# Low-Cost Grid Resilience Projects

Grid Deployment Office
U.S. Department of Energy

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GRID DEPLOYMENT OFFICE

## Introduction

Authorized by Section 40101(d) of the Bipartisan Infrastructure Law (BIL), the Grid Resilience State and Tribal Formula Grants program is designed to strengthen and modernize America's power grid against wildfires, extreme weather, and other natural disasters that are exacerbated by the climate crisis. Grid resilience formula grants may be used for activities, technologies, equipment, and grid hardening measures to reduce the likelihood of and consequences of disruptive events.

## Purpose of this Guide

This guide is intended to provide tribal recipients of 40101(d) grid resilience formula grants with:

- Overview of 40101(d) allowable projects that are likely to cost under $500,000 and can be impactful against a range of outage threats, including both cost estimates and potential benefits for these projects.
- Understanding of cost match requirements depending on subaward arrangements.
- Suggestions for how to work with utilities to show the benefit of this opportunity and select mutually agreeable projects for potential subawards.

It is important to note that all **cost estimates in this document are meant to provide a rough order of magnitude.** Actual equipment and project costs may fall outside of ranges provided herein based on vendor, supply chain, labor costs, location, utility experience, and other factors.

Additionally, the project types listed herein are not exhaustive; rather they are an illustrative list meant to highlight common hazards to energy infrastructure and various ways targeted investments can mitigate vulnerabilities to those hazards. Common hazards that lead to outages include wildfire, extreme temperatures, strong winds, flooding, ice accumulation, and contact with debris or vegetation. Throughout this guide, the hazard types that each investment addresses are noted.

## Subaward and Cost Match Considerations

The Grid Resilience State and Tribal Formula Grants program distributes funding to states, territories, and federally recognized Indian tribes, including Alaska Native Village Corporations and Alaska Native Regional Corporations. These grant recipients are then required to subaward funding to either an electric grid operator; electricity storage operator; electricity generator; transmission owner or operator; distribution provider; or fuel supplier. If a grant recipient does not wish to subaward to any of these listed eligible entities, the grant recipient can apply to be designated as an eligible entity and, if approved, subaward the grant funding to themselves.

### Cost Match Considerations

*The entity the grant recipient decides to subaward to will significantly impact the types of projects that can be funded, as well as the required cost match.*

Generally, the following cost-match will be required:

- Regardless of subaward entity, the grant recipient is required to match 15% of the amount of each grant provided to the grant recipient, either via funding or an in-kind contribution.
- The subaward entity (regardless of whether the subaward entity is also a tribal entity) will need to provide an additional 100% cost match or in-kind contribution for the Federal funds awarded. In cases where the subaward entity qualifies as a "small utility" – defined as a utility that sells less than 4 million MWh per year – the subaward entity must only provide a 33% cost match of the Federal funds awarded (either via funding or in-kind contribution.)

Grant recipients are encouraged to contact their assigned Federal Project Officer for clarification on cost match requirements for specific subaward arrangements.

### Collaborations with non-tribal eligible entities

When collaborating with a non-tribal entity (e.g., an investor-owned utility) on an investment, ensuring that the benefits are clear to both parties will help ensure project success. The remaining sections in this guide identify a wide range of small project ideas for tribes to consider and can serve as a starting place for discussions with eligible entities. Many utilities have reliability, climate resilience, storm hardening, and/or wildfire mitigation plans in place and may be interested in ways to fund portions of these plans. Often, these plans will be presented to the state Public Utility Commission and there will be a docket and/or rate-case filing for these plans publicly available on the Public Utility Commission website. Relevant plans may also be embedded in planning dockets (such as integrated resource plan filings) or may be under development at a utility without having been filed with a regulatory authority. Selecting projects that align with not only the tribe's resilience goals, but also the stated goals of a utility's resilience plans will increase the likelihood of selecting a project of mutual benefit[1]. Tribes may also find it beneficial to explore whether the organization they would like to partner with has a government affairs or tribal engagement liaison; finding an ally in the organization will help the collaboration be more successful.

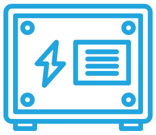
The remaining three sections illustrate the types of small projects that can be funded based on which elements of the power grid they target: (1) generation, (2) fuel stock, or (3) distribution lines (the poles and wires that serve a community). Note that the project types below are not exhaustive and proposed subawards are subject to U.S. Department of Energy review.[2]

## Generation-Related Projects

This section describes grid resilience investments relevant to any generation source that serves a tribal community. This generation source could be connected to transmission or distribution lines.

**Hardening of existing thermal generation.**

Thermal generation is any type of electricity generation using fossil fuels, including diesel generators for backup purposes. These generators can withstand storms with strong winds and precipitation, but they can fail in extreme cold temperatures or if flooded. Large utility-scale generating units can be expensive to weatherize, however smaller (<5MW) diesel and gas generators could also benefit from weatherization and cost less due to their size.



| Hardening Type | Benefit | Costs |
|---|---|---|
| Anti-icing materials and coatings<br><br>Improves performance against freezing temperatures | To prevent generators from freezing, one could coat the generator in anti-icing liquid when extreme cold temperatures are expected. | ~$500-$1500 for 50 gallons [1] |
| Cold weather package<br><br>Improves performance against freezing temperatures | Sometimes a backup generator will not start in freezing conditions, so having items such as a battery warmer or oil heater can ensure the key components of the system are working when contingency power is needed. | ~$100-$400 per kit [2] |

1 Additional DOE guidance on forming legal business partnerships with non-tribal entities is available here: https://www.energy.gov/sites/prod/files/2016/04/f30/indian_energy_legal_handbook.pdf.

2 For additional guidance on eligibility of projects, recipients are encouraged to consult the Administrative and Legal Requirements Document or contact their assigned Federal Project Officer. The most recent Administrative and Legal Requirements Document can be found by clicking on "DE-FOA-0002736" at the bottom of the "Documentation" panel here: FedConnect: Opportunity Summary.

**Hardening of existing thermal generation.** *(continued)*

| Hardening Type | Benefit | Costs |
|---|---|---|
| Thermal insulation<br><br>Improves performance against freezing temperatures | To protect generators and power equipment from freezing or icing, one could consider different pipe material or sleeves for pipes to keep components of the generator and power equipment insulated during cold waves. | ~<$5,000 [3] |
| Engine and other component system replacements<br><br>Improves performance against all outage types | Generators need regular maintenance to reach their expected lifetime (25 years). If a generator is located in a harsh climate and exposed to extreme temperatures and weather, components of the generator may need to be replaced more frequently. Examples of engine components that could be repaired or replaced include crankshafts, valves, filters, and/or pumps. | $20,000-$500,000 depending on the size (capacity rating) of the generator and which components need to be replaced. Upper bound of range assumes generator units are less than 5MW.[3] |

**Hardening of existing solar panels.**

Solar panels are particularly vulnerable to strong winds and flooding events. Investing in stronger panels and protective equipment can increase resilience to extreme weather events.

| Hardening Type | Benefit | Costs |
|---|---|---|
| Through-bolting<br><br>Improves performance against strong winds | Bolting panels directly to racks ensures panels are not ripped from their racks during strong winds. | ~$8/kW based on the capacity rating of all installed panels combined [4] |
| Higher grade steel<br><br>Improves performance against corrosion | Using either marine grade or stainless steel for panel framing and supports can prevent corrosion, especially in coastal areas near the ocean. | ~$13/kW based on the capacity rating of all installed panels combined [4] |
| Three-rail racking system<br><br>Improves performance against strong winds | Typically, solar panels use a two-rail racking system, adding a third rail would create more attachment points for the panel, making it more secure during storms. | ~$60-$150/kW based on the capacity rating of all installed panels combined [4] |
| Raising ground-mounted solar panels<br><br>Improves performance against flooding | The risk of flood damage can be mitigated by raising equipment on elevated pads and/or encasing equipment in watertight containers. | ~$12/kW based on the capacity rating of all installed panels combined [4] |
| Wind-calming fence for ground-mounted panels<br><br>Improves performance against strong winds | For ground-mounted panels placed in high wind corridors, installing a wind-calming fence to deflect high pressure winds can avoid panel damage. | ~$150/kW based on the capacity rating of all installed panels combined [4] |

[3] Cost estimates derived from scaling down the costs to purchase a standby generator in the range of 20kW-5MW.

**Hardening of existing wind turbines.**
Wind turbines are particularly vulnerable to freezing temperatures and strong winds.

| Hardening Type | Benefit | Costs |
|---|---|---|
| Anti-icing materials and coatings<br><br>Improves performance against freezing temperatures | To prevent the turbine from freezing, one could coat the blades in anti-icing liquid when extreme cold temperatures are expected. | • ~$500-$1500 for 50 gallons [1] |
| Wind direction controls<br><br>Improves performance against strong winds | This involves using a battery to operate a motor that reorients the turbine blades down-wind during strong wind events to prevent them from breaking. | • ~$40,000-$60,000 per turbine [5] |

**Batteries.**
Batteries can provide short duration (<4-6 hours) power when the bulk power system loses power. Batteries can be deployed by themselves at a critical facility, be connected to *existing* generation at a critical facility, or even connected to primary or secondary distribution lines that could provide power for several hours to customers downstream during an outage. When the battery location and installation is carefully designed to address potential flood and fire risk, this investment improves performance against all outage types.

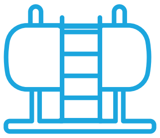
| Benefits | Costs |
|---|---|
| While the main grid is operating normally, a short duration battery at a critical facility (e.g., healthcare center, community center, school, etc.) will be charged. When power from the main grid is lost, the battery can provide power for up to ~4-6 hours or possibly longer if the battery is connected to a generation source (i.e., solar panels). This extra time could allow communication systems to remain operational and better coordinate emergency response. | • Residential-sized battery will have an installed capital cost of roughly $15,000-$20,000 (5kW/14kWh battery is typical) [6].<br>• Residential-sized battery can also provide backup power to a small critical facility such as a health clinic, a government building, or a small general store. |

## Fuel Source Projects

This section describes grid resilience investments relevant to any fuel source that serves a tribal community.

**Increase fuel stock.**

For any tribal entity that relies on propane or diesel fuel for electricity or heat, ensuring there is a large enough supply on hand in case of an emergency will allow the community to be more resilient to a long-duration power outage. This type of investment improves performance against all outage types.



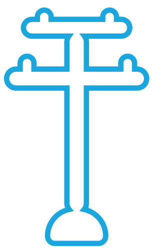
| Benefits | Costs |
|---|---|
| An increased fuel supply may extend a community's ability to endure extreme weather events during which it may be difficult for emergency responders to reach the community. | • A 500-gallon residential propane storage tank costs roughly $1000-$2000 [7].<br>• Diesel fuel requires replacement or fuel polishing every two years to be usable, which will impact how cost-effective it is to store large volumes of fuel [8]. |

## Distribution Line Projects

This section describes grid resilience investments relevant to the poles and wires that transmit power to customers within a community.

**Pole Replacement.**

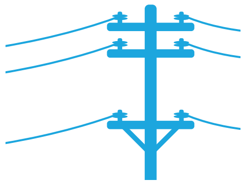
Recipients could target and replace vulnerable utility poles within their community with stronger, more durable poles that are weather and wildfire resistant. The capital cost of overhead distribution pole replacement is small compared to other grid infrastructure investments and does **not** require system-wide replacement to see improvement in disruption events. For example, a recipient could target pole replacements in a particularly vulnerable corridor or hard-to-reach area. A recipient could also consider adding stronger poles spaced out strategically on the system that remain standing when adjacent poles begin to break, thus preventing cascading failures.



| Pole Material | Benefits | Costs |
|---|---|---|
| Wood<br><br>Improves performance against strong winds | Replacing wood poles with taller or thicker wood poles can increase the strength and durability of the pole at relatively low cost. Wood poles tend to be safer for line-workers than other materials because they are less conductive and easier to climb. | • ~$300-$800 per pole for material and installation costs on the distribution system [9].<br>• Note, wood poles are not as resilient as other non-wood materials. |
| Steel or concrete<br><br>Improves performance against strong winds and wildfires | Non-wood poles are fire-resistant, avoid damage from wildlife and insects, can withstand higher windspeeds, and can last longer than wood poles. | • ~$1500-$3000 per pole for material and installation costs on the distribution system [9, 10].<br>• It can be more labor intensive to replace non-wood poles because the poles are heavier. |

**Reconductoring.**

In addition to replacing poles, a utility can increase resilience by replacing wires. For example, increasing the conductor size and/or covering the conductor makes the wires more resistant to impact. Additionally, using breakaway systems or quick disconnect wires immediately disconnects the wire from the pole to avoid damaging the pole, making restoration time much faster.



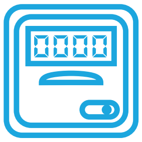
| Conductor Type | Benefits | Costs |
|---|---|---|
| Reconductoring with heavier and thicker wire to increase line strength<br><br>Improves performance against ice storms and vegetation | Higher gauge wire is more resistant to ice loading on lines and can better withstand light impact from debris in high wind events. | • $5,000-$10,000 per mile on the distribution system [9].<br>• Note, these lines are still vulnerable to heavy debris and vegetation impacting lines. |
| Covered conductor<br><br>Improves performance against wildfires, vegetation, and strong winds | Covering conductors with insulating materials can reduce faults related to extreme heat (sagging of lines), ignition during wildfires, corrosion, wind damage from lines touching, or trees falling on lines. Covered conductors can also protect line workers. | • ~$150,000-$900,000 per mile on distribution system<br>• In some cases, re-wiring covered conductors can take longer than re-wiring standard conductors, which can increase restoration time post-outage event [9, 11, 12].<br>• Although a full mile of covered conductor is expensive, targeting smaller sections of lines that are prone to vegetation outages could be cost-effective. |
| Breakaway disconnect systems<br><br>Improves performance against vegetation and strong winds | Poles are far more time consuming and costly to replace than conductors; thus, using a breakaway disconnect system to preserve the pole when a line is impacted can significantly reduce restoration time. | • ~$1000 per breakaway kit [13, 14] |

**Smart Meters.**

Assuming the distribution provider has the software infrastructure to process smart meter data (often referred to as advanced metering infrastructure), recipients could consider adding smart meters to customers within the community. Smart meters send customer power usage data signals back to the utility in real time. Traditional meters require a utility worker to read the meter data manually at the point of connection at a customer's home. This investment type can improve performance against all outage types.

| Benefits | Costs |
|---|---|
| Smart meters can improve restoration time by quickly notifying the utility and more precisely locating customers who lost power. Without smart meters, the utility relies on customers to report the outage before it sends line workers searching for the exact location of the fault. | • Devices are roughly $150 each, plus an additional $200-$300 for installation [9].<br>• The reduction in restoration time is only achieved with high adoption rates because the utility needs a complete picture of customer energy usage to better locate outages. |

**Monitors and Sensors.**



In addition to smart meters that provide customer load situational awareness to the utility, other sensors and monitors (e.g., flood and temperature sensors, line monitors, fault indicators) located throughout the distribution network can help the utility identify where problems are occurring, and even preemptively prevent outages through early-warning detection. For this investment type, performance improvement will depend on sensor/monitor type.

| Benefits | Costs |
|---|---|
| Monitors and sensors increase situational awareness on the system. These devices help the utility identify problems on the system more quickly and can sometimes help the utility resolve problems more quickly as well. Monitors and sensors are often combined with additional control devices that add flexibility to the system, allowing the operator to temporarily change how power flows on the system to avoid an outage. | • $5,000-$25,000 per device [9, 15, 16, 17]<br>• In cases where funding is limited, deploying a small number of monitors at key locations will provide the most benefit for reducing the impact of disruptions. For example, investing in a few temperature or flood monitors for a substation that serves a large portion of the community would ensure the single pathway of power into the community is maintained appropriately. |

**Protective devices.**

These devices on the distribution system are responsible for ensuring no fault on the system causes a short circuit. Short circuiting is dangerous because it can cause fires or explosions and further damage utility equipment. Protective devices typically include circuit breakers, reclosers, relays, and fuses. This investment type improves performance against all outage types.

| Benefits | Costs |
|---|---|
| Protective devices can help reduce the number of customers impacted by a fault on the system. While these devices cannot prevent the fault from occurring, they can limit the number of customers who experience an outage due to a fault. When there are many well-coordinated protective devices deployed on a given circuit, the customer power interruptions are even further reduced. | • $10,000-$80,000 per device [9, 15, 16, 17]<br>• In cases where funding is limited, deploying a smaller number of devices at key locations will provide the most benefit by reducing the impact of disruptions. For example, often targeting a single circuit will allow for high enough penetration of new devices to improve customer reliability on that circuit. Focusing on a particularly vulnerable circuit or a circuit that serves critical infrastructure may yield the greatest benefit. |

**Vegetation Management.**

Vegetation-related outages are very common on the distribution system and can be exacerbated by strong storms or wildfires. Utilities need to trim vegetation close to overhead power lines on a regular basis and it can be difficult to keep up with vegetation growth depending on the location of the lines and climate of the region. This investment type improves performance against strong winds, snow/ice, and wildfires.

| Benefits | Costs |
|---|---|
| Vegetation is one of the main causes of distribution system outages. While utilities clear away vegetation from power lines as often as they can, it is incredibly time-intensive and very costly. Aiding in keeping vegetation away from power lines can greatly reduce outages during storm or wildfire events. | • ~$50-$5,000 per item (mowers, tree, climbers, saws, etc.) [18]<br>• There may be additional training costs and other overhead costs when contracting with the utility. |

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