LEK

SPECIAL REPORT

How To Invest in Shoring Up the US Grid

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Introduction

A reliable and resilient grid is one that delivers an adequate, secure and stable flow of electricity to consumers and that withstands, responds to and quickly recovers from major power disruptions. These features of the modern American grid have long been taken for granted by most of the business owners that require a reliable flow of energy.

But the energy sector is currently undergoing a vast degree of change: rising levels of consumer and commercial electrification, a switch from legacy generation assets to an increasingly decentralized set of renewable resources, more impactful and more frequent climate disasters that are disrupting the aging U.S. grid infrastructure via major outages, and an increasing number of heat waves that cause demand peaks and localized demand surges.

These destabilizing developments — which pose significant risks to operational continuity, competitiveness and asset protection — will only become more prominent for U.S. businesses going forward. Ensuring a secure, reliable grid requires investing in its modernization, both by the corporations looking to mitigate the impacts of grid instability on their business and by investors/energy value chain players looking for investment opportunities.

Greener generation, growing demand and an outdated grid

There are numerous components to grid resilience and reliability, from the overall power supply/demand balance and the timing of supply and demand to the location of generation and transmission and distribution assets and the ability of these assets to respond to demand surges, as well as the frequency with which these assets are threatened by climate disasters and the systems underpinning and supporting their safe operation.

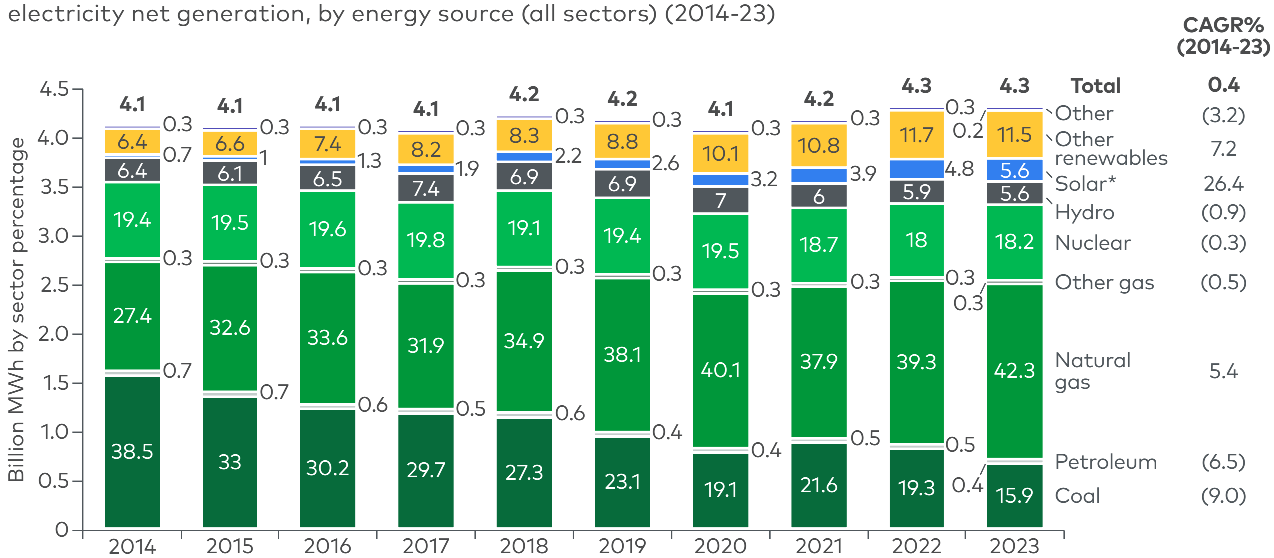
Each of these components, and others not mentioned here, play a role in determining the ability of the U.S. grid to regulate itself. And they are being impacted by three major trends: a switch to green energy generation, the electrification of consumer energy, and the impact of disasters, both human-made and natural.

A switch to greener generation leads to volatility

By far the biggest story in U.S. electrical generation over the past decade has been the switch from fossil fuels (e.g., coal, gas) to renewable energy, primarily solar and wind generation. From 2010 to 2023, the percentage of renewable generation grew from 13.4% to 22.7% (see Figure 1).

Figure 1

US electricity net generation, by energy source (all sectors) (2014-23)



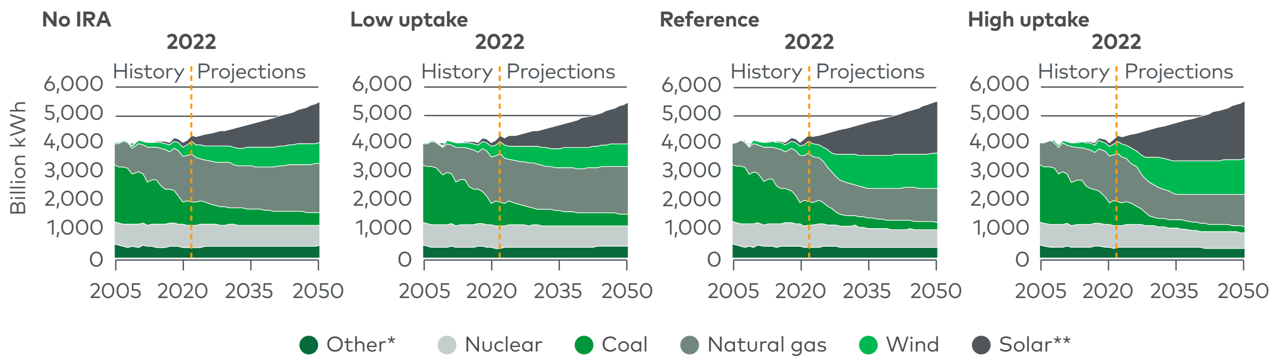
*Solar includes nonutility generation (e.g., residential, construction, industrial)

Note: MWh=megawatt-hour; CAGR=compound annual growth rate

Source: U.S. Energy Information Administration 2023 data; L.E.K. research and analysis

This shift, which is a critical part of federal energy policy, is expected to continue, with the Energy Information Administration forecasting that wind and solar will make up about 48% of U.S. energy generation by 2034 (see Figure 2).

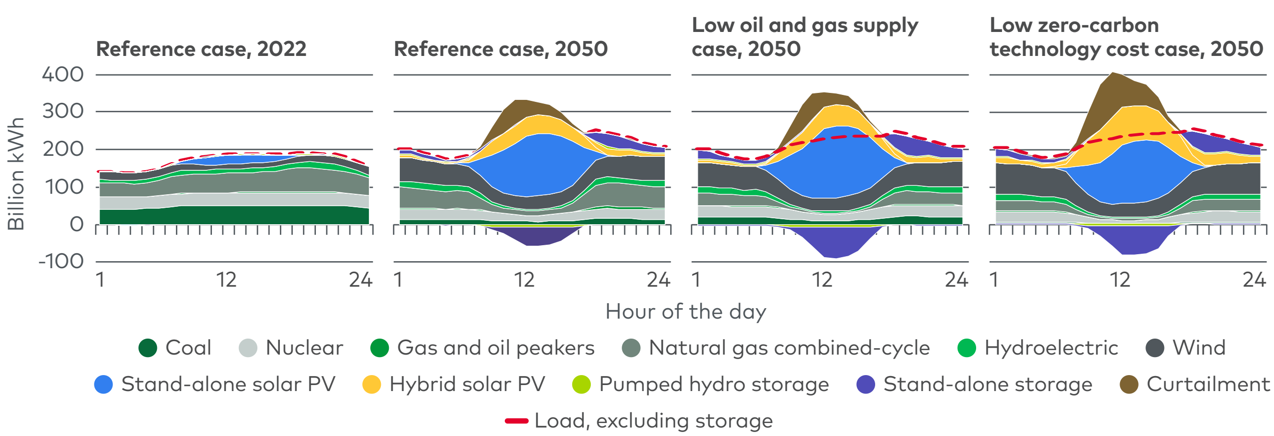
Figure 2
US net electricity generation by fuel



*Other includes petroleum, conventional hydroelectric power, geothermal, wood and other biomass, pumped storage, nonbiogenic municipal waste in the electric power sector, refinery gas, still gas, batteries, chemicals, hydrogen, pitch, purchased steam, sulfur and miscellaneous technologies
**Solar includes utility-scale and end-use photovoltaic generation and excludes off-grid photovoltaics
Note: IRA=Inflation Reduction Act; EIA=Energy Information Administration; kWh=kilowatt-hour
Source: EIA, Annual Energy Outlook 2023 (AEO2023)

While this shift is integral to combating climate change, it creates volatility in daily and seasonal energy supply (see Figure 3).

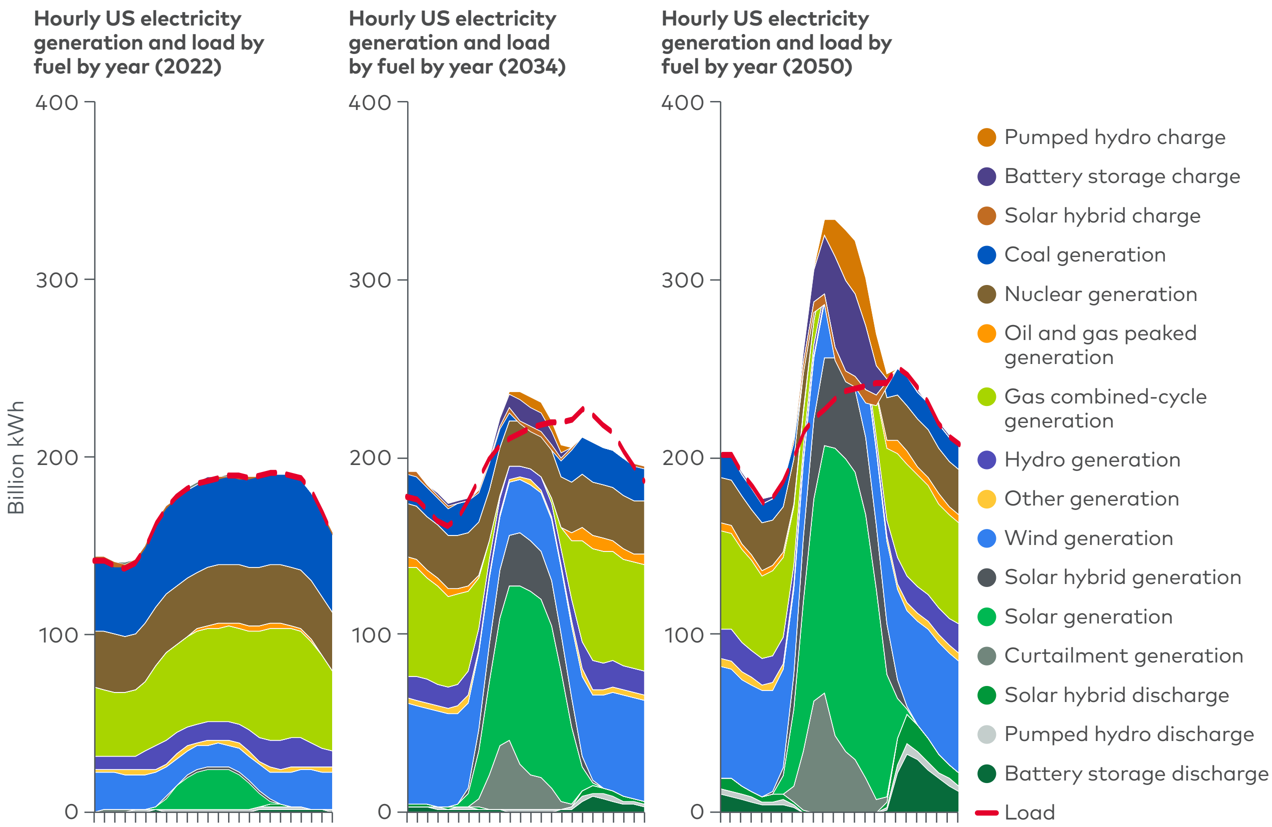
Figure 3
Hourly US electricity generation and load by fuel for selected cases and representative years



Note: Negative generation represents charging of energy storage technologies such as pumped hydro storage and battery storage; hourly dispatch estimates are illustrative and are developed to determine curtailment and storage operations; final dispatch estimates are developed separately and may differ from total utilization as this figure shows; stand-alone solar PV includes both utility-scale and end-use PV electricity generation
Note: PV=photovoltaic; EIA=Energy Information Administration; kWh=kilowatt-hour
Source: EIA, Annual Energy Outlook 2023 (AEO2023)

Unlike large turbine-based generation (e.g., nuclear, coal, natural gas, hydroelectric), solar power and wind power will regularly cease to generate electricity within a daily time series — clouds and nighttime hamper solar generation, while lower winds can slow wind production (see Figure 4).

Figure 4
Overview of hourly US electricity generation and load (2022, 2034 and 2050)

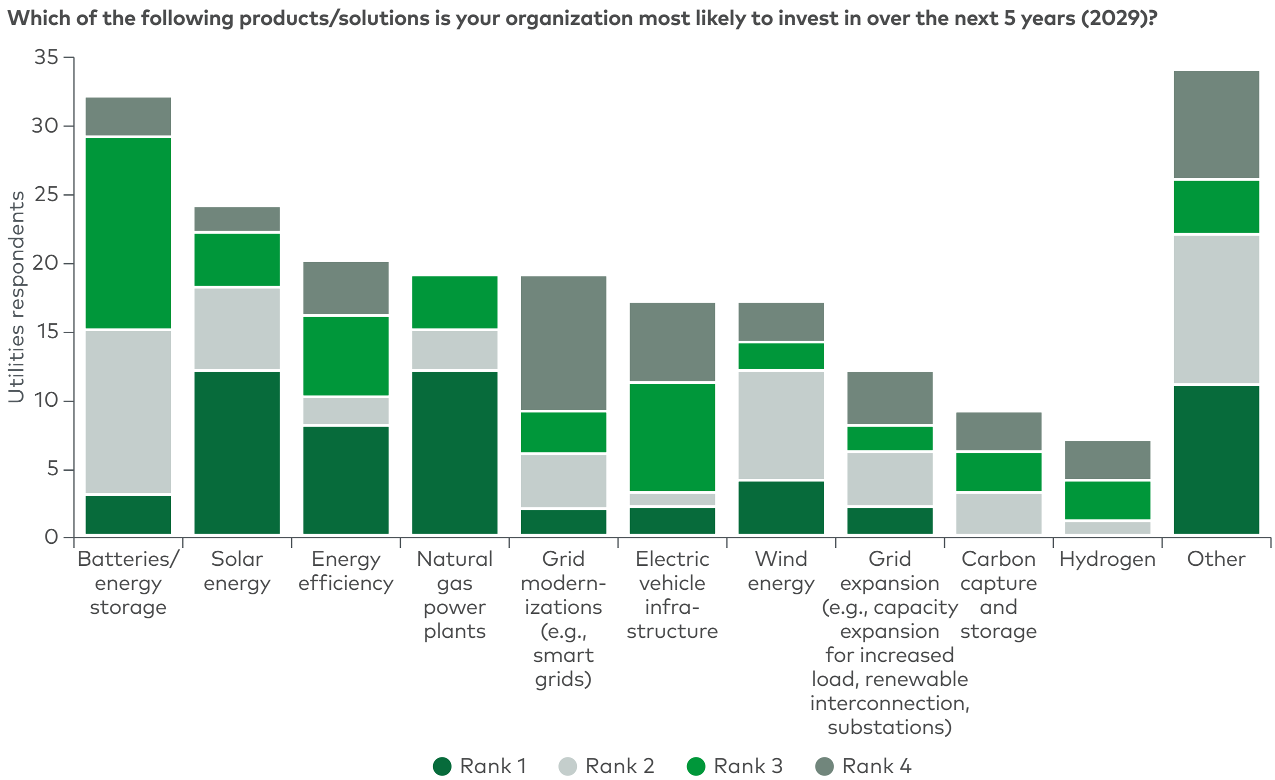


Note: kWh=kilowatt-hour
Source: L.E.K. research and analysis

This intraday volatility has a few knock-on effects, including a reliance on storage technologies (e.g., batteries) to supply power during periods of low generation. With that in mind, utilities companies expect batteries/energy storage to be a primary focus of their investments over the next five years (see Figure 5).

Figure 5

Investments into utilities products/solutions over the next 5 years (2029)



Source: L.E.K. research and analysis

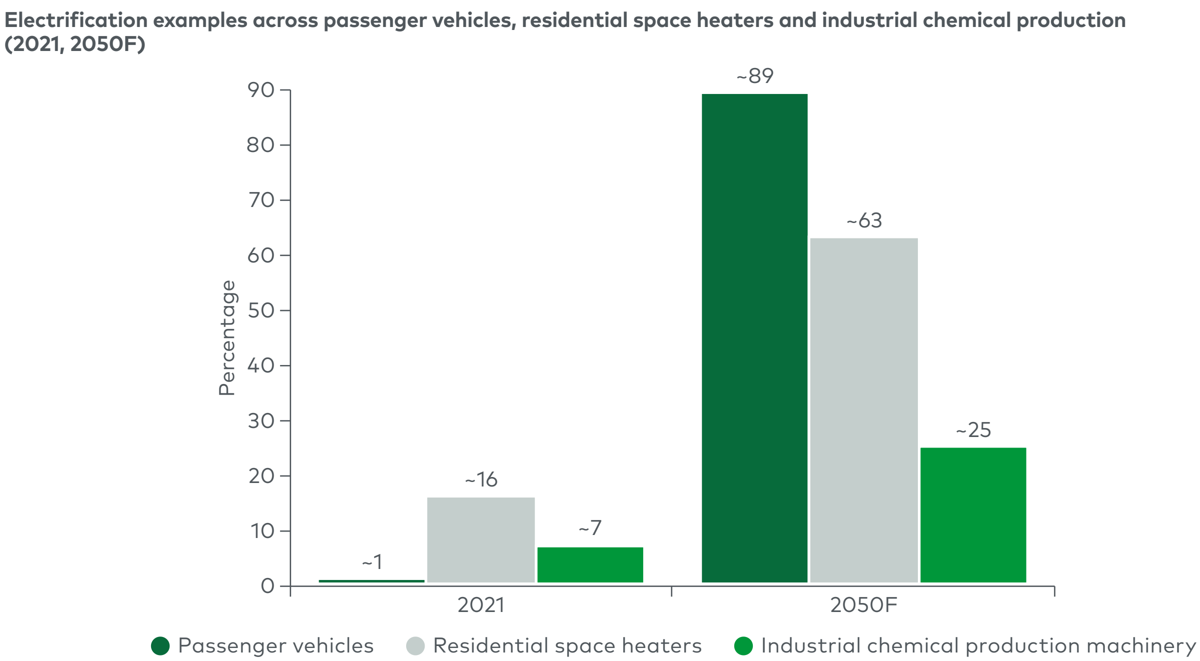
One additional effect of the intraday volatility is the increasing importance of backup fossil fuel power generation, which is used to ramp up output to meet demand spikes. Another is the need to incentivize customers to utilize power when it is available, rather than when they want it.

Despite these issues, the green energy revolution provides opportunities to create a more resilient grid. Generation, once only the purview of large power plants, has become increasingly decentralized, with solar, wind and battery farms finding their way to corporate campuses, city halls and even homeowner rooftops. Managing these decentralized assets is not just an option for the asset owner looking to save money and increase reliability to their own site, but also a critical concern for utilities looking to reliably forecast supply at a local level, utilize and store excess production, and meet energy demands.

Electricity demand — and demand volatility — is increasing

U.S. electrical demand has begun to rise for the first time in nearly two decades due to more onshoring, data center expansion and electrification of both industrial (e.g., factory machinery) and consumer products (e.g., heating/cooling, cooking, vehicles) (see Figure 6).

Figure 6
Overview of US electricity demand (2021, 2050F)



Source: L.E.K. research and analysis

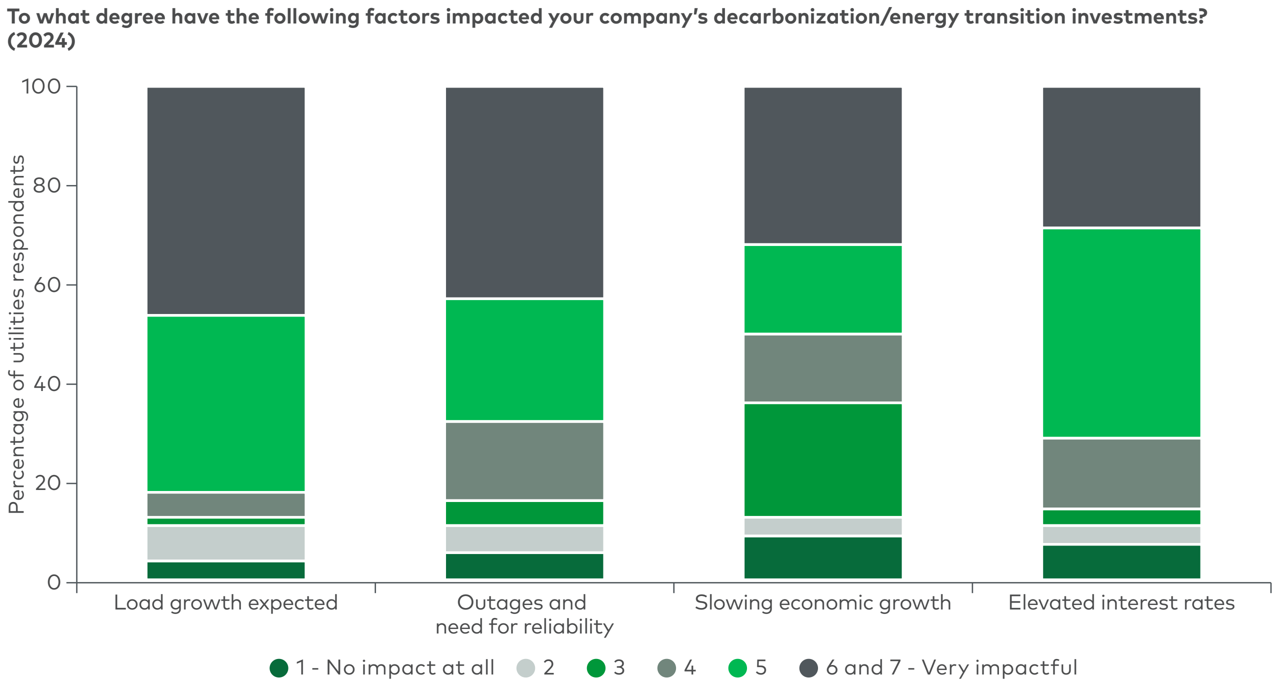
In addition to being a key component of the plan to fight climate change, this electrification drives up electricity demand — and increases volatility — in an already shaky supply environment.

Beyond surges in demand, electrification also contributes to intraday volatility. In a fully electrified scenario, workers return home from their workday and at roughly the same time plug in their cars to charge them and turn on electric heat pumps to heat their homes. In the meantime, both geopolitical tensions and economic realities have increasingly encouraged manufacturers to onshore their facilities to the U.S., leading to higher industrial demand. And the continued build-out of always-on, high-energy data centers is expected to support this escalating demand going forward.

Utilities reflect the impact of demand and volatility growth by citing expected load growth and the need for reliability as the two most important factors impacting their energy transition investments (see Figure 7).

Figure 7

Primary challenges impacting US utilities company investments (2024)



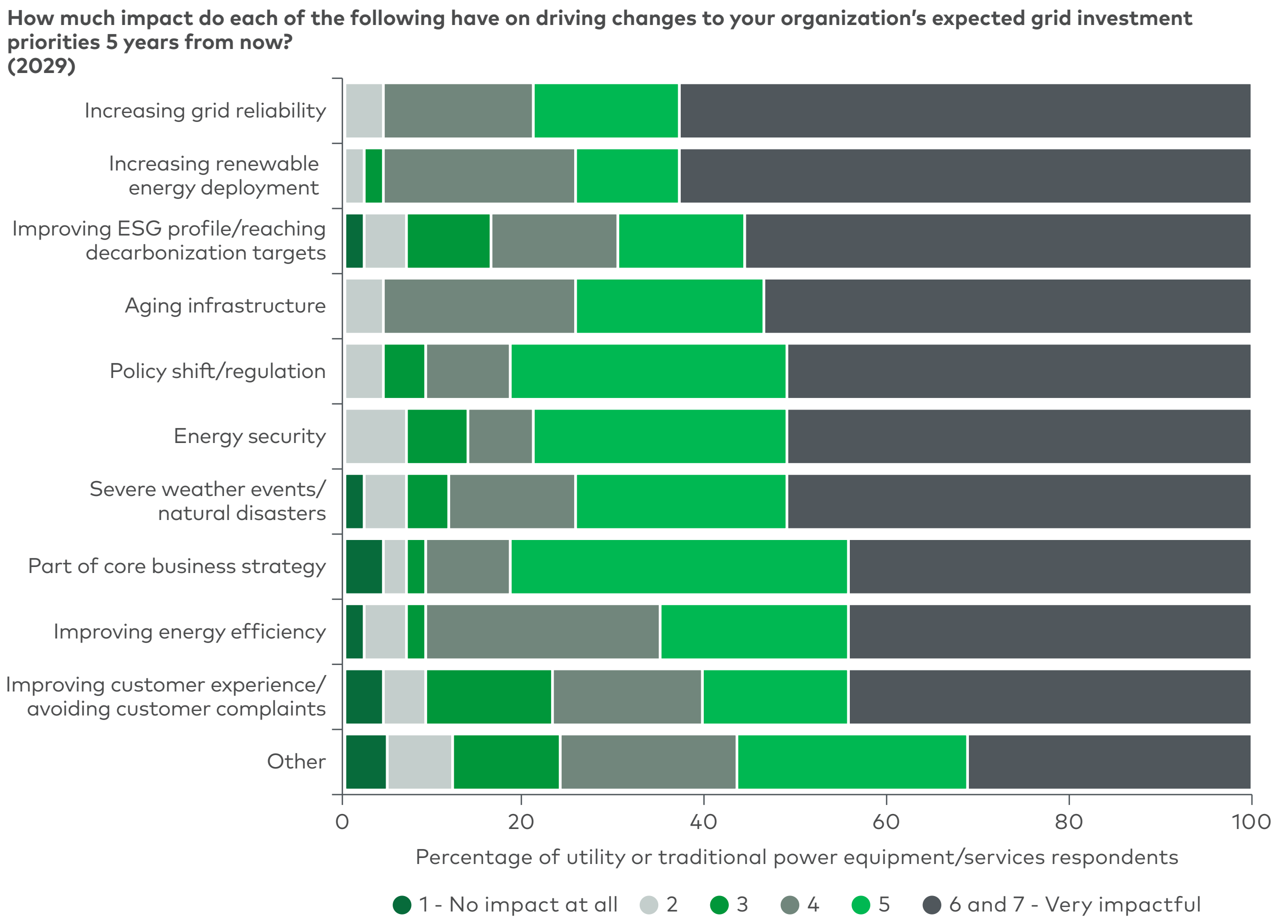
Source: L.E.K. research and analysis

But electrification may also provide some solutions to the problems it causes. For example, while charging car batteries can pose a challenge, these same batteries present an option for drawing power during high-demand times.

The grid is increasingly old and inflexible

Meanwhile, the grid, like much of America's infrastructure, is simply old. According to the Department of Energy, 70% of it was built more than 25 years ago. Indeed, utilities cite grid reliability and aging infrastructure as primary drivers of their investment priorities over the next five years (see Figure 8).

Figure 8
Primary drivers impacting future US utilities company investments (2029)



Note: ESG=environmental, social and governance
Source: L.E.K. research and analysis

Additionally, poor grid interconnections (e.g., between the Texas grid, aka ERCOT, and the rest of the country) pose challenges to managing power demand with available supply.

Grid-related disasters have huge economic costs

In recent history, the price of natural and human-made disasters has been steep, in the form of billions of dollars in economic costs and damages to the grid.

The 2021 Texas winter storm-related power outage, for example, which stemmed primarily from the state's unpreparedness for extreme cold weather conditions, was exacerbated by the inadequacies of its independent power grid. The outage caused widespread disruptions, including water supply issues, food shortages and the loss of heating in freezing temperatures. It posed significant risks to public health and safety, ultimately leading to 210 deaths, as well as an estimated $80 billion to $130 billion in damages along with broader economic repercussions.

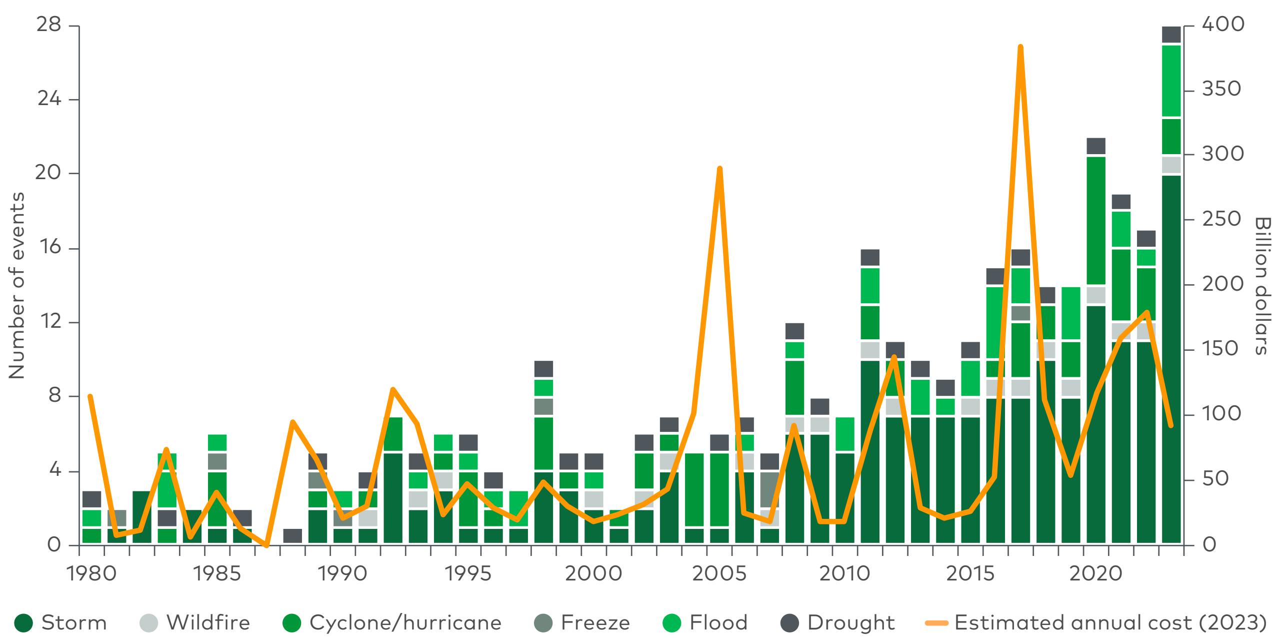
Other grid-related disasters have included the Northeast blackout of 2003, the Great Southwest Blackout of 2011 and the 2012 derecho blackout in the Midwest, which together resulted in more than $10 billion in economic losses.

The risk of grid-related disasters is increasing

Expanding and aging infrastructure coupled with increasingly extreme weather and geopolitical risk mean the potential for disasters and subsequent power outages is only rising.

The number of all-cause natural disasters resulting in economic costs of $1 billion or more trended consistently upward from 1980 to 2023 as climate change brought about increasingly extreme weather, including freezing temperatures in historically temperate climates, high numbers of hurricanes and prolonged droughts that heighten the chance of wildfires (see Figure 9).

Figure 9
US number of billion-dollar weather and climate disaster events (1980-2023)



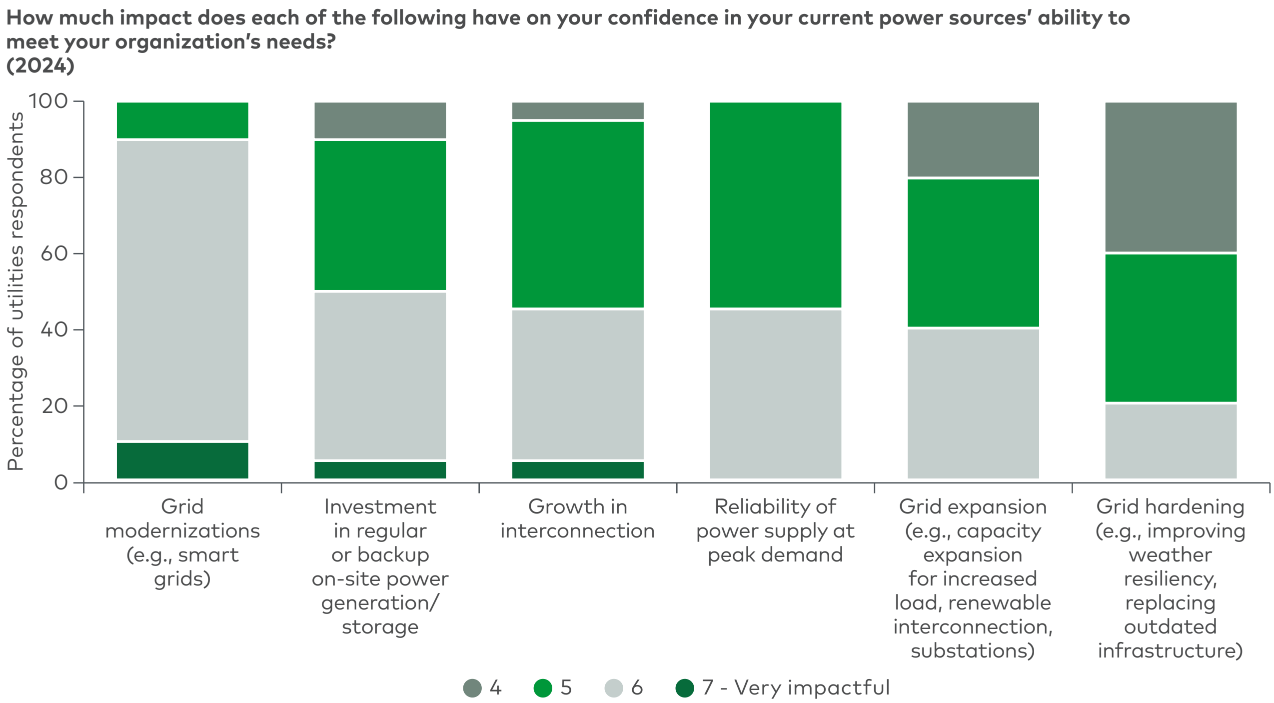
Source: L.E.K. research and analysis

Cyberattacks are an additional threat to grid resilience, especially as geopolitical tensions rise with sophisticated state actors such as China and Russia. According to the North American Electric Reliability Corp., the number of potential software and hardware weaknesses in the U.S. grid has grown in recent years, to an estimated 23,000-24,000 in 2023. This is only expected to continue unless work is done to mitigate and harden these critical aspects of the energy infrastructure.

What the grid will look like in 10 years

Currently, data center operators cite grid modernization as the most important factor affecting their confidence in their current power sources' ability to meet their organizations' respective needs (see Figure 10).

Figure 10
Primary factors impacting US utilities company needs



Source: L.E.K. research and analysis

With that in mind, the U.S. grid may look quite different in 10 years than it does now, with significantly more renewable energy, more reliance on storage capacity and more demand than ever before. The impacts on the grid — and its resilience — will be significant.

To start, energy demand will surge due to onshoring, data centers and electrification. Currently, daily electricity generation is forecast to rise by approximately 15%, with growth in the number of data centers expected to be highest along the East Coast and in Texas and the Northwest. That demand will be met by new, more diurnal and volatile generation sources, namely solar and wind, while natural gas and coal plants simultaneously come offline. Solar and wind generation is expected to increase by approximately 350% and 150%, respectively, while coal is forecast to decline by roughly 60%.

All of this, in turn, will put a greater reliance on storage as a driver for stability. Demand will become increasingly localized, and software solutions will be used to forecast and balance supply and demand. Energy storage is not currently projected to provide enough energy during off-peak solar hours, and battery development lags renewable energy generation, so the U.S. will need further technology advances in energy storage — including long-term energy storage — to meet any excess power demand. And weather- and bad actor-related outages will continue to rise and put more pressure on an already aging grid, so investment in infrastructure, transmission and distribution will be necessary to adapt to these events (e.g., Hurricane Beryl).

Strategic actions to take and investments to make

In light of the current concerns about the reliability and resilience of the grid, there are specific steps that both corporations looking to shore up the reliability of their businesses — and make good on their environmental, social and governance (ESG) commitments — and funds and other investors looking for investment opportunities can take.

How energy-dependent corporations can help ensure a reliable electricity supply

To shore up their electrical supply, companies that are energy-intensive and/or depend on a reliable source of energy should pursue microgrid development (e.g., on-site/local energy storage and generation). Currently, roughly 44% of data center operators expect to use on-site solar as their primary power technology in 2029 compared with roughly 10% today.

They should also seek to work with partners (e.g., electrical utilities) on further behind-the-meter investments and should find ways to balance their system solutions, such as by enclosing all nonpanel components of their solar energy-generating photovoltaic systems.

They should leverage load management services as well as systems and software to align their electricity usage with peak power generation, and automate all heating, cooling and electrical usage within their building systems. Energy generation management and storage solutions will enable them to maximize the benefits of microgrids/on-site solar generation, in particular when it comes to data centers.

Expert advice is another route they can take, in the form of data and advisory services such as energy usage and generation consulting, as are decarbonization initiatives and investing in ways that lower institutional power demand overall.

The transforming grid requires investment — and offers the potential for increased profit

These critical grid issues also present opportunities for investors and energy value chain players alike to create positive changes in the future U.S. grid, via a multitude of different avenues.

Substations — to harden the grid and ensure that it's safe from both natural and human-made disasters, as well as to modernize the components. That includes shoring up any or all of the substations' individual components, such as:

- **Power transformers**, the electrical instruments used in transmitting electrical power from one circuit to another without changing the frequency. Investment in transformers will be imperative for grid modernization: About 90% of consumed U.S. power passes through high-voltage transformers, and an estimated 70% of the country's transformers are at least 25 years old.
- **Switchgear**, the electrical disconnect switches, fuses and circuit breakers used to control, protect and isolate electrical equipment. Together those components ensure undisturbed interconnectivity, higher capacity and enhanced reliability, which are key to grid modernization.
- **Meters**, frequency changers, bus bars, insulators, capacitors, etc.
- **Substation support structures**, the materials, equipment and structures necessary to build and operate grid infrastructure. Materials (e.g., steel) and construction offer the most notable investment opportunities in this category.
- **Security**, etc.

Line and line-adjacent equipment — to further weatherproof and build out the grid, subsequently increasing reliability and interconnectivity.

- **Line switchgear**, electrical devices that control, protect and isolate power systems and, in the process, boost the reliability, capacity and interconnectivity of those systems.
- **Transmission line insulators**, essential components of grid equipment (such as overhead power lines, electrical transformers, circuit breakers) that increase safety and reduce leakage.
- **Ground wires**, conduits, high- and low-voltage cables, etc., as well as line hardware, towers and poles — all equipment and structures necessary to support the more than 5 million miles of power lines in the U.S.
- **Distribution transformers**, electrical devices that convert high-voltage electricity from the power grid into lower-voltage electricity for everyday use.

Utility services

- **Construction services**, and engineering and design, which are necessary to support the increasing electrical load handled by the U.S. grid.
- **Field services**, testing and inspection, on-site services integral to both everyday

maintenance and the management of extreme weather events.

- **Software support systems**, including automated checks, drones, protection and control services, etc.

Battery development

Behind-the-meter equipment

- **Reliability solutions**, the generators, batteries, energy and storage equipment necessary to supplement and back up renewable energy solutions such as wind and solar.
- **Power conversion/distribution systems**, which act as intermediaries between energy storage systems and the power grid and which will benefit from growth in the battery market.
- **Balance-of-system solutions**, which encompass all nonpanel components of photovoltaic systems, which are used to generate solar energy.
- **Electric vehicle (EV) charging infrastructure**, which is necessary to support the proliferation of EVs, whose per annum growth is expected to be approximately 18% through 2028.

Behind-the-meter services

- **Demand-side management**, systems and software used to align electricity usage with peak power generation.
- **Building systems/automation**, including heating, ventilating and air-conditioning; fire; and security systems for the more than 100 million buildings in the U.S.
- **Data center services**, including cooling systems, backup power, etc., and all associated maintenance used to minimize data center downtime.
  The capacity of data centers, which use vast amounts of energy, is expected to grow by approximately 14% annually through 2033.
- **Energy solutions**, including distributed solar and battery storage, which are key components of renewable energy.
- **Energy management services**, which manage energy generation and storage for microgrids/on-site solar generation and which are growing in popularity among high energy users (e.g., data centers).
- **Data and advisory services**, such as carbon tracking and management, which are becoming an increasingly important focal point of corporate ESG reporting.

Production and control of decentralized generation assets

- **Virtual power plants**, systems that integrate decentralized energy-producing assets such as solar panels and wind turbines (i.e., primary renewable energy sources) to supply appropriate amounts of energy to the grid.
- **Decentralized energy resource management systems**, in particular those that manage primary renewable energy sources such as solar panels and wind turbines.

Conclusion

The raft of factors putting pressure on the U.S. grid now are set to continue unabated going forward. But there are a multitude of areas where both corporations and investors/energy chain players could invest that would measurably improve the grid's stability — and generate profit.

For more information, please contact us.

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