CIGRE-303 **2020 CIGRE Canada Conference**
Toronto, Ontario, October 19-22, 2020

# UTILIZING COMMUNITY STORAGE FOR VIRTUAL POWER PLANTS

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## SUMMARY

Over the past decade there has been an explosion in the number of renewables and other energy resources integrated onto the distribution grid. These solar panels, batteries, and other devices are generally referred to as distributed energy resources (DER). Certain regions, such as California, have been especially impacted by this evolution in the grid. While there are many benefits to the increasing number of DERs, there are also challenges that come with this change. California's "duck curve," for example, is extremely stressful on the grid and has caused several issues.

While California is a special case due to the large adoption of solar, many other areas will start to see similar issues from DER adoption in the coming years. One solution to prevent or minimize these issues is to utilize virtual power plants (VPPs). VPPs can improve the distribution grid's reliability, reduce distribution asset upgrades, and increase grid stability.

While there are numerous resources and programs that might constitute a VPP, in this paper we focus on the use of community storage for VPPs. The benefits of community storage VPPs are starting to be realized across the globe. Utility and commercial deployments from Canada, the United States, Australia, and Europe will be discussed. Benefits from each example will be explored – from grid reliability in the Australian energy market to asset deferral at Toronto Hydro. We'll discuss various approaches to pair solar and other generation resources with community storage in order to take advantage of multiple benefit streams.

In addition to the benefits, this paper will cover some of the challenges of deploying and maintaining community storage solutions. We'll discuss telecommunications, installation, troubleshooting, and preventative maintenance. We'll also consider the operational challenges with community storage VPPs. Finally, we'll address the costs associated with a fleet of community storage and how this compares to other alternatives. Rather than just focusing on the initial deployed cost, we'll consider the total lifecycle cost of this VPP.

Upon completion of the technical discussion, we'll cover the regulatory environment for community storage as part of a VPP. We will cover how community storage in a VPP can help to manage supply and demand, defer the addition of traditional generation sources, modify peak demand management, and be used for energy arbitrage.

As the electric grid changes from the traditional central generation station model with one-way power flows to a grid with a variety of DERs and two-way power flow, VPPs will play an important role in addressing technical and regulatory issues. Utilizing community storage for VPPs will be challenging, but it will ultimately provide flexibility to use the VPP for much more than balancing supply and demand.



## KEYWORDS

Virtual power plant
Community storage
Distributed energy resources
Generation deferral
Battery
Distribution grid

## Introduction

Over the past decade, distributed energy resources (DER) have become a viable strategy to move the power industry toward a lower carbon future. Comprised primarily of renewables — mostly solar and wind — DER have become an important new source of generation, contributing many gigawatts of power to the North American grid.

Wind and solar facilities have each been deployed at utility scale for bulk power needs, while solar photovoltaic (PV) systems have become the "go to" resource for DER, even in geographies outside the so-called Sun Belt. These solar systems are increasingly paired with battery energy storage systems, inverters and other control and communications devices and often are part of multi-faceted programs to modernize distribution grids. Solar PV, coupled with battery storage may function together in islanded configurations, or be connected with the grid.

California has emerged as the North American leader in pioneering new concepts in DER and, as a consequence, has faced a number of challenges in maintaining grid reliability and resilience. California's widely reported "duck curve" — a term coined by CAISO in 2012 to describe the timing imbalance between peak solar power production and peak demand during later periods when solar production is declining — has stressed the grid in a number of ways.

Nevertheless, California's aggressive goals to achieve 100% of its power supply from zero-carbon sources by 2045 (zero carbon includes nuclear power) has made it a leader in pioneering many new approaches to the future of power delivery and generation. California is leading the way in incorporating solar PV and is utilizing different configurations of battery storage — along with other forms of storage — to flatten the "duck curve" and maintain system reliability and resilience. These efforts are making California — along with a few other states who are aggressively incorporating solar power — a proving ground for a number of innovative new concepts that have promise of transforming the power industry.

One of those innovative new concepts is the virtual power plant (VPP). VPPs can improve the distribution grid's reliability, defer the need for distribution asset upgrades and improve grid stability. While there are many resources and programs that might constitute a VPP, this paper will explore the use of community storage for VPPs.

## VPPs and Community Storage Defined

VPPs can consist of a variety of energy production or even demand-response curtailment strategies. Although there are many differences across these options, one similar feature between VPPs is widespread dispersal over a defined geographic area.

One type of VPP is community storage. Community storage has become the industry catch-all term used to describe any energy storage system deployed at the distribution system level. This could be at a number of points on the distribution network. As long as the storage assets are not centralized at a substation or power generation facility, it is considered community storage.

Community storage can be controlled by an aggregator or by the local utility. Both scenarios offer potential to direct and dispatch the energy at the time of day when it is most needed, or to correct conditions that could threaten grid reliability. For utility-controlled storage, the utility directly chooses when to charge and discharge the batteries. For aggregator-controlled storage, the utility may "call upon" the aggregator to charge and discharge as needed by the utility, through incentive programs or through time varying rates intended to impact aggregator behavior.

Typically, community storage is comprised of battery banks of varying capacities connected to solar or other intermittent renewable energy sources. These battery systems act as sponges to soak up the excess energy when it is not needed for the primary loads. In the case of distributed solar facilities, the battery installations would then be available to release energy once the sun begins to set and output from the PV installations begins to decline. The batteries are available to provide additional load support for air conditioning and other needs while the intermittent power source output declines. These energy sponges can be placed in a distributed manner near load centers, instead of at a central location.

In other scenarios, community storage may not incorporate renewable energy sources. In these applications, the batteries could be charged via traditional means during periods of off-peak use, and then discharged during peak use to even out demand. This scenario might even reduce the need for additional generation sources.

Distributed community storage can be installed in a range of capacity increments ranging from less than 100 kilowatt-hours (KWh) up to hundreds of megawatt-hours (MWh), depending on the size of the configuration. Battery installations may be either pole mounted or, for underground distribution systems, mounted on pads at ground level or within interior spaces such as utility rooms.

**Benefits of Community Storage**

The benefits of community storage VPPs are starting to be recognized across the globe. Utility and commercial deployments are occurring in Canada, the U.S., Australia, Europe and many parts of Asia. Use cases range from grid reliability in Australia to deferral of asset maintenance or replacement in Canada.

In the U.S., several utilities are piloting projects in multi-tenant residential locations to prove out the benefits of community storage configurations as a means to reduce peak demand, offset rising energy costs for consumers and support distribution system loads as needed. As more and more projects are introduced and piloted, more benefit streams are developed.

A few examples can serve as illustrations of various use cases.

**Rocky Mountain Power**

In Herriman, Utah, located near Salt Lake City, a large multi-tenant residential complex has become a testing ground for a community storage configuration controlled by local utility Rocky Mountain Power. The facility incorporates more than 600 Sonnen ecoLinx batteries that serve as backup capacity for the local distribution grid. The batteries are installed in the residential living spaces and can be dispatched as needed.

The 22 buildings in the complex can provide an aggregate of up to 12.6 MWh of energy from the batteries, which be recharged by 5.2 MW of solar panels installed in rooftop configurations.

While Rocky Mountain Power can dispatch 100% of available battery power, the assets are actually located behind the meter and owned by Wasatch, a third-party aggregator that developed the project. The power from the apartment complex is available on call and can be allocated by the utility to the distribution grid to help alleviate a number of issues.

When not needed by the utility, power from the solar cells and battery storage units is available to residents, offsetting some of their monthly utility bills. The development is one of several similar grid modernization projects that have been approved by Utah utility regulators.

Project financials are being examined closely by others throughout the power industry to learn if the model can work in other areas of the country, particularly in western regions where relatively low-cost power is available from the grid. The Utah project received a combination of local, state and federal tax incentives that offset approximately 50% of project costs.

**Liberty Utilities**

In New Hampshire, Liberty Utilities has introduced a program allowing 300 Tesla Powerwall batteries to be placed in homes in and around Lebanon, NH. This VPP pilot could later be expanded to cover approximately 1,000 homes under a modified program that will allow other battery vendors (in addition to Tesla) to provide batteries and related equipment under the program.

Like the program in Utah, the Liberty Utilities VPP is configured as a community storage asset in which the utility can call on the battery-provided power as needed for grid support during peak demand periods.

Under the program, Liberty Utilities' customers have the option of paying $1,000 upfront for the Powerwall system, or paying for it on a 10-year monthly installment plan of $10 per month. Liberty Utilities, a subsidiary of Ontario-based Algonquin Power Utilities Corp., has announced it will spend a total of approximately $7 million to install the battery systems at customer locations. This will result in estimated monthly savings of $700,000 on average in reduced generation, transmission and distribution costs. Liberty estimates its customers participating in the program will save a total of $1.8 million over a 10-year cycle of electricity bills.

**New South Wales, Australia**

A large-scale program underwritten by Tesla is moving toward providing Powerwall batteries to hundreds of homes in regions of South Australia. One $23 million program in the city of Adelaide would enable Tesla Powerwall 2 home batteries to be installed in up to 1,200 homes and provide approximately 8 MW of backup battery-based power. The program would go beyond simply providing community storage and would include demand response programs as well.

A much larger 50,000-home VPP program in South Australia that also incorporates Tesla batteries and equipment was recently credited with helping maintain grid stability when a coal-fired generating plant tripped off in Queensland, reducing system supply by 748 MW. The outage caused system frequency to drop below normal levels but the battery system was dispatched nearly instantly to return the system back to stable levels.

The 50,000-home VPP project has experienced some delays but is now expected to move forward, equipping houses with 5-kW rooftop solar systems, matched with 13.5-kWh Tesla batteries. When complete, this VPP is expected to have the capacity to deliver up to 250 MW of solar power, plus 650 MWh of energy storage available for grid resilience, reduced peak demand costs for utilities and rate reduction for consumers and more efficient utilization of excess solar energy.

The program follows on the heels of the much-publicized Hornsdale Power Reserve project in South Australia, which was completed by Tesla in under 100 days in the wake of devastating recent wildfires that had taken out much of the region's conventional power supply.

**Toronto, Ontario**

In Ontario, Toronto Hydro is taking a slightly different approach by installing hundreds of small pole-mounted battery storage systems to help reduce peak demand from fossil-based generation and provide additional support for local distribution grids. These relatively small units are paired with 50-kW transformers in pole-mounted configurations at strategic points within the distribution network.

This VPP is intended to extend the life of transformers on distribution feeder circuits by storing energy during off-peak hours that is then released to homes and businesses during peak demand periods. The goal is to curtail some output from conventional fossil fuel generating plants and meet peak load demand through the batteries distributed throughout the system. The dispersed energy from batteries serves to reduce stress on transformers to average loads, thus extending the life of these assets and creating the possibility of deferred maintenance.

Toronto Hydro reports that the program is already showing results with extended life of transformers and other critical distribution assets. The VPP is also proving to be an effective backup source of power in the event of outages or voltage sags. During these events, homes connected to transformers with pole-mounted battery units receive instantaneous power correction to the point where many don't even know there was an event.

**Challenges of Community Storage**

If there are so many benefits to community storage, why haven't these systems been deployed everywhere? As with every new technology, there are downsides.

The first major hurdle for community storage systems is the required telecommunications infrastructure. Without communications, battery systems would only be able to act in response to local conditions. The whole "community" aspect wouldn't be feasible; rather, a single battery could act based on voltage, current, time of day, or other conditions that are measured at that particular device. Communications systems allow distributed storage devices to charge and discharge in concert. The latency, or speed of the communications required, depends on the particular use case desired from the community storage. Some applications require very fast communications, and others might be able to utilize a slower network. Regardless, *some* communications infrastructure is required, and if the utility doesn't already have a field area network deployed throughout the distribution grid, this challenge alone could be a deal breaker. Deploying communications to the "last mile" is a large project in and of itself.

The next major challenge with community storage is the deployment of these systems. When a utility considers a traditional storage solution, only a single location needs to be identified and vetted for feasibility. With community storage, *many* locations need to be identified. While these batteries are typically located on existing utility infrastructure, the infrastructure may not be suitable as-is. If collocating on utility poles, the poles at the desired locations (based on geography and grid location) might require repair or might have too many attachments already collocated. Batteries for use with an underground distribution system may require revisions to pad mount transformers, which could result in digging, and thus, lots of customer engagement. Although each battery installation is a small project, planning and executing lots of these small projects is challenging.

If a utility addresses the communications network and the installation challenges of community storage, the next hurdle is the operations and maintenance of the system. Just as all utility assets need to be maintained throughout their lifecycle, so will these batteries. When issues arise, someone will need to troubleshoot and fix problems. Unfortunately, there isn't one work group in most utility organizations today that can address all potential issues with these systems. Field technicians, distribution automation engineers, and IT personnel may all be needed to troubleshoot a non-responsive battery, for example. If a utility decides to embark on a community storage deployment, serious consideration should be given to the operational ownership of the batteries. This will help to reduce the troubleshooting ping pong that commonly leads to delayed resolutions.

Lastly, the cost of community storage is one of the significant challenges. When simply considering the cost of the actual batteries, this approach is very affordable. However, a complete lifecycle cost must be considered when comparing community storage to other initiatives on the distribution grid. Distributed site selection, communications infrastructure creation/upgrades, labor for operations and maintenance, and expected lifespan of the batteries should all be factored into the cost. All of these costs mean that this solution can prove to be more costly over its life cycle than some centralized alternatives.

**Future Potential Benefits of Community Storage**

Community storage VPPs offer a number of benefits that are yet to be realized, including:

- Energy trading on the bulk wholesale power markets, serving a need for energy arbitrage in which the capacity becomes available as wholesale prices rise in response to periods of high load demand.
- A future consumer-based "energy exchange" in which buyers and sellers of energy are matched up via intermediaries such as Blockchain.
- Ancillary services for system operators ranging from power quality applications like synchronous phasing to asset deferral, similar to the program being developed by Toronto Hydro.
- Energy sources for fast-charging EV stations located at strategic points along Interstates or at truck stops.
- Potential community storage VPPs comprised of hundreds or even thousands of EVs equipped with vehicle-to-grid (V2G) charging equipment.

To realize all of these benefits, regulatory frameworks will need to be revised in the coming years. While many progressive regulations have recently been approved, a consistent nationwide approach would help jumpstart the potential for community storage VPPs.

**Conclusion and Recommendations**

As the grid transitions from a traditional central generation station model with one-way power flows to a grid featuring dynamic, two-way power flows, VPPs will play an increasingly important role. Though benefits are many, one of the most important is instantaneous correction of voltage sags, outages and other power issues, all made possible by robust telecommunications and a variety of DER deployed throughout the network.

Unlocking this potential requires a combination of progressive, forward-thinking regulatory models, a robust distribution communications infrastructure, a modified utility organizational structure to better facilitate distribution automation and DERs, and an infusion of private capital as developers see the potential to earn reasonable returns.

Community storage VPPs can be one solution to resolve a number of technical and engineering challenges that are emerging as the grid transforms. They will ultimately become a resource that does far more than simply balance supply with demand, providing the flexibility and resilience that will be needed for a robust modern grid.