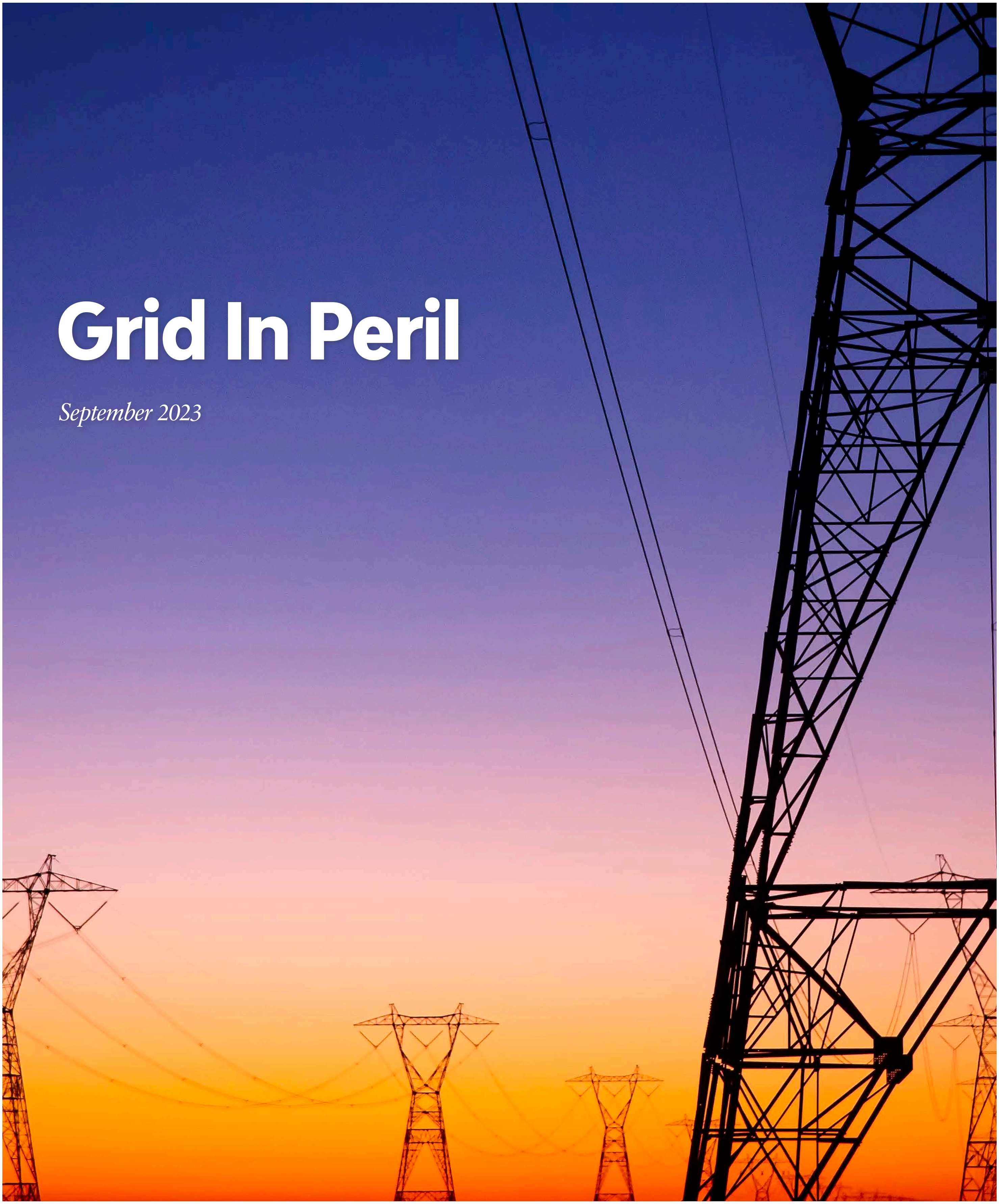


Grid In Peril

September 2023

SAFE | Grid Security Project

Executive Summary

The United States' electric power grid continues to experience significant risks that threaten its ability to provide reliable and resilient electric power. Over the last several years the grid has experienced cyber and physical attacks, blackouts as a result of climate change and weather phenomena, and generation and transmission deficiencies which threaten the ability of the grid to meet existing and future demand.

As the United States continues to electrify its transportation system and works to reindustrialize its economy, the demands on the power grid will be significantly greater than they are now. New wind and solar resources will replace older fossil units but will also require incremental transmission capacity to reliably move electrons from the source to markets and load centers. Fossil resources will still be needed to meet peak demand, but may not be compensated effectively if their operating time becomes significantly reduced as a result of an increase in renewable sources. Abundant and reasonably priced sources of electricity will be needed to compete on the world stage and ensure that the United States is able to effectively reindustrialize our economy. Our current policies are failing us and are not adequate to overcome the significant challenges that we face. SAFE supports the following to effectively manage the imminent risks to power grid reliability:

- Cyber security and physical attacks of power grid infrastructure have already demonstrated that the power grid can be taken down from cyber or physical attacks. The United States must bolster its cyber security defense systems to counter the rise and severity of attacks.
- Additional infrastructure to meet both demand and reliability requirements. SAFE supports additional permitting reform to ensure that requisite infrastructure needed for power grid reliability is expedited.
- During the mid-transition years toward a low carbon grid, fossil-fired resources will be needed for reliability. Market structures must adequately compensate generators for the reliability and resilience attributes that they are providing. As emerging technologies for distributed generation, small modular nuclear reactors, distributed battery storage, and other peaking products are developed, policies must be implemented to compensate these resources for the reliability services they are able to provide.
- Transmission must be built out efficiently, effectively, and competitively to bring the energy from new renewable resources from wind and solar rich areas to load and population centers. SAFE will support activities and legislation that will streamline siting and permitting processes to allow for more expeditious buildout of the necessary infrastructure, as well as the interregional transfer capability needed to meet our transmission needs for a reliable power grid.
- The ability to transfer power across regions minimizes disruptions and black-outs and optimizes least cost dispatch to ensure that reliability is increased and costs are decreased. As a result, SAFE supports the build out of the nation's transmission system to support inter-regional transfers of power across the U.S. interconnections as well as within them.
- SAFE supports a more effective approach to transmission permitting that includes the ability for the Federal Energy Regulatory Commission (FERC) to use the power it has while ensuring state and local authorities' jurisdictional review processes are honored.

FORT WORTH, TX - FEBRUARY 16: Pike Electric service trucks line up after after a snow storm on February 16, 2021 in Fort Worth, Texas. Winter storm Uri brought historic cold weather and power outages to Texas as storms swept across 26 states. (Photo by Ron Jenkins/Getty Images)

Introduction

A reliable power grid is the most critical infrastructure needed for economic growth as well as national security, yet our power grid is failing us. Electricity is our lifeblood. It creates economic opportunity, improves the quality of our lives, and enables the modern digital economy. Its importance is reflected by the National Academy of Engineering's selection of the electrical grid as the greatest engineering achievement of the 20th century.[1]

Given electricity's central role in modern life, the electric power system must be as reliable, safe, secure, and resilient as possible. Yet, the risks to the grid from natural, human-caused, and political disruptions, increasing demand, and an evolving portfolio of generators appear to be growing. Dependence on the grid penetrates deep into the heart of our digital economy which touches nearly every aspect of our lives, and is becoming even more central to new revolutionary technologies, such as the acceleration of electric vehicle adoption, which is expanding reliance on the grid into the transportation sector.

The threats to the grid are increasing, from rolling blackouts in California due to uncontained wildfires, to the unprecedented heat that has undermined reliability in the Northwest, to the cyber-attack on the Colonial Pipeline, to the devastating grid failure during the February, 2021 Texas cold snap.

It is time to act, but the question remains, what to do? Cybersecurity and reliability policy in the energy sector is as complicated as the industry itself. The grid is overseen and regulated by a patchwork of federal, state, and regional authorities, each with their own regulations and priorities. The sector has a tendency of focusing on the last problem and failing to look forward to future problems that will arise as the grid evolves through a period of unprecedented change. The country must not simply revisit past battles, but must also prepare for the challenges that lie ahead.

Moreover, policies supporting power generation and transmission have proliferated in recent years—both in words and in practice—in the name of grid reliability, resilience, national security, and sustainability. But these issues have been politicized, which has increased the difficulty of addressing issues that are already complex. The Trump Administration Department of Energy's (and several states') proposal(s) to subsidize nuclear and coal power plants to enhance reliability attracted criticism for serving as a bulwark for fossil fuel, which obscured the underlying conversation about the need for greater reliability and resilience.[2] More recently, the Biden Administration's steadfast commitment to a generational investment in renewable power and establishment of a goal that the grid be emission free by 2035,[3] and the transmission grid to support development of a low carbon grid, overlook the critically important role of dispatchable power in operating a reliable grid.[4]

The challenge that we face today in the electric power sector is acute. But its roots lie a century ago as the regulatory structure governing the electric power sector was developing. Key policy decisions back then affected the physical development of the transmission grid. And the progeny of the infrastructure on which our great-grandparents once relied is increasingly inadequate to serve as the foundation of today's modern economy.

1 Wm. A. Wulf, "Great Achievements and Grand Challenges," The Bridge, Vol. 30 at 6 (Fall/Winter 2000).

2 Steven Mufson, "Trump Orders Energy Secretary Perry to Halt Shutdown of Coal and Nuclear Plants," Washington Post (June 1, 2018).

3 "Fact Sheet: President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target Aimed at Creating Good-Paying Union Jobs and Securing U.S. Leadership on Clean Energy Technologies," The White House (Apr. 22, 2021).

4 See, e.g., M. Baroni, "The Integration of Non-dispatchable Renewables," in M. Hafner and G. Luciani, "The Palgrave Handbook of International Energy Economics," (2022).

Background

Nearly a century ago, Congress passed landmark legislation that effectively shaped the electric power sector.

Electric power utilities historically developed as vertically integrated firms that typically generated and distributed power to their customers. As companies grew to take advantage of economies of scale, they were often acquired by holding companies, that operated across state lines, perhaps to evade state rate regulation which did not, at the time, extend to companies engaged in interstate commerce. In 1935, concerned about power companies' growing power, Congress passed legislation that subjected electric power holding companies to federal regulation and limited power companies' ability to merge with other utilities that served contiguous areas.[5] As a result, the grid developed largely as a series of vertically integrated utilities that operated within a single state with relatively weak physical connections to the grids in adjoining states. The grid connections that did exist were intended primarily to enhance reliability but not to transmit large volumes of power between utilities. Utilities typically shipped fuel (coal or gas) to load centers and generated power near consumers, minimizing the need to transmit electricity over great distances.

During the hydropower boom in the 1960s the United States built large long-distance transmission lines. President Kennedy, for example, was directly involved in the development of the Pacific Intertie, a high-voltage, direct-current line that delivers low-cost hydropower generated in the Pacific Northwest to the Los Angeles region.[6] Yet, the transmission system remained generally otherwise unchanged. In one of the early steps that began the transformation of the electric power sector, in 1978, in an effort to promote innovation, efficiency, and renewable power, Congress mandated that utilities purchase power from qualified cogenerators or small renewable power generators at either avoided costs or an agreed upon price.[7]

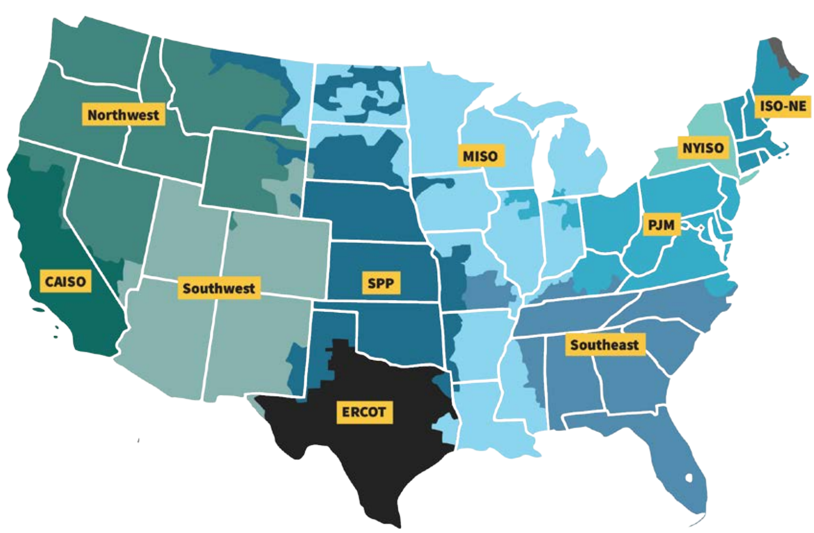
In the early 1990s, Congress made further steps toward a system based on market principles, allowing

5 Public Utility Holding Company Act of 1935, Pub. Law 74-333.

6 Joshua D. Binus, "Bonneville Power Administration and the Creation of the Pacific Intertie, 1958 -1964," Portland State University (2008).

7 Public Utility Regulatory Policies Act, Public Law 95-617.

Figure 1 Electric Power Markets in the United States



Source: FERC

President Franklin Roosevelt, signs the Public Utility Holding Company Act of 1935 (Wheeler-Rayburn Act). It imposed consumer protection regulations on public utilities and was bitterly fought by the industry. Aug. 26, 1935. (CSU Archives/Everett Collection)

non-utility generators to sell power to wholesale customers, competing against traditional utilities.[8] In the late 1990s, the Federal Energy Regulatory Commission (FERC) exercised its authority to mandate open access to the transmission grid so that independent generators had the ability to transmit power to their customers on a non-discriminatory basis, requiring utilities to separate generation, transmission, ancillary services, and offer equal stakeholder access to the electronic information system used to obtain information about the operation of the transmission grid.[9] It then encouraged, but did not require, utilities to join Independent System Operators (ISOs) or Regional Transmission Organizations (RTOs). These new independent entities take operational control of the grid in defined regions, are responsible for short-term reliability, and operate efficient, reliable, and non-discriminatory markets to support grid operations. They also are responsible for tariff administration and design, congestion management, provision of ancillary services, grid planning and expansion, and interregional cooperation.[10]

Since the turn of the century, the electric power system has begun an evolution that is destined to reshape the sector. The 20th century was an age of fossil-based and nuclear power. In 1949, 68 percent of U.S. power was generated from fossil fuels. The supply of fossil fuel-based power grew on a sustained basis until about 2007 when it peaked. In 1957, the year EIA reports the first power generated by nuclear power, fossil and nuclear power generated 79 percent of all power generated in the United States. In 2022, fossil and nuclear power generated 78 percent of all power generated in the United States, though the composition shifted with the share of power generated from coal falling from 55 to 20 percent and the share generated from gas rising from 18 to 40 percent. Petroleum-fueled power fell from 6 percent to about 0.5 percent of all power generated.[11]

The recent shift in the respective shares of coal and gas-fired generation has been stark. In 2006 coal was responsible for 50 percent of all power generation in the United States, and gas was responsible for 20 percent.[12] By 2022, coal had declined by more than half to 20 percent, and gas had doubled to 40 percent.[13] This shift has been driven by several factors. The shale boom has vastly expanded the production of natural gas and its price has fallen. Gas production is up by more than 80 percent since then,[14] and prices have declined steadily.[15] Emission standards have also favored gas over coal, due to its superior emissions profile. At the same time, there has been

8 Energy Policy Act of 1992, Public Law 102-486; 15 USC 79z-5a; 16 USC § 824j.

9 Federal Energy Regulatory Commission, "Order No. 888, Promoting Wholesale Competition Through Open Access Nondiscriminatory Transmission Services by Public Utilities; Recovery of Stranded Costs by Public Utilities and Transmitting Utilities," FERC Statutes and Regulations ¶31,036, 61 Fed. Reg. 21,540 (1996).

10 Federal Energy Regulatory Commission, "Order No. 2000, Regional Transmission Organizations," FERC Statutes and Regulations ¶31,089, at 30,995 (2000), 65 Fed. Reg. 809 (2000).

11 Energy Information Administration, "Monthly Energy Review," at Table 7.2a (Mar. 2023).

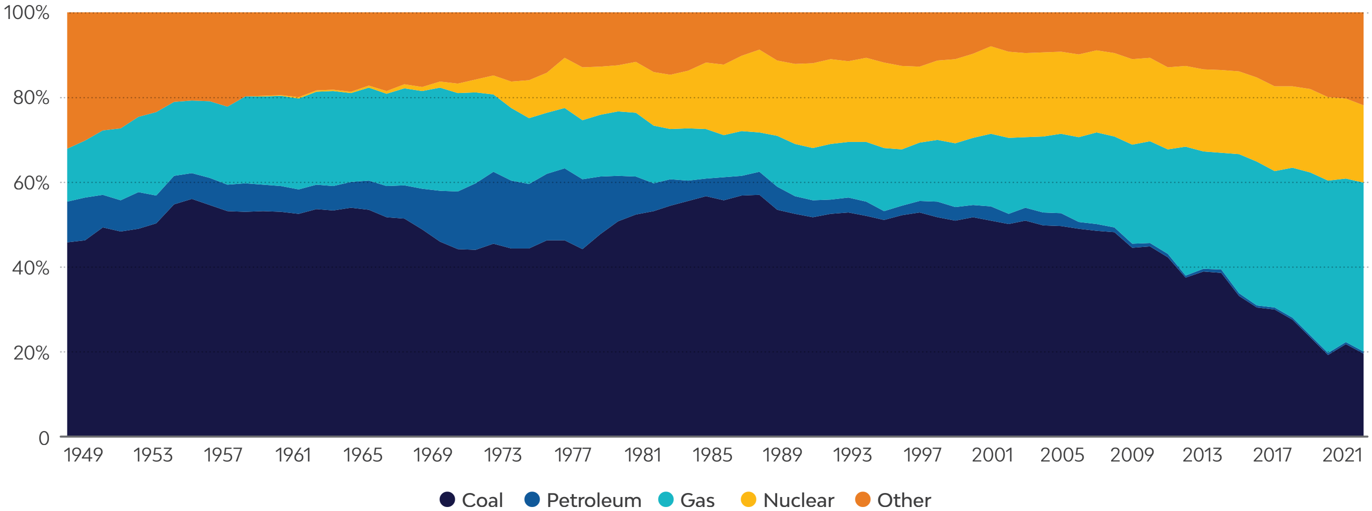
12 Id.

13 Id.

14 Energy Information Administration, "U.S. Natural Gas Withdrawals," available at www.eia.gov/dnav/ng/hist/n9010us2m.htm.

15 Energy Information Administration, "Henry Hub Natural Gas Spot Price," available at www.eia.gov/dnav/ng/hist/rngwhhdA.htm.

Figure 2 Fossil and Nuclear vs. All Other Generation



Source: EIA

a slow decline in the volume of power generated by nuclear reactors. From 1990 until 2019, nuclear power generally held steady, generating about 20 percent of all power.[16] It has recently begun a slow decline due to the retirements of old nuclear plants which are unlikely to be replaced with new nuclear plants for the foreseeable future. There is only one new nuclear plant under construction in the entire nation. That plant is the first new plant to enter service since 2016 and only the second new reactor to enter service since 1996.[17]

Another critical change in the generation portfolio is the recent growth of non-hydro renewable power. Though wind and solar power have been around for decades, their contribution to the power system was negligible until recently. It was not until 2006 that wind power exceeded 0.5 percent of power generation for the first time, and solar did not reach that same threshold until 2012.[18] With substantial support in the form of federal tax credits, state mandates for renewable power, and sharply declining costs, wind and solar power contributed respectively 10 and 3 percent of all generated power in 2022, and are on an aggressive upward trajectory.[19] In areas with high concentrations of renewables they have reached previously unforeseen levels of generation. In 2021, for instance, wind powered 58 percent of Iowa's net power generation, a level that was expected to grow as more wind generation is brought online.[20]

Even as the electric power system has evolved it has remained a highly reliable system. It is important to note when discussing reliability, that there are no standard definitions of reliability which means that it can be difficult to identify reliable and consistent data. In a 2017 report, the Department of Energy identified 150 large power outages, defined as affecting more than 10,000 customers, 93 of which were weather related, and 35 of which were the result of equipment failure.[21] Using a different measurement tool, DOE found that the average power customer nationwide lost power for 198 minutes a year, translating to 99.96 percent reliable service, with customers in the best performing state losing power for just 85 minutes a year and the worst state losing service nearly 14 hours a year.[22] DOE also reported that over 90 percent of all outages occur on the distribution system, the part of the grid that carries lower voltage power from substations to customers' homes and businesses.[23]

16 Energy Information Administration, "Monthly Energy Review," at Table 7.2a (Mar. 2023).

17 Energy Information Administration, "Frequently Asked Questions: How Old Are U.S. Nuclear Power Plants, and When Was the Newest One Built?," (Mar. 7, 2022).

18 Energy Information Administration, "Monthly Energy Review," at Table 7.2a (Mar. 2023).

19 Id.

20 Energy Information Administration, "State Profile and Energy Estimates: Iowa," (July 21, 2022).

21 Department of Energy, "Quadrennial Energy Review: Transforming the Nation's Electricity System: The Second Installment of the QER," at p. 4-28 (Jan. 2017).

22 Id. at 4-5.

23 Id. at 4-2.

Generation Adequacy

In recent years there has been growing concern about generation adequacy, whether there is enough capacity to generate sufficient electricity to meet peak demand with an adequate margin of safety to account for the possibility of some generators being unexpectedly unavailable.

For example, a recent North American Electric Reliability Corporation (NERC) assessment has determined that several areas in the United States lack adequate generating capacity and supplies to meet their peak demand.[24] In the midwestern United States, the Midcontinent Independent System Operator (MISO), which dispatches power for a broad swath of the United States, is projected to be short on adequate reserve margins to meet demand when it is at its highest, typically during the heat of the summer.[25] This forecast shortfall does not take into account insecurity of fuel supplies needed for generation which can exacerbate the lack of adequate reserves. Looking forward and taking into consideration projected retirements of existing generation, the situation becomes even more dire with MISO's level of anticipated reserves expected to go negative indicating that even in the best of circumstances the area will not be able to generate enough power to meet their demand.[26]

The generation shortfall in the MISO region is the result of several factors. In recent years, with growing concern about carbon emissions and a regulatory landscape that appears to disfavor fossil-based generation in favor of renewables, there is growing incentive to retire fossil fuel generation and little incentive to bring new fossil-fueled generating capacity online. Since 2015, the Department of Energy reports that 33,970 MW of nameplate generating capacity was retired in the MISO region.[27] Of that, approximately 33,693 MW was fossil fuels, nuclear, or otherwise dispatchable.[28] Over that same time period, 32,671 MW of new nameplate generating capacity was brought

24 North American Electric Reliability Corporation, "2023 Summer Reliability Assessment," (May 2023).

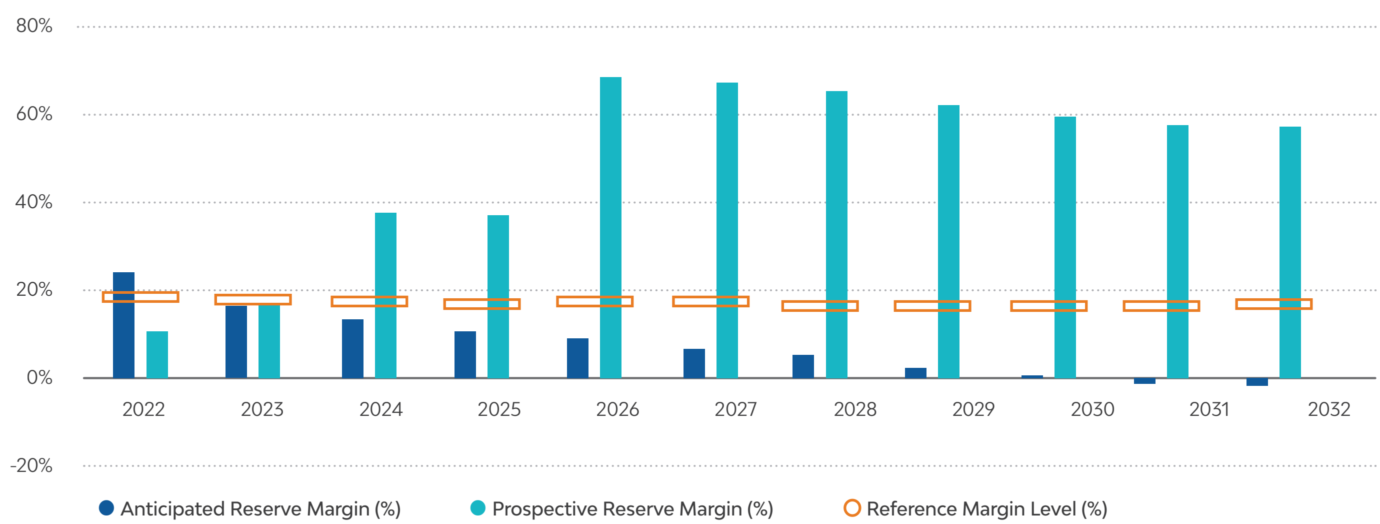
25 Id. at 14.

26 Energy Information Administration, "Inventory of Operating Generators," (April 2023).

27 Id.

28 Id.

Figure 3 Planning Reserve Margins in the United States



Source: MISO

MANCHESTER, OH - SEPTEMBER 10 : The J.M. Stuart Station is seen at sunset on September 10, 2019 near Manchester, Ohio. The power plant closed in 2018 and had been in operation for 48 years. (Photo by Stephanie Keith/Getty Images)

online.[29] Of that, approximately 11,064 MW was fossil or otherwise dispatchable, and approximately 21,607 MW was either wind or solar.[30] So while nearly every MW of generating capacity that was retired during that time period was replaced, the generating capacity that was retired was over 99 percent dispatchable while about two thirds of the new generating capacity was intermittent. Furthermore, of the announced planned 14,019 MW of nameplate capacity, 10,416 MW is wind and solar, and 3,613 MW is dispatchable fossil fueled generation.[31] The replacement of dispatchable power with intermittent power undermines reliability because while dispatchable power is available when it is needed, intermittent power is only available when the resource (i.e., sunshine or wind) is available.

During that same general time period it became more difficult and expensive to connect new generating capacity to the MISO grid. As of the end of 2021, MISO's interconnection queue had over 160,000 MW of generation and storage capacity actively seeking grid interconnection, but also included data about 366,000 MW of projects that had withdrawn their application.[32] In fact, only 24 percent of projects seeking to connect to MISO between 2000 and 2016 had achieved commercial operation at the end of 2021.[33] Moreover, during that time period the cost of connecting to MISO's grid increased substantially.[34]

California is also at risk of not being able to meet their projected demand for power and has also experienced a large increase in the number of power outages across the state. In fact, California has had the most power outages of any state in the last twenty years.[35]

The three largest utilities in California, Pacific Gas & Electric, Southern California Edison, and San Diego Gas and Electric have had to resort to rolling blackouts to maintain the integrity of the grid during peak periods and to avoid larger scale outages. Additionally, it has become almost routine for California and other areas in the West to declare Public Safety Power Shutoffs whereby transmission lines are de-energized during periods of fire risk and as a result precautionary blackouts put thousands of homes and businesses in the dark without heat or air conditioning. Public Safety Power Shutoffs were first implemented in 2019 and now occur several times a year during periods of drought, high winds, and fire danger. While the Public Safety Power Shutoffs have resulted in lower risks of grid-induced wildfires, they also demonstrate an additional area where grid reliability has experienced degradation.

Texas has now demonstrated that it has a year-round risk of outages. In addition to the loss of power to millions of homes and businesses during Winter Storm Uri, summer resources necessary to meet peak demand are also in question. Whereas the average peak system load for the summer in the Electric Reliability Council of Texas (ERCOT) region is about 82,000 MWs, the summer of 2023 has already seen days exceeding 85,000 MWs of peak load.[36,37] With

29 Id.

30 Id.

31 Id.

32 Joachim Seel, Joe Rand, Will Gorman, Dev Millstein, Ryan Wiser, Will Cotton, Nicholas DiSanti, and Kevin Porter, "Interconnection Cost Analysis in the Midcontinent Independent System Operator (MISO) Territory," Lawrence Berkeley National Laboratory, at 2 (Oct. 2022).

33 Id.

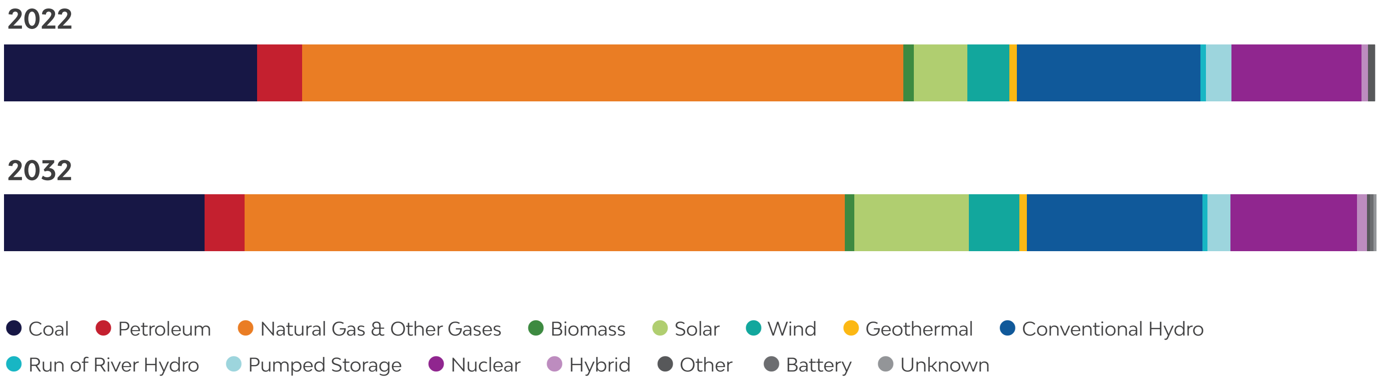
34 Id. at 4-5.

35 U.S. Department of Energy Office of Cybersecurity, Energy Security, and Emergency Response, "Annual Summary 2023", available at https://www.oe.netl.doe.gov/OE417_annual_summary.aspx

36 Electric Reliability Council of Texas, "Seasonal Assessment of Resource Adequacy for the ERCOT Region (SARA) Summer 2023," (May 3, 2023) (ERCOT SARA).

37 Electric Reliability Council of Texas, "2023 Peak Demand Records," available at https://www.ercot.com/static-assets/data/news/Content/a-peak-demand/2023/all-time-records.htm

Figure 4 U.S. Generation Mix



Source: NERC 2022, *Long Term Reliability Assessment*, December 2022, at 16.

97,000 MWs of potential capacity available,[38] if just over 10 percent of expected generation were to experience outages or a situation where fuel was unavailable, Texas would be confronted with a situation where it could experience load shed.

The recent spate of power outages underscores the need for better system planning from both a generation and transmission standpoint. It is critical that as we move toward more renewable sources of energy that we also have the resources in place that are critical to meet peak demand.

Generators must be able to demonstrate that they have the requisite fuel contracts in place to ensure fuel security. While fossil fired resources will decline in the long term they will still be necessary for the foreseeable future to provide both base load and peaking services. Figure 3 shows a breakdown of the U.S. generation mix in 2022 versus the U.S. generation mix projections in 2032. These projections underscore a future generation paradigm that continues to project substantially more wind and solar with continued reductions in fossil fuel generation as a result of the global push to reduce carbon emissions.

In addition to having sufficient generation capacity to meet demand, grid operators also need to have the right type of generating capacity. Because electricity is difficult to store, the volume of electricity being consumed at any given time must equal the volume of electricity being generated at that same time. Grid operators have little control over the demand for power at any given moment, so it is critical that they can adjust the supply available to match demand. Furthermore, the grid must always remain balanced and have the right level of voltage, frequency response, and system inertia. Most fossil-fueled generating plants and some hydropower generators are fully dispatchable, meaning that grid operators can turn them on and off as needed. The increasingly prevalent wind and solar generators, however, are non-dispatchable, meaning that their ability to produce power is dependent on the availability of sunshine or wind. Distributed generation can complement either dispatchable or intermittent sources of power and provide incremental peaking capacity.

Generally speaking, grid operators need to have dispatchable generation available to compensate for variations in the production of renewable power. As the electric power system integrates more renewable power into the grid, as discussed above, for example, regarding the MISO region, the more difficult it can be to have sufficient dispatchable generating capacity to maintain the reliability of the grid. A more robust transmission system can help address this challenge, but enabling a region to obtain power for other areas where it may be sunny or windy, and the development of both grid-scale and behind-the-meter battery storage will also help enhance the reliability of the grid.

Market reforms since the 1990s have expanded power markets within regions, like New England, Mid-Atlantic, Upper Midwest, to allow for regional distribution of electricity. But regional distribution systems cannot solve a national-scale problem. The country's renewable resources are not evenly distributed; to provide all of the United States with clean electricity, we need a truly national electric market, and that in turn requires a significantly more robust transmission grid.

38 ERCOT SARA.

Transmission Capacity

As the United States moves to a new system of generating power, one that emphasizes the generation of renewable power and deemphasizes fossil-fueled power, we also need a new type of transmission system to move power to market.

Historically, as explained above, the transmission grid was built as a collection of small regional grids owned by utilities that typically served concentrated geographic regions within a state. The grids of each utility were loosely connected, primarily for the purpose of reliability, but not for the purpose of moving large quantities of power. With each vertically integrated utility generating its own power, and in the absence of wholesale power markets, there was no reason to move large quantities of power between utilities, and the grid was therefore not engineered to do so. Typically, the utilities brought fuel in the form of coal, gas, petroleum, or uranium to locations near load, and built generators that were relatively close to load to minimize the need to transmit large volumes of power over unnecessarily long distances.

Unlike fuel, which can be moved to market, renewable power must be generated where the resource is located. Solar power is best generated in places with consistent strong exposure to the sun, such as the desert Southwest, and wind power is best generated in areas that are windy, such as the downslope of the Rocky Mountains and areas offshore. This means that instead of moving the fuel to the market to generate power, utilities have to move power to the market from the geographic regions rich in renewable resources. Effectively, the electric power system needs to replace the rail lines that move coal and the pipelines that move natural gas with transmission lines that move electricity. In short, to support a low-carbon economy, the electric power sector needs a transmission grid that is highly robust and interconnected, bringing together all generating resources to amply supply growing market demand for electric power.

Renewable power is destined to play a critical role in a low-carbon electric power system. But accessing that power is a barrier to fulfilling its promise. By delivering low-cost renewable power from the geographies where the most wind blows and the most sun shines to places where Americans and American businesses actually need electricity, and connecting to new utility-scale and distributed storage systems, we can ultimately de-carbonize the transportation, commercial, and industrial sectors. Indeed, that is the only way to decarbonize the electric sector by 2035. Without significantly enhanced transmission capacity, it will be nearly impossible to use our abundant renewable resources to decarbonize the economy through electrification.

A robust transmission system can do more than just deliver renewable power to market. It can enhance overall system reliability and resilience. A more robust transmission grid, that offers greater connectivity between different sources of generation and different areas of load is inherently more reliable than a less well-connected system. The electric power system is no different than suppliers of other goods in that the greater the number of potential suppliers of a good, the easier to replace one supplier with another in the event of a supply disruption. If a utility that experiences a shortfall of generating capacity is linked to only one other utility, it has only one path to secure additional power to address its shortage. If that same utility is connected to five other utilities, it has more opportunities to obtain needed power and the likelihood of a shortage that causes a blackout can be reduced.

In fact, a lack of transmission that can move large amounts of power from areas with ample generation capacity to load centers has been linked to a definite cause in recent black outs. The ERCOT Roadmap to Improving Grid Reliability recommends additional transmission within Texas in order to reduce the risk of subsequent black outs. The FERC/NERC Report on the Texas cold weather event in February 2021 also recommends additional studies to be conducted to research

Transmission lines cross plains with wind turbines. As the United States moves to a new system of generating power, one that emphasizes the generation of renewable power and deemphasizes fossil-fueled power, we also need a new type of transmission system to move power to market. (Getty Images)

additional interconnections between ERCOT, the operator of the Texas grid, and the grid in the remainder of the nation.[39] Interconnection links would have the ability to bring power from other regions such as the Eastern Interconnection and Western Interconnection into the Texas market and allow for out-of-state generation including wind power and solar power to be transmitted to Texas and alleviate potential power losses. This same conclusion equally applies to other regions across the United States.

Expanding the capacity of the transmission grid is complicated by the fact that planning, siting, and permitting of transmission lines can be burdensome and time consuming. The routing and interconnection of transmission lines can affect the operations of facilities already connected to the grid, and their owners often seek to delay the construction of infrastructure that might affect incumbents' economics. Siting and permitting of transmission lines often requires dealing with communities that the lines traverse, who often oppose lines, especially when they believe that lines that traverse a region bring little direct benefit to their immediate area. Line developers have often found it difficult to obtain approval to traverse federal lands, particularly in the West where the federal government is a significant landowner. It can also be difficult to finance lines that are large enough to meet current projections for renewable energy. It seems difficult to overcome these challenges until policymakers elevate the transmission system to an issue of national priority, identifying a path to oversee the planning and execution of grid expansion, directing the federal stakeholders to work together to expeditiously solve problems as they arise, addressing regulatory barriers that unreasonably impede construction of needed transmission capacity, and offering appropriate incentives to the private sector to make the requisite investments.

39 Federal Energy Regulatory Commission and the North American Electric Reliability Council, "The February 2021 Cold Weather Outages in Texas and the South Central United States: FERC, NERC and Regional Entity Staff Report," at p. 20 (Nov. 2021) (FERC Texas Storm Report).

New Threats: The New Normal of Blackouts and Physical & Cyber Attacks

In recent years the United States has faced several categories of new threats. There has been an increase in outages related to an increasingly volatile weather dynamic that continues to put the grid under stress.

As discussed above, the United States has encountered increasing risks related to a lack of fuel and generating resources. Adding further stress to the system is the increasing threat of both cyber and physical attacks by governments or other entities that might seek to harm the United States.[40]

The United States Government Accountability Office has warned that climate change is expected to have far-reaching effects on the electricity grid that could affect every aspect of the power grid from generation, transmission, and distribution to demand for electricity.[41] Black swan events are now becoming the normal. Winter Storm Uri in 2019 (Texas and South Central United States) resulted in more than 200 deaths.[42] The Federal Reserve Bank of Dallas estimated that the outages caused direct and indirect losses to the Texas economy of between $80 to $130 billion.[43] As a result of this event the Texas grid operator ordered 20,000 MWs of rolling black outs to prevent a complete grid collapse.[44] This resulted in the largest controlled load shedding event in U.S. history with over 4.5 million people losing power.[45] As figure 4 shows the cause of blackouts were multi-faceted, including issues with: (1) lack of sufficient transmission connections to neighboring regions; (2) equipment freezing; (3) fuel

40 See Idaho National Lab, "Cyber Threat and Vulnerability Analysis of the U.S. Electric Sector," (Aug. 2016).

41 United States Government Accountability Office, "Electricity Grid Resilience: Climate Change Is Expected to Have Far-reaching Effects and DOE and FERC Should Take Actions," (Mar. 5, 2021).

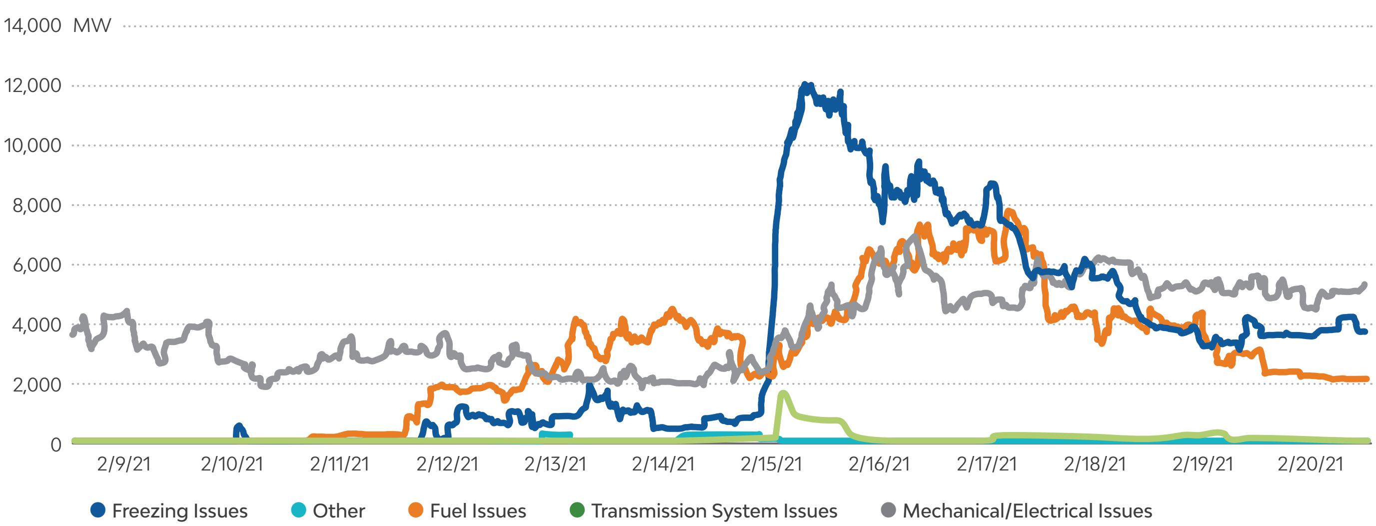
42 FERC Texas Storm Report at 9.

43 Garrett Golding, "Cost of Texas' 2021 Deep Freeze Justifies Weatherization," Dallas Fed Economics (Apr. 15, 2021).

44 FERC Texas Storm Report at 10.

45 Id. at 9.

Figure 5 ERCOT Generation Outages and Derates (MW) by Cause, Natural Gas-Fired Generation Units, February 8-20, 2021



Source: Trading Economics, 2023

Power outage after Hurricane Sandy, New York City, USA. (Getty Images)

supply; and (4) mechanical failures indicating that there are myriad breakdowns in power grid infrastructure and planning that are causing large scale blackouts.[46]

While the investigations regarding blackouts, loss of life, and economic losses continue around Winter Storm Uri, Winter Storm Elliott in December of 2022 underscored that risks around both generation and fuel supply will continue to call into question the ability of utilities to keep the lights on. During this event over 45 GWs of generating capacity in Pennsylvania-New Jersey-Maryland Interconnection (PJM) experienced forced outages or immediate reductions in output of a generating unit.[47] This loss of generating capacity represented about one quarter of the 186 GWs of total generating capacity in PJM, reflecting the severity of the crisis.[48] Figure 5 shows the level of forced outages by fuel type during this event on December 24, 2022.[49] Although blackouts were averted, the possibility of another Texas Winter Storm Uri type event with loss

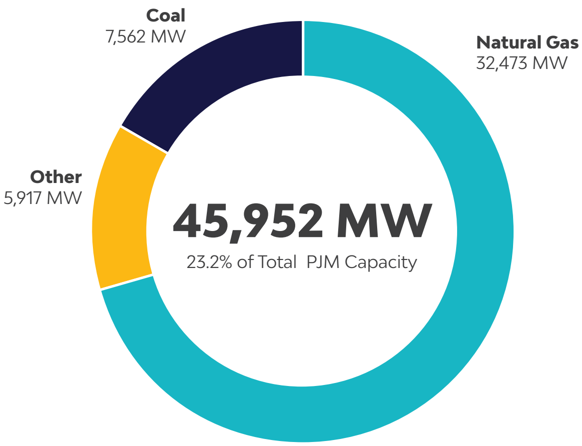
46 Id. at 162.

47 PJM, "Winter Storm Elliott Frequently Asked Questions," at 3 (Apr. 12, 2023).

48 PJM, "Winter Storm Elliott," at 11 (Jan. 11, 2023) available at www.pjm.com/-/media/committees-groups/committees/mic/2023/20230111/item-0x---winter-storm-elliott-overview.ashx.

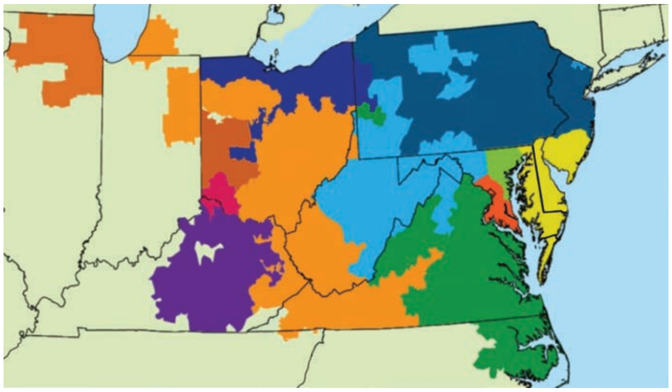
49 Id.

Figure 6 Total Forced Outages, December 24, 2022



Note: Other includes nuclear, oil, wind, solar, etc.
Source: PJM

Figure 6 PJM Service Territory and Associated Electric Utility Service Territories



Commonwealth Edison, AEP, Dayton Power & Light, Duke, EKPC, First Energy, Duquesne Light Co, Allegheny Power, Pennsylvania Electric, PP&L, PECO Energy, MetEd, JCPL, PSG&E, Rockland Electric, Atlantic City Electric, Delmarva Power & Light, Baltimore Gas & Electric, Dominion Power, PepCo

Source: PJM

CARTHAGE, USA - DECEMBER 05: A view of the substation while work is in progress as tens of thousands are without power on Moore County after an attack at two substations by Duke Electric were shot at in Carthage NC, United States on December 05, 2022. (Photo by Peter Zay/Anadolu Agency via Getty Images)

of life and significant economic damages is a real and imminent threat.[50]

PJM serves approximately 65 million people and covers a geographic area that includes major metropolitan areas such as Chicago, Cleveland, Philadelphia, and Washington D.C. A lack of adequate transmission to bring electric supplies from other areas through inter-regional transfers contribute to these near blackout situations which are occurring with more frequency and severity than have historically been experienced.

In addition to natural events that jeopardize U.S. grid reliability due to a lack of adequate transmission and generation, there are also looming threats of cyber and physical attacks on the grid both domestically and abroad. A 2013 attack on an electric power substation near San Jose, California underscored the vulnerability of electric power equipment to physical attacks. This attack was carried out on 17 transformers and required the grid operator to reroute energy to avert a wide-scale blackout.[51] Nearly a decade later, on December 3, 2022, a substation in Moore County, North Carolina was attacked by bullets resulting in the loss of power of up to 40,000 people. Some customers were without power for over a week.[52]

Utilities and policymakers are also concerned about the risk of cyberattacks on the U.S. electric power system. In 2018, MISO communications were interrupted by a cyberattack, though one that did not directly affect customers. In 2007, the Idaho National Laboratory demonstrated how a cyberattack could destroy a generator by connecting it to the grid out of phase. And there have been cyberattacks abroad that created widespread backouts, in Ukraine in 2015,[53] and in Brazil in 2005 and 2007.[54] And though not part of the electrical grid, the Colonial Pipeline, a key fuel supply pipeline on the East Coast, was the subject of a cyberattack in 2022.[55]

50 Id.

51 California Public Utility Commission, Safety and Enforcement Division, "Security and Resilience for California Electric Distribution Infrastructure: Regulatory and Industry Response to SB 699," (Jan. 2018).

52 Duke Energy, "Duke Energy restores thousands of customers after substation vandalism in N.C.," (Dec. 5, 2022).

53 Department of Homeland Security, Cybersecurity and Infrastructure Security Agency, "Cyber-Attack Against Ukrainian Critical Infrastructure," (July 20, 2021).

54 Michael Mylrea, "Brazil's Next Battlefield: Cyberspace," Foreign Policy Journal (Nov. 15, 2009).

55 Congressional Research Service, "Colonial Pipeline: The Dark Side Strikes," (May 11, 2021).

Conclusion and Policy Priorities

The power grid is experiencing a vast transformation that has consequences greater than any previous challenges that the power grid has experienced. While wind and solar resources as well as other renewable and non-carbon emitting resources are significantly helping the power grid achieve its carbon reduction goals, a lack of adequate transmission and generation resources are sacrificing the integrity of the power grid and the ability to provide power to homes and businesses when it is needed most.

Large swaths across the United States are lacking adequate generation to meet their demand during the coldest and hottest periods and a lack of a national integrated transmission system is preventing these areas from bringing power from wind- and solar-rich areas to population and load centers. Over the last several years power outages have resulted in significant loss of life and economic opportunity that has not been seen throughout the history of the power grid. Bad actors pose significant threats through cyber attacks on the power grid which have already proved to be both plausible and successful in putting nations into the dark. The number of outages, the severity of the outages, and the duration of outages are all increasing.

The viability of American success is dependent on a reliable power grid and the United States cannot afford to be in the dark, losing lives, and sacrificing our economy. Electrification and reindustrialization will increase the demands on a power grid which is struggling to perform. Now is the time that change needs to occur to protect our power grid and economy. SAFE recommends and will advocate for the following priorities:

- Cyber security and physical attacks of power grid infrastructure have already demonstrated that the power grid can be taken down from cyber or physical attacks. The United States must bolster its cyber security defense systems to counter the rise and severity of attacks.
- Additional infrastructure to ensure reliability needs to be built to meet both demand and reliability requirements. SAFE supports additional permitting reform to ensure that requisite infrastructure needed for power grid reliability is expedited.
- During the mid-transition years toward a low carbon grid, fossil-fired resources will be needed for reliability. Market structures must adequately compensate generators for the reliability and resilience attributes that they are providing. As emerging technologies for distributed generation, small modular nuclear reactors, battery storage and other peaking products are developed, policies must be implemented to compensate these resources for the reliability services they are able to provide.
- Transmission must be built out efficiently, effectively, and competitively to bring the energy from new renewable resources from wind- and solar-rich areas to load and population centers. SAFE will support activities and legislation that will streamline siting and permitting processes to allow for more expeditious build-out of the necessary infrastructure, as well as the interregional transfer capability, needed to meet our transmission needs for a reliable power grid.
- The ability to transfer power across regions minimizes disruptions and black-outs and optimizes least cost dispatch to ensure that reliability is increased and costs are decreased. As a result, SAFE supports building out of the nation's transmission system to support inter-regional transfers of power across U.S. interconnections as well as within them.

SAFE supports a more effective approach to transmission permitting which includes the ability for FERC to use is statutory power while ensuring state and local authorities' jurisdictional review processes are honored.

SAFE

SAFE is an action-oriented, nonpartisan organization committed to transportation and energy policy solutions that advance the economic and national security of the United States, its partners, and allies. SAFE has convened business and former military leaders since 2004 to advocate for secure, resilient, and sustainable energy solutions. SAFE relies on the knowledge and experience of four-star retired military officers, Fortune 500 CEOs, and its expert staff to produce high-quality, fact-based analysis and policy recommendations for lawmakers, regulatory agencies, and the public.

ENERGY SECURITY LEADERSHIP COUNCIL

The Energy Security Leadership Council (ESLC), a group of business and former military leaders committed to reducing U.S. oil dependence. The ESLC is chaired by Adam Goldstein, Former Vice Chairman, Royal Caribbean Cruise Lines, and General James T. Conway, the 34th Commandant of the U.S. Marine Corps, and retains its strategic mix of business and four-star former military leaders.

Grid Security Project

SAFE's Grid Security Project provides policy analysis and recommendations to reverse troubling trends and build out the national electrical infrastructure. More reliable and affordable power will be necessary to support the mass adoption of electric vehicles and enable America's reindustrialization.

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