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Typical Use Cases for Energy Storage in Rural Areas

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1.0 Introduction

Public power utilities and cooperatives play a crucial role in delivering reliable and affordable electricity to remote and sparsely populated regions. Unlike their urban counterparts, these utilities often face a unique set of challenges that can complicate their operations and service delivery. One of the primary challenges is the vast geographical area they must cover, which often results in higher transmission and distribution costs per customer. Additionally, public power utilities in rural areas often cannot afford the investments required to maintain and upgrade aging grid infrastructure to provide reliable and resilient power or withstand the impacts of recurring, severe weather events, which can cause extended outages and disrupt service delivery.

Energy storage has emerged as a promising tool to help public power utilities meet these challenges. By enabling the storage of excess energy during low demand periods and providing a source of backup electricity during outages, energy storage systems can help utilities balance supply and demand more effectively. Additionally, they can help integrate a portfolio of various energy sources, reduce the need for expensive peak power purchases and provide ancillary services that stabilize the grid. This white paper describes potential use cases for energy storage in rural areas as well as documents a set of relevant example projects by project types.

2.0 Energy Storage Use Cases

Energy storage can provide a variety of benefits to public power utilities, including bulk energy services, ancillary services, transmission and distribution infrastructure services, or customer energy management services (Table 1). Residential behind-the-meter (BTM) energy storage can also provide benefits directly to consumers and electric cooperative members. The available use cases and value created from each depend strongly on regional characteristics as well as policy and market mechanisms. While battery energy storage systems are technically capable of serving numerous different use cases, actual deployed systems must balance the value provided by each available use case with the feasibility of simultaneously serving each purpose. For example, a residential system designed to provide backup power in case of an outage and provide bill savings during normal operation must balance how much of the battery's capacity is held in reserve in case of an outage and how much is elected to participate in bill management. Increasing bill savings comes at the cost of reduced capacity left in reserve and therefore reduced ability to ride through an outage, and vice versa. Table 1 describes the various use cases of energy storage and the corresponding energy storage deployment locations that support each use case.

Table 1. Energy Storage Use Cases and Corresponding Deployment Locations.

Energy Storage Use Case	Description	BTM	Utility	ISO/ RTO
Backup Power or Power Reliability	An alternative supply of stored energy used to provide uninterrupted electricity access during a utility power outage.	✓	✓	
Integration of Variable Generation Sources	Energy storage can support the integration of a wide range of energy generation by reducing the variability in output. For example, when paired with a solar photovoltaic (PV) array or a natural gas turbine, energy storage can store energy at times when optimal, efficient operation of the generator exceeds demand and release energy during periods of low or zero generation, ensuring a continuous and reliable power supply.	✓	✓	
Demand Charge Reduction (Peak Shaving and Load Shifting)	Because energy storage can store energy generated during off-peak times and discharge during peak periods, it can provide peak shaving by providing stored energy at peak times, and load shifting by charging at off-peak times. This can reduce the maximum power demand from the utility to avoid peak demand charges	✓	✓	
Time-of-Use Bill Management	Supplies energy to a building at times when utility-purchased electricity is especially high (called peak period) to reduce utility bills.	✓		
Investment Deferral	Energy storage can defer the need for utility investments in system upgrades to accommodate load growth or voltage regulation by reducing the load on the distribution or transmission system. While peak loads occur on just a few days or hours per year, energy storage can serve as a natural supply buffer to meet that annual, seasonal, and even daily peak loads.	✓	✓	
Transmission Congestion Relief	Discharging energy downstream of congested transmission lines to provide relief and cost savings.	✓	✓	
Resource Adequacy	Reduces or defers the need for new generation capacity by providing energy during times of peak energy consumption.	✓	✓	
Black Start	Provides grid stability required to restore the electric grid after a power outage or blackout.	✓		✓
Voltage Support	Provides reactive power to the grid as needed to maintain consistent grid voltage.	✓		✓
Frequency Regulation	Supplies or absorbs energy according to supply and demand to balance the grid's frequency.	✓		✓

Spinning and Non-Spinning Reserve	Either online (spinning) or capable of being brought online (non-spinning) generation capacity that synchronizes to the grid as needed.	✓	✓
Energy Arbitrage	Trading in the wholesale energy market by purchasing energy at times of low prices (off-peak) and selling that energy at times of higher price (peak).	✓	✓

References: Fitzgerald, Garrett, James Mandel, Jesse Morris, and Hervé Touati. The Economics of Battery Energy Storage: How multi-use, customer-sited batteries deliver the most services and value to customers and the grid. Rocky Mountain Institute, September 2015.; Balducci, P., Alam, M. J. E., Hardy, T. D. & Wu, D., 2018. Assigning Value to Energy Storage Systems. Royal Society of Chemistry.

3.0 Project Types and Examples

Energy storage is a uniquely flexible asset capable of both storing and delivering energy depending on the situation. Battery inverters and control technologies enable rapid dispatch and response, allowing energy storage assets to serve multiple use cases for the building owner and the grid at large to provide maximum benefits. It is therefore impractical to isolate projects by use case; as such, the following examples are presented based on the type of building or project.

3.1 Residential Behind-the-Meter

A residential behind-the-meter energy storage asset provides backup power in case of a utility outage. This is often considered its main purpose, especially for households with critical loads or medically sensitive individuals whose safety depends on continuous electricity service. For those with time-varying rate tariffs, such as a time-of-use rate, energy storage can also provide bill savings by dispatching energy to meet the household loads during more expensive, or peak times of the day. Similarly, if the household is subject to a peak demand charge, the energy storage can help reduce the peak load to mitigate this charge, called peak shaving. The battery can charge from the utility during reduced prices, or off-peak times, to repeat the cycle of bill savings the following day. Energy storage systems accompanying rooftop solar can charge from excess solar generation, rather than the utility, to further reduce the utility bill while also increasing self-consumption of renewable generation.

Depending on the utility or state policies, residential energy storage systems may be able to provide ancillary services to benefit the grid while also providing revenue for the system owner. In these cases, the battery would respond to a utility signal to charge or dispatch in response to grid conditions, providing services such as frequency regulation, voltage support, or resource adequacy. Many utilities have pilot programs to support the latter, remotely calling upon all program participants to dispatch their batteries at especially peak times, such as during a cold snap or heat wave. By coordinating a large number of small assets in this way, the combined capacity of all these distributed energy resources acts as virtual power plant to meet grid demand. System owners are compensated for their participation in these events at an agreed-upon rate which may differ from their normal rate tariff. An example of such a program is Rocky Mountain Institute's Wattsmart Program[1].

[1] https://www.rockymountainpower.net/savings-energy-choices/wattsmart-battery-program.html

3.1.1 Holy Cross Energy: Glenwood Springs, Colorado

Holy Cross Energy, a rural electric cooperative in Colorado, offers a program to help electric coop members install distributed standalone battery storage. This allows members to back up critical loads during power outages, as well as help the coop manage its energy resources, reducing stress on transmission lines, and decreasing the need to buy power from outside sources during periods of peak demand[2]. This program also provides peak shaving by storing surplus energy from local generation sources during the middle of the day and discharges the stored energy in the evenings during periods of peak demand.

3.2 Off Grid

An off-grid energy storage asset can allow isolated communities located far from the main power grid to meet power needs without relying on diesel generators. Energy storage is a key component of microgrids – a group of interconnected loads and distributed energy resources that act as a single controllable entity with respect to the grid[3]. In a microgrid, energy storage can store energy generated from any local generation source, typically with a variable energy output, which can then be used to provide reliable power.

3.2.1 Navajo Tribal Utility Authority: Dilkon, Arizona

The Navajo Nation is the largest Native American reservation in the United States, distributed across rural and remote areas of Arizona and parts of New Mexico and Utah. The reservation's sparse population has made it difficult to provide power to all residents, with more than 15,000 living without power as of 2022. The Navajo Tribal Utility Authority, in partnership with Sandia National Laboratories, completed a 3 kW / 13 kWh off-grid demonstration project in Dilkon, Arizona in 2022[4]. The zinc manganese dioxide ($ZnMnO_2$) battery system was paired with 1.8 kW of solar to serve as an off-grid residential system.

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2 https://www.holycross.com/member-programs/powerplus

3 https://www.energy.gov/sites/prod/files/2016/06/f32/The%20US%20Department%20of%20Energy%27s%20Microgrid%20Initiative.pdf

4 https://energy.sandia.gov/news/deployment-of-uep-battery-energy-storage-system-on-the-navajo-nation/

Figure 1. Navajo Tribal Utility Authority 3 kW / 13 kWh Off-Grid Demonstration Project[2].

3.2.2 Marine Energy Microgrid: Village of Igiugig, Alaska

In the rural community of Igiugig in Alaska, a 125 kW / 253 kWh BESS allows a microgrid powered by marine energy to reduce reliance on diesel generators and lower energy costs.[5]

3.2.3 Ho'ahu Energy Cooperative Molokai: Ho'ahu, Hawaii

The Ho'ahu Energy Cooperative Molokai, through the U.S. DOE's Energy Storage for Resiliency Hubs program, partnered with the Pacific Northwest National Laboratory and Sandia National Laboratories to design off grid PV-BESS systems for 15 qualified families on Molokai. The project's goals extended beyond providing energy to off grid residents to also alleviate the economic burden of reliance on fossil-fuel generators as well as to improve the health and well-being of the communities' most vulnerable members[6].

3.3 Small Business

Small businesses, especially in rural areas, face economic hardship from rising electricity prices that threaten sustainable profit margins required to stay in business. These businesses serve smaller populations but may be the one of the only providers of critical resources, such as groceries or hardware, that support community resilience during electric outages if they are able to continue operating during emergencies. The following examples highlight energy storage projects that serve rural small businesses.

3.3.1 Long's Pic Pac Grocery: Pineville, Kentucky

The Pineville grocery store added a 60-kWh battery to support their existing rooftop solar array with the help of federal tax credits, a Rural Energy for America Program (REAP) grant from the USDA, and support from the Mountain Association, a member of the Appalachian Community

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[5] https://www.energy.gov/sites/default/files/2023-12/Village-of-Igiugig-Alaska-2023.pdf

[6] https://hoahuenergy.coop/microgrids/

Capital[7]. The store's high energy bills contained monthly demand charges as high as $3,900 due to the store's use of refrigeration, deli ovens, and fryers. The cost savings from the new energy storage project are expected to save Long's Pic Pac more than $15K annually, supporting the small business, local jobs, and food security in the community.

3.3.2 Marsh River Cooperative: Brooks, Maine

The Marsh River Cooperative is a food coop that serves as a hub for more than 70 local farmers serving Brooks, Maine, which has a population just over 1K. The rising costs of electricity in Maine, coupled with the energy-intensive cooler and refrigeration needs of the coop, produced great financial stress for the business. They sought out a low-cost solar loan in combination with a grant from the USDA REAP program[8], which allowed them to install a 47-kW solar array on the roof of the barn behind the cooperative's retail store, offsetting a substantial portion of their monthly electricity bills and increasing their electric reliability[9]. The barn required structural work to support the weight of the panels, which delayed installation and increased the total costs, however, the project was successful due to community support and local donors. This project does not include any energy storage; however, it serves as another example of a local energy generation project that supports rural businesses.

3.4 Community Center

Energy storage projects tied to community centers can be one of the most effective ways to serve an entire community in a single project. Not only do these projects provide resilient power and bill savings opportunities for the building owners, often these projects turn community centers into resilience hubs, supporting local emergency response and disaster recovery efforts. These community centers provide cultural, educational, and recreational opportunities and therefore serve as trusted resources and gathering places within local communities. Energy storage projects that enable community centers to become resilience hubs can have a transformative effect on local emergency preparedness and disaster response. These hubs can provide shelter, critical information, basic first aid, clean water, food, continuous electricity to support small communication devices and small medical equipment. In response to the needs of communities experiencing severe weather events, there has been a nationwide movement to support the development of a network of resilience hubs to bolster community resilience; please refer to the following white paper[10] and guidance document[11] for additional information.

3.4.1 Bolinas Community Center: San Rafael, California

The Bolinas Community Center received $40K of financial contributions from MCE Clean Energy, the Marin Community Foundation, and the California Public Utilities Commission's Self Generation Incentive Program to install 23 kWh of energy storage, capable of providing backup power during emergencies to bolster the local community's resilience through increased ability to prepare, respond, and recover from electricity disruptions[12]. The project is tied to an existing

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[7] https://greenbankforruralamerica.org/project-example/longs-pic-pac/
[8] https://greenbankforruralamerica.org/project-example/marsh-river-cooperative/
[9] https://www.rd.usda.gov/newsroom/success-stories/marsh-river-co-op-finds-easiest-way-reduce-overhead-costs
[10] https://www.usdn.org/uploads/cms/documents/usdn_resiliencehubs_2018.pdf
[11] http://resilience-hub.org/wp-content/uploads/2019/10/USDN_ResilienceHubsGuidance-1.pdf
[12] https://mcecleanenergy.org/bolinas-community-center-adds-battery-storage-to-solar-secures-community-access-during-outages/

solar array and is expected to reduce energy costs by an estimated $2K over 7 years by increasing self-consumption of the PV-generated electricity during times of high energy price.

3.4.2 Hemphill Community Center: Neon, Kentucky

The Hemphill Community Center in Appalachian Kentucky serves a county of 20K as a cultural gathering place for music, dance, and art workshops, as well as a provider of community resources and programs supporting local jobs and affordable energy programs. The community center received technical assistance from the Mountain Association to perform energy audits and energy efficiency upgrades ahead of installing solar with $48K of financial assistance, all of which have resulted in approximately $7K in annual bill savings[13]. The center is poised to expand their existing solar array in addition to adding new battery energy storage to increase community resilience, as the area is especially prone to flooding and subsequent power outages.

3.4.3 Community Renewable Energy Grant Program

The Oregon Department of Energy Community Energy Grant Program supports the planning and construction of renewable energy and energy resilience projects for tribes, public bodies, and consumer-owned utilities. In 2024, some of those grant awardees were[14]:

- The Confederated Tribes of Warm Springs: $1M to install 108-kW PV and 240 kW energy storage at their Indian Head tribal casino.
- City of Depoe Bay: $95K for planning efforts for 130 kW PV, 100 kW BESS, and 180 kg Hydrogen Fuel Cell storage at the town's City Hall, which provides emergency operations and serves as a community center, storing emergency food, supplies, and serving as an emergency shelter in times of crisis.
- Hood River County: $920K to construct a solar and energy storage project for the Mount Hood Town Hall community center or for emergency operations. The county was a recipient of a planning grant the previous year from this same program to support this project's development.

3.5 Community Microgrid

A microgrid is a collection of interconnected distributed energy resources (DERs) and loads that can be controlled independently of the main electric grid. Microgrids can serve a single load, like a home or business (sometimes referred to as a micro- or nano-grid), or can serve a collection of buildings and loads, as in the case of a community microgrid. As these projects connect multiple DERs, buildings, and loads, they require the participation and support of numerous stakeholders and the local community. Community microgrids may provide relief from high utility prices, market participation, or grid support, but are often originally motivated by a need to bolster community resilience. These community microgrids can be used to support a neighborhood of residents at the grid edge that struggle with electric reliability, or they can be centrally located in town centers to support the community's critical infrastructure, such as fire stations, hospitals, libraries, community centers, and groceries. The following are examples of community microgrid projects.

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[13] https://greenbankforruralamerica.org/project-example/hemphill-community-center/

[14] https://energyinfo.oregon.gov/blog/2024/9/24/oregon-department-of-energy-grant-program-supports-renewable-and-resilient-energy-development-in-communities-across-the-state

3.5.1 Poudre Valley REA Cooperative: Red Feather Lakes, Colorado

Red Feather Lakes, Colorado is a remote mountain community of fewer than 400 people in Colorado that is frequently at risk of extended outages, especially from wildfires, severe winter storms, and car accidents. Served by a single transmission line, the community's outage history supports the need for increased resilience. The community microgrid connects the Volunteer Fire Department, library, community building and shelter, post office, local businesses, and other loads to a 140 kW / 446 kWh battery energy storage system integrated with 8 kW of solar and a 139-kW propane generator[15]. The project took off when the local library was awarded grant funding for a 20-kW rooftop solar array[16], which inspired conversations aimed to bolster community-wide resilience. The microgrid is capable of isolating from the surrounding grid using a microgrid controller, enabled by a set of distribution upgrades at the isolation point. The microgrid is designed to support the community in islanded mode for up to eight hours in times when the grid is unavailable.

3.5.2 Blue Lake Rancheria Tribe Microgrid: Blue Lake, California

In rural Humboldt County in California, a microgrid provides reliable and resilient power to the Blue Lake Rancheria Tribal's campus, both while grid-connected and during outages. The 420 kW solar PV, 1,150 / 1,950 kWh BESS microgrid powers tribal offices, EV charging, a gas station, and a hotel and casino.

During a public safety power shutoff event in 2019, the microgrid provided critical services, including a safe, warm community space, cell phone charging and internet access, fuel delivery, and housing for people whose medical needs require access to electricity. The microgrid served about 10,000 people during the power shutoff (~10% Humboldt County's population) and was credited with saving the lives of people with acute medical needs[17].

3.5.3 Orcas Power and Light Company: Decatur, Washington

In 2018, Orcas Power and Light Company built a solar-powered microgrid on Decatur Island in the San Juan Islands of Washington state. The energy storage component of the microgrid (1 MW / 2.6 MWh) helps manage the intermittent nature of solar PV, increasing the local consumption of the electricity generated by the community solar array (504 kW)[18]. The microgrid can power ~500 homes for 4 hours. Additionally, this project provides a variety of cost-saving and efficiency benefits, including demand charge reduction (peak shaving and load shifting), transmission charge reduction, submarine cable replacement deferral, energy cost reduction, voltage regulation, and outage mitigation.[19]

This project is helping defer the upgrade of a BPA-owned submarine cable, energized in 2022 with an approximate 40-year lifespan. Reducing heating on the cable and acting as a reactor

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[15] https://pvrea.coop/the-co-op/news/microgrid-brings-increased-resiliency-red-feather-lakes/
[16] https://www.electric.coop/colorado-co-op-helps-disaster-prone-mountain-community-build-a-microgrid
[17] https://microgridknowledge.com/blue-lake-rancheria-microgrid-outages/
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[18] https://www.opalco.com/quick-fact-decatur-island-battery-storage-project/2021/05/
[19] https://www.opalco.com/wp-content/uploads/2018/12/PNNL-OPALCO-Battery-Storage-Presentation.pdf

that compensates for the submarine cable's large capacitance could extend the length of its useful life by 3.3 years. Deferral value was calculated to be $2M.[20]

3.6 Utility Scale

Rural public power utilities and electric cooperatives often depend largely or wholly on the wholesale electricity market to meet the demand of their customers and members. For power that is not able to be generated locally, the utility purchases electricity from the wholesale electricity market at the current market price. The market price of wholesale electricity varies like a time-of-use rate, but with less certainty due to the real-time pricing market structure. Large scale utility storage assets can be used for peak shaving, which can shield utilities, cooperatives, and their customers or members from these high prices by charging the energy storage during off peak times of low wholesale market price to be dispatched during peak times of much higher market price. These large energy storage systems benefit from economies of scale, providing substantial savings by avoiding large volumes of high-priced electricity purchases.

Utility scale batteries can also improve system reliability and provide ancillary services, as they are controlled and dispatched by the utility, upstream of many of the distribution feeders within the service territory. Some example projects are detailed below.

3.6.1 United Power Cooperative: Firestone, Colorado

The United Power Cooperative in Firestone, Colorado recently completed a 4 MW / 16 MWh community energy storage project designed to pass the cost savings of peak shaving directly onto its members. The utility scale battery serves to shield the cooperative from extreme prices in the wholesale electricity market, charging during low prices to meet cooperative demand during times of high prices. The project is expected to save $1 Million USD annually[21]. To provide direct member savings, and to help finance the project, the cooperative offered members subscription share portions of the battery's total capacity. In practice, the member is charged a flat subscription fee on their utility bill according to their share size in kWh and then receives bill credits as if a residential battery system of the same size were located at their home, operating to provide demand charge savings. This virtual community energy storage model allows for grid-scale benefits, economies of scale, and ease of siting and operation (since it is utility-owned), while also providing substantive benefits to cooperative members in the form of bill savings. By virtue of being virtual, any member can participate—not just those who own their home, have adequate space, and have the required electric infrastructure to support an onsite battery. Additionally, the subscribe-and-save model mitigates the upfront cost of participation, which is often the largest barrier to residential energy storage adoption. At the utility's discretion, reduced or subsidized subscriptions can be extended to low-income members or customers to further increase access and reduce consumer risk of participation.

3.6.2 Dairyland Power Cooperative: La Crosse, Wisconsin

In 2024, the Dairyland Power Cooperative (DPC) received funding from the U.S. Department of Energy, Office of Clean Energy Demonstrations to develop behind-the-meter energy storage at distribution centers to provide up to 700 kW of power for up to 10 hours for rural communities in

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[20] https://www.opalco.com/wp-content/uploads/2018/12/PNNL-OPALCO-Battery-Storage-Presentation.pdf

[21] https://www.unitedpower.com/energy-projects#heading-accordion-3665-1

Illinois, Iowa, and Wisconsin. DPC plans to collaborate with distribution cooperatives to improve grid resiliency, reliability, and provide backup power to the distribution network served by project sites.[22]

3.6.3 Holy Cross Energy: Glenwood Springs, Colorado

Holy Cross Energy's Colorado Mountain College 4.5 MW solar PV and 5 MW BESS supplies enough locally-produced energy to power approximately 1,000 homes and storage capacity to help the coop meet peak loads, helping the coop avoid operating natural gas peak power plants and reducing costs for coop members.[23]

3.6.4 Anza Electric Cooperative: Anza, California

Southern California's Anza Electric Cooperative was solely reliant on Southern California Edison lines to import power. During public safety power shutoff events, they would often lose power. They found that adding a new transmission line would cost more than the coop's total value. As a result, they developed a solar-powered microgrid (3.4 MW Solar PV and 2 MW / 4 MWh BESS) to be self-reliant during outages and avoid the transmission upgrade. The microgrid allows the coop to feed critical loads and keep well water running during outages.[24]

4.0 Conclusion

The use cases presented here represent emerging applications of energy storage systems uniquely suited to the challenges faced by public power utilities and cooperatives providing reliable and affordable power in rural areas. By enabling better management of supply and demand, enhancing grid stability, and supporting the integration of diverse energy sources, energy storage systems can significantly improve the reliability, resilience, and affordability of electricity services.

This paper outlines key use cases of energy storage in rural areas. Energy storage systems provide a variety of benefits, including back-up power for isolated microgrids, community centers, and community microgrids, offsetting small business electricity bills, and improving grid resiliency, reliability, and providing back-up power for utilities and cooperatives. Leveraging energy storage systems can allow rural community members, business owners, and utilities to have access to reliable and resilient power.

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22 https://dairylandpower.com/sites/default/files/post_attachments/Factsheet_LDES_Dairyland_11.4.24.pdf

23 https://www.holycross.com/blog/cmc-ameresco-solar-plus-storage-largest

24 https://www.microgridknowledge.com/distributed-energy/article/11427860/how-rural-electric-cooperatives-can-power-through-california-outages-with-microgrids

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