



Resilience Solutions that also Decarbonize and Reduce Electricity Costs

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by Steve Hoffman President



ABSTRACT

Is there a solution that helps electric utilities enhance resilience, decarbonize, AND reduce electricity costs for their customers? Could screening a large number of potential solutions to identify ones that meet this three-part criterion provide a quick, simple way to get started prioritizing resilience solutions? This white paper addresses these questions by describing not one, but eight distinct solutions that meet all three of these criteria. Providers of consulting services to electric utilities may benefit from awareness of the potentially under-considered value of these solutions in their discussion with utility clients and prospects.

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THREE CHALLENGES

Electric Power Resilience to Extreme Weather and Wildfires

The electric utility industry worldwide faces a significant challenge to enhance its resilience to extreme weather, wildfires, and other threats. To help address this challenge, each individual electric utility typically considers a broad range of solutions. These may include improved vegetation management (tree pruning along transmission and distribution [T&D] rights of way), selective T&D undergrounding, modified operating procedures, planned outages, expanded local weather data gathering and forecasting, training and drills, improved storm response practices, elevated substations, and many others. These resilience solutions harden against, or enhance response and recovery to, extreme weather and wildfires.

The question of whether climate change increases the frequency and intensity of extreme weather and wildfires is addressed in the scientific field of "extreme event attribution." With regard to wildfires, one study confirms the connection between wildfires and climate change. As the "bushfires" raged in Australia in January 2020, a research team completed a review of 57 peer-reviewed papers published since 2013 on wildfires and climate change. The review concluded that "human-induced climate change promotes the conditions on which wildfires depend, increasing their likelihood" [1]. A 2021 study from the National Oceanic and Atmospheric Administration (NOAA) concluded that climate change is the main driver of increasing fire weather in the western United States [2]. With regard to extreme weather, the extreme event attribution literature is extensive, and a detailed review is beyond the scope of this paper. For example, the Climate Attribution Database currently contains 201 articles on the topic of "extreme event attribution," which it defines as "examining how change in the global climate system affect the probability and characteristics of extreme events" [3].

With the assumption that climate change increases the frequency and intensity of extreme weather and wildfires, these threats are an *effect* of climate change. Hence, efforts to enhance resilience against extreme weather and wildfires essentially address the *effects* of climate change.

Decarbonization

While electric utilities address the resilience challenge, many of them are simultaneously taking on a second challenge – decarbonization. Utilities typically do this by working towards emission of less carbon in power generation, and by encouraging their customers to adopt carbon neutral or carbon free end uses (e.g., via efficient electrification powered with renewable energy). The fundamental premise underlying this work, as well as the Paris Agreement within the United Nations Framework Convention on Climate Change, is that reducing emissions of carbon (i.e., decarbonizing) will ultimately address the *causes* of global climate change.

The conclusion is that, while resilience solutions address the *effects* of climate change (e.g., extreme weather and wildfires), solutions for this second challenge of decarbonization address the *causes* of global climate change.²

² One can also argue that decarbonization is a long-term resilience solution. Viewed this way, decarbonization eventually reduces the cause of the problem (climate change) to help solve the immediate problem (wildfires and extreme weather). By decarbonizing, a utility essentially commits to addressing long-term resilience.



¹ The California Public Utility Commission and the California utilities call these controversial practices "public safety power shutoffs. (PSPSs)."

Electricity Affordability

A third challenge that most utilities face is the issue of electricity affordability. In the United States, for example, public utility commissions (PUCs) in each state make decisions regarding changes in the electricity rates that the electric utility can charge its customers, based on changes in the utility's rate base (i.e., assets and costs that the commission allows the utility to include in its calculation of electricity rates to recover its costs). Electricity rates are rising across the United States, and in many cases, PUCs establish incentives for utilities it regulates (i.e., investor-owned utilities) to find ways to minimize rate increases, keep rates level, or even reduce them. At the same time, utility customers are increasingly empowered by growing awareness of their ability to produce power (e.g., by installing rooftop solar photovoltaics systems, in some cases with electricity storage systems). They have become "prosumers." In most cases, these self-generation options reduce the customer's electricity costs in both the short-term and long-term future. This combination of factors brings to the fore the need for utility solutions that enable customer electricity costs to level or decrease. In contrast to resilience solutions, which address less common extreme events (e.g., extreme weather and wildfires), solutions to this third challenge address improvement in everyday utility service.

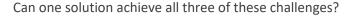
CAN ONE SOLUTION MEET ALL THREE CHALLENGES?

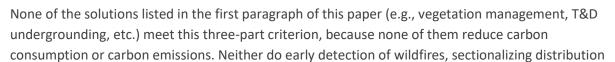
This discussion of electric power resilience to extreme weather and wildfires, decarbonization, and electricity affordability begs the following question:

Can a single solution address all three of these challenges?

To do that, this illustrious solution would need to enable a utility to:

- Enhance resilience to extreme weather and/or wildfires (i.e., address the effects of climate change)
 and
- Reduce carbon combustion and emissions (i.e., address the causes of climate change)
 and
- Increase electricity affordability, thus improving everyday provision of service to customers³





³ Even if the apparent strong connection between climate change and extreme weather/wildfires is not convincing, the case for the benefits of a solution that meets these three criteria remains strong. This is primarily due to the broad interest among many U.S. utilities, communities, and organizations 1) to enhance electric power resilience to extreme weather/wildfires in light of recent tragic occurrences of these, 2) to decarbonize to achieve various benefits, including reduced transportation costs, improved air quality, reduced water usage, and improved human health, and 3) to enhance everyday provision of high-value electricity to increase productivity and provide myriad other benefits.



lines, hardening of any type of central station power generation or T&D assets, and myriad other tactical hardening and response solutions.

Following is a description of not one, but eight distinct solutions that meet these three criteria.

Energy Efficiency

The first is enhanced energy efficiency in buildings and industrial facilities. Here's how it meets the three criteria:

- Energy efficiency aids resilience to extreme weather and wildfires because it delays the
 depletion of customer on-site fuel supplies, delays the maximum severity of failures (e.g., due
 to reduced air leakage rates in energy efficient buildings), uses decentralized technologies
 (e.g., weather stripping and heat pumps) that are less vulnerable than centralized ones, and
 several other reasons [4].⁴
- Energy efficiency decarbonizes because it reduces end use energy consumption (electricity or natural gas) for a given load, thus reducing either local carbon emissions, central station carbon emissions, or both.
- Energy efficiency aids electricity affordability because utility customers that adopt it can save money over the life of their investment, and utilities can benefit from lower on-peak demand.

Distributed Renewable Generation

Energy efficiency works synergistically with a second solution that meets all three criteria: distributed renewable generation, such as rooftop solar (photovoltaics, PV). Utility customers with PV systems are more resilient because they can continue to generate power to meet a portion of the electric load for their home or business during lengthy power outages (assuming their PV system is undamaged and the sun shines). PV decarbonizes because it can displace combustion of fossil fuels, and PV helps customers during business-as-usual operation for the same reason as energy efficiency.



Distributed Electricity Storage

A third no-regrets solution is distributed electricity storage (DES). Although not yet economical in many areas, the number of DES implementations is growing. The International Renewable Energy Agency (IRENA) reports that "40% of recent rooftop solar photovoltaic systems in Germany have been installed with BTM (behind the meter) batteries" [5]. A Wood Mackenzie study showed that 11% of US residential solar installations were paired with storage in the third quarter of 2023 [6]. DES can further enhance PV's resilience value by storing energy for a few hours, facilitating use of the solar power gathered when needed. DES decarbonizes by further extending the practical use of fossil-fuel-displacing PV and easing the limitations of PV's intermittent nature. Once economical, DES will aid business-as-usual operation for the same reason as energy efficiency.

⁴ In their 1982 book on resilience, authors Amory Lovins and L. Hunter Lovins characterize end-use efficiency as the "most resilience per dollar" [3].



Electric Transportation

Electric transportation is a fourth solution that meets the criteria. An electric vehicle (EV) aids resilience by providing a home or business a mobile rechargeable electricity storage device (i.e., "vehicle-to-building" resilience). It can replace or augment DES. During an extended power outage, in some situations, homeowners may be able to drive their EVs to undisrupted areas, recharge them, and return home to power some portion of their critical loads for a period of time, increasing their resilience [7].

Electric transportation decarbonizes by displacing gasoline and diesel-fuel-consuming vehicles, assuming that the electricity generated to power them uses non-carbon emitting resources. EVs are beneficial in everyday use by reducing the overall vehicle cost of ownership for customers and by building load for electric utilities.

Demand Response

Due to a recent advancement, demand response now joins this illustrious group of solutions. Demand response aids resilience by reducing stress on the grid during extreme events. It can reduce emissions (decarbonize) via "automated emission reduction" (AER), according to nonprofit WattTime. AER enables online end-use appliances and devices to reduce emissions using real-time grid data on plant emissions and online control of these devices. WattTime also claims that AER can boost participation in distributed energy resource programs. In business-as-usual operation, demand response smooths electricity consumption peaks — its original raison d'etre [8].

Community Microgrids

The sixth solution integrates the previous five solutions in the form of a community microgrid. Incorporating energy efficient homes and businesses, distributed renewable generation, DES, and EVs, these microgrids can operate independent of the grid (i.e., in "islanding mode") during some extreme events. This makes them a promising community-level resilience solution. Via their consolidation of decarbonizing technologies into local grids, community microgrids can extend decarbonization to the neighborhood level. Their benefits extend to everyday operation, as many universities and enterprises have found, and a growing number of communities are finding [9, 10, 11].



Dynamic Electricity Rates

A recent advancement now being demonstrated in the United States involves the use of dynamic electricity rates to enhance resilience, decarbonize, and enhance affordability. Demonstrated at three California electric utilities using a tariff approved by the California PUC, the system enables customers and utilities to automatically buy and sell electricity in real time and in the future. It represents a promising improvement on existing real-time pricing and prices-to-devices programs. The system meets the three criteria by enhancing the value of the solutions described above, including distributed renewable generation, DES, and electric transportation [12].

Combined Heat and Power

Combined heat and power (CHP) facilities, also known as cogeneration (or trigeneration when cooling is also involved), are resilient because they use local resources to help ensure energy continuity in an extended outage. They support sustainability due to their inherent high energy efficiency. They enhance electricity affordability via their reduced overall energy use due to energy efficiency, which typically reduces their lifecycle costs compared to traditional means of providing electricity and heating. CHP facilities are commonly used in conjunction with district heating systems, which extend the resilience, decarbonization, and affordability benefits to an industrial park or community [13].

RECOGNIZING THE RESILIENCE VALUE OF THESE SOLUTIONS

Most electric utilities already operate energy efficiency, distributed renewable generation (e.g., PV), and demand response programs. Many encourage adoption of EVs and are working with customers to form microgrids. Some utilities are beginning to encourage distributed storage implementation to enhance the value of rooftop solar systems.

But how many electric utilities are aggressively expanding these programs explicitly to help enhance their customers' resilience? How many PUCs are requiring utilities to consider this?

A comprehensive assessment of utility, government, and regulatory activities in this area is beyond the scope of this paper. However, awareness of the resilience value of these utility-customer programs is growing. As early as 1977, visionaries recognized the need for decentralized resources and energy efficiency to enhance resilience. In his landmark 1977 *New York Times* editorial entitled "Resilience in Energy Strategy," Amory Lovins describes how "relative decentralization can be more resilient," listing additional benefits such as lower cost [14]. Fast forward to 2019, when the U.S. Department of Energy's Better Buildings program described three case studies and a step-by-step guide for improving resilience in public buildings using distributed energy resources and energy efficiency [15]. More recently in 2023, the Smart Electric Power Alliance described how four US utilities helped "weather future storms with utility-led service offerings" [16].

BENEFITS OF EXPANDING IMPLEMENTATION OF THESE SOLUTIONS

A related question is whether electric utilities and regulators realize the three-pronged strategic value of these solutions. Do they realize that expanding implementation of energy efficiency, distributed renewable generation, distributed storage, EVs, demand response, microgrids, dynamic rates, and CHP have the potential to:



- Enhance customer resilience?
- Enhance utility infrastructure resilience in some cases by reducing stress on the grid during extreme events?
- Further reduce carbon emissions (decarbonize) due to decreased electricity consumption in buildings, industrial facilities, and transportation?
- Provide even more of the business-as-usual, affordability benefits that these programs were designed to deliver?
- Provide these benefits by significantly ramping up existing customer programs, as a complement to adopting new programs, technologies, approaches, and operating procedures?

In any case, providers of consulting and technical services to electric utilities may benefit from awareness of the potentially under-considered value of these solutions in their discussion with utility clients and prospects.

RESILIENCE INVESTMENT PRIORITIZATION

The single greatest challenge that utilities face regarding resilience is answering the following question: How do we prioritize the hundreds or thousands of potential ways to mitigate the threats of extreme weather and wildfires? This challenge discourages many entities from getting started with a resilience initiative. Following are the reasons why prioritization is so difficult:

- Many assets. A single distribution system operator may operate thousands or even millions of individual assets across a far-flung service territory. Which ones should be hardened?
- **Many customers.** A single operator may serve thousands or even millions of customers, many of which are becoming prosumers. How can an operator ensure resilience for all of them?
- Growing number of "critical loads." Critical loads now include home critical care, assisted living facilities, emergency supply facilities (gas and EV charging stations, grocery stores, community centers), cell phone towers, airports/ports, and more. How ensure resilience to all of them?
- Multiple threats. A single grid operator may face combined threats or multiple seasonal ones, including heat events, high winds, flooding, and wildfires. How protect against all of them?
- **Extreme event lifecycle.** Some resilience investments aid pre-event preparedness, some detect and alert, others help during the event, others recover and restore the power system after the event. How prioritize these?

To prioritize investments that enhance resilience, many consulting firms (and utilities avail themselves of) complex, data-intensive, multi-year assessments. These typically include threat characterization, vulnerability assessment, impacts assessment, and then investment prioritization. While there is a place for these detailed studies, many utilities can consider faster ways to get started with this process. One way is to quickly create a list of potential resilience-enhancing actions and then apply a three-part screening criteria to this list; the actions that pass all three of the criteria can then be implemented with confidence. The criteria need not be the three described in this paper (resilience, decarbonization, and affordability); the utility can define the criteria as they see fit, to address their specific corporate goals. The utility can conduct more sophisticated analyses, like those listed above, in parallel, depending on its specific needs.



CONCLUSION

For most utilities, some combination of tactical solutions that focus on enhancing resilience to extreme weather and wildfires, such as those listed in the first paragraph of this paper, is necessary. However, sometimes-overlooked ways to enhance resilience to these events may be worthy of utility consideration, including the eight solutions described here, due to their triple whammy of benefits. Energy efficiency, distributed renewable generation, distributed electricity storage, electric vehicles, community microgrids, demand response, dynamic rates, and CHP can provide:

- "Black sky" benefits (via enhanced extreme weather or wildfire resilience), and
- "Blue sky" benefits (via business-as-usual cost advantages), and
- "Future sky" benefits (via decarbonization that will benefit society in the future)



Black Sky Benefits: Resilience



Blue Sky Benefits: Business-as-Usual



Future Sky Benefits: Decarbonization

SEND US FEEDBACK

What other no-regrets solutions meet this three-part criterion? Send suggestions and comments on this paper to steve@hoffmanpowerconsulting.com or call Steve Hoffman at 408-710-1717.

ABOUT THE AUTHOR



Steve Hoffman is president and founder of Hoffman Power Consulting, a 12-person agency that specializes in providing consulting, writing, content marketing, and marketing communications for various stakeholders in the electric power industry. Steve has authored more than 500 technical and marketing documents in the electric power industry. His firm has written hundreds of white papers for leading clients around the world over the last 30 years. For more information and to view sample content that implements the practices in this paper, visit www.hoffmanpowerconsulting.com.

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