Electric Power Sector Faces a Changing Climate -Path to Resilience (Presentation)

overview of the scope and scale of the path to resilience

December 2023

Executive summary

Increasing frequency and severity of weather events is a growing threat to the electric power system

The modern world is increasing dependence on electric power and there is less tolerance for outages

Utilities have been leading investment in resilience, with a focus on hardening grid infrastructure

Households are investing in backup power and energy storage at an unprecedented rate



\$1 billion in weatherrelated damages occur every three weeks, on average, in the U.S.^[1]



64% increase in major power outages in the 2011-2021 timeframe compared to 2000-2010^[2]



demand growth in the electric power sector by 2050^[3]



20% of electric demand in 2050 will come from data centers ^[3]



invested by utilities in 2022 for climate adaptation and hardening efforts^[4]



increase in average electricity prices in the last 10 years ^[5]



7%

44%

improvement in outage performance during major weather events in last 20 years ^[2]



growth in the residential battery market in 2020^[6]

Source: [1] The Wall Street Journal, Nov. 14 2023; [2] DOE form OE-417 data analysis; [3] U.S. Energy Information Administration (EIA) [4] Edison Electric Institute (EEI): Enhancing Resilience [5] Average retail electricity prices [6] Office of Industries Working Paper ID-077 July 2021



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An extreme weather event can lead to multiple adverse effects within electric power value chain

Number of Outages Impacting at least 50,000 Customers ^[1]	Weather Event	Downstream Effects on Energy Markets	Impact Metrics
U.S. power outages [1]	Aug. 2023 Maui Wildfire	 90 miles an hour winds resulting from Hurricane Dora 500 miles ripped across the island Ignition of parched grasses and brush outside of Lahaina soon erupted into a fast-moving wildfire, stoked by the intense winds 	100 confirmed deaths and 2000+ acres burned ^[2]
	Dec. 2022 Winter Storm Elliot	 Caused extensive power outages due to unexpected plant equipment failure and fuel supply issues Triggered potential financial liabilities for power plant owners in PJM Interconnection Highlighted the vulnerability and reliability of gas-fired generators 	\$2B penalties faced by PJM generators for failing to run ^[3]
	Sep. 2022 Hurricane Ian	 Made landfall as a Category 4 storm in southwestern Florida before continuing on to South Carolina and North Carolina Third costliest hurricane in US history (after Katrina and Harvey) In addition to billions in damages, it claimed more than 100 lives 	\$116.3B in adjusted costs of damages caused by lan ^[4]
	Feb. 2021 Winter Storm Uri	 Triggered widespread power outages due to freezing of natural gas infrastructure Caused spike in electricity and natural gas prices Bankrupted several energy companies unable to cover high wholesale electricity costs 	\$195B estimated damages from storm impact ^[5]
- Weather-related - Non weather-related	Aug. 2020 California Heatwave	 Caused rolling blackouts due to high demand for air conditioning Highlighted need for additional grid flexibility and reliability Drove temporary electricity price spikes 	> \$1,000 CAISO wholesale electricity price/MWh at peak ^[6]

Energy companies, electric power customers, and governments all have a role to play in resilience





- Electric power companies look to minimize damage to their assets and maintain delivery of electric power services
- Electric utilities have invested more than \$30 billion in 2022 alone into climate adaptation and hardening efforts ^[1]
- \$4.8 trillion in energy infrastructure investment is needed to maintain grid infrastructure by 2039^[2]

- Corporate sector is increasingly focused on electric power consumption in the context of decarbonization targets, while also needing reliable and economical power
- Projections indicate 50% demand growth in electric power by 2050, with an anticipated doubling by the end of the century ^[3]

- Households are investing in back-up power and energy storage at an unprecedented rate, especially in jurisdictions with frequent disruptions
- Tesla reported a 222% increase in energy storage deployments in Q2 2023 compared to the same period in the previous year; Generac, fossil fuel generator sales increase of 30% in Q1 2023^[4]
- Public sector has multiple roles in resilience: setting policy and regulation (e.g., building standards), providing funding (e.g., grants) and directly developing resilience public projects (e.g., forest management, flood prevention)

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 \$13 billion Federal grants and programs dedicated to electric power resilience were funded by the Bipartisan Infrastructure Law (BIL)^[5]

Source: [1] Edison Electric Institute (EEI): Enhancing Resilience [2] American Society of Civil Engineers (ASCE) 2021 Infrastructure Report Card [3] U.S. Energy Information Administration (EIA) [4] Utility Dive, July 2023 [5] Department of Energy



Resilience Solution Space

SOLUTION TYPE:

Software/AI Hardware/smart devices

	Capability	Use Case Examples	Solution Examples	Company Examples
Execution	Climate Risk Assessment & Adaptation Strategy	 Understand strategic impact of climate risk on the business Estimate the risk exposure and impact thresholds of company assets Understand risks and impact of climate events on company customers, communities and supply chains Develop business cases and capital plans to mitigate climate risks Integrate climate risk into the overall strategy of the company and identify opportunities to provide resilience as a value to customers 	Climate scenario modeling and visualization tools Hazard specific and multi-peril compound models Asset failure prediction models / damage curves	JUPITER CE technosylva URBAN FOOTPRINT
			Risk mapping and simulation tools Integrated societal / economic impact tools	Descartes Simate Forecast Applications Network Cabs
	Forecasting and Situational Awareness	 Gather data on local conditions to predict severe climate disruption events and asset exposure to risk Develop hyper-local and tailored weather forecast that can be used for operational response to events Predict potential impact an upcoming weather event (e.g., major storm, extreme temperatures, high wildfire risk, etc.) Prepare for upcoming events by right-sizing and pre-staging resources (e.g., field crews, materials etc.) 	Remote sensors (e.g., weather stations) Imagery tech (e.g., satellites, LiDAR, cameras etc.) Data collection tech and services (e.g., drones) Weather modeling, forecasting and alerting Real-time event detection (e.g., fire ignition)	The planet.MUON SPACEWeather Company An IBM BusinessFIRESCOUTPANOTomorrow.io
	Energy system hardening and operations	 Hardening overhead facilities, such is improving feeder and pole strength Enhanced inspections and maintenance activities (e.g., risk-based vegetation management) Change system design (e.g., undergrounding, sectionalizing etc.) Predict when assets may fail in high impact areas and proactively replace them 	Grid-side hardware (poles, wires, etc.) Protective devices and fault detection Advanced vegetation management solutions Microgrid controllers Predictive asset failure / digital twins	IND.T PXISE ☆ AutoGrid PingThings ►> etap Exacter The Next Best-Practice in Reliability
	Customer experience	 Provide alternative and/or additional power sources to customers if back- up generation and storage Enable customer participation in the energy system to help prevent events (e.g., demand response) Information and visibility of impact and restoration during climate events 	Back-up generation and energy storage Inverters and islanding Demand response Customer portals / communication	TESLA GENERAC AMPERON Octopusedegy CO-Z VIOTAS DOMERONAME CO-Z VIOTAS OCODALZERO DIALENT Cocclergen
	Response and Recovery	 Automatically detect an event (e.g., wildfire, tornado) and respond to it (e.g., issue alerts) Increase real-time visibility into damages post-event Facilitate coordination of response resources and activities across multiple organization 	Automated ignition suppression technology Automated visual inspection for storm damages Coordination and visualization platforms	➢ INTTERRA [©] Concern Rain ⊙ ALERTUS' dt DISASTERTECH DTN°



The Path to a Resilient Future

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Resilience is an asset *and* a system feature – it requires both asset hardening and broad system evolution to withstand disturbances



Resilience planning is effectively community planning – the most cost-effective way to build resilience is to capture resilience value from existing infrastructure (natural and built)



Climate tech is a top focus for investors, including climate adaptation and resilience. Nevertheless, developing and executing an effective business model in resilience is difficult



Public-private partnerships will be key to achieving electric power system resilience, keeping electric power affordable, and ensuring vulnerable communities are not left behind

The synergy between industry innovation and community planning is pivotal in creating an enduring electric power infrastructure that actively contributes to the resilience of the served communities



Voice of Dynamo Community: Resilience Matters

As an electric power user, how big of a concern is climate 100% Major or highly significant concern resilience to your business?						
How much do you factor in reliability / grid resilience when you are selecting locations for facilities?						
Where do you see opportunities for innovation in resilience and climate tech space?						
"Revisit/assess current electrical safety standards: many are outdated and need to be changed [] for today's multi-directional grid and home electricity. This will help prevent fires, ensuring safety, and allow for current innovations to commercialize"	"The main opportunities I see are long-duration energy storage and grid enhancing technologies (modular power flow control, dynamic line rating)."	"System Operators like ERCOT in Texas should look for opportunities to be more innovative in their market design to maximize the utilization of Demand Response capability."	"New technologies to prevent the ravages and carbon release of wildfires are being developed that promise more resilience to communities, utilities, real estate and insurance companies, governments and indigenous populations."			

"Low-cost alternatives (such as storage) to expensive electric grid hardware/upgrades"

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