Battery Energy Storage Update: Utility Residential and Long Duration Use Case Studies

Overview

Stationary battery energy storage is a flexible resource that can be used for a variety of purposes. Electric cooperatives are continuing to implement battery systems for the following applications: infrastructure deferral, frequency regulation, resilience, demand management, renewables integration, and microgrids. The following advisory provides a selected group of projects that illustrate the various grid applications of BESS. These are being provided as part of NRECA's update to the 2020 Report: Battery Energy Storage Overview.

Introduction

Arguably the most notable change in the use of battery energy storage systems by electric cooperatives in the past two years has been the emergence of mainstream residential battery storage programs. Three of the four case studies presented in this advisory illustrate this development.

Though the ends are similar, the programs underway at Bandera Electric Cooperative, Holy Cross Energy, and Vermont Electric Cooperative feature distinctively different approaches:

- Bandera Electric does not utilize any controls, relies on voluntary response to signals, and participants grant the co-op access to monitor energy use (and production) within the home via a software developed by the cooperative. Bandera Electric will sell and install the batteries as a co-op energy service.
- Holy Cross finances the member batteries and directly controls the dispatch with limited opt-out, in return for a high financial incentive.
- Vermont Electric controls the batteries, but with a lighter member commitment to participate in control periods and is not involved in financing.

What the three programs have in common is that they are not pilot programs but fully deployed service offerings that return tangible value to the co-op in peak cost reductions and greater resiliency.

The fourth case study is of Trico Electric Cooperative's investment in a 15 MW utility-scale battery storage system, connected to its second 10 MW solar power facility, both located within the Trico service area. Trico is underway with plans to add 25 MW of battery storage in the next year or two.

Case Study #1
Bandera Electric Cooperative (Texas)

Bandera Electric Cooperative (BEC) is a distribution electric cooperative headquartered in Bandera, TX. BEC serves more than 28,000 member-consumers and 39,000 meters, with a peak winter load of 230 MW and a summer peak of 180 MW. Its service area covers a fast-growing (3.1% growth in 2021) swath of the Texas Hill Country north and west of San Antonio. BEC is one of four cooperatives that is a member of the Lower Colorado River Authority (LCRA). BEC receives 65 percent of its power supply from LCRA (a mix of hydro, natural gas and coal fired generation); the remaining 35 percent is a mix of solar, wind and combined cycle natural gas procured through power purchase agreements.

Application: Residential Battery Storage

Through a subsidiary, BEC Solar, Bandera EC is a licensed reseller of Tesla Powerwall residential systems in addition to solar PV. As of August 2022, Bill Hetherington, BEC's CEO, says that the cooperative has installed approximately 70 percent of the 650 residential battery systems owned by members.

BEC does not control the functions of the residential batteries but offers an economic incentive to members who will change the timing of battery charging and discharging in order to help the cooperative flatten peak demand during critical periods.

Approximately 70 percent of the participating members responded to the signal to discharge during Winter Storm Uri, saving BEC $43,000.

Narrative: Hetherington says that the significance of the impact of uncontrolled end-use appliances such as battery storage was vividly demonstrated during Winter Storm Uri in February 2021. The big freeze shut down generation resources within the Electricity Reliability Council of Texas (ERCOT), sent power prices skyrocketing, caused extensive blackouts and stranded hundreds of thousands of consumers across the state without power or water for days.

As a transmission-owning utility within ERCOT, BEC was forced into rolling blackouts and experienced more than 1500 outages in a three-day period. Thanks to a load-sensing, energy analytic software developed in-house in 2016, in the aftermath of Uri a forensic analysis conducted by the cooperative revealed how untimely energy consumption – and a lack of performance of distributed resources including solar PV and batteries – aggravated the situation. Pool pumps kicking on automatically when the freeze hit, well pumps working overtime as consumer kept faucets open to save water pipes, and batteries going into charge mode when the bad weather hit led to the average power draw per home within BEC increased by almost 500 percent during the freeze, compared to the consumption in the previous week. Demand from HVAC equipment increased by 620 percent.

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The cooperative's Apolloware software also revealed that local rooftop solar, which could have helped when ERCOT's power market cratered, produced significantly less power than the February average, and that a large percentage of residential battery systems were charging in order to replenish the batteries in homeowners' electric vehicles.
Even so, thanks to the insights revealed by Apolloware, BEC was able to detect that batteries were charging during the peaks. Approximately 70 percent of the members with batteries responded positively to BEC's signal to cease charging in those high cost, low supply periods during the freeze.

This analysis led BEC to step up its member education and its incentive program for voluntary load control. One year later, in a similar (though less intensive) cold snap in February 2022, the cooperative experienced only 10 outages in a three-day period, with changes in residential battery charge and discharge periods making a significant difference.

Key attributes of and lessons learned from BEC's voluntary control program for residential battery storage

- As a part of the interconnection agreement with the cooperative, all BEC members with distributed energy resources (primarily solar PV and battery storage), must install – and pay a fee for – BEC's Apolloware software. The software monitors in real-time the performance of the DERs and tracks the energy use within the home down to individual appliances.
- Apolloware is now installed with every new electric service, and existing non-DERs members can chose to purchase the software, track their home consumption and receive alerts about and the opportunity to change energy use when peak demand periods are expected. When members control use of appliances, including battery charging, they share in the savings experienced by the cooperative.
- Energy savings for members with Apolloware is an average reduction in monthly power bills of 24 percent.
- The cost of transmission services in ERCOT is socialized and determined by the load ratio of four coincident peaks during summer months (there is no demand charge in ERCOT). While only about 4.5 percent of Bandera EC member homes and businesses currently have Apolloware installed to improve energy efficiency and to optimize solar and storage operations, the energy savings achieved through peak reductions, energy efficiency gains and the response of members to alerts, the cooperative saved $265,000 in 2021.
- BEC's Hetherington is a firm believer in voluntary as opposed to cooperatively managed load control. "Our motto is, the utility should never control devices. I came out of the old school load control of air conditioning in Florida. Nobody likes that," he says. "I think the utility should be more involved in a higher level of engagement with the member on energy efficiency, but let the member dictate how they are going to benefit, not the utility."
- In a filing with the Public Utilities Commission of Texas, Hetherington made the case that an intelligent demand response program on a statewide basis that included automated but voluntary control of devices within the home when wholesale prices are high, could minimize the impact of future weather events like Winter Storm Uri.

Case Study #2
Holy Cross Energy (Colorado)

Holy Cross Energy (HCE) is an electric cooperative headquartered in Glenwood Springs, CO. HCE serves 44,500 member-consumers and 59,300 meters, with a peak winter load of 260 MW and a summer peak of 180 MW. Its service area on the western slope of the Rocky Mountains 160 miles west of Denver includes the ski areas of Aspen and Vail as well as farms, ranches and rural communities. HCE manages the procurement of its power supply and has committed to a 100 percent carbon-free energy mix by 2030.

Application: Residential Battery Storage

Behind-the-meter residential battery energy storage is dispatched to offset demand at the coincident hour of peak demand and reduce wholesale power costs. The batteries are also used to provide resiliency and improve integration of renewable energy.

Narrative

Following a pilot project in 2020, Holy Cross Energy launched its “Power+” battery energy storage program for residential and small commercial members in 2021. The program offers members the opportunity to purchase a battery storage system through HCE at a fixed rate allowing for a zero percent cost reimbursement, paid through monthly utility bills over ten years. Participating members can use the batteries to provide back-up power during outages, with the stipulation that the cooperative has the right to remotely control the batteries up to ten times a month in order to dispatch energy onto the grid to lower peak demand and for other grid management purposes. Members are paid a ‘distribution flexibility tariff’ as compensation for these control periods.

Member response to Power+ has surpassed expectations, with more than 200 members completing applications to join the program in the first year. The program is well on its way to building a planned fleet of 5 MW of utility-managed behind-the-meter energy storage.

Battery Technical Specifications

As of July 2022, contractors working under agreement with Holy Cross Energy have installed 183 Tesla Powerwall 5-kW battery systems at 44 HCE member sites, totaling 915 kW of capacity.

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Key attributes of and lessons learned from HCE's Power+ battery storage program

- The investment in the battery storage that is now part of the cooperative's resource base is made by individual members. The members are motivated by the desire to store power produced by their rooftop solar PV for self-consumption during outages, as well as by a willingness to "do their part" in helping the cooperative lower wholesale power costs and strengthen overall system resiliency. The member pays a significantly reduced price for their battery which is considered a cost of resilience, while the power supply cost savings from the peak reduction benefit the entire membership.
- The relative affordability of HCE's on-bill rate of the batteries is in part due to the U.S. Department of Agriculture's Rural Energy Savings Program. HCE successfully applied for an $11 million capital fund to be used for programs like this. The funds are paid back without any interest charges, creating a low-cost capital fund.
- Access to RESP-funded on-bill rate is simplified by waiving traditional consumer credit history qualification in favor of a history of on-time utility bill payment.
- The pace of members signing contracts for Power+ has far exceeded expectations, with more than 150 members waiting for installations of batteries as of July 2022.
- HCE's contracted installers have a ready supply of Tesla Powerwalls. The current backlog is due to non-battery supply chain and contractor labor constraints.
- Control communications between HCE and the Tesla batteries is an automated process. Tesla retains primary communication with the Powerwalls via a Wi-Fi connection in order to manage state-of-charge and deliver software updates. HCE uses a software interface to send a signal to the Tesla controls, which then send the desired dispatch (and charge) signals to the batteries.

Case Study #3
Vermont Electric Cooperative (Vermont)

Vermont Electric Cooperative (VEC) is an unaffiliated distribution electric cooperative headquartered in Johnston, VT. VEC serves more than 33,000 member-consumers and 41,000 meters, with a peak load of about 80 MW. Its service area in northern Vermont spans from Lake Champlain on the west, Quebec, Canada on the north and New Hampshire on the east, covering 2,056 square miles, eight counties and 75 communities. VEC manages the procurement of its power supply, a mix of short-and long-term power purchase agreements alongside purchases through the ISO-New England energy market. VEC has committed to a zero-carbon emission power supply by 2023 and a 100 percent renewable energy mix by 2030.

Application: Residential Battery Storage

VEC operates two battery storage programs as part of its efforts to lower peak demand and add resiliency to its distribution system.

Since 2019, VEC has contracted with Viridity Energy for 1 MW/4 MWh of a utility-scale lithium-ion battery storage system installed adjacent to VEC's Hinesburg substation. The stored power is an important tool in the cooperative's efforts to reduce its monthly and annual peak energy demand, contributing an approximate $82,000 of net savings through August 2022 in lowered transmission charges.

In 2021, VEC launched a behind-the-meter residential battery energy storage program for the same purpose. As of August 2022, VEC has 42 member-owned battery systems available to help meet the 13 forecasted peaks.

Narrative

The residential battery program is similar to one operated by Holy Cross Energy in Colorado with one significant difference – VEC does not finance or own the batteries. Members are invited to "bring-your-own-battery" to the cooperative's flexible load program, which also includes electric vehicle charging. Members have installed batteries as back-up power sources and the majority are connected to solar PV systems.

Members are paid an incentive to allow the cooperative to utilize the stored power in their batteries to help the cooperative meet the forecasted monthly and annual peaks. Priority for the use of the batteries lies with the members, who can opt out of a requested control period on the day of the event. VEC avoids drawing down batteries ahead of a weather event that holds the potential for power outages and always leaves 20% energy in the battery.

VEC hopes to grow the residential battery program to more than 200 systems, at which point the return on peak shaving will surpass the costs of the control software and integration fees.

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Key attributes of and lessons learned from VEC's residential battery storage program

- The VEC residential storage program is currently open to VEC members with one of three battery types: Tesla Powerwall, Sonnen or Generac PWRcell. As of August 2020, all but two of the 42 battery systems are Powerwalls.
- VEC offers two options for incentives: for a 5-kW battery system, either an upfront payment of $268 per kW (a total of $1,340) along with a $16 per month bill credit, or a $32 per month bill credit.
- The member agreement limits the control period to a maximum of 40 hours per month, with each control event on average two to four hours. Members have at least four-hours of advance notice.
- VEC staff uses weather data and three day ahead load forecasts and seven day ahead capacity forecasts from ISO New England to predict peak periods. Over the past four years, VEC has successfully predicted from 70 to 100 percent of the ISO New England and Vermont Electric Power Company (VELCO) peaks. VELCO is a regulated utility that operates the state's bulk transmission system. When successful, the cooperative reduces the $3.80 capacity commitment charges from ISO New England and the regional network services (transmission) fees from VELCO.
- VEC has a contract with Tesla to access its PowerHub software in order to dispatch member-owned Powerwall batteries. It uses Virtual Peaker software to communicate with Generac and Sonnen batteries.
- "If Powerwall enters the StormWatch mode [priority charging ahead of a weather event] and doesn't dispatch when we are in a control period, we're okay with that," says Dan Potter, power planning analyst at VEC. "We recognize that the primary use case for the battery is providing back-up power for the member."
- While the current value streams from its "bring-your-own-battery" program are reducing transmission network and ISO New England charges, VEC believes that additional opportunities to monetize the batteries will evolve in the future.

Lessons Learned

- **Winter conditions have a significant impact.** VEC was aware that the amount of energy delivered via members' solar panels to the batteries would be somewhat limited in winter because of snow cover and less sun. However, the extent to which those conditions limit the recharge of the batteries was not anticipated.
- **Up-front work with members can be time-consuming.** VEC often spends a fair amount of time with members gathering and compiling information in order to enroll a battery. (Once enrolled, administration of the program requires minimal VEC time commitment.)

Case Study #4
Trico Electric Cooperative (Arizona)

Trico Electric Cooperative is a distribution electric cooperative headquartered in Marana, AZ. Trico serves more than 46,000 member-consumers and 53,500 meters, with a peak winter load of less than 100 MW contrasted to a summer peak that reached 246 MW in 2021. Its service area covers a fast-growing area in three counties almost encircling the city of Tucson, from the western parts of the Santa Catalina Mountains in the north to the border with Mexico in the south. Trico is a Class A member of Arizona Electric Generating Cooperative (AEPCO).

Application: Utility Battery Storage

The final commissioning of Trico's Chirreon utility-scale solar plus battery storage project took place in September 2022, following 18 months of construction. The project, sited within the cooperative service area north of Tucson and close to a growing retirement community, will deliver power to members while deferring investments in new transmission and distribution infrastructure, and will play a significant role in managing peak demand for electricity.

Chirreon includes 10 MW of solar photovoltaic power and 15 MW/30 MWh of battery storage. The battery storage systems are Tesla Megapack lithium-ion units.
Trico receives the solar power and battery services through a power purchase agreement with Chirreon Energy, LLC ("Chirreon Energy"), which is a wholly owned subsidiary of Trico. CoBank Farm Credit Leasing provided financing and owns the project. CoBank Farm Credit Leasing leases the project to Chirreon Energy, which then sells the capacity and energy to Trico. The project was developed with the assistance of Torch Clean Energy and SOLV Energy was the engineering, procurement, and construction (EPC) company.

The project is the cooperative's first acquisition of battery storage. Trico envisions multiple value streams from the storage, including:

- The ability to quickly ramp up output to firm the capacity of the project's solar output,
- Delivering power to meet the end-of-day peak that occurs when solar production drops and high demand extends into the evening; and,
- The potential to provide arbitrage services to the wholesale market.

Narrative

Trico has a long-term commitment to reducing carbon emissions and has set a goal of reducing its emissions by 50% by 2032. "The motivations for service at every electric cooperative is a function of the interests of that co-op's membership," says Brian Heithoff, CEO of Trico. "Our cooperative members have a high interest in environmental stewardship, and we established our carbon reduction goals as a reflection of that interest."

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Trico's energy strategy focuses on reducing non-renewable power resources in a manner that balances reliability, sustainability and cost. From 2010 to 2022, Trico has reduced its reliance on coal from 70 percent to 20 percent, while increasing non-hydro renewables from less than one percent to 29 percent in the same time frame. In 2018, Trico brought it first utility-scale project on-line, the 10 MW Avion solar farm, sited in Marana and developed with a similar financial structure as Chirreon. In addition, Trico receives 5 MW from the AEPCO Apache solar farm [a 20 MW G&T solar facility sited outside the Trico service area in Cochise County].

Trico's renewable energy supply includes more than 4,000 member-owned residential PV systems; as of 2022, Trico was connecting 90-member solar systems per month.

Overall power demand is rising as the cooperative adds 1200 members a year, days of summer-time temperatures topping 100 degrees increases, driving air conditioning use, and as a result of the pandemic, more people working from home.

By siting solar (and battery storage) projects within the cooperative service territory, Trico can maximize the infrastructure, peak shaving, and resiliency benefits of a distributed resource. It also provides a renewable alternative for members who may be motivated to add PV to their rooftops, an alternative that the cooperative believes will deliver solar at a lower up front and overall price while reducing any financial burden or subsidy on non-solar members.

More battery storage is in the near-term pipeline at Trico. It is adding 15 MW of battery storage to its Avion solar farm in 2023 and is working with AEPCO to install 10 MW of grid-tied battery storage at an AEPCO substation that serves Trico.

Key attributes of and lessons learned from Trico's battery storage and renewable energy programs

- Trico's contract for Chirreon was set up to allow the cooperative to hire the EPC and oversee the project from the initial stages through commissioning. Following commissioning, CoBank Farm Credit Leasing assumed ownership and executed a lease with Chirreon Energy, LLC, which gives Chirreon the ability to sell the capacity and energy produced to Trico, with an option to purchase the project in the future.
- Tucson's more than 350 days of sunshine a year is ideal for solar production. However, excess heat can negatively affect solar output. Within a certain range, lithium-ion battery storage capacity can improve with higher heat. But there is a point where unchecked excess heat (and high use) can degrade battery life and raise safety concerns. As a result, Tesla installs thermal management systems with its Megapacks to provide cooling to keep the batteries within the correct operating temperatures. To provide an extra level of dependability, Trico COO Eric Hawkins explains that the cooperative chose to pay for a performance guarantee.
- Hawkins says that "these are complicated projects" but he believes that from the solar side, Trico benefited from its experience with the Avion solar farm. New factors presented fresh challenges, including the impacts of the pandemic on labor and supply chains, and the need to change solar panel providers due to tariff and delivery issues.

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- The learning curve was steeper with regards to the battery component. “Adding batteries to the mix adds a new challenge,” says Hawkins. One lesson learned was the difficulty in testing and commissioning the solar and battery systems at the same time. “In the future, we’ll work to avoid overlap in the commissioning of the solar field and the battery system.”
- Hawkins notes a significant advancement in PV output between Trico’s Avion and Chirreon projects. Both are nominally 10 MW systems, but Hawkins notes that the 28,000 panels at Chirreon produce slightly more power than the 40,000 panels installed four years earlier at Avion.
- In addition to more battery storage, Trico looks forward to supporting future solar acquisitions with high efficiency, fast response gas units being installed in partnership with AEPCO, pending regulatory approval and installation.
- Trico expects that provisions for direct access to tax credits for solar and storage under the Biden Administration’s Inflation Reduction Act will change the way it finances and contracts for future projects, including eliminating the need to find a third-party partner with a tax appetite to leverage and reducing the complexity and administrative costs of similar projects.
- While its current focus is on utility-scale battery storage, Trico is planning for the possibility of developing residential battery storage as part of a future Energy-As-A-Service program.

Additional Information

- Battery Energy Storage Overview Report (March 2020)

Contact for Questions

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