AMERICAN PUBLIC POWER ASSOCIATION
Powering Strong Communities

Behind-the-Meter Energy Storage

WHAT UTILITIES SHOULD KNOW

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INTRODUCTION

Energy storage is making headlines and garnering attention from the public, electric utilities, lawmakers, and regulators. Reasons behind this interest include a variety of potential benefits to customers and the grid, and a dramatic decrease in costs for certain energy storage technologies. Energy storage also has the flexibility to be deployed at different points on the grid: from onsite at a residential, commercial, or industrial customer's location (behind-the-meter or BTM), to in front of the meter co-located with other utility assets. Broader industry trends such as grid modernization, enhanced resiliency, growth of renewable energy and distributed energy resources (DER), and reevaluation of traditional rate design all typically include energy storage considerations.

This report outlines the values and challenges of BTM energy storage systems, from both the customer and utility point of view. The report focuses on lithium-ion battery storage because that is the predominant BTM energy storage technology.[1] This report also includes highlights of recent federal and state activities, and utility case studies.

Before diving into the market landscape, it is crucial to understand the technical specifications for energy storage assets. Energy storage systems can be described by their power output and energy capacity.[2] The power output is typically represented in kilowatts (kW) or megawatts (MW) and refers to the maximum instantaneous amount of energy that can be supplied.[3] The energy capacity, also called nameplate capacity, is often represented in kilowatt-hours (kWh) or megawatt-hours (MWh) and signifies the amount of energy that can be stored or discharged over a specific period before the battery must be recharged. Batteries also degrade over time, meaning that both the power and energy capacity will decrease as the battery is charged and discharged in use. Energy storage can be classified as short duration (less than 0.5 hour of nameplate capacity), medium duration (0.5-2 hours), or long duration (more than 2 hours).

Lazard's *Levelized Cost of Storage Analysis – Version 4.0*, from November 2018, provides a reference point for comparing energy storage costs. A summary of key findings for BTM energy storage is provided below.

Energy storage is a unique asset with both generator and load characteristics. This can make comparing the technology with other existing technologies challenging. From an economic

Table 1: Lithium-Ion BTM Energy Storage Levelized Cost Comparisons[4]

Use Case	Unsubsidized Levelized Cost of Storage ($/MWh)
Commercial and Industrial (Storage Only)	829-1,152
Commercial and Industrial (Solar Plus Storage)	315-366
Residential (Solar Plus Storage)	476-735

Table 2: Lithium-Ion BTM Energy Storage Capital Cost Comparisons[5]

Use Case	Capital Cost ($/kW)
Commercial and Industrial (Storage Only)	1,263-1,849
Commercial and Industrial (Solar Plus Storage)	3,248-4,995
Residential (Solar Plus Storage)	4,206-5,446

1 Based on Communication with the Energy Storage Association, a vast majority of BTM deployments are in California, and 2018 state data reveals that 99% of deployments are electrochemical. For this report, this data in combination with industry data on energy storage is extrapolated to indicate that a majority of BTM energy storage is in the form of lithium-ion batteries.

2 U.S. Energy Information Administration. "U.S. Battery Storage Market Trends." May 2018. https://www.eia.gov/analysis/studies/electricity/batterystorage/pdf/battery_storage.pdf.

3 1,000 kW is equal to 1 MW.

4 Lazard. "Lazard's Levelized Cost of Storage Analysis - Version 4.0." 2018. https://www.lazard.com/media/450774/lazards-levelized-cost-of-storage-version-40-vfinal.pdf.

5 Ibid.

TYPES OF BTM ENERGY STORAGE

Lithium-Ion Batteries

Lithium-ion batteries have dominated energy storage deployments over the past five years. This electrochemical technology is characterized by fast response times, high cycling efficiency, and high energy density. Expanded production capacity driven by increased demand for these batteries – both for energy storage and for use in electric vehicles – has helped drive costs down.[6] However, the increasing cost of raw materials and a need for manufacturing facilities expansion has slowed the rate of battery price decreases.

Grid-Interactive Electric Water Heaters

While batteries represent an electrochemical energy storage option for customers, electric water heaters are a thermal energy storage option. Unlike batteries, which represent an entirely new investment for customers, utility customers may already have electric water heaters in their home that can become grid interactive with a retrofit. As of 2016, there were about 45 million electric water heaters in the U.S.[7] Over 100 rural cooperative utilities have some degree of load control on customer electric water heaters and some of these utilities have decades worth of experience.[8] For example, Great River Energy, a generation and transmission company for cooperatives, has been controlling BTM electric water heaters since the 1980s.[9] Fort Collins Utilities, a public power utility, runs a Peak Partners Thermostat and Water Heater program, which also leverages electric water heaters for demand response.[10] This technology can be cost effective, with some research indicating that it can pay for itself within 5 years.[11]

Electric Vehicles

Instead of internal combustion engines, electric vehicles use batteries. As electric vehicles spend most of their time parked, the batteries inside them may be available to perform other electric service functions. Several utilities are conducting vehicle-to-grid pilots, where the battery in a customer's car is used like traditional BTM battery storage. Uses include light duty vehicles to larger vehicles like electric buses. To learn more about electric vehicles and vehicle-to-grid technology, read *A Public Power Guide to Understanding the U.S. Plug-in Electric Vehicle Market* and *Creating an Electric Vehicle Blueprint for Your Community: Public Power Strategies*, which are both available in the Association product store at www.PublicPower.org.

6 Simon, Brett, Daniel Finn-Foley, and Mitalee Gupta. U.S. Energy Storage Monitor: Q3 2018 Executive Summary. GTM Research & Energy Storage Association.
7 Lazar, Jim. "Teaching the "Duck" to Fly, Second Edition." The Regulatory Assistance Project. February 2016. http://www.raponline.org/wp-content/uploads/2016/05/rap-lazar-teachingtheduck2-2016-feb-2.pdf.
8 Ibid.
9 Podorson, David. 2016. "Grid Interactive Water Heaters - How Water Heaters Have Evolved Into a Grid Scale Energy Storage Medium ." American Council for an Energy-Efficient Economy. https://aceee.org/files/proceedings/2016/data/papers/6_336.pdf.
10 City of Fort Collins. "Peak Partners." https://www.fcgov.com/utilities/residential/conserve/energy-efficiency/peak-partners.
11 Hledik, Ryan, Judy Chang, and Roger Lueken. "The Hidden Battery: Opportunities in Electric Water Heating." January 2016. http://www.electric.coop/wp-content/uploads/2016/07/The-Hidden-Battery-01-25-2016.pdf.

standpoint, monetizing value streams and making a comparison to the capital, operations, and maintenance costs of energy storage is also difficult. Value streams to the customer can depend on retail rate design, and market and policy conditions. For example, for a customer to realize value in avoiding a demand charge, the customer must be served under a rate that includes a demand charge. Likewise, for a customer to derive value in an energy cost arbitrage use case, the effective retail rate must have time periods of higher and lower energy prices and a large enough pricing differential to offset the battery's charge/discharge inefficiencies. Similarly, market rules can dictate asset classes, participation schemes, aggregation, duration thresholds, and size of energy storage assets. Recent actions by the Federal Energy Regulatory Commission (FERC) are moving Independent System Operators (ISOs) and Regional Transmission Operators (RTOs) to remove barriers for energy storage to participate in wholesale markets.

Recent data reflects the growing interest in BTM energy storage. The Smart Electric Power Alliance found a 202 percent increase in residential energy storage deployments from 2016 to 2017.[12] Energy storage deployments are projected to increase in the coming years. By 2023, the U.S. is projected to deploy roughly 1.75 gigawatts of BTM energy storage each year.[13] IHS Markit found that prior to 2018, the US had 200 MW of residential battery energy storage deployed, and that by 2022, the capacity will increase to more than 850 MW deployed.[14] GTM Research predicts that BTM deployments will account for 47 percent of the annual market by 2023.[15] Bloomberg New Energy Finance has a similar projection, and expects that in the mid-2030s, BTM energy storage deployments will surpass front of the meter installments.[16]

States leading the BTM energy storage market are states notably active with other DERs as well. According to the September 2018 *Energy Storage Monitor*, California is the leading market for BTM energy storage both for residential and non-residential customers.[17] For residential storage, Hawaii comes in second, while New Jersey places second for non-residential storage.

For more on energy storage, the American Public Power Association report, *Understanding Energy Storage: Technology, Costs, and Potential Value*, is a useful primer that includes an overview of storage technologies, services and use cases, economics, and highlights of policy, legal, and regulatory developments pertaining to energy storage.

DEFINITIONS

Microgrids: According to the US Department of Energy, "Microgrids are localized grids that can disconnect from the traditional grid to operate autonomously."[18] Public power has a long history with microgrids, as many public power systems began as microgrids.

Back-up generation: Generation that is used when the primary source of generation is disrupted.

Self-generation: When a customer receives at least some energy from their own generation sources, such as solar PV or wind turbines.

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12 Maloney, Peter. "In first, US residential energy storage overtakes front-of-meter installations." Utility Dive. September 6, 2018. https://www.utilitydive.com/news/in-first-us-residential-energy-storage-overtakes-front-of-meter-installati/531682/?utm_source=Sailthru&utm_medium=email&utm_campaign=Issue:%202018-09-06%20Utility%20Dive%20Newsletter%20%5Bissue:16984%5D&utm_term=Utility%20.

13 Simon. Energy Storage Monitor: Q3 2018.

14 Barati, Camron. "United States to quadruple installed base of residential battery energy storage from 2018 to 2022." May 10, 2018. https://technology.ihs.com/602743/united-states-to-quadruple-installed-base-of-residential-battery-energy-storage-from-2018-to-2022.

15 Simon, Brett, Daniel Finn-Foley, Mitalee Gupta, Ravi Manghani, Austin Perea, and Colin Smith. 2018. U.S. Energy Storage Monitor: Q2 2018 Executive Summary. GTM Research & Energy Storage Association.

16 Bloomberg New Energy Finance. "Energy Storage is a $620 Billion Investment Opportunity to 2040." November 6, 2018. https://about.bnef.com/blog/energy-storage-620-billion-investment-opportunity-2040/.

17 Simon. Energy Storage Monitor: Q3 2018.

18 U.S. Department of Energy. "The Role of Microgrids in Helping to Advance the Nation's Energy System." https://www.energy.gov/oe/activities/technology-development/grid-modernization-and-smart-grid/role-microgrids-helping.

CUSTOMER PERSPECTIVE

The customer's economics of investing in energy storage requires evaluating the value the customer will derive from making the investment as it compares to the cost the customer incurs in installing BTM energy storage.

VALUE

There are multiple drivers for why utility customers might be interested in BTM storage. Primarily, utility customers consider the economic value of energy storage in terms of how much they can reduce their electric bill.

Energy storage allows a customer to save money under a time-of-use (TOU) rate, where the storage system can charge during lower cost off-peak times, and discharge during higher priced on-peak periods. Though this rate structure is not common for public power utilities, it is increasing in popularity.[19] For customers to save money under a TOU rate structure, there must be a lengthy off-peak period and a high rate differential between the on and off-peak periods, as batteries are not 100 percent efficient in their charging and discharging cycles. As energy storage technology and the accompanying controls advance, customers may be able to arbitrage energy consumption more easily. In May 2018, Tesla announced that Powerwall 2 owners could use the accompanying software to optimize for TOU rates.[20]

Customers can also reap value from storage systems through reduced demand charges. Demand charges can be designed in a variety of ways, but typically customers pay per kilowatt for their peak demand (usage) and the infrastructure needed to serve that demand. Demand charges can be aligned with the utility's peak, known as the coincident peak, or during the customer's peak demand in a defined period regardless of its alignment with the utility's peak, known as the non-coincident peak. Larger commercial and industrial customers are often subject to demand rates, while smaller commercial and residential customers generally are not.[21] If the customer pays a demand charge, energy storage can help the customer reduce their peak demand, thereby lowering the charge. This happens when the customer discharges the storage unit during a period in which their peak demand would otherwise occur, thus reducing peak consumption from the grid.

Sacramento Municipal Utility District (SMUD), a public power utility in California, says that residential customers with BTM energy storage can achieve bill savings between $200-$350 a year by charging during times with lower prices under its time of day rate.[22] However, SMUD explains that "Even with these savings, the annual savings would most likely not recover the upfront system costs."[23]

BTM energy storage may also allow a customer to maximize their investment in distributed generation, such as solar or wind. The Department of Energy (DOE) found that solar plus storage deployment in commercial settings led to greater reduction in demand than either technology being deployed alone. In calculating how much a customer's demand charge could be reduced with different technologies, DOE found the median reduction for solar only to be 8 percent, 23 percent for storage only, and 42 percent for solar plus storage.[24]

Energy storage can also help customers with installed solar store excess generation during the day to offset onsite energy consumption at night. Customers might find value in this for environmental, philosophical, or financial reasons. From an environmental standpoint, the customer can increase use of renewable self-supplied power. Other customers may desire to reduce their energy dependence on the utility. Finally, some customers might be interested in saving money on their electric bills. As utility solar policy has evolved, many utilities have moved away from compensating solar customers for excess generation at the full retail rate under net energy metering, and instead compensate such energy at a value of solar or avoided cost rate, which is usually lower. Coupling storage with solar allows this customer to store energy that would otherwise be compensated at avoided cost, to be used later to offset energy that would otherwise be billed at the retail energy rate.

Less than 10 percent of rooftop solar photovoltaic (PV) instal-

19 Utilities may not offer TOU rates for a variety of reasons, including the absence of the requisite metering infrastructure, such as "advanced metering infrastructure."
20 Walton, Robert. "Tesla software update allows Powerwall 2 owners to optimize for time-varying rates." Utility Dive. May 15, 2018. https://www.utilitydive.com/news/tesla-software-update-allows-powerwall-2-owners-to-optimize-for-time-varyin/523588/?utm_source=Sailthru&utm_medium=email&utm_campaign=Issue:%202018-05-16%20Utility%20Dive%20Newsletter%20%5Bissue:15344%5D&utm_term=Utility%2.
21 More utilities are implementing or are considering implementing residential demand charges than in the past.
22 SMUD. 2018. "Is battery storage right for you?" https://www.smud.org/en/Going-Green/Battery-storage/Homeowner.
23 Ibid.
24 Gagnon, Pieter, Anand Govindarajan, Lori Bird, Galen Barbose, Naim Darghouth, and Andrew MIlls. "Solar + Storage Synergies for Managing Commercial-Customer Demand Charges." October 2017. https://emp.lbl.gov/sites/default/files/solarstorage_synergies_report.pdf.

lations have storage, but that proportion is expected to grow substantially as future BTM storage sales increasingly become tied to the sale of a solar system. GTM Research expects that 95 percent of residential BTM storage in 2018 will be paired with solar.[24] Multiple companies are also offering this technology pairing for customers, including Sunnova, Vivint Solar, Tesla, and SunRun.

Resiliency is another reason for customer interest in BTM energy storage. Storage can provide backup power to the customer in the case of a grid outage. For residential customers, BTM energy storage may be viewed as a resource to maintain comfort and convenience. For commercial and industrial customers, maintaining continuous electric service can be critical to operations and bottom line performance. Even electric outages of very short duration may interrupt business, resulting in financial losses.

Other customers, likely commercial and industrial, may be a part of a microgrid or have their own microgrid. For example, some hospitals, university campuses, and military installations are microgrids. A microgrid has fewer connected assets than the centralized grid, so a BTM energy storage's generator and load qualities can be leveraged to maintain operations when the microgrid has disconnected from the main grid.

In all situations where resiliency is a motivator for deploying BTM energy storage, it is important to remember that most storage devices cannot supply storage for long periods. Recall that long duration storage is considered more than two hours. Therefore, a typical storage unit might not be able to help a customer maintain power at their residence or business during prolonged outages. Furthermore, the duration of storage relates to the load. Customers might need to reduce usage by turning off heat or air conditioning, compressors, or fans. If the device is paired with distributed generation, then the energy storage asset may cycle between charging and discharging depending on the availability of the intermittent resource. This pairing could allow a customer to maintain a supply of electricity to their residence or facility for a longer time during an electric outage.

Market participation for BTM energy storage is still being established. However, as discussed later, FERC issued an order that seeks to remove barriers for energy storage participation in such markets. Insofar as customers with installed energy

Table 3: Summary of BTM Energy Storage Values for Customers

Value	Use Case	Description
Bill Savings	Demand Charge Reduction	Energy storage can lower a customer's peak demand or shift to off-peak demand periods.
	Time-Of-Use Bill Management	Energy storage can shift loads, charging during times of low demand and discharging .... during times of high demand.
Increased Distributed Generation Self- Consumption	Solar plus Storage	Energy storage can store excess distributed generation to offset future consumption from the utility.
Resiliency	Backup Power	Energy storage can provide backup power in the event of an outage (if utilities allow). This can apply to residential, commercial, or industrial customers, as well as microgrids.

[25] Maloney, Peter. "Residential storage faces sunny prospects this year." Utility Dive. April 10, 2018. https://www.utilitydive.com/news/residential-storage-faces-sunny-prospects-this-year/520966/?utm_source=Sailthru&utm_medium=email&utm_campaign=Issue:%202018-04-10%20Utility%20Dive%20Storage%20%5Bissue:14826%5D&utm_term=Utility%20 Dive:%20Storage.

storage may be able to directly participate in formalized energy markets, such an evolution in policy could unlock another potential value stream for storage assets.

COST

Economic evaluations compare costs versus benefits, or in this case, potential value streams. Cost considerations for BTM energy storage encompass the capital cost, operating costs, and ownership or financing options.

The capital cost for BTM energy storage is the upfront cost for the technology. As discussed in the introduction, energy storage costs continue to decline. A downwards trend in prices will help the technology become an increasingly appealing option for customers. Incentives, like tax credits or utility rebates, may be available to lower the upfront costs for BTM energy storage. A key development in the energy storage market is whether energy storage may qualify for the federal investment tax credit. The Internal Revenue Service clarified that residential energy storage can qualify for the 30 percent federal investment tax credit if the storage asset is charged entirely from solar.[26] The only state with a tax credit solely for BTM energy storage is Maryland, and this serves as another way for customers to lower their costs. As discussed in more detail later in this report, some utilities provide a rebate for energy storage, which is an additional opportunity for customer to save on their purchase.

Operating costs for energy storage are another layer of costs that come into play after the upfront costs. For BTM energy storage, a key operating cost it the cost of electricity, since electricity is used to charge the battery. Further, any ongoing maintenance costs would also fall under the category of operating costs that ultimately impact the customer's economics of installing BTM energy storage.

To allow customers greater flexibility in mitigating the up-front cost of energy storage, different BTM energy storage ownership and/or financing options are becoming available. An emerging opportunity for prospective energy storage customers is to rent or lease energy storage systems from a third-party, rather than purchasing the system outright. For example, Younicos announced an energy storage rental option in 2018 as it expects renting will be a cheaper option in most scenarios.[27] Though not a direct comparison, the solar industry experienced growth when residential systems were leased to customers as opposed to requiring customers to purchase the system outright. Another emerging area is utilities deploying BTM energy storage and providing financing options for customers. Case studies from Green Mountain Power and Liberty Utilities demonstrate real-world examples of this type of scenario.

Table 4: Summary of BTM Energy Storage Cost Considerations for Customers

Cost Considerations	Description
Capital Cost	This cost category takes into account the upfront cost of the technology along with any incentive opportunities.
Operating Costs	Energy storage operating costs tie to the cost of electricity and any maintenance costs.
Financing	Customers may choose to own or rent energy storage. In limited cases, utilities are allowing customers to pay a one time or monthly fee to benefit from utility owned energy storage BTM.

[26] Bade, Gavin. "IRS: Residential storage eligible for ITC when charged by onsite solar." Utility Dive. March 5, 2018. https://www.utilitydive.com/news/irs-residential-storage-eligible-for-itc-when-charged-by-onsite-solar/518377/.

[27] Maloney, Peter. "New business models may be the next frontier in lower energy storage costs." Utility Dive. March 20, 2018. https://www.utilitydive.com/news/new-business-models-may-be-the-next-frontier-in-lower-energy-storage-costs/519480/.

UTILITY PERSPECTIVE

The rise of DERs is graying the dividing line between the utility and the customer, which has traditionally been drawn at the customer's meter. BTM energy storage deployment has the potential to impact how much energy customers use and when they use it, and how much power can be supplied to the grid, all of which impact a utility's load and revenue.

Energy storage, like other DERs, can also open up new channels to engage with customers. Customers and utilities alike can reap value from BTM energy storage, and services associated with energy storage that are not provided by the utility might be filled by other third-party providers seeking this value.

VALUE

A customer's energy storage system can provide value to the local utility in several ways, including:

- Deferral or avoidance of infrastructure investments through reduced peak demand, system congestion, or system stress
- Reduced payments to wholesale power suppliers (where applicable) for demand or capacity, and a decrease in energy purchases if paired with distributed generation
- Reduced need for curtailment of intermittent renewable energy resources
- Demand response
- Increased system and localized load factor
- Increased system efficiency
- Increased service offering opportunity, such as being a storage aggregator or owner

BTM energy storage has the potential to reduce a utility's peak demand, which can help a utility defer or avoid investments in generation, transmission and/or distribution infrastructure, hence energy storage being referred to as a "non-wires alternative." Substantial load reduction could also help a utility defer or avoid resource adequacy investments. If a utility is a power purchaser (non-vertically integrated) and customers install BTM storage, the utility may be able to design rates to allow customers to reduce the utility's power purchase obligations. BTM storage alone can reduce demand/capacity charges, and BTM paired with DG can reduce energy charges. Such value is dependent on whether the utility has the technical and ratemaking capabilities to quickly either aggregate and dispatch BTM storage or for customers to adequately respond to pricing signals that reduce the utility's costs. Additionally, BTM energy storage can improve the utility's load factor[28] and increase the efficiency of the system, which can save money on power supply by either increasing power plant efficiency or lower the average cost of power purchased from a power supplier, or both.

Many utilities offer demand response programs to help manage peak load, and BTM energy storage can be a platform for customers to participate in the programs and for utilities to benefit from reduced load. This provides the utility with an opportunity to engage directly with its customers.

Utilities might have intermittent renewable energy resources as part of their local or regional generation mix. In some areas, depending on the time of day and weather, there is more renewable energy available than can be accommodated, which may result in curtailment of these resources for safety and reliability reasons. Common examples are solar curtailment in California during the day, and wind energy curtailment in Texas during the night. With BTM energy storage, customers can charge their energy storage asset during periods of high renewable generation output and low utility load, reducing the need for curtailment of generation resources. This scenario is more likely with higher energy storage penetration and with incentives for customers to charge during such times.

Another potential value for utilities is to become the aggregator of BTM energy storage systems and operate a virtual power plant.[29] Third-parties or utilities could provide this service. If utilities choose to aggregate BTM energy storage, they can operate the assets like a fleet to support grid reliability by providing services such as variable resource integration, voltage support, and frequency regulation. By operating as the aggregator, utilities also gain greater visibility into the grid edge

[28] Load factor represents a utility's average load divided by their peak load. If BTM energy storage is used to reduce peak demand, it can improve the utility's load factor.

[29] Battaglia, Andrew. "Florida Utilities Need to Begin Leveraging Intelligent Residential Energy Storage." GTM. June 29, 2018. https://www.greentechmedia.com/articles/read/florida-utilities-need-to-leveraging-residential-intelligent-energy-storage#gs.dH1VyEQ.

and can better manage the impacts of storage to the system. Utilities that can aggregate BTM storage assets will have access to key information such as the number of assets available, location, state of charge, and capacity available. As discussed in later sections, as wholesale power markets look to facilitate access for BTM energy storage, utilities that aggregate storage can be a key player in this process.

An emerging area of potential value for utilities is direct ownership and operation of BTM storage. In several cases with investor-owned utilities, customers pay the utility a fee to have energy storage at their home. The customer benefits from added resiliency, and the utility benefits by operating the device as a grid asset. If the utility provides this service, it can provide value to its customers, support the grid, and earn revenue from associated customer fees.

CHALLENGES

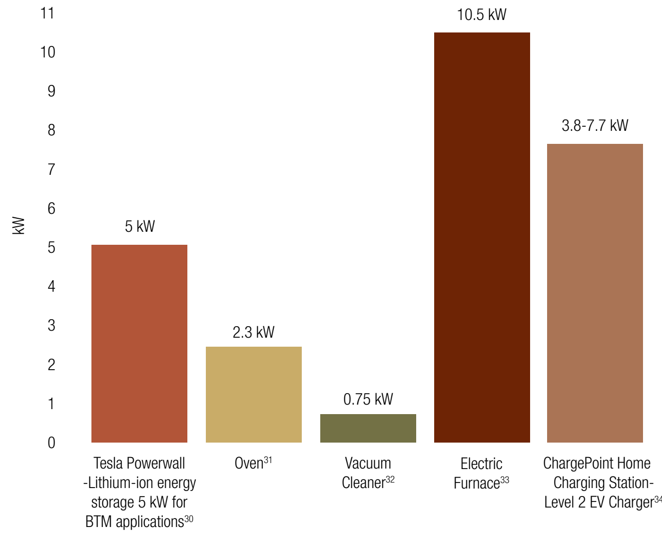
Utilities that have customers with BTM energy storage face challenges including:

- Changes to load
- Reduced sales
- Grid defection

BTM energy storage enables customers to alter their load patterns. For example, if a customer is taking advantage of a TOU rate structure, they may use storage to shift their load to cheaper off-peak periods. Energy storage can also be used to reduce a customer's demand. Depending on how the demand charge is designed, a customer's reduced demand might not reduce the utility's system peak, meaning that deployment of BTM might not reduce future capacity-related utility costs.

Customers with BTM energy storage not connected to distributed generation will slightly increase their electricity usage because of efficiency losses between charging and discharging the battery. As shown in graph, when BTM energy storage units are charging, they can be a significant contributor to demand. If this scales from one to numerous customers charging at the

Figure 1: Energy use of household electric devices compared to energy storage systems



same time in close proximity, utilities will want to ensure that distribution assets such as transformers will not be overloaded. With small levels of BTM energy storage deployment, overall grid impacts would be minimal, but it is important for utilities to monitor load trends for shifts or changes in peak to ensure reliability of the system.

The potential load challenges discussed above also have implications for energy sales. For example, a customer with solar plus storage can largely flatten their load shape. While enhanced customer load factor can benefit the system overall, this reduction in usage also leads to a reduction in electricity sales and by extension, revenue for the utility. Customers taking advantage of TOU rate structures and demand charge optimization will result in fewer earnings for utilities. Customers lowering their overall electric usage will also lower electricity sales. These impacts on utility financials could be significant with large scale deployment of BTM energy storage if there is not also a corresponding decrease in the utility's costs. This corresponding cost reduction depends on the utility's fixed vs. variable cost structure and its efficacy in ratemaking.

Like with other DERs, BTM energy storage can lead to cost allocation issues between and within customer classes if rates do not reflect the true costs to serve customers. Fully allo-

[30] Tesla. "Powerwall." November 1, 2018. https://www.tesla.com/sites/default/files/pdfs/powerwall/Powerwall%202_AC_Datasheet_en_northamerica.pdf.
[31] Silicon Valley Power. "Appliance Energy Use Chart." http://www.siliconvalleypower.com/for-residents/save-energy/appliance-energy-use-chart.
[32] Ibid.
[33] Ibid.
[34] ChargePoint®. "ChargePoint® Home Charging Station." September 2018. https://www.chargepoint.com/files/datasheets/ds-home.pdf.

cated cost of service studies should be performed every 3-5 years to help keep rates reflective of the current operating environment. Further, utilities should be mindful in designing rates that appropriately compensate customers for the value installed DERs bring to the utility's system.

Another possible challenge BTM storage poses to utilities is the potential for grid defection, which refers to a customer disconnecting from the central electric system.[35] Under current circumstances, customers do not typically consider grid defection to be economically or technically feasible. However, if technologies evolve, energy storage costs continue to decrease, and/or if electric rates increase, then the perceived value of defection could increase.

According to the Association report, *The Value of the Grid*, "Complete grid defection, where customers disconnect from all utility service and rely on self-supply, is unlikely and counterproductive to customers seeking low-cost reliability or a decarbonized future. While DERs become more economical, other factors limit the potential of complete grid defection."[36] The report notes that electrification – especially of the vehicle fleet but also home heating and home water systems – makes grid defection less likely. But any degree of grid defection will lead to changes in utility load profiles and electric sales and should therefore be monitored by the utility.

CASE STUDY

Salt River Project, Arizona

In May 2018, Salt River Project launched a 36-month incentive program to support residential lithium-ion battery storage.[37, 38] Under the program, 4,500 residential customers can receive up to $1,800 for a battery storage system on a first-come, first-served basis. SRP cites helping customers reduce their demand, studying battery performance, and examining how batteries impact customer energy usage and the grid as key benefits of the program. Energy storage can also enable solar customers to increase their utilization of self-generated power.[39] In October 2018, Salt River Project and the National Renewable Energy Laboratory announced a partnership for the largest home energy storage study to date.[40] Utility customers participating in the incentive program can be selected for the three-year research study which explores the impacts of battery storage and customer usage.

CASE STUDY

JEA, Florida

JEA initiated a battery storage incentive program for residential customers on April 1, 2018.[41] A one-time 30 percent rebate up to $4,000 per household is available for the purchase and installation of the battery storage system for residential customers with distributed generation for a limited time. JEA hopes that by incentivizing storage, the technology can become more mainstream. Customers can use the storage to improve their resiliency during storms, reduce demand during peak periods, and further utilize solar PV. JEA explains that this program "is a great example of our commitment to our customers and our delivery of innovative solutions."[42]

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[35] Frankel, David and Wagner, Amy. "Battery storage: The next disruptive technology in the power sector." McKinsey & Company. June 2017. http://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/battery-storage-the-next-disruptive-technology-in-the-power-sector

[36] Zummo, Paul. 2018. The Value of the Grid. American Public Power Association. https://www.publicpower.org/system/files/documents/Value%20of%20the%20Grid_1.pdf.

[37] The program is tied to an SRP and SolarCity legal settlement.

[38] Sowers, Scott. "SRP launches residential storage incentive program." Public Power Daily. May 4, 2018. https://www.publicpower.org/periodical/article/srp-launches-residential-storage-incentive-program.

[39] Garcia-Likens, Patty. "SRP Offers Incentive for Residential Battery Storage." May 1, 2018. https://www.srpnet.com/newsroom/releases/050118.aspx.

[40] National Renewable Energy Laboratory. Arizona Utility and NREL Launch One of the Largest-to-Date Home Energy Storage Studies. October 25, 2018. https://www.nrel.gov/news/program/2018/arizona-utility-and-nrel-launch-home-energy-storage-study.html.

[41] JEA. "Battery Incentive Program." https://www.jea.com/ways_to_save/residential_rebates/solar_battery_incentive_program/

[42] Communications, JEA Email. December 2018.

FEDERAL AND STATE ACTIVITIES

Federal and state policymakers are becoming increasingly involved in energy storage markets. Though Congress has held hearings on energy storage, BTM energy storage has not been the focal point of any recent legislation at the federal level. The most notable federal activity related to BTM energy storage in 2018 occurred at FERC. State activities have spanned across legislators, regulators, and state energy offices as they seek to advance the technology and address barriers.

PARTICIPATION IN ELECTRICITY MARKETS

FERC issued Order No. 841, *Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators*, in February 2018. The order is aimed at removing barriers to the participation of energy storage resources (including BTM resources) in the organized wholesale electricity markets (as capacity, energy, and ancillary services).[43] In response to this rule, each independent system operator (ISO) and regional transmission organization (RTO) is required to revise its tariffs and market rules to address the unique operational and physical attributes of energy storage. FERC writes that "This order will enhance competition and promote greater efficiency in the nation's electric wholesale markets and will help support the resilience of the bulk power system."[44] A number of organizations requested FERC to reconsider various aspects of the new rule. FERC has not yet acted on these requests. RTO and ISO compliance filings in response to Order No. 841 were submitted in early December 2018, and implementation is required by December 2019.[45]

The Association, along with American Municipal Power, Inc. and the National Rural Electric Cooperative Association, were among the organizations that requested rehearing of Order No. 841. While the rehearing request voiced general support for FERC's efforts to facilitate greater participation by storage resources in the markets, the Association expressed concern that rules allowing wholesale market participation by storage resources interconnected to the distribution system or BTM could improperly override state and local authority and present operational, reliability and regulatory challenges. The Association argued that participation in wholesale markets by BTM and distribution-connected storage should only be allowed with the consent of state and local utility regulators.[48]

Thus, while Order No. 841 could facilitate greater participation by BTM storage in the organized wholesale markets, many practical and regulatory issues associated with their participation remain unsettled.

CASE STUDY

Liberty Utilities, New Hampshire

Investor-owned utility Liberty Utilities is launched a BTM energy storage pilot in which the utility owns the storage asset.[46, 47] This pilot will help Liberty Utilities study battery impacts on the distribution system. During the first fifteen-year phase of the pilot, participating customers will receive two Tesla Powerwall batteries along with accompanying software controls. Phase one will result in the installation of 100-200 total batteries. Participating customers can choose to pay a $25 per month fee for ten years or a one-time upfront fee of $2,433. The utility will then anticipate system peak and discharge customer stored electricity up to four times per month to lower power market costs. Customers will be allowed access to their system's stored power except when a demand peak is predicted. As part of the program, participating customers will be moved to a time-of-use rate. In the second phase of the project, Liberty Utilities can add up to 300 additional batteries and third parties can install up to 500 batteries. Phase two is contingent upon the results of the first phase showing a cost-effective reduction in system peak demand.

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43 U.S. Energy Information Administration. "U.S. Battery Storage Market Trends."

44 Federal Energy Regulatory Commission. "FERC Issues Final Rule on Electric Storage Participation in Regional Markets." February 15, 2018. https://www.ferc.gov/media/news-releases/2018/2018-1/02-15-18-E-1.asp.

45 Energy Storage Association. "Kicking the Tires on FERC Order 841: Details, Opportunities, And Challenges." March 28, 2018. http://energystorage.org/system/files/resources/order_841_webinar_3.28.2018_final.pdf.

46 Carlson, Kristin. "GMP Launches New Comprehensive Energy Home Solution from Tesla to Lower Costs for Customers." May 12, 2017. https://greenmountainpower.com/news/gmp-launches-new-comprehensive-energy-home-solution-tesla-lower-costs-customers/.

47 Trabish, Herman. "New Hampshire settlement moves 'cutting-edge' utility BTM storage pilot forward." Utility Dive. November 27, 2018. https://www.utilitydive.com/news/new-hampshire-settlement-moves-cutting-edge-utility-btm-storage-pilot-for/542866/.

48 American Municipal Power, Inc., The American Public Power Association, & The National Rural Electric Cooperative Association. "Request for Rehearing." March 19, 2018. https://elibrary.ferc.gov/idmws/file_list.asp?document_id=14651444.

STATE ACTIVITIES

State activities supporting BTM energy storage technology include incentives, grants, research, and demonstration projects. States are also evaluating the potential rate design effects of energy storage and assessing the potential benefits and challenges of broader wholesale market participation by energy storage.

Maryland

In the past few years, Maryland has initiated several programs that support the advancement of BTM energy storage. In 2018, Maryland became the first state to offer tax credits for energy storage.[49] The credit is for 30 percent of the installed cost of an energy storage system, up to $5,000 for residential projects and $75,000 for commercial projects. The 2018 Energy Storage Tax Credit Program had $750,000 available to eligible customers. The credits will be claimed on a first-come, first-served basis. A variety of energy storage technologies are eligible, such as those that store electrical energy, mechanical energy, chemical energy, and thermal energy. This program was launched to promote energy storage deployment within the state and enhance grid resiliency.[50]

Maryland is also seeking to advance BTM energy storage through research. With passage of House Bill 0773/Senate Bill 0715 in 2017, the state's Power Plan Research Program studied regulatory and market conditions to increase the deployment of energy storage.[51] The study covers use cases, incentives, policies, procurement targets, and interconnection processes for storage. The final report and recommendations were due to the General Assembly on December 1, 2018. Regarding BTM energy storage, the report cites concerns that "Utility ownership of BTM storage poses additional challenges to competition" and makes several recommendations such as limiting utility ownership and ensuring third-party access to data.[52]

The Maryland Public Service Commission is similarly examining energy storage. It initiated the Transforming Maryland's Electric Grid (PC44) proceeding in 2016 to examine the electric distribution system in a series of facilitated workshops.[53] The topics of these workshops include rate design, electric vehicles, competitive markets and customer choice, interconnection process, energy storage, and distribution system planning. Based on the PSC initial notice, both in front of the meter and BTM energy storage are within the scope of the workgroup.

Massachusetts

Massachusetts has taken several approaches to advance energy storage. The most notable action was the creation of the state energy storage target of 200 MWh by 2020.[54] The Massachusetts Department of Public Utilities (DPU) is also exploring BTM energy storage specifically. On October 3, 2017, the DPU initiated an inquiry as to the eligibility of energy storage systems for net metering as well as the qualification and bidding of net energy metering systems in the ISO New England Forward Capacity Market.[55] As of the publication of this report, the inquiry remains open.

The Massachusetts Department of Energy Resources and Massachusetts Clean Energy Center conducted a comprehensive study of energy storage and detailed their findings in the September 2016 report, *State of Charge*.[56] The report illustrates use cases for energy storage, including front of meter and BTM options for residential and commercial customers.[57] The authors describe how energy storage systems can provide value for both the owner as well as the electric grid. When discussing storage paired with solar, the report explains that "Behind-the-meter storage systems can preserve the full value of all the solar generation regardless of net-metering policies."[58] The report suggests that customers can reduce their reliance on the grid during times of peak demand, thereby reducing demand

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49 Walton, Robert. "Maryland is first state to launch energy storage tax credit." Utility Dive. February 13, 2018. https://www.utilitydive.com/news/maryland-is-first-state-to-launch-energy-storage-tax-credit/517011/.

50 Maryland Energy Administration. "Maryland Energy Administration Offers Pilot Program: "First in the Nation Energy Storage Tax Credit Program." February 13, 2018. http://news.maryland.gov/mea/2018/02/13/maryland-energy-administration-offers-pilot-program-first-in-the-nation-energy-storage-tax-credit-program/.

51 General Assembly of Maryland. "Clean Energy - Energy Storage Technology Study." 2017. http://mgaleg.maryland.gov/webmga/frmMain.aspx?pid=billpage&tab=subject3&id=hb0773&stab=01&ys=2017RS.

52 Maryland Power Plant Research Program. "Energy Storage in Maryland." 2018. http://dnr.maryland.gov/pprp/Documents/Energy-Storage-In-Maryland.pdf.

53 Maryland Public Service Commission. "Transforming Maryland's Electric Grid (PC44)." 2018. https://www.psc.state.md.us/transforming-marylands-electric-grid-pc44/.

54 Commonwealth of Massachusetts. "Energy Storage Target." 2018. https://www.mass.gov/service-details/energy-storage-target.

55 Maloney, Peter. "Massachusetts starts inquiry into energy storage eligibility for net metering." Utility Dive. October 9, 2017. https://www.utilitydive.com/news/massachusetts-starts-inquiry-into-energy-storage-eligibility-for-net-meteri/506751/.

56 Commonwealth of Massachusetts. "Energy Storage Study." 2018. https://www.mass.gov/service-details/energy-storage-study.

57 Massachusetts Department of Energy Resources & Massachusetts Clean Energy Center. "STATE OF CHARGE." 2016. https://www.mass.gov/files/documents/2016/09/oy/state-of-charge-report.pdf.

58 Ibid.

Table: BTM Commercial & Industrial Solar Plus Storage[59]

Recipient	Application Team	Technology	Capacity	Description	Purpose
Advanced Microgrid Solutions, Inc	National Grid Business Development AAH	Lithium Ion Battery	500kW/1000kWh	Two energy storage systems deployed across two Walmart locations, one with existing solar PV and one without	Peak demand management
Borrego Solar Systems, Inc. (Acushnet Company)	Acushnet Company Genbright LLC	Lithium Ion Battery	1500kW/3000kWh	Energy storage at golf ball manufacturing plant	Monetizable and non-monetizable energy storage value streams
University of Massachusetts - Boston	Enel Green Power North America, Inc. Demand Energy Networks, Inc. EnterSolar	Lithium Ion Battery	500kW/1820kWh	Energy storage for UMass-Boston community	Grid resilience, greenhouse gas reductions, education, and workforce development
General Electric Company	RDK Engineers Suffolk AECOM	Latent Heat Storage	181kW/1840kWh	Ice storage system for GE headquarters under development, will be co-located with solar PV	,
Boston Medical Center	Alternative Power Source, Inc.	Lithium Ion Battery	520kW/1044kWh	Energy storage for medical center	Resiliency, reducing grid congestion and frequency response
Tesla, Inc.	Wynn Boston Harbor	Lithium Ion Battery	1044kW/4200kWh	Energy storage for new resort	Potential model for property developers

Table: BTM Residential Storage Dispatched by Utility[60]

Recipient	Application Team	Technology	Capacity	Description	Purpose
SolarCity dba Tesla	National Grid Green Homes	Lithium Ion Battery	5kW/13.2kWh	500 aggregated Powerwall home batteries	Resiliency and distribution infrastructure deferral
Sunrun, Inc.	National Grid	Lithium Ion Battery	5kW/9.3 kWh	200 aggregated Brightbox energy storage systems paired with solar PV	Backup power and net energy metering, time of use

[59] Ibid.
[60] Ibid.

charges, and improve their resiliency during power outages. The report also recommends grant and rebate funding support for energy storage.

Massachusetts also launched an Energy Storage Initiative in May 2015 to advance energy storage in the state through research and pilot projects.[61] In December 2017, grant recipients were announced for energy storage demonstration projects, and eight projects were ultimately approved (two residential, six commercial and industrial).[62, 63] The tables on the previous page summarize each project.

Five out of the six grants for commercial and industrial customer applications are for battery storage, and more specifically, lithium-ion batteries. The sixth grant in this category will demonstrate thermal energy storage technology. All six of the grants have solar energy involved with the project. Both residential customer applications involve aggregating lithium-ion batteries across residences.

California

California is the leading market for residential and non-residential BTM energy storage.[64] The state helped propel storage development through programs such as the energy storage target, incentives, funding opportunities, and streamlining of interconnections. In October 2013, the California Public Utilities Commission (CPUC) instituted an energy storage target of 1,325 MW for the state's three investor-owned utilities by 2020.[65] In 2016, the CPUC added another capacity mandate for the IOUs, requiring a total of 500 MW of energy storage capacity to be installed, of which up to 25 percent could be behind the meter.[66] Though this mandate does not apply to public power utilities, it is a major driver for energy storage within the state and also a factor in the advancement of the US BTM energy storage market.

Currently, the CPUC provides incentives for DERs through the Self-Generation Incentive Program (SGIP).[67] A majority of the funding is earmarked for energy storage, and in 2017, the CPUC revised the program to earmark 25 percent of the funding for distributed energy storage for low income communities.[68] In 2018, the governor extended SGIP until 2026 and brought funding up to $800 million.[69] CPUC analysis of the SGIP performance in 2016 found that it has been helpful in reducing peak demand and customer electricity bills.[70] DOE's Energy Information Administration found that in 2016, 83 percent of reported small-scale storage in California fell under the SGIP.[71]

The program uses incentive rates that vary based on program administrator (Pacific Gas and Electric Company, Southern California Edison Company, Center for Sustainable Energy, and Southern California Gas Company), "step" within the program, and whether the customer falls within the low-income/"equity" classification. For example, Pacific Gas and Electric Company advertises a rate of $0.30/Wh for small residential energy storage and a rate of $0.35/Wh for residential storage equity.[72]

The California Energy Commission (CEC) has also supported energy storage by funding demonstration projects. CEC found that energy storage helps with state clean energy goals by reducing greenhouse gas emissions, reducing peak demand, deferring infrastructure upgrades, and enhancing reliability. The CEC includes responsiveness to TOU rates and demand charge reduction among the customer benefits of installing BTM storage.

61 Commonwealth of Massachusetts. "ESI Program Goals." 2018. https://www.mass.gov/service-details/esi-program-goals.califor
62 Commonwealth of Massachusetts. "ESI Demonstration Program Advancing Commonwealth Energy Storage (ESI ACES)." 2018. https://www.mass.gov/service-details/esi-demonstration-program-advancing-commonwealth-energy-storage-esi-aces.
63 Commonwealth of Massachusetts. "Advancing Commonwealth Energy Storage: Awardee Summary." 2017. http://files.masscec.com/ACES%20Project%20Details.pdf.
64 Simon. Energy Storage Monitor: Q3 2018.
65 California Public Utilities Commission. "Energy Storage." 2018. http://www.cpuc.ca.gov/General.aspx?id=3462.
66 California Energy Commission. "California Energy Commission – Tracking Progress." August 2018. http://www.energy.ca.gov/renewables/tracking_progress/documents/energy_storage.pdf.
67 California Public Utilities Program. "Self-Generation Incentive Program." 2018. http://www.cpuc.ca.gov/sgip/.
68 Maloney, Peter. "California allocates $55M for energy storage in low income neighborhoods." Utility Dive. October 17, 2017. https://www.utilitydive.com/news/california-allocates-55m-for-energy-storage-in-low-income-neighborhoods/507385/.
69 Maloney, Peter. "Energy storage gets a boost as California legislature extends SGIP." Utility Dive. August 31, 2018. https://www.utilitydive.com/news/energy-storage-gets-a-boost-as-california-legislature-extends-sgip/531350/?utm_source=Sailthru&utm_medium=email&utm_campaign=Issue:%202018-09-04%20Utility%20Dive%20Storage%20%5Bissue:16954%5D&utm_term=Utility%20Dive:%20Sto.
70 Maloney, Peter. "California's BTM energy storage moves forward, but is it good for the climate?" Utility Dive. September 4, 2018. https://www.utilitydive.com/news/californias-btm-energy-storage-moves-forward-but-is-it-good-for-the-clima/531463/?utm_source=Sailthru&utm_medium=email&utm_campaign=Issue:%202018-09-05%20Utility%20Dive%20Newsletter%20%5Bissue:16969%5D&utm_term=Utility%20D.
71 U.S. Energy Information Administration. "U.S. Battery Storage."
72 State of California and the Self-Generation Incentive Program. "Incentive Step Tracker." https://www.selfgenca.com/home/program_metrics/.

CASE STUDY

Austin Energy, Texas[73]

As discussed in *Understanding Energy Storage: Technology, Costs, and Potential Value*, the Austin Sustainable and Holistic Integration of Energy Storage and Solar Photovoltaics (SHINES) project supports demonstration projects for both utility scale and BTM energy storage projects. Austin Energy does not currently offer incentive programs for energy storage, but results from the SHINES project may help inform future programs. Data collection for the demonstration phase of all SHINES efforts will run from early 2019 through September 2019. SHINES will help Austin Energy explore how to facilitate higher densities of solar on the grid. Goals of this project include the ability to model future business cases and learning how to maximize the value of DERs through the optimization of value streams. The findings of this project will be shared publicly, enabling utilities nationwide to learn about integrating energy storage and solar with the grid.

Through SHINES, Austin Energy is exploring BTM energy storage applications in both residential and commercial settings. Six homes with existing solar in Austin's Mueller neighborhood were retrofitted with 10 kWh lithium-ion batteries from LG Chem.[74] Smart inverters were utilized to enable control of the storage assets. Austin Energy is partnering with Pecan Street, who acts as the residential energy storage aggregator. Another project partner, Doosan Gridtech, provides the utility control platform, known as the Distributed Energy Resource Optimizer (DERO). The utility is experimenting with different levels of utility control, varying from DER aggregation through Pecan Street, utility control by sending signals directly to each distributed energy resource, and autonomous control, which means no utility control. Ultimately, Austin Energy wants to see how to control the batteries for the benefit of the utility as well as the customer. Austin Energy does not currently have a time-of-use rate schedule or demand charge for residential customers. The five key value streams that Austin Energy is analyzing for residential DERs include utility peak load reduction, day ahead energy arbitrage, real time price dispatch, voltage support, and distribution congestion management.

Three commercial customers are participating in the SHINES project. Two customers each have a 144 kWh lithium-ion battery while the remaining customer has a 36 kWh lithium-ion battery. STEM is acting as the aggregator for these customers, controlling the energy storage systems from a STEM control platform which also communicates with DERO to enable functionality for utility value streams. The three participating commercial customers have existing solar, but do not have smart inverters. Since commercial customers do have a demand charge component on their bill, these customers can benefit from a demand charge reduction value stream. The main utility value streams being analyzed are utility peak load reduction, day ahead energy arbitrage, real time price dispatch, and distribution congestion management.

[73] Shaver, Russell, interview by Patricia Taylor. SHINES Discussion. November 28, 2018.

[74] The assets are currently owned by Austin Energy and the Department of Energy. At the end of the project, Austin Energy and the Department of Energy will decide whether the devices remain in place and what the ownership structure will be.

To help customers interconnect their BTM energy storage devices, Assembly Bill 546 was signed by the governor in September 2017 to make energy storage permitting documentation more accessible to the public.[75] For example, depending on city or county population, permitting information must be available online. This law will help customers gain clearer and easier access to key documents.

Colorado

Colorado is supporting BTM energy storage by asserting customer rights and helping streamline interconnection processes. In March 2018, the Colorado governor signed SB18-009 into law, which outlines customer rights to interconnect energy storage systems.[76] In support of this law, legislators cited grid benefits such as enhanced efficiency and reliability, monetary savings, and energy storage as a non-wires alternative to otherwise necessary generation upgrades. The law directs the Colorado PUC to adopt rules pertaining to the installation, interconnection, and usage of BTM energy storage systems. This law serves to protect customers from any "burden of unnecessary restrictions or regulations" and "unfair or discriminatory rates or fees." According to Navigant research, "The uptake of residential energy storage has been slow in Colorado, partially due to the relatively high permitting and interconnections costs charged by utilities."[77]

Hawaii

Hawaii has put forth numerous energy storage bills in recent years, but none have been signed into law. However, a law to develop performance-based ratemaking was passed in April 2018, which has implications for BTM energy storage.[78] According to the Ratepayer Protection Act (SB 2939), the Hawaii PUC has until 2020 to create incentives and penalties that tie the utility's revenues to its ability to meet customer-related performance measures. Among other measures, such as reliability, the law includes measures for integration of renewable energy and interconnection of BTM resources like solar and energy storage.

The Hawaii PUC has also been active on the topic of BTM energy storage in relation to customer program eligibility and compensation models. In October 2017, the PUC issued a decision and order to approve the Smart Export program for customers who install rooftop PV plus battery storage.[79] The storage device is to be powered during the day from the solar energy and discharged at night to power the home. Any excess power exported to the grid during daylight hours results in a monthly bill credit. The credit is based on the time-based value of the energy supplied.

CASE STUDY

Green Mountain Power, Vermont

Green Mountain Power is an investor-owned utility conducting an 18-month pilot where up to 2,000 Tesla Powerwall batteries will be deployed in customers' homes.[80] The utility describes a variety of benefits for both customers and the utility. From a customer perspective, the program is expected to enhance customer "comfort, energy use, and resilience of their own homes."[81] Resilience, for example, can be improved by solar plus storage customers powering their homes during power outages. GMP projects a 10 MW reduction in peak load, which will help the utility save on transmission and capacity costs while improving reliability. The storage resources will be aggregated and dispatched into the New England wholesale electricity market. These savings can in turn help lower costs for customers. Costumers who grant GMP and Tesla access to their storage device during peak events receive compensation. To participate, customers pay $15 a month or a one-time fee of $1,500.

[75] California Legislature. "AB-546 Land use: local ordinances: energy systems." October 2017. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180AB546.
[76] Colorado General Assembly. "Allow Electric Utility Customers Install Energy Storage Equipment." https://leg.colorado.gov/bills/sb18-009.
[77] Eller, Alex. "Can Colorado Become the Next Big Energy Storage Market?" March 29, 2018. https://www.navigantresearch.com/news-and-views/can-colorado-become-the-next-big-energy-storage-market.
[78] Pyper, Julia. "Hawaii Gov Signs Performance-Based Ratemaking Into Law." GTM. April 24, 2018. https://www.greentechmedia.com/articles/read/performance-based-ratemaking-becomes-law-in-hawaii.
[79] Hawaii Public Utilities Commission. "HPUC Expands Options for Customers to Install Rooftop Solar and Energy Storage." October 20, 2017. https://puc.hawaii.gov/wp-content/uploads/2017/10/Hawaii-PUC-Rooftop-Solar-and-Storage-Press-Release-10-20-17-FINAL.pdf.
[80] Trabish, Herman K. "Is New Hampshire on the verge of battery energy storage history?" Utility Dive. June 19, 2018. https://www.utilitydive.com/news/is-new-hampshire-on-the-verge-of-battery-energy-storage-history/525876/?utm_source=Sailthru&utm_medium=email&utm_campaign=Issue:%202018-06-20%20Utility%20Dive%20Newsletter%20%5Bissue:15844%5D&utm_term=Utility%20Dive.
[81] Carlson, Kristin. "GMP Launches New Comprehensive Energy Home Solution from Tesla to Lower Costs for Customers." May 12, 2017. https://greenmountainpower.com/news/gmp-launches-new-comprehensive-energy-home-solution-tesla-lower-costs-customers/.

CASE STUDY

Sacramento Municipal Utility District, California

SMUD launched a battery storage incentive program for both residential and commercial customers in July 2018.[86] The program provides an opportunity for the public power utility to engage with customers to better understand the value of energy storage.[87] SMUD cites customer benefits such as reducing peak demand, shifting solar generation, lowering a customer's carbon footprint when paired with a low-carbon energy source, and having access to backup power. Furthermore, with residential time-of-day rates going into effect in 2019, customers can also reduce and shift their usage to achieve bill savings. Commercial customers can additionally save on demand charges.

Both residential and commercial customers must make specific commitments on system operations to participate in the storage incentive program.[88, 89] For customers eligible for net energy metering, the system owner must commit "that at least 51% of the proposed battery capacity will be used to shift energy generated from solar to offsetting loads during the on-peak periods. Any incidental energy (kWh) discharge to the grid will be credited at normal net energy metering rates." For customers that only have batteries and are not eligible for net energy metering, the system owner needs to commit "that at least 51% of the proposed battery capacity will be used to shift energy usage from on-peak periods to off-peak periods." Storage that is not connected to solar is ineligible for net energy metering under the program.

Residential customers benefit from a $300 incentive for storage systems 1kW to 10 kW and a $600 incentive for systems 11 kW and above. SMUD offers commercial customers a range of credits based on system size (see table below).

Table: Summary of Commercial Customer BTM Energy Storage Incentives[90]

Storage	Incentive per site
15kW - 30kW	$600
30.1 kW - 75kW	$1,000
75.1kW - 150kW	$2,000
150.1kW+	$5,000

New York

New York is supporting energy storage technology and deployment through the Reforming the Energy Vision strategy, the Energy Storage Roadmap, and an energy storage target of 1,500 MW by 2025 and 3,000 MW by 2030.[82, 83] BTM storage fits within the state's strategy, and the state is providing customers with information on energy storage interconnections and permitting, funding opportunities, and technical assistance.

In January 2018, the governor committed $200 million to the NY Green Bank for deploying energy storage and $60 million for New York State Energy Research and Development Authority (NYSERDA) to pilot energy storage programs and initiatives.[84] Both programs support a variety of storage technologies deployed at different parts of the grid. In recent years, NYSERDA worked with an engineering firm to perform a market and technical assessment of BTM storage.[85] The project analyzed technologies' fit for BTM applications, business and revenue streams, and opportunities to minimize implementation barriers.

[82] Maloney, Peter. "New York's energy storage target could end up at 3 GW by 2030." Utility Dive. July 10, 2018. https://www.utilitydive.com/news/new-yorks-energy-storage-target-could-end-up-at-3-gw-by-2030/526895/.
[83] Morehouse, Catherine. "New York Gov. Cuomo pledges 100% carbon-free electricity by 2040." Utility Dive. December 18, 2018. https://www.utilitydive.com/news/new-york-gov-cuomo-pledges-100-carbon-free-electricity-by-2040/544587/?utm_source=Sailthru&utm_medium=email&utm_campaign=Newsletter%20Weekly%20Roundup:%20Utility%20Dive%2012-22-2018&utm_term=Utility%20Dive%20Weekender.
[84] Colthorpe, Andy. "New York sets bigger energy storage target than California." Energy Storage News. January 3, 2018. https://www.energy-storage.news/news/new-york-sets-bigger-energy-storage-target-than-california.
[85] ERS. "BEHIND-THE-METER BATTERY STORAGE." 2018. http://www.ers-inc.com/portfolio/behind-the-meter-battery-storage/.
[86] Matyi, Bob. "SMUD offers battery storage incentive for residential customers." Public Power Daily. July 30, 2018. https://www.publicpower.org/periodical/article/smud-offers-battery-storage-incentive-residential-customers.
[87] SMUD has time-of-day rates for residential customers.
[88] SMUD. "Is battery storage right for you?"
[89] SMUD. 2018. "Is battery storage right for your business?" https://www.smud.org/en/Going-Green/Battery-Storage-Business.
[90] Ibid.

CONCLUSION

We are in a time of rapid transformation, seen in both the electric industry and in customer behaviors. Public power utilities must do more than keep the lights on, they must evolve to serve their communities in new ways.

From the top down, government is increasingly active in promoting deployment of and reducing barriers to energy storage technology, which is increasing the potential value of energy storage for customers. Market projections indicate that BTM energy storage deployments will continue to increase dramatically in the coming years, bringing potential impacts on utility operations.

BTM energy storage presents a share of challenges and opportunities for utilities. The technology can support larger grid benefits, open new utility service offerings, and provide another avenue to connect with customers. Utility examples of involvement with BTM energy storage range from incentive programs, to research projects, and ownership of BTM systems. Utilities can begin to explore these opportunities now or watch as third parties step in instead.