Title

2025 Large Load Literature Review

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Large Load Literature Review

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ENERGY TECHNOLOGIES AREA
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Large Load Literature Review

- Reviewed more than 90 publications and categorized into 12 themes.
  - Load forecasting
  - Artificial Intelligence (AI) and infrastructure
  - Reliability and resource adequacy
  - Large load interconnection
  - Demand flexibility
  - Generation
  - Co-location
  - Large load tariffs
  - Policy options
  - Maps and tools
  - Design and operations
  - Data sources

- Each report is linked and has a short description and key takeaways.
- The reports are organized in chronological order, with the newest reports listed first. Ongoing activities (e.g., task forces, working groups) are listed last.
- There is a 'Data Sources' section that identifies data and inputs used in report analysis. Reports that have information on supporting data sources are marked with an asterisk (*).
- This is a living document and will continue to be updated.

Load Forecasting

Load Forecasting (1) - *New*

- **[Forecasting for Large Loads: Current Practices and Recommendations](#) (Energy Systems Integration Group's Large Loads Task Force, December 2025)**
  - This report is one of the 8 reports from ESIG's Large Loads Task Force. It tracks and reviews over two dozen forecasts of large loads across various U.S.
  - Key finding from the task force is that existing large load forecasting practices are inconsistent and lack transparency.
  - To address this, the report recommends all forecasts consistently use and clearly describe five core metrics to characterize new loads: Project Realization, Energization Date, Load Realization, Load Ramping, and Load Factor/Load Shape. These factors would be used to characterize and weight information appropriately, helping improve the accuracy of forecasts.
  - Another recommendation is to develop and maintain a shared national database to collect large load forecasts. This will ensure consistency in comparing different load forecasting models and methodologies, and also help with validation techniques.

Load Forecasting (2)

- **Forecasting Large Loads in the Age of AI and Data Centers (E3, December 2025) - *New***
  - This report presents a dynamic approach for forecasting load growth from data centers, built on verified baselines and diverse scenario-based modeling.
  - It particularly focuses on integrating demand response (DR) and rate design into the forecasting methods, as critical tools to manage financial risk, protect ratepayers, and enhance system flexibility.
- **Power Demand Forecasts Revised Up for Third Year Running, Led by Data Centers (Grid Strategies, November 2025)***
  - This report is the third update to their annual reports studying near-term load forecasts from utilities and regional transmission operators, and the impact of data center load growth on these forecasts.
  - Key finding from the report is that the nationwide aggregate of 2025 utility projections for forecasted summer demand in 2030 is 166 GW, up from utility projections in 2022 of 24 GW, representing an increase of six-fold.
  - Their market analysis finds that national aggregated utility load forecast for data centers in 2030 (~90 GW) is likely overstated by roughly 25 GW (40%).

Load Forecasting (3)

- Long-Term Load and DER Forecasting **(Energy Systems Integration Group, August 2025)**
  - This report emphasizes the need for more granular spatio-temporal load forecasting, within the context of an evolving energy landscape with large loads such as data centers.
  - The report suggests ways to enhance forecasting for large loads like data centers, such as - 1) using bottom-up modeling utilizing parameters like IT hardware specifications and cooling infrastructure for more accurate and reliable estimates, and 2) enhanced data sharing between technology companies, utilities, ISOs, and researchers to ensure transparency on those parameters.
- Scaling Intelligence: The Exponential Growth of AI's Power Needs **(Electric Power Research Institute (EPRI), Epoch AI, August 2025)**
  - This white paper analyzes the current and projected electricity demand driven by artificial intelligence (AI), particularly the training of large-scale frontier AI models.
  - Findings state that the training of such large AI models, which currently consume around 100–150 MW each, are projected to reach 1–2 GW per training run by 2028, and exceed 4 GW by 2030.

Load Forecasting (4)

- **Uncertainty and upward bias are inherent in data center electricity demand projections (London Economics, July 2025)**
  - This report analyzes projections of electricity demand from data centers in the United States, concluding that these projections are highly uncertain and likely overestimated. The authors cite various reasons for this overestimation, such as duplicate requests from data center developers.
  - Report findings include that actual load growth my be weaker than projected due to bottlenecks in equipment for generation and transmission, global chip supply constraints, and potential demand flexibility from data centers.
  - The report concludes that over-forecasting data center growth poses substantial risks for existing utility customers. If new energy infrastructure is built based on speculative projections and the demand does not materialize, the costs would likely be shifted to other ratepayers through higher electricity bills.

Load Forecasting (5)

- A Review of Load Growth Drivers & Associated Resource Planning Activities **(Sandia National Laboratories, June 2025)**
  - This report provides a comprehensive summary of the drivers causing load growth in the U.S.
  - It identifies six drivers, including data centers that are projected to consume up to 12% of U.S. electricity by 2030. Other drivers are: manufacturing, electrification, water and wastewater utilities, population trends, and extreme weather events.
  - The report also includes a case study on the U.S. Southwest, focusing on the Integrated Resource Plans (IRPs) of six utilities in the region.
  - One finding is that there is a lack of detailed understanding in the specific projections for load growth, both at the national and regional levels.
  - One recommendation is to address these knowledge gaps by developing shared datasets, metrics, and analyses.

Load Forecasting (6)

- **Energy and AI: Evaluating Future Grid and Water Stress Due to Data Centers (Pacific Northwest National Laboratory (PNNL), June 2025).**
  - This project focused on two tasks - studying the impacts of data center electricity demand growth scenarios on grid stress in the Western Interconnection in the near term (2025-2035); and studying the grid and water implications of data center demands, siting, and configuration.

- **Electricity Demand Growth and Data Centers: A Guide for the Perplexed (Koomey Analytics, Bipartisan Policy Center, February 2025)**
  - This report emphasizes the deep uncertainty in projecting future electricity demand from data centers due to national and regional growth trends, sources of electricity load growth (e.g., manufacturing, data centers) unpredictable AI growth and the potential for efficiency improvements.
  - It cautions against overly aggressive projections and calls for utilities, regulators, and policymakers to base expectations on accurate and updated data and models.

Load Forecasting (7)

- Rising current: America's growing electricity demand (ICF, 2025)
  - This report analyzes the recent increase in U.S. electricity demand and its implications for reliability and affordability.
  - ICF estimates U.S. electricity demand is expected to grow 25% by 2030 and 78% by 2050 from 2023 levels. Similarly, U.S. peak electricity demand is expected to grow 14% by 2030 and 54% through 2050.
  - Based on their modeling forecasts, residential retail rates could increase between 15% and 40% by 2030, depending on the market.
  - The report provides recommendations to manage demand growth for energy developers and investors, utilities, state energy offices, and federal agencies.

Load Forecasting (8)

- **2024 United States Data Center Energy Usage Report (Lawrence Berkeley National Lab (LBNL), December 2024)***
  - The report updates the 2016 estimate of data center electricity consumption and provides future demand scenarios to 2028.
  - The analysis is a "bottom-up" energy use model, calculating total electricity consumption based on data center equipment (e.g., servers, storage, and network equipment) and their associated infrastructure, such as cooling systems.
  - Findings include that U.S. data center annual energy use remained stable between 2014-2016 at around 60 TWh. From 2017 onwards, with the rise of GPU-accelerated servers for AI, electricity use increased, reaching 176 TWh by 2023 (4.4% of total U.S. electricity consumption).
  - Due to the rapid emergence of AI hardware, future energy use is presented as a range (325 to 580 TWh in 2028), accounting for variations in equipment shipments, operational practices, and cooling energy use. This range represents 6.7% to 12.0% of total U.S. electricity consumption forecasted for 2028.

Load Forecasting (9)

- Strategic Industries Surging: Driving Up US Power Demand **(Grid Strategies, December 2024)**
  - The report provides an overview of load growth and load forecasts in the U.S., noting that in the past two years, the 5-year load growth forecast has increased by almost a factor of five, from 23 GW to 128 GW.
  - The study finds that the primary drivers of this growth are investments in data centers (especially artificial intelligence (AI) and manufacturing, with data centers alone potentially accounting for over 90 GW of future demand.
  - Texas (ERCOT) is noted for the addition of 37 GW to its 2029 forecast, reaching 43 GW total load growth. Other areas driving load growth include PJM, Georgia Power, and the Pacific Northwest.
  - The report emphasizes the critical need for policy changes, such as permitting reform for transmission, and improved load forecasting methods that account for these new, volatile drivers to prevent risks to America's economic, technological, and geopolitical leadership.

Load Forecasting (10)

- Powering Data Centers: U.S. Energy System and Emissions Impacts of Growing Loads **(Electric Power Research Institute (EPRI), October 2024)***
  - This paper presents “what-if” scenarios for future regional load growth projections from data centers, estimates load growth from other sources (manufacturing, electrification, electrolytic hydrogen), and examines how these loads might affect electric sector investments and CO_2 emissions under different policy and corporate strategy scenarios.
  - Data center electricity use is higher than previously estimated, accounting for 4% of total U.S. electricity demand in 2023 (doubling from 2017) and projected to reach 5-11% by 2030.
  - The paper further elaborates on scenario inputs and assumptions, and details the changes in capacity and generation across scenarios
  - The report also places special emphasis on data center flexibility, demonstrating that when data center load can be shifted temporally, the average price of power coinciding with data center consumption is reduced.

Artificial Intelligence (AI) and Infrastructure

Artificial Intelligence (AI) and Infrastructure (1)

- Utility Planning Best Practices: Data Center Load Considerations **(Charles River Associates for Ameren Missouri, September 2025)**
  - Ameren Missouri's IRP update includes a report by Charles River Associates on data center load forecasting and interconnection (report begins on page 55 of IRP update)
  - The report concludes with a summary of utility best practices across the above themes.

- Power Stabilization for AI Training Datacenters **(Microsoft, NVIDIA, OpenAI, August 2025)**
  - This paper discusses power swings that may result from power draws associated with AI training workloads. At a large scale, these computing loads could pose challenges to grid stability.
  - The authors present a multi-faceted approach that utilizes software smoothing, GPU-level control features, and rack-level energy storage.
  - The study concludes with a comparison of the above solutions, and calls for collaborative actions between utilities, grid operators and AI industries.

Reliability and Resource Adequacy

Reliability and Resource Adequacy (1)

- Characteristics and Risks of Emerging Large Loads: Large Loads Task Force White Paper **(National Electric Reliability Council (NERC), July 2025**)
  - The paper identifies, validates, and prioritizes the characteristics and risks of emerging large loads to the bulk power system (BPS) to raise awareness among entities responsible for operating and planning facilities on the BPS.
  - The paper offers six recommendations to the NERC Large Load Task Force and other NERC Working Groups as guidance for future work to ensure the reliability and security of the bulk power system.
- FEWER NEW MILES: Strategic industries held back by slow pace of transmission **(Americans for a Clean Transmission Grid, July 2025)**
  - This report highlights that the pace of building new high-voltage transmission lines in the U.S. is insufficient to meet growing electricity demand from strategic industries like AI and semiconductor manufacturing.
  - It emphasizes the need to address problems with planning, paying, and permitting, to build more transmission and suggests using FERC Order 1920 implementation as a primary solution.

Reliability and Resource Adequacy (2)

- Data Center Connections Workshop: Powering the Data Revolution (AEIC Center for Operational Excellence)
  - Summary report from workshop with participants from utilities, data center developers and industry experts)
  - Workshop explored strategies to integrate data centers into the transmission and distribution system while minimizing grid strain and uploading reliability, and identified 15 gaps and challenges identified during the workshop.
- Resource Adequacy for State Utility Regulators: Current Practices and Emerging Reforms (NARUC, November 2023)
  - Provides a brief history of resource adequacy; describes federal, regional, state and local regulatory authorities involved in the resource adequacy process and discusses foundational resource adequacy concepts
  - Explores resource adequacy reforms and supplemental approaches, regulatory considerations for extreme weather and interplay between state resource planning and regional reliability.

Reliability and Resource Adequacy (3)

- North American Electric Reliability Corporation (NERC) Large Loads Task Force **(LLTF, ongoing)**
  - The purpose of the Large Loads Task Force (LLTF) is to better understand the reliability impact(s) of emerging large loads such as Data Centers (including crypto and AI), Hydrogen Fuel Plants, etc. and their impact on the bulk power system (BPS).
  - The LLTF will first focus on identifying the unique characteristics and risks associated with emerging large loads, and then validate and prioritize these risks. Following this, the LLTF will identify gaps and mitigation of potential risks to support BPS reliability including enhancements to existing planning and operations processes to help transmission planners and operators mitigate these risks.
- Energy Systems Integration Group (ESIG) LLTF – Resource Adequacy (ongoing)
  - Large electrical loads, such as data centers, hydrogen production facilities, and EV fleet charging centers, present significant challenges for the electric power industry.
  - To address these challenges, ESIG created a LLTF to unite stakeholders, identify practical solutions, and develop harmonized practices that ensure reliable and efficient grid integration while supporting industry growth.
  - The LLTF has eight project teams, including one focused on resource adequacy areas.

Large Load Interconnection

Large Load Interconnection (1) - *New*

- Interconnection Queue Rationing Reforms **(Grid Strategies LLC, American Council on Renewable Energy (ACORE), November 2025)**
  - This report reviews interconnection queue rationing/prioritization mechanisms adopted by PJM, MISO, SPP, and CAISO.
  - The study finds that there are trade-offs inherent in such fast-track programs, such as increasing uncertainty and additional costs for projects left in the standard queue.
  - The authors propose a two-pronged approach to balance these issues with the need for speed for projects to interconnect. This includes a fast lane for projects that address reliability needs, and a proactive baseline queue that takes into account capacity and long-term transmission planning.

Large Load Interconnection (2) - *New*

- **Characterizing Large Loads: A Taxonomy to Support Large Load Integration (Idaho National Laboratory, October 2025)**
  - This report aims to address the gap in classifying large loads by proposing a taxonomy to categorize such high-demand electricity customers.
  - This approach considers the net impact that a large load has from the grid perspective, taking into account load characteristics such as load size, load variability, and load flexibility.
  - Load size is split into three categories - 50–99 MW, 100–999 MW, and >1,000 MW. Load flexibility is defined as either flexible or inflexible, while load variability is defined as fast or slow. This gives 12 categories of large load classification.
  - This framework is intended to provide a shared vocabulary for utilities, grid operators, regulators, and other stakeholders

Large Load Interconnection (3)

- MegaWatt Mayhem: Grid Operator Challenges with Large Loads **(Idaho National Laboratory, September 2025)**
  - The report summarizes challenges posed to grid operators due to the growth of large loads such as data centers. Challenges are grouped based on: Planning and cost, normal operations, reliability risk and voltage ride through, resilience and large load operations, and emerging key issues in operations.
  - It provides examples across the challenges, such as the large load loss events in Dominion Energy territory and ERCOT.
  - The report concludes with topics that require further studies, grouped into the same categories of challenges.
- Practical Guidance and Considerations for Large Load Interconnections **(Elevate and Grid Lab, May 2025)**
  - This report describes large load interconnection process challenges and provides a practical guide to improving and harmonizing utility practices for processing, studying, and assessing large load interconnection requests.
  - It highlights the importance of establishing clear technical interconnection requirements for large loads, drawing lessons from Europe's Demand Connection Code.
  - The report emphasizes that addressing these challenges is crucial for balancing the economic benefits of large loads with the imperative of maintaining grid reliability and fairness to existing ratepayers.

Large Load Interconnection (4)

- **Data Center Growth: Utilities are Developing New Approaches (Association of Edison Electric Companies (AEIC), April 2025)**
  - AEIC convened a forum with twenty-three utilities to explore the current gaps in streamlining data center interconnections.
  - This article discusses how utilities are adapting to the increase in data center loads, highlighting approaches such as standardized interconnection processes, structured cost-sharing models for developers seeking to connect to the grid.
  - The article concludes that ongoing collaboration among utilities, developers, and policymakers is crucial for navigating this evolving energy landscape.

Large Load Interconnection (5)

- An Assessment of Large Load Interconnection Risks in the Western Interconnection **(Elevate Energy Consulting for Western Electricity Coordinating Council, February 2025)*** – *New*
  - This report assesses the risks to the Bulk Power System (BPS) from the exponential growth of large loads, driven primarily by data centers, which comprise nearly 80% of new interconnection requests (at the time of report publication).
  - Key findings include a critical lack of standardized interconnection procedures and data sharing, which is vital for accurate grid planning and modeling.
  - The report concludes that the electric power industry must rapidly apply lessons learned from the integration of Inverter-Based Resources (IBRs) to develop new, mandatory reliability standards for large loads before major grid disturbances occur.

- Energy Systems Integration Group (ESIG) Large Load Task Force (LLTF) – Interconnection (ongoing)
  - Large electrical loads, such as data centers, hydrogen production facilities, and EV fleet charging centers, present significant challenges for the electric power industry.
  - To address these challenges, ESIG created a LLTF to unite stakeholders, identify practical solutions, and develop harmonized practices that ensure reliable and efficient grid integration while supporting industry growth.
  - The LLTF has eight project teams, including one focused on the large load interconnection process, and one focused on large load interconnection requirements.

Demand Flexibility

Demand Flexibility (1) - *New*

- [Flexible Data Centers: A Faster, More Affordable Path to Power] **(Camus, encoord, and Princeton ZERO Lab, December 2025)**
  - This study utilizes real-world utility transmission data and combines it with in-house optimization tools to evaluate the role of flexibility in data center interconnections.
  - Key finding is that data centers with flexible grid connection and their own accredited generation capacity (known as bring-your-own capacity (BYOC)), data centers can connect to the grid **three to five years faster** than through traditional interconnection processes.
  - Another benefit of flexibility and BYOC is in internalizing incremental system costs arising from data center interconnections. This means that through the combination of these mechanisms, data centers can cover nearly 100% of the costs associated with its increased load. This ensures that these costs are not shifted to other electricity customers.

Demand Flexibility (2)

- How DOE's Proposed Large Load Interconnection Process Could Unlock the Benefits of Load Flexibility **(Duke University, November 2025) - *New***
  - This policy brief explores large load flexibility commitments in connection to DOE's Advanced Notice of Proposed Rulemaking (ANOPR) directing FERC to establish rules for interconnection of large loads to the transmission grid.
  - It discusses that flexibility commitments should have clearly defined terms in their transaction agreements.
  - The authors state that within the right framework, large load flexibility commitments can enable faster interconnection times, reduced infrastructure costs, and even potential reliability benefits to the electrical grid.

- Dodging the Firm Fixation for Data Centers and the Grid **(Energy Innovation, November 2025)**
  - This report makes the case for modular, diverse portfolio of resource solutions as an effective strategy to meet data center demand.
  - It also highlights that interconnection processes provide an opportunity to incentivize data center developers toward flexible solutions that support both the local grid and the broader electrical system.

Demand Flexibility (3)

- ESIG Large Loads Task Force: Background Information, Data and Flexibility Needs **(ESIG, November 2025)**
  - The webinar discusses data gaps, such as proprietary load profiles and flexibility characteristics, which affect accurate forecasting.
  - The study suggests that aligning data sharing and standardizing load modeling approaches could address such data gaps.
- Opportunities to Use Energy Efficiency and Demand Flexibility to Reduce Data Center Energy Use and Peak Demand **(ACEEE, October 2025)**
  - The paper explores opportunities for improving the energy efficiency of data center operations, through improving efficiency of software and hardware components, AI-optimized cooling, and heat recovery.
  - It describes metrics that capture the effectiveness of data center operations.
  - The paper reviews how technology companies, utilities, and research organizations are studying demand flexibility in data centers through various projects.

Demand Flexibility (4)

- Bringing Data Center Flexibility into Resource Adequacy Planning: A Case Study of NV Energy **(GridLab, Telos Energy, September 2025)***
  - This report demonstrates the benefits of data center flexibility through a NV Energy example.
  - It identifies utilities that are considering data centers as inflexible loads in their Integrated Resource Planning (IRP) process, and present a framework for considering data center flexibility within IRP modeling.
  - The study finds that 1-2 GW of datacenter flexibility results in NPV savings of ~300-400 million (using 7.08% discount rate for analysis period 2025-2050).
  - Another finding is that incentivizing small levels of data center flexibility participation has significant outcomes, with 1 GW flexibility being able to defer 60-85% of the data center's capacity needs, based on the required availability percentage.

Demand Flexibility (5)

- Turning AI Data Centers into Grid-Interactive Assets: Results from a Field Demonstration in Phoenix, Arizona **(Electric Power Research Institute (EPRI), Emerald AI, Salt River Project (SRP), July 2025)**
  - The journal article presents the field demonstration results of a software-only approach to demand flexibility in AI data centers using real-time grid signals.
  - Conducted at a 256-GPU cluster running representative AI workloads within a commercial, hyperscale cloud data center in Phoenix, Arizona, the trial achieved a 25% reduction in cluster power usage for three hours during peak grid events while maintaining AI quality of service (QoS) guarantees.
- Grid Flexibility Needs and Data Center Characteristics **(EPRI, June 2025)**
  - This whitepaper from EPRI's Data Center Flexible Load Initiative (DCFlex) project explores the concept of flexibility in power systems and how data centers can contribute to it.
  - Presents 4 categories of data center characteristics - size, reliability, workload, and ownership model - which could influence data center flexibility and potential power system impacts
  - Identifies 3 main sources of flexibility within the data center: compute assets, balance of plant, and power assets.

Demand Flexibility (6)

- **[Vulcan Test Platform: Demonstrating the Data Center as a Flexible Grid Asset] (NREL, Verrus LLC, June 2025) - *New***
  - This study demonstrates and validates the demand flexibility approach taken by Verrus data centers. This design integrates a "novel grid-aware power flow management system with long-duration battery energy storage systems into a microgrid-controlled, medium-voltage power distribution architecture".
  - This approach ensures Verrus data centers can act as grid assets, by quickly responding to utility service requests.
  - NREL leveraged its Advanced Research on Integrated Energy Systems (ARIES) virtual emulation environment to validate these capabilities by modeling a 70-MW grid-interactive data center.
  - The findings show that data centers can play a pivotal role in enhancing grid flexibility and reliability without sacrificing service level guarantees.

Demand Flexibility (7)

- [Rethinking Load Growth: Assessing the Potential for Integration of Large Flexible Loads in US Power Systems](#) **(Duke University, February 2025)***
  - This study presents an analysis of the existing US electrical power system's ability to accommodate new flexible loads.
  - Findings include that 76GW of new load could be integrated if the new load can curtail 0.25% of their maximum uptime; the quantity of new load that could be integrated increases with higher curtailment percentages.
  - It was outside of the report scope to analyze planning considerations such as adequate transmission capacity, ramping capability and ramp-feasible reserves; and assumed that the new loads do not change current demand patterns. This limits the applicability of the results.

Demand Flexibility (8)

- DOE Data Center Load Flexibility Workshop Summary (Lawrence Berkeley National Lab (LBNL), January 2025)
  - Summary report from workshop held in November 2024 with 49 participants representing data center owners, operators, developers, electric utilities, regulators, industry stakeholders and researchers.
  - Key themes are organized responses to four questions posed at the workshop (need for demand flexibility in data centers, opportunities for data centers to be responsive to grid needs, challenges to implementing data center flexibility and opportunities for DOE and national labs to address challenges).
- Data Center Flexibility (DC Flex) Initiative (EPRI, ongoing)
  - Initiative that aims to demonstrate how data centers can support and stabilize the electric grid while improving interconnection and efficiency.
  - Currently there are three workstreams: (1) Grid informed flexible data center designs, (2) Transformational utility programs and (3) Grid planning for operational flexibility.

Demand Flexibility (9)

- **Center of Expertise for Energy Efficiency in Data Centers (Lawrence Berkeley National Lab (LBNL), ongoing)**
  - LBNL's Center of Expertise for Energy Efficiency in Data Centers offers tools, technologies, and analysis to enhance energy performance in data centers.
- **Chip-to-Grid (C2G) Data Center Initiative (National Laboratory of the Rockies (formerly NREL), ongoing)**
  - The C2G initiative is designed to address multiple data center challenges including planning, capacity, security, and energy management.
  - Key goals include maximizing demand flexibility, promoting advanced cooling solutions, optimizing energy use, and improving grid integration through hybrid microgrid power systems

Generation

Generation (1)

- Navigating Integration: Key Challenges for Data Centers, Nuclear Stakeholders, and Utility Operators **(Idaho National Laboratory, August 2024)**
  - This report summarizes the challenges faced by data center developers, nuclear energy providers, and utility companies and explores opportunities that could arise from collaboration.
  - One such topic discussed is how nuclear power can be used as part of an integrated energy system to match variations in data center load profiles.
- Navigating Economies of Scale and Multiples for Nuclear-Powered Data Centers and Other Applications with High Service Availability Needs **(Idaho National Laboratory, October 2024)**
  - This paper focuses on assessing the tradeoffs between economies of scale versus mass production to identify promising reactor sizes to meet data center demands.
  - The findings of this study showcase that identifying the optimal size for a reactor is likely more nuanced and dependent on the application and its requirements.
  - Overall, the study shows potential economic promise for coupling nuclear reactors to data centers and industrial heat applications under certain key conditions and assumptions.

Generation (2)

- Powering Data Centers with Clean Energy: A Techno-Economic Case Study of Nuclear and Renewable Energy Dependability **(Idaho National Laboratory, June 2024)**
  - This study examines the techno-economic viability of powering data centers with clean energy, specifically comparing nuclear and renewable energy sources.
  - Key findings indicate that fully nuclear-powered configurations outperformed the fully renewable and mixed renewable-nuclear configurations in terms of cost, ranging from $1B to $10B (2023 USD), compared to fully renewable configurations which exceeded $40B.
  - Small modular reactors (SMRs) showed better economic performance than large-scale nuclear models, due to lower projected capital costs, demonstrating the applicability of firm, dispatchable electricity resources from baseload generators like nuclear power plants for operating facilities that run at constant power without daily variability.

Co-Location

Co-Location (1)

- The Challenges and Opportunities of On-site Resources in Accelerating Data Center Interconnection and Reliability **(The Brattle Group, Mintz, June 2025)**
  - This webinar addresses strain on existing grid infrastructure from increasing AI data center loads, proposing the solution of co-locating new data centers on-site with generation (new or existing).
  - It outlines the benefits of such an approach, providing examples of companies that have explored this.
- Accelerating the Integration of New Co-located Generation and Loads **(The Brattle Group, Bloom Energy Corporation, April 2025)**
  - The authors propose an "Energy Park Integration (EPI)" process as a solution to accelerate connection times, reduce transmission upgrades, and alleviate resource adequacy concerns, to address the challenge of integrating new, large electricity loads (like data centers) into the grid, focusing on PJM.
  - The report outlines the benefits of EPI, and necessary reforms to realize the speed and cost-effectiveness benefits of energy park integration

Co-Location (2)

- Advanced Nuclear Technology: A Guide for Co-locating Data Centers with Nuclear Plants **(EPRI, April 2025)**
  - This report discusses opportunities and challenges of using new or existing nuclear generation to power data centers.
  - The authors state that connecting data centers to the grid with high quantities of nuclear generation can provide the technical benefits associated with nuclear power, such as firm baseload power to the grid.

- Existing power plants sharing grid access with renewables can lower costs and double US Generation capacity **(Grid Lab, February 2025)**
  - Using high-resolution satellite imagery, researchers estimated the renewable energy potential within a 6x6-mile buffer zone around existing fossil power plants in the United States (U.S.). Findings include that:
    - Existing fossil power plants can economically share grid access with around 800 GW of RE currently, and around 1,000 GW by 2030 as the economics of renewable energy improve.
    - The co-location strategy discussed in the paper can optimize the use of existing infrastructure, helps address the interconnection bottleneck, and generation additional revenue for power plant owners and tax revenue for local communities.
    - Adding renewable energy at the interconnection of existing thermal power plants does not directly increase peak generation capacity in the grid, but by integrating storage with existing RE plants, it can enhance interconnection utilization.

Co-Location (3)

- How "Power Couples" Can Help the United States Win the Global AI Race **(RMI, February 2025)**
  - The article proposes a strategy called "Power Couples" to rapidly supply clean electricity to data centers, crucial for the growing AI revolution.
  - A Power Couple is defined as the pairing of a large electricity consumer with new-build solar, wind, and battery resources sized to meet the on-site load, all located near an existing generator with an approved interconnection.
  - RMI's analysis suggests that Power Couples at existing gas generators could supply over 50 GW of new load with an average of 88% carbon-free energy for less than $200 per MWh, and over 30 GW for less than $100/MWh.

- ENERGY PARKS: A New Strategy to Meet Rising Electricity Demand **(Energy Innovation Policy & Technology LLC, Energy Systems Integration Group, December 2024)**
  - This study elaborates on the concept of an "energy park", which combines generation assets, complementary resources like storage, and connected customers (co-located loads).
  - It provides an example of the Meitner project, consisting of 400 Megawatts (MW) of hydrogen electrolyzers with 460 MW of on-site wind and 340 megawatts of on-site solar renewable electricity.
  - The study emphasizes that energy park projects like the Meitner project can integrate multiple renewable energy sources, storage solutions like batteries, and potentially co-located electricity consumers such as manufacturing facilities or data centers, all connected to the grid at a single point.

Co-Location (4)

- **Maryland Public Service Commission's (PSC) Report on Co-Location (Maryland PSC, December 2024)**
  - This report addresses the co-location of end-use electricity customer load with existing or planned electric generation facilities, as mandated by Senate Bill 1 (SB1)/Chapter 537, Section 6, of 2024.
  - The PSC studied potential cost impacts to Maryland ratepayers; potential impacts to wholesale markets (capacity, energy, and ancillary) and planning functions; potential impacts to the reliability of the electric transmission and distribution systems serving Maryland; and provided recommendations to manage or mitigate any of these impacts.
  - The primary focus is on non-Network or "Type B" loads that are "off-system" and exclusively served by co-located generation. The report recommends that relevant authorities clarify the scope of such co-located loads.

- **Commissioner-led technical conference regard large loads co-located at generation facilities (FERC, November 2024)**
  - The purpose of the technical conference is to discuss generic issues related to the co-location of large loads at generating facilities.
  - Issues explored at the technical conference included whether co-located loads require the provision of wholesale transmission or ancillary services, related cost allocation issues, and potential resource adequacy, reliability, affordability, market, and customer impacts.

Co-Location (5)

- [Redeveloping Coal Power Plants: Data Centers (Pacific Northwest National Laboratory (PNNL), September 2024)]
  - This initiative explores the opportunity to repurpose retired coal power plants into sites for data centers, while also potentially integrating clean energy generation
  - Key benefits of this approach include leveraging existing points of interconnection and other infrastructure, and community benefits through job creation, local tax revenues, and direct investment from data center companies.
  - A case study of the Widows Creek coal power plant, which became a Google data center, is provided. The document concludes by outlining the various stakeholders involved in such redevelopment projects, including data center developers, utilities, regulators, clean energy developers, economic development agencies, and local governments, emphasizing the importance of coordination among them.

- THE CO-LO CONUNDRUM: Protecting Customers in Nuclear-Data Center Colocation **(Wilkinson Barker Knauer LLP, Copper Monarch LLC, September 2024)**
  - This white paper critically examines the growing trend of co-locating data centers with existing nuclear power plants. The authors argue that while proponents like the Nuclear Energy Institute (NEI) claim benefits such as "speed to market" and environmental advantages for this model, colocation raises significant public interest and equity concerns, particularly regarding who bears the associated costs and impacts on grid reliability.
  - The authors urge policymakers to investigate these arrangements thoroughly and ensure equitable cost allocation to protect general electricity consumers.

Co-Location (6)

- The Co-Located Load Solution (Kormos, July 2024)
  - Report asserts that in order to bring large data center projects online efficiently and equitably, the electric industry should be focused on finding solutions that best manage reliability, affordability (for all), efficiency, and speed.
  - Authors focus on three aspects of the solution (1) Separating co-location facts from general concerns about new load, (2) Benefits of co-location and (3) Market re-design to prevent cost shifts.
- **What Happens When A Nuclear Plant And A Data Center Shack Up? (Wilkinson Barker Knauer LLP, Copper Monarch LLC, April 2024)**
  - This white paper examines the increasing trend of data centers co-locating with existing nuclear power plants, particularly within RTO (Regional Transmission Organization) markets.
  - One such reason driving this trend of co-location is the emergence of power purchase agreements (PPAs), which not only offer the seller a higher average price than what the market would deliver, they also provide a certain price to nuclear operators, compared to the volatility of the RTO's wholesale electricity markets.

Large Load Tariffs

Large Load Tariffs (1) - *New*

- Tailored for Scale: Designing Electric Rates and Tariffs for Large Loads (E3, December 2025)
  - This white paper provides an overview of existing rate designs and contract structures for large loads, with an emphasis on best practices to prevent cost shifting to existing customers.
  - It includes case studies on Amazon data centers across different geographies and utilities (Pacific Gas & Electric in California, Umatilla Electric Cooperative in Oregon, Dominion Energy in Virginia, and Entergy in Mississippi)
  - One of the key finding is that evaluated data centers either have a neutral impact or have the potential for ratepayer benefits through 2030. According to their analysis, evaluated Amazon data centers are estimated to generate $33,500/MW.of surplus utility revenue in 2025, projected to be between $33,500/MW- $60,650/MW in 2030.

Large Load Tariffs (2)

- Database of Emerging Large-Load Tariffs (DELTa) (Smart Electric Power Alliance and NC Clean Energy Technology Center, July 2025)
  - Publicly available database of contemporary utility rates and contracts for large loads.
  - Dataset will be updated quarterly
- Load growth on utility terms: A comparative analysis of large load tariffs **(Wood Mackenzie, June 2025)**
  - This report distinguishes between conventional commercial tariffs and large load tariffs, highlighting key elements of the latter such as megawatt and load factor threshold beyond which the tariff applies to a customer, and utility cost recovery mechanisms.
- Electricity Rate Design for Large Loads: Evolving Practices and Opportunities (Lawrence Berkeley National Lab (LBNL), January 2025)
  - This report reviews ~20 tariffs and identifies characteristics of large load tariffs across different jurisdictions, including opportunities to allocate costs, mitigate ratepayer and utility risk, and attract large loads.

Large Load Tariffs (3)

- [Review of Large Load Tariffs To Identify Safeguards and Protections for Existing Ratepayers (Energy Futures Group, January 2025)]
  - This report analyzes how electricity tariffs and special contracts for large-scale energy consumers (like data centers and cryptocurrency mining operations) can be structured to protect existing ratepayers and environmental goals.
  - According to the report, safeguards should include defined contract terms, tiered load requirements, penalties for poor load/power factors, demand ratchets, clear cost assignment and collateral, interruptible service, and ensuring adequate available capacity backed by the customer or renewable energy.
- [Large Load Tariff Design Principles (RMI and Advanced Energy United, no date)]
  - This document outlines key considerations for designing tariffs for large-load customers.
  - The principles cover customer eligibility, ensuring participation from diverse large-load customers; fairly allocating costs among customer classes; and recommending tariffs to include price signals to encourage optimal siting, utility operations, and customer behavior for efficiency.

Policy Options

Policy Options (1)

- **Power System Implications of Operating Large Loads: A Summary of International and Domestic Initiatives (Idaho National Laboratory, October 2025)**
  - This memo summarizes initiatives taken at the federal and state levels to address the power system implications of large loads, especially data centers.
  - It also highlights efforts made by ISOs/RTOs, industry working groups, and international organizations.

- **Business Models and Finance to Enhance Energy Efficiency in AI and Data Centres in Emerging Economies (UNEP, September 2025)**
  - This policy brief discusses the escalating energy demand from AI and data centers within the context of emerging economies.
  - It explores business models for energy efficiency in AI workloads and data center energy use, such as usage-based pricing and wholesale co-location.

Policy Options (2)

- [Connection Costs] **(Union of Concerned Scientists (UCS), September 2025)**
  - This policy brief asserts that regulatory gaps in cost collection from large data centers that connect to the transmission grid have resulted in the cost of building new transmission to serve these data centers being passed on to other utility customers.
  - The study finds that this issue has resulted in over $4.3 billion of additional costs for customers in seven PJM states in 2024, with more expected in the future.
  - UCS provides recommendations to FERC, state PUCs, and utilities to track such transmission costs and address this issue.

- At the Crossroads: A Better Path to Managing Data Center Load Growth **(NRDC, September 2025)**
  - This report addresses the challenges and opportunities presented by AI-driven data centers' load growth, particularly focusing on strategies to accelerate time to power for data centers and policy measures to protect consumer interests.

Policy Options (3)

- **Balancing Risk and Growth: Best Practices for Utility Credit and Collateral Requirements for Large Load Customers (E3, July 2025)**
  - The report presents a risk-aligned and flexible framework for credit and collateral policy that helps utilities, regulators, and large-load customers balance financial risk with economic opportunity.
  - It also provides specific recommendations for utilities, regulators, and data center developers.
- **Data Centers, AI, and the Power Grid (Pacific Northwest National Laboratory, July 2025)**
  - This presentation provides an overview of the energy-water nexus implications of data centers, driven by growth in AI.
  - It highlights the steps legislators, regulators, and utilities in some states are taking to address data center grid needs, including standardizing data collection and addressing speculative interconnection requests.

Policy Options (4)

- **Data Center Impacts in the West (Western Resource Advocates, July 2025)**
  - Resource for state policymakers to understand energy and water impacts of data centers, with a focus on western states.
  - Provides eight options for policymakers to consider (clean transition tariffs, behind the meter resources, efficiency and load shifting, resource planning and acquisitions, contract provisions, ratemaking best practices, economic development rates and water efficiency and reporting).
- **Optimizing Grid Infrastructure and Proactive Planning to Support Load Growth and Public Policy Goals (The Brattle Group, July 2025)**
  - The report highlights four key areas for action to address the challenges of rapid load growth in the US power sector: maximizing the value of the existing power system; cost-effectively accelerating new load connections; implementing proactive planning and procurement processes; and introducing targeted affordability measures.
  - The report includes a stakeholder action matrix outlining responsibilities for regulators, utilities, grid operators, governors, legislators, and other actors. It also includes case studies and examples of successful implementations of these solutions in various jurisdictions.

Policy Options (5)

- **[Demand Growth & Risk Management: Investing in Energy Infrastructure to Meet Customer Needs](#) (Critical Consumer Issues Forum (CCIF), July 2025)**
  - Outcome of year-long collaborative process with participation from state commissions, consumer advocates and electric companies resulted in document identifying 13 consensus principles.
  - First eight principles outline a forward thinking framework geared toward addressing challenges and opportunities form rapid electricity demand growth.
  - Last five principles focus on risk management pertaining to extreme weather and other catastrophic events and advance recognition of growing financial risks to the electric sector and its customers.
- **Load Growth: What States are Doing to Accommodate Increasing Electric Demand (Clean Energy State Alliance (CESA), July 2025)**
  - This report surveys and summarizes strategies states are employing to address significant new load growth.
  - The strategies explored include gas generation build out, delaying fossil plant retirements, maintaining clean energy targets, expanding nuclear generation, investing in renewables and storage, energy efficiency, demand response, transmission investments, and limiting ratepayer impacts
  - The report focuses on states seeing the most large load growth.

Policy Options (6)

- A State Playbook for Managing Data Center-Driven Load Growth **(Johns Hopkins, June 2025)**
  - Resource for state policymakers to improve understanding of how data centers interact with grid.
  - Provides four levers for policymakers to consider (improving data collection, clarifying utility regulators' ability to tailor rates, establishing substantive requirements for new requests and moratoriums).
- Assessing the United States' Additional AI Power Capacity by 2030 **(RAND, June 2025)**
  - This report focuses on the additional power capacity needs in the U.S. that will be posed by rapidly increasing electricity demand from AI data centers, considering both front-of-the-meter (FTM) and behind-the-meter (BTM) energy systems.
  - The authors propose a new "available capacity" metric that accounts for project completion uncertainties, effective capacity, and transmission/distribution losses, allowing for direct comparison with future AI data center power needs.
  - Estimate that the available capacity will increase by approximately 82 GW by 2030. FTM additions will add approximately 33 GW of the net available capacity, while BTM additions will increase capacity by 49 GW to reduce grid peak loads.
  - The majority of planned FTM additional capacity is in the ERCOT region, while BTM additions are split among ERCOT, Midcontinent ISO, and non-administrative regions.

Policy Options (7)

- Texas SB6 Explained: Addressing Large Load Impacts **(EPRI, June 2025)**
  - This report provides an overview of the Texas Senate Bill 6 (SB6) addresses the impact of large electric loads (with capacity at least 75 MW), particularly data centers, on the ERCOT-operated Texas grid.
  - Key aspects of SB6 include financial commitments for large loads in the form of interconnection study fee, co-location arrangements, and the introduction of a new reliability service

- US power struggle: How data centre demand is challenging the electricity market model **(Wood Mackenzie, June 2025)**
  - This report analyzes the impact of surging data center development on the US electricity market.
  - According to the authors, vertically integrated regulated utilities are best equipped to handle the demand growth due to their integrated planning processes, ability to accelerate project timelines and gain local support, and utilizing existing transmission and fiber infrastructure.

Policy Options (8)

- **[Future-Proof AI Data Centers, Grid Reliability, and Affordable Energy: Recommendations for States](#) (American Council for an Energy-Efficient Economy (ACEEE), April 2025)**
  - This white paper discusses metrics relevant to AI, and policy interventions that are critical to ensuring AI data centers operate efficiently.
  - Asserts that traditional efficiency metrics like Power Usage Effectiveness (PUE) are insufficient for AI workloads. They propose new metrics, such as energy per AI task and grid-aware computing, to ensure that AI data centers optimize energy consumption across all levels of operation.
  - Policy solutions include grid integration requirements, efficiency targets, transparency requirements, and financial incentives. Collaboration between industry and regulators is key to ensuring best practices, setting efficiency standards, and avoiding unnecessary infrastructure expansion.

Policy Options (9)

- **[Extracting Profits from the Public: How Utility Ratepayers Are Paying for Big Tech's Power](#) (Harvard University, March 2025)**
  - The authors argue that the sudden surge in electricity demand from data centers is shifting utilities' focus from societal needs to serving a few energy-intensive consumers.
  - They state that data centers co-located with power plants (co-location) may bypass traditional utility ratemaking and delivery fees, which could lead to increased power market prices and distorted regulated electricity delivery rates for the public.
  - The authors provide several recommendations for state regulators and legislators to protect consumers, such as requiring new data centers to use tariffs instead of one-off special contracts.

Policy Options (10)

- Get a Load of This: Regulatory Solutions to Enable Better Forecasting of Large Loads **(RMI, February 2025)**
  - This report addresses the recent surge in electricity demand in the United States after decades of stagnation. It highlights that utilities are expecting a 20% load growth from 2023 to 2035, driven by large new loads like data centers, advanced manufacturing, and electric vehicles.
  - It outlines best practices for improving forecasts, such as employing scenario-based methods, integrating end-use with econometric forecasting, and ensuring consistent use of forecasts across planning processes.
  - Case studies of Dominion Energy (Virginia), Duke Energy (North Carolina), and Georgia Power are presented to illustrate emerging forecasting practices and challenges.

Policy Options (11)

- Proactive Regulatory Approaches to Electrification and Load Growth **(Pacific Northwest National Laboratory, RMI, January 2025)**
  - This report summarizes a workshop which aimed to identify proactive regulatory approaches to manage electrification and load growth while minimizing risks and costs to customers.
  - It proposes both near-term and long-term solutions, along with potential roles for legislators, commissions, utilities, stakeholders, and national organizations like NARUC. These include coordination in planning, enhancing forecasting methodologies, streamlining regulatory processes, better characterizing and leveraging DERs, clarifying funding sources for societal goals, and developing new cost allocation frameworks.
  - The report outlines actions that the Department of Energy (DOE) and national labs can take to support these proactive actions on electrification and load growth These include providing technical training, compiling best practices, convening discussions, and conducting quantitative analysis.

Policy Options (12)

- Virginia Data Center Study: Electric Infrastructure and Customer Rate Impacts, (Energy+Environmental Economics (E3), December 2024)*
  - This study, prepared for the Virginia Joint Legislative Audit and Review Commission (JLARC) by E3, examines the impact of data center growth on Virginia's electric infrastructure and customer rates.
  - It concludes that data centers are projected to experience an increase in 3-4 cents/kWh by 2040, compared to an estimated increase of 1-3 cents/kWh for residential customers
  - The study proposes various tools to help manage risk and widen the path to integration of data center loads
  - It additionally presents modeling of grid reliability and scenarios pertaining to combinations of energy sources, infrastructure upgrades, and load projections.
- Load Growth Is Here to Stay, but Are Data Centers? (E3, July 2024)
  - This paper provides an overview of large load growth and load projections, offers historical context, and proposes innovative ideas for large load developers, power industry planners, and investors to mitigate risks and take advantage of potential opportunities.
  - It provides detailed options that large load Customers, utilities, system planners and regulators can take, along with examples already taking place.

Policy Options (13)

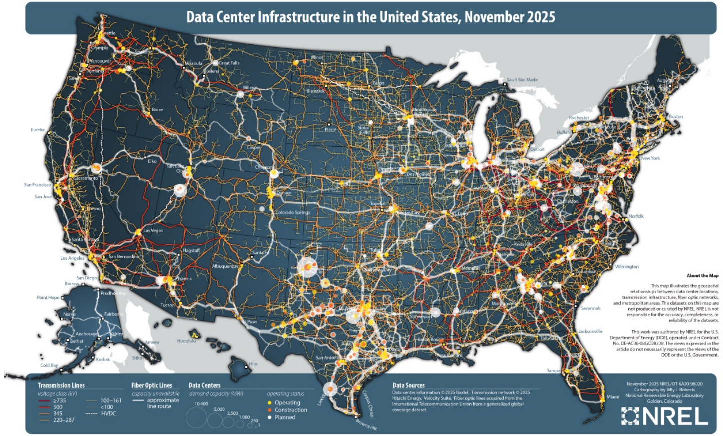
- **Meeting Growing Electricity Demand without Gas: A Brief for Utility Regulators (Energy Innovation Policy & Technology LLC, March 2024)**
  - This brief provides an overview of the growing demand arising from new factories, data centers, and electric vehicles, and elaborates on how utilities are looking to invest in new gas-fired power generation to address this load growth.
  - It is geared towards policymakers, especially the public utility commissioners, urging them to remain skeptical of plans to add new gas.
  - This brief proposes two main solutions: Prioritizing resource efficiency, and leveraging technology and market solutions to bolster resource adequacy.
- **NARUC-NASEO Comprehensive Electricity Planning initiative (ongoing)**
  - Ongoing initiative that builds on the prior Task Force on Comprehensive Electricity System Planning
  - Virtual learning series includes information on load forecasting and planning in an era of load growth
- **NASEO Powering Up data center discussion webinar series (ongoing)**
  - Ongoing discussion series exploring specific strategies State Energy Offices can use to address growing data center electricity demand while supporting energy affordability and grid reliability.

Maps and Tools

Maps (1)

[Data Center Infrastructure in the United States, November 2025](#) (National Laboratory of the Rockies (formerly NREL), November 2025).

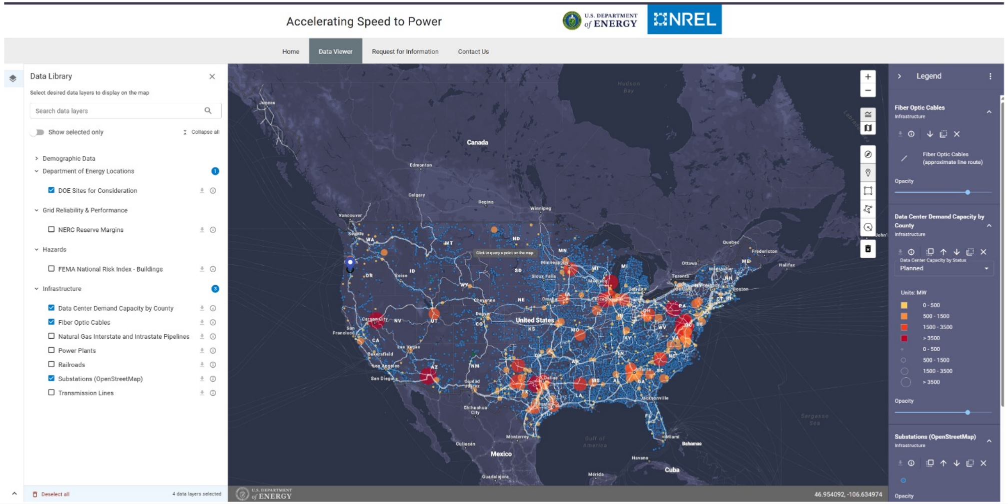
This map provides latest illustration of the geospatial relationship between data center locations, transmission infrastructure, fiber optic networks, and metropolitan areas.



Maps (2)

[Data Center Infrastructure in the United States, 2025]() **(National Laboratory of the Rockies (formerly NREL), October 2025)**

This updated interactive data viewer provides a geospatial relationship between data center locations, transmission infrastructure, fiber optic networks, and metropolitan areas.



Maps (3)

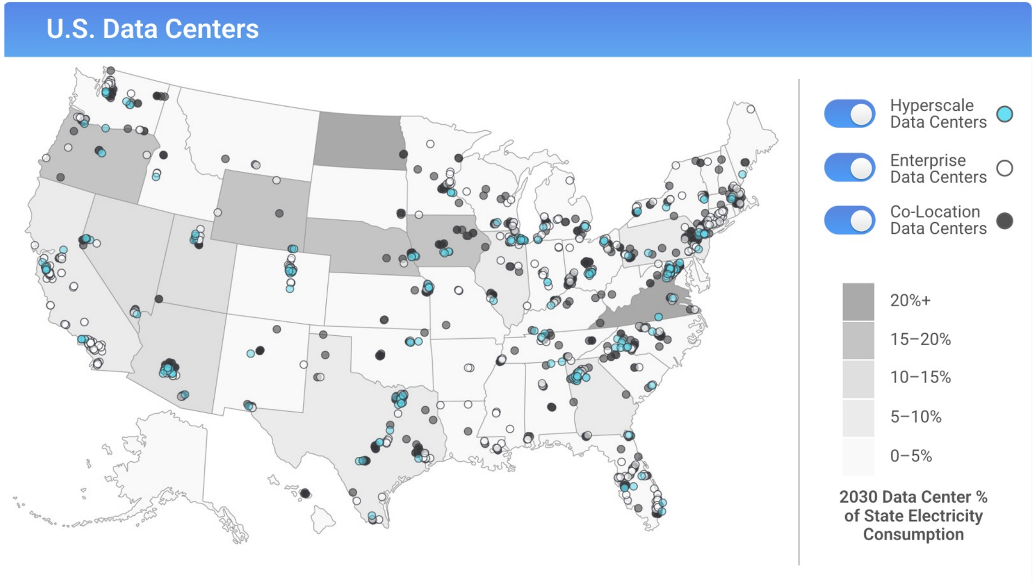
[Utility and Grid Operator Resources for Future Power Systems](#) (National Laboratory of the Rockies (formerly NREL), July 2025).

- This webinar series demonstrates the lab’s tools that can facilitate data center siting, evaluating power system impacts of connecting data centers to the grid, and performing resource adequacy assessment
- Other webinars include topics such as rate and tariff design, integrating transmission and distribution, aimed at utility and grid operators

Maps (4)

[Interactive Map of Data Centers (EPRI, 2025)]

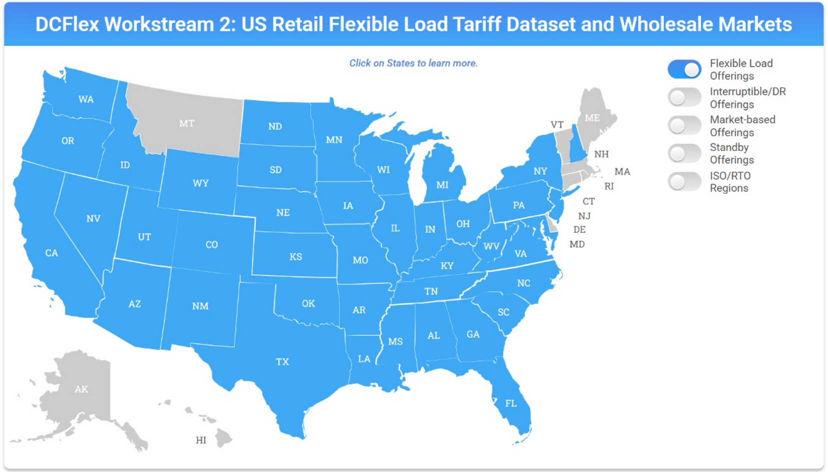
Interactive map on location of data centers and data center percent of electricity consumption.



Maps (5)

[Interactive Summary of Flexible Retail Programs and Wholesale Markets](#) (EPRI, 2025)

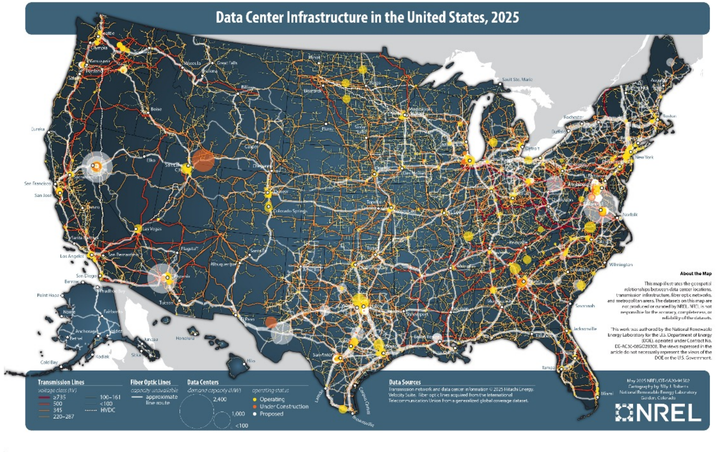
Interactive map created by EPRI as part of their DC Flex initiative that displays flexible, interruptible, market based and standby programs by state.



Maps (6)

[Data Center Infrastructure in the United States, 2025](#) (National Laboratory of the Rockies (formerly NREL), May 2025).

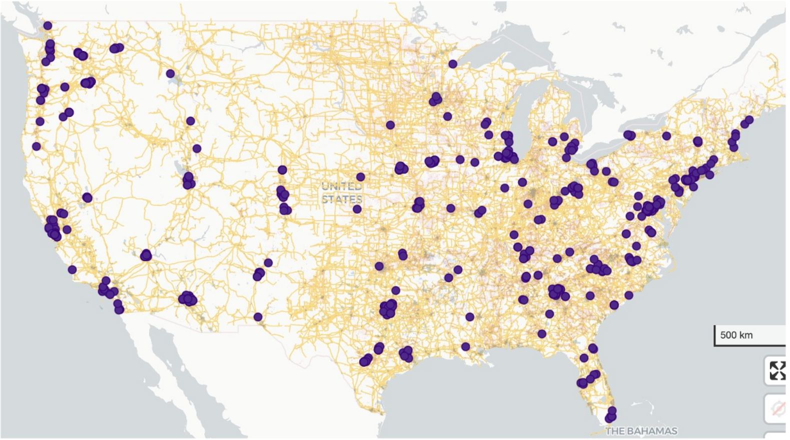
This map illustrates the geospatial relationship between data center locations, transmission infrastructure, fiber optic networks, and metropolitan areas.



Maps (7)

IM3 Open Source Data Center Atlas (PNNL, 2025)

- The IM3 Open Source Data Center Atlas provides locations and facility footprints (when available) of existing data centers across the United States (U.S.).
- Additionally, the dashboard also provides complementary information on electricity infrastructure, municipal water supply, and high-speed fiber availability.



Design and Operations

Design and Operations

CENTER OF EXPERTISE FOR ENERGY EFFICIENCY IN DATA CENTERS

DOE/LBNL data center program assists organizations with optimizing the design and operation of energy and water systems in data centers.

Assistance

- Project and technical assistance from the Center of Expertise including identifying and evaluating ECMs, M&V plan review, and project design review
- Support optimization of high-performance and enterprise data centers

Tools

- Data Center Profiler (DC Pro) Tools (x2)
- Air Management Tools (x3)
- IT Equipment Tool
- Electrical Power Chain Tool
- Energy Assessment Worksheets
- Data Center Master List of Energy Efficiency Actions

Key Resources

- Best Practices Guide for Energy-Efficient Data Center Design
- Center of Expertise Library – filterable list of reports, guides and presentations
- Small Data Centers, Big Energy Savings: An Introduction for Owners and Operators

Training

- Data Center Energy Practitioner (DCEP) Trainings
- Better Buildings webinar series
- On-demand FEMP data center trainings
- Center of Expertise Webinars

https://datacenters.lbl.gov/

Data Sources

Data Sources (1) – *New*

- An Assessment of Large Load Interconnection Risks in the Western Interconnection **(Elevate Energy Consulting for Western Electricity Coordinating Council, February 2025)***
- **Underlying Methodology:** Quantitative data collection and analysis to estimate the large load interconnection queue size and breakdown by category.
- **Key Inputs/Data Sources:**
  - *Self-administered questionnaire:*
    - Western Electricity Coordinating Council's industry advisory group (IAG), also known as Large Load IAG
  - *Data Center Demand Forecasts:*
    - McKinsey & Co.
  - *Operational Data on Load Loss Events (expressed as Load Loss or Reduction in MW):*
    - ERCOT

Data Sources (2)

- Power Demand Forecasts Revised Up for Third Year Running, Led by Data Centers **(Grid Strategies, November 2025)**

- **Underlying Methodology:** Market analysis based on utility forecasts and proprietary database of data center projects.

- **Key Inputs/Data Sources:**
  - *National and Regional forecasts of peak load and energy use:*
    - FERC Form 714 Filings
    - Plans from RTOs/ISOs: SPP, ERCOT, PJM, MISO, CAISO, NYISO
  - *Data Center Projects and Market Analysis:*
    - Cleanview Tracker
    - TD Cowen

Data Sources (3)

- **Virginia Data Center Study: Electric Infrastructure and Customer Rate Impacts, (Energy+Environmental Economics (E3), December 2024)**

- **Underlying Methodology:** Using in-house modeling - capacity expansion model (RESOLVE) and loss-of-load probability model (RECAP) to study the impacts of data center growth on Virginia's electric infrastructure and corresponding costs.

- **Key Inputs/Data Sources:**
  - *Load Forecasts and Projections:*
    - University of Virginia Weldon Cooper Center (WCC)
    - 2024 PJM Forecast
  - *Transmission Constraints:*
    - Energy Exemplar's PJM database
  - *VA State Goals*

Data Sources (4)

- Bringing Data Center Flexibility into Resource Adequacy Planning: A Case Study of NV Energy (GridLab, Telos Energy, September 2025)
- **Underlying Methodology:** Analyzes data center flexibility (in terms of percentage up-time and gigawatts of participation) as an accredited supply-side resource by running and to re-running a capacity expansion model and quantify the benefits of data center flexibility.
- **Key Inputs/Data Sources:**
  - *Peak Demand Forecast, Generator Capacities, Forced Outage Rates*: Adapted from NV Energy's 2024 IRP
  - *Load Profiles*: GridPath RA Toolkit study of the Western United States
  - *Energy profiles*: National Laboratory of the Rockies (formerly NREL) Toolkit and DB

Data Sources (5)

- **2024 United States Data Center Energy Usage Report (Lawrence Berkeley National Lab (LBNL), December 2024)**
- **Underlying Methodology:** Bottom-up energy use model, which is the product of IT equipment wattage, product shipments, and the modeled Power Usage Effectiveness/Water Usage Effectiveness (PUE/WUE)
- **Key Inputs/Data Sources:**
  - *Non-AI Server Wattage* - Green Grid Server Energy Efficiency Database (SEED), SERT, Standard Performance Evaluation Corporation (SPEC)
  - *AI workloads* - empirical data from Brookhaven National Laboratory data, open-source benchmarking data from Sustainable Metal Cloud
  - *Shipments* - IDC's Worldwide Quarterly Server Tracker for servers; IDC's 2024 Q2 Data Center Semiconductor Consumption Report, IDC's 2023 Processors AI Tracker for AI servers; Omdia Research for GPU shipments
  - *PUE/WUE* - Market data for data center space type and cooling system, Typical meteorological year (TMY) climate data

Data Sources (6)

Powering Data Centers: U.S. Energy System and Emissions Impacts of Growing Loads (Electric Power Research Institute (EPRI), October 2024)

- **Underlying Methodology:** State-level data center capacity data is translated to energy use by making assumptions about capacity factors using state-level EIA electricity demand data across different sectors. Future data center electricity load is projected using three scenarios of average annual growth rate.
- **Key Inputs/Data Sources:**
  - *State-level datacenter capacity* - Baxtel
  - *State-level electricity demand data* - Energy Information Administration (EIA), 2024
  - *Nominal capacity factors* - assumed 70-90%
  - *Data center average annual growth rate* - assumed 6%, 12%, and 18% for Low, Medium, and High scenarios, respectively. Scenarios represent varying levels of AI tool usage, efficiency improvements in data center hardware or algorithms

Data Sources (7)

Rethinking Load Growth: Assessing the Potential for Integration of Large Flexible Loads in US Power Systems (Duke University, February 2025)

- **Underlying Methodology:** Leveraging the headroom in seasonal load factors (= average seasonal load/maximum seasonal load) and combining it with varying % of data center load curtailment can allow new loads (in MW) to be added with relatively low rates of curtailment.
- **Key Inputs/Data Sources:**
  - *Hourly load data* - EIA Hourly Load Monitor (EIA-930) which contains data for the 22 balancing authorities
  - *Load curtailment limits* - assumed 0.25%, 0.5%, 1.0%, and 5.0%

Additional resources?

If you are aware of other reports that would be useful to include in this literature review, please send the resource to nfrick@lbl.gov.

Thank you

Contact

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