooling equipment, is redirected through the district's energy system, demonstrating an energy-efficient approach to energy reutilization [25].

Scalable Clean Energy Use

As digital services proliferate and demand for computational power intensifies, scalable clean energy supplies are important to avoid increases in greenhouse gas emissions [64]. Corporate commitments to acquire carbon-free electricity on an annual or hourly-matched basis are emerging and can play a significant role in reducing data center emissions impacts. These include:

- Clean electricity procurement from the grid and clean onsite generation: Data center owners have been instrumental in driving the corporate shift towards contracting for renewable energy to provide their power needs. In 2021, Apple, Google, Meta, and Microsoft matched their operational electricity consumption, predominantly from data centers, on an annual basis with the purchase or generation of renewable electricity—2800 MWh, 18,300 MWh, 9400 MWh, and 13,000 MWh respectively [55, 56, 57, 58]. Meanwhile, Amazon's operations consumed 30,900 MWh, 85% of which was matched on an annual basis by generation from renewable sources, and the company aims to reach 100% renewable energy by 2025 [25, 16, 41]. Moreover, a growing number of organizations are working towards 24/7 CFE, which entails matching their electricity demand with carbon-free sources in the same region on an hourly basis. This hourly matching will require flexible technologies such as batteries that can shift solar or wind output to times when they are needed as well as firm clean capacity such as nuclear, fossil plants with carbon capture and storage, or geothermal, that typically operate around the clock. Spurring deployment of flexible and clean firm assets can help speed the path to a net-zero power sector [42, 44].
- Cleaner onsite backup power systems: Backup power systems at most existing data centers typically operate for less than 100 hours annually when the grid or primary power supply are unavailable. Accordingly, they constitute only a small portion of a data center's environmental footprint. Shifting from the most common backup technology, diesel generators, to lower-emitting alternatives, like battery energy storage systems (BESS) or cleaner fuels—such as renewable natural gas, biodiesel, or clean hydrogen or ammonia, especially when the latter are integrated with fuel cells—can reduce backup GHG emissions and, in some instances, allow more frequent operation of these resources, creating the potential for them to serve as a grid resource when/if needed [9, 42].
- Clean onsite or nearby technologies such as nuclear generation or renewable generation coupled with long-duration energy storage that can match the growing size of data centers: With currently proposed data centers reaching 1 GW or more at a single site, the scale of power demand is escalating rapidly. In the near term, uprating, relicensing, or restarting existing nuclear plants near data centers could provide one solution. Amazon's purchase of a data center in Pennsylvania co-located with a Talen nuclear power plant provides one example of utilizing existing nuclear. Looking forward, small modular reactors (SMRs) offer a scalable power solution that can grow with the demands of a data center. Companies such as NuScale are exploring scalable capacities of 250–600MW for SMRs [9, 42]. Standard Power has chosen NuScale's SMR technology to power two facilities it plans to develop, one in Ohio and the other in Pennsylvania [69]. However, while SMRs might supplement power supplies in the future, their waste output, operational risks, and regulatory challenges call for a comprehensive assessment of benefits against potential environmental concerns.

Monitoring and Analytics

Advances in monitoring and analytics of power consumption play a crucial role in realizing operational savings in data centers. These processes enable precise tracking of energy usage, identification of inefficiencies, and implementation of advanced technologies, thus driving cost reduction and enhancing overall efficiency:

- Efficient server management: Traditionally, data centers have grappled with up to 30% server underutilization, where servers consume energy but don't fully utilize their computational capabilities. However, with the adoption of innovations like advanced scheduling and dynamic resource allocation, some companies are aiming to reduce underutilization rates to below 10% within the next five years [18, 40, 63, 70]. In addition, the implementation of virtualization and containerization can enhance server efficiency significantly, potentially increasing server capacity utilization by 45% by having a single physical server handle more workloads through virtual or containerized environments. If successful, this is estimated to reduce the number of physical servers needed, leading to about 20% less energy consumption per unit of computation over the next decade [15, 33, 42].

- Flexible computation strategies: Optimizing data center computation and geographic location to respond to electricity supply conditions, electricity carbon intensity, and other factors in addition to minimizing latency enables data centers to actively adjust their electricity consumption [71]. For example, some could achieve significant cost savings—as much as 15%—by optimizing computation to capitalize on lower electric rates during off-peak hours, reducing strain on the grid during high-demand periods [38, 72]. With technological and regulatory advances, these strategies could evolve to incorporate real-time energy market dynamics enabling data centers to not only adjust their operations based on grid demands but also actively participate in energy markets to optimize their benefits and support grid stability.

Reducing Data Centers' Environmental Footprint

The previous sections focus on actions that data center owners and operators are actively pursuing to diminish their carbon footprint, focusing primarily on onsite direct emissions such as from onsite generation (Scope 1 emissions) and emissions associated with the purchase of electricity (Scope 2 emissions) [64]. These strategies involve reducing their electricity needs through the adoption of advanced computation, cooling, and operational technologies, shifting toward cleaner onsite backup power, and moving towards various strategies for matching their hourly loads with carbon-free electricity [73]. Several of the hyperscale companies have fully matched their annual power purchases with carbon-free electricity on an annual basis and are moving forward on hourly matching. Progress is slower on shifting to cleaner backup power (although this, as noted earlier, represents only a small fraction of their environmental footprint).

In recent years, some companies have taken the additional step of quantifying and setting reduction targets for their (Scope 3) indirect emissions, which include emissions associated with supply chains and end-user services [7, 44, 66]. Key actions include sourcing materials from environmentally responsible vendors, minimizing the carbon footprint associated with transportation and logistics, and ensuring that the lifecycle of data center components is managed sustainably, from manufacturing to end-of-life disposal and recycling [42, 74, 75].

ACTIONS TO SUPPORT RAPID DATA CENTER EXPANSION

Data centers are one of the fastest growing industries worldwide. These facilities—and advanced cloud computing and AI technologies that are proliferating and driving further growth—represent large point loads and are at the leading edge of an anticipated global rise in electricity demand driven by efficient electrification and production of low-carbon fuels.

In the United States, data center power demand growth, coupled with increasing electricity demands from EVs, heat pumps, electrification in industry, and the onshoring of manufacturing incentivized by the CHIPS Act, Inflation Reduction Act (IRA), and Infrastructure Investment and Jobs Act (IIJA), is placing both immediate and sustained pressure on the electric grid to accommodate new loads.

Clusters of new, large point loads create several challenges. Data centers' speed from breaking ground to operation—often within two or three years—requirements for highly reliable power, and requests for power generated by new, non-emitting generation sources can create local and regional electric supply challenges and test the ability of electric companies to keep pace. The most serious challenges to data center expansion are local and result from the scale of the centers themselves and mismatches in infrastructure timing.

EPRI highlights three essential strategies to support rapid data center expansion. These strategies, each of which is explained below, emphasize increased collaboration between data center developers and electric companies and are:

- Improve data center operational efficiency and flexibility
- Increase collaboration through a shared energy economy model for sustainable data centers

- Better anticipate future point load growth through improved forecasting and modeling

Improve Data Center Operational Efficiency and Flexibility

Over the past decade, economy-wide electricity demand in the United States has remained relatively flat in large part due to enhanced energy efficiency, which has offset potential increases driven by economic expansion and population growth. Specific to data centers, power demands from rapid expansion in computation, communication, and data storage were largely offset by efficiency gains for over a decade. This is largely due to technological advancements in computation, improved cooling systems, sophisticated energy management strategies, and the replacement of many small data centers with more efficient cloud data centers. However, since around 2018, efficiency gains have slowed, data center expansion accelerated (in part due to lifestyle changes caused by the pandemic), and AI has proliferated, leading to an increase in data center power consumption.

Meeting the increasing electricity demands of AI and data centers while limiting the growth of CO_2 emissions necessitates a comprehensive strategy that intertwines technological advancements that improve efficiency with power purchase and production strategies that favor low-carbon resources and that increase both temporal and spatial flexibility to link intense operation periods to the availability of low-cost, low-carbon generation.

Computational efficiency gains require investing in the next generation of energy-efficient processors and server architectures and enhancing AI training algorithms for greater computational efficiency. From an architectural viewpoint, virtualization stands out, with its capability to run multiple virtual machines on one physical server, potentially cutting hardware needs by 30–40% with consequent electricity savings [9, 75]. Implementations like software-defined infrastructure (SDI) offer dynamic resource allocation in real time, potentially increasing allocation efficiency by 30%, potentially increasing spatial flexibility in computation loads. Hybrid cloud solutions provide a balance between on-premises infrastructure and shared cloud services, potentially providing locational flexibility by reducing onsite requirements by 25% during peak periods.

In addition, continued gains in data center infrastructure efficiency can be achieved through more effective cooling technologies, adopting energy management systems that leverage AI for optimized power usage, and setting stringent industry targets for energy consumption. Continuous monitoring and analytics can help data centers better anticipate and react to dynamic energy needs, ensuring optimal operational efficiency and rapid adaptability [42, 50, 78]. Embedding real-time monitoring tools within AI and data center ecosystems can facilitate immediate insights into fluctuations in electricity usage. Pilot projects to explore and validate novel energy conservation methods, which document and disseminate findings broadly, can accelerate adoption of proven sustainable strategies [10, 70].

Increase Collaboration through a Shared Energy Economy Model for Sustainable Data Centers

Electric companies are challenged as they must meet the increasing and uncertain load from data centers while also ensuring reliability, affordability, and sustainability for all customers. Developing a deeper understanding of data center power needs, timing, and potential flexibilities—while assessing how they match available electric supplies and delivery constraints—can create workable solutions for all.

EPRI, in collaboration with major data center builders/operators/owners and the electric companies that power these facilities, is exploring sustainable approaches to powering the growing wave of AI data centers. Enabled by technology and supporting policies, data center backup generators, powered by clean fuels, could support a more reliable grid while reducing the cost of data center operation. Shifting the data center-grid relationship from the current "passive load" model to a collaborative "shared energy economy"—with grid resources powering data centers and data center backup resources contributing to grid reliability and flexibility—could not only help electric companies contend with the explosive growth of AI but also contribute to affordability and reliability for all electricity users.

This new paradigm of collaboration between data centers and electric companies, which transforms data centers from passive consumers to active participants in maintaining the grid, is crucial for ensuring electric companies are prepared for the explosive growth of AI. Under this model, data centers move from being a burden on the grid—acting as passive loads demanding specific power levels within defined timeframes and at affordable rates—to becoming partners in a sustainable future, serving as a grid reliability resource. The goal is the complete integration of grid and data center power resources. Clean power generators co-located with data centers act as both grid and data center power sources. During grid outages, these resources can seamlessly form a microgrid to provide uninterrupted power to data centers, eliminating the need and cost of standard diesel backup generators.

More research is needed into how data centers and electric grids can collaborate in a shared energy economy model, as well as the benefits and challenges of doing so. Focusing on U.S. AI training data centers using backup generators powered by clean fuels, EPRI suggests a study of the economic, environmental, social, and technological implications of this shared energy economy model compared to other, more traditional models. The results of this study could provide suggestions and guidelines for data centers and electric grids to adopt and implement the shared energy economy model, or parts of it, in their operations and planning.

Better Anticipate Future Point Load Growth through Improved Forecasting and Modeling

The lead time for constructing and bringing a large data center online is around two to three years, while adding new electric infrastructure (generation, transmission, substations) can take four or many more years. This highlights the need for better forecasting and decision tools to anticipate where and when data center connection requests may appear and characterizing the operational characteristics of that load, especially as the size of interconnection requests grow from hundreds of MW to thousands of MW.

In the current environment, electricity companies are often receiving multiple requests for the same project from the owner and from developers trying to support the owner. Also, a single data center project may seek interconnection information in multiple locations. And the ramp up to full power demand and operational characteristics on the data centers can vary widely, depending upon their function (e.g., cloud, AI training, AI inference). Therefore, new approaches are needed not only to project where load will grow, but also its operational characteristics and opportunities for flexible operation.

EPRI's Load Forecasting Initiative (https://msites.epri.com/lfi), initiated in late 2023, has research activities underway to help address some of these key uncertainties.

APPENDIX A: STATE-SPECIFIC SCENARIOS

Projected Data Center Load Scenarios for Top 15 States

Figures A1 through A15 apply the projected U.S. load growth rates under EPRI's higher-, high-, moderate-, and low-growth scenarios to 2023 estimated state-level data center loads. The figures show projections for the 15 states with the highest data center demands in 2023, comprising around 80% of U.S. data center load in that year. As noted above, the projections utilize the projected national growth rate and do not reflect the deferential regional growth rates implied by Integrated Resource Plan analyses that have emerged recently.

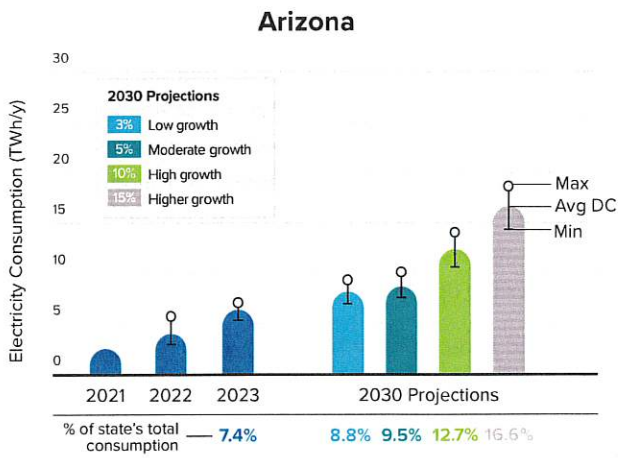


Figure A1.
Projected electricity consumption in Arizona data centers

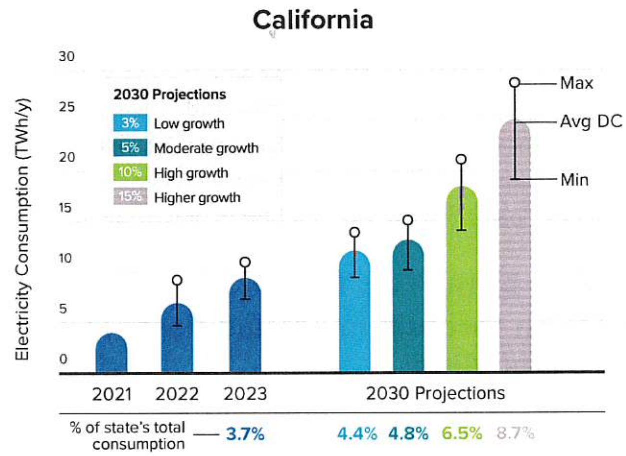


Figure A2.
Projected electricity consumption in California data centers

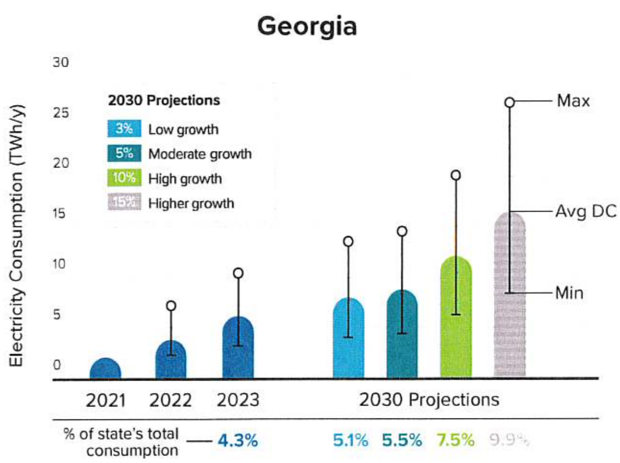


Figure A3.
Projected electricity consumption in Georgia data centers

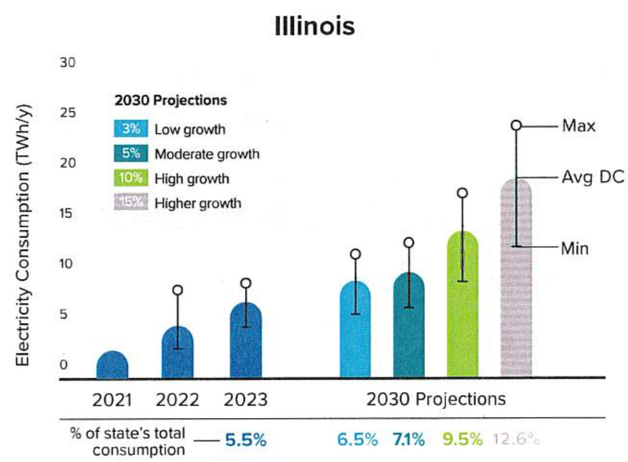


Figure A4.
Projected electricity consumption in Illinois data centers

Iowa

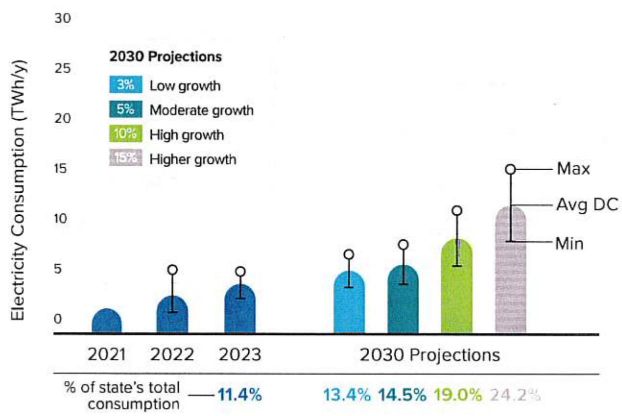


Figure A5.
Projected electricity consumption in Iowa data centers

Nebraska

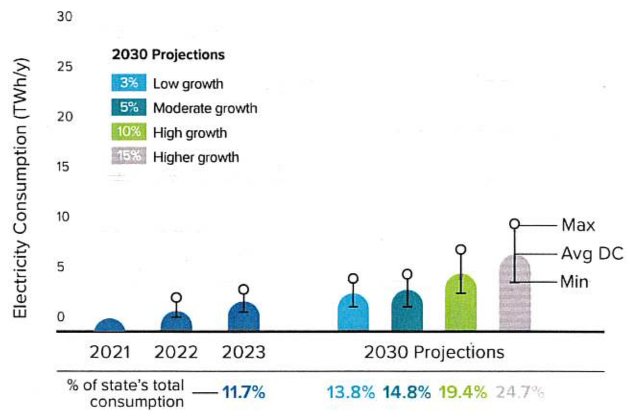


Figure A6.
Projected electricity consumption in Nebraska data centers

Nevada

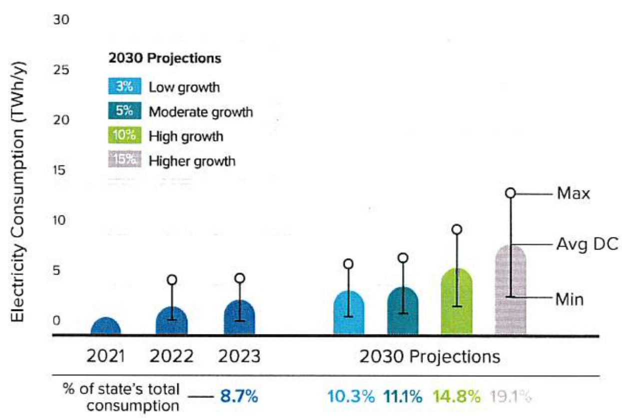


Figure A7.
Projected electricity consumption in Nevada data centers

New Jersey

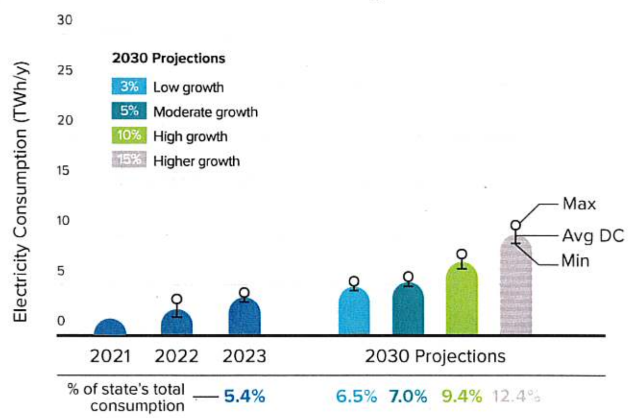


Figure A8.
Projected electricity consumption in New Jersey data centers

New York

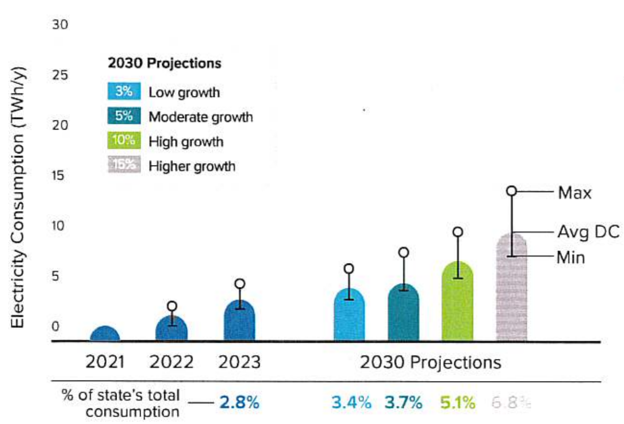


Figure A9.
Projected electricity consumption in New York data centers

North Dakota

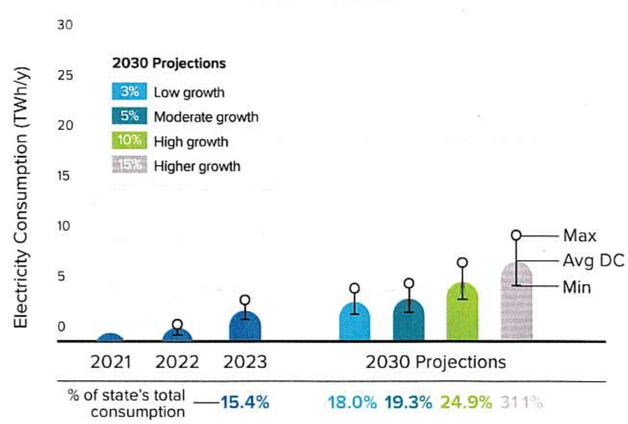


Figure A10.
Projected electricity consumption in North Dakota data centers

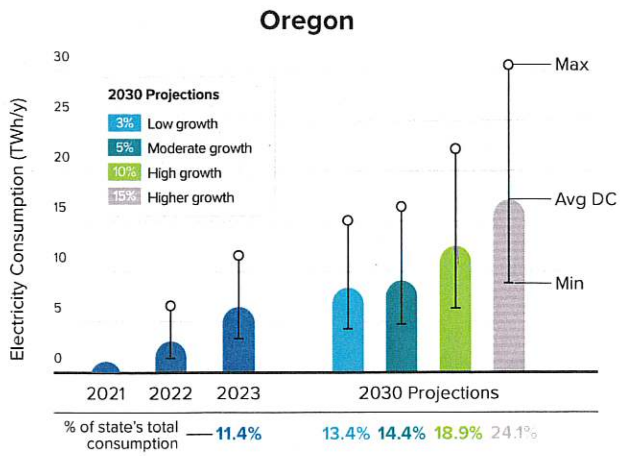


Figure A11.
Projected electricity consumption in Oregon data centers

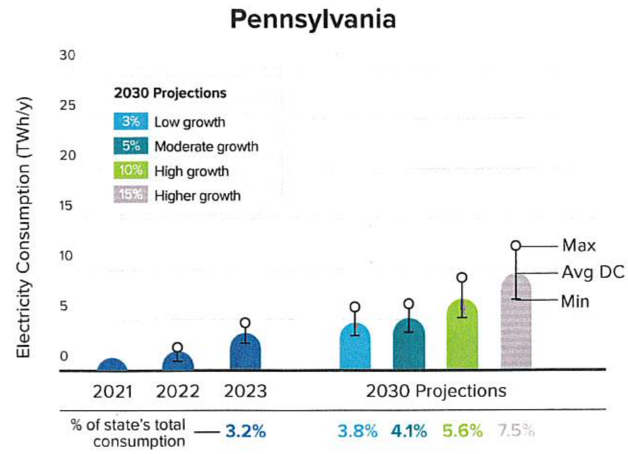


Figure A12.
Projected electricity consumption in Pennsylvania data centers

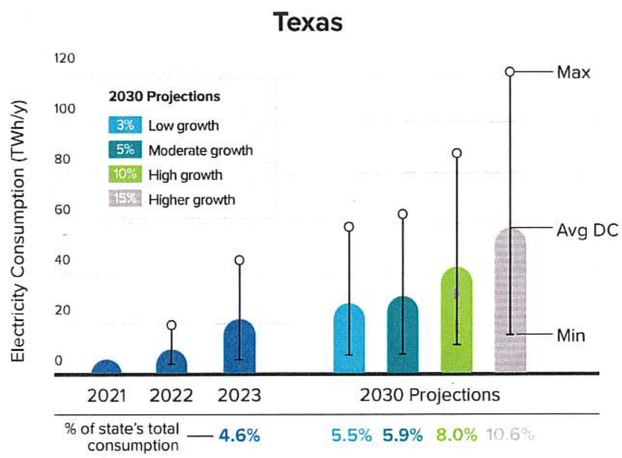


Figure A13.
Projected electricity consumption in Texas data centers

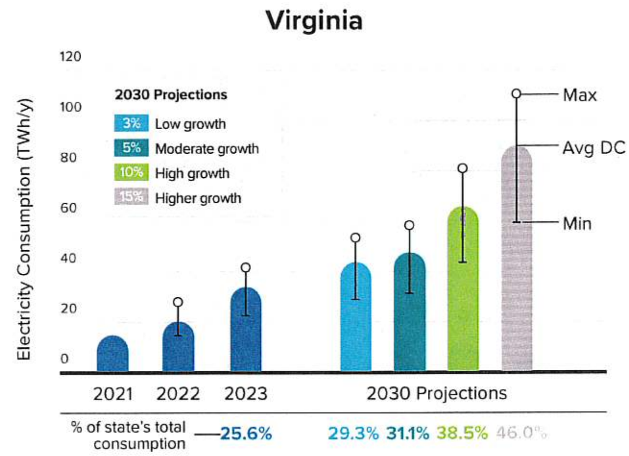


Figure A14.
Projected electricity consumption in Virginia data centers

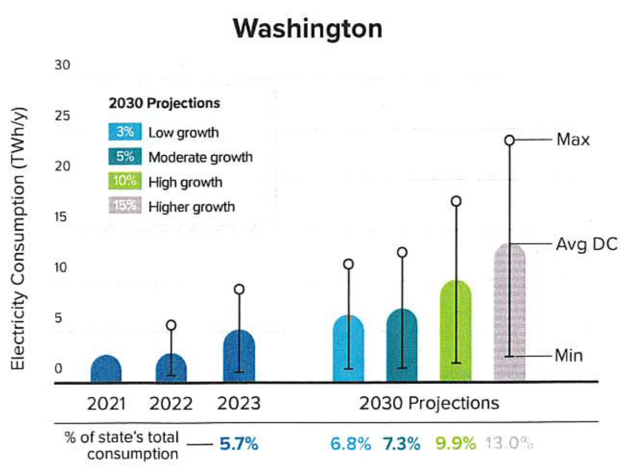


Figure A15.
Projected electricity consumption in Washington data centers

Regional Differences in Data Center Capacities by Metropolitan Area

Data center development is heavily clustered in a few counties/cities across the country rather than evenly spread within states, exacerbating power delivery challenges. **Figure A16** provides a snapshot for leading metropolitan areas of current data center capacity (measured in MW); additional capacity under development; absorption rates, reflecting the percentage of capacity leased by customers over a specific period of time; and vacancy rates, indicating unutilized space within these data centers.

Northern Virginia is the clear leader in terms of current capacity and current construction. Other regions, such as Dallas-Ft. Worth, Silicon Valley, Chicago, New York Tri-State, and Atlanta, highlight current construction activity that is projected to lead to a 50% or more increase in power demands. [29].

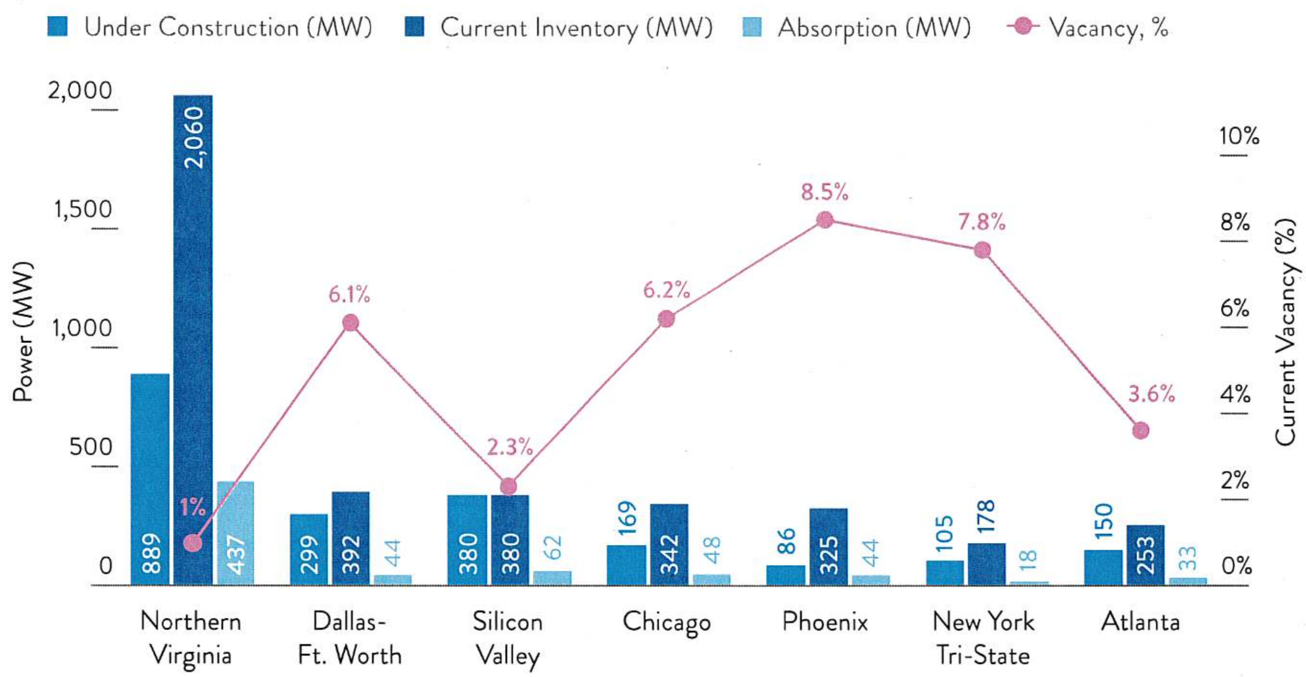


Figure A16. Data center development: Key U.S. regions (2022)

Projections of Potential Power Consumption for 44 States

Table A1 presents a detailed view of the energy consumption from data centers in each of the 44 states that had significant data center load in 2023 and contrasts it with projections for 2030. These projections are categorized into three scenarios: low growth, moderate growth, high growth, and higher growth [1, 2, 4, 8, 14].

Table A1. Projections to 2030 of potential power consumption for states with significant data center load in 2023 [4, 8, 9]

FORECASTED SCENARIOS: PROJECTIONS OF POTENTIAL POWER CONSUMPTION BY STATE (2023–2030)										
	2023 Load		Low-growth Scenario (3.71%)		Moderate-growth Scenario (5%)		High-growth Scenario (10%)		Higher-growth Scenario (15%)	
STATE	MWh/y	% of Total State Electricity Consumed (%EC)	MWh/y	% of Total State Electricity Consumed (%EC)	MWh/y	% of Total State Electricity Consumed (%EC)	MWh/y	% of Total State Electricity Consumed (%EC)	MWh/y	% of Total State Electricity Consumed (%EC)
Alabama	1,489,200	1.71%	1,921,753	2.05%	2,095,454	2.23%	2,902,030	3.07%	3,954,074	4.13%
Arizona	6,253,268	7.43%	8,069,590	8.81%	8,798,975	9.53%	12,185,850	12.73%	16,603,465	16.58%
California	9,331,619	3.70%	12,042,078	4.43%	13,130,525	4.81%	18,184,686	6.54%	24,777,000	8.70%
Colorado	1,509,640	2.66%	1,948,130	3.18%	2,124,215	3.46%	2,941,861	4.73%	4,008,345	6.34%
Connecticut	262,800	0.95%	339,133	1.14%	369,786	1.24%	512,123	1.71%	697,778	2.31%
Florida	1,384,080	0.56%	1,786,099	0.67%	1,947,540	0.73%	2,697,180	1.01%	3,674,963	1.37%
Georgia	6,175,391	4.26%	7,969,093	5.08%	8,689,396	5.51%	12,034,090	7.48%	16,396,690	9.92%
Hawaii	8,760	0.10%	11,304	0.12%	12,326	0.13%	17,071	0.18%	23,259	0.24%
Idaho	148,920	0.57%	192,175	0.68%	209,545	0.74%	290,203	1.03%	395,407	1.40%
Illinois	7,450,176	5.48%	9,614,151	6.53%	10,483,145	7.08%	14,518,285	9.54%	19,781,455	12.56%
Indiana	192,720	0.19%	248,697	0.23%	271,176	0.25%	375,557	0.35%	511,704	0.48%
Iowa	6,193,320	11.43%	7,992,230	13.44%	8,714,623	14.48%	12,069,029	18.99%	16,444,294	24.21%
Kansas	8,760	0.02%	11,304	0.03%	12,326	0.03%	17,071	0.04%	23,259	0.05%
Kentucky	1,620,600	2.15%	2,091,319	2.58%	2,280,347	2.80%	3,158,091	3.84%	4,302,962	5.16%
Louisiana	78,840	0.08%	101,740	0.10%	110,936	0.11%	153,637	0.15%	209,333	0.20%
Maine	26,280	0.22%	33,913	0.27%	36,979	0.29%	51,212	0.40%	69,778	0.55%
Maryland	96,360	0.16%	124,349	0.19%	135,588	0.21%	187,778	0.29%	255,852	0.40%
Massachusetts	1,062,369	2.08%	1,370,944	2.50%	1,494,860	2.72%	2,070,257	3.72%	2,820,766	5.01%
Michigan	525,600	0.52%	678,266	0.63%	739,572	0.68%	1,024,246	0.95%	1,395,555	1.28%
Minnesota	824,316	1.24%	1,063,747	1.49%	1,159,895	1.62%	1,606,359	2.23%	2,188,696	3.01%
Missouri	972,360	1.21%	1,254,791	1.45%	1,368,208	1.58%	1,894,855	2.18%	2,581,777	2.95%
Montana	578,160	3.71%	746,092	4.43%	813,529	4.81%	1,126,670	6.54%	1,535,111	8.71%
Nebraska	3,959,520	11.70%	5,109,601	13.75%	5,571,442	14.81%	7,715,984	19.41%	10,513,184	24.71%
Nevada	3,416,707	8.69%	4,409,122	10.28%	4,807,649	11.10%	6,658,195	14.75%	9,071,924	19.07%
New Hampshire	17,520	0.16%	22,609	0.19%	24,652	0.21%	34,142	0.29%	46,519	0.40%
New Jersey	4,038,360	5.42%	5,211,341	6.46%	5,682,378	7.00%	7,869,621	9.44%	10,722,517	12.44%
New Mexico	402,960	1.48%	520,004	1.78%	567,005	1.94%	785,255	2.66%	1,069,926	3.60%
New York	4,067,385	2.84%	5,248,796	3.40%	5,723,219	3.69%	7,926,182	5.05%	10,799,583	6.75%
North Carolina	2,672,676	1.92%	3,448,981	2.30%	3,760,724	2.50%	5,208,289	3.44%	7,096,399	4.62%
North Dakota	3,915,720	15.42%	5,053,079	18.00%	5,509,811	19.31%	7,630,631	24.89%	10,396,888	31.11%
Ohio	2,363,886	1.58%	3,050,500	1.90%	3,326,225	2.07%	4,606,545	2.84%	6,276,510	3.83%
Oklahoma	1,226,400	1.76%	1,582,620	2.12%	1,725,668	2.30%	2,389,907	3.16%	3,256,296	4.26%

FORECASTED SCENARIOS: PROJECTIONS OF POTENTIAL POWER CONSUMPTION BY STATE (2023–2030)										
	2023 Load		Low-growth Scenario (3.71%)		Moderate-growth Scenario (5%)		High-growth Scenario (10%)		Higher-growth Scenario (15%)	
STATE	MWh/y	% of Total State Electricity Consumed (%EC)	MWh/y	% of Total State Electricity Consumed (%EC)	MWh/y	% of Total State Electricity Consumed (%EC)	MWh/y	% of Total State Electricity Consumed (%EC)	MWh/y	% of Total State Electricity Consumed (%EC)
Oregon	6,413,663	11.39%	8,276,574	13.39%	9,024,668	14.43%	12,498,415	18.93%	17,029,342	24.14%
Pennsylvania	4,590,240	3.16%	5,923,520	3.78%	6,458,929	4.11%	8,945,079	5.61%	12,187,850	7.49%
Rhode Island	17,520	0.23%	22,609	0.28%	24,652	0.30%	34,142	0.42%	46,519	0.57%
South Carolina	2,023,560	2.45%	2,611,323	2.93%	2,847,352	3.18%	3,943,346	4.36%	5,372,888	5.84%
South Dakota	70,080	0.52%	90,435	0.63%	98,610	0.68%	136,566	0.94%	186,074	1.28%
Tennessee	1,327,140	1.30%	1,712,621	1.56%	1,867,419	1.70%	2,586,220	2.34%	3,523,777	3.16%
Texas	21,813,159	4.59%	28,149,002	5.47%	30,693,306	5.94%	42,507,676	8.04%	57,917,564	10.64%
Utah	2,562,037	7.68%	3,306,206	9.10%	3,605,044	9.84%	4,992,686	13.13%	6,802,635	17.08%
Virginia	33,851,122	25.59%	43,683,508	29.28%	47,631,928	31.10%	65,966,260	38.47%	89,880,357	46.00%
Washington	5,171,612	5.69%	6,673,757	6.77%	7,276,977	7.34%	10,078,009	9.88%	13,731,490	13.00%
Wisconsin	148,920	0.21%	192,175	0.26%	209,545	0.28%	290,203	0.39%	395,407	0.53%
Wyoming	1,857,120	11.26%	2,396,538	13.24%	2,613,154	14.27%	3,619,002	18.73%	4,930,962	23.90%

APPENDIX B: INSIGHTS INTO THE ENERGY USE OF AI MODELS

To better appreciate how AI uses such enormous amounts of electricity, it can be useful to understand more about AI models and how they work. AI models are typically divided into three types:

- Process automation and optimization (PAO), which focuses on streamlining and enhancing operations
- Predictive analytics (PA), which deals with forecasting trends and patterns
- Natural language processing (NLP), which interprets and generates human language

Moreover, machine learning (ML), a subset of AI, employs statistical methods to enable machines to improve at tasks with experience. Deep learning (DL), a further subset of ML, involves neural networks with multiple layers that autonomously learn from vast amounts of data. ML and DL have evolved significantly, with industrial applications overtaking academic contributions in recent years. Industry's edge stems from its vast data access, advanced computing capacities, and robust financial backing, positioning it above academia and nonprofit sectors in this subset of the AI domain. ML's broad capabilities enable advancements in PAO, PA, and NLP models, while DL's complex neural networks further refine these applications [81, 82].

Each AI model type has distinct energy implications due to its unique computational requirements. Understanding these distinctions is essential for assessing the broader energy impact of AI's spread. **Table B1** provides a comparative analysis of various AI models' energy consumption and key characteristics, offering a view of their energy footprints and their computational complexity [44, 51, 57, 63, 84, 85, 86, 87, 88].

Table B1. Comparative analysis of AI model load consumption and characteristics [44, 51, 57, 63, 84, 85, 86, 87, 88]

LOAD CONSUMPTION: BY SPECIFIC AI MODEL					
MODEL NAME	**AI TYPE**	**YEAR**	**TRAINING (DAYS)**	**CONSUMPTION (MWH)**	**MODEL DESCRIPTION**
T5	PA	2019	~20	85.7	A versatile model trained to convert text inputs into text outputs, suitable for various tasks like translation and summarization.
Meena	NLP	2019	~30	232	A chatbot model developed by Google designed to engage in conversations and understand context more naturally.
Evolved Transformer	PAO	2019	~7	7.5	A machine learning model designed using neural architecture search for improved performance on tasks.
Switch Transformer	PAO	2020	~27	179	A variant of the Transformer model designed to handle a large number of parameters more efficiently by dynamically routing activations to a subset of experts.
GShard-600B	PAO	2020	~3	24.1	Google's model optimized for large-scale multitask training, aiding in handling vast amounts of parameters.
ChatGPT-3	NLP	2021	~34	1,287	A state-of-the-art language model by OpenAI known for generating coherent and contextually relevant sentences over long passages.
BERT	PA	2021	~6	2.8	A model that understands the context of words in a sentence by analyzing them in both directions (left-to-right and right-to-left), widely used in sentiment analysis and other prediction tasks.
Gopher	NLP	2022	~23	1,066	Large language models on many tasks, particularly answering questions about specialized subjects like science and the humanities, such as logical reasoning and mathematics.
BLOOM	PA	2022	~117	433	Multilingual and open source, the Bloom model, which has emerged from the BigScience participatory project, aims to help advance research work on large language models
ChatGPT-4	NLP	2023	~100	62,318.8	An advanced version of OpenAI's ChatGPT series, designed for more nuanced and context-aware language generation.
OPT-175B	NLP	2023	~33	324	A state-of-the-art language model by Meta known for generating coherent and contextually relevant sentences over long passages.

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May 2024

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June 4, 2024

VIA ELECTRONIC MAIL

U.S. House Committee on Energy and Commerce
Subcommittee on Energy, Climate, and Grid Security
2125 Rayburn House Office Building
Washington, DC 20515

RE: Hearing titled "Powering AI: Examining America's Energy and Technology Future"

Dear Chairman Duncan and Ranking Member DeGette:

Neste appreciates the opportunity to offer a perspective on the challenge of meeting the growing electricity demand for data centers. As the world's largest producer of renewable diesel, Neste encourages the committee to consider how those data centers can be made more resilient – and reduce their emissions – by switching to low-carbon liquid fuels in their backup diesel generators.

Renewable Diesel

Renewable diesel is chemically identical to fossil diesel, meets ASTM D975 specifications, and can be used as a 100% replacement to fossil diesel. Compared to fossil diesel, however, renewable diesel reduces GHG emissions by up to 75% over its lifecycle. Of additional benefit to stationary power generation applications, renewable diesel is stable and can be stored for extended periods of time – far longer than fossil diesel or fatty acid methyl ester (FAME) biodiesel – and performs well in cold temperatures.

Made from renewable and sustainably sourced raw materials, Neste's renewable diesel also contains no aromatics and significantly reduces fine particulates and nitrogen oxides. These properties allow users to reduce their carbon footprint as well as their emissions of criteria pollutants. Specifically, Neste's renewable diesel produces up to 33% lower levels of fine PM, 24% lower carbon monoxide emissions, and 9% less NOx emissions than fossil diesel. These reductions are particularly important for the people working and living around data centers or other facilities where diesel generators are used.

Use in Power Generation

Diesel generators are able to provide uninterrupted power during periods of peak electricity demand. They are an essential backup for data centers, able to provide baseload power ensuring continued, uninterrupted operation with their unique combination of power-density and full electrical load handling, rapid response time, reliability and self-contained fueling supply.[1]

The use of renewable diesel in these generators is well documented. Indeed, major manufacturers of reciprocating engines for power generation – including Caterpillar, Cummins, Deere, Kohler Power, and MTU/Rolls-Royce Solutions America – have all approved renewable diesel for use in their generators. Likewise, companies including Amazon Web Services, Microsoft, LCL, Compass Datacenters, Digital Realty have committed to switch their existing diesel generators from fossil diesel to renewable diesel.[2]

Conclusion

Neste again applauds the committee for investigating the challenges and opportunities presented by the enormous growth of data centers and their energy demands. In addition to the attached white paper prepared for the Engine Technology Forum, Neste offers our technical experts should the committee have further questions or interest in the use of renewable diesel in stationary power generation for data centers or other applications.

Thank you again for the opportunity to share these thoughts.

Sincerely,

Jordan Haverly
Senior Manager, US Federal Affairs
Neste, US

CC:
Chairwoman Cathy McMorris Rogers
Ranking Member Frank Pallone

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[1] Transport Energy Strategies, *"The Benefits of Renewable Bio-Based Diesel Fuels,"* whitepaper prepared for the Engine Technology Forum. October 2023
[2] Ibid

transportenergy strategies

The Benefits of Renewable Bio-Based Diesel Fuels

Whitepaper prepared for the Engine Technology Forum

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Founder & CEO

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transportenergy strategies

Executive Summary

Renewable diesel (RD) is a hydrocarbon that is chemically equivalent to petroleum diesel. It can be used as a replacement fuel up to 100% or blended with any amount of petroleum diesel in both new and existing diesel engines without any changes in fueling infrastructure or vehicles. RD can be used as a “drop-in” biofuel that can be easily transported and sold at retail stations with or without blending with petroleum diesel. RD supply has grown rapidly since 2019, largely responding to demand created by state low carbon fuel program requirements, doubling from 800 million gallons to 2.6 billion gallons (BG) as of March 2023. U.S. RD production capacity could reach 5.9 billion gal/y, by the end of 2025. Eighty-three percent of all RD consumption occurred in California in 2022.

Numerous studies have evaluated the greenhouse gas (GHG) and criteria air pollutant emissions benefits from using RD. RD can reduce GHG emissions 50-85% or even more compared to petroleum diesel and reduces nitrogen oxide (NOx), particular matter (PM) and other emissions as well. For example, numerous studies have reported reductions in up to 33% lower levels of fine PM, up to 30% less hydrocarbons (HC), up to 24% lower carbon monoxide (CO) emissions, up to 9% less NOx emissions and reduced levels of polyaromatic hydrocarbons (PAH).

RD is approved by manufacturers for use in a wide variety of engines, machines, equipment, and vehicles. Interest in using RD and RD-biodiesel blends for use in many backup generator (BUG) applications including data center, hospitals, military, and other generator customers is growing significantly. These users see RD as a means to preserve and continue to utilize existing generator assets while addressing new demands to decarbonize and meet other corporate goals. All heavy-duty generator manufacturers welcome the use of RD in their products.

Demand for BUGs is expected to increase as the frequency of weather-related outages increases, as the transition from traditional fossil baseload power to intermittent renewables takes place and as overall electricity demand continues to outpace supply. This is particularly true in areas such as California that have enacted zero emissions power sector goals in the near term. Most RD in California is incentivized by the Low Carbon Fuel Standard (LCFS) program to be used in the transportation market.

However, RD and RD-biodiesel use in the BUG sector represents a significant opportunity to achieve real-world GHG emission reductions now as the power generation sector continues to transform. California could and should set an example that other states can follow by adopting policies that encourage the use of RD and RD-biodiesel blends in BUGs. Policy options could include allowing RD to generate credits for RD use in generator applications the same as it does transportation uses, including RD in California’s Renewable Portfolio Standard (RPS) and other measures.

Renewable Diesel Background & Overview

RD is a hydrocarbon that is chemically equivalent to petroleum diesel.[1] It can be used as a replacement fuel up to 100% or blended with any amount of petroleum diesel. RD can be used as a "drop-in" biofuel that can be transported and sold at retail stations with or without blending with petroleum diesel and meets ASTM D975 specifications for petroleum diesel.[2] Further, it can be seamlessly blended, transported and even co-processed with petroleum diesel at the refinery. The use of RD does not require the purchase of new vehicles, equipment, or engines. RD uses fats and oils such as soybean, canola, and distiller's corn oil as well as used cooking oil and other waste fats and greases as feedstocks for production.

Nearly all RD in the U.S. produced through hydrotreatment (sometimes known as hydrotreated vegetable oil or (HVO)), which involves reacting a feedstock with hydrogen under elevated temperatures and pressures in the presence of a catalyst. It is a similar process to that used to remove sulfur from diesel to comply with federal regulations. For this reason, existing petroleum refineries can be converted for RD production with only modest retrofits resulting in lower capital expenditure than would be possible if constructing a greenfield facility. There are other RD production pathways as well:

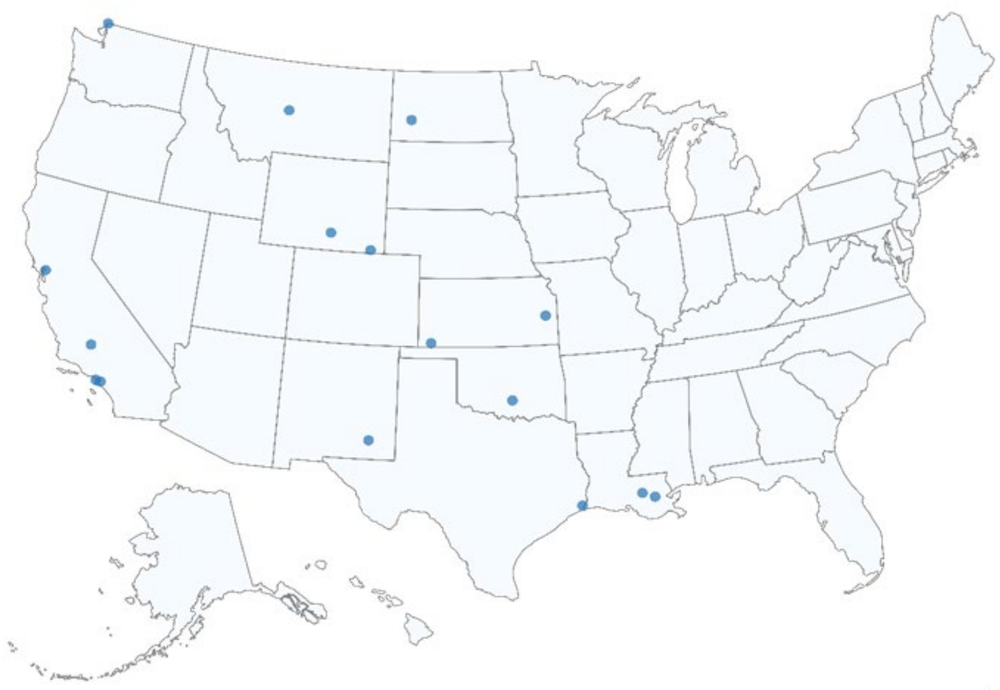
- **Gasification:** During this process, biomass is thermally converted to syngas and catalytically converted to hydrocarbon fuels.
- **Pyrolysis**: This pathway involves the chemical decomposition of organic materials at elevated temperatures in the absence of oxygen. The process produces a liquid pyrolysis oil that can be upgraded to hydrocarbon fuels, either in a standalone process or as a feedstock for co-feeding with crude oil into a standard petroleum refinery.
- **Hydrothermal processing**: This process uses high pressure and moderate temperature to initiate chemical decomposition of biomass or wet waste materials to produce an oil that may be catalytically upgraded to hydrocarbon fuels.[3]

A massive RD production scale up began in 2020, with capacity doubling from 800 million gallons to 1.6 BG, according to the Energy Information Administration (EIA). It grew even more between 2021 and 2022 – 225% -- and now stands at 2.6 BG as of March 2023.[4] As Figure 1 shows, there are 16 facilities in the U.S. currently

[1] RD is different than biodiesel, which is a mono-alkyl ester produced via transesterification, must meet separate specifications under ASTM D6751. It is also approved for blending with petroleum diesel.
[2] U.S. Energy Information Administration, Biofuels Explained, https://www.eia.gov/energyexplained/biofuels/biodiesel-rd-other-basics.php (last updated June 29, 2022) (hereinafter "EIA Overview").
[3] U.S. Department of Energy, Renewable Diesel, https://afdc.energy.gov/fuels/renewable_diesel.html#:~:text=Renewable%20diesel%20is%20a%20fuel,and%20EN%20590%20in%20Europe (last accessed May 4, 2023) (hereinafter "DOE Overview").
[4] Maria Gerveni and Scott Irwin, Department of Agricultural and Consumer Economics, University of Illinois and Todd Hubbs, Economic Research Service, U.S. Department of Agriculture, Overview of the Production Capacity of U.S. Renewable Diesel Plants through December 2022, Mar. 8, 2023 at https://farmdocdaily.illinois.edu/2023/03/overview-of-the-production-capacity-of-u-s-renewable-diesel-plants-through-december-2022.html (hereinafter "FarmdocDaily Capacity Article").

operating as of December 2022. During 2022, six plants began operation, representing 38 percent of total current nameplate capacity. These new plants include Diamond Green Diesel LLC in Port Arthur, Texas; Calumet Montana Refining in Calumet, Montana; Holly Frontier in Artesia, New Mexico; CVR Energy in Oklahoma City, Oklahoma; Cheyenne Renewable Diesel Company LLC in Cheyenne, Wyoming; and Seaboard Energy in Hugoton, Kansas.[5]

Figure 1: Location of RD Plants in the U.S., December 2022

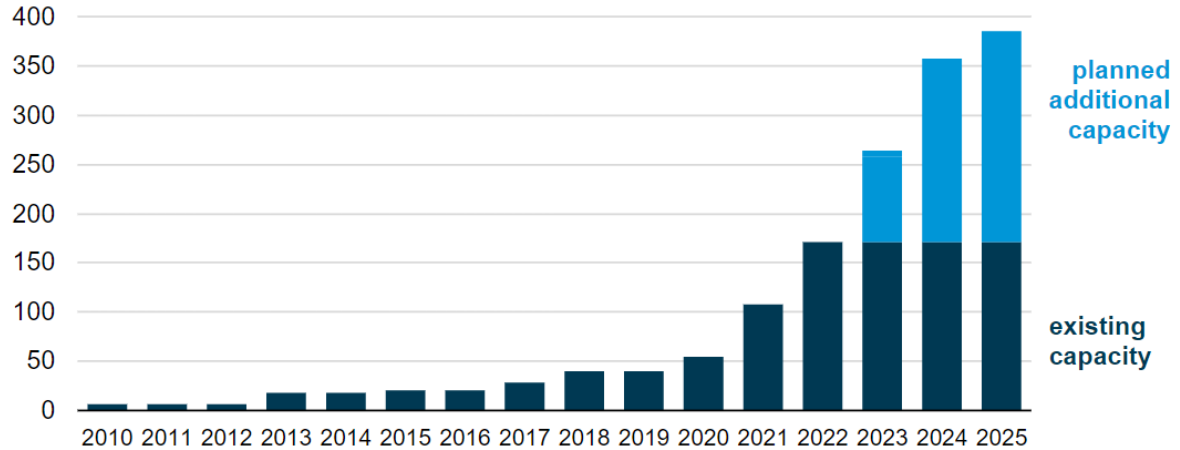


Source: EIA, *Render* and *Biodiesel* Magazines farmdocDAILY

According to EIA, RD production capacity was 170,000 barrels per day (b/d), or 2.6 billion gallons per year (gal/y), at the end of 2022.[6] Though it expects some announced projects will be delayed or canceled, if all projects begin operations as scheduled, U.S. RD production capacity could reach 384,000 b/d, or 5.9 billion gal/y, by the end of 2025. Figure 2 summarizes annual production capacity with an outlook to 2025.

[5] See FarmdocDaily Capacity Article.
[6] Jimmy Troderman, Estella Shi, U.S. EIA, Domestic Renewable Diesel Capacity Could More Than Double Through 2025, Feb. 2, 2023, at https://www.eia.gov/todayinenergy/detail.php?id=55399.

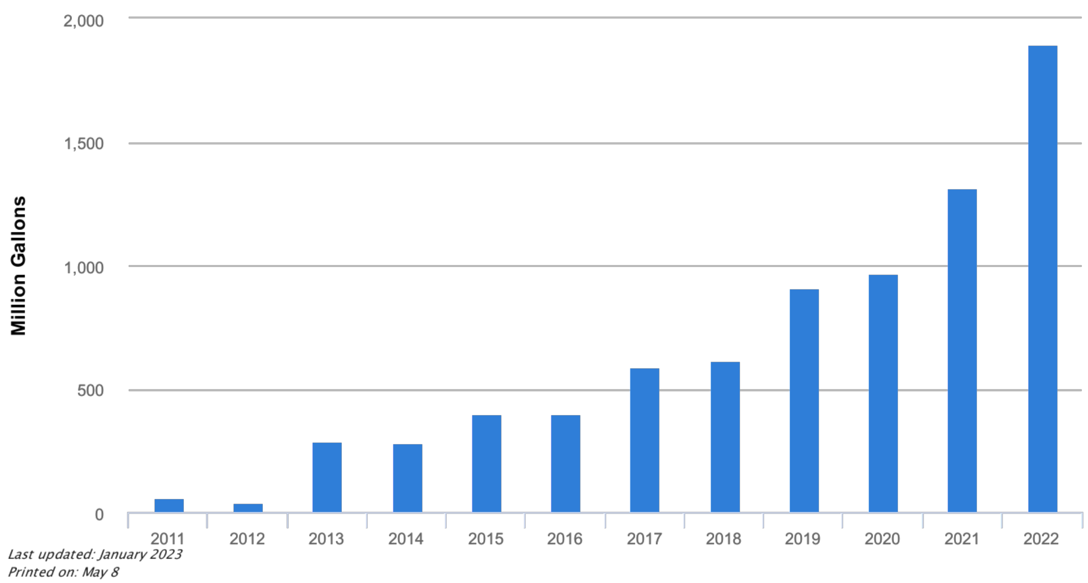
Figure 2: Annual Existing and Expected RD Production Capacity (2010-2025) (Thousand Barrels Per Day)



Source: U.S. EIA, February 2023 citing data from company announcements

As Figure 3 shows, 1.89 BG of RD was supplied in 2022, which included domestic production as well as imports from the Finnish clean fuels producer Neste from its facilities in Singapore, the Netherlands and Finland. Eighty-three percent of consumption occurred in one state, California.[7]

Figure 3: RD Net Supply, 2011-2022



Source: EPA Public Data for the Renewable Fuel Standard. RINs Generated Transactions.

[7] Maria Gerveni and Scott Irwin, Department of Agricultural and Consumer Economics, University of Illinois and Todd Hubbs, Economic Research Service, U.S. Department of Agriculture, Renewable Diesel and Biodiesel Usage Trends over 2011–2022, Apr. 19, 2023 at https://farmdocdaily.illinois.edu/2023/04/renewable-diesel-and-biodiesel-usage-trends-over-2011-2022.html.

Because RD is a drop-in replacement for petroleum diesel, it is suitable for use in any diesel engine, vehicle, or equipment without any modifications to the engine or fueling system. To date, the largest volumes of RD use have gone to commercial on-highway applications, such as truck and bus fleets operating in California, as a result of the Low Carbon Fuel Standard program. RD has been successfully used in diesel engines of all sizes, marine[8] and rail[9] applications, farm and construction, mining[10] and power generation[11] applications.

Numerous studies have evaluated the GHG and criteria air pollutant emissions benefits from using RD. RD can reduce GHG emissions 50-85% or even more compared to petroleum diesel and reduces NOx, PM, and other emissions as well.[12] For example, numerous studies and field trials of Neste's MY Renewable Diesel™ has shown:

- Up to 33% lower levels of fine PM.
- Up to 30% less HC.
- Up to 24% lower CO emissions.
- Up to 9% less NOx.
- Reduced levels of PAH.[13]

Moreover, a recent study by Stillwater Associates for the Diesel Technology Forum found that fueling the diesel vehicles with 100% RD fuel resulted in six times larger cumulative GHG reductions by 2032 than the EV scenarios considered for medium and heavy-duty electric vehicles (EV).[14] It also led to lower PM than for EVs because of U.S. grid electricity mix. From a performance standpoint, RD has a high cetane (70-95) which ensures clean combustion, is generally suitable for use in cold weather conditions and has excellent storage properties which ensures no deterioration of the fuel.

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[8] Dr. T. Bruce Applegate Jr. and Lynn Russell, University of California – San Diego, Longitudinal Study of the Performance Characteristics and Environmental Impacts of Renewable Diesel Fuels in Marine Engines: Final Report, 2013 at https://www.maritime.dot.gov/sites/marad.dot.gov/files/docs/environment-security-safety/office-environment/746/renewable-diesel-fuel-oil-tests-scripps-institution-oceonography.pdf.

[9] Union Pacific, Can Biofuel Power a Locomotive Fleet to Reduce GHG Emissions?, Aug. 30, 2022 at https://www.up.com/customers/track-record/tr090622-biofuel-locomotive-fleet.htm#:~:text=Traditionally%2C%20locomotives%20have%20run%20on%20petroleum%20diesel%20fuel.,renewable%20resources%20and%20burn%20cleaner%20than%20petroleum%20diesel.

[10] Reuters, Rio Tinto's California Mine Shifts Trucks to Run on Renewable Diesel, June 2, 2023 at https://www.reuters.com/sustainability/rio-tintos-california-mine-shifts-trucks-run-renewable-diesel-2023-06-02/.

[11] Caterpillar, Power from Renewable Fuels: Biodiesel and HVO at https://www.cat.com/en_US/by-industry/electric-power/electric-power-industries/renewable-liquid-fuels.htm (last accessed July 18, 2023).

[12] Cummins, Comparing Emission Reductions Across Alternative Fuels, Oct. 3, 2022, at https://www.cummins.com/news/2022/10/03/comparing-emission-reductions-across-alternative-fuels.

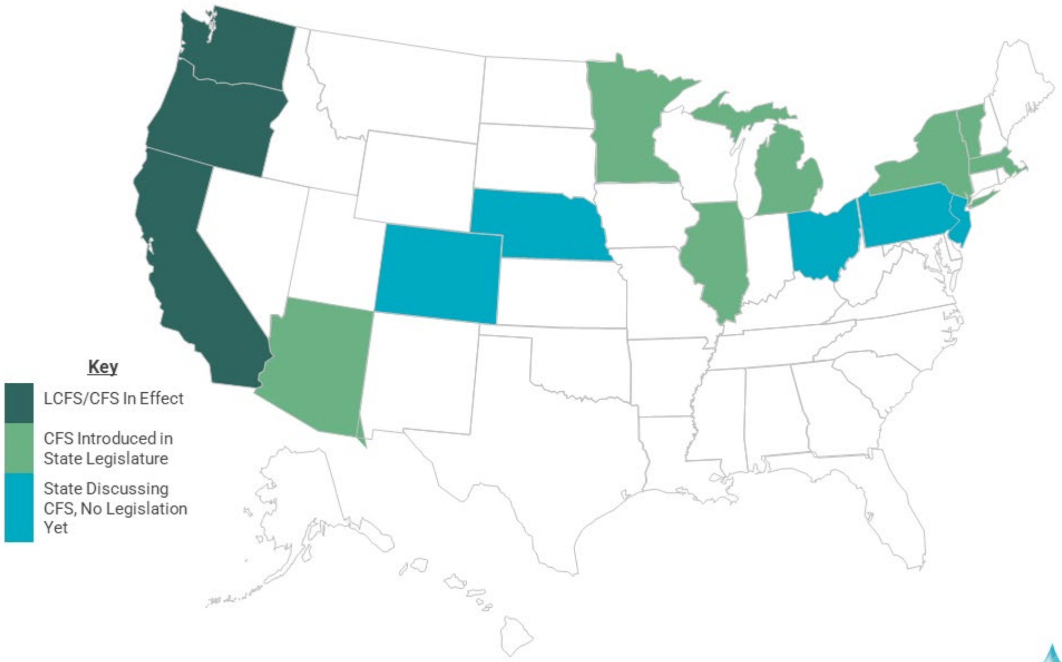
[13] Neste, Reduced Emissions, https://www.neste.com/products/all-products/renewable-road-transport/reduced-emissions#be10a7e9 (last accessed May 4, 2023).

[14] Waste Advantage Magazine, Research Finds More Emissions Benefits at Lower Cost from Accelerated Fleet Turnover and Use of Bio- and Renewable Fuels than Switching to Electrified Medium and Heavy-Duty Trucks, July 22, 2022 at https://wasteadvantagemag.com/research-finds-more-emissions-benefits-at-lower-cost-from-accelerated-fleet-turnover-and-use-of-bio-and-renewable-fuels-than-switching-to-electrified-medium-and-heavy-duty-trucks/. *See also* Stillwater Associates, Environmental Benefits of Medium- and Heavy-Duty Zero Emission Vehicles Compared with Clean Bio- & Renewable-Fueled Vehicles 2022-2032, July 19, 2022, at https://dieselforum.egnyte.com/dl/MWHPcRW4e6.

Existing Treatment of RD in Key Federal and State Regulations

Federal and state regulations such as the Renewable Fuels Standard (RFS2) and California LCFS have spurred demand for RD. The LCFS will be discussed in the next section which focuses on RD and California, but at the outset, other states have taken California's lead and are setting or considering LCFS/CFS policies of their own, shown in Figure 4.

Figure 4: State Clean Fuel Standard (CFS) Policies



Source: Transport Energy Strategies, July 2023 citing Drive Clean, State Sources

Another driver has been the federal biodiesel tax credit (BTC), which provides a US$1/gallon credit that also applies to RD.[15] The need to address environmental, social, and corporate governance (ESG) concerns from investors, shareholders, banks, and customers is beginning to serve as another driver for scaling up RD.

[15] The tax credit is scheduled to sunset Dec. 31, 2024, and convert into the Clean Fuel Production (CFP) tax credit created under the Inflation Reduction Act. RDs that have an emissions rate not greater than 50 kilograms CO_2e per MMBtu as determined by GREET and are not derived from co-processing with petroleum qualify for the credit.

Brief Review of the RFS2 Program

The RFS2 program is a national policy that requires specific volumes of renewable fuel to replace or reduce petroleum-based transportation fuels, heating oil or jet fuel volumes and mitigate GHG emissions. Obligated parties, those responsible for compliance, include refiners and importers of gasoline and diesel. The U.S. Environmental Protection Agency (EPA) calculates and establishes "renewable volume obligations" (RVOs) every year for these parties through rulemaking relative to gasoline and diesel production projections for the coming year based on data from EIA.[16]

Four categories of renewable fuels were created under the original legislation with specific GHG reduction targets. EPA, in implementing the legislation through regulation, developed "D code" assignments for renewable fuels essentially based on its fuel pathway so that credits, or Renewable Identification Numbers (RIN), could be generated and traded in the market. The four renewable fuel categories under the RFS2 program, their GHG percentage reduction, and D code assignment are summarized in Table 1.[17] RD can generate a D4, D5 or D6 RIN.

Table 1: Renewable Fuel Types, GHG Reduction Targets & D Code Assignments

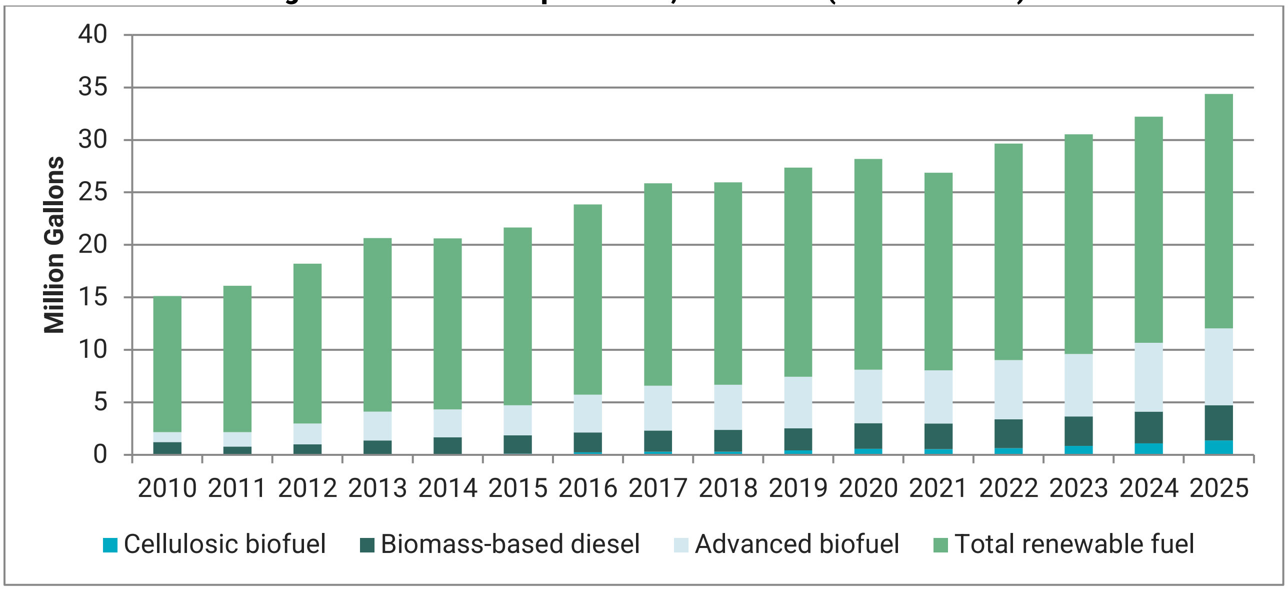
Renewable Fuel Type	GHG Reduction Target (in %)	D RIN Code Assignment	Definition
Biomass-based diesel (BBD)	50%	D4	"a renewable fuel that has lifecycle greenhouse gas emissions that are at least 50 percent less than baseline lifecycle greenhouse gas emissions and meets all of the requirements of this definition: (i) Is a transportation fuel, transportation fuel additive, heating oil, or jet fuel. (ii) Meets the definition of either biodiesel or non-ester renewable diesel. (iii) Is registered as a motor vehicle fuel or fuel additive."
Cellulosic biofuel	60%	D3 or D7	"renewable fuel derived from any cellulose, hemi-cellulose, or lignin that has lifecycle greenhouse gas emissions that are at least 60 percent less than the baseline lifecycle greenhouse gas emissions."
Advanced biofuel	50%	D5	"renewable fuel, other than ethanol derived from cornstarch, which has lifecycle greenhouse gas emissions that are at least 50 percent less than baseline lifecycle greenhouse gas emissions."
Renewable fuel	20%	D6	"a fuel which meets all of the requirements of paragraph of this definition: (i) Fuel that is produced from renewable biomass. (ii) Fuel that is used to replace or reduce the quantity of fossil fuel present in a transportation fuel, heating oil, or jet fuel. (iii) Has lifecycle greenhouse gas emissions that are at least 20 percent less than baseline lifecycle greenhouse gas emissions."

[16] EPA makes such a determination based on the volume requirements under the original Energy Independence and Security Act of 2007 enacted by Congress (and subsequently codified under the Clean Air Act (CAA)).
[17] These four fuel types are "nested." In other words, advanced biofuel includes cellulosic biofuel and biomass-based diesel (BBD); these two fuels can be considered advanced biofuels as well. Advanced biofuels are nested within the renewable fuel category. Advanced biofuels, cellulosic biofuels and BBD are all renewable fuels.

Source: EPA; Code of Federal Regulations

Annual RVOs set for the four renewable fuel types are shown in Figure 5.

Figure 5: Final RVO Requirements, 2010-2025 (Million Gallons)



Source: Compiled by Transport Energy Strategies citing data from U.S. EPA, May 2023
Note: An additional supplemental amount of 0.25 billion gallons renewable fuel was finalized as well for 2023.

Refiners and importers (obligated parties) achieve compliance with the RFS either by blending renewable fuels into transportation fuels, or by obtaining the tradable RIN credits described above to meet the EPA-specified RVO. Obligated parties must obtain sufficient RINs for each of the four categories to demonstrate compliance with the annual standard. RINs are generated whenever a renewable fuel producer makes a gallon of renewable fuel. At the end of the compliance year, obligated parties document their accumulated RINs to demonstrate compliance. RINs can be traded between parties, obligated parties can buy volumes of renewable fuel with RINs attached, and RINs can also be purchased outright. Obligated parties can carry over unused RINs between compliance years. In other words, a compliance deficit can be carried into the next year but must be made up in that year.

Some biofuels generate more RINs per volume than others because of the difference in the fuel's energy content. This difference is accounted for by a metric referred to as the equivalence value (EV) of the biofuel. The EV of a renewable fuel represents the number of gallons that can be claimed for compliance purposes for every physical gallon of renewable fuel used, and it is generally the ratio of the energy content of a gallon of the fuel to that of a gallon of ethanol. For RD, the EV is 1.7.

RD Use in California

The California LCFS has been a major, if not primary, driver of RD scale up in the U.S. As noted above, 83% of RD produced in the U.S. in 2022 was consumed in California. RD is the largest credit-generating fuel in the LCFS program, generating 36.5 percent of all credits yet accounting for less than eight percent of the liquid fuel volume.[18] California petroleum diesel consumption, according to EIA, was about 4.2 billion gallons in 2022 and RD represented over one-third of that demand.[19]

RD producers are able to "stack" credit values for both the LCFS and the RFS2 programs along with the BTC. That allows them to pass some of that benefit on to end users, meaning that in California, fleets have been able to purchase RD at affordable prices on a par with conventional diesel.[20] This has provided an immediate, affordable way to address sustainability and emissions reductions concerns without requiring significant new capital investments while offering reduced operational costs associated with maintaining diesel particulate filter (DPF) systems.[21]

Brief Review of the LCFS Program

California's LCFS was originally established by executive order in 2007 and requires a 20% reduction in the carbon intensity (CI) of transportation fuels by 2030 over the baseline year of 2010, summarized in Figure 6.[22] The California Air Resources Board (CARB) developed, implemented, and enforces the program. Regulated parties include providers of fuels and biofuels in the state. The LCFS is designed to reduce GHG emissions in the transportation sector, which is responsible for about 40% of GHG emissions, 80% of ozone-forming gas emissions, and over 95% of diesel PM.

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18 Robert Lane, Fastmarkets, LCFS Credit Bank Swells with Renewable Diesel Credits, Feb. 3, 2023, at https://www.fastmarkets.com/insights/renewable-diesel-credits-on-the-rise.

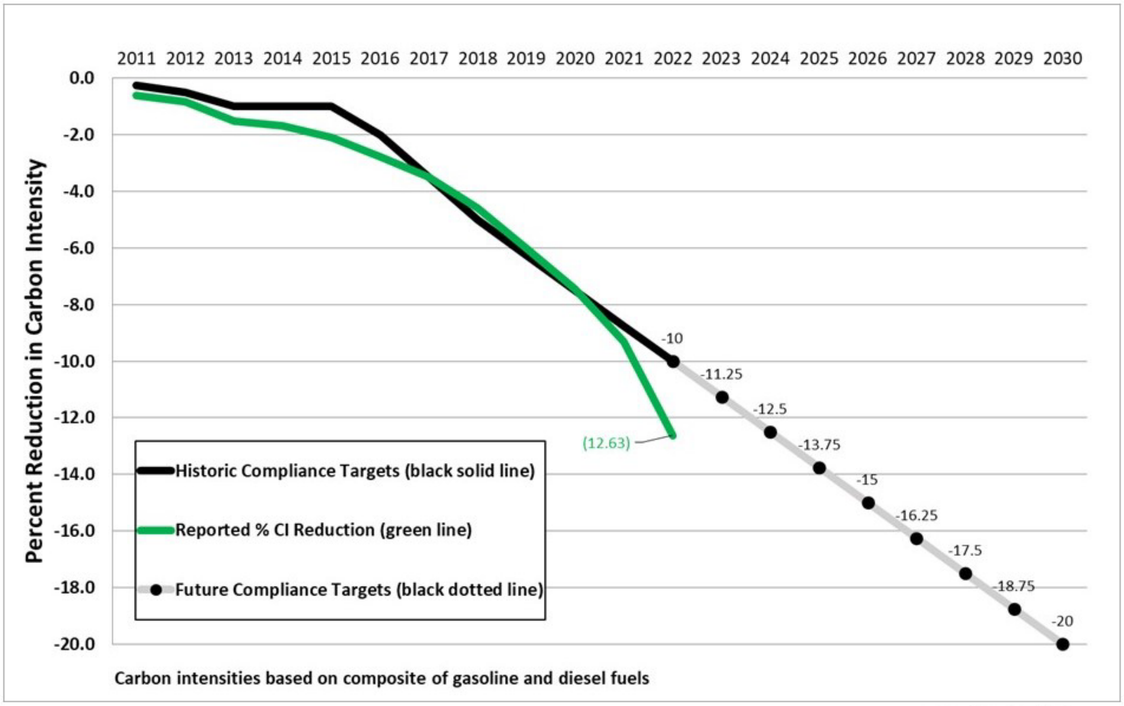
19 U.S. EIA, California Energy Profile at https://www.eia.gov/state/print.php?sid=CA (last updated Apr. 20, 2023). See also California Air Resources Board, LCFS Dashboard at https://ww2.arb.ca.gov/resources/documents/lcfs-data-dashboard (data under Figure 2) (last updated Apr. 28, 2023).

20 Gladstein, Neandross and Associates, Renewable Diesel as a Major Transportation Fuel in California: Opportunities, Benefits, Challenges, August 2017 at https://cdn.gladstein.org/pdfs/whitepapers/renewable-diesel-as-a-major-transportation-fuel-in-ca-report.pdf (hereinafter "GNA Report").

21 GNA Report at 19.

22 CI under the regulations is measured on a lifecycle basis expressed as grams of carbon dioxide equivalent per unit energy of fuel (gCO_2e/MJ).

Figure 6: LCFS Annual Compliance Targets



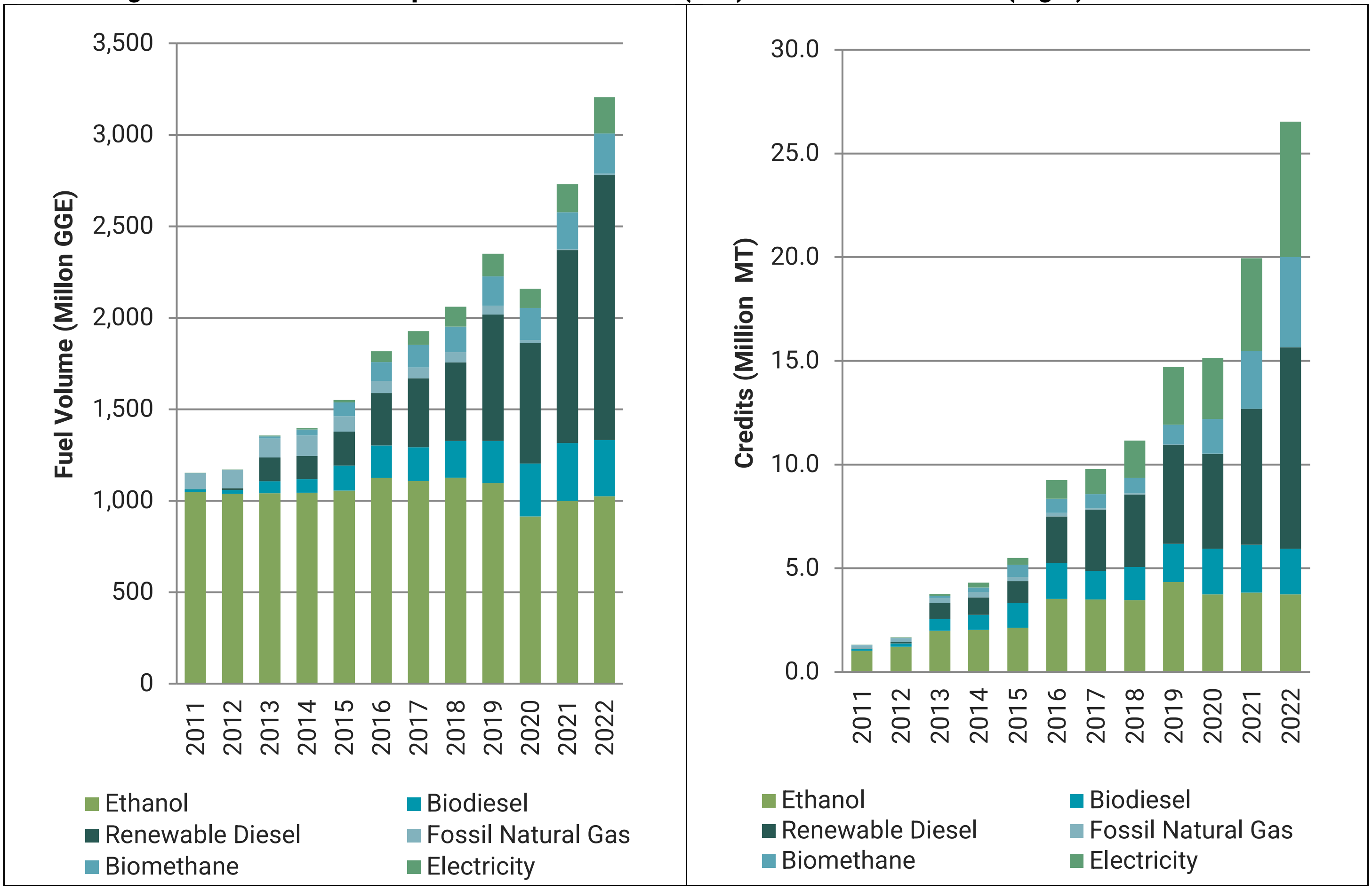
Source: CARB, April 2023

The LCFS has been implemented using credits and deficits, with each credit denoting one metric ton of CO_2 reduction based on the lifecycle CI of the fuel. There are three ways to generate credits in the LCFS:

- **Fuel Pathways**: All transportation fuels need a carbon intensity score to participate in the LCFS, and the fuel type dictates which process is used to determine that CI. Providers of low carbon fuels used in California transportation generate credits by obtaining a certified CI and reporting transaction quantities on a quarterly basis. Credits are calculated relative to the annual CI benchmark and will undergo verification post credit generation.
- **Projects**: Projects that reduce GHG emissions in the petroleum supply chain, such as for carbon capture and storage. Crediting for projects is based on lifecycle emission reductions, and credits are issued after the reported reductions are verified.
- **Zero Emission Vehicle (ZEV) Infrastructure:** Credits can be generated for ZEV infrastructure (generally, electricity for EVs and hydrogen) based on the capacity of the hydrogen station or EV fast charging site minus the actual fuel dispensed.

The intent of the program is to foster the development, commercialization, and large-scale uptake of the lowest CI fuels in transportation, and the program has become highly reliant on RD as illustrated below in Figure 7.

Figure 7: Alternative Transportation Fuel Volumes (Left) and Credit Generation (Right) under the LCFS



Source: CARB, April 2023

Compliance is achieved by offsetting deficits against credits; credits can be banked and traded. The credits do not expire and can be used anytime for compliance. Lifecycle CIs for a range of different fuels and production pathways have been developed and approved by CARB over the last few years. Essentially, the program has been designed to incentivize, in a fuel and technology-neutral way, the uptake of low carbon fuels for transportation. The lower the CI, the larger the premium that fuel captures in the state's fuel marketplace. RD is among the lowest CI fuels in the program and is thus capturing that premium.

A recent analysis found that while the percentage of both biodiesel and RD grew from 0.4% in 2011 to 20.8% in 2020 through the LCFS and generated 44% of credits in 2020, the state experienced a 16% decrease in GHG emissions through the use of both biofuels.[23] Without renewable fuels like biodiesel and RD, the analysis notes,

[23] Clean Fuels Alliance, Clean Fuels Highlights Biodiesel and Renewable Diesel Role in California's GHG Drop, Oct. 31, 2022 at https://cleanfuels.org/home/2022/10/31/clean-fuels-highlights-biodiesel-and-renewable-diesel-role-in-california-s-ghg-drop. See also California Air Resources Board, Greenhouse Gas Inventory at https://ww2.arb.ca.gov/our-work/programs/greenhouse-gas-inventory?utm_medium=email&utm_source=govdelivery.

California's tailpipe fossil CO2 would have been 15 million metric tons higher in 2020. The reduction is equivalent to taking 3.2 million passenger vehicles off the road for the year. In addition to GHGs, the need to reduce ozone and PM pollution in transport continues to be a major focus for CARB as significant parts of the state are in nonattainment of the federal National Ambient Air Quality Standards (NAAQS) for both ozone and PM.

Off-Road Diesel and Commercial Harbor Craft Regulations

To that end, CARB in November 2022 proposed to mandate 99-100% RD for use in off-road vehicles such as those used in construction, mining and industrial operations.[24] In addition to the mandate, the amendments will require fleets to phase out use of the oldest and highest polluting off-road diesel vehicles in California and prohibit the addition of high-emitting vehicles to a fleet.[25] The regulations phase-in beginning in 2024 through the end of 2036. CARB expects the regulation to further reduce NOx and PM.

From 2024 through 2038, the regulation is expected to generate an additional reduction above and beyond the current regulation of approximately 31,087 tons of NOx and 2,717 tons of fine PM (known as PM2.5). About half of those additional reductions are expected to be realized within the first five years of implementation, according to CARB. With respect to R99-R100, CARB found in testing a reduction of NOx emissions of approximately 10 percent and a reduction in PM emissions of approximately 30 percent compared to CARB ultra-low sulfur diesel (ULSD).[26] CARB also noted:

> *"A recent study comparing RD99/100 to CARB reference diesel when used in a legacy off-road engine also showed approximately 30 percent reduction in PM when compared to the CARB reference fuel. Due to RD99/100's emissions reductions, RD99/100 has health benefits over conventional CARB ULSD such as: reduced ambient PM levels, reduced potential cancer risk, reduced population impacted by potential cancer risk, along with reduced incidents of premature death, hospital admissions, ER visits, and other noncancer health outcomes."*[27]

Similarly, CARB began requiring commercial harbor craft (CHC) to use R99-R100 beginning Jan. 1, 2023, and found similar results in emissions testing for both PM and NOx.[28]

Benefits of Blending Biodiesel and RD

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24 Other off-road vehicles and machinery are excluded, including excluding locomotives, aircraft, waterborne vessels, portable equipment, and agriculture.

25 See California Air Resources Board, Proposed Amendments to the In-Use Off-Road Diesel-Fueled Fleets Regulation at https://ww2.arb.ca.gov/rulemaking/2022/off-roaddiesel (last reviewed Apr. 10, 2023).

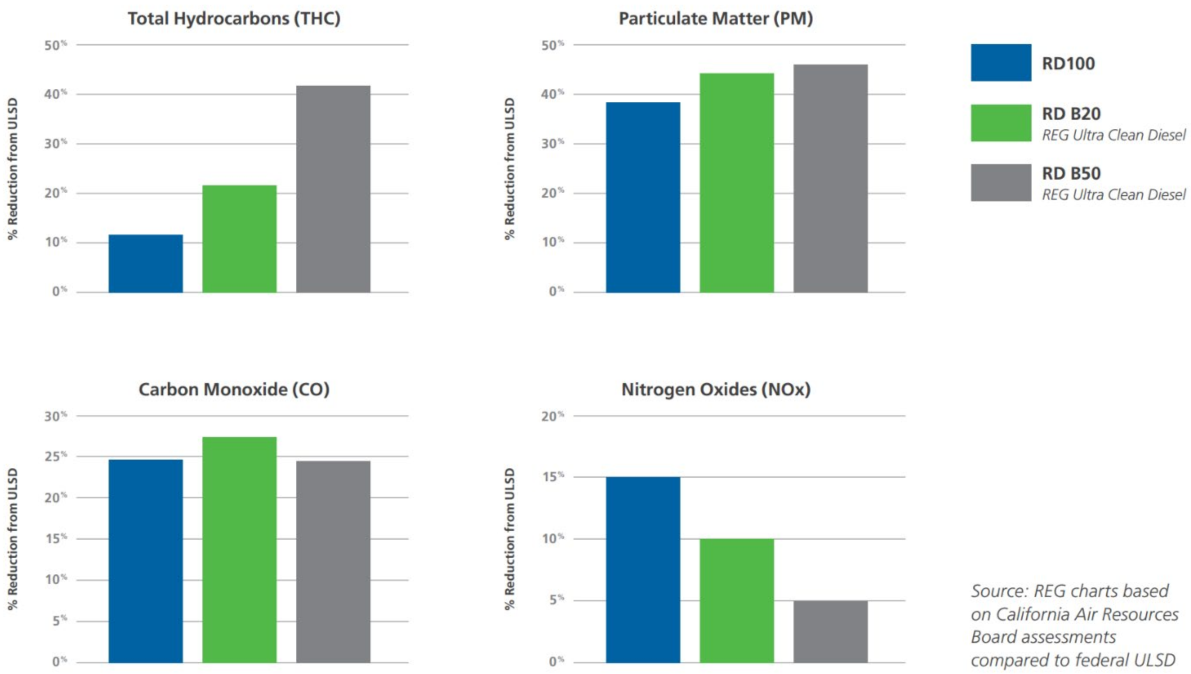
26 California Air Resources Board, Initial Statement of Reasons: Off-Road Diesel Regulation, November 2022 at Public Hearing to Consider Proposed Amendments to the In-Use Off-Road Diesel-Fueled Fleets Regulation Staff Report: Initial Statement of Reasons (ca.gov) (hereinafter "Off-Road ISOR").

27 Off-Road ISOR at 130.

28 California Air Resources Board, Staff Report: Initial Statement of Reasons, Sept. 21, 2021, at https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2021/chc2021/isor.pdf.

RD demand is continuing to skyrocket in California. While there are a number of planned facilities in various stages of development and construction, there is a supply gap. One way to fill the gap has been to offer blends of biodiesel and RD. These blends generally offered as 50 percent biodiesel (B50), 50 percent RD or B20-R80, not only extends the supply pool, but also offers significant air quality benefits shown in Figure 8. In addition to the potential to generate both LCFS and RFS2 credits and meet the requirements of both programs, biodiesel-RD blends can offer pricing advantages over straight RD and making its use cost-effective for users, generally fleets. These blends also offer increased cetane, higher lubricity and improved compatibility.

Figure 8: Emission Reduction Estimates for Biodiesel-RD Blends[29]



Opportunities for Expanded Use of RD in Electric Power Generating Systems

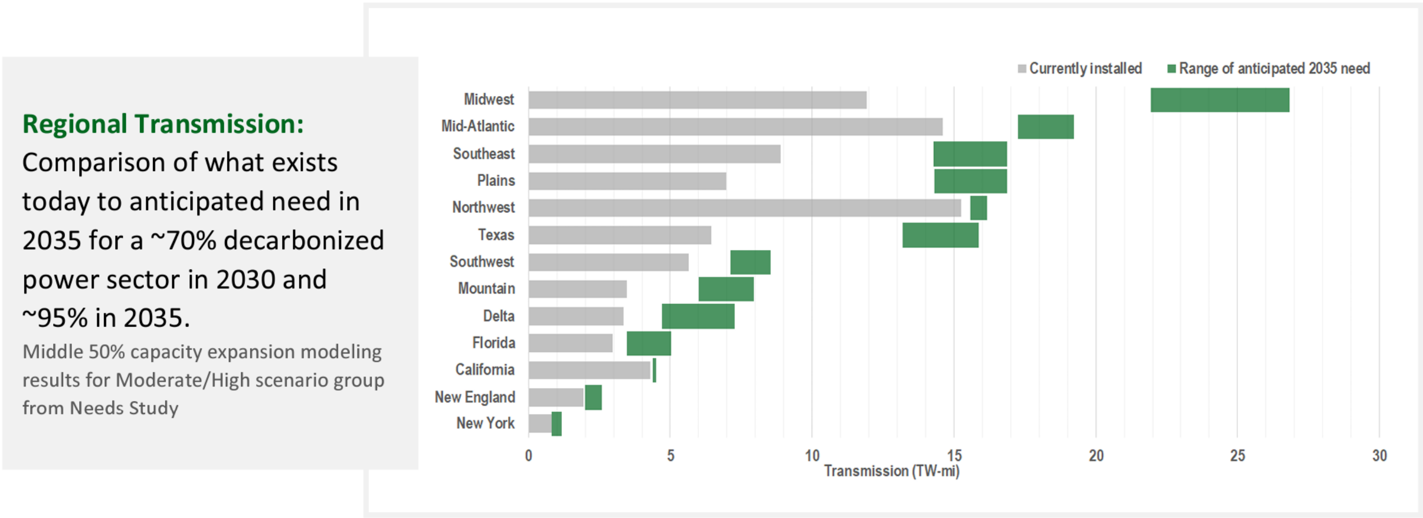
National efforts to decarbonize the economy and move away from fossil fuels to renewable energy sources are well underway. This includes shutting down traditional coal and natural gas-fired generators, in favor of renewables such as solar, wind and hydropower. As a result, forecasters warn of resource shortfalls over most

[29] Chevron Renewable Energy Group, REG Ultra Clean Diesel Fact Sheet, https://www.wwcleancities.org/assets/docs/REG-Ultra-Clean-Diesel-The-Latest-Innovation-In-Renewable-Fuel.pdf (last accessed May 4, 2023).

of the U.S. electric grid over the next 3-5 years.[30] There is also an increasing focus on the ability of the electric grid to handle resulting new and increased demands for electricity and distribute it reliably.[31]

A U.S. Department of Energy (DOE) study on national electric transmission needs in 2023 found that "[t]here is a pressing need for additional electric transmission infrastructure. Nearly all regions in the United States will benefit from improved reliability and resilience given additional investments."[32] Figure 9 summarizes regional transmission operational capacity today versus what will be required by 2035 to reach decarbonization targets. Moreover, capacity is not being added at a quick enough pace to meet decarbonization targets. A recent report found that if the U.S. cannot build new transmission at a faster pace, roughly 80 percent of the emissions reductions expected from that bill might not happen.[33]

Figure 9: Regional Transmission Capacity Requirements, Currently Installed and Required by 2035



Source: U.S. Department of Energy, April 2023

Reaching net-zero by 2050, will require building the clean energy equivalent of 3,000 power plants, according to the American Clean Power Association.[34] All of that new generation will require permits which can take 10

[30] Robert Walton, Most of US Electric Grid Faces Risk of Resource Shortfall Through 2027, NERC Finds, Dec. 16, 2022 at https://www.utilitydive.com/news/nerc-grid-resource-adequacy-shortfall-reliability-assessment/638949/#:~:text=Grid%20operators%20in%20California%2C%20Ontario,Term%20Reliability%20Assessment%20released%20Thursday.
[31] Nadja Popovich and Brad Plumer, New York Times, Why the U.S. Electric Grid Isn't Ready for the Energy Transition, June 12, 2023 at https://www.nytimes.com/interactive/2023/06/12/climate/us-electric-grid-energy-transition.html (hereinafter "New York Times Article").
[32] U.S. Department of Energy, Grid Deployment Office, Draft 2023 National Transmission Needs Study, April 2023 at https://www.energy.gov/sites/default/files/2023-05/Draft-2023-National-Transmission-Needs-Study-Fact-Sheet_April-2023.pdf.
[33] See New York Times Article.
[34] Josh Saul, Cailley LaPara, and Jennifer A. Dlouhy, Bloomberg, Permits for US Energy Projects Are So Bad Unlikely Allies Emerge, June 7, 2023 at https://www.bloomberg.com/news/articles/2023-06-07/renewable-energy-projects-are-held-up-by-us-permitting-rules?srnd=premium&sref=UBrhZ1ro (hereinafter "Bloomberg Article").

years or even more. "With such lengthy delays, [President] Biden's stated goal of purging polluting fossil fuels from the electrical grid by 2035 looks out of reach."[35]

Ensuring the supply of continuous electric power is an increasingly important consideration for utilities, governments, and businesses alike. Diesel generators (gensets) dominate the backup power market due to their unique combination of power-density and full electrical load handling, rapid response time, reliability and self-contained fueling supply. The expanded use of RD in back up diesel power systems or microgrid applications can be an increasing part of a sustainable power solution that achieves real-world GHG emission reductions in line with the state and federal decarbonization goals as power generation plants and transmission projects are added.

Nationwide, diesel generators are also the most common source for backup power, as they are reliable, cost-effective, and have refueling capabilities that give them the ability to operate for extended run times. Because of this, the diesel generator market has increased rapidly, crossing the $25 billion mark in 2020. The firm Global Market Insights is projecting a 5%-6% annual increase over the next seven years, mostly due to increasing weather severity, aging utility infrastructure, and the frequency of blackouts.[36]

Many businesses and mission critical services such as data centers, hospitals and military bases are bolstering their backup plans with microgrids which include solar and storage combinations, but a large part of those microgrids also include a gen-set, fired by natural gas or diesel, to deploy when circumstances require it. RD can be an effective solution to improve air quality, reduce GHG emissions, provide energy security and help companies meet their ESG commitments and goals.

Moreover, manufacturers of reciprocating engines for power generation including Caterpillar, Cummins, Deere, Kohler Power, and MTU/Rolls-Royce Solutions America have approved RD for use in their generators. Companies including Amazon Web Services, Microsoft, LCL, Compass Datacenters, Digital Realty have committed to switch their BUGs from diesel to RD, and STACK Infrastructure, Kao Data, Equinix and Ark Data Centers are also testing the use of RD in their BUGs.[37] The reason is that switching to RD for these companies will help them achieve their energy security and climate goals immediately and cost-effectively. An executive at real estate firm JLL stated:

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[35] See Bloomberg Article.
[36] Kenneth Kutsmeda, Engineered Systems, The Sustainable Future of Backup Power Generation, May 24, 2022 at http://www.esmagazine.com/articles/102365-the-sustainable-future-of-backup-power-generation.
[37] Neste, Biodiesel Magazine, Neste Helps Data Center Power Emergency Generators with Biofuel, Dec. 29, 2022 at https://biodieselmagazine.com/articles/2518477/neste-helps-data-center-power-emergency-generators-with-biofuel. See also Rich Miller, Data Center Frontier, Data Centers Embrace Vegetable Oil as Cleaner Fuel for Generators, June 6, 2022 at https://www.datacenterfrontier.com/energy/article/11427333/data-centers-embrace-vegetable-oil-as-cleaner-fuel-for-generators (hereinafter "Data Center Frontier Article"). See also Biobased Diesel Daily, Amazon Web Services Transitions to Renewable Diesel for Backup Generators at Data Centers in Europe, Mar. 22, 2023 at https://www.biobased-diesel.com/post/amazon-web-services-transitions-to-renewable-diesel-for-backup-generators-at-data-centers-in-europe.

"We need generators, and they're not going anywhere for a while. They have a huge installed base, are extremely reliable, and have a global distribution replenishment infrastructure, so when you run out, a truck comes and fills you up… [I]f you come in and bring an alternative fuel, which burns cleaner and reduces your carbon impact across a fleet of thousands or tens of thousands of units, that's a that's a pretty good compromise. Replacing fuel doesn't change your operations and maintenance protocols, and you can drive down your emissions. That's a smart approach that evolves the current technology."[38]

David Hall of Equinix noted:

"[RD] is a great solution for those assets that already exist. We have 250 data centers, and they have perfectly good generators that represent a bunch of carbon and a bunch of investment. The problem is that the fuel source is poor, from a sustainability perspective. We think that globally, we can get access to HVOs that offer improvements for the emissions performance of generators, with no real impact on efficiency, and only slight reduction on absolute power output. It's a great transition away from (diesel)."[39]

Biodiesel-RD blends are another option for decarbonizing BUGs, particularly as RD production facilities continue to scale up. As noted above, B20-R80 and B50-R50 blends have been proven to reduce air pollutants such as NOx and PM and reduce GHG emissions as well.

Renewable Diesel Use for California Backup Power Systems

California's goals of achieving 100% zero-carbon electricity sales and economy-wide net-zero GHG emissions by 2045 pose an increasing threat to the supply of continuous electrical power. The California State Legislature in 2022 set interim goals of 90% zero-carbon electricity sales by 2035 and 95% by 2040.[40] That will mean a massive expansion of non-fossil based electricity generation capacity nearly four times larger than today's. Five gigawatts (GW) of utility-scale solar must be built every year for the next 20 years, which is five times faster than today's rate, and batteries capable of storing large quantities of clean electricity must be built several times faster than current rates.[41] The NGO Clean Air Task Force notes:

"The state estimates it would need the equivalent of 180 similar projects to reach its 2045 goals of 100% zero-carbon electricity sales and economy-wide net-zero greenhouse gas emissions. More projects mean steeper competition for suitable land, more time investment to engage with local communities, and greater need for upgraded and new transmission lines. The longer it takes to get clean energy projects underway, the steeper the climb to reach net-zero emissions."[42]

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[38] Data Center Frontier Article.
[39] Data Center Frontier Article.
[40] Senate Bill 1020 (2022), Chapter 361, Statutes of 2022 at https://leginfo.legislature.ca.gov/faces/billHistoryClient.xhtml?bill_id=202120220SB1020.
[41] Alex Breckel, Nicole Pavia, Clean Air Task Force, California's Climate Goals Are Ambitious. A Clean Energy Deployment Plan Can Help Get It There, Nov. 10, 2022 at https://www.catf.us/2022/11/californias-climate-goals-ambitious-clean-energy-deployment-plan-help-get-there/#:~:text=The%20state%20is%20a%20leader,2035%20and%2095%25%20by%202040 (hereinafter "CATF Blog").
[42] CATF Blog.

It is a tall order, especially given the frailty of the existing, aging grid and vulnerability to weather-related supply disruptions as power demand continues to grow. In California, researchers documented 44 weather-related outages between 2019 and 2021 – more than a third of the state's total since 2000. And, they said, wildfires are a growing threat to stable electricity there. Utilities in California are required to implement public safety power shutoffs to reduce risks of equipment flaring during extreme wildfire days. At least 14 of the state's 44 outages during that time were due to these preemptive shutdowns.[43]

Moreover, despite adding new power plants, building huge battery storage systems, and restarting some shuttered fossil fuel generators, the state still relies heavily on power from other states.[44] In 2022, state officials had difficulty procuring those supplies because of competing demand in other states. As temperatures in the state soared, electricity demand kept increasing and so did prices, some to almost $2,000 per megawatt-hour, compared with normal prices of less than $100, according to the *New York Times*. Blackouts and planned outages have become the norm for managing the grid.

That presents huge operational challenges and energy security uncertainty for utilities and a wide variety of businesses and consumers. The California Public Utility Commission (CPUC) in 2021 decided to allow California's utilities to continue to rely on diesel backup generators (BUGs, also known as "gen sets") to provide reliable electricity supply during planned outages known as public safety power shutoffs.[45] Meantime, BUGs climbed by double-digit percentage points in 2021 in California. PG&E is one utility using RD for its BUGs.[46]

Two air quality districts, the South Coast and Bay Area, alone have more than 23,000 backup generators – nearly all diesel – representing 12.2 GW of electricity capacity, close to 15 percent of California's entire grid.[47] Based on conservative estimates, BUG use in these two districts in 2021 alone produced annual emissions of 86,899 metric tons of carbon dioxide (MTCO2), roughly 20 MT of fine particulate matter, 62 MT of VOCs, and almost 1,000 MT of NOx.[48] These data may be an understatement since BUG use is self-reported. This means the state may not have a real handle on real-world BUG use and thus the resulting GHG or criteria pollutant

[43] Rachel Ramirez, CNN, Power Outages Are on The Rise, Led by Texas, Michigan, and California. Here's What's to Blame, Sept. 14, 2022, at https://www.cnn.com/2022/09/14/us/power-outages-rising-extreme-weather-climate/index.html.

[44] Ivan Penn, New York Times, Dodging Blackouts, California Faces New Questions on Its Power Supply, Sept. 25, 2022 at https://www.nytimes.com/2022/09/25/business/energy-environment/california-energy-grid-heat.html.

[45] Work Truck Online, California Public Utilities Commission Approves Diesel Generators, Feb. 21, 2021 at https://www.worktruckonline.com/10135686/california-public-utilities-commission-approves-diesel-generators.

[46] Kavya Balaraman, Utility Dive, PG&E Plan to Reserve Temporary Generators for Wildfire Season Has Groups Worried About Diesel Use, Mar. 31, 2021 at https://www.utilitydive.com/news/pge-plan-to-reserve-temporary-generators-for-wildfire-season-has-groups-wo/597603/.

[47] Rod Walton, Power Engineering, Backup Plan: Diesel-Fueled Generators Grow 22 Percent in California Since 2020, Oct. 7, 2021 at https://www.power-eng.com/on-site-power/backup-plan-diesel-fueled-generators-grow-22-percent-in-california-since-2020/.

[48] See M.Cubed, Diesel Back-Up Generator Population Grows Rapidly in the Bay Area and Southern California, 2021 at https://www.bloomenergy.com/wp-content/uploads/diesel-back-up-generator-population-grows-rapidly.pdf.

emissions. If those generators all ran on RD, the total annual greenhouse gas emissions could be reduced by over 331,000 MT, delivering the same climate benefits of turning 71,986 cars into zero-emissions.[49]

With economy-wide efforts on decarbonization now underway, effective policies that apply to the currently installed base of gen sets and future backup power generation installations should be considered. Companies with diesel BUGs are opting for RD to preserve existing assets as longer-term solutions such as electric and hydrogen battery storage are not practical or available cost-effectively at scale yet.

However, though RD and RD-biodiesel blends are increasingly being used for BUGs, such blends do not qualify for credit generation under the LCFS program, since it focuses squarely on GHG emission reduction in transportation. Without specific policies to encourage the use of RD and RD-biodiesel blends in BUGs, they will simply be used in the LCFS program for transportation where they will generate both a LCFS credit and a RFS2 RIN.

Considering this, California policymakers should align climate and air quality goals and foster the use of RD and Biodiesel-RD blends in this sector. The use of RD/HVO fuels, in alignment with OEM recommendations, should be viewed as a positive source of near-term emission reductions as the transition to other low carbon fuels and powertrains will take time. Policies that could be considered include:

- Allowing investor-owned and municipal utilities to include the use of RD and biodiesel-RD blends toward meeting state Renewable Portfolio Standard (RPS) requirements and allow them to generate Renewable Energy Credits (RECs). Doing so will help further move the state toward its RPS goal of 60% renewables by 2030.
- Expanding the LCFS to allow RD and RD-biodiesel blends to generate credits for non-transportation uses, similar to the RFS2, which allows heating oil as a non-transportation use to generate RINs under the program.
- Reducing or eliminating the state diesel excise tax as it applies to RD and biodiesel-RD blends.
- Creating a state tax incentive based on GHG reduction that is structured similar to the Clean Fuel Production tax credit under the recently enacted Inflation Reduction Act (IRA). The tax incentive can and should be based on GHG emission reduction using the CA-GREET model, and rate of the incentive should increase for every percentage point beyond 50 percent.

Such policies are straightforward to implement, provide real-world GHG emission reductions in alignment with both state and corporate decarbonization goals, and could serve as a model that other states can follow.

49 MicroGrid Knowledge, Unleashing Renewable Fuels Now to Bridge the Gap to Net Zero, Jan. 7, 2022 at https://www.microgridknowledge.com/resources/microgrid-perspectives/article/11427502/unleashing-renewable-fuels-now-to-bridge-the-gap-to-net-zero.

HUGGING FACE

May 31st, 2024

The Honorable Jeff Duncan
Chairman
Subcommittee on Energy,
Climate & Grid Security
Committee on Energy and Commerce
U.S. House of Representatives
Washington, DC 20515

The Honorable Diana DeGette
Ranking Member
Subcommittee on Energy,
Climate & Grid Security
Committee on Energy and Commerce
U.S. House of Representatives
Washington, DC 20515

Re: Subcommittee Hearing: "Powering AI: Examining America's Energy And Technology Future"

Dear Chairman Duncan and Ranking Member DeGette,

As one of the global experts on the environmental impacts and energy demands of Artificial Intelligence (AI), I highly appreciate your attention to this topic and the time you are dedicating to it.

Recent research that I published on this topic has found that:

- Currently, popular generative, multi-task models (BLOOM, LLaMa) use up to 30 times more energy to answer a factual question compared to models that were trained to do a single task.
- Generating a single high-definition image using an AI model uses around half a smartphone charge per image generation (according to a recent estimate provided by the Environmental Protection Agency (EPA)).
- Training a large language model uses hundreds of millions of times more energy than deployment, which adds up quickly as models are used by millions of users daily.

This means that as we are switching out legacy AI systems that carry out tasks such as Web search to generative models that generate text and images, this uses orders of magnitude more energy. The field's uncertainty around how much energy is being used and how that is evolving over time harms our ability to estimate near-term energy needs and the responses needed.

In the near term, what we need as users and regulators of AI technologies is more transparency into how much energy is used by different stages in the AI development and deployment process – from training to deployment. Developing a simple, accessible rating system such as the AI Energy Star project can help shed light on the energy usage of AI models and help users make informed decisions around the models they wish to use depending on the task and context at hand. Organizations such as the U.S. EPA and the National Institute of Standards and Technology (NIST) can contribute towards testing models more systematically and standardizing and developing new metrics and standards for comparing models and tasks.

In conclusion, I am convinced that we need more transparency into the energy demands of AI systems, to track these demands over time and make informed decisions as a society.

Yours sincerely,

Dr. Alexandra Sasha Luccioni
Researcher and Climate Lead, Hugging Face

CC: Members of the Subcommittee

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June 3, 2024

The Honorable Jeff Duncan
Chair, Subcommittee on
Energy, Climate and Grid Security
House Committee on Energy and
Commerce
2229 Rayburn House Office Building
Washington, D.C. 20515

The Honorable Diana DeGette
Ranking Member, Subcommittee on
Energy, Climate, and Grid Security
House Committee on Energy and
Commerce
2111 Rayburn House Office Building
Washington, D.C. 20515

Dear Chair Duncan and Ranking Member DeGette,

In advance of the House Energy and Commerce Subcommittee on Energy, Climate, and Grid Security's hearing titled "Powering AI: Examining America's Energy and Technology Future," I am writing to highlight several ways in which artificial intelligence (AI) is being deployed to increase the efficiency and resilience of our nation's energy grid. TechNet has been closely monitoring AI developments in the energy space and appreciates the Subcommittee's attention to this important issue.

Modernizing our nation's energy infrastructure and integrating new means of power generation and management is critical to meeting future energy demands. AI can significantly enhance grid management and optimize power production and use forecasting. AI can analyze real-time data on energy production, consumption, and grid conditions to optimize the operation of energy storage systems. This allows efficient storage and discharge of electricity aligned with low-carbon generation and demand patterns, enhancing the integration of renewables into our nation's grid. Global annual cost savings from AI-enabled grids are projected to exceed $125 billion within five years.

AI can also enhance grid resilience and self-healing capabilities in the face of disruptions or outages. From 2011 to 2021, weather-related outages in the U.S. rose by nearly 80 percent, at an annual cost of $70 billion to $120 billion. With AI, "self-healing" smart grids can identify a network's weak spots in real-time, more accurately predict severe weather events or surges in demand and help to avoid or contain power failures. These advanced tools can quickly detect and respond to grid disturbances, predict potential disruptions, reroute energy flows, and optimize grid operations to restore power and maintain system stability.

AI can also enable demand response systems that can communicate with smart devices, including smart appliances, to lower energy use during peak demand or peak carbon-intensive periods. For example, TechNet member Dell is helping Siemens build more efficient buildings with AI by addressing building performance issues, like optimizing HVAC systems, predicting energy demand, and identifying energy leaks in real time. By analyzing real-time data and user preferences, AI can optimize energy usage, schedule energy-intensive tasks during periods of high renewable energy availability, and encourage energy-efficient behaviors. This helps balance the grid and reduces the need for additional energy generation from non-renewable sources.

Although AI does require energy to run, tools are already being deployed to reduce its energy consumption. Large-scale commercial and industrial systems like data centers that power advanced AI tools require a lot of energy. One of the primary sources of energy consumption for data centers is cooling. Google DeepMind's machine learning system has been able to consistently achieve a 40 percent reduction in the amount of energy used for cooling data centers, which equates to a 15 percent reduction in overall power usage effectiveness overhead. When considering the environmental impacts of AI, we must keep in mind its ability to increase efficiencies, accelerate the development of energy-saving technologies, and decrease overall energy demands.

Thank you for considering our perspective and for your important work on AI policy. Please do not hesitate to reach out if you have any questions or if TechNet can provide additional assistance to you and your staff.

Sincerely,

Linda Moore

Linda Moore
President and CEO

https://www.wsj.com/business/energy-oil/data-centers-energy-georgia-development-7a5352e9

BUSINESS | ENERGY & OIL

There's Not Enough Power for America's High-Tech Ambitions

Georgia is a magnet for data centers and other cutting-edge industries, but vast electricity demands are clashing with the newcomers' green-energy goals

By David Uberti Follow

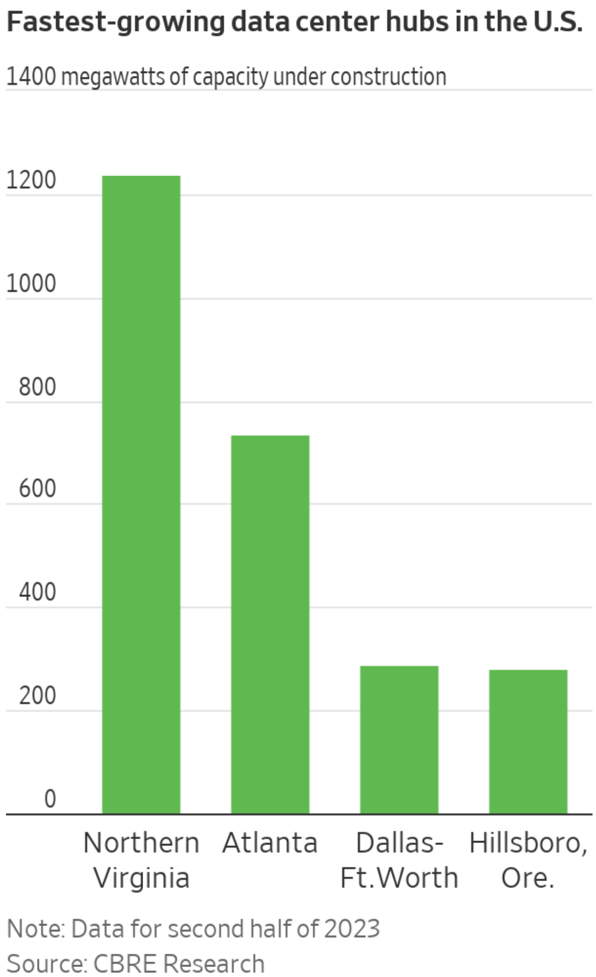
Updated May 12, 2024 12:16 pm ET

ATLANTA—Bill Thomson needs power fast. The problem is that many of the other businesspeople racing into Georgia do too.

Thomson heads marketing and product management at DC Blox, which in recent years built a string of data centers in midsize cities across the fast-growing Southeast. The company more recently set its sights on Atlanta—the would-be capital of the region—joining a slew of tech and industrial firms piling into the state.

Vying for a piece of one of America's hottest markets, those businesses tend to have two things in common. One is that they represent a U.S. economy increasingly driven by advanced manufacturing, cloud computing and artificial intelligence. The other is that they promise to hoover up huge amounts of electricity.

That combination means Georgia's success in luring this development comes with a side effect: Power is a big source of tension. The clean-energy goals of companies and governments are running up against the need for projects to break ground fast. So far, climate advocates fear the imperatives of growth mean more fossil fuels.



Georgia's main utility, Georgia Power, has boosted its demand projections sixteen-fold and is pushing ahead on a hotly contested plan to burn more natural gas. Critics warn it will yield higher bills and unnecessary carbon emissions for decades. Some companies are scrambling to secure bespoke renewable-energy deals to power their development.

One major source of disruption is data centers. The facilities are ballooning in size as people spend more of their waking hours online and companies digitize everything from factory processes to fast-food drive-throughs. All that computing requires power—and for firms like DC Blox to lock it in as quickly as possible.

"Generally," Thomson said, "we find the guys with the fastest power win."

The DC Blox project in Douglas County, west of Atlanta, is one of several data centers being developed in the area. PHOTO: DC BLOX

Similar quandaries are rippling through other hubs of the new American economy, with utilities in Tennessee and the Carolinas forecasting their own unexpected surges in load growth. U.S. power usage is projected to expand by 4.7% over the next five years, according to a review of federal filings by the consulting firm Grid Strategies. That is up from a previous estimate of 2.6%.

The projections come after efficiency gains kept electricity demand roughly flat over the past 15 years, allowing the power sector to limit emissions in large part through coal-plant closures.

“We haven't seen this in a generation,” said Arne Olson, a senior partner at consulting firm Energy and Environmental Economics. “As an industry, we've almost forgotten how to deal with load growth of this magnitude.”

For states like Georgia, the fear is missing out on what could be once-in-a-generation investments. Wall Street is salivating over an artificial-intelligence-fueled tech bonanza, while Washington is throwing billions of dollars into domestic manufacturing.

The added wrinkle is that it is all happening as many parts of America—corporate America included—are trying to wean themselves off fossil fuels.

“These companies all have clean-energy goals,” said Patty Durand, a Georgia Power critic who is campaigning to be a utility regulator in the state. “Those goals are at risk if Georgia Power gets what it wants.”

The Peach State's energy quandary stems from the type of economic dynamism that many counterparts would envy. Its growth has consistently outpaced the nation's. A smaller portion of Georgians are jobless than the U.S. average, while their incomes tend to be rising faster.

State and local economic-development teams have courted large businesses to set up shop with sales pitches that have included generous financial incentives. Rail lines, ports and America's largest air hub also provide access to faraway customers.

Pat Wilson, commissioner of the Georgia Department of Economic Development, said energy is increasingly part of those discussions with newcomers. Officials tout the newly expanded Plant Vogtle, America's largest nuclear power plant, as a sign the state is ready for long-term growth.

"We have a utility partner to make sure you can meet your energy needs on day one," Wilson said.

Those needs include affordability, reliability and sustainability for firms like Aurubis, a German metals giant building a recycling plant in the outskirts of Augusta.

U.S. energy prices are far lower than those in Europe. That is a boon for Aurubis, which uses mammoth equipment to shred old circuit boards and electrical wiring, melt the scraps, and separate copper from other materials.

The company also boasts aggressive emissions-reductions targets for its power-intensive smelters. At its roughly $820 million Georgia plant, Aurubis will use up to 31 megawatts of electricity, enough to power thousands of homes.

"Not every project itself has to reduce carbon emissions," said David Schultheis, president of the Georgia facility. "But the overall set of projects has to guide us there."

The firm has made strides to that end in Europe by bolstering its usage of wind or solar power in a portfolio stretching from Belgium to Bulgaria. In Georgia, Schultheis pointed to Plant Vogtle, visible just 12 miles away, as a symbol of reliable energy.

David Schultheis is in charge of a new recycling plant being built by German metals giant Aurubis in the outskirts of Augusta. PHOTO: KENDRICK BRINSON FOR THE WALL STREET JOURNAL

Companies prize nuclear power plants, since they produce carbon-free energy and —unlike wind or solar power—don't depend on the weather. But the projected power needs of new businesses in the state far exceed the expected output of the plant's recently added reactors, the second of which went online last month.

Despite Aurubis' proximity to Vogtle, which is co-owned by Georgia Power, it is also difficult to trace the source of electricity that reaches the substation on the German company's property nearby. Schultheis instead relies on the utility's overall power production for his carbon accounting, meaning the Georgia site will add more to Aurubis' carbon footprint.

"We get the full grid—the mix of the grid—of what they produce," he said.

Many of the battles over that energy mix have been fought in a windowless room in one of the imposing government buildings crammed into Atlanta's South

Downtown area. That is home to meetings of the Georgia Public Service Commission, which oversees utilities including Georgia Power.

The investor-owned utility last fall made an unusual update to its periodic resource proposal to regulators. Citing a boom in new business customers, Georgia Power boosted its projected demand growth over the next seven years from less than 400 megawatts to 6,600 megawatts, or about a third more than the utility's total capacity at the beginning of 2023.

To make up the gap, the company put forward a plan that includes adding battery storage, buying power from fossil-fuel-burning plants in Mississippi and Florida, and building three new gas-fired turbines in Georgia.

The Southern Co. subsidiary has since sparred with renewable-energy-minded organizations as divergent as local municipal governments, the Sierra Club and the Pentagon.

Opponents argued the utility should accelerate demand-side responses, such as allowing customers to dial down energy usage depending on costs. Others proposed more-aggressive use of solar power and batteries, or so-called "virtual power plants" that allow consumers with solar panels to sell energy back to the grid.

In Georgia Power's view, adding gas is key to providing stable power and quickly ramping up electricity for moments of peak usage on the hottest days of summer and coldest days of winter. That is especially crucial given the utility's gradual retirement of coal-fired plants.

The state is attracting so many power users, Georgia Power contends, that new investments will actually suppress ratepayers' bills.

"We anticipate that we will not need to increase rates to cover the costs of these resources that we're adding," said Aaron Mitchell, the company's vice president of pricing and planning.

A view of the Aurubis recycling plant. PHOTO: KENDRICK BRINSON FOR THE WALL STREET JOURNAL

Some Georgians are skeptical, noting utilities' previous overestimates of demand growth. Power companies have a financial incentive to pursue capital projects, critics say, and overbuilding now would risk saddling ratepayers with assets that have decadeslong shelf lives.

The recent history of energy development in the state has also been rocky. The Georgia Power-led project to expand Plant Vogtle, the first U.S. nuclear development in decades, ran up more than $30 billion in costs and lagged years behind schedule.

Since the project's early stages in 2007, the 12-month moving average of residential power costs for the utility's customers has surged 68%, according to the Georgia Center for Energy Solutions. That outpaced inflation, as well as cost increases for industrial and commercial customers.

Price pressures and climate fears have pushed communities such as suburban Atlanta's DeKalb County, which has pledged to slash emissions, to lobby regulators for more aggressive oversight of the investor-owned utility. Ted Terry, a DeKalb County commissioner, warned that the state is using a 20th-century energy playbook while trying to attract 21st-century industries.

The state's energy market "is not working for all of us," Terry said. Regulators approved much of Georgia Power's plan on April 16.

'Essential to our economy'

The DC Blox data center in Myrtle Beach, S.C., is one of the firm's five facilities across the Southeast. More are on the way. PHOTO: DC BLOX

The tension hasn't slowed businesses' rush to the state.

Alphabet's Google has operated data centers in Georgia for more than two decades, gradually expanding its footprint. In 2021, Microsoft established a new U.S. data-center region emanating from greater Atlanta. An Amazon Web Services spokesman said the firm recently bought land in the Peach State and is evaluating possible server-farm locations.

All three firms purchase massive amounts of renewable energy to help power their facilities around the world. All three are also members of the Clean Energy Buyers Association, a trade group pushing utilities, including Georgia Power, to go green.

Priya Barua, the organization's senior director of market and policy innovation, said the added difficulty in much of the Southeast is that traditionally regulated power markets sometimes give firms fewer opportunities to shop around for wholesale electricity.

"They're more limited in how they can get clean energy," she said.

Some analysts believe that could change as companies exert more pressure on regulators and developers strike deals with independent power producers. As part of Georgia Power's recent planning update, the utility said it would work with trade groups like Barua's to explore how commercial and industrial customers might build or contract their own clean-energy projects in the future.

Those setups have been confined in recent years to nonprofit electricity cooperatives that tend to serve rural areas. Instagram-owner Meta, for example, joined with a Georgia co-op and solar developer Silicon Ranch as part of a broader deal to power data centers.

But even in a more-competitive market, those deals may remain out of reach for most companies, such as DC Blox, the data-center operator building two facilities on opposing outskirts of Atlanta.

Founded in 2014, the firm constructed its first data center in an old paper plant in Chattanooga. Power usage: one megawatt. DC Blox has since built out a network from Myrtle Beach, S.C., to Huntsville, Ala., leasing space to municipalities, universities and manufacturers.

Aurubis uses mammoth equipment to shred old circuit boards and electrical wiring, melt the scraps, and separate copper from other materials. PHOTO: KENDRICK BRINSON FOR THE WALL STREET JOURNAL

Now, the company is big-game hunting for big-tech customers. The larger of its two Atlanta-area sites could reach up to 300 megawatts.

"The smart states and smart utility commissions are going to figure out how to do this because this isn't going to stop," said Thomson, the DC Blox executive. "AI is coming next."

DC Blox executives see themselves as part of Atlanta's evolution from logistics center to the digital hub of the Southeast. Nowhere is that more apparent than west of the city in Douglas County, the most sought-after corner of the region's data-center market.

Local officials including Chris Pumphrey, president of the public-private Elevate Douglas Economic Partnership, began seeking out data centers about a decade ago. While the facilities employ few full-time employees, operators and tenants pour property and sales taxes into public coffers. Another benefit to Douglas County was that the new industry reduced truck traffic to warehouses peppering the area.

"At that period of time," Pumphrey said, "there wasn't this significant concern about energy."

These days, Douglas County is home to current or forthcoming data centers by companies including Google, Microsoft, DC Blox, Flexential and Switch. As hundreds of construction workers etch the concrete structures into sides of hills like fortresses, Pumphrey is eagerly awaiting the payoff.

"They're essential to our economy," Pumphrey said. As for the energy concerns, he added, "We have to figure something out."

Cooling towers at Plant Vogtle, a nuclear power station, are visible behind the new Aurubis facility.
PHOTO: KENDRICK BRINSON FOR THE WALL STREET JOURNAL

Write to David Uberti at david.uberti@wsj.com

Corrections & Amplifications

U.S. power usage is projected to expand by 4.7% over the next five years. An earlier version of this article incorrectly said usage is projected to expand by 4.7% annually over the next five years. (Corrected on May 12)

Appeared in the May 13, 2024, print edition as 'Emerging Industry Strains Power Grid'.

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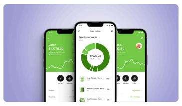

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UTILITY DIVE

DIVE BRIEF

AEP Ohio proposes data center, crypto financial requirements amid 30 GW in service inquiries

The proposed tariffs aim to ensure data centers and cryptocurrency operations pay for their share of any transmission buildout needed to serve them in the PJM Interconnection.

Published May 15, 2024

Ethan Howland
Senior Reporter

AEP Ohio on May 13, 2024, proposed specific rates for data centers and cryptocurrency operations at the Public Utilities Commission of Ohio.
gorodenkoff via Getty Images

Dive Brief:

- Facing about 30 GW in potential data center load, AEP Ohio on Monday asked state utility regulators to approve a proposal that would set increased financial requirements for new data centers and cryptocurrency operations.

- The proposed rates for data centers larger than 25 MW and crypto and mobile data centers bigger than 1 MW would help ensure that they pay for new transmission needed to serve them, which could cost billions, according to filings at the Public Utilities Commission of Ohio.

- "AEP Ohio's proposed data center tariffs will require data centers to make long-term financial commitments — to have more skin in the game — to mitigate the risk that transmission infrastructure will be built for data centers but not needed," Matthew McKenzie, vice president of regulatory and finance for AEP Ohio, said in testimony at the PUC.

Dive Insight:

There is about 600 MW of data center load in AEP Ohio's service territory in Central Ohio, according to filings with the PUC. The utility has agreements to connect an additional 4.4 GW of data center load by 2030, which can be accommodated by the region's transmission system.

However, AEP Ohio has received inquiries from companies considering building data centers that could add an additional 30 GW of load, which would require new transmission — possibly 765-kV lines — on the PJM Interconnection's system, according to the utility.

PJM recently approved about $5 billion in transmission projects in the Dominion Energy and First Energy territories to help serve more than 7.5 GW of data center load in the northern Virginia area, Kamran Ali, vice president of transmission planning and analysis for American Electric Power Service Corp., told the PUC.

In response to the inquiries, AEP Ohio in March 2023 paused accepting new service requests from data center customers so it could evaluate how they would affect the utility's power delivery system, Ali said.

The proposed tariffs will help AEP begin potential siting activities and identify transmission routes into the Central Ohio area as well as PJM's development of potential regional solutions through a competitive solicitation process, he said.

“Without requiring data centers to make long-term financial commitments to support transmission investment, data center load growth could leave AEP Ohio with insufficient transmission capacity to support the kind of ordinary, non-data-center economic growth that creates jobs and powers Ohio’s economy,” McKenzie said.

Also, if the transmission facilities are built, but the data center load doesn’t materialize as expected, retail customers in PJM would have to pay for unneeded transmission capacity, he said.

Under AEP Ohio’s proposal, data centers would be required to commit to ten-year electric service contracts, with an option to pay an “exit fee” after five years, according to McKenzie. Also, data centers would be required to pay minimum demand charges based on 90% of their contract capacity, up from 60% under the utility’s current general service tariff, he said. Mobile data centers, such as cryptocurrency mining operations, would be required to pay minimum demand charges based on 95% of their contract capacity.

The proposal would apply to service agreements made after AEP Ohio’s moratorium on them is lifted.

In the past, AEP Ohio’s largest customers have been industrial facilities with peak demand in the range of a few hundred megawatts, according to McKenzie. Now, AEP Ohio has had multiple customers say they are considering building data centers that could have loads of 1 GW or more, he said.

AEP Ohio has a general obligation to serve all customers in its service territory, but that obligation doesn’t require the utility to extend service to customers in a way that would be unreasonable or unjust for the utility and its other customers, McKenzie said.

Data centers have less of an effect on the local economy than typical commercial and industrial customers, Lisa Kelso, AEP Ohio vice president of customer experience, told the PUC.

On average, non-data center C&I customers support about 25 direct full-time equivalent jobs per megawatt while data center customers support less than one direct FTE job per megawatt, she said.

Owners of hyperscale data centers are attracted to Central Ohio because of reliable electric service from AEP Ohio, available fiber connectivity, water resources and retail choice for power supply, according to Kelso.

Some mobile cryptocurrency operations have appeared in AEP Ohio's service territory and then left, she noted.