Preparing States for Extreme Electrical Power Grid Outages

Executive Summary

The electrical power grid is the backbone of the U.S. economy and society, with most goods and services depending on its safe, secure and reliable operation. Increasingly, natural and human-made hazards pose risks to the grid, some of which could lead to lasting and widespread outages. Although improbable, such disruptions would have a substantial effect and result in the failure of other critical infrastructure sectors such as water, transportation, financial services and communications; endanger the health and well-being of the public; and lead to considerable economic losses. Most states have energy assurance plans in place to address energy system disruptions, but few contemplate an extreme power grid outage. Governors can play a unique role in preparing their states for such an incident by recognizing and planning for the specific threats that face their state, coordinating with key players and communicating plans with the public.

Recognizing the potential threat to states, the National Governors Association Center for Best Practices (NGA Center) in 2014 and 2015 convened roundtables of states and subject matter experts to identify the cascading effects of a prolonged and widespread electrical grid disruption. Those discussions also included actions governors can take to help prepare for prolonged, widespread outages and discussed how those preparations could improve responses to less severe outages and enhance resiliency within a state. In 2016, the NGA Center hosted state-specific retreats in **Washington** and **Wisconsin** to help these states examine their existing plans, identify gaps, develop action plans to address those gaps and ultimately improve their overall planning. This paper captures the recommendations and lessons learned at the experts roundtables and state retreats and presents additional research findings.

Since development of the Pearl Street Station in lower Manhattan in 1882, the U.S. electrical power grid—a collection of three systems that span North America—has grown into a complex network of more than 300,000 miles of interconnected distribution and high-voltage transmission lines delivering power to customers from more than 7,200 large power generation plants.[1] Private companies typically own the grid, and more than 2,000 electric utilities are responsible for its operation. Regulatory and market oversight authority is split between state public utility commissions, regional transmission operators and federal agencies such as the Federal Energy Regulatory Commission.[2]

The power grid generally functions well, but threats to reliable power delivery and the risks associated with a prolonged and widespread grid outage in the United States are becoming more pronounced for several reasons:

- Weather and other natural disasters are becoming more frequent and severe;
- The grid is becoming increasingly digitized, opening utility systems to cyberattacks;
- Critical infrastructure remains vulnerable to physical attack;
- Threats from natural and human-produced electromagnetic disturbances have grown; and
- Human error and other threats continue to be factors.

Although it varies by region, the electrical grid is largely privately owned. Governors are responsible for

the safety and security of the people and industries in their state. Therefore, governors, alongside the private sector and local and federal government, play a key role in planning for, responding to and recovering from an outage. In addition to existing efforts directed at less severe outages, governors can take the following actions to better prepare their state for a potential prolonged and widespread outage:

- Determine the potential risks to and consequences for the state;
- Identify the plans currently in place and determine whether they are sufficient;
- Ensure that plans consider the effects of grid outages on other critical infrastructure;
- Enhance stakeholder preparedness by conducting joint exercises;
- Define roles and responsibilities clearly and appropriately;
- Understand and communicate the process for restoring power;
- Determine the capacity for backup generation and address limitations; and
- Develop a strategy for communication with the public and key players.

Background

What Constitutes a Prolonged and Widespread Disruption to the Electrical Grid?

There is no single way to describe a prolonged and widespread disruption to the electrical grid. Each state defines such an event differently based on its unique circumstances. The definitions that do exist center on the cause of the disruption, the extraordinary and catastrophic nature of the event and its effects on other infrastructure. For example, the Electric Infrastructure Security Council describes a prolonged and widespread disruption to the electrical grid as "a catastrophic event that severely disrupts the normal functioning of critical infrastructures in multiple regions for long durations."[3] Despite the lack of a formal, common definition, several characteristics of a prolonged and widespread disruption to the grid distinguish it from a major or severe outage:

- Multiweek duration;
- High percentage of customers without power;
- Widespread geographical scale;
- Severe physical damage to the grid; and
- Failure of other critical infrastructure sectors.

Severe outages—for example, the 2003 Northeast blackout, the 2012 derecho that affected the Ohio Valley and Mid-Atlantic regions and Hurricane Sandy—provide glimpses into the potential effects of a prolonged and widespread electrical grid disruption, but scenarios such as earthquakes in the Cascadia subduction zone in the Northwest or the New Madrid seismic zone in the Midwest could cause a long-term, wide-scale electrical disruption the effects of which would far exceed those experienced in the severe outages mentioned above. Unlike routine outages and some of the severe major events already experienced (for more information about those events, see Appendix on page 13), a prolonged, widespread event will have greater cascading effects.

Potential Threats That Could Lead to a Prolonged and Widespread Electrical Disruption

Although the probability of disruption from an extreme outage is low, several factors may contribute to such an occurrence, including the age of the electrical grid infrastructure; more severe weather events;and the threat of malicious attacks, such as a larger scale version of the 2016 cyberattacks in Ukraine or the 2013 attack on the Metcalf substation in California.[4] Threats include the following:

- **Severe weather and natural disasters.** Severe storms, such as hurricanes, are contributing to the increased frequency of widespread power outages. Power outages affecting 50,000 customers or more are occurring more often than in the past, and weather causes an overwhelming majority of

those outages: Between 2003 and 2012, weather-related power outages cost the United States an average of $18 billion to $33 billion annually. Hurricane Sandy alone is estimated to have cost between $27 and $52 billion.[5,6] Although hurricanes are traditionally viewed as the primary hazard responsible for power outages, earthquakes, floods, wildfires and snowstorms also can cause disruption. Currently, attention in the United States focuses on two historically active fault lines—the New Madrid subduction zone in the Midwest and the Cascadia subduction zone in the Northwest—that pose particularly dire earthquake risk and could lead to a prolonged, widespread power outage.

- **Malicious attacks.** The electrical grid is also vulnerable to malicious cyber- and physical attacks. According to the U.S. Department of Homeland Security (DHS), from fiscal year 2011 to 2014, a cyberattack or physical attack occurred on the U.S. power grid once every four days.[7] Because electrical generation, distribution and metering systems are increasingly digitized and automated, there are more opportunities for parties with ill intentions, including state and non-state actors, to damage or take down electrical distribution infrastructure through a computer-based attack. Similarly, coordinated physical attacks intended to damage critical generation or distribution components can cause outages that affect a significant percentage of electric customers.

- **Electromagnetic pulse (EMP).** An EMP is a short, powerful burst of electromagnetic energy that typically occurs as a result of heightened solar activity, but these bursts can also occur when a nuclear device detonates above the atmosphere. The U.S. Government Accountability Office indicated that if an EMP were long enough, it "can result in grid collapse and potentially damage transformers."[8] EMPs can damage electronic circuitry and, if large enough, cause damage to or possibly destroy other components of the power grid, resulting in widespread outages.

- **Human error and other threat.** Managing a power grid is a complicated process that requires balancing supply and demand across a wide, interconnected geographic area. Although local transmission and distribution utilities as well as regional transmission operators do so successfully most of the time, systems can fail and humans can make mistakes, as was illustrated in the 2003 Northeast blackout. Even wildlife or a transmission line contacting foliage can cause an outage.

Overview of NGA Retreats in Washington and Wisconsin

In 2014 and 2015, the National Governors Association Center for Best Practices (NGA Center) hosted two experts roundtables to understand the consequences for states in the event of a prolonged and widespread electrical grid outage. Using lessons learned in those meetings, the NGA Center hosted state retreats in 2016 with two of the participating states—**Washington** and **Wisconsin**—to help them identify key issues associated with a prolonged and widespread electrical grid outage. Those retreats brought together stakeholders from the energy, homeland security and emergency management sectors as well as federal officials and private utility companies. As a result of the retreats, both Washington and Wisconsin developed strategic action plans that will help address gaps in their existing plans, clarify roles and responsibilities, improve communication and strengthen partnerships within state government and the private sector.

Actions for Governors

Although each threat has unique risk factors associated with an extreme outage event, governors can take several actions to mitigate risks and prepare their state for the eventuality of a prolonged and widespread power outage, regardless of its cause. Many of those actions have the additional benefit of helping prepare for less severe events. These actions include:

- Determining the potential risks to and consequences for the state;
- Identifying the plans currently in place and determining whether they are sufficient;
- Ensuring that plans consider the effects of grid outages on other critical infrastructure;
- Enhancing stakeholder preparedness by conducting joint exercises;
- Defining roles and responsibilities clearly and appropriately;
- Understanding and communicating the process for restoring power;
- Determining the capacity for backup generation and addressing limitations; and
- Developing a strategy for communication with the public and key players.

Determine the Potential Risks to and Consequences for the State

A prolonged and widespread disruption to the electrical grid is a low-probability, high-consequence incident that all states face. Assessing the risks and effects of such an incident is challenging. To do so, governors should take the following three steps:

- **Work with key advisors to examine and assess the threats their state faces.** Each state has a different mix of hazards threatening to cause large power outages. The National Association for Regulatory Utility Commissioners recommends focusing first on those hazards that are likely to occur, those to which the state is particularly vulnerable and those that would have the most devastating consequences because each hazard may require unique considerations and prioritizations for recovery.[9] As part of this effort, states may want to review the state-specific risk profiles that the U.S. Department of Energy (DOE) State Energy Risk Assessment Initiative (SERAI) has developed. (See the "U.S. DOE State Energy Risk Assessment Initiative" box on page 5.)

- **Assess and understand the state's vulnerabilities to those threats that, if exposed, would cause the most harm and potentially complicate response efforts**. In that assessment, governors should consider the state-specific economic climate, demographics, geography and interdependencies among sectors. A thorough vulnerability assessment helps states prioritize their resources based on need and availability. Similarly, it helps states identify where resource gaps exist and the external resources the state needs to augment its capabilities. State agencies should communicate information learned from the assessment to utilities so that they can factor the information into the restoration process.

- **Examine the effects or consequences that might arise if the threats were to materialize.** As mentioned, each state has unique threat vectors that could cause prolonged and widespread power outages, and each threat comes with its own unique consequences. Of particular concern are the potential effects on other critical infrastructure sectors like health care and emergency services that rely on electricity to function. Similarly, the electric sector relies on water, transportation and telecommunications systems to operate. These interdependencies among the electric and other critical infrastructure sectors could lead to profound cascading effects that result in rapidly deteriorating operating conditions and ultimately failure of infrastructure systems.

U.S. Department of Energy State Energy Risk Assessment Initiative

In 2015, the U.S. Department of Energy—in collaboration with state associations such as NGA—launched the State Energy Risk Assessment Initiative, the aim of which was to make states more aware of the benefits of quantitative risk assessment for energy assurance and the tools available for performing those assessments.[10] As part of the initiative, U.S. Department of Energy commissioned the creation of energy risk profiles for each state that provide state and regional information about natural and human-made hazards that could cause disruption to the electric, petroleum and natural gas infrastructures.[11]

Examples of such effects include inaccessibility to clean water; the inability to treat wastewater and maintain sewage plants; the lack of availability of and inability to deliver fuels, oil and natural gas; inoperable nuclear power plants; and health care facilities' inability to provide care to their patients.

States also may want to develop and perform a quantitative risk assessment. The use of quantitative risk assessments is nascent at the state level, but these assessments can help states better understand the relative value of different investments in hardening or resilience for the electrical power grid to prevent or mitigate the effects of a large-scale, prolonged power outage. As part of the SERAI, NGA sought input from governors' energy and homeland security advisors on their use of quantitative risk assessments. Three key findings emerged from that inquiry:

- Use of quantitative risk assessments at the state level was generally limited to the Threat Hazard Identification and Risk Assessment (THIRA) tool that the Federal Emergency Management Agency (FEMA) developed;
- THIRA is limited in its ability to fully predict the consequences of a disruption (a key element of risk assessment); and
- Most assessments incorporate information from private-sector infrastructure owners such as utilities on only a limited basis.

Given those findings, states may want to consider risk assessments in addition to THIRA. One potential tool that states can leverage is the Infrastructure Survey Tool (IST) that was developed by DHS. The IST provides individual critical infrastructure owners and operators an avenue to request a quantitative assessment to identify and document the overall security and resilience of the facility. It compares facility risks, protective measures, and overall resilience with similar facilities that have been the recipient of an IST assessment. Also, individual critical infrastructure owners and operators can request quantitative assessments from the DHS Regional Resiliency Assessment Program that compare their risks and protections with other, similar operators in their region.[12] States should link their findings from the assessment to a discussion of consequences (see the "Cascadia Seismic Event: State Planning and Preparedness" box on page 6). Finally, states should consider how they can incorporate information from the private sector.

Identify the Plans Currently in Place and Determine Whether They Are Sufficient

Most state and local governments already have plans to address energy assurance, homeland security and emergency management that help guide how they act in specific circumstances. In addition, the federal government and utility companies have their own plans. However, those plans may not account for the unique challenges associated with a prolonged and widespread disruption. Similarly, many of

Cascadia Seismic Event: State Planning and Preparedness

Oregon and **Washington**, two states that are in the midst of evaluating the risks and potential consequences of a prolonged and widespread outage resulting from the massive earthquake and tsunami predicted to occur within the century, provide an example for other states. Oregon and Washington sit on the Cascadia subduction zone, which stretches 700 miles along the Pacific Northwest coast. Many scientists are predicting an earthquake of magnitude 9.0 or greater within the next 100 years—a quake that would be 30 times more powerful than any earthquake expected on the infamous San Andreas Fault in **California**.[13] An earthquake so close to the coast in the Pacific Ocean would generate a tsunami that would cause massive destruction and damage to the electrical grid, leading to cascading failures in other critical infrastructure sectors. Specifically, under a leading scenario, the event would lead to the failure of Washington's five petroleum refineries, the three interstate natural gas and petroleum pipelines and water and wastewater treatment plants. In addition, health care facilities would have limited backup power and face water shortages, making it difficult for them to treat patients admitted before the event and limiting their capacity to handle new cases.

Oregon has conducted an impact assessment of the damages from a magnitude 9.0 earthquake and estimates the following consequences in that state alone:[14]

- Earthquake and tsunami deaths: 1,250 to 10,000;
- Buildings destroyed: 24,000;
- Buildings requiring extensive, long-term repairs: 85,000;
- Economic losses: $32 billion; and
- Displaced households: 27,600.

In addition, Oregon has conducted assessments to identify how long it would take to restore critical functions to specific parts of the state—coastal and valley zones—hardest hit. Many of the estimates suggest that restoration efforts could take at least a year.[15]

those plans are not developed in coordination with one another. Following severe flooding in his state in 2013, **Colorado** Governor John Hickenlooper established the Colorado Resiliency and Recovery Office to coordinate recovery efforts across public and private entities, promote transparency and ensure that resiliency and recovery remain state priorities. At the NGA Center state retreat on preparing for and responding to a prolonged and widespread electrical grid outage, **Washington** discussed a proposal to enhance their existing "Resilient Washington" process by creating a new subcabinet and preparing new annex plans that address long-term electrical grid outages.

Governors and key advisors should familiarize themselves with existing plans, and then assess gaps and contradictions. In addition, governors should share plans with local governments, bordering states, the federal government and industry partners and request that they share their plans. That two-way exchange will help all stakeholders understand how to plan for a disaster. States should also update those plans regularly to ensure that response activities remain applicable. Whenever those plans change, state officials should make local officials, the federal government and other partners aware of the updates.

Finally, governors and their key advisors should build contingencies into existing plans or annexes that account for the uniqueness of a long-term,

widespread disruption of the electrical grid. **Oregon** and Washington have developed playbooks designed to help state officials act quickly. Specifically, Oregon's Cascadia Playbook accounts for the projected effects of a magnitude 9.0 earthquake and initiates response protocols such as deploying first responders, assessing shelters and distributing supplies in the areas expected to suffer the greatest damage. The playbook is also meant to provide guidance for other, less severe disasters.

Ensure That Plans Consider Effects of Grid Outage on Other Critical Infrastructure

Many plans assume the availability of power after an event. Even plans that do not make that assumption might not account for how the loss of power affects access to the other critical infrastructure sectors that play a role in response. State officials, in collaboration with their governmental and private-sector partners, should examine whether existing plans consider how the lack of power may force a change in response efforts, particularly if the disruption persists or the severity changes. For instance, if there is a sustained outage, communication systems could break down, and water and wastewater plants could experience reductions in service that would have significant implications for public health. Moreover, if the outage occurs over a large region, shared resources will be in short supply.

A recent challenge in the oil and gas sector provides insights into existing plans and promotes modifying them in response to a major natural gas leak. In October 2015, a methane gas leak at the Aliso Canyon natural gas storage facility, which services 11 million people, threatened to create long-term power outages. In response to the leak, several **California** offices—including the California Independent System Operator, California Energy Commission and the California Public Utilities Commission (PUC)—partnered with Southern California Gas to develop a contingency plan to reduce energy consumption and mitigate the probability of a future blackout (California's electrical generation fleet relies heavily on natural gas). The plan outlines mitigation efforts that the state and industry are taking to prevent a widespread outage and also advises citizens to prepare for the possibility of a blackout lasting up to 14 days.[16]

Enhance Stakeholder Preparedness by Conducting Joint Exercises

In addition to sharing plans and routinely updating them, stakeholders can familiarize themselves with each other's plans by conducting joint exercises. Such exercises allow stakeholders to test preparedness levels, determine where shortcomings exist and subsequently address weaknesses. They also provide an opportunity to help formalize roles and responsibilities among state, local and federal government officials as well as private-sector representatives. Moreover, exercises allow all stakeholders to identify their expectations. Key to that is developing comprehensive exercises that are goal oriented and inclusive. Therefore, exercises focused on a prolonged and widespread electric disruption should focus on areas of interdependencies and include state and local homeland security, emergency management and energy officials as well as federal partners, neighboring state officials and industry partners. For example, participants in the Cascadia Rising exercise, which focused on the consequences of the Cascadia earthquake mentioned in the text box "Cascadia Seismic Event: State Planning and Preparedness," included participants from **Idaho, Oregon** and **Washington**; federal government agencies such as DOE and FEMA; tribal nations; the private sector; and international partners that met for four days to test existing capabilities and identify areas of improvement.

Create Opportunities for Cross-Agency Coordination and Public-Private Partnerships

Managing a widespread, long-term power outage will require the expertise of several state agencies, as well as the coordinated action of both public and private entities. The **Wisconsin** Homeland Security Council brings officials across state agencies together on a monthly basis to prepare for emergencies such as these. Collective

state agency input is assisting in the development of a long-term power outage initiative in Wisconsin, which will culminate in a major exercise in 2018. The council also allows for individual agency briefings on relevant topics, such as the Public Service Commission's (PSC) ongoing engagement with utilities on security planning and risk assessments. It also provides guidance for the development of the state's cyber disruption strategy, which includes the participation of critical infrastructure owners and other private entities. This nexus opportunity is possible with combined leadership from the governor, adjutant general, PSC chairperson, the state's chief information officer, and other state agency and local officials. It has led to the integrated planning and participation in joint exercises within the state, as well as with regional efforts led by FEMA and North American Electric Reliability Corporation.

Define Roles and Responsibilities Clearly and Appropriately

Given the unpredictability of a prolonged and widespread disruption of the electrical grid, it is imperative that governors, their staff members and key stakeholders clearly understand their roles, authority and responsibilities. Governors have unique powers during an emergency. A governor may need to implement immediate actions to mitigate any cascading effects and protect critical lifeline sectors in the event of a prolonged and widespread electrical disruption. A governor's legal authority in disasters varies from state to state based on legislation and constitutional provisions. For example, in some states, using older reserve energy sources may violate emission standards, whereas some governors may use those older sources to help in the restoration process. Governors should determine whether they have the emergency authority to waive standards during this type of disruption and work to clarify authority if necessary. In addition, governors and their key advisors will need to work with the U.S. Environmental Protection Agency to request a waiver so they are in compliance with federal standards. Governors should become familiar with all legal emergency response options at their disposal to expedite the response.

State officials should also understand their roles, responsibilities and legal authority and how they fit into the overarching state response to an electrical grid disruption. Governors and state officials should review emergency operations and energy plans carefully to make sure that roles and responsibilities are clearly delegated and defined. In particular, it should be clear to each official how his or her role and responsibilities change if the length or scale of an event changes, especially if other states or federal agencies are involved in the response.

In addition, governors should recognize their limitations, determine the additional resources they will need and where to get them and work to coordinate with utility leaders on the resources needed to maximize available aid. States can request assistance through the Emergency Management Assistance Compact, which allows states to borrow resources from each other when a governor declares a state of emergency. Most utility companies participate in a mutual aid program called "regional mutual assistance groups" (RMAGs). RMAGs allow utility companies to provide resources for restoration efforts. In the event of a prolonged and widespread disruption of the electrical grid, the Edison Electric Institute (an association of private, investor-owned utilities) can enhance that effort through its National Response Event process, which allows utility chief executive officers to request all available RMAG emergency restoration resources and coordinate those efforts with public power entities.

It is important to note that governors are not the only responders in the event of an outage. A prolonged and widespread electric disruption will exceed the capabilities of any state, requiring federal—and possibly international—assistance. In addition, the private sector owns and operates much of the affected infrastructure. Nongovernmental organizations (NGOs) will have resources to bring to bear, as well. Given the variety of stakeholders involved, governors

will want to engage and partner with these groups before an event occurs to ensure effective preparation and response efforts as well as minimize duplication and conflicting efforts. Oregon's Cascadia Playbook outlines the process for engaging key officials at all levels of government, the private sector and NGOs.[17]

Understand the Process for Restoring Power to Help With Coordination and Consistent Communication

If and when the power goes out, the priorities of utilities, regulators and policymakers must shift to efforts to restore power. Depending on the region, private utilities are the primary owners and operators of electricity generation, transmission and distribution, and are responsible for restoring power. In other areas, that responsibility will fall to public utilities or a combination thereof. Restoration is complex and situation specific, and the electricity sector has to consider many factors when deciding how it restores power. For instance, utilities are likely to prioritize repairs that return power to emergency functions to critical lifeline sectors such as health care facilities and to the largest number of customers first.

Governors are the face of large-scale disasters and will have to answer to the public for any prolonged outages, so it is important that governors work with their state's PUCs and utilities to learn about the restoration process and the key factors that inform that process, such as physical considerations and customer prioritization. The governor should also play a role in prioritizing power restoration. Governors should make sure that a member of their staff or state energy office works with the utilities and PUCs in advance of any power outage to understand the restoration process better and make sure gubernatorial priorities for restoration, such as ensuring that residents have access to basic needs like food and water and ensuring that first responders can conduct emergency response activities, are considered in that process, when appropriate. In addition, a representative from the governor's office can help make the governor aware of the technical requirements with which utility companies must comply to restore segments of the electrical grid without causing additional damage.

Governors are expected to provide updates to the public, and so it is important that they know—in real time—the status and prioritization of recovery efforts. Therefore, governors should explore effective avenues of communication with public and private organizations in the event of an outage to develop coordinated, informed messages to the public. Those messages should focus on the status and timing of power restoration and any other emergency information necessary. Governors should identify the existing processes for receiving information and updates from utility companies through their state emergency operations centers, determine whether that process is sufficient and identify areas for improvement.

Determine the Capacity for Backup Generation and Address Limitations

A variety of technologies and restoration capabilities are available to provide backup power, interim on-site power generation, fuel diversity and accelerated restoration that governors may want to consider implementing as part of a strategy to mitigate the effects of an outage. Some options may be associated with the goal of enhancing resiliency, whereby the effect is lessened and the recovery is faster and easier. The following is a list of the more common technologies governors can consider implementing or encourage state facilities and critical infrastructure to adopt:

- **Combined heat and power.** CHP, also known as "cogeneration," is a technology that enables the simultaneous generation of electricity and thermal energy from a fossil fuel source, usually natural gas. These systems are typically located onsite at commercial, industrial or public facilities to provide off-grid power during normal grid operations or outage events. Governors can explore strategies to deploy CHP to critical public and private assets to improve resiliency in the event of a prolonged

and widespread power outage. **New York** has partnered with DOE's Better Buildings Combined Heat and Power Resiliency Accelerator to explore CHP resiliency technologies and policies.[18] Agencies in **Maryland, Pennsylvania** and **Utah** have also joined this partnership. Governors may want to join similar initiatives, initiate pilot programs to explore technologies, provide rebates for the installation of CHP systems at critical infrastructure or establish enabling policies such as interconnection.

- **Microgrids.** A "microgrid" is defined as "a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid, allowing it to operate in both grid-connected or island-mode."[19] Microgrids can give critical assets the ability to disconnect and operate autonomously from the bulk power grid when power is lost in a process known as "islanding." With power generation located onsite and the ability to distribute that power over a limited distance, critical assets can remain operational in the event of an emergency.

  Microgrids can be powered by fossil fuels generators, a combination of renewable technologies and storage or CHP. Governors considering the use of microgrids in their state should weigh the benefits and drawbacks of each of these sources as they develop plans. For example, microgrids powered by fossil fuel generators such as diesel generators are reliable when fuel supply lines are active but may not operate if fuel is unavailable during an emergency. Microgrids that renewable generation—such as wind or solar—supply would not suffer from a fuel supply shortage, assuming those resources are amply available, but would need some form of energy storage to accommodate the intermittency of those renewable resources. Multiple states have explored the use of microgrids for resiliency purposes. Former Maryland Governor Martin O'Malley created the Maryland Resiliency Through Microgrids Task Force, which released a report recommending policy for the state to pursue public-purpose microgrids following the 2012 derecho storm.[20] Similarly, **Minnesota** explored microgrid technologies and policies for the state through the "Minnesota Microgrids: Barriers, Opportunities, and Pathways Toward Energy Assurance Report."[21]

- **Diesel backup generators.** These backup generators have been a mainstay for critical assets, powering buildings such as hospitals to ensure continuity of service for as long as fuel supplies last. Similarly, backup generators can be deployed at vehicle fueling stations to enable the continued use of private, fleet and emergency vehicles during a power shortage. Governors can establish incentive programs to encourage station managers to procure backup generation. To address this concern, Maryland, through the Maryland Service Station Energy Resiliency Grant Program, offered grants to gas station owners to support the installation of wiring and backup power generation capabilities at fueling stations.[22] One of the state action steps from the Washington grid outage retreat in September 2016 was for the state's Department of Commerce to explore a solution for similar resiliency measures at fueling stations.

Diversifying fuel sources for fleet vehicles to protect against fuel supply shortages is another option for governors to explore. A power outage may coincide with or even cause shortages in the supply of certain fuels; for example, a storm that causes a power outage could also block transportation networks and fuel delivery routes. In the wake of storms such as Hurricane Sandy, states such as **New Jersey** and New

York have been exploring alternative fuel sources for vehicle fleets such as compressed natural gas, propane, biofuels and electric vehicles to improve resiliency and maintain operations in the event of a power outage. The NGA Center, the National Association of State Energy Officials, states and other stakeholders are participating in the Initiative for Resiliency in Energy through Vehicles (iREV), which encourages state fleet resiliency.[23] Through iREV, states are gaining access to tools and case studies that will facilitate fleet vehicle fuel diversification so that fleets can remain operational in the event of a longer term power outage or other fuel shortage. Many states already offer rebates for private entities seeking to purchase natural gas, propane, electric and other alternative fuel vehicles. States can also consider diversifying their agency fleets to improve resiliency.

Develop a Strategy for Communication With Public and Key Players if Traditional Platforms Are Inoperable

Keeping the public informed during disasters and emergencies is a key component of disaster preparedness and response. Such information provides individuals with details about the magnitude of the disaster and how to act before, during and after it. Typically, state and local officials rely on traditional communication modes such as radio, television and newspapers to inform their residents, but recently, state and local government officials have incorporated social media platforms such as Facebook and Twitter to provide information that is more timely and reflective of the current situation. A major disruption to the grid will most likely result in the inoperability of most communication systems, making it difficult for state and local officials to provide the information necessary to keep people informed and safe. Similarly, officials will have difficulty communicating with each other because their usual communication tools will experience technical difficulties that make sharing information among key players and stakeholders problematic.

Communicating and sharing information effectively during traditional disasters are challenging, and a prolonged and widespread disruption to the electrical grid will exacerbate those challenges. Recognizing that, governors should identify alternative messages to communicate because scarce resources will make it difficult for responders to provide immediate assistance. Because of the threat of a large-scale earthquake in the Cascadia subduction zone, Washington has updated its messaging to residents who should prepare for an outage lasting up to 14 days. In addition, Washington is encouraging citizens who live in the subduction zone to have evacuation plans. Communicating this message before the potential outage occurs will help manage the public's expectations should a prolonged and widespread outage occur.

In addition to alternative messaging, governors should identify whether alternative communication systems are available for use during response and recovery. Wisconsin has identified several backup communication methods on which the state can rely in the event of a prolonged and widespread electrical disruption, including using ham radios, hosting town hall meetings and issuing leaflets and posters. The emergency management office has also identified ways to maintain and execute its alternative communication plans so that it remains operable for an extended period.

Governors should recognize that alternative communication systems have limitations and will not have the same capacity as regular communication devices. Therefore, they must focus on essential information. In collaboration with their key advisors and the private sector, governors must determine what actionable information is crucial to share with each other and the public and how that sharing will occur. Those essential elements may include specific data about available power, health care facilities, water availability and resource availability.

Looking Ahead

The electrical grid provides great service and benefits, but because it is connected to so many aspects of everyday life, our dependence on it

creates a vulnerability that states must manage and address. Many people are unprepared to handle the consequences of a power outage that lasts for an extended period of time. Governors are uniquely positioned to help state residents prepare for a prolonged and widespread electric disruption and engage key stakeholders to work together. Recognizing that outages are predicted to occur more frequently and that preparations for low-probability but high-consequence events can improve overall preparation gives governors the opportunity to begin considering how they would respond to a long-term, widespread disruption. Moving forward, governors should employ practices and policies that better protect their states from the consequences of a massive electric disruption.

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Appendix. Examples of Past Severe and Major Power Outages

Major severe power outages have occurred many times in recent history—with devastating effects. Whether the result of extreme weather, natural disasters or human error, governors will have to address the consequences when their residents are left in the dark. The following examples represent some of the most severe power outages to strike the United States and the world in recent years:

- **The Northeast blackout of 2003.** On August 14, 2003, a series of technical and human errors led to a power surge that caused a blackout across eight states and Ontario. Ultimately, a region with more than 50 million people was without power for up to four days. The total estimated cost of the incident to the United States was between $4 billion and $10 billion.[24] The widespread nature of the event resulted in disruptions in transportation systems, water supply, communication equipment and other critical sectors dependent on the reliable delivery of electricity.

- **2011 Japanese earthquake and tsunami.** In March 2011, a magnitude 9.0 earthquake struck Japan, resulting in a tsunami that produced waves up to 30 feet and caused widespread damage to the power grid and other critical infrastructure. This event took approximately 8 percent of Japan's power-generating capacity offline. More than five million households were without power. Nearly two weeks later, authorities had been unable to restore power fully, and rolling blackouts continued.[25]

- **The June 29, 2012 derecho.** On June 29, 2012, a derecho, which "is a widespread, long-lived wind storm" that can cause destruction at a scale similar to tornadoes, swept across the Ohio Valley and Mid-Atlantic regions, traveling 700 miles across more than 10 states.[26,27] Utilities reported that 4.2 million customers lost power across 11 states and the District of Columbia. Power had not been fully restored up to 10 days later, in part because of the sudden nature of the storm and the damaging winds.[28]

- **Hurricane Sandy.** Moving north off the U.S. East Coast and making landfall in **New Jersey** as a tropical cyclone with hurricane-force winds, Hurricane Sandy caused more than 8 million customers in 20 states to lose power. Approximately two-thirds of New Jersey residents and nearly a quarter of New York residents lost power.[29] Some people were without power for up to 13 days.[30]

- **2013 Metcalf sniper attack.** On April 16, 2013, attackers simultaneously took down telephone lines and a Pacific Gas and Electric transmission substation near San Jose, **California**. This attack was relatively small scale, and power was restored quickly, but it took 27 days to complete physical repairs to the damaged infrastructure. A larger scale attack targeting multiple strategic assets or critical customers would have more severe repercussions.

- **2015 Ukraine blackout.** In 2015, a cyberattack led to a blackout in Ukraine. The event consisted of a series of well-coordinated attacks that ranged from using malware to gain access to remote industrial controls to deleting critical files through another malware attack to delay recovery.[31] The result was a blackout that covered eight utility service areas. Although power was restored relatively quickly, this incident highlights the growing risk a cyberattack on the power grid poses as grid components become increasingly digitized.

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NATIONAL GOVERNORS ASSOCIATION

Addendum

PREPARING STATES FOR EXTREME ELECTRICAL POWER GRID OUTAGES

Energy is critical to all facets of modern life, with individuals, businesses and critical infrastructure systems relying on a steady flow of electricity and fuel. Disruptions to electric power can be dangerous and damaging to the economy, public health and safety. The impacts of an electrical outage are compounded during an extreme, prolonged outage. In 2016, NGA released a resource titled "Preparing States for Extreme Electrical Power Grid Outages" discussing strategies Governors can take to prepare their state or territory for a potential prolonged and widespread electrical outage. While there is no single definition of an extreme electrical power outage, the paper identifies an extreme outage as lasting for multiple weeks, causing a high percentage of customers to lose power, spanning a large geographical area, impacting other critical infrastructure and causing severe physical damage to the electrical grid. Not only has the threat environment continued to increase, but the supply chain to restore services to the grid has also become more constrained. For example, the Department of Energy estimates that large power transformers could take years to replace following an incident, underscoring the need to protect current assets. While the recommendations to Governors from the 2016 paper remain relevant, new resources have been released and actions have been taken that can further inform or support Governors' efforts to prepare for a potential extreme outage.

Since the publication of NGA's 2016 paper, the threats of natural disasters and malicious attacks on critical infrastructure have grown, and there has been a notable increase in the number of cyberattacks and physical attacks on energy infrastructure:

Cyberattacks

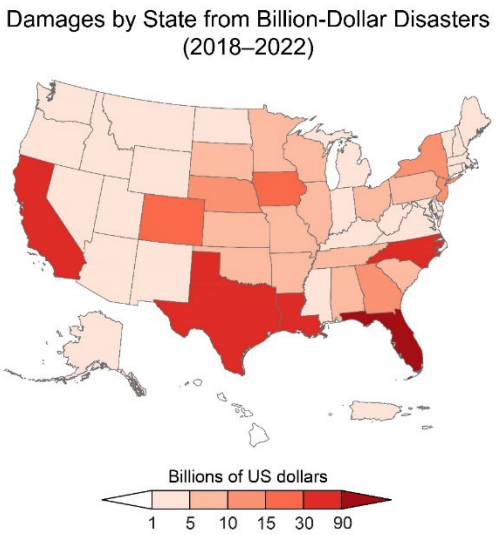
- In May 2021, a ransomware attack on the Colonial Pipeline infected the data and information technology (IT) systems of the pipeline, leading operators to preemptively shut down the pipeline for multiple days out of an abundance of caution, protecting operational systems but also leading to consumer panic buying that resulted in fuel supply concerns.
- The use of cyberattacks on critical infrastructure during the Russian war in Ukraine has raised concerns for the National Security Agency (NSA).[1]
- In February 2024, the Federal Bureau of Investigation (FBI), Cybersecurity and Infrastructure Security Agency (CISA), and the NSA released a joint assessment highlighting that People's Republic of China state-sponsored cyber actors are seeking to pre-position themselves on IT networks for disruptive or destructive cyberattacks against U.S. critical infrastructure, including the energy sector.

Physical Attacks

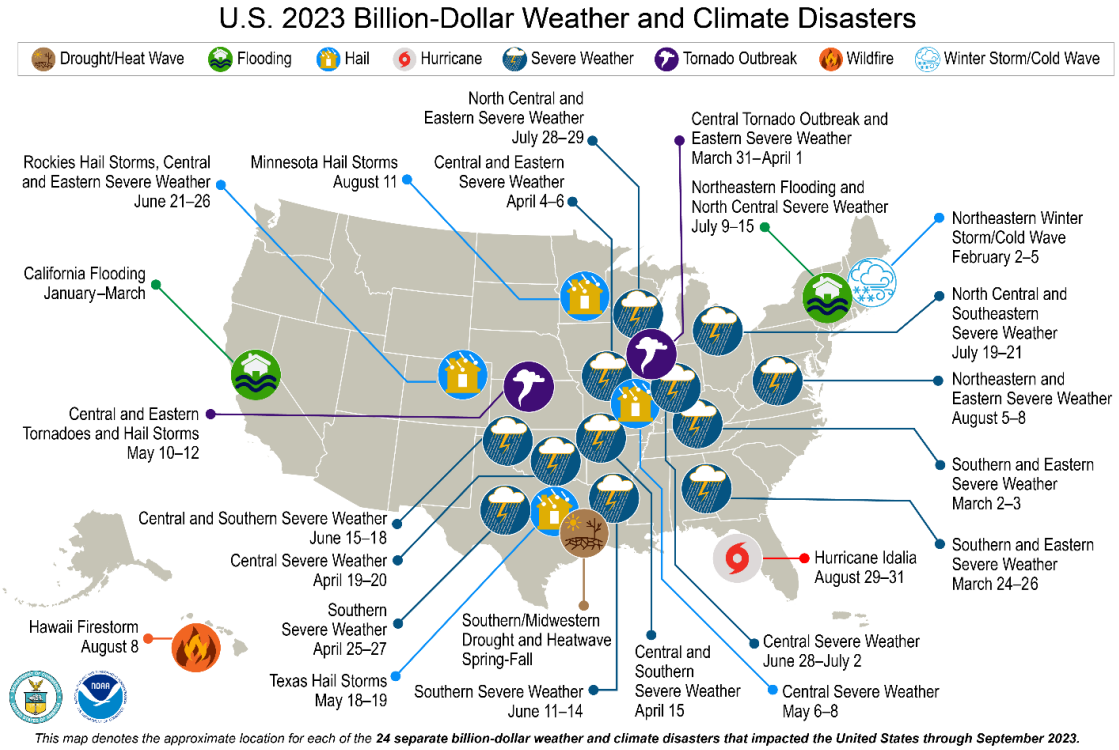
- In 2022, there were multiple high-profile physical attacks on substations across the United States, including in North Carolina and Washington. According to the U.S. Department of Energy (DOE), physical attacks on the grid increased 77% to 163 incidents from 2021 to 2022. While none of these events led to an extreme outage, a more robust or coordinated attack could cause a major disruption.

Severe Weather

- Since 2016, many major weather events have caused electrical outages, including extreme outages in Puerto Rico and the U.S. Virgin Islands (USVI) in 2017. Hurricanes Irma and Maria, respectively category five and four hurricanes that occurred within two weeks of one another, caused catastrophic damage to the electrical grids in Puerto Rico and USVI. The hurricanes caused numerous deaths, severely damaged infrastructure, and caused electricity and cellular service outages for an extended period of time. Hurricane Maria caused the longest power outage in U.S. history; in Puerto Rico, power was knocked out to all 1.5 million customers and was not fully restored for 11 months.



- In 2022, Hurricane Fiona hit Puerto Rico and once again knocked out power to 100% of the electrical grid. While devastating, the storm did not have as catastrophic of an effect on Puerto Rico as the 2017 hurricanes did. Two weeks after Hurricane Fiona made landfall, over 90% of customers had restored power.
- In 2023, Typhoon Mawar hit Guam as a Category 4 typhoon—the strongest to hit the territory in over 20 years. As a result of investments to strengthen the grid, such as converting wooden power line poles to concrete, energy was able to be restored to more than 90% of the territory within 5 weeks.
- In August 2020, a Derecho storm swept across the Midwest causing major damage and power outages in Illinois, Indiana, Iowa, Michigan, Ohio, Nebraska, South Dakota and Wisconsin. Nearly two million customers lost power during the thunderstorms between August 10 through 13. Although the outage was not an extreme duration (most customers regained power within seven to 10 days), the 2020 Derecho caused catastrophic damage to the health, safety and economies of the affected states.
- As evidenced by the 2020 derecho storm, severe weather events with the potential to cause extreme outages are not limited to coastal states or islanded territories. According to the National Oceanic and Atmospheric Administration, the frequency of billion-dollar disasters in the United States is on the rise. The Fifth National Climate Assessment also highlighted that the United States now experiences on average a billion-dollar weather or climate disaster every three weeks. In addition, these severe storms are occurring in irregular locations and outside of the traditional time-bounds of storm seasons.



*This map denotes the approximate location for each of the **24 separate billion-dollar weather and climate disasters that impacted the United States through September 2023.***

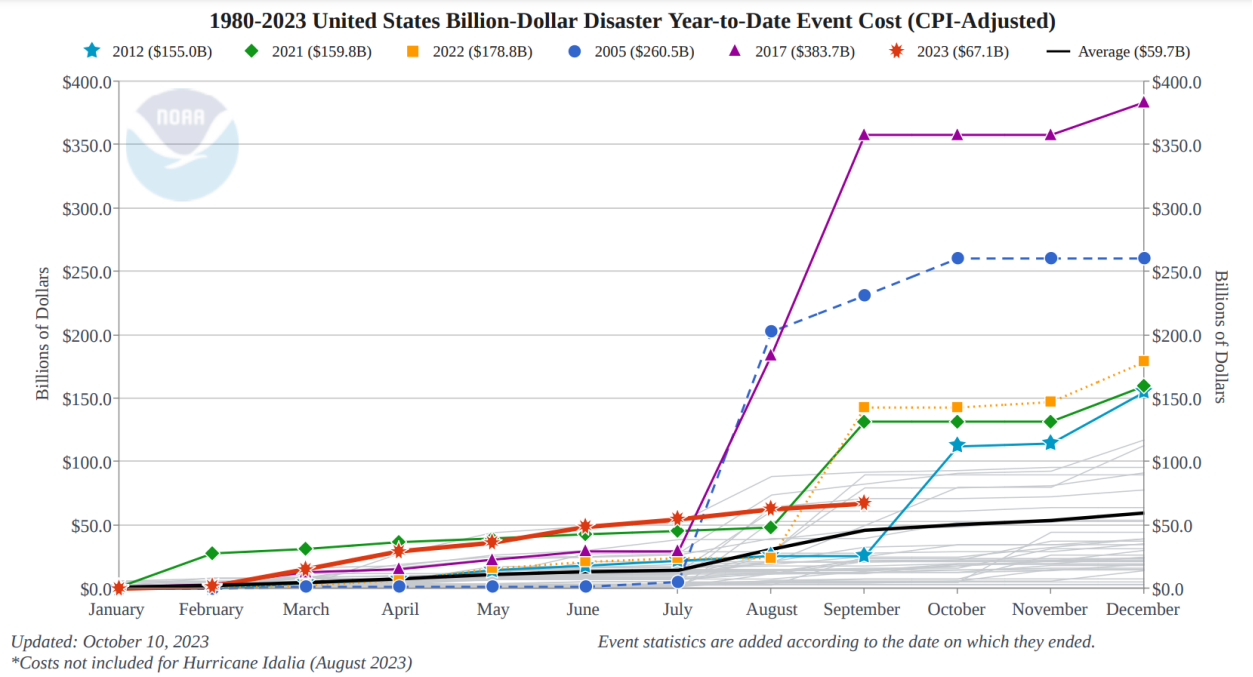
Federal Funding Opportunities for Grid Resilience and Energy Security

Recent federal legislation has created large funding opportunities for states and territories to advance energy security. In 2021, the Infrastructure Investment and Jobs Act (IIJA) was signed into law, containing robust funding for grid hardening and modernization, cybersecurity and resilience. Hardening the grid and increasing the cybersecurity of grid infrastructure are key strategies to reducing the likelihood and mitigating the effects of an extreme electrical outage. Pertinent grid hardening and security programs include:

- The U.S. Department of Energy (DOE) Building a Better Grid Initiative, which includes the following programs, among others:
  - $10.5 billion for the Grid Resilience and Innovation Partnerships (GRIP) program
  - $2.5 billion for the Grid Resilience State/Tribal Formula Grant Program

    (also referred to as 40101(d))
  - $2.5 billion for the Transmission Facilitation Program
- $250 million for DOE's Rural and Municipal Utility Advanced Cybersecurity Grant and Technical Assistance (RMUC) Program
- The Federal Emergency Management Agency's Building Resilient Infrastructure and Communities Program
- The DHS Cybersecurity and Infrastructure Security Agency's State and Local Cybersecurity Grant Program

Detailed information about these and other programs can be found on NGA's IIJA Implementation Resources page.



State Energy Security Planning (IIJA Section 40108)

Governors should be aware of the IIJA provision Section 40108 that elevated State Energy Security Plans (SESPs) to include a Governor's review and certification. This provision requires states and territories submit **State Energy Security Plans** to DOE by the end of the federal fiscal year until the sunset of the law (October 31, 2025) as a condition of eligibility to receive funding from the U.S. Department of Energy (DOE) State Energy Program (SEP). According to additional guidance states and territories have received from DOE following their 2024 State Energy Security Plan submissions, "delivery of applicable FY25 federal financial assistance to a state or territory may be delayed or withheld under Part D of Title III of EPCA, if a fully compliant SESP is not received and verified by DOE."

The DOE reviews these plans to ensure they fully address the six Congressionally-defined elements:

- An overview of all energy sources and regulated or unregulated energy providers;
- A state energy profile including production, transmission, distribution and end-use energy estimates;
- An assessment of potential hazards to each energy sector or system, including physical and cybersecurity threats and vulnerabilities;
- A risk assessment of energy infrastructure and cross-sector interdependencies;
- A risk mitigation strategy; and
- Regional, tribal (if applicable), and multi-state coordination plans as well as mutual assistance.

Once a state or territory has fully addressed all six elements, a Governor's certification letter may be sent to DOE in lieu of a plan. The IIJA provides an additional $500 million to State Energy Offices via the State Energy Program (SEP) in addition to funding provided through the annual appropriations process.

Energy Security Planning is an important way for states to coordinate the many public and private entities with a role in ensuring energy reliability and resilience against threats to energy infrastructure. In addition to regularly updating their State Energy Security Plans, many states and territories are supplementing those efforts by engaging in in-state exercises to test their plans and assess their emergency preparedness.

The U.S. Department of Energy's Office of Cybersecurity, Energy Security, and Emergency Response (CESER) has many resources for states and territories, including but not limited to:

- DOE State Energy Security Plan Guidance
- Energy Security Resource hub
- SLTT Program Resource Library | Department of Energy

In addition to these resources, CESER and the National Association of State Energy Officials (NASEO) published an Energy Emergency Response Playbook for States and Territories in May 2022. This resource provides states and territories with best practices for energy emergency planning that could be incorporated partially or fully in their state energy security plans and includes a specific guidance for preparing for and responding to power outages.

New Federal Resources

Multiple reports focused on preparing for and responding to an extreme power outage have been published by federal agencies in recent years.

- In 2017, the U.S. Department of Homeland Security (DHS) Federal Emergency Management Agency (FEMA) released the "Power Outage Incident Annex: Managing the Cascading Impacts from a Long-Term Power Outage." This resource provides guidance for federal level responders to provide response and recovery support to local, state, tribal, territorial and insular area efforts in the wake of an extreme power outage.
- In 2018, the President's National Infrastructure Advisory Council released a study entitled "Surviving a Catastrophic Power Outage: How to Strengthen the Capabilities of the Nation." This report studied the national preparedness for a prolonged and widespread electrical outage, finding existing plans to be ill-equipped to respond to such a crisis. Also in 2018, the Center for Climate and Energy Solutions published a report "Resilience Strategies for Power Outages" that outlines policies state and local governments can adopt to increase the resilience of the electrical grid against outages.
- In 2023, the Cybersecurity and Infrastructure Security Agency (CISA) working with the Resilient Power Working Group (RPWG) developed this document, "Resilient Power Best Practices for Critical Facilities and Sites with Guidelines, Analysis, Background Material, and References," to provide resilient power best practices for critical facilities and sites.

NGA Resources

2023 Energy Cybersecurity Resources for Governors' Advisors: NGA recently published an updated energy cybersecurity resource guide that provides an overview of federal and state cybersecurity standards for the energy sector as well as a collection of energy cybersecurity resources from NGA, the federal government, and other state focused organizations.

This addendum was prepared by Fiona Forrester, Policy Analyst, NGA Center for Best Practices. For additional energy assurance and security resources, please reach out to the energy or homeland security program leads at the NGA's Center for Best Practices: Dan Lauf (dlauf@nga.org) and Jessica Davenport (jdavenport@nga.org).

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[1] In March of 2023, the Office of the Director of National Intelligence (DNI) released the 2023 Annual Threat Assessment of the U.S. Intelligence Community, which raises concerns of the threat of cyberattacks on critical infrastructure by nation-state actors.