Weatherization Technology and Equipment

Resilience Investment Guide

SEPTEMBER 2024

GRID DEPLOYMENT OFFICE

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Acknowledgments

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Resilience Investment Strategy Overview

This resilience investment guide is one of six guides that describes the costs and benefits of a range of projects that are eligible under the Grid Resilience State and Tribal Formula Grant program and the Grid Resilience Utility Industry Grant program as described in Section 40101 of the Bipartisan Infrastructure Law (BIL). These two U.S. Department of Energy (DOE) grant programs are designed to enhance electric grid resilience against extreme weather, wildfire, and other natural disasters and are intended for states; federally recognized Indian tribes, including Alaska Native Village and Regional Corporations; U.S. territories; electric grid operators; electricity storage operators; electricity generators; transmission owners or operators; distribution providers; and fuel suppliers. This guide focuses on grid investments in cold weatherization technology and equipment. Weatherization of homes is not covered because these resilience fact sheets focus on grid investments.

Since 2011, the Federal Energy Regulatory Commission (FERC) and North American Electric Reliability Corporation (NERC) have provided detailed recommendations for weatherization technology and equipment and issued annual winter preparedness reminders via Regional Entity workshops [9]. For example, a FERC and NERC report following a February 2011 cold weather event in the Southwest detailed the following freeze protection measures: heat tracing, thermal insulation, windbreaks and temporary measures to prevent freezing [10]. In combination with these measures, renewable power sources such as wind farms and photovoltaic plants also use protective coatings to reduce ice and snow accumulation, which may shut down or significantly reduce output under extreme cold conditions [11,12]. FERC and NERC define these cold weatherization technologies and equipment as [10]:

- **Heat tracing:** application of a heat source to pipes, lines, and other equipment that must be kept above freezing.
- **Thermal insulation:** application of insulation material to inhibit the dissipation of heat from a surface.
- **Windbreaks:** temporary or permanent structures erected to protect components from wind.
- **Temporary measures to prevent freezing:** installing space heaters, draining non-essential water lines, generator antifreeze, fuel additives and management practices, and placing small heat lamps in cabinets.
- **Protective coatings**: materials applied to surfaces to prevent damage, slow degradation and, in cold climates, reduce ice and snow accumulation particularly for solar panels (Figure 1), and wind turbine blades.

Utilities also implement measures to protect electrical cables from extreme heat, which are covered in the Wires Investments fact sheet.

Strengthens grid reliability and resilience by:

- Preventing initial outages
- Preventing cascading outages

Improves performance against these hazards:

- Tornado
- Thunderstorm
- Hurricane
- Derecho
- Ice/Snowstorm
- Extreme cold

Figure 1. Researchers in Fairbanks, Alaska test a protective coating that sheds ice and snow from solar panels under extreme cold conditions [12].

Advantages

Weatherization measures, like the options recommended by NERC and FERC in 2011, could have delivered advantages for utilities and their customers under the conditions of recent winter storms like Elliott and Uri [1,2]. During Winter Storm Elliott in December 2022, a lack of cold weather protection for power plants, and the fuel system serving them, contributed to 90.5 GW, or 13% of the capacity of the Eastern Interconnection covering two-thirds of the U.S., failing to run at full capacity [6,7]. Similar issues led to 4 million customers in Texas losing power at the peak of Winter Storm Uri in February 2021 [2,3,4]. As one of the worst natural disasters in that state's history, 246 people died, with power outages as a contributor, as people succumbed to hypothermia or had accidents while seeking alternate heat sources [8].

The primary advantage of weatherizing electricity infrastructure is substantially reduced vulnerability to disruption from extreme hot and cold weather, resulting in both reliability and resilience improvements [1,2,3,4,5,6]. Therefore, the resulting safety benefits during extreme weather are another advantage that arises from the increased reliability and resilience that weatherization provides.

Disadvantages

The higher cost of weatherization equipment and technology infrastructure is their primary disadvantage [4,10]. In addition, certain cold weather protection measures may increase the cost of extreme heat preparations, and vice versa [2]. For example, while installing windbreaks and thermal insulation improve resilience to cold weather conditions, these same measures could increase the cost of preparations for extreme heat, potentially requiring the removal of windbreaks and insulation prior to the summer.

Finally, if the fuel supply that serves power plants is insufficient because cold weather preparedness measures are not implemented for the fuel delivery and storage system, winterization measures for electricity infrastructure will have a limited benefit. For example, system operator PJM reported that freezing temperatures during Winter Storm Elliot caused up to six times more lost gas supply than predicted, because of well freeze-offs [3]. These fuel supply issues contributed to gas generators accounting for 70% of the outages on December 24, 2022 [5].

Costs

FERC and NERC reported in 2011 that winterizing Texas gas-fired power plants could cost between $50,000 and $500,000 per facility (in 2011 dollars) [10]. Adjusted for inflation, the U.S Federal Reserve Bank of Dallas estimates that installing the recommended equipment on all 162 gas-powered plants in Texas could cost up to $587,000 per facility (in 2021 dollars), or around $95 million in total for the state. Compared to a probability-adjusted benefit of $430 million annually for the value of lost load, the authors find that the investment is economically justified [4]. Furthermore, the value of lost load is significantly higher during extreme cold conditions with widespread power outages that lead to safety issues, so the annual benefit is most likely higher than $430 million.

For wind power, manufacturers offer cold weather packages with heat tracing, insulation and/or protective coatings that allow the turbine to continue operating in temperatures as low as negative 22°F [11]. The price for these cold weather packages is a 5% to 10% cost premium compared to a wind turbine without the package, “or up to $400,000 more [in 2021 dollars] on a 2.5-megawatt utility-scale wind turbine, depending on the system chosen” [13]. For solar panels, various types of protective coatings are still in development and commercial pricing is not readily available. Researchers estimate that a spray-on coating in development for solar photovoltaic panels has a material cost of less than $1 per square foot [14], plus the cost of labor and application equipment needs.

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