The U.S. Electric Grid: A Critical Backbone for the Economy and National Security

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SECTION 1:
EXECUTIVE SUMMARY

This report, prepared by Concentric Energy Advisors, Inc., examines the U.S. electric grid as a critical national asset and evaluates how utility investment, modernization, and integrated planning support economic growth and national security. The grid is an integrated system of critical infrastructure that generates, transmits, and delivers electricity to customers. It spans more than 22,000 generators, 55,000 substations, 642,000 miles of high voltage transmission lines, and 6.3 million miles of distribution infrastructure. This report provides data driven insights into grid reliability, resilience, and the importance of maintaining a highly interconnected system for an economy that depends on uninterrupted power. The report's key findings include:

- **The U.S. electric grid is critical to our economy, national security, and modern life.** The grid is the enabling platform for economic and national security by supplying reliable power to all sectors of the economy, including essential services such as defense, emergency response, water systems, and communications.
- **Utilities continue to invest steadily in the grid while prioritizing affordability for customers.** Utilities are driving sustained investments in the grid that support reliability and the deployment of new technologies to help keep energy as affordable as possible for customers. By making system-wide improvements at scale, utilities can deliver these benefits more cost-effectively than through smaller, stand-alone projects.
- **Utilities are leading the deployment of new technologies.** These new grid-enhancing technologies (GETs) and other innovative solutions help utilities identify issues earlier, make better use of existing infrastructure, integrate new energy resources, and serve growing demand more efficiently, all while keeping the lights on and maintaining high levels of reliability for customers.
- **New large customers should be connected to the grid.** New large customers broaden the customer base over which fixed costs are recovered and support investment in advanced technologies that benefit all customers. Leveraging the existing grid also avoids costly, duplicative infrastructure.
- **A modern, interconnected grid remains the most scalable platform for reliable power delivery.** Paired with integrated utility planning, continued investment in the grid is a foundational enabler of U.S. economic growth and prosperity. Any efforts to reduce investment in the grid could jeopardize this economic engine.

The Grid is the Backbone of U.S. Economic and National Security

The grid is the backbone of nearly all U.S. economic activity and public services. It is essential to national security, it supports the livelihood of every American, and it is becoming increasingly critical as the U.S. economy becomes more electrified. While the electric power industry is one of the sixteen critical infrastructure sectors identified by the U.S. Cybersecurity & Infrastructure Security Agency (CISA), **the grid is an enabling platform for nearly all other critical infrastructure sectors**. The stable energy supply provided by the grid protects health and welfare and allows the U.S. economy to function. Investor-owned electric utilities focus on preventing long-duration outages, which the Lawrence Berkeley National Laboratory (LBNL) estimates could reduce regional Gross Domestic Product (GDP) by billions of dollars. **The grid has remained strong and stable over time, with an average reliability factor of 99.95%** according to the National Laboratory of the Rockies (NLR). This means that the grid's true value is not reflected just in electricity prices, but in the enormous economic activity that depends on uninterrupted power, and in the costly disruptions that are avoided when the grid works as intended.

The Grid is Resilient and Utility Investment Enables Continuous Modernization

The grid is not a single system but a layered network of generating facilities, transmission lines, substations, distribution systems, control equipment, and software. Utilities routinely inspect, upgrade, and replace components based on condition and performance to deliver high levels of reliability to support modern economic activity and public services. The North American Electric Reliability Corporation (NERC) found that **the bulk power system remained "highly reliable and resilient"** in 2024, while noting that severe weather and natural disasters, not routine equipment failure or asset degradation, caused the most severe outages. Utilities have been able to achieve this level of resilience by making ongoing investments in grid hardening and other upgrades, while federal programs complement these investments through targeted funding for grid resilience and modernization. NLR recently estimated that **every dollar invested in transmission infrastructure saves customers $1.60-1.80 in future system costs**. In addition, recent utility projects have demonstrated that dynamic line rating (DLR) technology can increase capacity ratings by 10-30% during favorable conditions, while reconductoring with advanced conductor lines can substantially increase line capacity, sometimes even doubling it. The electric utility sector's mutual assistance programs and interconnection across regions also provide redundancy and flexibility, enabling utility workers and grid resources to be rerouted during emergencies to accelerate recovery from disruptions. Altogether, **utility industry efforts are strengthening the capabilities of the grid** to serve customers during extreme events and enabling utilities to maintain essential services when they are needed most.

Grid Connected Large Customers Provide Advantages

The U.S. is experiencing one of the most significant shifts in electricity demand in decades, driven by growth in data centers, artificial intelligence, manufacturing, and electrification. As a result, reliable electric service is increasingly important for economic competitiveness and energy security. Connecting large customers to the grid provides clear advantages because **new large customers broaden the customer base over which fixed costs are recovered,** improve asset utilization, and support investment in advanced technologies that benefit all customers. In addition, the grid can deliver lower long-term costs through economies of scale and provide access to diverse generation resources. By contrast, widespread off-grid configurations can increase system-wide costs, reduce resilience, and put pressure on finite manufacturing capacity and critical supply chains. To ensure reliability on their own, off-grid customers must build substantially more on-site generation and storage – often 70% or more above peak demand – than would be required if they were connected to the grid. A recent Concentric report estimates that if large load customers do not pay their share of fixed grid costs, the resulting cost shift to other customers could total between $120 billion and $169 billion over a 30-year period nationwide. Through thoughtful planning and appropriate cost allocation, **the integration of new large customers strengthens the grid and benefits all customers**.

Conclusion

The evidence provided in this report supports a clear conclusion: **the U.S. electric grid is a strategic national asset** that utilities continuously strengthen and modernize through sustained, strategic investment, operational improvements, and technology deployment. These actions deliver broad, economy-wide benefits and enhance national security by sustaining the energy backbone for defense, communications, healthcare, financial systems, water systems, and other critical infrastructure. This implies that the grid's economic value is not captured solely by the price of electricity, but by the avoided costs of disruption across the U.S. economy, which depends on continuous service. Additionally, connecting new large loads to the grid is the most efficient, reliable, and resilient approach to meeting rising electricity demand. In summary, **the U.S. electric grid enables economic growth and supports national security**, and it is the most scalable platform for reliable power delivery.

SECTION 2:
INTRODUCTION

For purposes of this report, the "**U.S. electric grid**" or "**the grid**" refers to the integrated system of critical infrastructure that **generates**, **transmits**, and **delivers** electricity to customers.[1] This includes generation, transmission, and distribution infrastructure, communications and control technologies, and the operational and planning institutions and companies that coordinate and deliver these services. Although it is often discussed as a single entity, the electric grid is a complex, interdependent system spanning approximately 22,000 generators, 55,000 substations, 642,000 miles of high-voltage transmission lines, and 6.3 million miles of distribution infrastructure, and operating continuously across a vast geographic footprint.[2] The reliability of the grid depends not only on physical equipment, but also on coordinated planning, system operations, and continuous investment across all levels and segments of the system.

The U.S. electric grid, and the way it is regulated, has evolved over more than a century as a highly resilient, highly capital-intensive system designed to serve diverse environments across different geographies and demand patterns. Grid components are routinely monitored, maintained, upgraded, and replaced based on condition, capability, and system need through sustained investments. Regulated utilities have the ability to recover the costs of these investments over a large customer base and over a long period of time, which delivers significant benefits for customers and grid operations with minimal cost impact to individual customers. U.S. electric utilities are therefore well positioned to continue making the necessary investments to ensure customers will continue to receive reliable and affordable energy for generations to come. This cycle of ongoing investment in the grid results in an infrastructure network that is continuously modernized rather than static. In parallel, the operational and market frameworks that govern how the system is planned, dispatched, and paid for have also evolved over time to reflect changing technologies, resource mixes, and participant needs.

The grid is operating in a period of significant transition. Electricity demand, which was largely flat or declining for much of the last two decades, has begun to increase, driven by data centers, industrial load expansion, and electrification of buildings and vehicles. Extreme weather events also place new stresses on infrastructure creating new challenges for planners. In addition, the resources used to generate electricity have shifted to include more intermittent capacity than ever before, with industry projections indicating that this trajectory will continue. These dynamics increase both the complexity of grid operations and the value of coordination.

1 "Generation" includes the power plants and other resources that produce electricity, ranging from large nuclear plants to smaller "behind-the-meter" or "distributed" resources. "Transmission" refers to the high voltage network of wires, towers, and substations that moves bulk electricity over long distances and connects regions, enabling power to flow from where it is generated to where it is consumed. "Distribution" consists of lower voltage infrastructure that delivers electricity from substations to homes, businesses, and institutions.

2 U.S. DOE, Electric Grid Supply Chain Fact Sheet, February 2022.

Against this backdrop, this report explores the ability of the grid to support increasing demand growth, new technologies, and evolving customer needs and puts into perspective the grid's scale, adaptability, and track record of performance.

This report supports the conclusion that the U.S. electric grid is a complex, interdependent system that is being continuously modernized to remain capable of meeting projected load growth, and details how and why the grid is the foundation for America's future. Furthermore, this report highlights the electric grid's importance to national security as it supports defense installations, emergency response facilities, water and wastewater systems, fuel supply chains, healthcare facilities, and telecommunications networks. The subsequent sections are intended to provide context for understanding the grid's performance today and its capacity to meet future needs, grounding the discussion in observable system characteristics and industry experience rather than isolated claims or assumptions.

SECTION 3:

THE GRID IS THE BACKBONE OF U.S. ECONOMIC AND NATIONAL SECURITY

The Electric Grid Enables All Economic Activity in the U.S.

It is intuitive to understand that electricity enables all sectors of the economy. Whether it is to power a ventilator in a hospital, to pump water to irrigate crops, or to run the complex algorithms that settle trades on the New York Stock Exchange, society cannot function safely and efficiently without the electric grid as we know it today. The conclusion then, is that the electric grid is not one input among many. It is the enabling platform that underpins virtually all economic activity, and therefore requires *continuous*, *stable*, *uninterrupted* service with little downtime from disturbances.

Reliability is Unique Because it Requires Coordinated Planning and Sustained Investment

Electric reliability is a shared system benefit whose value far exceeds the price of electricity itself. Its value shows up across the whole economy, not just for individual customers. Because of that, it can't be delivered through individual choices or short-term market outcomes alone; it requires coordinated planning, system-wide decisions, and sustained investment.

For policymakers, the fact that reliability is far more valuable than the cost of electricity matters. It explains why electricity reliability is treated differently from other infrastructure services, and why regulatory oversight,[3] coordinated planning, and quality standards have remained central features of the grid, even in wholesale markets[4] that otherwise rely on competition. Wholesale electricity markets facilitate real-time bulk power operations and short-term price signals, but they do not, on their own, internalize the full economic costs of widespread outages or the value of maintaining reserve margins, system flexibility, and resilience against rare but high-impact events. Since the

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[3] The U.S. electric power industry operates under a layered regulatory framework designed to ensure reliable service, fair pricing, and long-term system investment. At the federal level, the Federal Energy Regulatory Commission (FERC) oversees wholesale electricity markets, interstate transmission rates, and the reliability of the bulk power system. At the state level, state public utility commissions regulate retail electric service, transmission and distribution rates, distribution system reliability/service quality, and utility investment decisions within their jurisdictions. Together, these federal and state authorities establish the rules governing how electricity is planned, produced, delivered, and paid for. Regulators and participants balance the need for reliability and affordability with evolving public policy objectives. This regulatory oversight reflects the essential nature of the electric system as critical infrastructure and the long asset lives, high capital intensity, and reliability obligations associated with electric service.

[4] Electricity markets operate under different organizational models. In traditionally regulated or vertically integrated markets, a single utility owns and operates generation, transmission, and distribution assets within a defined service territory and has an obligation to serve all customers. Rates are set through cost of service regulation, with regulators reviewing investments and allowing recovery of prudent costs plus a reasonable return. In restructured or deregulated markets, generation and sometimes retail supply are provided by independent suppliers, while transmission and distribution remain regulated utility services. In these "wholesale markets," wholesale electricity prices are established through competitive market mechanisms administered by independent system operators (ISOs) or regional transmission organizations (RTOs), and retail generation prices reflect those market outcomes rather than utility cost of service. Although these market designs differ in how investment risk is allocated and how prices are formed, both models are supported by regulatory and operational frameworks intended to ensure reliable service, fair pricing, and long term system investment.

economic value of the grid extends well beyond the price customers pay for electricity, resource adequacy[5] and energy security cannot be left solely to short-term market outcomes; they require forward-looking coordination that reflects system-wide risk rather than individual participant profitability.

In practical terms, the grid's economic value lies in the vast scale of activity enabled by uninterrupted service. Grid reliability is an essential precondition for productivity and growth: it allows firms to deploy capital-intensive equipment, operate high-throughput logistics and manufacturing processes, deliver digital services, and coordinate supply chains premised on near-continuous power. As such, reliability is not merely a performance metric or consumer expectation; it is a foundational asset supporting economic growth, competitiveness, and national security. The electric grid remains among the most economically valuable and strategically important infrastructure systems in the United States.

The Avoided Costs of Disruption are Immense

A large research base demonstrates that outages create costs that extend well beyond the immediate value of lost electricity consumption. Costs include business interruption, lost output, equipment damage, inventory spoilage, increased safety risks, and cascading effects through supply chains and regional economies. Power disruptions pose serious risks to public health and safety and can lead to billions of dollars in lost economic output. The Lawrence Berkeley National Laboratory (LBNL) long-standing research program on interruption costs explicitly frames outage impacts as economic losses that can be estimated for localized, short-duration events as well as widespread, long-duration interruptions, reflecting the reality that outage costs scale with both duration and geographic extent, and are not linear.[6]

LBNL work provides a useful framework for distinguishing outage types and the associated economic mechanisms. For short-duration outages (up to 24 hours), the Interruption Cost Estimate (ICE) Calculator translates survey-based customer responses into economic estimates used widely in utility planning and regulatory proceedings. For widespread, long-duration outages, LBNL has estimated that widespread interruptions of 1, 3, and 14 days could reduce regional Gross Domestic

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[5] Resource adequacy, energy security, and reliability are closely related but distinct concepts that together describe how the electric grid is designed and operated to serve customers safely and continuously. "Resource Adequacy" refers to having sufficient generating resources to meet demand plus a reserve margin to account for contingencies. Resource Adequacy considers the amount of generation capacity that is available, as well as generation resource attributes, such as availability, flexibility, and operating history. "Energy Security" refers to the resilience of the grid to disruptions, be they physical, fuel-related, weather-related, cyber, or geopolitical in nature. Energy security considerations include infrastructure hardening, fuel diversity, supply chain integrity, cybersecurity protections, and coordinated emergency response and restoration planning. "Reliability" refers to the overall ability of the electric grid to deliver electricity to customers consistently and within acceptable quality standards. It integrates both resource adequacy and energy security, combining adequate supply and system capacity with the operational resilience needed to manage real time conditions and recover from disturbances.

[6] *See for example*, Baik, LaCommare, Geraci, and Johnson, "Estimates of the Economic Impacts of Long-Duration, Widespread Power Disruptions in Puerto Rico," Prepared for the Federal Emergency Management Agency and U.S. Department of Energy Grid Deployment Office, March 2025.

Product (GDP) by billions of dollars, illustrating how quickly outage costs compound when geographic scope and duration increase.[7]

> *The grid's economic value is not captured solely by the price of electricity, but by the avoided costs of disruption across an economy that depends on continuous service.*

From a policy and planning perspective, these findings matter because they demonstrate that reliability and resilience investments can yield benefits that are far greater than the incremental cost of electric system investment, especially when these investments reduce the frequency and duration of the most economically damaging events. They also support a broader point relevant to this report's framing: the grid's economic value is not captured solely by the price of electricity, but by the avoided costs of disruption across an economy that depends on continuous service.[8] In 2024 the National Laboratory of the Rockies (NLR) found that "the average U.S. customer loses power less than two times per year for a total of less than five hours, which represents 99.95% reliability," meaning that the U.S. grid is extremely reliable.[9]

National Security and Critical Infrastructure Depend on Reliable Electricity

The electric grid is an enabling platform: the U.S. Cybersecurity & Infrastructure Security Agency (CISA) refers to the energy sector "as uniquely critical because it provides an 'enabling function' across all critical infrastructure sectors."[10] This interdependence creates a distinct risk profile: grid disruptions can cascade into water and wastewater systems, telecommunications, healthcare delivery, fuel supply chains, emergency response, financial services, and transportation systems. The Department of Homeland Security (DHS) Strategic Guidance for U.S. Critical Infrastructure Security and Resilience (2024–2025) explicitly situates "energy grids" alongside water, transportation, healthcare, and communications as systems "vital for public safety, economic security, and national security."[11]

Interdependencies also intensify the importance of "time to restore" as an economic variable. Even when outages are relatively infrequent, the economic consequences rise sharply when restoration is slow or when outages affect critical nodes. NERC reports that, for major transmission-impacting hurricanes, functional transmission restoration times have improved and that generator

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7 Wing et al. Journal of Nature Communications, "A Method to estimate the economy-wide consequences of widespread, long duration electric power interruptions," April 8, 2025.

8 The North American Electric Reliability Corporation (NERC) 2025 State of Reliability Report stresses that, "because of industry's continuous adaptation to these transitions," concerns were mitigated "before having catastrophic results," and that efforts to address weather-driven challenges have "led to consistently reliable performance except in the most extreme circumstances."

9 NLR, Top 10 Things To Know About Power Grid Reliability, January 26, 2024, available at: https://www.nlr.gov/news/detail/program/2024/top-10-things-to-know-about-power-grid-reliability.

10 CISA, Energy Sector, available at: https://www.cisa.gov/topics/critical-infrastructure-security-and-resilience/critical-infrastructure-sectors/energy-sector.

11 U.S. DHS Memorandum, "Strategic Guidance and National Priorities for U.S. Critical Infrastructure Security and Resilience (2024-2025)," June 14, 2024.

performance is improving during winter storms.[12] This indicates that system hardening, coordination, and mutual assistance can translate into faster restoration of core system functionality, which is an important pathway for reducing the economic burden of extreme events.

The U.S. Department of Energy (DOE) National Transmission Needs Study began with a simple conclusion: "[a] robust transmission system is critical to the Nation's economic, energy, and national security."[13] From a national security perspective, the electric grid supports defense operations and the resilience of the domestic "defense ecosystem," including the industrial base and the critical civilian functions that underpin military readiness. These functions include emergency response, water and wastewater systems, fuel supply chains, healthcare facilities, and telecommunications networks. DHS's 2024–2025 strategic guidance frames critical infrastructure resilience as "of paramount importance" in an era of "dynamic global volatility," and highlights energy grids as essential to national security outcomes.[14] The guidance also explicitly identifies threats posed by nation-state actors (including cyber capabilities targeting critical infrastructure) and emphasizes the need to build resilience to withstand and recover from threats.

The scale and interconnected nature of the U.S. grid are not only operational advantages, but also central to national security and the protection of critical infrastructure. Research consistently shows that interconnected power systems are better able to withstand extreme weather events, localized equipment failures, and supply interruptions than isolated or off-grid systems.[15]

Diversity of resources across regions reduces the risk of simultaneous failures, while access to shared reserves enables faster and more effective recovery following disturbances. In this way, the bulk power system functions as a critical infrastructure backbone that supports essential services, economic stability, and national defense, reinforcing the importance of maintaining a robust and interconnected grid.

12 NERC, 2025 State of Reliability Report, June 2025, at 4.
13 U.S. DOE, National Transmission Needs Study, October 2023.
14 U.S. DHS Memorandum: "Strategic Guidance and National Priorities for U.S. Critical Infrastructure Security and Resilience (2024-2025)," June 14, 2024.
15 *See for example*, "Measuring and Valuing Resilience: A Literature Review for the Power Sector." Laura Leddy, Donald Jenket, Dana-Marie Thomas, Sean Ericson, Jordan Cox, Nicholas Grue, and Eliza Hotchkiss, National Renewable Energy Laboratory, 2023.

SECTION 4:

THE GRID IS RESILIENT AND UTILITY INVESTMENT ENABLES CONTINUOUS MODERNIZATION

The Grid Delivers High Levels of Reliability Because it is Continuously Maintained and Modernized

Asset age is not a meaningful indicator of system performance, reliability, or resilience.

What matters is how infrastructure is maintained, how it performs under operating conditions, and how utilities deploy capital to address evolving system needs.

The electric grid is not a single machine with a uniform age or design life; it is a layered, interconnected system that combines long-lived assets such as transmission lines and transformers with shorter-lived assets such as breakers and control software that are regularly updated. As a result, the grid reflects a portfolio of assets at different stages of their lifecycle, rather than a static system. Through routine maintenance, replacement, upgrades, reconductoring, and modernization utilities materially extend the useful life and capability of core infrastructure, saving money for customers. NLR recently estimated that every dollar invested in transmission infrastructure saves customers $1.60-1.80 in future system costs.[16]

To guide planning decisions, utilities apply condition- and risk-based asset management frameworks that evaluate infrastructure based on condition, performance history, criticality, and cost-effectiveness for customers. The benefits of this approach include capital savings by deferring premature asset replacement, lower operating and maintenance costs through targeted interventions, extended asset life, and early detection to avoid unplanned outages.[17] They are complemented by regional transmission planning processes administered by ISOs/RTOs, which rely on utility data and planning inputs to identify broader system needs, while utilities retain responsibility for maintaining and upgrading their infrastructure to meet reliability standards.[18]

Outside of major weather-driven disruptions, the U.S. electric grid continues to deliver a high level of day-to-day reliability, with performance that has remained broadly stable over time.

These practices translate into strong, observable reliability outcomes. Standard reliability metrics – System Average Interruption Duration Index (SAIDI), System Average Interruption Frequency Index (SAIFI), and Customer Average Interruption Duration Index (CAIDI) – show that, outside of major weather-driven disruptions, the U.S. electric grid continues to deliver a high

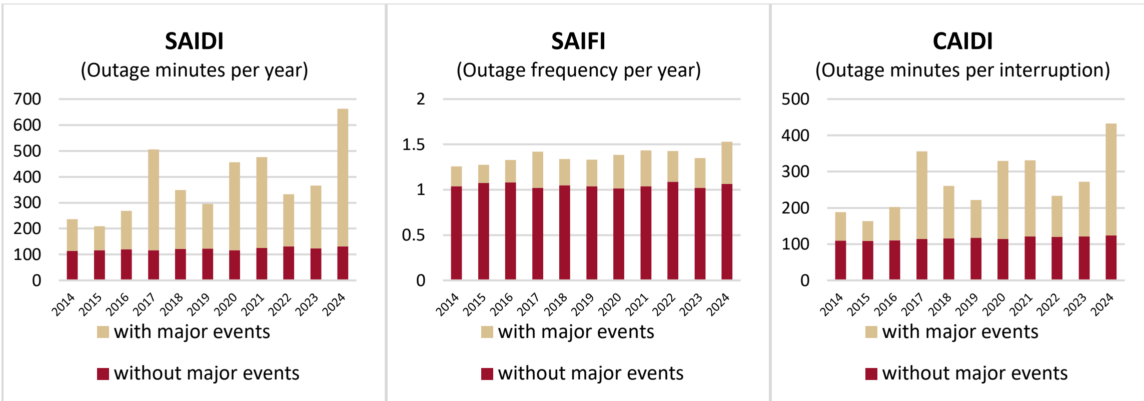
16 Mercer, Emily. National Transmission Planning Study. National Laboratories of the Rockies, Oct. 3, 2024. Available at: https://www.nlr.gov/news/feature/2024/national-transmission-planning-study

17 EPRI, Condition-Based Replacement for T&D Assets, February 2021.

18 For example, in Massachusetts, electric utilities are required to submit Electric Sector Modernization Plans to the Department of Public Utilities every 5 years, providing information on the current state and projected needs of the distribution system. See also Lawrence Berkeley National Laboratory, State Requirements for Electric Distribution System Planning (December 2024), which identifies jurisdictions that impose similar requirements.

level of day-to-day reliability, with performance that has remained broadly stable over time (see Figure 1).

Figure 1: SAIDI, SAIFI, and CAIDI of the U.S. Electric Distribution System (2014-2024)[19]



The largest and most disruptive outages in the U.S. are overwhelmingly driven by severe weather, rather than by routine equipment failure or asset degradation. Analyses show that approximately 80% of all reported outages between 2000 and 2023 were associated with major weather events, such as hurricanes, winter storms, heat waves, and wildfires. In 2024, this pattern persisted: roughly 80% of total customer-hours without electricity were attributable to major storms, including Hurricanes Beryl, Helene, and Milton.[20] Moreover, the number of weather-related outages in the most recent decade is roughly double that observed in the first decade of the period analyzed, reflecting the increasing frequency and severity of extreme weather rather than a deterioration in underlying grid condition.[21] This trend is consistent with National Oceanic and Atmospheric Administration (NOAA) data showing that billion-dollar weather events have increased from an average of about 1.5 per year in the 1980s to 23 per year over 2020–2024, with annual damages rising more than twenty-fold over the same period (see Table 1).[22]

80% of outages are driven by major weather events.

19 Metrics reflect results reported by utilities using IEEE reliability reporting standards.
20 U.S. EIA, Hurricanes in 2024 Led to the Most Hours Without Power in the United States in 10 Years, Today in Energy, December 1, 2025.
21 Climate Central, Weather-Related Power Outages Are Rising, April 24, 2024.
22 NOAA National Centers for Environmental Information (NCEI), U.S. Billion-Dollar Weather and Climate Disasters (2025), available at https://www.ncei.noaa.gov/access/billions/summary-stats.

Table 1: Time-Period Comparison of Weather Events in the U.S. Between 1980-2024 that Exceed One Billion Dollars (Nominal Dollars)

Time Period	Event Count	Events/Year	Cost	Cost/Year
1980s (1980-1989)	15	1.5	$62.2B	$6.2B
1990s (1990-1999)	42	4.2	$146.4B	$14.6B
2000s (2000-2009)	55	5.5	$377.5B	$37.8B
2010s (2010-2019)	119	11.9	$747.5B	$74.8B
2020-2024	115	23	$684.4B	$136.9B
2024	27	27	$182.1B	$182.1B
All Years (1980-2024)	346	7.7	$2,018.0B	$44.8B

This distinction matters for interpreting reliability metrics correctly. When major storms are excluded, national reliability metrics show far more stability. EIA data indicate that, excluding major event days, SAIDI, SAIFI, and CAIDI values have remained relatively flat since at least the mid-2010s, despite rising system complexity, growing electricity demand, and increasing integration of new technologies and resource types.[23] This stability is inconsistent with claims of broad, system-wide reliability decline. National reliability assessments reinforce this conclusion: the bulk power system remains highly reliable, with improved restoration outcomes and fewer cascading failures, even under more challenging operating conditions.[24]

A central finding across multiple data sources is that the largest and most disruptive outages in the U.S. are overwhelmingly driven by severe weather, rather than by routine equipment failure or asset degradation.

Reliability outcomes also vary across regions based on geography and exposure to weather-related risks rather than uniform differences in system condition. Coastal regions face hurricane and flooding risks, northern regions experience ice and extreme cold, and western regions face wildfire exposure. These differences underscore that higher outage durations in certain areas are typically driven by localized risk factors rather than systemic underperformance.[25] International comparisons further support this interpretation: analysis by the IEA finds that the U.S. is among the advanced economies most affected by natural-hazard-driven outages, rather than outages caused by human error, fuel shortages, or equipment failure.[26]

Taken together, these findings demonstrate that the grid's strong reliability performance is the result of continuous utility investment, proactive asset management, and coordinated planning. The system

23 U.S. EIA, Reliability Metrics of the U.S. Distribution System, 2014-2024, available at https://www.eia.gov/electricity/annual/html/epa_11_01.html.

24 NERC, 2025 State of Reliability Report, June 2025, at 3.

25 U.S. EIA, Electric Power Annual, Tables 11.4 and 11.5 (SAIDI and SAIFI values), available at https://www.eia.gov/electricity/annual/table.php?t=epa_11_04.html and https://www.eia.gov/electricity/annual/table.php?t=epa_11_05.html.

26 IEA, Electricity Grids and Secure Energy Transitions, November 2023, at 43.

is dynamic and continuously modernized, enabling it to maintain high levels of performance while adapting to evolving risks and operating conditions.

Utilities are Investing to Strengthen Reliability, Resilience, and Affordability

The U.S. electric utility industry is in a sustained period of elevated investment to maintain, modernize, and expand the grid in response to growing demand, evolving risks, and increasing system complexity. These investments span generation, transmission, and distribution infrastructure, as well as advanced technologies that improve system performance and operational flexibility. Because utilities operate under a regulated model and serve a broad customer base, they are able to recover costs over long time horizons, allowing for continuous investment while maintaining affordability for customers.

Utility spending has increased 12% from 2003-2023.

*Meanwhile, national residential electricity costs as a fraction of personal expenditures and income have **trended down** since 2010.*

Edison Electric Institute (EEI) industry financial data going back to the year 2000 shows that industry capital investments have increased by approximately four-fold in the past quarter century in nominal dollars, significantly outpacing inflation, with incrementally higher capital investments nearly every year since 2010.[27] This trend holds true in constant dollars as well: the EIA found that annual spending by major utilities to produce and deliver electricity increased by 12% from 2003 to 2023 in real 2023 dollars, with capital investments more than doubling over this period and primarily driving the overall increase.[28] Current EEI projections indicate that during the five-year period from 2025 through 2029, industry capital investments are expected to reach approximately $1.1 trillion, which compares to roughly $1.3 trillion from the ten-year period 2015 through 2024, reflecting continued investment to support load growth, electrification, and system modernization.[29]

Regulated utilities have the ability to recover the costs of these investments over a large customer base and over a long period of time, which delivers significant benefits for customers and grid operations with minimal cost impact to individual customers.

These higher investments have paid dividends for customers: A recent report from LBNL found that national residential electricity costs as a fraction of personal expenditures and income have *trended down* since 2010.[30] This means that U.S. electric utilities have made investments that not only provide a high level of reliability,

[27] Annual industry capital investment data was compiled from EEI Financial Review annual reports. EEI's annual Financial Review is available at https://www.eei.org/issues-and-policy/finance-and-tax.

[28] U.S. EIA, Today in Energy: Grid infrastructure investments drive increase in utility spending over last two decades, November 18, 2024.

[29] EEI, Strengthening America's Energy Infrastructure to Increase Reliability & Lower Costs, September 2025, available at: https://www.eei.org/issues-and-policy/finance-and-tax.

[30] Lawrence Berkeley National Laboratory, Retail Electricity Price Trends and Drivers: Data Update–2026 Edition, April 2026.

but also have kept electricity bills affordable relative to other consumer goods.

> *Roughly one quarter (21%-33%) of transmission and distribution infrastructure investment is driven by **adaptation, hardening, and resilience (AHR)** initiatives.*

A growing share of utility investment is specifically targeted toward resilience and risk mitigation. Approximately 21% of transmission investment and 33% of distribution investment is directed toward adaptation, hardening, and resilience (AHR) initiatives, including undergrounding lines, strengthening structures, and relocating critical equipment.[31] These investments reflect an increasing focus on preparing the grid for more frequent and severe extreme weather events, as well as emerging physical and cybersecurity threats. Industry surveys reinforce this trend, with a large majority of utility executives identifying transmission and distribution upgrades, resilience, and cybersecurity as top strategic priorities.[32]

Utility investment also reflects a broader shift toward building a more flexible and resilient system. Capital is being deployed across a wide range of infrastructure categories, including transmission expansion, distribution upgrades, and customer-sited resources to make the grid more resilient and to meet demand. Transmission spending has nearly tripled since 2003, while distribution investment has increased by more than 160%, with significant investments to serve customers in lines, substations, transformers, and emerging technologies such as distributed energy storage.[33] These investments are improving the system's ability to operate under more dynamic conditions while maintaining reliable service.

At the same time, investment strategies vary across regions based on local risk profiles, system configurations, and market structures. In some regions with organized wholesale markets, resource adequacy is supported through market-based mechanisms that incentivize new entry and retention of generation resources. In vertically integrated regions, utilities address reliability and resource adequacy needs through long-term planning processes, such as integrated resource planning. This approach has a long track record of supporting reliability because it places clear accountability for serving load on a single entity with an obligation to serve, and it enables utilities to make multi-year commitments across generation, transmission, and distribution rather than relying on decentralized market-based decisions.[34]

Federal initiatives are complementing utility-led investments. Recent efforts administered through the DOE's Office of Energy Dominance Financing emphasize hardening critical infrastructure,

31 EEI, Adaptation, Hardening, and Resilience, 2025, available at: https://www.eei.org/issues-and-policy/finance-and-tax.

32 Guidehouse and Public Utilities Fortnightly, State and Future of the Power Industry, June 2025.

33 U.S. EIA, Today in Energy: Grid infrastructure investments drive increase in utility spending over last two decades, November 18, 2024.

34 Borenstein, Bushnell, and Mansur characterize the two approaches as such: "In the past, vertically integrated monopoly utilities have ensured that supply is adequate to meet demand and maintain grid stability, but with deregulation of generation, assuring adequate supply has become much more complex. The unique characteristics of electricity distribution means that there are immense potential externalities among market participants from supply shortfalls." The Economics of Electricity Reliability, 2023, at 2.

accelerating deployment of advanced technologies, and improving the grid's ability to withstand and recover from severe events.[35] For example, the Energy Dominance Financing Program (Section 1706) primarily provides loan guarantees and direct lending to large, capital-intensive energy infrastructure projects that expand system capacity, strengthen reliability, or reinvest in existing assets.[36] By lowering financing costs for qualifying projects, these programs can accelerate deployment timelines while enabling utilities to secure financing on more favorable terms, ultimately reducing costs for customers.

Coordinated Industry Action and Proactive Planning Strengthen Grid Reliability and Resilience

Pooled, geographically diverse response capability allows U.S. electric utilities to manage increasingly severe and widespread events without maintaining costly excess capacity year-round.

This effectively transforms resilience from an individual utility attribute into a coordinated, industry-wide capability.

The reliability and resilience of the U.S. electric grid are supported not only by utility investment, but by a high degree of coordination across utilities, system operators, and government partners. This coordinated structure allows the industry to respond to disruptions more effectively, share resources across regions, and plan for emerging risks on a system-wide basis rather than in isolation.

One of the clearest examples of this coordination is the electric utility industry's mutual assistance network, which enables rapid, large-scale restoration following major outages. When disruptions exceed a single utility's local capabilities, utilities mobilize workers, equipment, and materials from across the country to support restoration efforts. For example, more than 65,000 workers from at least 44 states were deployed in response to Winter Storm Fern in 2026, significantly accelerating service restoration.[37]

Industry coordination is further strengthened through formal structures such as the Electricity Subsector Coordinating Council (ESCC), which facilitates collaboration between utilities and government agencies on reliability, security, and emergency response. The ESCC is focused on improving security, reliability, and operational continuity across the bulk power system through coordinated planning, information sharing, and executive-level engagement. Working closely with the Electricity Information Sharing and Analysis Center (E-ISAC), the ESCC supports sector-wide situational awareness, cybersecurity threat sharing, and incident response coordination.[38]

In parallel, proactive planning processes play a central role in strengthening the grid's ability to meet future needs. Regional and interregional transmission planning has evolved to take a longer-term,

[35] U.S. DOE, Office of Energy Dominance Financing, Energy Dominance Financing Program, available at: https://www.energy.gov/edf/energy-dominance-financing-program.
[36] U.S. DOE, Office of Energy Dominance Financing, Title 17 Energy Infrastructure Reinvestment (EIR) Financing, available at: https://www.energy.gov/edf/title-17-energy-infrastructure-reinvestment-eir-financing.
[37] EEI, Reliability, Resilience & Emergency Response, available at: https://www.eei.org/en/issues-and-policy/reliability-emergency-response.
[38] ESCC Overview, available at: https://www.electricitysubsector.org/.

forward-looking approach. FERC Order No. 1920 requires planning regions to conduct 20-year transmission planning assessments and identify cost-effective upgrades to meet future demand and reliability needs. The rule also strengthens coordination between regions and between local and regional plans, recognizing that a more integrated grid improves reliability and lowers costs by sharing resources. This policy shift formalizes a larger role for proactive regional and interregional transmission projects to meet rising demand and enhance grid resilience cost-effectively.[39]

Regional grid operators are also implementing measures to enhance reliability and resilience of the bulk power system under evolving weather, resource, and load conditions. For example, Southwest Power Pool (SPP) has approved separate seasonal planning reserve margin requirements (36% winter and 16% summer) and is modernizing resource accreditation through FERC approved methodologies: Effective Load Carrying Capability for renewable/storage resources and Performance-Based Accreditation for conventional units. SPP also advanced an Expedited Resource Adequacy Study process intended to accelerate qualifying resources to address near-term adequacy needs. Independent System Operator New England (ISO-NE) is pursuing winter energy-security initiatives (including interim compensation constructs and improved energy emergency forecasting/reporting protocols) and publishes the 21-Day Energy Assessment Forecast and Report, a rolling three-week outlook designed to provide early warning of potential energy shortfalls. Midcontinent Independent System Operator (MISO) advanced an Expedited Resource Addition Study process intended to accelerate resource additions and is advancing Long Range Transmission Planning portfolios designed to support system reliability over a 20-year-plus horizon, while also coordinating with neighboring planning regions and implementing seam-related efforts such as joint projects with SPP. The Electric Reliability Council of Texas (ERCOT) is strengthening winter readiness through a structured weatherization and inspection program, expanded firm fuel supply and forecast improvements, and enhanced operational tools such as ancillary services.

Utilities Are Expanding System Capability and Operational Flexibility

Utilities and grid operators are expanding the operational capability of the electric system through improved system monitoring, enhanced planning tools, and the deployment of advanced technologies. These capabilities provide greater visibility into grid conditions, allow operators to anticipate risks earlier, and enable more flexible and efficient system operation under increasingly dynamic conditions.

At the core of these improvements is enhanced system monitoring and situational awareness. Utilities and system operators are deploying advanced sensors, communications systems, and real-time data platforms that provide continuous visibility into system conditions across generation, transmission, and distribution infrastructure. These capabilities improve fault detection, enable faster restoration, and support more informed operational and planning decisions.

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[39] FERC, Transmission Planning and Cost Allocation Final Rule, Docket No. RM21-17; Order Nos. 1920 (May 13, 2024), 1920-A (November 21, 2024), and 1920-B (April 11, 2025).

At the national level, reliability oversight and system awareness are strengthened by the North American Electric Reliability Corporation (NERC), which produces regular assessments of system reliability and emerging risks. By identifying and quantifying emerging reliability issues, NERC is able to provide risk-informed recommendations and support a learning environment for industry to pursue improved reliability performance.[40] NERC's Large Loads Action Plan strengthens electric utility reliability by tackling the risks created by rapidly proliferating emerging large loads (especially data centers and other computational loads) whose size, speed, and sometimes unpredictable nature can stress bulk power system planning and operations.[41] NERC's Extreme Weather Grid Reliability Rules include planning requirements to address long-term extreme-weather risks. Grid planners must incorporate extreme heat and cold scenarios over broad regions and "implement corrective actions as needed," rather than relying on historical averages. Separately, FERC ordered transmission providers to assess their systems' vulnerabilities to extreme weather and report mitigation strategies. Prompted by rising severe weather events, these reforms are intended to ensure planning processes explicitly account for future climate-driven risks and bolster system preparedness.[42]

The Electric Power Research Institute (EPRI) is also supporting resilience on multiple fronts. EPRI's Distribution Grid Resiliency work synthesizes a decade of lessons into a structured, data driven approach for hardening infrastructure, improving vegetation management, deploying modern distribution technologies, and strengthening storm response practices.[43] In addition, EPRI's Climate READi initiative provides a science-based playbook (and a companion navigation tool) for physical climate risk assessment and adaptation planning, including guidance on using climate data, assessing asset vulnerability, and integrating climate considerations into system modeling and investment prioritization.[44] Looking forward, EPRI has also launched the RADAR initiative to modernize how utilities detect, anticipate, and respond to emerging reliability risks in more dynamic grids (e.g., high inverter-based and distributed resources), pairing advanced analytics/workflow improvements with targeted training for utility planners and operators.[45]

Complementing these capabilities, utilities and system operators are adopting more advanced analytical tools and operational frameworks to manage system complexity. These include improved forecasting methods, enhanced resource adequacy constructs, and planning processes that account for a wider range of operating conditions. Together, these tools enable more dynamic system operation while maintaining high reliability performance, even as demand patterns, resource mixes, and risk profiles continue to evolve. Across the transmission and distribution system, utilities and system operators are increasingly deploying a suite of tools ranging from GETs to advanced sensors, digital controls, and distributed resource platforms that collectively increase usable capacity and

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40 NERC Reliability Assessments, available at: https://www.nerc.com/our-work/assessments.
41 NERC Large Loads Action Plan, available at: https://www.nerc.com/initiatives/large-loads-action-plan.
42 FERC, News Release: FERC Finalizes Plans to Boost Grid Reliability in Extreme Weather Conditions, June 15, 2023.
43 EPRI, Enhancing Distribution Grid Resilience: A Decade of Progress and Key Learnings, March 23, 2026.
44 EPRI Climate READi, available at https://www.epri.com/research/sectors/readi.
45 EPRI RADAR, available at https://msites.epri.com/radar.

improve situational awareness.[46] Rather than relying solely on new infrastructure, these investments allow utilities and system operators to extract greater performance from existing assets by leveraging digital tools, enhanced materials, and distributed coordination.

The DOE identifies technologies such as dynamic line ratings (DLR), advanced power flow control, topology optimization, and advanced conductors as GETs that can be deployed on existing infrastructure to improve reliability and efficiency without requiring new rights-of-way.[47] For example, by incorporating real-time weather conditions, DLR can increase line ratings by 10-30% during favorable conditions, while reconductoring with advanced conductors can substantially increase line capacity, sometimes even doubling it.[48] However, experience from early DLR demonstrations shows that realizing these benefits at scale requires overcoming practical implementation challenges, including validating the accuracy and availability of sensor data, integrating dynamic ratings into existing energy management and planning systems, and addressing expanded cybersecurity and communications requirements.[49] Similarly, deploying advanced conductors at scale can be constrained by higher upfront costs, supply chain and equipment availability constraints, and outage requirements or complex live-line work.[50]

The benefits of many GETs, particularly those that rely on real-time conditions, are inherently operational because technologies such as DLR do not always provide firm, continuously available capacity in the way that traditional infrastructure does. Instead, they offer probabilistic or time-varying increases in transfer capability that depend on ambient conditions, system configuration, and operating practices. As a result, while these tools can deliver significant real-time value, they are often more difficult to incorporate into long-term planning processes that rely on deterministic assumptions and firm capacity contributions.[51]

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46 For example, Distributed energy resource management systems (DERMS) and virtual power plants (VPPs) aggregate and coordinate distributed resources such as rooftop solar, battery storage, and demand response to provide system-level services. By enabling visibility and control at the distribution level, DERMS and VPPs enhance load flexibility, support peak management, and provide incremental capacity during contingency events.

47 U.S. DOE, Advanced Transmission Technologies Report, December 2020.

48 Idaho National Laboratory (INL), A Guide to Case Studies for Grid-Enhancing Technologies, December 2022; and Advanced Conductors Scan Report, September 2024.

49 U.S. DOE, Dynamic Line Rating Systems for Transmission Lines, April 2014.

50 Energy Innovation Policy & Technology LLC, Supporting Advanced Conductor Deployment: Barriers and Policy Solutions, April 2024.

51 PJM reiterated this point in multiple comments filed with FERC. For example: "[T]he Commission's focus should be on noting DLR's operational benefits in certain defined circumstances rather than as a broad planning solution that somehow obviates the need for long term regional transmission planning, most especially reliability criteria-based transmission planning." Motion for Leave to Comment and Supplemental Comments, at 2, FERC Docket No. AD22-5-000 (Jan. 17, 2024).

SECTION 5:

GRID CONNECTED LARGE CUSTOMERS PROVIDE ADVANTAGES

Connecting New Large Loads to the Grid is Beneficial to All Customers

Off-grid systems are typically more expensive and less reliable than grid connected service.

After decades of near-flat electricity demand, U.S. power consumption is now growing rapidly. For many years, electricity use increased by less than 1% annually. Since 2022, however, growth has accelerated sharply, with forecasts projecting demand rising by more than 5% per year through the end of the decade.[52] This shift is driven by two primary groups of large electricity customers.

The first and largest group is digital infrastructure, including traditional cloud computing and enterprise data centers that support general computing and online services, as well as data centers specifically supporting artificial intelligence. Data center facilities account for roughly half of all projected new electricity demand. The second group includes industrial and electrified load, such as advanced manufacturing, semiconductor and battery plants, oil and gas operations, and electrification of transportation.[53]

The rapid growth of large load presents both challenges and opportunities for the U.S. power system. Today's grid planning and interconnection rules were largely developed during decades of slow demand growth and are now being updated to respond to the surge in electricity demand driven by the data center boom. This transition has created an initial mismatch between how quickly large loads are developed and the time required to plan, permit, and build grid infrastructure.

In response, some large load developers are exploring off-grid systems, including private, parallel electricity grids,[54] rather than connecting to the shared electric grid. While these alternatives are sometimes perceived as faster, they often face similar delays due to equipment shortages and permitting challenges. More importantly, off-grid systems are typically more expensive than grid connected service and lack access to the reliability benefits of the diversified grid. They can expose developers and their customers to energy cost shocks when reliant on a single fuel source. In addition, off-grid systems remove large, high-usage customers from the shared cost base – customers that would otherwise help spread fixed costs and put downward pressure on electricity rates for everyone else. At scale, widespread off-grid configurations can further strain finite manufacturing capacity and critical supply chains, increasing the overall cost of serving electricity customers.

A grid connected approach offers a better path forward. When planned carefully, large load customers can help strengthen the shared grid by supporting new investment in power plants,

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52 Energy Systems Integration Group, Historical and Modern Large Loads: Characteristics, Context, and Industry Actions to Meet Grid and Customer Needs, March 2026, at 3.

53 Grid Strategies LLC, Power Demand Forecasts Revised Up for Third Year Running, Led by Data Centers, November 2025, at 4.

54 *See for example*, CATO Institute, The Case for Consumer-Regulated Electricity: Private Electricity Grids Offer a Parallel Path to Energy Abundance, February 2026.

transmission lines, and modern grid technologies. Their steady and predictable demand improves the efficient use of existing infrastructure and allows costs to be spread across more customers. Furthermore, large loads benefit directly from grid connection through lower long-term costs, greater reliability, stronger protection during outages and extreme weather, and access to a wide and diverse mix of energy resources.

Large Loads Share Grid Costs and Support Grid Modernization

When new large loads are added to the grid through careful planning and fair cost-sharing arrangements, they can strengthen the electric system and deliver broad benefits to all customers. Large loads expand the customer base over which the fixed costs of generation, transmission, and distribution are recovered, helping spread costs more efficiently across the system. Because these customers often use electricity steadily and at high levels, they make better use of existing infrastructure, improving efficiency and helping to put downward pressure on electricity rates for existing customers.

For example, a recent agreement between a utility in the southern U.S. and its regulator includes provisions that guarantee annual rate reductions of more than $100 for existing customers.[55] Other utilities have announced data center agreements that require large customers to share in storm recovery cost and to help fund state-of-the-art new generation and reliability-driven backbone transmission investments.[56] State regulators in nearly half of U.S. jurisdictions have already approved large load tariffs for new customers, and many regulators that haven't are actively considering doing so.

Beyond cost sharing, growth in large loads can also help modernize the electric grid. The scale of these customers can justify investments in new transmission lines, substations, and modern grid technologies that improve real-time monitoring, automation, and control. These upgrades are essential to support electrification, accommodate future growth, and keep the system reliable as demand increases.

Additionally, once large loads have demonstrated they can offer flexibility to the grid, that flexibility can serve as a grid asset in integrating large load customers and optimizing grid performance. Established approaches, such as demand response and on-site generation can enable large loads to actively respond to system conditions and provide operational value to the grid. When load behavior is well understood, performance obligations are enforceable, and costs are allocated correctly, load flexibility can unlock existing system headroom, support faster interconnection timelines, and reduce near-term infrastructure needs.

A stronger grid supported by new technologies and enhanced load flexibility benefits everyone by reducing the risk of outages, improving recovery from extreme weather events, and enhancing

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[55] Georgia Power Co., Stipulated Agreement Reached to Help Keep Electricity Affordable and Meet Future Energy Demand in Georgia, December 10, 2025.

[56] Entergy Corp., Entergy Announces $5B in Customer Savings Delivered by Data Center Agreements; Issues "Fair Share Plus" Pledge, March 5, 2026.

overall system performance. By ensuring these large loads are integrated transparently and pay their fair share, they can serve as catalysts for a more reliable, resilient, and cost-effective electric grid.

Off-grid Systems Raise Costs and Weaken System Resilience

Large load growth is beneficial because it allows investments to be recovered over a larger customer base.

As discussed earlier in this report, the need for capital investment is increasing even without large loads, due to added system complexity and increasing extreme weather, among other reasons. Grid connected large loads typically help support the fixed costs of maintaining and modernizing the system. Large load growth is beneficial because it allows investments to be recovered over a larger customer base. When large load customers opt out, that contribution is lost, while the need for system upgrades remains. In other words, when large loads operate off-grid, a greater share of fixed system costs is shifted onto existing customers, particularly households and small businesses.

Recent analysis underscores the magnitude of this impact. A recent Concentric report[57] estimates that if large load customers do not pay their share of fixed grid costs, the resulting cost shift to other customers could total between $120 billion and $169 billion over a 30-year period nationwide – and this estimate reflects transmission costs alone. Additional cost shifts associated with generation and distribution investments would further increase the burden on grid connected customers.

If large load customers do not pay their share of the fixed costs, the resulting cost shift to other customers could total between $120 billion to $169 billion over a 30-year period nationwide.

Beyond cost impacts, off-grid development by large loads raises significant concerns from an efficient resource-allocation perspective. An off-grid approach fragments the energy system and requires individual customers to self-provide a level of reliability that the shared grid delivers more efficiently at scale. To ensure reliability on their own, off-grid customers must build substantially more on-site generation and storage – often 70%[58] or more above peak demand – than would be required if they were connected to the grid. A grid-interconnected customer, by

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[57] Concentric Energy Advisors, Inc., "The Risks of Cost Shifts in Serving Large Loads Under a Framework with Direct Allocation of Transmission Costs," March 30, 2026, at 2.
While Concentric's report did not directly examine the transmission cost shift effects of off-grid large loads, it estimated the magnitude of cost shift under a closely related scenario—one in which large loads pay only for directly assigned transmission upgrades, rather than contributing to the grid's shared fixed costs through Network Integration Transmission Service rates. This scenario is a reasonable proxy for off-grid development. Like directly assigned facilities, off-grid systems cover their own incremental costs but do not share in the ongoing fixed costs of the broader grid. As a result, the remaining grid connected customers bear a larger share of system costs, producing a similar cost shift effect.

[58] International Energy Agency, Key Questions on Energy and AI: Executive Summary, April 2026. The IEA analysis finds that supplying reliable on-site, gas-fired power for data centers requires 30%–70% more generation capacity than demand, even when facilities still rely on the grid for critical services such as frequency control, voltage support, and black-start capability. A fully off-grid data center would require even greater over-investment. Without grid support, it would need additional generation, redundancy, and control systems to self-provide reliability and resilience—making true off-grid solutions significantly more costly and inefficient than grid integration.

To ensure reliability on their own, off grid customers must build substantially more on-site generation and storage – often 70% or more above peak demand – than would be required if they were connected to the grid.

comparison, does not need to be concerned with individual generators that need to be offline for regular maintenance. This systematic overbuilding consumes a disproportionate share of scarce global equipment and materials, placing unnecessary strain on already oversubscribed manufacturing capacity and supply chains, where utility-grade electrical equipment producers are operating near full utilization to address a significant infrastructure backlog.

The scale of this inefficiency becomes more apparent when considered in aggregate. S&P Global forecasted approximately 73 gigawatts (GW) of new large load growth nationwide between 2025 and 2033.[59] If even 20% of this projected growth (roughly 14.6 GW) were to develop off-grid, and if combined-cycle gas turbines were used to serve this load, the capital costs would be substantial. At an average cost of approximately $2,000 per kilowatt,[60] building generation sufficient to serve this load on a grid connected basis would require roughly $30 billion in generation investment. However, if these loads were developed off-grid and overbuilt by 70% to ensure stand-alone reliability, generation investment alone would increase to approximately $50 billion.

That additional $20 billion represents duplicative and largely idle infrastructure – capital deployed to serve individual customers that would otherwise be shared across the system and utilized more efficiently. These inefficiencies are particularly concerning in a supply-constrained environment. Critical components such as turbines and transformers can take up to seven years to procure.[61] Off-grid projects tie up limited equipment and highly specialized labor in redundant backup systems that are only occasionally used, placing additional strain on already tight supply chains. This makes it more difficult, and more expensive, for utilities to obtain the equipment needed to maintain and modernize the public electric grid, driving up costs for all customers.

Finally, off-grid systems undermine the fundamental efficiencies of planning and operating the electric system at a regional scale. By isolating large loads from the shared grid, these arrangements reduce the ability to pool diverse resources across locations and technologies, making the overall system more expensive and less flexible. They also increase vulnerability during extreme weather events, when small, self-contained systems are most exposed and lack access to neighboring support.

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59 S&P Global, Garrett Hering & Susan Dlin, Data Center Grid-Power Demand to Rise 22% in 2025, Nearly Triple by 2030, October 14, 2025, According to S&P Global, large load demand nationwide was approximately 61.8 GW in 2025 and is forecast to increase to 134.4 GW by 2030. This represents a nationwide large load addition of 72.6 GW over the 2025-2030 period.

60 GridLab, New Report Finds Rising Cost of New Gas Plants Outpacing Planning Assumptions, September 10, 2025.

61 S&P Global, Jared Anderson, U.S. Gas-Fired Turbine Wait Times as Much as Seven Years; Costs Up Sharply, May 20, 2025, available at: https://www.spglobal.com/energy/en/news-research/latest-news/electric-power/052025-us-gas-fired-turbine-wait-times-as-much-as-seven-years-costs-up-sharply.

Utilities are Building a Faster, Stronger, Grid-Connected Path Forward

The scale of utilities enables investment in new infrastructure and grid-enhancing technologies that optimize the use of existing assets and deliver system improvements more strategically and cost effectively than smaller, stand-alone efforts.

Policy and regulatory frameworks across the U.S. are rapidly evolving to better align the pace of large load development with the timelines required to plan and build grid infrastructure. While on-site generation can be a potential interim solution as projects await full grid interconnection, widespread reliance on off-grid systems is not a durable path forward. Recognizing this, major technology companies such as Amazon are actively partnering with utilities to strengthen the grid rather than bypass it.[62] The most effective approach is to modernize planning, permitting, and interconnection processes so the shared grid can accommodate large loads more quickly, while safeguarding reliability and affordability for all customers. Global experience[63] underscores the importance of this strategy. China's massive investment push, streamlined approvals, and all-of-the-above resource approach have enabled it to add generation capacity at an unprecedented pace. Since 2021, China added more generation than the U.S. has added in its entire history.

The U.S. is already acting. Federal initiatives are speeding up permitting[64] and standardizing how large loads connect to the grid[65]. FERC has updated interconnection rules and strengthened long-term transmission planning, while NERC is updating reliability standards to reflect rapid growth in large electricity users. States are also supporting proactive infrastructure investment through integrated resource planning, targeted incentives, and requirements for utilities to develop large load tariffs or other rules and regulations. Utilities and large customers are working together on practical solutions, such as minimum contract terms, phased load growth, and customer contributions to infrastructure, to deliver faster access to power without shifting costs onto other customers.

Across these efforts, a consistent conclusion is emerging: grid connected solutions, supported by modern planning and fair cost allocation, offer the most scalable, reliable, and affordable path for serving large loads. The investor-owned utility business model, in particular, plays a critical role. The scale of utilities enables investment in new infrastructure and grid-enhancing technologies more strategically and cost-effectively than smaller, stand-alone efforts. These investments strengthen grid operations, enhance reliability, and lay a strong foundation for meeting the nation's growing electricity needs. By modernizing and reinforcing the shared electric grid, we create a durable, system-wide solution that can rise to future demand. This path powers sustained economic growth while ensuring electricity remains reliable, affordable, and accessible for all customers.

[62] Matt Garmen, Amazon Web Services, "A responsible path forward for America's energy future," March 4, 2026.
[63] Josh Nye, RBC Global Asset Management, Data Center Power Struggle, April 15, 2026.
[64] H.R. 3898, the Promoting Efficient Review for Modern Infrastructure Today (PERMIT) Act.
[65] PJM Co-Located Load proceeding EL25-49; SPP High Impact Large Load proceeding ER26-247.

SECTION 6:
CONCLUSION

The evidence summarized in this report supports a clear conclusion: the U.S. electric grid is a strategic asset that is being continuously strengthened and modernized through sustained investment, operational improvements, and technology deployment. Grid modernization efforts, AHR initiatives, advanced monitoring and controls, and grid-enhancing technologies are expanding effective capacity, improving situational awareness, and reducing outage risk while enabling faster, more cost-effective integration of new resources. These actions deliver broad, economy-wide benefits:

- Protecting economic productivity and public safety by reducing the frequency and severity of disruptions.
- Improving affordability by leveraging economies of scale, regional coordination, and more efficient dispatch.
- Enhancing national security by sustaining the energy backbone for defense, communications, healthcare, water systems, and other critical infrastructure.

Importantly, all of this implies that the grid's economic value is not captured solely by the price of electricity, but by the avoided costs of disruption across an economy that depends on continuous service.

Connecting new large loads to the grid, rather than pursuing widespread off-grid solutions, creates a cycle of shared benefits. Grid interconnection provides large load customers with superior reliability, redundancy, and access to diverse resources and balancing services that isolated configurations cannot match at comparable cost or risk. Furthermore, large loads can strengthen the grid when integrated through thoughtful planning, phased development, and appropriate cost responsibility.

High load factors improve asset utilization, expand the base over which fixed costs are recovered, and support timely investment in infrastructure and advanced capabilities that benefit all customers. By aligning utility planning, operator processes, and regulatory frameworks around speed-to-power and long-term reliability, the U.S. can serve the next wave of data-driven and industrial growth efficiently.

In summary, the U.S. electric grid is a strategic national asset that enables economic growth, supports national security, and underpins modern life. It is being actively modernized through sustained investment, new technologies, and evolving planning and regulatory frameworks. Connecting new large loads to the grid is the most efficient, reliable, and resilient approach to meeting rising electricity demand. A modern, interconnected grid remains the most scalable platform for reliable power delivery and paired with integrated utility planning, is a foundational enabler of U.S. economic growth and prosperity.

ACRONYM LIST

AHR	Adaptation, Hardening, and Resilience
CAIDI	Customer Average Interruption Duration Index
CISA	U.S. Cybersecurity & Infrastructure Security Agency
CRE	Consumer-Regulated Electricity
DERMS	Distributed Energy Resource Management Systems
DHS	U.S. Department of Homeland Security
DLR	Dynamic Line Ratings
DOE	U.S. Department of Energy
EEI	Edison Electric Institute
EIA	U.S. Energy Information Administration
EIR	Energy Infrastructure Reinvestment
E-ISAC	Electricity Information Sharing and Analysis Center
EPRI	Electric Power Research Institute
ERCOT	Electric Reliability Council of Texas
ESCC	Electricity Subsector Coordinating Council
FERC	Federal Energy Regulatory Commission
GDP	Gross Domestic Product
GETs	Grid-Enhancing Technologies
GW	Gigawatts
ICE	Interruption Cost Estimate
IEA	International Energy Agency
INL	Idaho National Laboratory
ISO-NE	Independent System Operator New England
ISOs	Independent System Operators
LBNL	Lawrence Berkeley National Laboratory
MISO	Midcontinent Independent System Operator
NCEI	National Centers for Environmental Information
NERC	North American Electric Reliability Corporation
NLR	National Laboratory of the Rockies
NOAA	National Oceanic and Atmospheric Administration
RTOs	Regional Transmission Organizations
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SPP	Southwest Power Pool
T&D	Transmission and Distribution
VPPs	Virtual Power Plants