Business & Technology Report
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Battery Energy Storage Systems in Rural Electric Utilities

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America's Electric Cooperatives

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Executive Summary

This report provides an overview of the applications, technologies, and economic trends of battery energy storage systems (BESS) and presents information about BESS projects deployed by rural electric cooperatives.[1]

The U.S. electric grid is becoming increasingly reliant on intermittent wind and solar generation. From 2016 to 2023, wind and solar capacity at electric cooperatives more than doubled from 6.7 GW to 14.2 GW. Most of this capacity growth has been added through power purchase agreement (PPA), where the co-op purchases the storage and energy services of the BESS from a third-party who owns and operates the project. Intermittent resources are not dispatchable and can lead to grid challenges when their generation does not align with demand. Adding batteries and other storage technologies can help address these challenges by allowing a degree of dispatchability and providing a firm capacity asset for the grid when there is an unexpected drop in generation or a sudden increase in demand.

A BESS can maximize the value of intermittent renewables by firming or maintaining the flow of electricity when the renewable resource is not generating energy. Depending on whether the BESS is placed in-front-of- or behind-the-meter, applications range from energy arbitrage and peak shaving to transmission and distribution (T&D) deferral.

Battery technologies used for BESS have certain characteristics that may make them more suitable for one application over another. A systems approach is needed for safe operations and maintenance of the BESS, and parameters such as cost and operation temperature must be accounted for, along with the battery properties, to have optimal storage system performance.

The economic viability of deploying BESS projects has been improving over the last few years due to increased lithium supply, domestic manufacturing buildout, and tax credits. Furthermore, a direct-pay option for the tax credits is available for electric cooperatives, making BESS even more favorable to adopt for these electric utilities.

Analysis of publicly available information shows that there are 112 BESS projects owned or contracted by rural electric utilities across 24 states, and 73 of these projects are operational as of October 2024. The majority (70%) are owned or contracted by distribution cooperatives, with a wide range of rated power and storage capacity. Moreover, it was found that a diverse set of technology providers were utilized for the projects, and several BESS projects identified are hybrid systems, with most being paired with solar photovoltaic (PV). The intended use and battery technology of the storage systems were mostly peak shaving and lithium-ion, respectively.

Multiple funding streams (federal, state, and private) were used to fund at least partially some of the BESS projects identified.

[1] While this report generally uses “cooperatives” or “co-ops,” it also includes data on NRECA’s other rural utility members, mostly rural public power districts as well as small municipal, tribal, and mutual utilities.

Introduction

The increased adoption of intermittent energy resources, both at the grid-scale and the distribution-scale, has challenged electric utilities to continue providing reliable electricity while fulfilling the need to add new diverse generation sources to their grids. Although the integration of intermittent energy resources plays an important role in meeting a growing demand, the dependence on solar or photovoltaic (PV) and wind turbines alone may not be sufficient to provide reliable electricity.[1] Fortunately, deploying battery energy storage systems (BESS) in either the grid- or distribution-scale can stabilize the grid by storing energy at low demand times and discharging it to the grid when needed (e.g., during peak demand, low wind speed, low solar radiation).[2]

Electric cooperatives share the industry concern for providing reliable electricity as renewable resources proliferate the electric grid. The bulk of the renewable energy capacity added by electric cooperatives over the last decade has been from wind and solar generation projects. Figure 1 shows that wind is the largest non-hydro renewable resource in the national cooperative fuel mix, followed by solar. Solar has been experiencing accelerated growth in recent years due to the increasing size of projects across the country. Both wind and solar capacity in electric cooperatives have been increasing over the years, more than doubling from 6.7 GW in 2016 to 14.2 GW in 2023 – and growth is accelerating, with more than 5 GW of additional capacity announced to come online between 2024 and 2026. In many cases, this growth comes at the same time as dispatchable fossil fuel plants are being retired, making energy storage more critical than ever. Figure 1 includes utility-scale resources interconnected on both the bulk electric grid, primarily by generation and transmission (G&T) cooperatives, as well as smaller projects deployed on co-op distribution grids. Currently, about 90% of the capacity presented in Figure 1 is under power purchase agreements, but due to the availability of direct pay tax credits, more cooperative-owned projects are expected to be commissioned in the coming years.[3]

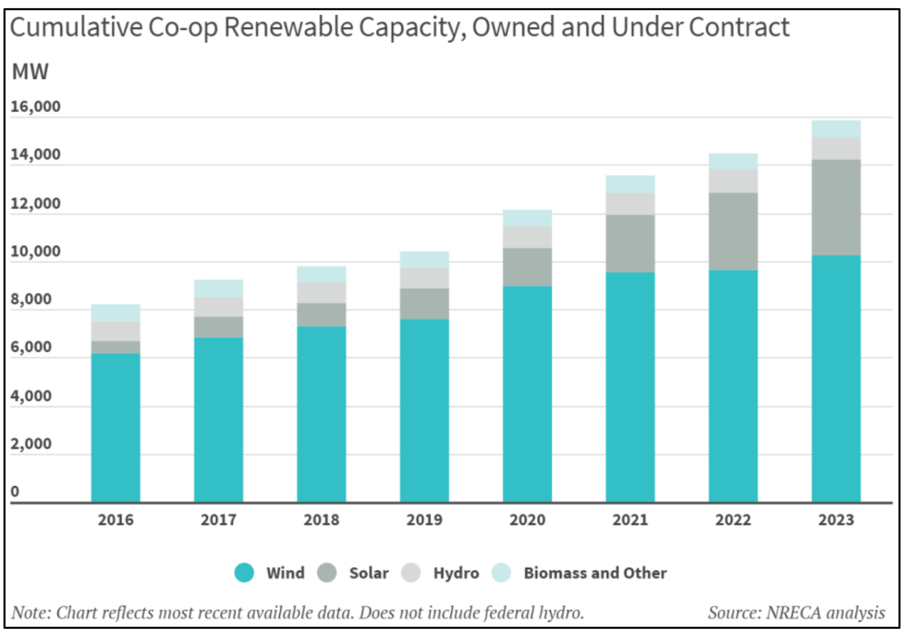

Figure 1. Cumulative Renewable Capacity Owned and Contracted by Electric Cooperatives [3]

Applications / Use Cases

The applications for battery energy storage systems depend on their location relative to the electricity meter: front-of-the-meter (FTM) and behind-the-meter (BTM). The FTM systems serve the bulk grid and are often paired with utility-scale renewable resources to prevent disruptions. These FTM BESS can also be built in many locations, and some have been built in retired and existing power plants.[4] Use cases for FTM BESS include renewable firming, peak shaving, energy arbitrage, investment deferral or reducing the need for new transmission developments, and fast-response frequency regulation.[4],[5]

On the other hand, BTM systems are used locally, like in microgrids, commercial and industrial (C&I) or residential settings. Similar to FTM systems, these BTM systems are frequently paired with distributed generation systems and can also serve as a backup power supply during power outages and for charging electric vehicles (EV).[4] The BTM BESS are also typically used to enhance the efficiency of distributed energy resources by storing excess energy generation for later use, for power cost optimization, or for demand-side management. For increasing capabilities for residential-level EV charging infrastructure, the system draws power from on-site distributed generation or the grid to charge its battery during off-peak utility hours and then uses the stored energy from the battery to charge the vehicle.[4],[5]

Typical use cases for battery energy storage systems are detailed in Table 1. Value stacking or combining multiple use cases for a storage project is also common in both BTM and FTM systems, as this achieves maximum benefits for the BESS.[6] However, some use cases may not be combined with others. For example, a battery that is intended for short-duration use cases may not provide significant value when it comes to transmission/distribution investment deferral. Furthermore, having multiple use cases may increase the amount of charge and discharge cycles, shortening the usage life of the battery.[6]

Table 1. Typical Use Cases for Battery Energy Storage Systems [5]

Use Case	Definition
Demand-side Management / Peak Reduction	Use energy storage to reduce electricity demand during peak demand periods, recharging during low demand periods. This may be implemented by the member or the utility.
Electric Service Reliability / Resilience	Provide backup power during outages, including integration with distributed generation sources.
Energy Arbitrage	Purchase off-peak electricity at low prices for charging the storage system, so that stored energy can be used or sold at a later time when the price of purchased electricity is high.
Fast Response Frequency Regulation	Manage the interchange flows between control areas to maintain frequency within the tolerance bands. FERC Order 755 promotes energy storage as an option for frequency regulation, allowing for a premium to be paid in markets for ancillary services for the rapid response of energy storage to maintain system frequency.
Microgrids	The use of dispatchable and non-dispatchable generators, often combined with energy storage, to produce energy for distribution to a local set of loads that can be intentionally islanded from the larger grid. This is usually done for energy resilience or economic optimization purposes.
Off-grid systems	This applies to systems that are not connected to the bulk power system. These range from solar-powered streetlights and mountaintop microwave repeaters to individual homes and even whole communities that are typically located in remote or isolated areas such as Hawaii and Alaska
Renewables Firming	Use energy storage in tandem with intermittent resources to provide a more predictable power supply.
Transmission / Distribution System Deferral	Defer and/or reduce the need to build new generation/distribution capacity or purchase generation capacity in the wholesale electricity marketplace. Distribution applications include deferral of transformer upgrades or line reconductoring.

Storage Technologies

Various use cases exist for BESS; however, the characteristics of the batteries used must be considered to balance the trade-offs and match the systems' intended use.

Figure 2 illustrates the typical use case for different energy storage technologies and their corresponding discharge time and power rating ranges. Lithium-ion batteries—the most common type of batteries—can be utilized for transmission and distribution grid support, and to some extent for bulk power management. These batteries have a system power rating that ranges from approximately 1kW to over 1 MW, with a discharge time between several minutes to hours. Lead-acid batteries cover the largest range of system power rating of around 1 kW to approximately 10 MW.[7]

Flow batteries are composed of a positive and a negative electrolyte, and pump circulates the electrolytes though porous electrodes as oxidation-reduction reaction occurs. This reaction frees electrons that are then used to power devices during battery discharge, and stores electrons when charging.[8] The system power rating can reach up to over 10 MW, and there are various types of chemistries used for flow batteries.[7]

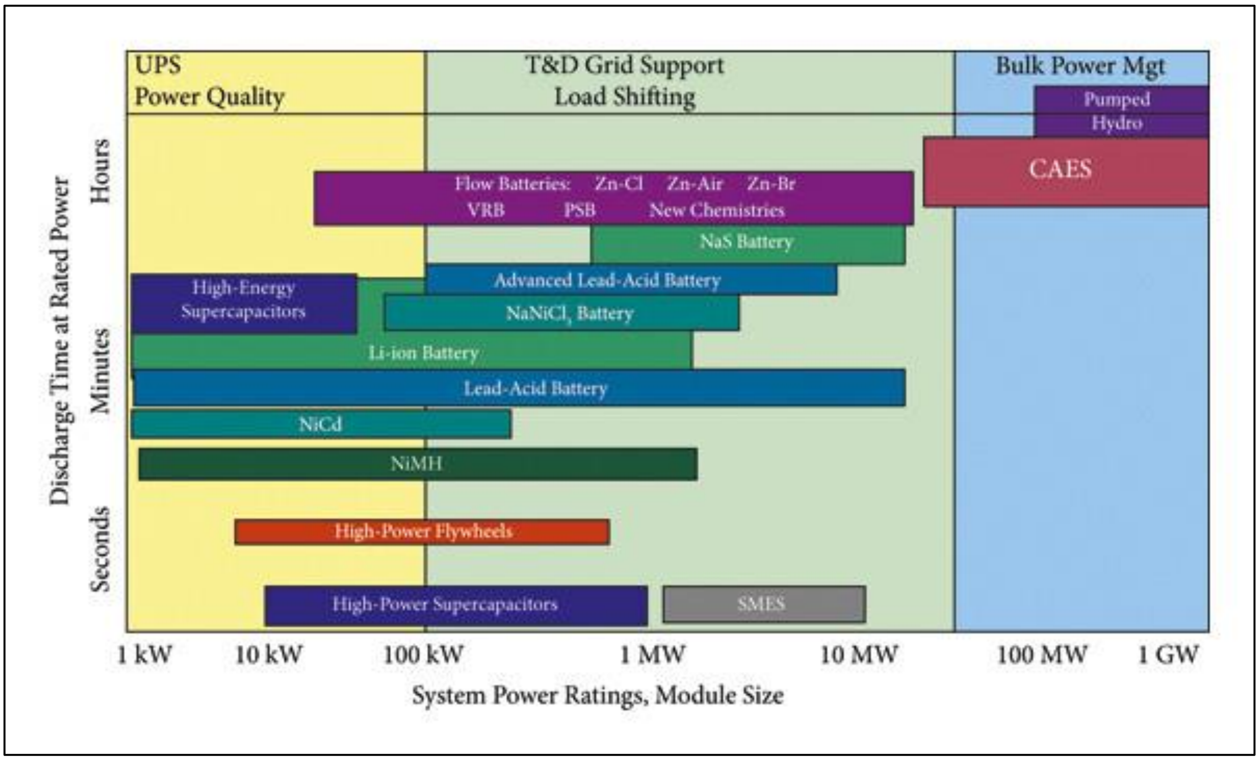

Figure 2. Comparison of Discharge Time and Power Rating for Various Grid-Level Energy Storage Technologies [7]

For those familiar with traditional generators, battery energy storage systems use slightly different terms to describe their output, because they can act as both a load when the battery is charging and a generator when the battery is discharging. For BESS "power capacity" is analogous to the nameplate capacity of traditional generators and is measured in kW or MW, depending on the scale of the battery. Power capacity refers to the greatest amount of energy a battery can discharge in a given moment. “Energy capacity” refers to the total amount of energy these batteries can store, measured in kWh or MWh. The Energy Information Administration (EIA) calculates a battery’s duration by using the ratio of energy capacity to power capacity.[9]

The relationship of these three parameters is described by Equation 1. For example, a battery with 1 MW of rated power and 2 MWh of storage capacity will have a storage duration of two hours.

Equation 1

$$Storage\ Duration = \frac{Storage\ Capacity}{Rated\ Power}$$

Other aspects of various energy storage chemistries are shown in Table 2. The energy density determines how big the battery will be for a desired rated power. The energy density can influence the size and weight of the battery, making it an important factor to consider if space is limited or if other features of the battery project can be significantly impacted. Batteries with lithium-ion and sodium chemistries have a high energy density, while other technologies like lead-acid have low energy density.

Round trip efficiency refers to the ratio of the energy expended in charging the battery to the energy that can be extracted from it. In general, energy losses in a round trip of charging and discharging the battery can reach up to 40% of the stored energy. Two types of batteries that are among the most efficient are lithium-ion batteries which operate with almost no round-trip losses and sodium-ion batteries which reaches up to 90% efficiency. Compared with other battery technologies, sodium-ion batteries have longer usage and can be operated at high temperatures as noted in Table 2.[10] The battery chemistry can have a high impact on the value of certain applications, such as energy arbitrage.

Table 2. Some Characteristics of Different Battery Storage Technologies [10]

Battery type	Energy density (Wh/kg)	Efficiency	Usage life (years)	Cycle life (cycles)	Operation temperature (°C)	Cost (/kWh)
Lead–acid	30–50	75–80%	2–3	500–1000	18–45	$300–600
Ni–Cd	50–75	60–70%	> 10	2000–2500	− 40 to 50	~ $1000
Ni–MH	40–110	–	> 5	300–500	− 30 to 70	–
Na–S	150–240	75–90%	10–15	~ 2500	300–350	$300–500
Li-ion	100–250	~ 100%	5–6	> 1000	20–65	~ $600–2500
Zinc–bromine	75–85	65–75%	5–10	> 2000	20–50	$150–1000
Vanadium redox	10–50	75–85%	5–15	12,000–14,000	5–45	$150–1000

Safety

There has been increased adoption of BESS in the electricity grid over the past several years, and projections show a continual increase in capacity additions for batteries in the United States' grid.[11] However, as more battery projects are planned and commissioned, safety concerns and incidents related to BESS have resulted in public pushback on the development of new projects in some communities.[12]

While lithium-ion technologies are commonly used for BESS due to their high energy density, efficient charging and discharging, and relatively long lifespan, as mentioned previously, a safety concern is that they are also extremely flammable.[13]

Figure 3 illustrates the steps during a lithium-ion cell *thermal runaway*—the chain reaction of chemical reactions in a battery that causes an uncontrollable increase in temperature. During a thermal runaway, technical failures cause the battery's solid electrolyte interphase (SEI) to decompose within seconds. Then, the battery becomes deformed and short circuits as it reaches extremely high temperatures. Finally, thermal runaway occurs as the battery temperature rapidly and uncontrollably rises, accompanied by a sharp increase in pressure that forces gases and heat out of the battery.[14]

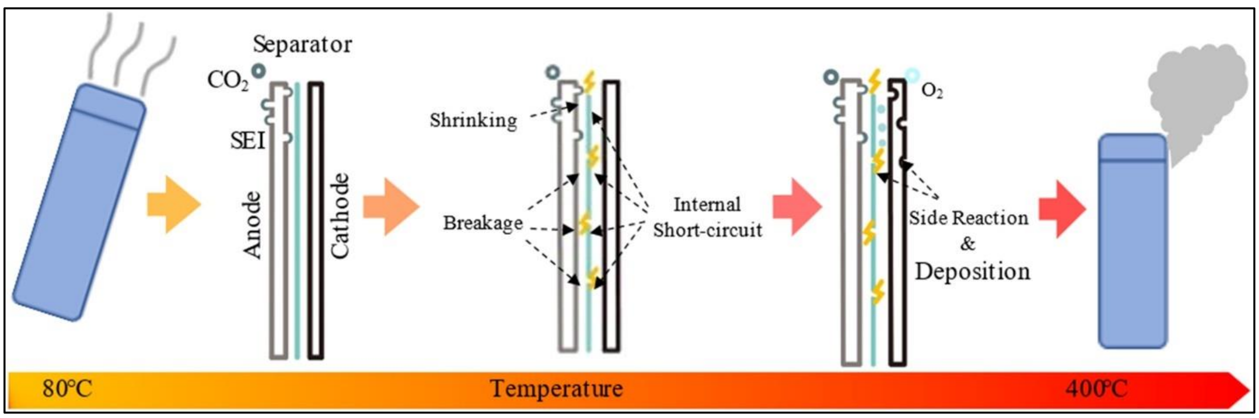

Figure 3. Steps of Lithium-ion cell thermal runaway.[14]

A battery can undergo thermal runaway due to external failures (e.g., overheating or excessive cooling, external short circuit, mechanical deformation, and overcharging and discharging) or due to internal failures (e.g., manufacturing defects, internal short circuit, and dendrite formation and aging).[15] Figure 4 shows the damage propagation until a lithium-ion battery pack exhibits thermal runaway. The method used to establish battery failure was nail penetration. This experiment was conducted at near-ambient conditions, using a 3S3P pack with three 1S3P modules.[16]

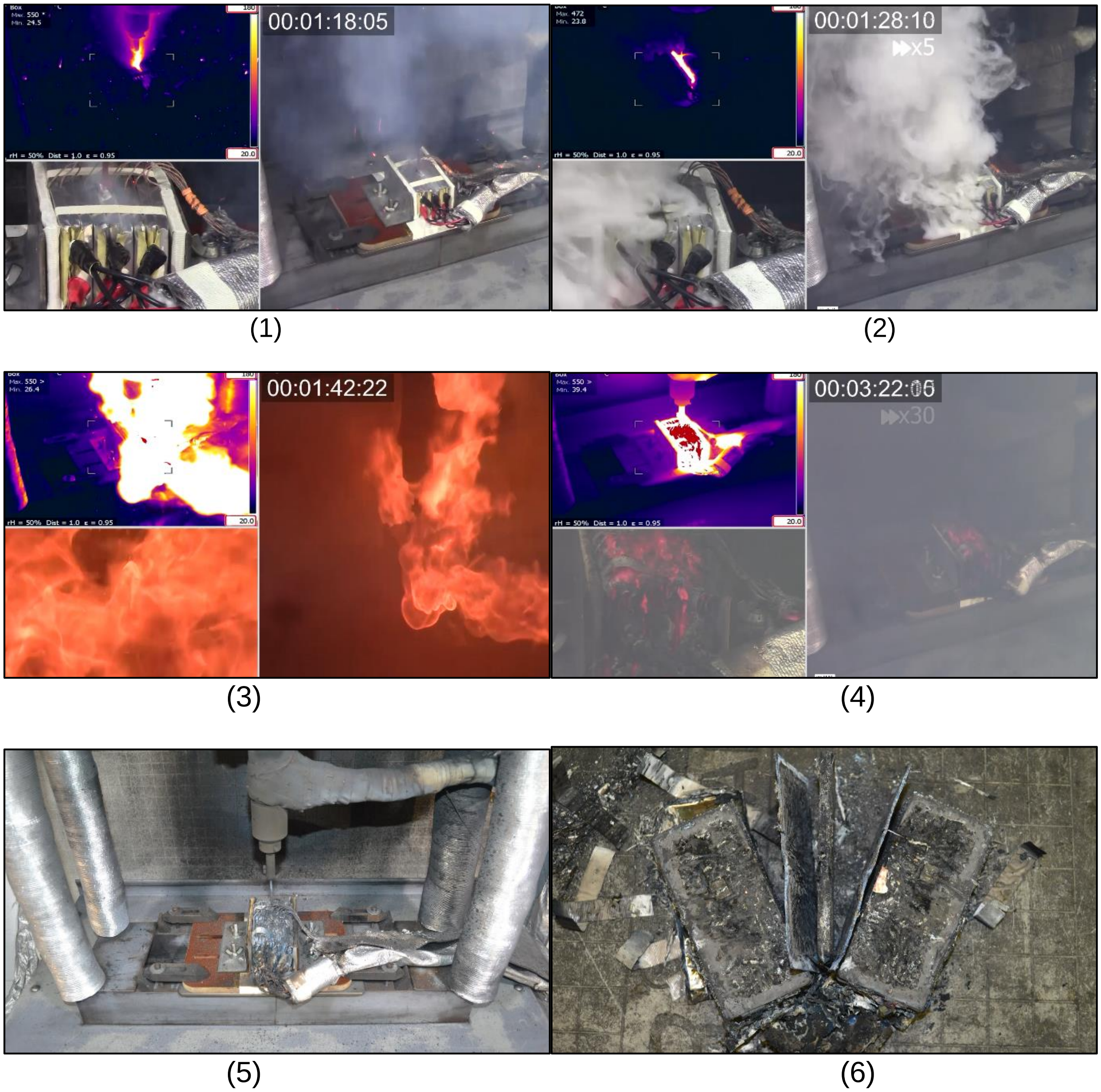

Figure 4. Image series, from (1) to (6), showing lithium-ion cell thermal runaway using nail penetration to create battery failure. [16]

Photo courtesy of Sandia National Laboratories Battery Abuse Test Laboratory (BATLab).

Other battery technologies also have associated risks. Thermal runaway is less of a concern for lead-acid batteries, while flow and zinc batteries do not undergo thermal runaway at all. However, these technologies do raise other safety concerns, such as acid spills and toxic gas discharge. See Table 3 for more details on the safety concerns raised by various technologies. [17]

Table 3. Summary of Primary Safety Concerns for Energy Storage Technologies [17]

Technology	Primary Safety Concerns
Flow batteries	- H_2 gas generation - Strong acid/base electrolyte spill if containment breach
High-temperature batteries (e.g., NaS, $NaNiCl_2$, liquid metal)	NaS: exothermic reaction of molten sodium
Hybrid systems	- Known issues associated with the individual technologies - Mismanagement of controls for the different technologies
Lead-acid batteries	- Thermal runaway less common and severe than Li-ion - Vented lead acid cell spills
Li-ion batteries	Thermal runaway leading to fire or explosion Fires emit toxic gases such as HF and PM 2.5
Zn batteries	- H_2 gas generation - Spill of acidic/basic electrolyte if breached

A systems approach must be taken to mitigate safety risks in BESS operations, as well as address any negative impacts if safety issues arise. This approach cautions against utilizing a cell from sources that are not a reputable Tier 1 supplier (direct suppliers of the final product). In addition to this, a full-system design will ensure safe operations of the BESS by having proper thermal and environmental management, a battery management system, power conversion system, enclosure, grounding, communications, workmanship, and proper design for operations and maintenance. Furthermore, it is also recommended to ensure quality/compatibility of integration and workmanship.[12]

Moreover, the battery energy storage system must follow the relevant codes and standards, as shown in Figure 5. These codes and standards are for the installation, operation, and minimum safety requirements of performance for BESS, as well as the individual components included in a BESS.

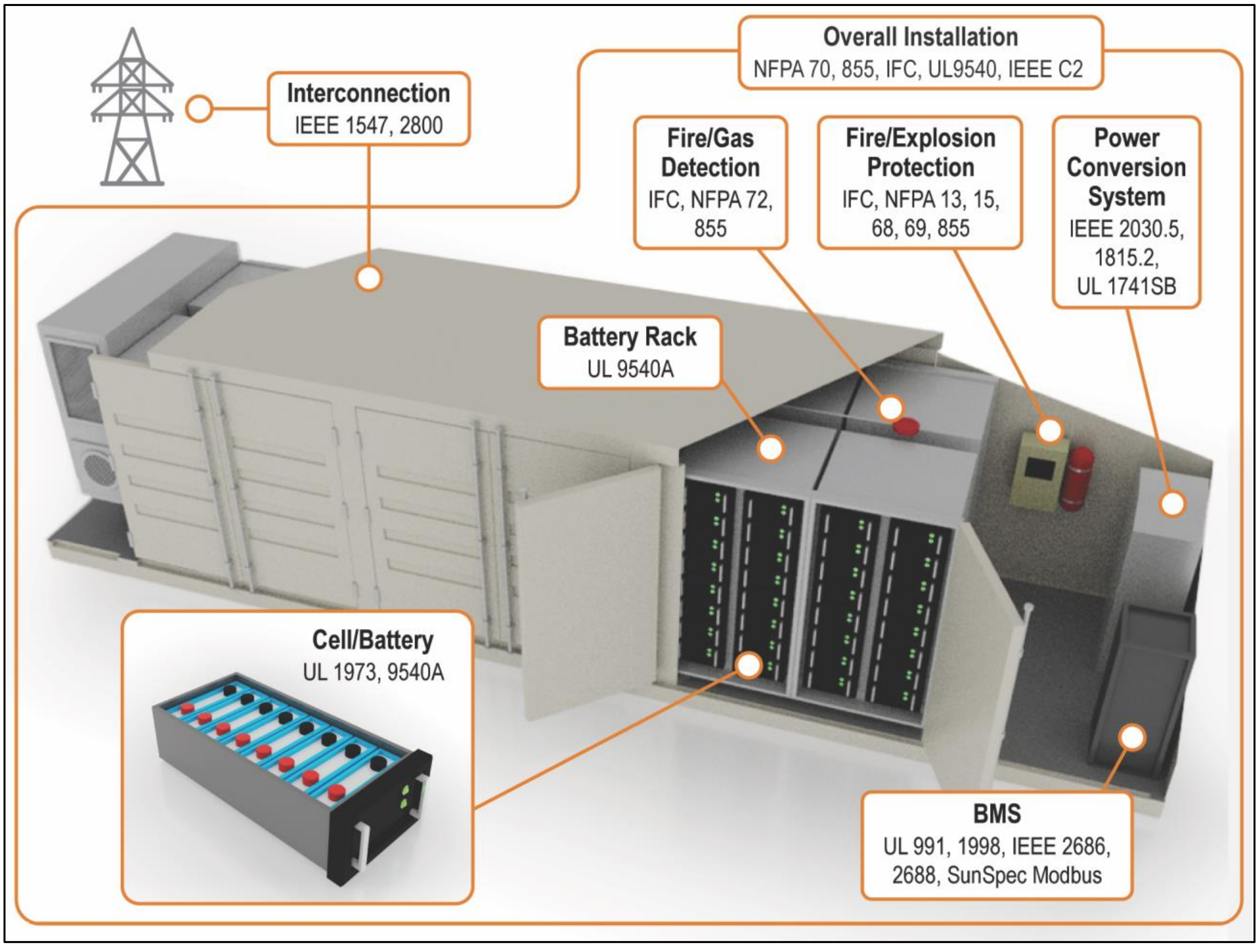

Figure 5. Key Codes and Standards for Battery Energy Storage Systems [12]

Economics of BESS

The cumulative capacity of operational hybrid BESS in the United States (battery plus other generation source) installations has reached about 32 GW by the end of Q1 of 2024 — growing around 10 times from 2015 to 2023, as illustrated in Figure 6. The growth of hybrid storage capacity is largely driven by solar plus storage systems, growing from about 5 GW in 2020 to approximately 25 GW in Q1 of 2024.[18]

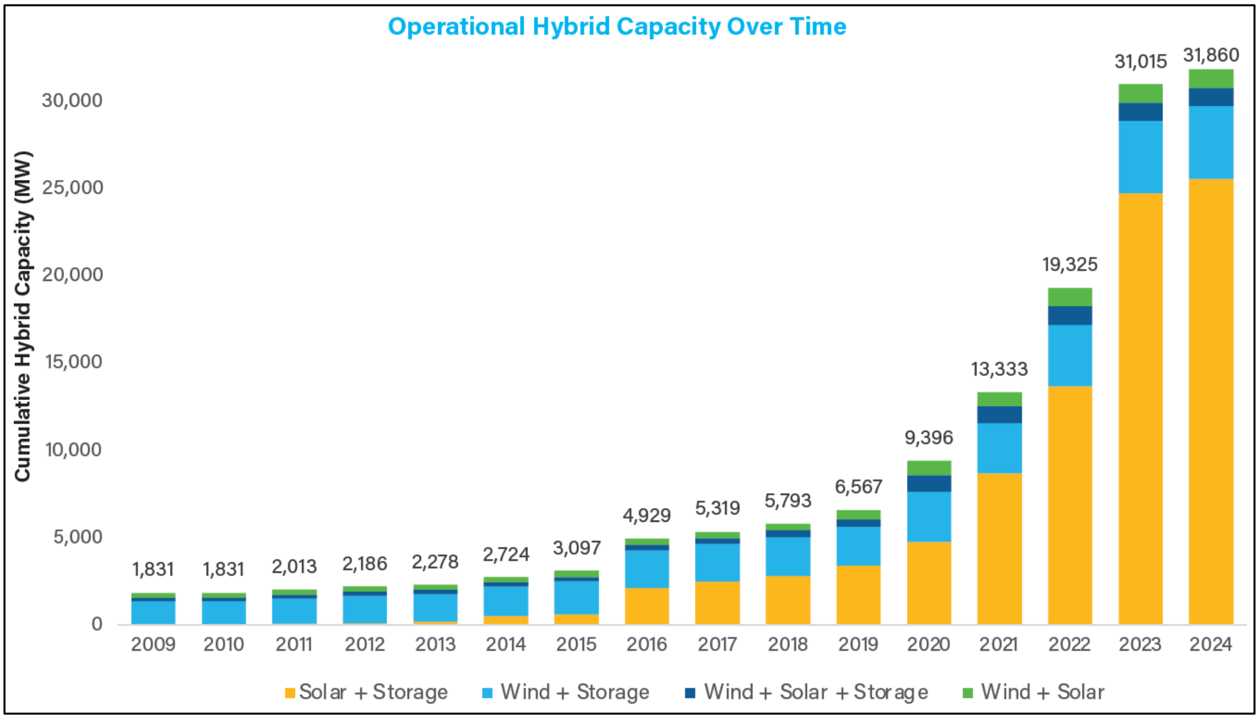

Figure 6. Cumulative Hybrid Storage Capacity in the United States [18]

In tandem with the BESS capacity growth was the decline of prices for battery systems. Outside of the price spike due to supply chain issues during the COVID-19 pandemic, BESS prices have fallen drastically over the last decade. In 2023 alone, Wood Mackenzie reports (see Figure 7) that grid-scale BESS prices fell from an average of $1,778/kW in Q1 2023 to $1,080/kW in Q1 2024 (grid-scale storage includes any installation over 1 MW, excluding those that are part of community-scale programs).[19] Clean Energy Associates reports similar price drops and states that prices could fall another 18% by the end of 2024.[20]

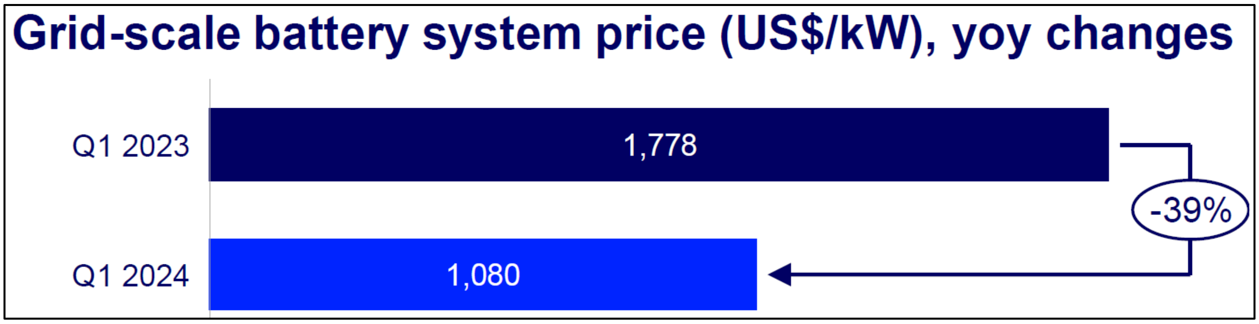

Figure 7. Grid-Scale Battery System Price (US$/kW) [19]

Figure 8 shows the cost of a utility-scale lithium-ion energy storage system (4-hour duration, 240 MWh usable energy). The bulk (63%) of the cost is attributed to the battery pack, while the rest of the components have minor cost contributions. This implies that the economics of the battery itself have a relatively strong influence on the overall price of a BESS. [21]

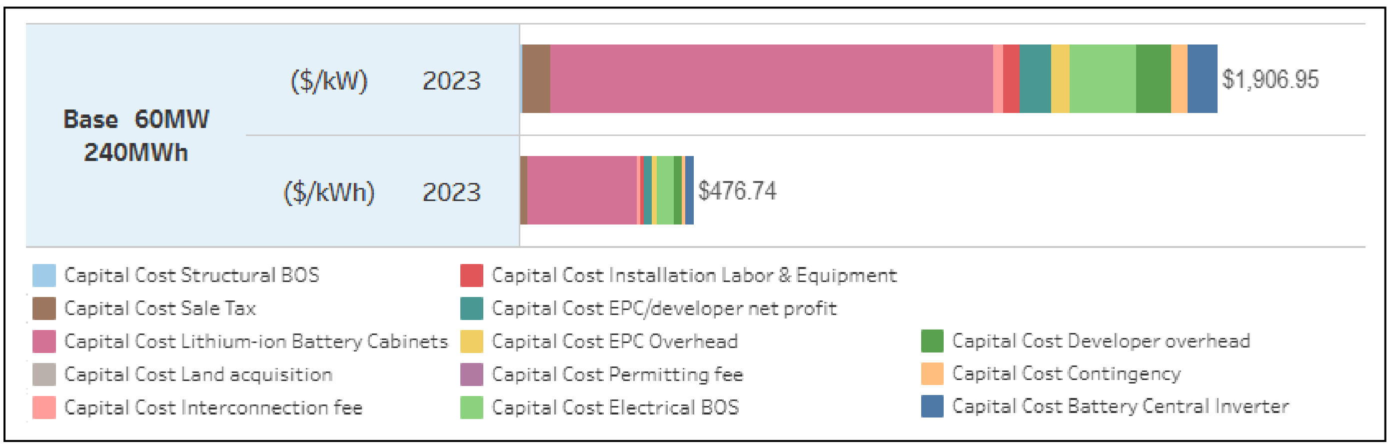

Figure 8. Costs For A 4-Hour Utility-Scale Stand-Alone Lithium-Ion Battery (2022$) [21]

The increasingly favorable BESS market in terms of price can be attributed to several factors. New lithium deposits have been discovered, which has led to increased lithium supply, bringing lithium prices down, and therefore storage prices.[22] On top of this decline in lithium prices, tax credits from the Inflation Reduction Act (IRA) passed in 2022, such as the investment tax credit and battery storage installation credit, make BESS even more affordable and allow cooperatives to take advantage of these tax credits with direct pay. [23] Additionally, domestically manufactured batteries can be part of a BESS or a solar plus storage system which may qualify for the 10% domestic content bonus tax credit from the IRA.[19] Electric cooperatives are also eligible for this domestic tax credit.

With a progressively competitive BESS market, more storage projects are projected to be planned and become operational in the future. Figure 9 shows that the estimated installed battery capacity in the United States will jump from around 18 GW in 2023 to 30 GW of capacity this year alone.[11]

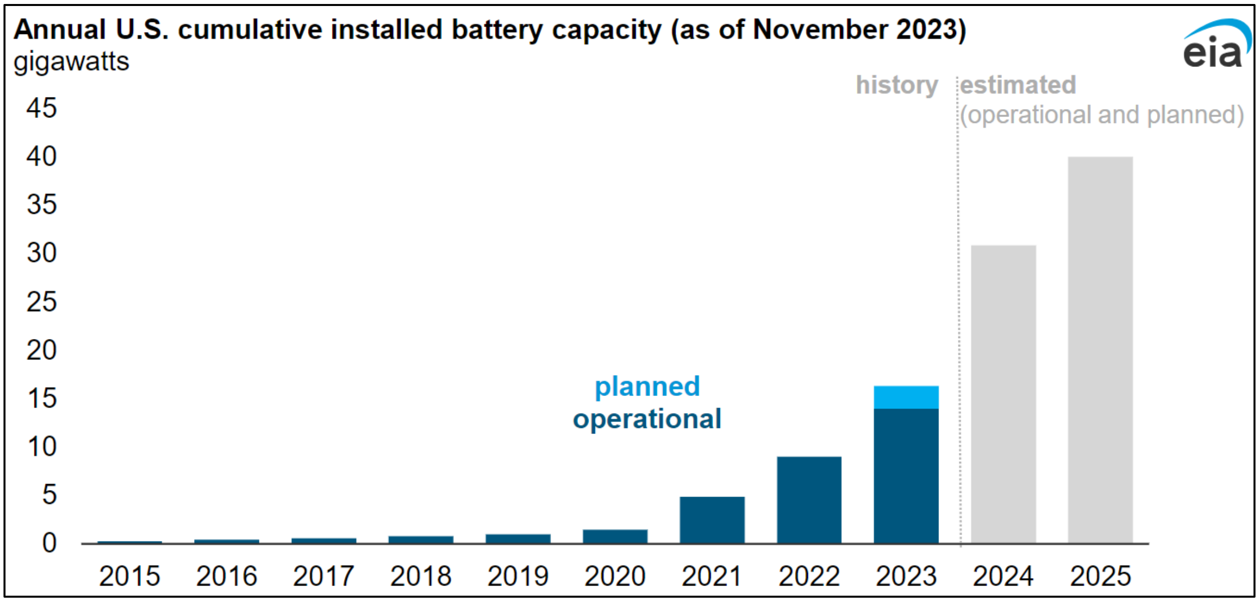

Figure 9. Annual Installed Battery Capacity in the United States [11]

The optimistic trends on BESS pricing and capacity positions the energy system to benefit from the multitude of positive impacts that come with BESS integration. The role that BESS can play in optimizing the grid, bolstering reliability, and enabling a clean grid can lower energy rates at the consumer level in the long run. Using a system that pairs BESS with solar and wind can increase cheap renewable energy generation. Furthermore, these hybrid systems can help reduce energy waste while maximizing the benefits from renewable energy through storing surplus energy in the batteries and releasing it when it is needed. The convenient storing and dispatching of energy from BESS can help with balancing energy supply and demand, which can improve grid efficiency and lower system costs overall. [24]

The availability of immediate dispatchable energy can reduce or eliminate the need to outsource expensive energy when supply is low, thereby increasing energy security. Moreover, there can be increased energy system reliability since power outages can be prevented or become less frequent. [24]

Battery Energy Storage Systems (BESS) in Rural Electric Cooperatives

Across the country, a growing number of electric cooperatives are deploying or considering deploying battery energy storage systems to meet a variety of system needs from peak shaving and resilience to transmission and distribution deferment. This report uses publicly available data to track the battery storage projects owned or contracted by electric cooperatives and provides an overview of the BESS projects in the electric cooperative landscape.

Project Status and Location

NRECA has identified a total of 112 BESS projects owned or contracted through a PPA by electric cooperatives and other NRECA rural utility members, and most of these projects are operational. The projects identified also include 17 that have been announced and are expected to come online in the near future (e.g., undergoing engineering and design, and construction). Projects that have been announced but the information obtained about the BESS project has no indication of its stage of development were categorized under “Unverified.” Table 4 summarizes the status of the BESS projects identified.

Table 4. Project Status of Storage Projects Identified

Status	No. of Projects
Operational	73
Expected	17
Unverified	22

The 112 BESS projects identified are in various states throughout the United States, as illustrated in Figure 10. With 42 operating or planned BESS projects owned or under contract, North Carolina leads in terms of total projects, followed by Alaska and Arizona with 11 projects and 10 projects, respectively.

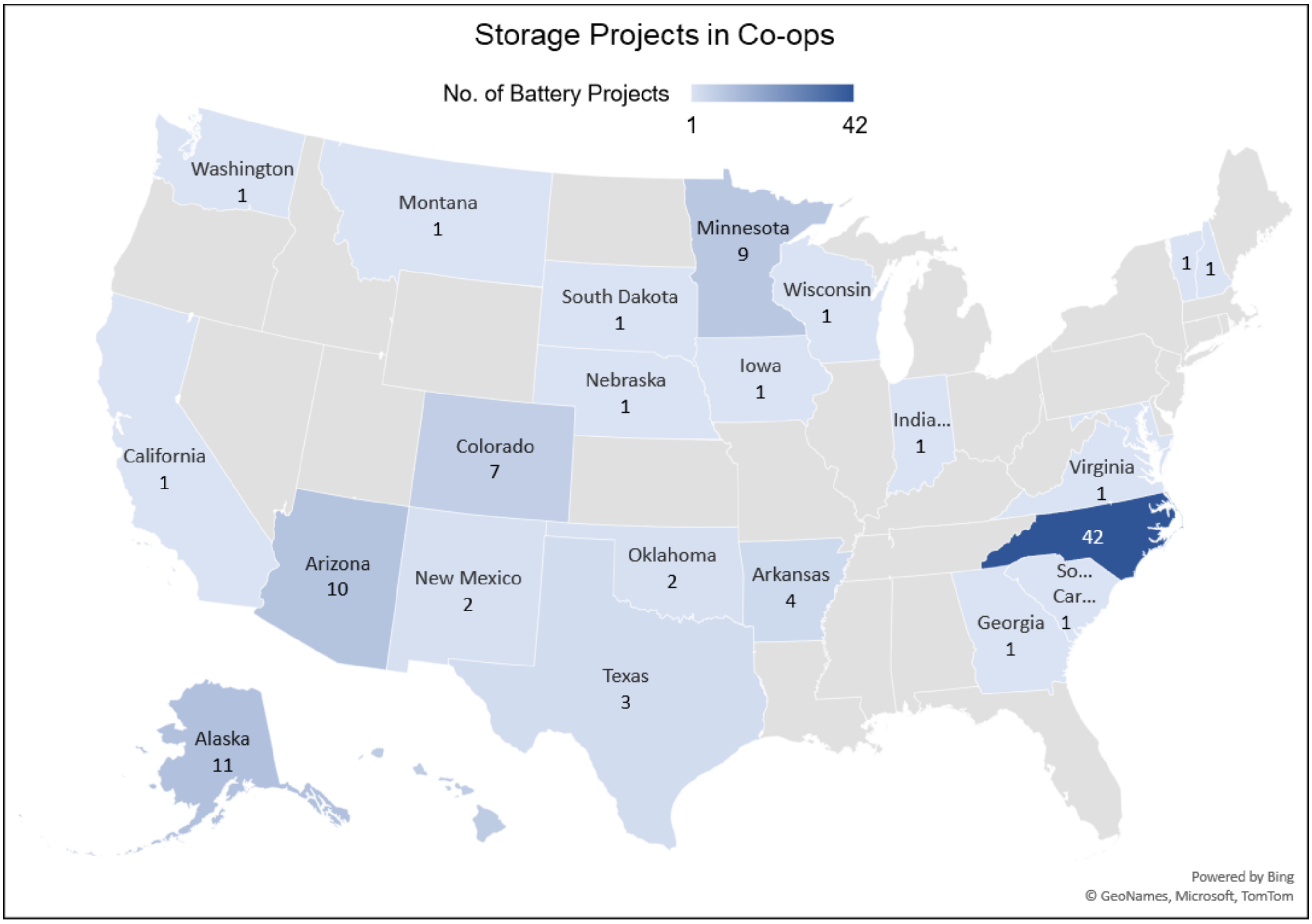

Figure 10. Storage Projects Identified per State

Among the 112 BESS projects identified, 73 are already online. These projects are found in 20 different states, with North Carolina having the greatest number of operational projects. The majority of the operational BESS projects in North Carolina came online after 2020, and several are also part of a microgrid. Information found of the operational projects in Minnesota show that four of these eight BESS projects have a use case of energy arbitrage. Figure 11 shows a map of states that have operational BESS projects. Approximately 74% of these projects have a rated power of 1 MW or above.

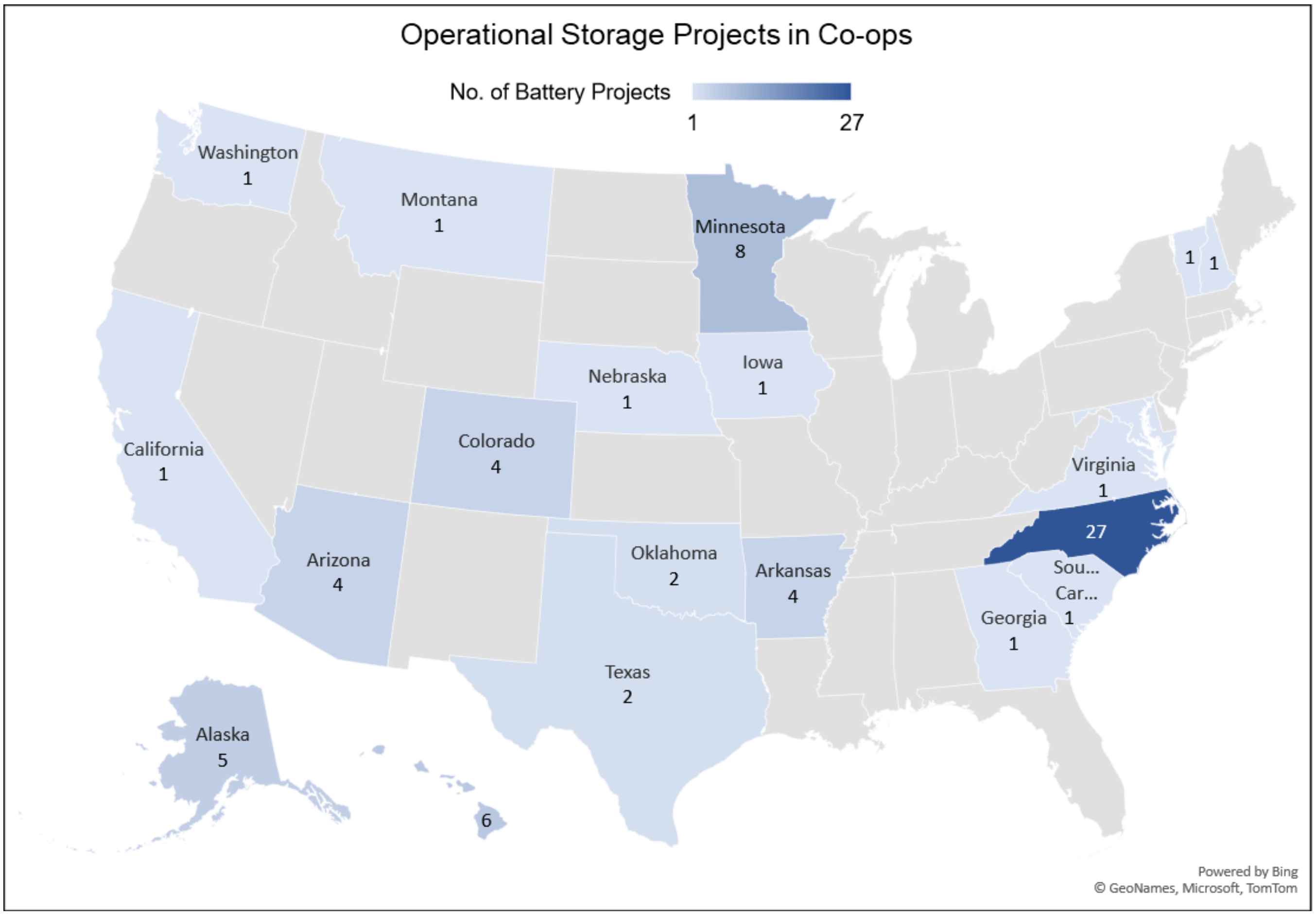

Figure 11. Operational Storage projects identified.

The 17 projects that are expected to come online are in Alaska, Arizona, Colorado, Hawai'i, Minnesota, New Mexico, and South Dakota, as shown in Figure 12. It was found that around 82% of these upcoming projects have a rated power of at least 1 MW — a relatively greater share than those projects that have already come online.

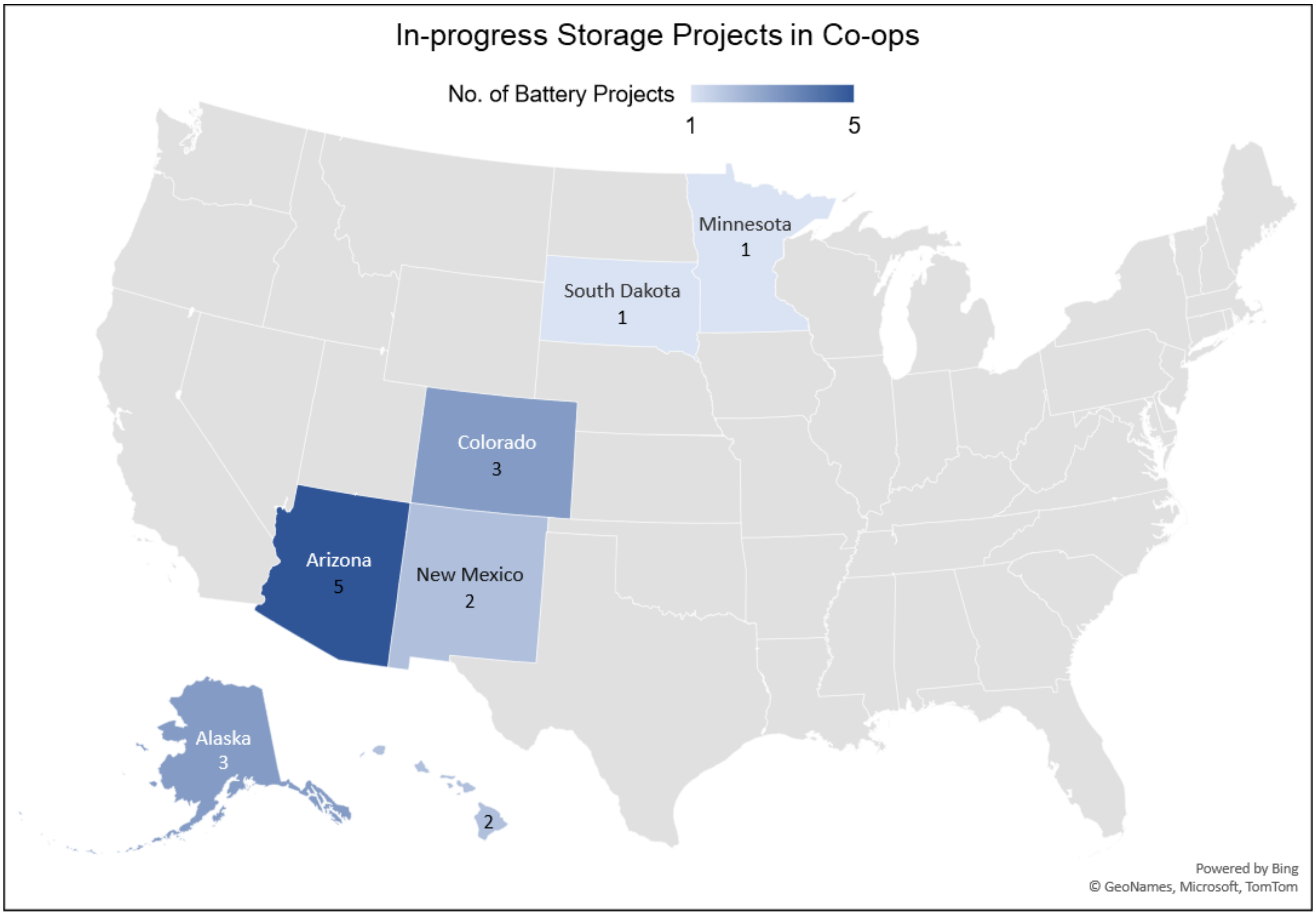

Figure 12. In-Progress BESS Projects Identified

Several BESS projects have come online over the past two decades, and the number of batteries that were commissioned per year peaked in 2021 and 2022, as shown in Figure 13. A continuous upward trend was seen from 2018 to 2021. The drop in the number of projects being commissioned since 2022 may be attributed to supply chain issues, largely due to the COVID-19 pandemic, which led to delays in commissioning some projects.

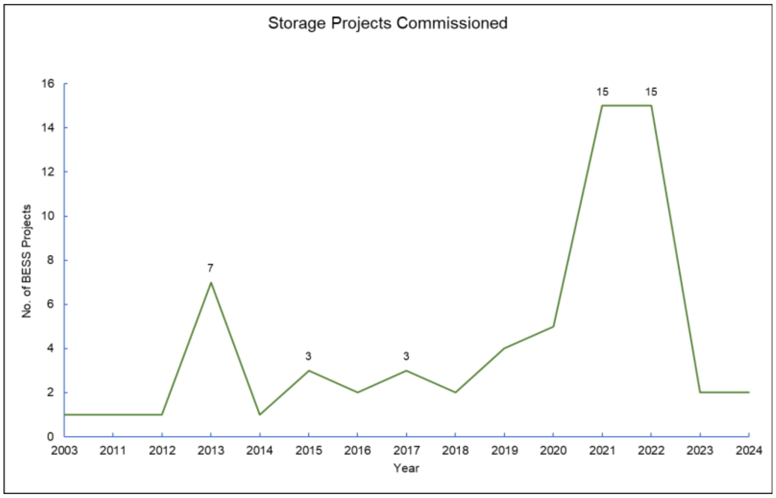

Figure 13. Storage Projects Commission Timeline

All of the BESS projects identified are either owned or contracted by distribution co-ops/utilities and G&T co-ops. The G&T electric cooperatives account for 30% of the projects identified (see Figure 14). These projects have a median storage capacity of approximately 7.7 MWh. This is greater than the median rated storage capacity of the BESS projects owned or contracted by distribution cooperatives, which is about 4.6 MWh.

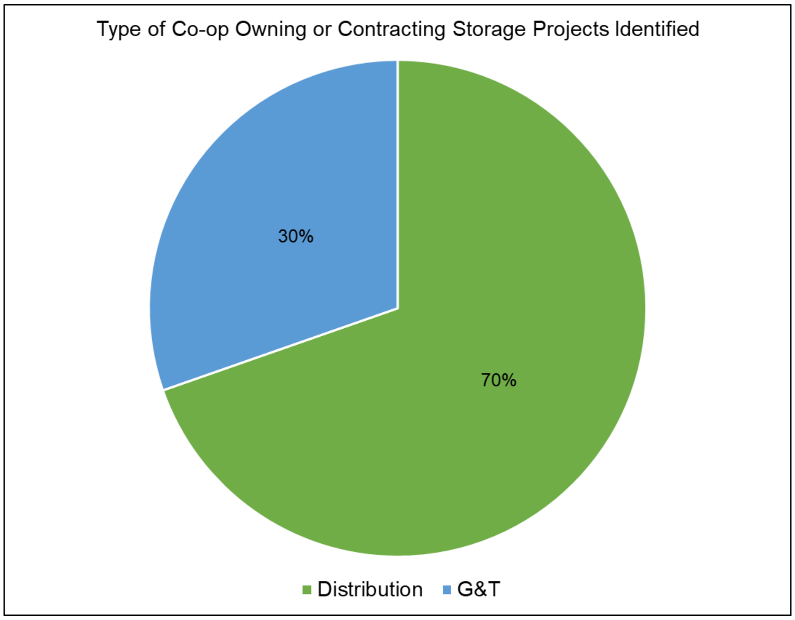

Figure 14. Type of Electric Cooperative Owning or Contracting Storage Projects Identified

Ownership Model

The battery energy storage system projects identified include a mix of utility-owned and third-party-owned, where the co-op is the offtaker through a power purchase agreement. The third-party owners include AES Distributed Energy, Bluestem Energy Solutions, NextEra Energy Resources, and Convergent Energy + Power and Today's Power, Inc., which is a subsidiary of Arkansas Electric Cooperatives, Inc.[25]

Power Capacity and Energy Capacity

Table 5 summarizes the power capacity of the BESS identified, while Table 6 shows the average storage capacities. The minimum rated power for a BESS project is 3 kW, while the maximum is 200 MW. These projects have a median power capacity of 2.5 MW with a total rated power of about 889.8 MW.

As for the energy capacity of the BESS projects identified, the smallest is 10 kWh. On the other hand, the largest energy capacity for a project is 800 MWh — showing a wide range of energy capacity of BESS owned or contracted by rural electric utilities. The median energy storage is 6.9 MWh, which means that 50% of BESS projects have capacities that fall below and at the same time are greater than 6.9 MWh. Overall, the BESS projects owned or operated by rural electric utilities can generally store up to 2.6 GWh of energy.

Table 5. Power Capacity of the Batteries in the Storage Projects Identified

Power Capacity	
Minimum	3 kW
Maximum	200 MW
Median	2.5 MW
Total	889.8 MW

Table 6. Storage Capacity of the Batteries in the Storage Projects Identified

Rated Storage Capacity	
Minimum	10 kWh
Maximum	800 MWh
Median	6.9 MWh
Total	2.6 GWh

Use Case

Further analysis of the data on BESS projects owned or contracted by electric cooperatives shows the applications or intended use of BESS. Figure 15 illustrates that peak shaving is the most common application of BESS in electric cooperatives portfolio. This indicates that many electric cooperatives intended to use energy storage to reduce electricity demand during peak demand periods while recharging during low demand periods. Another prominent use case is reliability/resilience, or providing backup power during outages, including integration with distributed generation sources in the electric cooperative service territory.

Although individual use cases are plotted in the Figure 15 graph, some BESS projects may have a combination of at least two use cases.

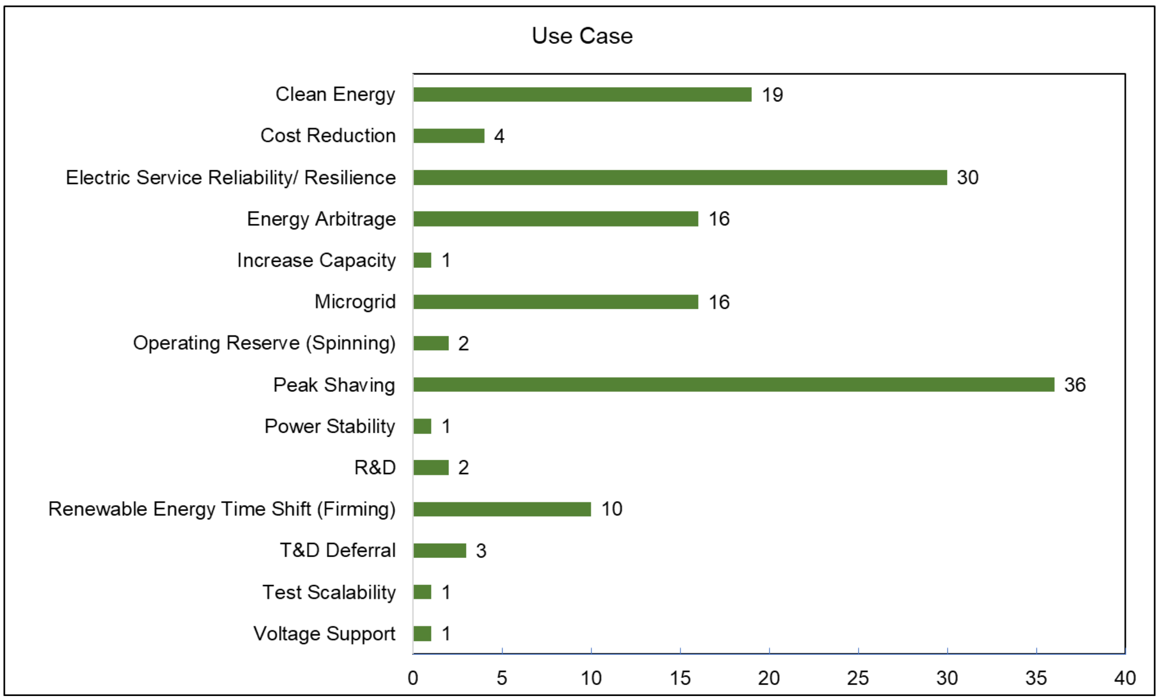

Figure 15. Intended Applications of the BESS Projects Identified

Hybrid Power Plants

Some of the BESS projects identified are not standalone storage, but are paired with other energy-generating resources as part of a hybrid power plant. Solar PV tops the list with 53 BESS projects having PV + storage, generating a total of around 511.1 MW of power. Other paired technologies identified are wind generation, hydroelectric generation, fossil fuel generation, methane/biogas generation, and controllable water heating or HVAC, as shown in Table 7.

The types of paired resources are tabulated individually however, some of the BESS projects identified are a combination of storage and multiple paired resources (e.g., PV + Wind + Storage). Several BESS projects are also part of a microgrid system, a type of hybrid that can operate independently to provide resilience during a wider grid outage.

Table 7. Resources Paired with the Batteries in the Storage Projects Identified

Paired Resources	No. of Projects	Total (MW)
Solar PV	53	511.1
Wind Generation	6	264.5
Hydroelectric Generation	2	66.3
Fossil Fuel Generation	9	17.2
Methane/Biogas Generation	1	0.2
Controllable Water Heating/HVAC	1	N/A
Grand Total (MW)		**859.2**

Battery Chemistry

Among the numerous battery technologies, the most common type of battery used for the BESS projects identified is lithium-ion. Furthermore, 10 of the projects using lithium-ion batteries were identified to be lithium-iron-phosphate batteries. Lead acid batteries were used in eight BESS projects, as shown in Table 8. Other chemistries identified were NiCad and Zinc and one BESS project utilized an iron-air-type battery.

Table 8. Chemistry of the Batteries Used for the Storage Projects Identified

Technology	No. of Projects
Lithium-ion	44
Lithium-Iron Phosphate	10
Lead acid	8
Flow	1
NiCad	1
Zinc	1
Iron-air	1

Technology Provider

The electric cooperatives owning or contracting the BESS projects identified used 25 different technology providers. The most utilized technology is Tesla, followed by FlexGen. The other technology providers are shown in Figure 16.

Please note: NRECA is vendor and technology neutral and reminds electric cooperatives to do their own due diligence to evaluate vendors and technologies to determine the one(s) that best meet their own unique needs and circumstances.

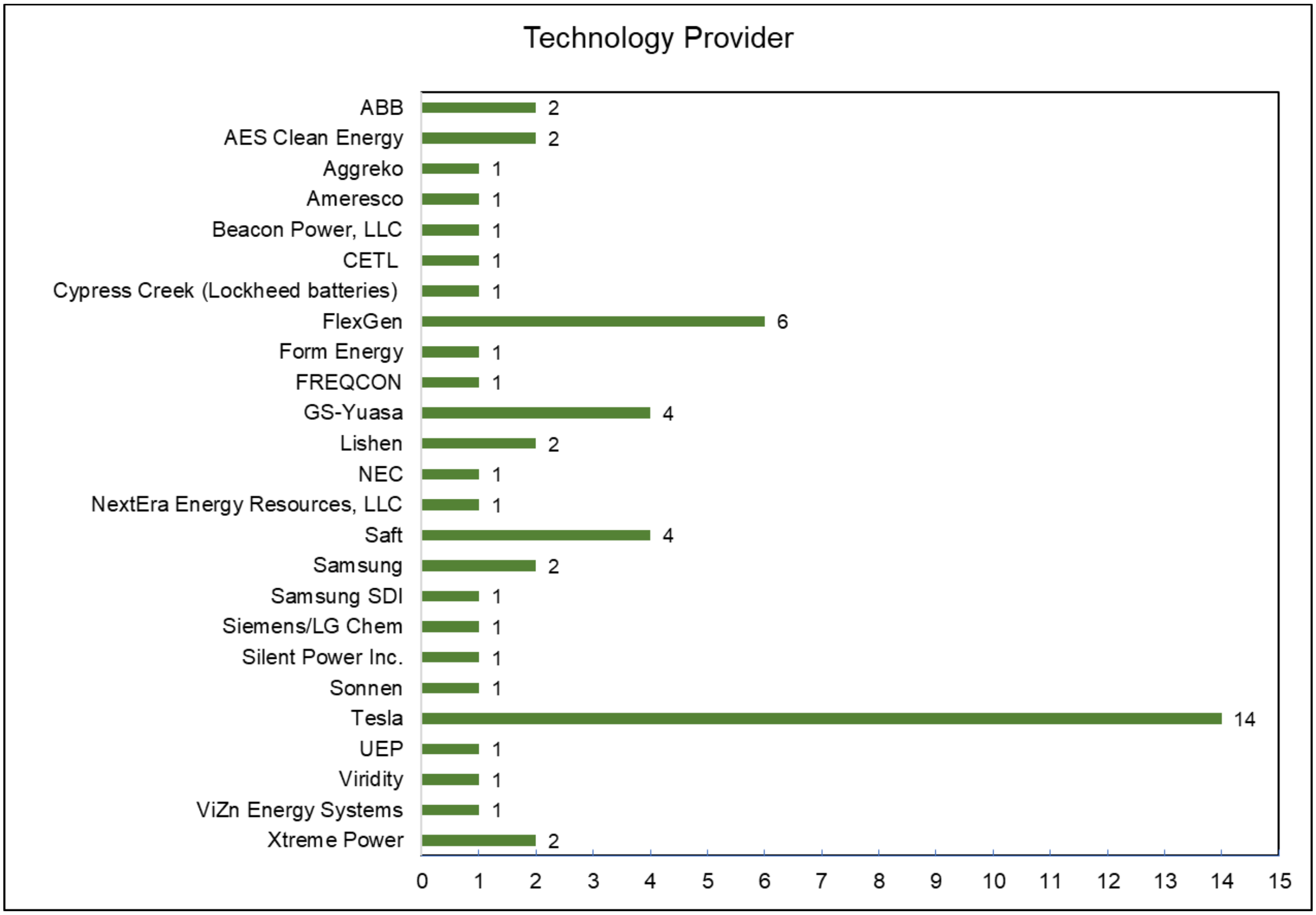

Figure 16. Technology Providers for the BESS Identified

Funding Resources

Government funding from various programs was used to fund 20 of the BESS projects identified. The summary in Table 9 shows that a mix of Federal and State funding resources was used by the electric cooperatives to fund their BESS projects. The funding sources listed may also serve as examples for other electric utilities seeking to pursue funding for their own BESS projects.

Table 9. Funding Sources for the Storage Projects Identified

Funding Sources	No. of Projects
CEF2 Grid Modernization Program	1
Federal/National American Recovery and Reinvestment Act of 2009	1
Federal/National Debt	1
Nebraska Environmental Trust	1
Pacific Northwest National Laboratory	1
Sandia National Laboratory	1
State of California	1
Texas Commission of Environmental Quality	1
U.S. Department of Agriculture (USDA)	9
U.S. Department of Energy	6

Case Study: Navajo Tribal Utility Authority

The Navajo Tribal Utility Authority (NTUA) is a tribal utility owned and operated by the Navajo Nation, providing electricity and other utility services.[26] A BESS demonstration project in Dilkon, AZ was commissioned in May 2022 and was the product of NTUA's collaboration with the U.S. Department of Energy's Office of Electricity, Sandia National Laboratories, and Clean Energy States Alliance (see Figure 17). It consists of a 3 kW/13 kWh BESS paired with a 1.8 kW PV System and uses rechargeable zinc manganese dioxide batteries (developed by Urban Electric Power). This type of battery chemistry does not pose a risk for thermal runaway and requires little maintenance, thereby saving NTUA operation and maintenance costs.

The large number of off-grid homes in the Navajo Nation emphasized the need for electricity access. Further justification for this BESS project cites the recent estimates showing that 15,000 Navajo Nation residents had no power in the Navajo Nation. Aside from helping power homes with this type of off-grid system in place, it will also help predict, compare, and validate the performance of the battery, and determine the important aspect of how much the BESS can reduce operations and maintenance costs for NTUA.[27]

Figure 17. NTUA BESS Project in Dilkon, AZ [27]

Case Study: Northeastern Rural Electric Membership Corporation

Northeastern Rural Electric Membership Corporation (NREMC) is a distribution cooperative based in Columbia City, Indiana.[28] NREMC is not a member of any G&T and procures its own power supply. Rising peak power and transmission costs prompted the development of five BESS projects at NREMC's substations, totaling 31 MW/108 MWh of capacity (see Figure 18).

The systems are primarily intended for energy arbitrage and peak reduction and have successfully reduced the co-op's summer critical peak by nearly 20%. This reduces wholesale power costs and eases upward pressure on member rates. NREMC's BESS projects are ultimately expected to save NREMC's consumers at least $35 million over the next couple of decades, and the power cost savings are projected to be enough to offset the cost of the systems by 2027. The BESS are also capable of providing around three hours of emergency power. The five BESS owned and operated by Northeastern REMC utilize lithium-iron phosphate batteries procured by FlexGen.[29], [30]

Figure 18. Northeastern REMC BESS Project in Indiana [29]

Case Study: Burt County Public Power District

Burt County Public Power District (PPD) is a publicly-owned electric distribution utility headquartered in Decatur, NE. The PPD serves 4,226 customers and owns 2,059 miles of line in Burt County and portions of four other adjoining counties.[31] Burt County PPD partnered with Nebraska-based developer Bluestem Energy Solutions through a long-term PPA to develop a utility-scale solar + storage hybrid project that combined a BESS with two solar arrays in Burt and Dodge counties (see Figure 19). The project reached commercial operation in June 2021. Part of the funding to complete the project was sourced from the Nebraska Environmental Trust.

The solar arrays were designed to provide a total of 1.4 MW (AC) of power. The solar sites were seeded with native grasses and flowers to create a habitat that is suitable for pollinators. The 6 MW BESS is composed of Tesla Megapack lithium-ion batteries. The hybrid system was the first of its kind in Nebraska and will be used for peak shaving and maintaining reliability as more renewable energy resources are being deployed. The Nebraska nameplate capacity tax will be applied in Burt and Dodge Counties where the project components are located. [32]

Figure 19. Burt PPD's Solar + Storage Project in Tekamah, Nebraska [32]

Conclusion

The past few years have seen a rapid proliferation of battery energy storage systems in the United States. Whether at the front or behind the meter, BESS serves multiple applications, such as peak shaving, energy arbitrage, and transmission and distribution deferral. It has also been a critical supporting structure to ensure reliability as the energy grid transitions towards using more intermittent energy sources, like solar and wind. Moreover, BESS can serve as support for the growing electric vehicle industry.

Despite a wide range of applications, there is currently no single type of battery technology or chemistry that is suitable to be utilized for all the BESS use cases. In choosing a battery technology for a BESS project, multiple factors — aside from cost and use case — must be weighed to receive the optimal benefits of the BESS. The discharge time, system power rating, energy density, efficiency, usage life, and operation temperature are some of the factors that are taken into consideration to determine the most suitable technology for a BESS project. Another important factor that must be built into the planning and operations of a BESS is safety. A systems approach to BESS operations is needed to help ensure safety and to deal with the aftermath of hazardous events.

On the economic aspect of BESS, historical data has shown a growing competitive market for BESS as lithium prices decrease and there is economic stimulation from the Inflation Reduction Act and the projects, will come online as battery technologies are being refined and BESS economics and popularity improve.

A growing number of electric cooperatives nationwide are installing or planning to install BESS to address a range of system requirements. Using publicly available information, it was found that 112 BESS projects are owned or contracted by rural electric utilities across 24 states. The majority (73) are operational and 17 are expected to be commissioned in the coming years.

Distribution cooperatives owned or contracted the bulk of the BESS projects identified (70%), but BESS projects from the G&T cooperatives generally had larger energy capacities. The BESS projects identified have a wide range of rated power and storage capacities, but the majority are intended for peak shaving and reliability/resilience. The most popular technology among the electric cooperatives is the lithium-ion battery, and for the hybrid BESS, solar PV was the most frequently paired resource. Technology providers varied, but Tesla was involved with the greatest number of BESS projects owned or contracted by electric cooperatives. For several BESS projects, at least a part of the funding was outsourced. Sources include grants and loans from federal and state agencies, as well as national laboratories.

Overall, the favorable economics of BESS, especially for electric cooperatives, the growing demand for intermittent energy resources, and the improving body of knowledge on batteries make BESS an attractive technology for electric cooperatives to continue providing reliable and affordable energy.

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