U.S. Department of ENERGY | Office of Energy Efficiency & Renewable Energy

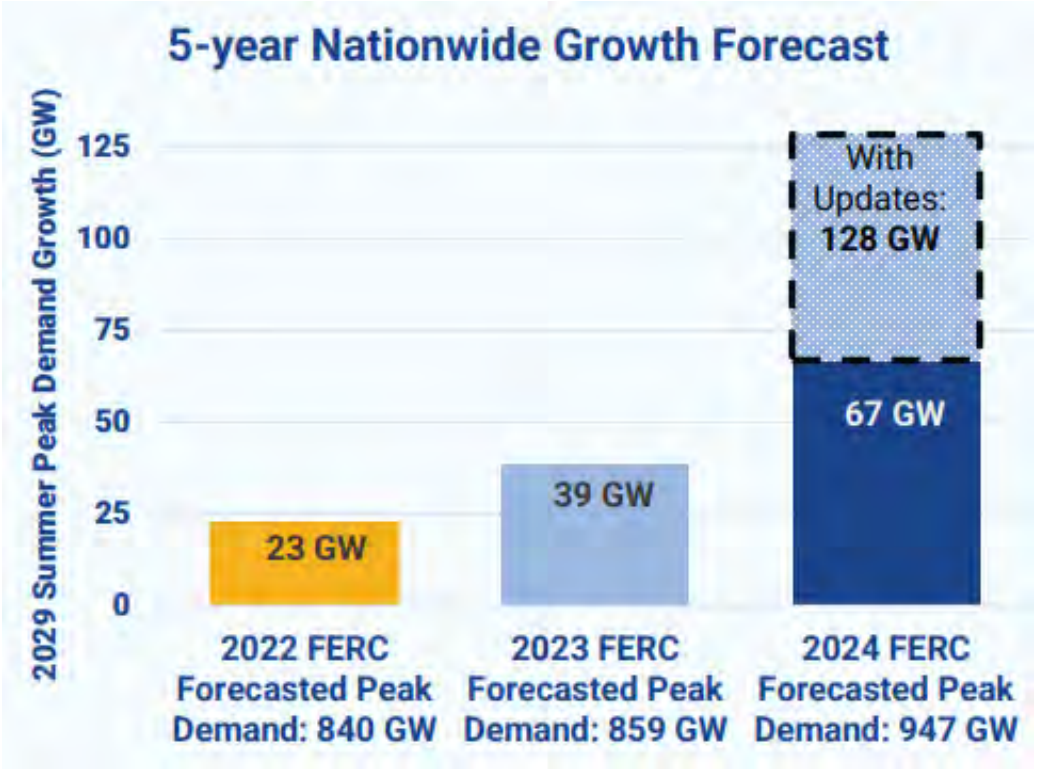
Growth of Large Loads

NASEO - Jan 2025

LOAD GROWTH: NATIONAL PEAK LOAD 5X INCREASE TO 128 GW

Future Growth Drivers:

1) Rise of AI & Data Center Growth
2) New Domestic Manufacturing
3) Increased Demand from Transportation & Buildings
4) Increased Oil and Gas Production
5) Hydrogen & Synthetic Fuel Production
6) Extreme Weather

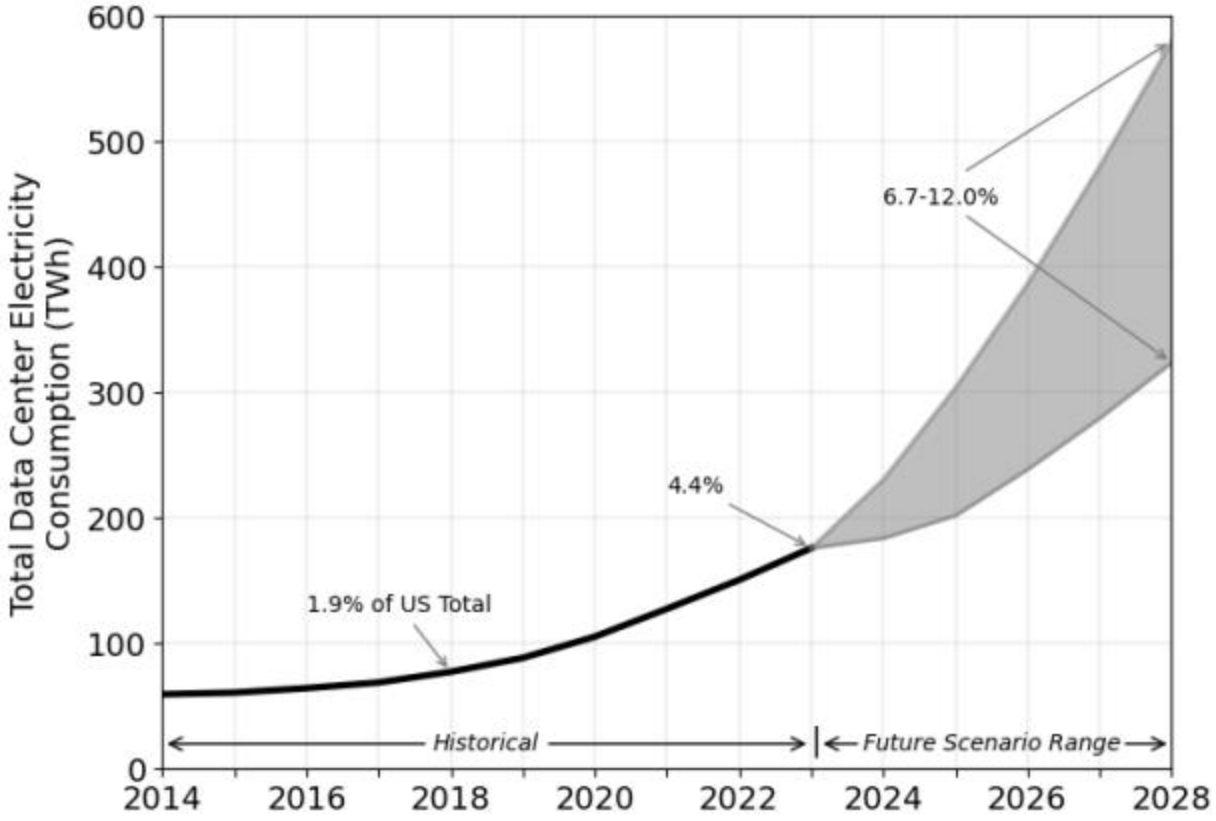


For the last two decades, the utility industry has been in a period of low growth (<1% per year). Deploying sufficient generation, energy storage, demand-side resources, and transmission and distribution infrastructure will challenge existing utility planning and investment cycles as well as regulatory processes.

Sub-optimal utility planning & investment could have negative consequences for US global leadership in strategic industries (e.g. AI),domestic growth, jobs, and grid reliability

Source: Grid Strategies (2024) *Strategic Industries Surging: Driving US Power Demand*

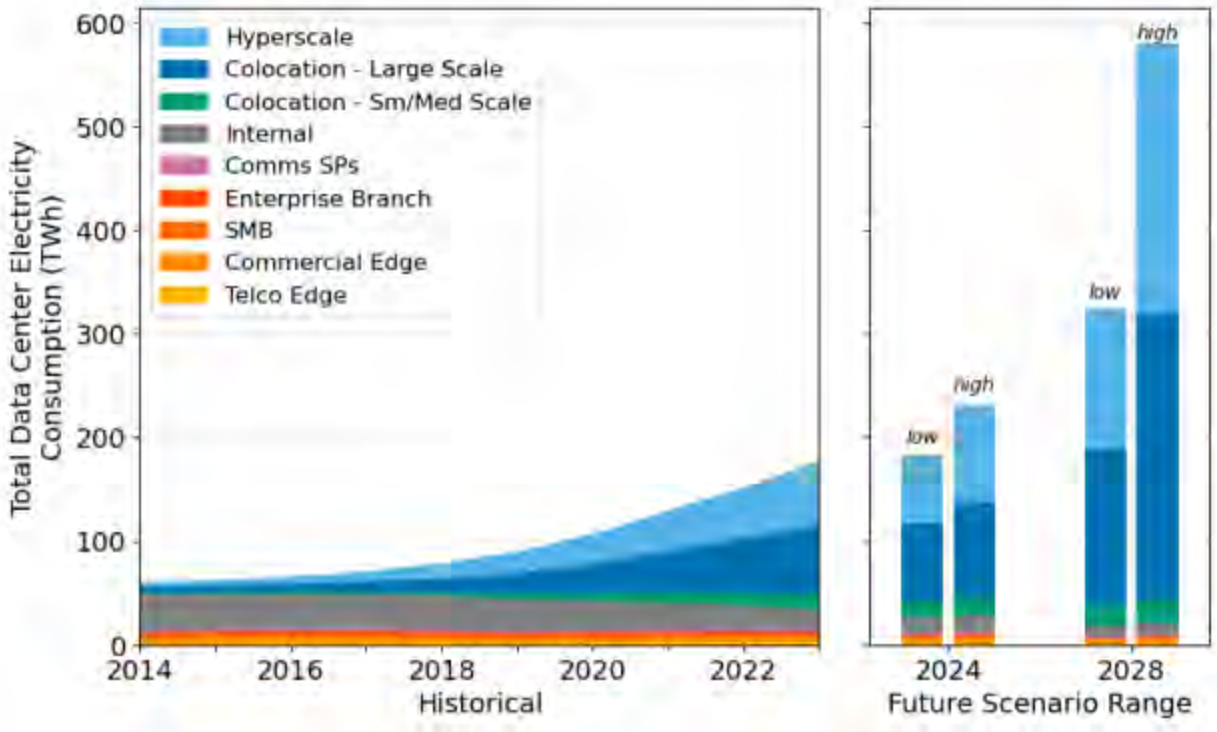
DATA CENTERS ARE A MAJOR SOURCE OF NEAR-TERM LOAD

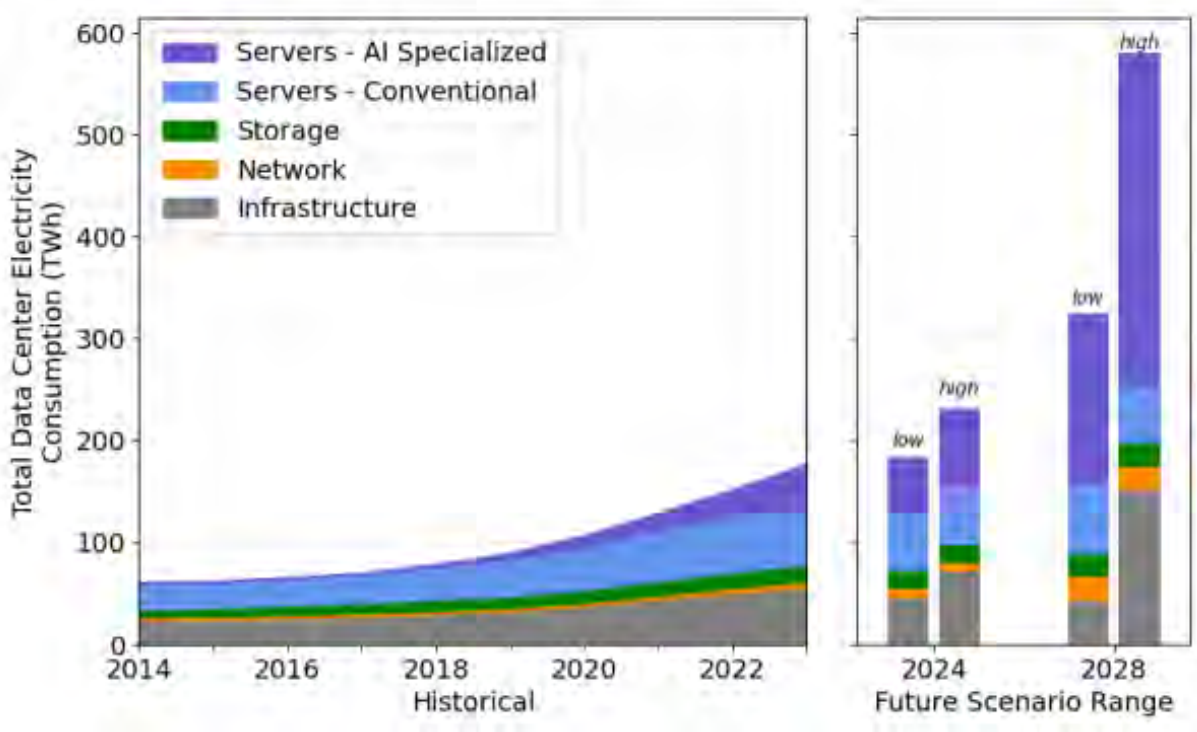


- By 2030, data centers could represent 10% or more of total U.S. electricity demand
- Data center are not homogenous – operational parameters and energy requirement vary across hyper-scalers, AI learning models, co-locators, communication service providers, enterprise branches, and other small/medium businesses.
- By 2028, AI server consumption could represent between 240 and 380 TWh of total data center consumption
- The relationship between computational scale and AI capability improvements suggests that efficiency gains will typically be reinvested in larger models rather than reducing absolute power demand
- The scale and capital intensity of these facilities creates strong incentives for operational efficiency, particularly in cooling and power delivery systems.

Source: LBNL (2024) *2024 United States Data Center Energy Usage Report*

DATA CENTERS ARE NOT MONOLITHIC & EVOLVING





Source: LBNL (2024) *2024 United States Data Center Energy Usage Report*

DATA CENTERS REGIONALLY CLUSTERED BUT PROLIFERATING

- Current data center hubs are located in Northern Virginia, Eastern Oregon, Silicon Valley, and Columbus Ohio
- New hubs are emerging in Indiana, Mississippi, and other areas of the Midwest and South
- Future growth will be driven by availability and price of land, power, water, infrastructure (including fiber optic) and a trained workforce.
- Data center developers are also looking for partners who can maintain public acceptance and move through permitting processes expeditiously

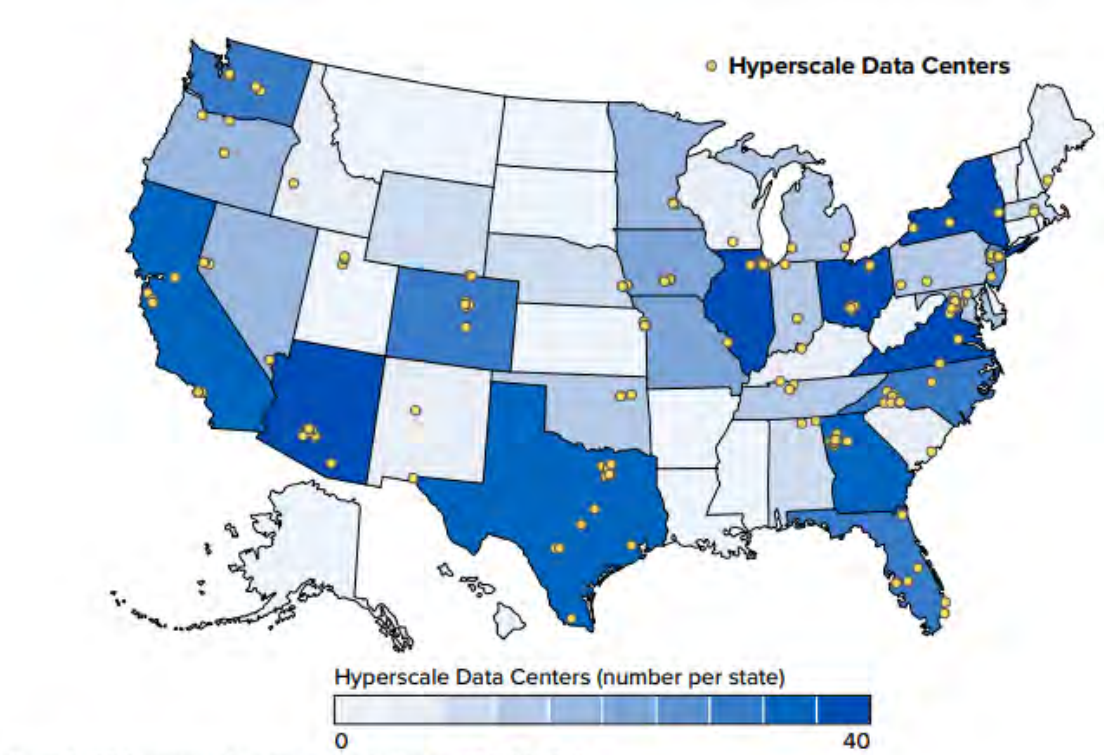


Figure 3. U.S. hyperscale data center distribution as of 2022 [4, 8, 9]

Source: EPRI (2024) *Powering Intelligence Analyzing Artificial Intelligence and Data Center Energy Consumption*

LARGE LOAD CAN CREATE RELIABILITY CHALLENGES

Large load can present new, unique challenges to grid reliability. NERC has set up a task force to address the risks associated with large data centers, potentially leading to new reliability standards.

One new, unique risk posed by large data centers is the impact of large, rapid changes in load. Large, rapid changes in load can occur for GW, reasons, including:

- **Price response** – Crypto mining operations can increase or decrease load by almost 100%. When they respond collectively, the cumulative effect can be challenging to manage. Other large computing operations show little or no sensitivity to electricity price signals.
- **"Ride-through"** – Due to the sensitive nature of computer equipment, data centers automatically activate backup power systems in response to even small changes in voltage. Lightning strikes and other grid faults trigger voltage changes of this size.
- **Normal operations** – AI data center "training models" can vary load significantly on a scale of just seconds.

Where large amounts of load suddenly disappear (or reappear) due to any of these causes, it can require a large, almost instantaneous response by grid operators.

ERCOT has experienced sudden load reductions of up to 400 MW. Nonetheless, grid operators view existing data center behavior as manageable. However, some proposed projects could exceed 1 GW, and some system expect aggregate demand of over 50 GW. At such a large scale, load drops could cause severe reliability problems.

SOURCES | NERC, Large Loads Task Force Work Plan Review (October 8, 2024).
David Ball (AEP), Large Data Centric Flexible Load Operational Impact Review (October 8, 2024).
Agee Springer (ERCOT), Large Loads in ERCOT – Observations and Risks to Reliability (October 8, 2024).

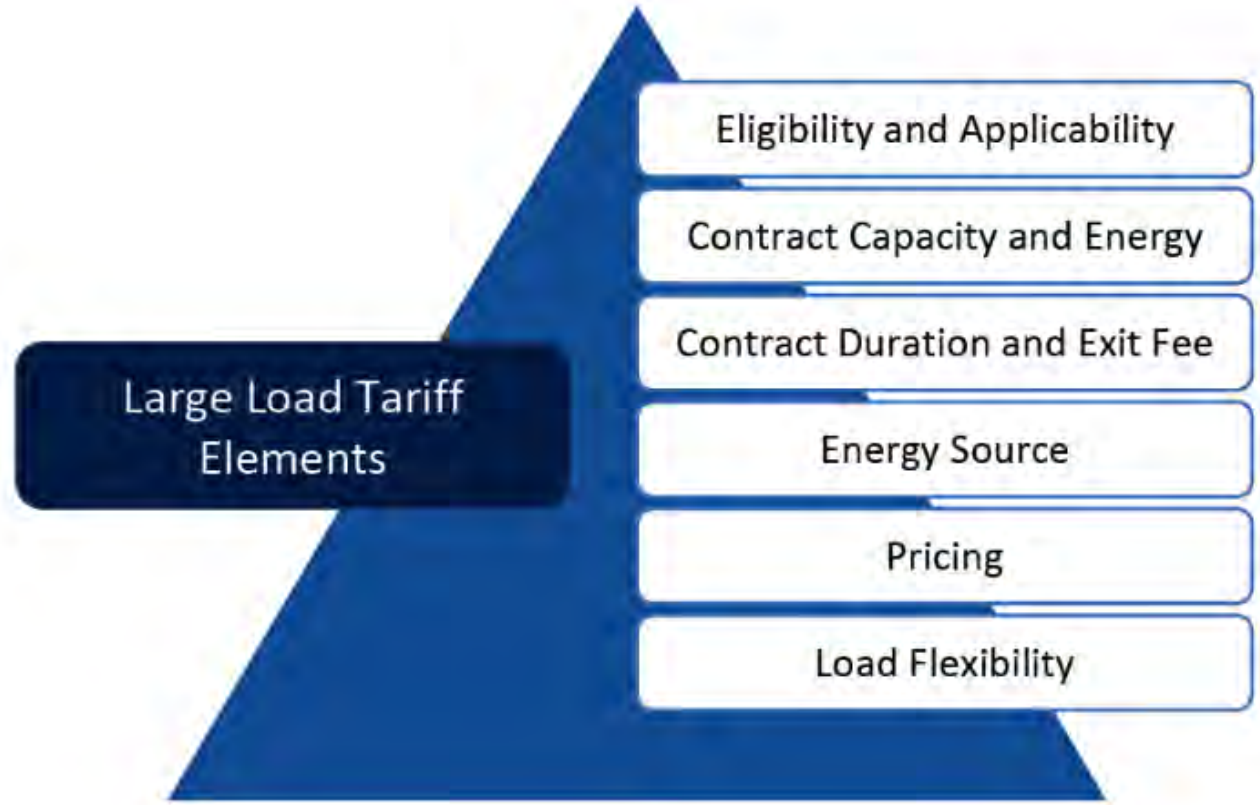
NO ONE SIZE FITS ALL SOLUTION; PORTFOLIO APPROACH

Generation & Storage Deployment	Infrastructure Enhancement & Expansion	Efficiency & Flexibility
		
Expand Existing Supply *(including repurposing existing infrastructure)* • *Solar* • *Wind* • *Storage* • *Hydro* • *Conventional Geo* • *Nuclear* • *Gas*	**Enhance Existing Transmission & Distribution** • *Advanced Reconductoring* • *Dynamic Line Rating* • *Topology Optimization* • *Advanced Power Flow Control* • *Distribution Automation* • *Flexible Transformers*	**Improve Efficiency** • *Building Efficiency* • *Geothermal Heating & Cooling* • *Process Automation* • *Hardware Efficiency* • *AI Algorithm Efficiency*
Scale Emerging Solutions • *Small Modular Reactors* • *Enhanced Geothermal* • *Long Duration Storage* • *CCS* • *Hydrogen* • *CSP*	***Expand Grid Infrastructure*** • *Advanced Conductors* • *Inter- and Intra-regional high voltage AC & DC transmission* • *Distribution System*	**Manage & Flex Demand** • *Demand-Side Flexibility* • *DERs & VPPs* • *Microgrids* • *On-Site Generation & Facility Design Optimization*
Advance Key Enablers • *Proactive Planning* • *Modernized Interconnection Procedures* • *Streamlined Permitting Processes* • *New Financing Structures* • *Supply Chain & Workforce Development*		

LARGE LOAD GROWTH FOCUSED ACTIVITIES

Key Objectives:

- **Improve Forecasting and Planning Data, Tools, & Methods**
- **Assessing Opportunities for AI-Driven Load Forecasting & Grid Planning**
- **Assessing Trade-Offs and Best Practices for Large Load Customer Tariffs & Interconnection Processes**
- **Leverage Best Practices from Industry, Regulators, and Other Key Decision Makers**



Source: LBNL (2025) *Electricity Rate Designs for Large Loads: Evolving Practices and Opportunities*

RESOURCES FOR STATES

State Technical Assistance Program

- Open to Utility Commissions, Energy Offices, and Other State Entities
- "**Help Desk**" Up to 4 hours of Subject Matter Expertise Provided On-Demand
- "**Expert Match**" Up to 80 Hours of Subject Matter Expertise Provided on a Rolling Basis
- "**In-Depth**" 12-18 Months of Assistance Selected Semi-Annually
- https://emp.lbl.gov/projects/state-TA-program/

Utility and Grid Operator Technical Assistance Program

- Open to Municipal, Cooperative, Investor-Owned Utilities & ISO/RTOs
- "**Key Assist**" Up to $1M of Lab Research to Support In-Depth Modeling and Simulation, Hardware Testing, or Other Technical Challenges
- "**Interconnection Assistance**" Up to 12 Months of Support for Transmission and Distribution Interconnection Issues
- "**Rolling Technical Assistance**" Up to 100 Hours of Subject Matter Expertise Provided on a Rolling Basis
- https://www.nrel.gov/state-local-tribal/utility-grid-operator-technical-assistance.html

Energy Innovator Fellowship

- Enables experts from diverse backgrounds to spend up to two years with eligible Host Institutions, including electric cooperatives, grid operators, municipal utilities, public utility commissions, state energy offices and Tribal entities. Innovator Fellows receive a stipend to support their participation in the program and an allowance for education and professional development opportunities.
- https://orise.orau.gov/ceif/default.html

Thank You!

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