Testimony of
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U.S. House of Representatives Select Committee on the Climate Crisis
"Keeping the Lights On: Strategies for Grid Resilience and Reliability"
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Good afternoon, Chair Castor, Ranking Member Graves, and other members of the Select Committee. Thank you for the opportunity to appear before you today to participate in this important hearing on the resilience and reliability of the nation's electricity grid.

My name is Karen Wayland, and I am the CEO of GridWise Alliance. The GridWise Alliance leads a diverse membership of electricity industry stakeholders focused on accelerating innovation that delivers a secure, reliable, resilient, and affordable grid to support decarbonization of the U.S. economy. GridWise is unique in its focus on the electric grid's broader ecosystem, advocating the value of integrating technologies that modernize and transform the grid. We drive impactful change through our diverse membership of utilities, manufacturers, grid operators and researchers united in a common belief that the electric grid is the critical enabling infrastructure of a decarbonized economy.

The GridWise membership includes investor-owned utilities, municipal utilities, rural cooperative utilities, regional transmission operators, grid equipment manufacturers and technology companies, vendors, national laboratory and research institutions, and others. GridWise has been convening member companies that have been leading the transformation of the electricity industry since our founding in 2003. For our utility members, the resilience, reliability, and affordability of electricity is of paramount importance, and all are committed to a low-carbon power supply.

Threats to the Nation's Electricity System

The massive Texas power failure in February 2021 and wildfires in California have focused public attention on the electric grid[1] and emphasized the growing dependence of all sectors of the economy on reliable electricity. The Texas blackout exposed some market and regulatory issues unique to that state, and the scale of economic loss is related to the size of the nation's largest state over which those losses are projected, but increasingly severe weather threatens power grids across the country. There were a record 22 weather events in 2020 in which the costs of damage exceeded $1 billion,[2] and the last two decades have seen a 67% increase in major power outages from weather events (Texas ranks second

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[1] GridWise Alliance uses the term "electricity system" to encompass the entire network of generation, transmission, distribution and consumer/end users of electricity, and "electric grid" to refer to the transmission and distribution system. Here, we use "electric grid" as it has been used in the popular press.
[2] National Oceanic and Atmospheric Administration. "Billion Dollar Climate and Weather Disasters: Time Series." https://www.ncdc.noaa.gov/billions/time-series, accessed March 22, 2021.

behind Michigan in the number of major outages).[3] Five of the worst wildfires in US history occurred in the last four years.[4] The utility industry is also under increasing threats of disruption from cyberattacks from both state-actors, like Russia and non-state actors. And because our critical infrastructure systems are increasingly interdependent, power outages can lead to cascading failures that affect other systems like water treatment (as happened in Texas last month) or gasoline dispensing (as happened in New York following Superstorm Sandy).

We should use the Texas and California blackouts as drivers for conversations about enhancing grid resilience, but we should not lose sight of the ranges of threats that could disrupt power supply at the local, regional, or national level, or even globally, each requiring different risk management practices.

When I was at the U.S. Department of Energy (DOE), my policy team commissioned a report titled "Resilience of the U.S. Electricity System: A Multi-Hazard Perspective"[5] as part of the second installment of the Quadrennial Energy Review.[6] The report identified a range of threats to the electricity sector that grid owners and operators, and federal, state, and local regulators and policy makers must consider while planning for and investing in grid resilience (Table 1). These threats range from extreme weather (hurricanes, floods, winter storms) to geological (earthquakes and geomagnetic pulses) to human-caused (cyber and physical attacks), with likelihood of occurrence varying from extremely low but with high impact to very likely with low- to-high impact. Similarly, the risks differ across the components of the electricity system. Planning for grid resilience requires risk management strategies for the range of hazards and probabilities that could impact grid infrastructure.

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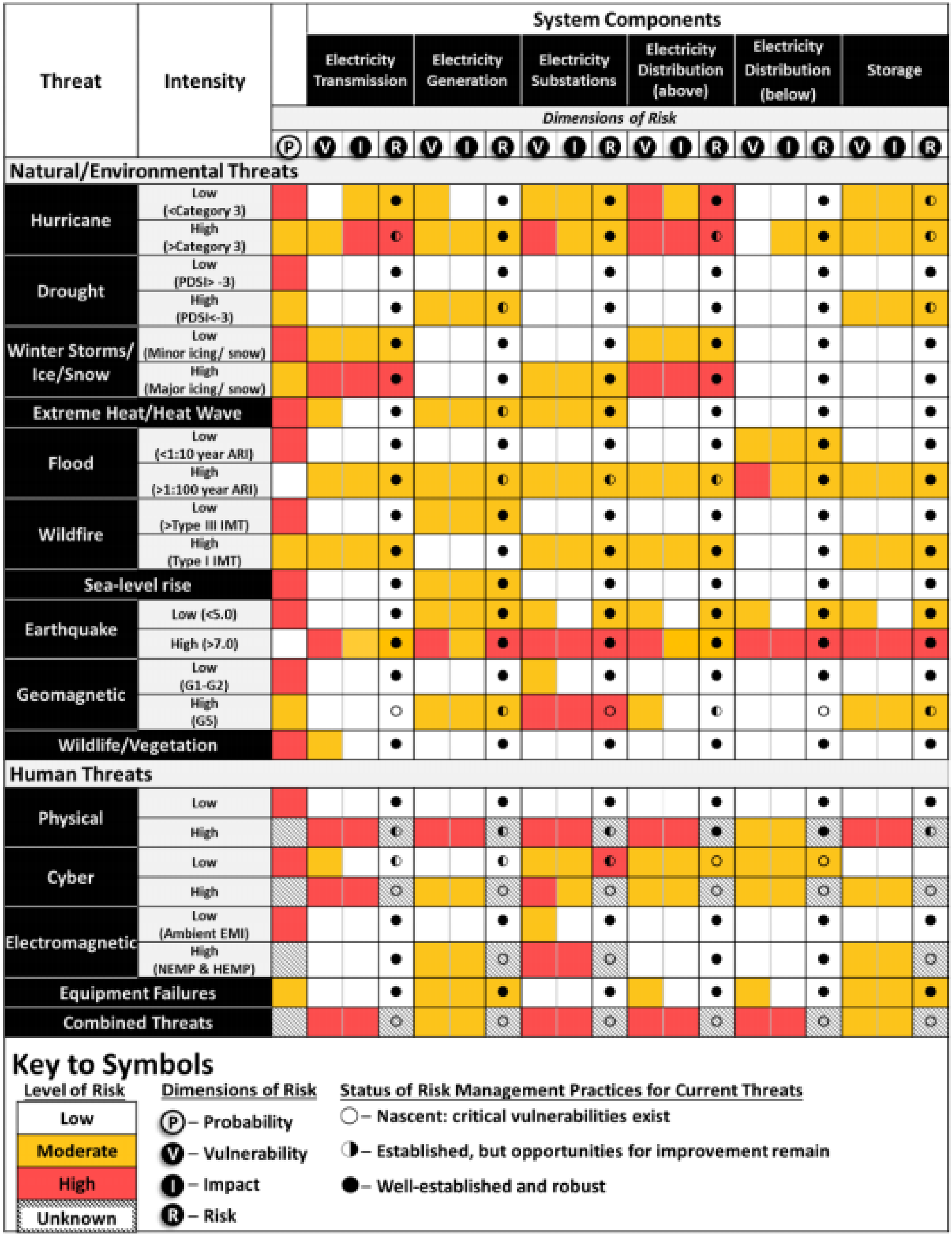
[3] Climate Central. "Power OFF: Extreme Weather and Power Outages." https://medialibrary.climatecentral.org/resources/power-outages, accessed March 22, 2021.

[4] New York Times. "These Changes Are Needed Amid Worsening Wildfires, Experts Say." https://www.nytimes.com/2020/09/10/climate/wildfires-climate-policy.html, accessed March 22, 2021.

[5] Argonne National Laboratory, Brookhaven National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, and Sandia National Laboratories. "Resilience of the U.S. Electricity System: A Multi-Hazard Perspective." https://www.energy.gov/policy/downloads/resilience-us-electricity-system-multi-hazard-perspective, accessed March 22, 2021.

[6] U.S. Department of Energy. "Quadrennial Energy Review--Transforming the Nation's Electricity System: Second Installment of the Quadrennial Energy Review." https://www.energy.gov/sites/prod/files/2017/02/f34/Quadrennial%20Energy%20Review--Second%20Installment%20%28Full%20Report%29.pdf, accessed March 22, 2021.

Table 1. Detailed Integrated Assessment of Risk and Resilience in the Electricity Sector.
Source: “Resilience of the U.S. Electricity System: A Multi-Hazard Perspective”



Threat	Intensity	System Components																		
			Electricity Transmission			Electricity Generation			Electricity Substations			Electricity Distribution (above)			Electricity Distribution (below)			Storage		
		Dimensions of Risk																		
		Ⓟ	Ⓥ	Ⓘ	Ⓡ	Ⓥ	Ⓘ	Ⓡ	Ⓥ	Ⓘ	Ⓡ	Ⓥ	Ⓘ	Ⓡ	Ⓥ	Ⓘ	Ⓡ	Ⓥ	Ⓘ	Ⓡ
Natural/Environmental Threats																				
Hurricane	Low (<Category 3)	🟥	⬜	🟨	🟨 ●	🟨	⬜	⬜ ●	🟨	🟨	🟨 ●	🟥	🟨	🟥 ●	⬜	⬜	⬜ ●	🟨	🟨	🟨 ◐
	High (>Category 3)	🟨	🟨	🟥	🟥 ◐	🟨	🟨	🟨 ●	🟥	🟨	🟨 ●	🟥	🟥	🟥 ◐	⬜	🟨	🟨 ●	🟨	🟨	🟨 ◐
Drought	Low (PDSI> -3)	🟥	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●
	High (PDSI<-3)	🟨	⬜	⬜	⬜ ●	🟨	🟨	🟨 ◐	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	🟨	🟨	🟨 ◐
Winter Storms/ Ice/Snow	Low (Minor icing/ snow)	🟥	🟨	🟨	🟨 ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	🟨	🟨	🟨 ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●
	High (Major icing/ snow)	🟨	🟥	🟥	🟥 ●	⬜	⬜	⬜ ●	🟨	🟨	🟨 ●	🟥	🟥	🟥 ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●
Extreme Heat/Heat Wave		🟥	🟨	⬜	⬜ ●	🟨	🟨	🟨 ◐	🟨	🟨	🟨 ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●
Flood	Low (<1:10 year ARI)	🟥	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	🟨	🟨	🟨 ●	⬜	⬜	⬜ ●
	High (>1:100 year ARI)	⬜	🟨	🟨	🟨 ●	🟨	🟨	🟨 ◐	🟨	🟨	🟨 ◐	🟨	🟨	🟨 ◐	🟥	🟨	🟨 ●	🟨	🟨	🟨 ●
Wildfire	Low (>Type III IMT)	🟥	⬜	⬜	⬜ ●	🟨	🟨	🟨 ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●
	High (Type I IMT)	🟨	🟨	🟨	🟨 ●	⬜	⬜	⬜ ●	🟨	🟨	🟨 ●	🟨	🟨	🟨 ●	⬜	⬜	⬜ ●	🟨	🟨	🟨 ●
Sea-level rise		🟥	⬜	⬜	⬜ ●	🟨	🟨	🟨 ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●
Earthquake	Low (<5.0)	🟥	⬜	⬜	⬜ ●	🟨	🟨	🟨 ●	🟨	⬜	🟨 ●	🟨	⬜	🟨 ●	🟨	⬜	🟨 ●	🟨	⬜	🟨 ●
	High (>7.0)	⬜	🟥	🟨	🟨 ●	🟥	🟨	🟥 ●	🟥	🟥	🟥 ●	🟥	🟨	🟨 ●	🟥	🟥	🟥 ●	🟥	🟥	🟥 ●
Geomagnetic	Low (G1-G2)	🟥	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	🟨	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●
	High (G5)	🟨	⬜	⬜	⬜ ○	🟨	🟨	🟨 ◐	🟥	🟥	🟥 ○	🟨	⬜	⬜ ◐	⬜	⬜	⬜ ○	🟨	🟨	🟨 ◐
Wildlife/Vegetation		🟥	🟨	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●
Human Threats																				
Physical	Low	🟥	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●
	High	▨	🟥	🟥	▨ ◐	🟥	🟥	▨ ◐	🟥	🟥	▨ ◐	🟥	🟥	▨ ●	🟨	🟨	▨ ●	🟥	🟥	▨ ◐
Cyber	Low	🟥	🟨	⬜	⬜ ◐	⬜	⬜	⬜ ◐	🟨	🟨	🟥 ◐	🟨	🟨	🟨 ○	🟨	🟨	🟨 ○	⬜	⬜	⬜
	High	▨	🟥	🟥	▨ ○	🟨	🟨	▨ ○	🟥	🟨	▨ ○	🟨	🟨	▨ ○	🟨	🟨	▨ ○	🟨	🟨	▨ ○
Electromagnetic	Low (Ambient EMI)	🟥	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	🟨	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●
	High (NEMP & HEMP)	▨	⬜	⬜	⬜ ●	🟨	🟨	▨ ○	🟥	🟥	▨ ○	⬜	⬜	⬜ ●	⬜	⬜	⬜ ●	🟨	🟨	▨ ○
Equipment Failures		🟨	⬜	⬜	⬜ ●	🟨	🟨	🟨 ●	⬜	⬜	⬜ ●	🟨	⬜	⬜ ●	🟨	⬜	⬜ ●	🟨	🟨	🟨 ●
Combined Threats		▨	🟥	🟥	▨ ○	🟨	🟨	▨ ○	🟥	🟥	▨ ○	🟥	🟥	▨ ○	🟥	🟥	▨ ○	🟨	🟨	▨ ○

Key to Symbols

Level of Risk	Dimensions of Risk	Status of Risk Management Practices for Current Threats
⬜ Low	Ⓟ – Probability	○ – Nascent: critical vulnerabilities exist
🟨 Moderate	Ⓥ – Vulnerability	◐ – Established, but opportunities for improvement remain
🟥 High	Ⓘ – Impact	● – Well-established and robust
▨ Unknown	Ⓡ – Risk	

Caption: Assessments of risk and status of risk management practice are based on information in Section 4, published literature, and expert judgment (for statistically unknown threats). Table cells represent a qualitative assessment of risk by electric system component and threat. Some threats are divided into low or high intensity threats. Estimates of individual sub-components of risk are presented for each system component and threat: probability refers to the frequency or likelihood of a threat occurring; vulnerability refers to the sensitivity of a system component to harm or damage; impact refers to the potential severity of damage in terms of financial costs, affected customers, and/or health and safety. This table forms the basis for Table 7 in Section 5.2.

Achieving Resilience

The North American Electric Reliability Corporation (NERC), the organization that sets standards for the reliability of the nation's bulk power system, defines reliability as the ability "to meet the electricity needs of end-use customers even when unexpected equipment failures or other factors reduce the amount of available electricity."[7] Reliability metrics capture the frequency (System Average Interruption Frequency Index, or SAIFI) and duration (System Average Interruption Duration Index, or SAIDI) of power outages. These metrics are inadequate to describe the ability of the electricity system to withstand disruptions, minimize the consequences of disruptions that do occur, and quickly recover from those disruptions, which are the defining characteristics of system resilience. A resilient electricity system can also adapt through post-incident learning that feeds into planning and future response.

Enhancing the resilience of the electricity grid is a multi-pronged approach encompassing planning, operations, and technology. The "Resilience of the U.S. Electricity System: A Multi-Hazard Perspective"[8] report identified three facets of building resilience:

- Resourcefulness: in practice this could be applied to the power transmission and distribution system by implementing a constant monitoring and optimized dispatching and/or load shedding to respond to anomalies. For example, if a critical transmission line is lost, power might still be delivered by temporarily overloading parallel/alternative routes and monitoring conductor temperature and time of overload conditions.
- Redundancy: over-engineering critical systems to be able to function, at least at a reduced level, in critical conditions.
- Restoration: coordination and integration among stakeholders of restoration efforts, plans optimized for a variety of scenarios to avoid the need of improvising a solution during critical conditions. Sharing best practices among different organizations (from local to global, nationwide) and practicing simulated emergencies should be mandated and coordinated at the national level. This sharing should include mutual assistance programs and their resources (personnel, equipment, parts) during the restoration phase. Electric utilities have a range of resilience options depending on the threats and hazards facing the region and specific infrastructure. Table 2 presents a list of options that utilities are pursuing to enhance system resilience with the goal of protecting the system, reducing the impact and areal extent of any damage, and accelerating restoration time.[9]

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[7] North American Electricity Reliability Corporation. "Frequently Asked Questions." https://www.nerc.com/AboutNERC/Documents/NERC%20FAQs%20AUG13.pdf, accessed March 22, 2021.

[8] Argonne National Laboratory, Brookhaven National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, and Sandia National Laboratories. "Resilience of the U.S. Electricity System: A Multi-Hazard Perspective." https://www.energy.gov/policy/downloads/resilience-us-electricity-system-multi-hazard-perspective, accessed March 22, 2021.

[9] Argonne National Laboratory. "Front-Line Resilience Perspectives: The Electric Grid." https://www.osti.gov/biblio/1344876, accessed March 22, 2021.

Utilities have a suite of options to enhance resilience of grid infrastructure (Table 2). Grid resilience measures aim to prevent disruptions to power supplies and reduce the severity of impacts and time to recovery in the event of power loss. Hardening of critical infrastructure for resilience may include undergrounding of some power lines, upgrading poles and towers to withstand high winds, and elevating substations above projected flood levels. Trees are the leading cause of power outages,[10] so utility vegetation management programs reduce flammable materials near power lines and remove trees at risk of falling. Utilities conduct practice drills and exercises throughout the year to prepare for disaster response. In the days leading up to an event, utilities will pre-stage crews and equipment in advance of events and may have plans to deenergize some facilities to prevent damage. Mutual assistance agreements with neighboring utilities help speed restoration efforts by deploying emergency response crews to disaster areas. But hardening and disaster planning alone are not sufficient to improve resilience.

New grid technologies that improve situational awareness and control of grid equipment can improve the reliability and resilience of the electricity system. Sensors can alert grid operators to localized disruptions, allowing more targeted response by line crews, and automated grid equipment can automatically sense and response to conditions in the field, including rerouting power around downed lines and self-healing damage. Remote sensing technologies allow utilities to obtain data from drones or NASA images to more effectively manage power line vegetation or assess damage. Advanced meter infrastructure (AMI), or “smart meters,” help grid operators identify local outages and prioritize response crews and verify when power is restored, both reducing the time of outages and the cost of response by reducing “truck rolls” or repair visits.

GridWise member Siemens Energy describes some of its new technologies that utility and power generation customers are deploying to improve resilience:

- **Mobile Resiliency Flexible Extra High Voltage Large Power Transformers**: different from the traditional solutions in the industry, these Siemens Energy units can be deployed and energized extremely quickly (in benchmark times and much quicker than standard in the industry), are extremely flexible (can be used in a variety of configurations and voltage levels) and have large power (MVA) ratings to be used in large substations and power plants. While several utilities in the US have purchased these units to store in their equipment yards, Siemens Energy also operates a leasing program in which a Resiliency Generator Step Up (GSU) Large Power Transformer is owned by Siemens Energy in the US and leased to customers during contingency situations until they are able to source a permanent replacement transformer.[11] Note: that transformer is currently deployed at a power plant and other utilities have requested Siemens Energy deliver it to their sites as soon as it is again available.
- **Mobile Substations**: A mobile substation can act as a stand-by emergency grid restoration solution. It can be mobilized and set up within a couple of hours in the event of a grid failure, hence reducing the technical and financial impact of power outage.

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[10] T&D World. “Plan for Better Vegetation Management in 2019. https://www.tdworld.com/vegetation-management/article/20971840/plan-for-better-vegetation-management-in-2019, accessed March 22, 2021.

[11] https://financialpost.com/pmn/press-releases-pmn/business-wire-news-releases-pmn/siemens-energy-installs-worlds-first-leased-rapid-response-transformers-allowing-a-large-generating-facility-to-return-to-service#:~:text=Siemens%20Energy%20is%20leasing%20the,their%20existing%2C%20conventional%20GSU%20transformer.

Table 2. Electric Utility Resilience Enhancement Options.

Source: Argonne National Laboratory, Front-Line Resilience Perspectives: The Electric Grid (ANL/GSS-16-2).

Resilience Enhancement Options	Definition	Example
Hardening	Physical changes that improve the durability and stability of specific pieces of infrastructure	Raising and sealing water-sensitive equipment
Security measures	Measures that detect and deter intrusions, attacks, and/or the effects of manmade disasters	In-depth security checks on all employees, badged entry and limited access areas, and surveillance and monitoring
Maintenance and general readiness	Routine efforts to minimize or prevent outages	Vegetation management and regular inspection and replacement of worn-out components
Modernization, control enhancements, and smart-grid technology	Technology and materials enhancements to create a more flexible and efficient grid	Integration of smart-grid technologies, such as smart meters and phasor measurement units
Diversified and integrated grid	Transitioning of the grid from a centralized system to a decentralized generation and distribution system	Integration of distributed generation sources, such as renewable energy sources and establishment of microgrids
Redundancy, backup equipment, and inventory management	Measures to prepare for potential disruptions to service	Maintenance of spare equipment inventory, priority agreements with suppliers, and maintenance of a supply of backup generators
Mutual aid programs	Agreements that encourage entities to plan ahead and put in place mechanisms to acquire emergency assistance during or after a disaster	Agreements between utilities to send aid or support after a disaster
Succession training, knowledge transfer, and workforce development	Planning for transfer of knowledge and skills from a large retiring workforce, to a smaller, younger workforce	Proactive efforts to create training and cross-training programs and succession plans
Business continuity and emergency action planning	A formal plan that addresses actions and procedures to maintain operations preceding an event	Components including employee awareness, training, and exercising
Models	Mathematical constructs that provide information on performance and/or disruptions to aide in decisionmaking	Probabilistic risk models to assist in predicting outage impacts after an event

- **Mobile SVC (STATCOM):** Siemens Energy developed a flexible, mobile substation for GridWise member Dominion Energy (Virginia) to help keep the grid stable to allow sufficient time to plan for renewables on its system. The substation technology also responds to any faults on the network within milliseconds.[12] Dominion notes that "The mobile STATCOM gives utilities the flexibility to develop short-term plans while successfully constructing a long-term solution. The ability to reduce outage contingencies and improve economic opportunity were the driving force."[13]
- **UPFC+ (Unified Power Flow Controller):** UPFC+ is used to effectively manage the transmission system and provide the stability and resilience through an extremely fast response with both series and parallel compensation to keep lines within the n-1 criterion and the electricity flowing. The UPFC can balance load flow in the AC grid, rapidly bypass overloaded line sections, provide reactive power and dynamic voltage control. It provides reactive power compensation, voltage control and active power load flow control in one unit.

Modern utility communication networks are critical for grid resilience. Modern networks improve operational speed and visibility for grid operators, and customer-facing communication channels provide information to customers on estimated time of power restoration as well as safety information and recommendations in the event of extended outages. Whether new utility applications provide grid situational awareness, automatically de-energize broken power lines before they hit the ground and start a wildfire, or coordinate small, distributed microgrids into a single virtual power plant, their operation will require utility private broadband networks -- both wireless and wired. For example, Anterix, a GridWise member, recently announced the publication of a joint White Paper with Schweitzer Engineering Labs detailing the successful testing of a wildfire mitigation solution that when deployed as part of a wireless broadband network, can de-energize a falling power line before it hits the ground, removing its ability to spark a wildfire.

As decarbonization efforts lead to increased reliance upon distributed renewable energy resources and vastly greater electrification, the reliable, resilient, efficient and safe operation of the grid will be of growing importance in major sectors of the economy, from manufacturing to transportation. Utilities' broadband communications networks are a foundational element supporting decarbonization goals -- they enable the smart grid capabilities utilities will rely on to reduce their greenhouse gas emissions. In the last year alone, a number of GridWise members have investigated, supported, or pursued the deployment of private wireless networks.

Distributed generation technologies such as microgrids and mobile generators can enhance the resilience of electric infrastructure serving critical loads, such as hospitals, water treatment facilities, and emergency shelters. Microgrids incorporate a generating source like a generator or solar panels with storage and energy management systems

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[12] https://www.smart-energy.com/regional-news/north-america/dominion-energy-to-utilise-mobile-svc-statcom-tech/#:~:text=US%20utility%20Dominion%20Energy%20will,fast%20and%20controlled%20reactive%20power.

[13] https://www.tdworld.com/digital-innovations/statcom/article/21132983/dominion-energy-develops-mobile-statcom

and can be “islanded” from the grid during power disruptions to provide back-up power. Mobile generators can provide temporary power to critical facilities, and utilities should identify locations where generators can be easily connected to the grid during emergency planning processes. Rooftop solar and storage systems can provide backup power to homes during short outages. Aggregated distributed energy resources can contribute power to meet load during extreme heat or cold events and mitigate disruptions associated with distribution or transmission line failure or loss of generation units.

GridWise member Hitachi Energy notes that our power systems are evolving to be more interconnected and operating closer to their limits, making the ability to ride through critical disruptive events like extreme weather more important than focusing instead on avoiding disruptions entirely: “Power systems should be able to fall back in a mode using locally available sources in case the transmission grid is not available. Even if local generation capacity is insufficient to cover local load completely, supply critical infrastructures, such as water supply, hospitals or telecommunications networks, would be essential as the minimum.”[14] (Figure 1)

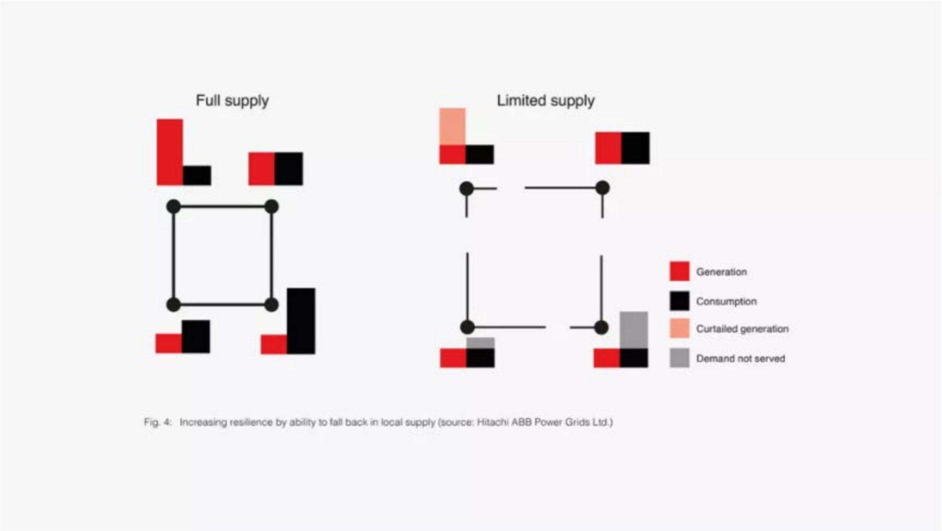

Figure 1. Increasing resilience by ability to fall back on local supply (Source: Hitachi Energy)

GridWise Alliance Member Investments in Grid Resilience

As noted above, the U.S. economy is increasingly dependent on electric power and this dependence is likely only to grow in coming years with growing electrification of the transportation, building and industrial sectors. The growing interdependency of lifeline systems and the electricity system increases the risk of a “cascading effect” during extreme events. As extreme weather events increase in frequency and strength, grid owners and operators are taking deliberate measures to ensure the system’s reliability and flexibility support the Nation’s needs. Utilities around the country are developing investment plans to deploy grid modernization technologies that can significantly enhance

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[14] https://www.hitachienergy.com/us/en/news/perspectives/2020/07/flexibility-and-resilience-our-aces-in-extraordinary-times

electric system reliability and resilience and prevent these cascading events. Several GridWise member utilities provided examples of their resilience investments to share with the Committee.

FPL (Florida)

The 2004 and 2005 hurricane seasons were one of the most extraordinary and challenging seasons on record for FPL and its customers. In 2004 alone, there were 15 storms and six major hurricanes. FPL was impacted by seven storms in its service territory, that resulted in significant customer outages and requiring extraordinary efforts to rebuild and restore the electric infrastructure which compelled FPL to re-examine and evaluate its infrastructure and policies.

Since 2006, FPL has been implementing Florida Public Service Commission-approved programs to strengthen its transmission and distribution ("T&D") infrastructure (See Figure 2). These programs include multiple storm hardening and storm preparedness programs, such as feeder hardening, replacing wood transmission structures, vegetation management, and pole inspections. As demonstrated by recent storm events, these ongoing storm hardening and storm preparedness programs have resulted in FPL's T&D electrical grid becoming more storm resilient, experiencing less infrastructure damage and reduced restoration times, as compared to non-hardened facilities. Specifically, Table 3 highlights the significant reduction in restoration times due to hardening the grid from Hurricane Wilma in 2005, and Hurricane Irma in 2017. Despite Hurricane Irma being a stronger storm, the average customer outage during Irma was over 60% less than Hurricane Wilma. FPL's hardened feeders have performed over 40% better than non-hardened feeders on day-to-day reliability not just storm events. The faster restoration during storm events results in positive economic impact to communities with customers getting back to normal operations sooner. FPL is an industry leader in the electric grid resiliency space and has shared best practices and strategies with other utilities across states.

These programs have also provided significant improvements in day-to-day reliability. When old conductors, equipment and connectors are replaced as part of feeder hardening, the system becomes more efficient and therefore improves line losses resulting in a positive economic and environmental benefits.

Additionally, as FPL President and CEO Eric Silagy stated late last year regarding climate change: "*Florida is a rapidly growing state on the front lines of climate change and our customers deserve bold, decisive, long-term actions as we continue building a more resilient and sustainable energy future all of us can depend on, including future generations."*

FPL Key Storm Hardening Initiatives

Feeder Hardening:

Feeders (main distribution lines) are the backbone and therefore a critical component of FPL's overhead distribution system. Since 2006, FPL has been hardening its distribution feeders to meet Extreme Wind Loading (EWL) as defined by NESC rule 250.C to existing and new feeders. This allows poles to withstand wind gusts in upward of 145 mph in many parts of our service area. The design loading impact to meet EWL usually requires some combination of stronger poles and shorter span lengths (distance between poles) to reduce the wind loading imposed on the conductors and cables.

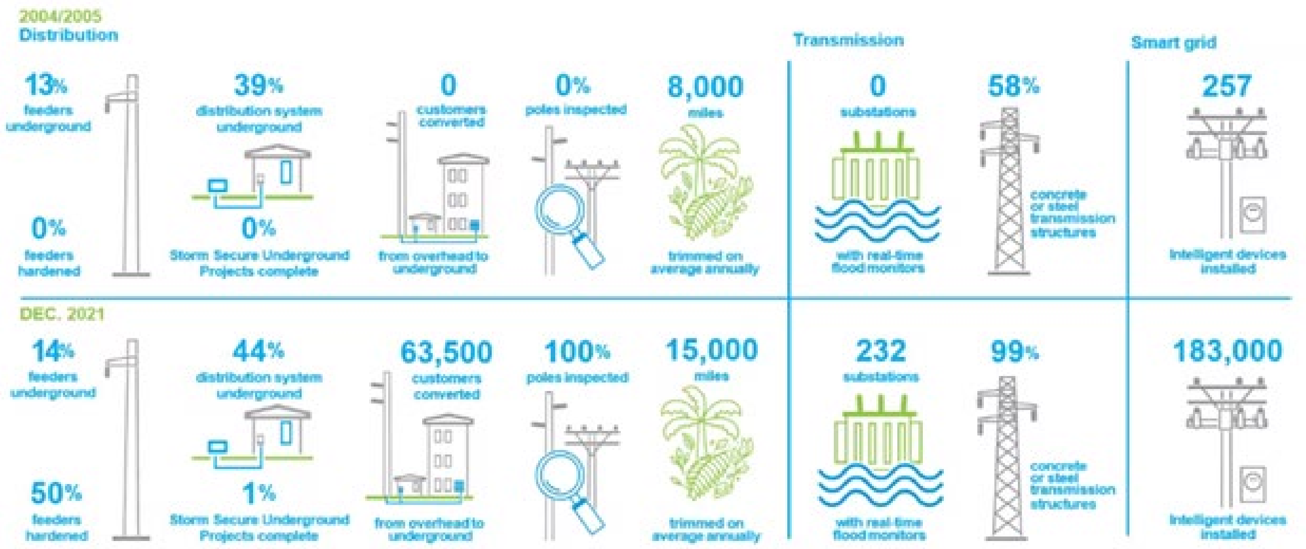

Figure 2. FPL investments in grid resilience.

Table 3. Improvement in restoration times from Hurricane Wilma to Hurricane Irma due to grid hardening.

	Hurricane Wilma (2005)	Hurricane Irma (2017)
Saffir-Simpson Scale	Category 3	Category 4
Fla. landfall max sustained winds	120 mph	130 mph
Cyclone Damage Potential Index	2.8	4.3
Customers outages avoided by AFS	N/A	~500K +
Customers affected	3.2 million (75%)	4.4 million (~90%)
Poles damaged	12400	2900
Transmission structures failed	100	5
Substations de-energized	241	92
Substations restored	5 days	1 day
50% of customers restored	5 days	1 day
100% of customers restored	**18 days**	**10 days**
Average customer outage	**5.4 days**	**2.1 days**

FPL's design strategy considered a philosophy of ***Prevention*** (EWL) / ***Mitigation*** (minimizing damage) and ***Restoration*** (improving the efficiency of restoration in the event of failure). FPL implemented a system-wide Design Guidelines containing criteria which will apply EWL to the design and construction of all new overhead facilities, major planned work, relocation projects, as well as daily work activities. These guidelines primarily are associated with changes in pole class, pole type and desired span lengths FPL began its efforts by hardening feeders serving Critical Infrastructure Facilities (CIF) such as hospitals, 911 Centers, special needs shelters, water treatment plants, police, and fire stations. In addition, FPL targeted feeders that served community needs such as gas stations, pharmacies, and grocery stores to help bring the community back to normalcy after a major storm event. FPL hardened over 125 highway crossings, that could otherwise impede traffic flow of support and emergency vehicles after a major storm and over 300 "01" switches (first pole out of a substation with a feeder switch). As of year-end 2021, nearly 2/3rd or 64% of FPL's feeders are either hardened or placed underground.

Distribution Pole Inspection:
FPL inspects all its distribution poles on an 8-year cycle or roughly 1/8th of its distribution poles annually. Inspections include a visual inspection, sound and bore, excavation and treatment where applicable. Strength calculations are also performed on wood poles to determine compliance with NESC requirements. The poles that are not suitable for continued service are designated for replacement or remediation.

Transmission Pole Inspection and Hardening:
FPL inspects its transmission circuits, substations, and other equipment on a six-year cycle. All of FPL's transmission structures are visually inspected from the ground each year. FPL performs climbing or bucket truck inspections on all wood transmission structures on a six-year cycle and all steel and concrete structures on a ten-year cycle. Inspections for wood structures include an overall assessment of the condition of the structures, as well as other pole/structure components including the foundation, all attachments, insulators, guys, cross-braces, cross-arms, and bolts. If a wood transmission structure does not pass visual inspection, it is designated for replacement with a concrete or steel transmission structure. Ninety-nine percent of transmission structures are now concrete or steel with the plan to reach one hundred percent by 2022. One hundred percent of ceramic post insulators on square concrete poles were replaced, to avoid cascading events. FPL has started a multiyear program for strategically converting overhead river crossings to underground.

Undergrounding:
To promote undergrounding, FPL provides cost credits towards applicable local government sponsored overhead to underground conversions. Over 63,000 customers have been converted as part of this initiative.

Vegetation:
FPL's has a systemwide three-year average trim cycle for distribution feeders and six-year average for lateral circuits (fused tap lines). FPL's transmission system is inspected annually to prevent vegetation-related outages.

Substation Storm Surge/Flood Mitigation Program:
FPL installed flood resistant substation doors and hardened windows and louvers, as well as flood monitoring systems both inside the relay vault and outside for situational awareness. FPL also developed a process to deploy an AquaDam System to help protect against flooding.

Storm Secure Underground Program (SSUP): Lateral Undergrounding
In 2018, FPL began the SSUP pilot which targets certain overhead laterals that were impacted by recent storms and that have a history of vegetation-related outages and other reliability issues for conversion from overhead to underground. Objectives of the pilot include determining the most cost-effective ways to underground lateral (neighborhood) power lines and testing different design and construction methods. FPL has completed approximately six hundred SSUP projects through the end of 2021, with another six hundred more planned in 2022.

Smart Grid:
In addition to making FPL's electrical system more resilient, the utility has installed several self-healing smart switches that help during storm events and reduce the time it takes to restore power. Those include more than 7,000 Automated Feeder Switches (AFS), more than 95,000 Automated Lateral Switches (ALS), more than 40,000 Automated Transformer Switches (ATS) and approximately 40,000 Intelligent Sensors. Since 2011, over ten million customer interruptions have been avoided because of smart grid devices.

Portland General Electric (Oregon)

Wildfire Mitigation:
PGE has developed plans to help mitigate increasing risk of wildfires in our service territory due to climate change. Mitigation activities include installing a network of weather stations and wildfire cameras to increase our situational awareness and respond to potential wildfire incidents in a more timely manner. System hardening projects include targeted undergrounding of high voltage infrastructure and/or reconductoring overhead lines in high risk fire zones with covered (insulated) conductors. Other mitigations include installing smart faulted circuit indicators, intelligent reclosers, and deploying smart protective relays and settings to limit the arc energy during a system fault and hence lowering the potential of starting a fire. These targeted system upgrades are over the next 10 years with an investment of $80-$100 million/year.

Benefit calculations for resiliency have not yet been developed, however we expect significant reductions in Customer Minutes Interrupted (CMI) in the areas that are transitioned to underground or covered conductors.

Mt Hood Reliability:
Due to increasing wildfire risk and impacts from more severe storm events, PGE is developing plans to increase reliability and resiliency along our transmission and distribution system that serves customers along the Mt Hood corridor. Included in this project is undergrounding our 57kV transmission system that is the energy source for the mountain and serves the City of Portland's Bull Run water and hydro generation facilities. The Bull Run reservoirs are the main water source to nearly 1 million residents in the Willamette valley and is located in the heavily treed forest on Mt Hood. The project aims to increase the resiliency of this water supply system and reduce the risk of a devastating wildfire in the protected area. Also included is developing a resiliency zone in the Welches downtown area that will serve residents during potential outages during winter storms and during wildfire season where a Public Safety Power Shutoff (PSPS) may be necessary to prevent a catastrophic wildfire event. This total project is expected to take 10 years to complete at an estimated cost of $400-$600 million dollars.

Willamette Valley Resiliency:
Due to increasing impacts from more severe storms, increasing load growth in the Willamette Valley, and aging assets, PGE is developing plans to increase reliability and resiliency on the transmission and distribution system in the Willamette Valley Area. Included in this project is the rebuild of six substations and the addition of two new transmission sources. As part of the rebuilds, five substations and their associated transmission lines are upgraded from 57 kV to 115 kV. To increase reliability and resiliency on the transmission and distributions systems, the upgraded substations are converted from simple bus to ring bus configurations, aging substation assets are replaced, direct buried feeders are replaced, and transmission lines are upgraded. This total project is expected to take 7 years at an estimated cost of $240 million dollars.

Energy Storage Microgrids:
PGE has developed two energy storage microgrids in our service territory to offer community resiliency benefits. Both projects leverage partnerships with customer investments in new solar resources paired up with utility investment in energy storage and microgrid controls. These projects were implemented with a PGE capital investment of $2.5 million.

Distribution Automation:
PGE has been implementing a Distribution Automation (DA) program for several years. This program installs intelligent devices on the distribution system to automatically switch around faulted sections of the system in order to restore customers quickly. PGE has spent at least $13 million since 2018 on its DA program, benefiting 134,000 customers. PGE deployed SCADA-integrated G&W Viper ST reclosers, Sentient MM3 and ZMI smart line monitors, S&C TripSaver II reclosers and SEL-751 feeder breaker protective relays. PGE estimates the TripSaver reclosers have prevented over 3 million customer outage minutes since 2019 and the G&W Viper ST reclosers prevented over 8 million customer outage minutes since 2018.

Bandera Electric Cooperative (Texas)

In February 2021, the ERCOT power grid collapsed, reflecting failures on several different levels. As a transmission-owning electric utility, Bandera Electric Cooperative (BEC) was forced into “rolling black-outs” to save the grid from complete collapse. Prior to the ERCOT-mandated outages, Bandera had over 1500 outage events between Feb 12-14, 2021. The lessons BEC learned from the February 2021 event was the need to understand what was going at the edge of the grid and behind- the-meter residential solar, energy storage, HVAC systems, and other distributed energy resources.

Having visibility into what is happening at the edge of the grid is critical to grid resilience. BEC developed an energy analytic platform called Apolloware that greatly improved grid resilience in 2022. Apolloware Control Module (ACM) installs on residential and commercial buildings where it monitors various appliance, solar panel power and inverter, and electric service circuits, providing granular real-time data on behind-the-meter energy consumption and generation. The ACM transmits this data to a secure Apolloware cloud using the local internet connection. Homeowners and authorized users can view this data from any device through the Apolloware mobile app or website. In February 2021, Bandera had over 400 service locations with Apolloware with another 200 units planned for deployment by the end of 2021.

Apolloware allowed BEC to analyze energy use at the appliance level after the 2021 freeze event and published the results in a paper entitled, "What was happening inside Texas homes during the February 2021 freeze?"[15] In this paper and a submission to the Public Utility Commission of Texas (PUCT, Docket 52373), BEC described the impact of energy efficiency on grid reliability and affordability. Average home power draw was almost 500% higher and average HVAC power demand 620% higher during the period of February 11-20 compared to February 1, 2021. However, the kWh/sqft of homes monitored by Apolloware varied by a factor of 21, meaning some homes were more cold-sensitive and used more energy the colder the outside temperatures relative to other homes. Apolloware also allowed BEC to gain insights into what appliances behind the meter were using electricity (Figure 3). BEC discovered that during the freeze event, home batteries were still being charged, so the utility was able to notify customers to stop charging to save energy.

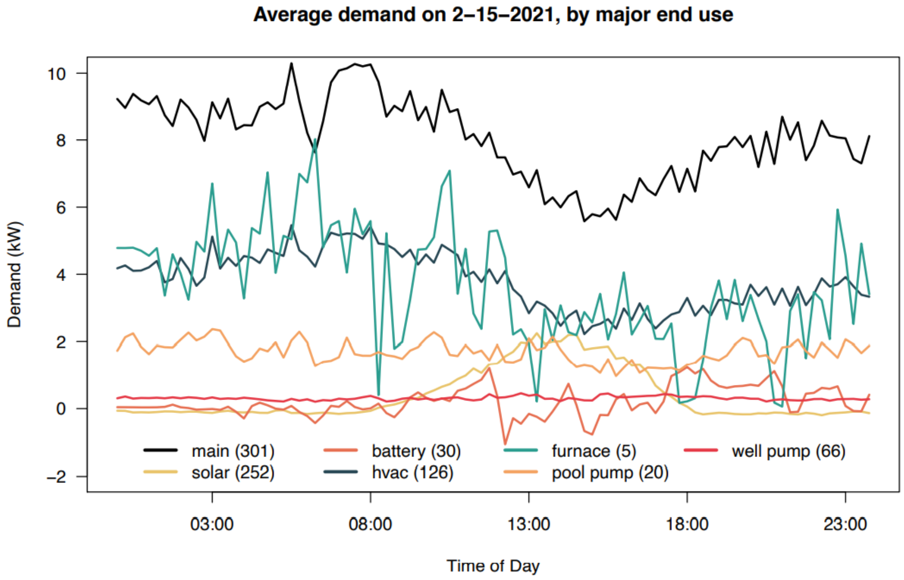

Figure 3. Average demand on 2-15-2021, by major end use within residential homes, as measured by Bandera Electric Cooperative.

While the weather in Texas on Feb 3-6 of 2022 was not as severe as 2021, Bandera experienced only 10 outages and was able to utilize energy analytics to provide better transparency of real time energy usage to its customers. In its submission to the PUCT in November 2021, BEC concluded that "Having granular individual data tied to substation, feeder and phase is an important aspect of understanding energy use tied to weather… Having behind the meter visibility and transparency would help ERCOT with better grid planning and more importantly better understanding of how to minimize black-outs through the development of an intelligent demand response program based on fleet wide monitoring

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[15] https://www.ideasmiths.net/wp-content/uploads/2022/02/BEC_TX_FREEZE_HOMES_APW_20220212_v2.pdf

and control of HVAC, Water Heaters and Pool pump devices ties to wholesale market prices. If this type of program had been in place during Winter Storm Uri the impacts would have been minimal. With the right pricing signals (utilities) could incentivize voluntary load reductions thereby avoiding MANDATORY rolling blackouts."

BEC's CEO, William Hetherington, concluded in the PUCT filing, "We have the technology to operate an intelligent grid down to the appliance level, but we need energy efficiency programs and individualized demand response programs that tie directly to market pricing to keep the loss of power voluntary. If these programs had been in place last February, I believe that Voluntary load reductions would have been adequate to keep the grid for rolling blackouts on a statewide basis."

Exelon (Multiple states)

Preparing for the impacts of climate change across all its jurisdictions, Exelon is investing to modernize its transmission and distribution grids to make them stronger and more resilient. Efforts include replacing poles to meet higher wind speeds, undergrounding select lines and expanding capacity to increase redundancies to meet critical load.

In New Jersey, as part of our broader strategic effort to better serve its customers and modernize the energy grid, Exelon (Atlantic City Electric) launched the Atlantic-to-Ocean Counties Reliability Project, which includes rebuilding 15.1 miles of critical transmission line using stronger utility poles and modern equipment between Port Republic and Tuckerton. This transmission line serves more than 22,000 customers in the eastern portion of our service area in South Jersey and is critical to customer reliability in Atlantic, Burlington and Ocean counties. Construction began in 2020 and will be completed by Summer 2022.

In the District of Columbia, the DC Power Line Undergrounding initiative (DC PLUG) is a $500 million multi-year Pepco partnership and engagement with the District of Columbia government to strategically underground lines to secure the most vulnerable distribution power lines in the face of increasingly severe weather. In 2020, Pepco energized the first completed feeder, located in Ward 3, and initiated new projects in Wards 7 and 8. This initiative is expected to improve resiliency against major storms and to improve reliability by an estimated 95% on selected feeders.

ComEd in Illinois is the first utility in the U.S. to permanently install superconductor cable technology at a substation in Chicago's Irving Park neighborhood. Superconductor technology can support 200 times the current of standard copper wire, and allows electricity to be rerouted, creating a backup system that keeps electricity flowing in the event of a major power grid interruption.

Grid Resilience in the Infrastructure Investments and Jobs Act

The bipartisan Infrastructure Investment and Jobs Act (IIJA) passed by Congress in 2021 includes significant investments to make the grid smarter, more secure and more resilient. Federal funding for grid modernization will leverage private capital, accelerate grid modernization plans, and help de-risk state public utility commission decisions.

GridWise Alliance developed a set of investment priorities, "**Grid Investments for Economic Recovery,**"[16] for an infrastructure package. The policy framework included recommendations for over $50 billion in funding for programs across the federal government to deploy technologies that would increase grid flexibility, improve the integration of buildings and vehicles with the grid, address cybersecurity threats, create a domestic supply chain for critical grid equipment, modernize utility communication networks and help address the digital divide, and provide workforce training for digital, high tech grid jobs. The GridWise investment recommendations also include over $18 billion for mission critical public infrastructure resilience and emergency preparedness. Our recommendations also include funding for wildfire detection technologies.

The IIJA includes significant funding as recommended in the GridWise policy framework to defray the costs of resiliency, smart grid flexibility, cybersecurity and other emergency preparedness investments. Federal funding will leverage billions of dollars in private capital total for grid-integrated resiliency infrastructure.

According to the 2020 U.S. Energy and Employment Report (USEER),[17] energy jobs grew faster in 2019 than job growth as a whole, and the transmission, storage, and distribution sector, which employed over 700,000 people, was projected to grow 3.5% in 2020. This growth can be restored or accelerated by federal investment. Smart grid funding of $8 billion in the 2009 recovery bill created 80,000 jobs and accelerated the deployment of new technologies. The overall 2009 clean energy investments, including renewable generation, advanced vehicles, transit, equipment manufacturing, and job training, resulted in at least 720,000 new jobs.[18] The grid investments in IIJA will create significant jobs over the five years of funding and spur economic growth.

GridWise Alliance Grid Resilience Workshop Outcomes

With support from DOE, the GridWise Alliance brought together experts from utilities and grid equipment manufacturers and vendors for a workshop to develop recommendations for improving grid reliability and resilience in the face of very large-scale events (VLSE) like the Texas freeze of 2021, Superstorm Sandy in 2012, and the California wildfires of 2012 and 2020. The 20 utilities participating in the workshop represented over 40% of the nation's electric customers. The workshop resulted in a set of key recommendations detailed in "Improving Electric Grid Reliability and Resilience: Lessons Learned from Superstorm Sandy and Other Extreme Events."[19] Those recommendations are relevant for today's hearing about grid resilience, implementation of IIJA, and further actions Congress can take to improve grid resilience and reliability.

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[16] GridWise Alliance. "Policy Framework for Grid Investments for Economic Recovery." https://gridwise.org/wp-content/uploads/2021/01/Policy-Framework-for-Stimulus-Investments-in-Grid-Modernization-FINAL-1.5.21-002.pdf, accessed March 22, 2021.

[17] National Association of State Energy Officials and Energy Futures Initiative. "U.S. Energy and Employment Jobs Report." https://www.usenergyjobs.org/, accessed March 22, 2021.

[18] White House Archives. "Impact of the American Recovery and Reinvestment Act on the Clean Energy Transformation." https://obamawhitehouse.archives.gov/blog/2010/04/21/impact-american-recovery-and-reinvestment-act-clean-energy-transformation, accessed March 22, 2021.

[19] GridWise Alliance. 'Improving Grid Reliability and Resilience: Lessons Learned from Superstorm Sandy and Other Extreme Events." https://gridwise.org/superstorm-sandy-report/, accessed March 22, 2021.

GRIDWISE LESSON LEARNED: GRID MODERNIZATION TECHNOLOGIES CAN PREVENT OUTAGES AND DECREASE PROJECTED IMPACTS

State and federal policy makers and electric utilities must accelerate the integration of existing grid modernization technologies to enhance grid resilience, reliability, safety, and security. Smart grid technologies can monitor and protect against disruption, optimize performance, and self-heal automatically. Improved situational awareness and control of grid equipment significantly enhance a utility's ability to reduce the impact of VLSEs and speed restoration efforts.

GRIDWISE LESSON LEARNED: DISTRIBUTED GENERATION TECHNOLOGIES SUCH AS MICROGRIDS AND MOBILE GENERATORS CAN ENHANCE THE RESILIENCE OF ELECTRIC INFRASTRUCTURE SERVING CRITICAL LOADS

A diversified and integrated grid can enhance resilience, with distributed energy resources able to provide back-up power to individual customers and flexibility for grid operations. Microgrids—distributed electric generation resources incorporating storage, load control, and energy management systems—are able to operate independently of the grid, although in normal operating conditions, they are integrated with the grid. On the customer side, distributed energy resources (DERs) like electric vehicles, rooftop solar, and storage can provide resilience to individual buildings; when DERs can be integrated with the grid and aggregated, they can provide services (e.g. power, voltage support, frequency regulation) that grid operators can harness to balance the grid during extreme events.

Microgrids

GridWise Alliance supports the expanded deployment of microgrids to provide power to critical infrastructure and isolated communities. Technical assistance should include identifying policy and regulatory issues that inhibit the management of microgrids and DERs during emergencies. Congress should ensure that as DOE implements its resilience grant programs that it engages stakeholders to explore potential solutions to regulatory and policy barriers associated with multi-customer microgrids. Some issues raised by GridWise resilience workshop participants include:

- Backup generators can run out of fuel; how will fuel supplies be obtained and ensured?
- Backup generators can be rendered inoperable due to flooding; are there ways in which to protect these assets from flooding?
- Renewable energy (e.g., rooftop solar) still requires an operational grid to supply local loads; how can the system supply these loads without grid power?
- Multi-customer microgrids have diverse operating requirements; who balances supply and demand on multi-customer microgrids?
- Some states prohibit third party sales of electricity; how will that affect the viability of multi-customer microgrids?
- Microgrids are becoming more prevalent; will utilities be allowed to own and/or manage microgrids?
- Regarding ways in which to integrate and tie multi-customer microgrids to the utility grid: what new rules, if any, are needed?

Distributed Energy Resources (DERs)

GridWise Alliance supports the expansion of DER deployment to meet resilience and climate goals and to meet changing customer expectations. To maximize the full value and potential of DERs for resilience and other goals, grid operators need a more flexible and agile grid architecture.[20] Advanced control and monitoring systems that can dynamically respond to system changes will enable safe and reliable power restoration and support safe dispatch of DERs during VLSEs. GridWise recommends pairing investments to scale deployment of DERs on the customer side with investments in grid modernization to achieve continued power quality and reliability at the distribution level through the optimization and aggregation of local DERs.

Congress should ensure that DOE funding for resilience and grid flexibility can be used to continue the deployment of Advanced Metering Infrastructure (AMI, or "smart meters") and smart inverters.

- Smart meters significantly contribute to grid resilience by providing grid operators with granular information about the location of power outages and verification that power has been restored. Utilities use this information to prioritize dispatching repair crews and in communicating with customers, which reduces restoration costs and total outage time. Customers also experience benefits, including less lost productivity, food spoilage, and inconvenience, and reduced public health and safety hazards.[21] GridWise resilience workshop participants estimated that integrating AMI meters with restoration processes shaved 2-3 days off the time it would have taken to completely restore power after Superstorm Sandy, a 10-15% improvement in the speed of restoration.
- Smart inverters provide grid support functions, such as voltage regulation, frequency support and ride through capabilities.[22] In the event of a power disruption, a rooftop solar system will automatically shut off to prevent electricity to flow onto the power lines and potentially electrocute line workers. Smart inverters may include a circuit to allow customers to power their homes without sending electricity to the grid. Solar-battery combinations also allow customers to island their systems from the grid during power outages but have the added resilience benefit of providing power when the sun is not shining.

Buildings and Energy Efficiency

Buildings consume 76% of electricity generated in the United States.[23] IIJA includes significant funding for weatherization and energy efficiency improvements for federal, residential, and commercial buildings through updated building codes, funding for building retrofits, state energy grants, and other policy levers. Improving the efficiency of the nation's building stock will enhance resilience to energy disruptions in addition to saving energy. Well-insulated buildings reduce heating and cooling load during

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[20] GridWise Alliance. "In an Accelerated Energy Transition, Can U.S. Utilities Fast-Track Transformation?" https://gridwise.org/wp-content/uploads/2019/12/Perspectives-on-a-Future-Distribution-System.pdf, accessed March 22, 2021.

[21] U.S. Department of Energy. "Smart Grid Investments Improve Grid Reliability, Resilience, and Storm Recovery." https://www.energy.gov/sites/prod/files/2014/12/f19/SG-ImprovesRestoration-Nov2014.pdf, accessed March 22, 2021.

[22] Interstate Renewable Energy Council. "Smart Inverters." https://irecusa.org/regulatory-reform/smart-inverters/, accessed March 22, 2021.

[23] U.S. Department of Energy. "Quadrennial Technology Review, Chapter 5: Increasing Efficiency of Building Systems and Technologies." https://www.energy.gov/sites/prod/files/2017/03/f34/qtr-2015-chapter5.pdf, accessed March 22, 2021.

periods of high electricity demand associated with extreme weather and keep occupants more comfortable during power outages. Focusing resources for weatherization on underserved and low-income communities is critical to ensure that those populations do not suffer disproportionately during energy disruptions. IIJA funding will result in the weatherization and retrofitting of millions of public and private buildings across the country.

Congress should ensure that any programs to retrofit buildings encourages the installation of grid-connected Energy Management Systems (EMS) in addition to insulation and energy efficient windows and appliances, where possible. Grid-integrated buildings can be significant assets to the grid through load shifting, demand response, and aggregation of distributed generation. According to the National Association of State Energy Officials (NASEO), greater optimization of the significant energy demand and supply functions that buildings offer—on an automated basis—has far-reaching electricity policy and regulatory implications. The benefits include lower costs, enhanced resilience, reduced peak loads, enhanced energy efficiency and better integration of distributed energy resources.[24]

Funding should facilitate aggregation and management of building loads through grid-connected Energy Management Systems (EMS) and smart equipment/appliances within the building, and Advanced Meter Infrastructure (AMI) at the grid-building interface. Though not the subject of today's hearing, electric vehicles (EV's) can also provide power and essential reliability services to the grid, and policies designed to increase deployment of EVs (Title IV) should also encourage vehicle-to-grid integration capabilities.

GRIDWISE LESSON LEARNED: INFORMATION AND COMMUNICATIONS TECHNOLOGY (ICT) INFRASTRUCTURES SHOULD BE MORE RESILIENT, RELIABLE AND SECURE

Utilities' investments in operational fiber and wireless broadband communications network are essential for a modern grid, as noted previously. The legacy communications networks utilities have used for decades to monitor and control the state of the grid and stay in contact with utility workers and customers are inadequate for integrating new grid and customer technologies, which are driving increased communications traffic. These include "demand response systems, advanced metering infrastructure (AMI), distributed grid operations, grid automation, operational systems for managing power generation, outages and flows, two-way communications for consumer energy efficiency initiatives, transmission interconnectivity, and network security monitoring and reporting."[25] Utility communication systems can include fiber networks and private wireless networks must be integrated with legacy communications networks.

The broadband provisions in IIJA recognize that modern communications networks can also be leveraged to provide middle mile broadband and last mile internet service for end-use consumers. A modern, digital communications network is therefore the backbone of a modern grid and can provide significant resilience benefits, but it will have to be more reliable than other grid infrastructure in order to support a resilient grid that can monitor and react quickly to disruptions.

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[24] National Association of State Energy Officials. "Grid-interactive Efficient Buildings: State Briefing Paper." https://naseo.org/data/sites/1/documents/publications/v3-Final-Updated-GEB-Doc-10-30.pdf, accessed March 22, 2021.

[25] Power Grid International. "Challenges, Solutions in Utility Communications Networks." https://www.power-grid.com/smart-grid/challenges-solutions-in-utility-communications-networks/#gref, accessed March 22, 2021.

GRIDWISE LESSON LEARNED: ENHANCED EMERGENCY RESPONSE PLANNING PROCESSES CAN RESULT IN BETTER DEPLOYMENT AND COORDINATION OF HUMAN AND OTHER RESOURCES

Electric utilities, in conjunction with the appropriate federal and state agencies, continually develop predictive restoration plans at a regional level. These plans can be informed by enhanced weather and damage forecasting and advances in situational awareness and should use real-time validations to continually refine and update such plans. Mutual assistance agreements with neighboring utilities help speed restoration efforts by deploying emergency response crews to disaster areas. In the days leading up to an event, utilities will pre-stage crews and equipment in advance of events and may have plans to deenergize some facilities to prevent damage. Congress has raised specific concerns about the vulnerabilities of large power transformers (LPTs) given the growing threats to transformers and the long lead time in replacing them and required DOE to submit a plan to Congress for the establishment of a strategic transformer reserve.[26] The utility industry has a number of initiatives to create spare transformer reserves and stockpile parts and related equipment. The House of Representatives recently passed the COMPETES Act, which includes language to create a Strategic Transformer Reserve.

Planning for the response and restoration of energy disruptions is not the sole purview of the energy sector. VLSEs often affect multiple interdependent infrastructures (e.g., ICT and water) and several states and/or regions. Thus, planning for an event of this magnitude must involve coordination and collaboration at the federal, regional, state, and local levels, and between the public and private sectors, to address the breadth and inter-related nature of these potential impacts. Such efforts also must integrate people, technologies, and processes to maximize preparedness. State and federal emergency management offices should conduct annual joint simulations, drills, and related “pre-event” scenario planning efforts at the local, state, and regional levels to test their plans and strengthen their ability to collectively respond to VLSEs.

In 2009, DOE provided $38 million in funding to states to update their energy assurance plans, and in 2010 provided $8 million for 43 cities to do the same.[27] (The funds came through the Infrastructure Security and Emergency Response division, or ISER, within the Office of Electricity; ISER is now within the Office of Cybersecurity, Energy Security, and Emergency Response, or CESER.) DOE also provided funding and technical assistance for a series of exercises to test the updated energy assurance plans. Energy assurance plans identify key public and private points of contact for the energy sector and emergency response units, formulate roles and responsibilities, lay out legal parameters, and identify critical infrastructure and potential hazards to each, as well as outline mitigation measures. Ideally these plans should be updated at least annually, but the reality is that most states and municipalities do not. In 2017, 12 states updated their energy assurance plans with some form of DOE assistance, and the National Association of State Energy Officials provided some technical assistance to three states in the process of updating their plans.[28] IIJA builds on this history with additional funding for state emergency planning.

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[26] U.S. Department of Energy. “Strategic Transformer Reserve: Report to Congress.” https://www.energy.gov/sites/prod/files/2017/04/f34/Strategic%20Transformer%20Reserve%20Report%20-%20FINAL.pdf, accessed March 22, 2021.

[27] U.S. Department of Energy. “Recovery Act: Local Energy Assurance Planning Initiatives.” https://www.energy.gov/ceser/recovery-act-local-energy-assurance-planning-initiatives, accessed March 22, 2021.

[28] U.S. Department of Energy. “State, Local, Tribal and Territorial Energy Assurance: 2017 Year in Review.” https://www.energy.gov/sites/default/files/2018/03/f50/SLTT%20Energy%20Assurance%202017%20Year%20in%20Review.pdf, accessed March 22, 2021.

CONCLUSION

GridWise Alliance thanks the Committee for the opportunity to discuss critical issues surrounding grid resilience and reliability. As Congress considers Build Back Better or other legislation related to the grid, we urge you to consider additional grid funding as recommended in the GridWise Alliance policy framework for grid investments.

GRIDWISE RECOMMENDATIONS

- **Increase funding for Smart Grid Investment Grant Program at DOE to enhance grid flexibility: $10 billion**

  To balance electricity supply and demand, the grid must have system flexibility. Grid technologies like controls, sensors, storage, data analytics, advanced communications networks, and software-as-service can provide flexibility by improving visibility of the system for grid operators, helping to quickly rebalance system stability, and facilitating the integration and aggregation of distributed energy resources, including electric vehicles, to serve as assets to grid operations. Utilities' investments in operational fiber and wireless broadband communications network are essential for a modern grid. Utility communication systems can include fiber networks and private wireless networks that could also be leveraged to provide middle mile broadband and last mile internet service for end-use consumers.

  If Congress creates significant new incentives for electric vehicles and charging infrastructure in Build Back Better, it must make commensurate investments in grid modernization to ensure the grid can serve as a platform for transportation electrification. Utilities will need to accommodate significantly increased load as well as provide customers with the tools to manage their charging, granular metering to generate billing to create rate plans and tariffs that reflect EV, upgraded communications and IT networks. Without parallel investments in grid modernization, utilities will face new challenges to grid reliability and stability at the local level driven by the forecasted electrification of fleets and residential vehicles. Also, rural cooperatives are less prepared for this type of engagement because historically EV adoption has been concentrated in urban and suburban neighborhoods where range anxiety is less of a concern.

- **Increase funding for DOE cybersecurity programs: $1.5 billion**

  Cyberattacks are one of the most significant threats to the security of the grid. DOE funds platforms that can monitor attacks and share information across the utility industry and can also provide funding for the deployment of technologies that can prevent cyberattacks from damaging grid equipment. Unlike cyber funding from other federal agencies, DOE programs are designed to support utility cybersecurity efforts. Even with federal funding for monitoring platforms and technology, protecting the grid from cyberattacks is hampered by the lack of qualified cyber professionals. The current cybersecurity workforce shortage in the United States alone is projected to be 498,480.[29]

  - **$250 million to DOE Cybersecurity for Energy Delivery Systems (CEDS) for cybersecurity workforce development**

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[29] https://www.cpomagazine.com/cyber-security/cybersecurity-workforce-shortage-continues-to-grow/

  - **$250 million to DOE CEDS for cyber assessments and cyber threat monitoring for small and medium utilities**
  - **$1 billion to DOE CESER for cybersecurity technology deployment**

- **Include the 48(c) manufacturing tax incentive: $8 billion**

  The Section 48C Advanced Manufacturing Tax Credit in ARRA originally provided a 30 percent investment tax credit to 183 domestic clean energy manufacturing facilities valued at $2.3 billion and was extended to provide an additional $150 million in 2013. The tax credit helped build a U.S. manufacturing capacity and supported significant growth in U.S. exports. Qualifying manufactured clean energy products must include advanced grid technologies.