NARUC
National Association of Regulatory Utility Commissioners

Regulators' Financial Toolbox: Behind-the-Meter (BTM) Energy Storage

The National Association of Regulatory Utility Commissioners (NARUC) Center for Partnership and Innovation (CPI) Regulators' Financial Toolbox series explores the types of financial tools utility regulators can use to support integration of electricity system technologies that benefit the public interest. This brief was prepared by Jamie Scripps of Hunterston Consulting LLC and is based upon work supported[1] by the Department of Energy under Award Number DE-OE0000925. The speakers' presentations and recordings can be found at www.naruc.org/cpi-1/energy-distribution/valuation-and-ratemaking/.

On October 10, 2023, NARUC's Center for Partnerships & Innovation (CPI) hosted a Regulators' Financial Toolbox Webinar on the topic of Behind-the-Meter (BTM) Energy Storage. The webinar featured opening remarks by the Honorable Katherine Peretick, Commissioner, Michigan Public Service Commission; and presentations by Ryan Chan, Principal Strategic Analyst, Pacific Gas and Electric Company (PG&E); Arushi Sharma Frank, Energy Market Design Lead and Senior Counsel for Energy Regulatory Matters and Greg Thurnher, Technical Program Manager, Tesla; and Mark LeBel, Senior Associate, Regulatory Assistance Project (RAP).

The webinar and this accompanying brief address:

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What is Behind-the-Meter (BTM) Energy Storage?

Energy storage is defined as "a resource capable of receiving electric energy from the grid and storing it for later injection of electricity back to the grid regardless of where the resource is located on the electrical system."[2] Energy storage includes any technology that allows power system operators, utilities, developers, or customers to store energy for later use.[3] Such technologies include "all types of electric storage technologies, regardless of their size, storage medium (e.g., batteries, flywheels, compressed air, pumped-hydro, etc.), or whether located on the interstate grid or on a distribution system."[4] As investment in renewable energy has grown, so has the need for energy storage at all levels of the system.

Behind-the-meter (BTM) energy storage refers to storage systems that are located at the customer's site (home or commercial/industrial facility), on the customer side of the utility meter.[5] The "meter" in "behind-the-meter" refers to the device that measures the customer's consumption of energy during a billing period.[6] BTM systems are usually owned by customers and intended for the customer's use.[7] BTM energy storage adoption has been primarily influenced by customer decisions aimed at obtaining savings or other benefits like reliability, as customers have typically been the principal investors in the BTM energy storage system.[8] As awareness of the grid benefits of BTM energy storage grows, utilities may choose to invest in BTM energy storage to benefit ratepayers and the grid as a whole.[9]

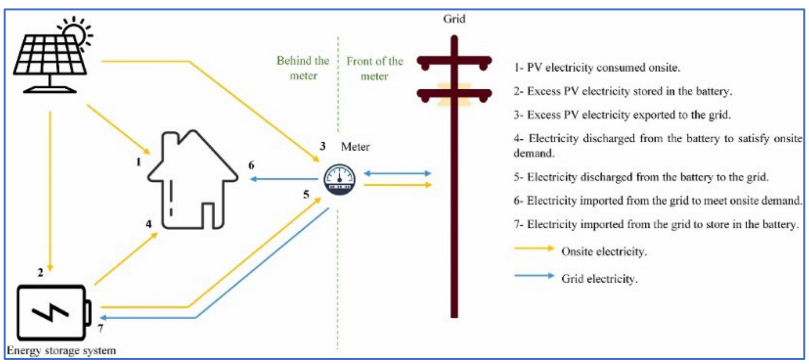

Figure 1: BTM vs. FTM Energy Storage Systems. Source: Renewable and Sustainable Energy Reviews, Volume 164, 2022.

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[2] "Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators," Notice of Proposed Rulemaking, 157 FERC ¶ 61,121, Nov. 17, 2016, at p. 12.

[3] National Renewable Energy Lab (NREL), Behind-The-Meter Battery Energy Storage: FAQ. August 2021. Available at https://www.nrel.gov/docs/fy21osti/79393.pdf.

[4] 157 FERC ¶ 61,121, Nov. 17, 2016, at p. 1.

[5] Tu A. Nguyen, Ph.D., "Maximizing Cost Savings for Utility Customers Using Behind-the-meter Energy Storage," Sandia National Laboratories, May 31, 2018, at slide 4. Available at https://www.osti.gov/servlets/purl/1513470.

[6] See U.S. DOE, Energy Saver - Electric Meters. Available at https://www.energy.gov/energysaver/electric-meters.

[7] Sandia National Laboratories at slide 4.

[8] NREL Behind-The-Meter Battery Energy Storage: FAQ at p. 2.

[9] "2023 BTM Customer Resiliency Battery Storage Initiatives," NARUC CPI Regulators' Financial Toolbox Webinar on BTM Energy Storage, Presentation by Ryan Chan, Principal Strategic Analyst, PG&E, at slide 1 (October 10, 2023). Available at https://pubs.naruc.org/pub/208431A2-BF2F-704B-430A-59B807924448.

In contrast with BTM energy storage systems, front-of-the-meter (FTM) energy storage systems are located on the utility side of the meter and feed electricity onto the distribution system where there is no customer use of the energy before it is injected into the grid. FTM applications may take the form of stand-alone energy storage, energy storage with a DER (such as community solar), or energy storage connected directly to utility-owned distribution system equipment, such as a substation.[10]

BTM energy storage systems have been in use for decades, mostly used as flexible load.[11] Newer forms of BTM energy storage have greater capabilities to charge or discharge electrical energy, unlocking additional value for both the utility and the customer.[12] Such capabilities include providing backup power generation for the customer and exporting energy to the grid, which can improve utility performance and reliability.[13] The value stack of using distributed energy resources (DERs) in combination with BTM energy storage can benefit not only the consumer but also the utility.[14]

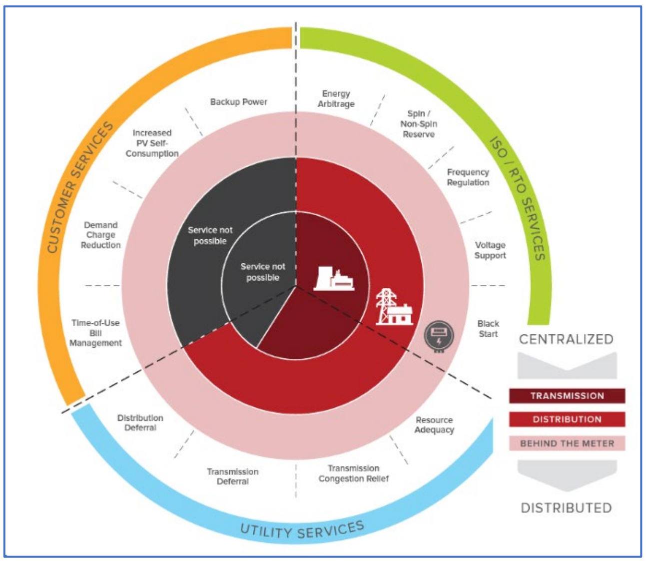

Figure 2: Services Provided by Energy Storage. Source: RMI, The Economics of Battery Energy Storage, October 2015.

Benefits of BTM Energy Storage

BTM energy storage provides many potential benefits to customers and utilities,

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[10] New York State Energy Research and Development Authority (NYSERDA), "New York Energy Storage Value Stream Reference Guide for Developers and Contractors," at p. 12. Available at https://www.nyserda.ny.gov/All-Programs/Energy-Storage-Program/Developers-Contractors-and-Vendors/Technical-Assistance.

[11] "Rate Design and BTM Storage," NARUC CPI Regulators' Financial Toolbox Webinar on BTM Energy Storage, Presentation by Mark LeBel, Senior Associate, RAP, at slide 2 (October 10, 2023). Available at https://pubs.naruc.org/pub/208431A2-BF2F-704B-430A-59B807924448.

[12] Ibid.

[13] Ibid. See also "Distributed Storage Value Streams for Utilities," NARUC CPI Regulators' Financial Toolbox Webinar on BTM Energy Storage, Presentation by Arushi Sharma Frank, Energy Market Design Lead and Senior Counsel for Energy Regulatory Matters, and Greg Thurnher, Technical Program Manager, Tesla, at slide 2 (October 10, 2023). Available at https://pubs.naruc.org/pub/208431A2-BF2F-704B-430A-59B807924448.

[14] Tesla at slide 2.

including: 1) backup power at the customer's premises to avoid or mitigate disruption of service during grid outages;[15] 2) grid resilience and reliability; 3) balancing grid supply and improving power quality; 4) cost savings; and 5) customer engagement.[16]

Backup Power During Grid Outages

BTM energy storage helps customers to avoid disruption during power outages.[17] For example, residents in Puerto Rico have recently faced regular power system trouble and distribution outages.[18] The Puerto Rico Energy Bureau (PREB) has mandated energy efficiency and demand response programs to help build a more resilient and energy efficient energy grid that benefits all customers.[19] As part of this initiative, the Battery Emergency Demand Response Program (BEDRP) is designed to increase the availability of energy during emergency conditions, reduce electricity usage during peak times, and help meet customer demand with the use of BTM energy storage already installed on the island.[20] In partnership with third-party emergency demand response aggregators, customers are incented to use DERs, including BTM energy storage and solar, to export excess energy to the grid during emergency conditions.[21] About 75,000 Tesla Powerwalls installed on the island have so far helped to contribute 375 MW of capacity, where the peak load for the island is around 2400-2800 MW.[22] This means that in short duration, from 15 minutes to 2 hours, Tesla Powerwalls could carry close to 20-25% of Puerto Rico's peak demand.[23]

In California, wildfires pose a significant risk to the electric grid. According to the State of California Energy Commission: "Over the 2000-2016 period, wildfire damages to the transmission and distribution system in selected areas exceeded $700 million."[24] PG&E recently implemented two types of wildfire safety outages to reduce the risk of ignition. Public Safety Power Shutoffs (PSPS) are preannounced outages that affect a specific geography. They vary in duration and can last up to several hours. Another type of safety outage uses Enhanced Powerline Safety Settings (EPSS), which are sensitivity settings that automatically shut off power when hazards are detected on the line. While shorter in duration compared to PSPS, the EPSS outages are unplanned. BTM energy storage installations have the potential to minimize the disruption to customers' daily lives while keeping the system safe when wildfire-related outages are necessary.[25]

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[15] Tesla at slide 4.

[16] Tesla at slide 8. See also PG&E at slide 1.

[17] *See* Energy Information Administration, Energy Storage for Electricity Generation. Available at https://www.eia.gov/energyexplained/electricity/energy-storage-for-electricity-generation.php.

[18] Tesla at slide 5.

[19] LUMA Energy, Battery Emergency Demand Response (DR) Program Cost Structure. August 21, 2023. Available at https://energia.pr.gov/wp-content/uploads/sites/7/2023/09/20230823-DR-Program-Cost-Structure-filed-in-Compliance-with-August-11.pdf.

[20] Tesla at slide 5.

[21] LUMA Energy.

[22] Tesla at slide 5.

[23] Ibid.

[24] State of California Energy Commission, "Assessing the Impact of Wildfires on the California Electricity Grid: A Report for California's Fourth Climate Change Assessment," August 2018, p. iv. Available at https://www.energy.ca.gov/sites/default/files/2019-11/Energy_CCCA4-CEC-2018-002_ADA.pdf.

[25] PG&E at slide 1.

Grid Resilience and Reliability

BTM energy storage can also provide increased grid resilience and reliability. Major events threatening grid continuity of service are on the rise, impairing perceived and actual grid reliability experienced by customers.[26] The U.S. Department of Energy (DOE) defines energy resilience as "the ability of the grid, buildings, and communities to withstand and rapidly recover from power outages and continue operating with electricity, heating, cooling, ventilation, and other energy-dependent services."[27] Traditional utility metrics such as Customer Average Interruption Duration Index (CAIDI), System Average Interruption Frequency Index (SAIFI), and System Average Interruption Duration Index (SAIDI) quantify industry performance delivering continuity and quality of service.[28] Recent increases in major weather events have threatened the continuity of service, with significant declines in distribution reliability and accompanying increases in outage duration and restoration times.[29] This recent decline in reliability may be offset where BTM energy storage is applied. In some instances, utilities have installed BTM energy storage devices not only to reduce the impact of major events but also to improve the continuity of service experienced by their electric customers.[30]

Balancing Grid Supply and Improving Power Quality

BTM energy storage can also provide ancillary services to the utility, improving power quality.[31] According to the Energy Information Administration, "Power quality is an important attribute of grid electricity because momentary spikes, surges, sags, or outages can harm electric equipment, appliances, and other devices powered by electricity."[32] BTM energy storage is a good candidate to provide ancillary services because it reacts rapidly and accurately to signals, and can quickly switch from being a source of generation to being a source of load.[33] Energy storage systems can support the balancing of supply and demand of electricity by the second, minute, or hour, potentially providing ancillary services for power grids to maintain electric grid frequency on a second-to-second basis.[34]

Aggregated BTM energy storage devices can generate revenue by providing balancing services, easing the inconvenience of intermittency or resource contingencies.[35] As a region gains more renewables, the likelihood of an interruption to the renewable supply may decrease, but the magnitude of the potential interruption is higher.[36] The benefit of BTM energy storage is the ability to bridge disruptive events when this infrequent but high consequence disruption occurs.[37] There are a number of different programs across North America, with many ISOs and utilities aiming to harness the benefits delivered by

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[26] Tesla at slide 2.

[27] U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, Energy Resilience. Available at https://www.energy.gov/eere/energy-resilience.

[28] Tesla at slide 2.

[29] Tesla at slide 3. See also EIA https://www.eia.gov/todayinenergy/detail.php?id=45796.

[30] Tesla at slide 3.

[31] Tesla at slide 6.

[32] Energy Information Administration, Energy Storage for Electricity Generation. Available at https://www.eia.gov/energyexplained/electricity/energy-storage-for-electricity-generation.php.

[33] NREL Behind-The-Meter Battery Energy Storage: FAQ at p. 3.

[34] Energy Information Administration, Energy Storage for Electricity Generation.

[35] Tesla at slide 7.

[36] Ibid.

[37] Tesla at slide 7.

distributed storage when it is activated to participate in a wide area dispatch.[38] These programs include compensation of customers with BTM energy storage and/or the dispatch of distributed storage during grid disruptions. Further, numerous ISOs and utilities operate programs that allow aggregations of BTM energy storage to balance interruptions to traditional or renewable supply.[39] The flexibility offered by BTM energy storage, especially when designed with a program that allows an ISO or utility to harness this capability, can inherently help to manage the uncertainty and potential fluctuations in available energy that may come with the growing integration of renewable capacity.[40]

Tesla operates a retail portfolio of aggregated DERs for Tesla customers that includes BTM energy storage (Tesla Powerwalls), solar and EVs in the competitive markets of ERCOT.[41] Through a unique ERCOT pilot program, several hundred residential dwellings with installed Tesla Powerwalls respond to ERCOT's dispatch signals by expressing their willingness to curtail at a price by relying on their BTM energy storage system instead of importing energy from the grid. ERCOT's pilot program has allowed Tesla to offer ancillary services or grid reserves such that Tesla can be compensated and pass along rewards to their customers for participation in the pilot program, reserving customers' capacity to flex when it is needed the most.[42]

BTM energy storage also supports improved utilization rates of renewable and non-renewable resources.[43] Multiple ISOs and utilities leverage Tesla Powerwalls as an economic alternative to peaking or flex resources, reducing system costs.[44]

Cost Savings

One of the key drivers of the adoption of BTM energy storage has been the falling cost of both energy storage and renewables. According to the Regulatory Assistance Project, "[T]he cost of distributed energy resources (DERs), such as clean distributed generation (DG), battery storage and energy management technologies, has declined substantially over the past two decades, and many jurisdictions have seen rapid development of DER technologies at customer sites, such as solar photovoltaic (PV) systems."[45] When a customer installs a BTM energy storage system, there is the opportunity for the customer to obtain additional cost savings through a reduction in electricity demand. Commercial and industrial customers may deploy BTM energy storage to reduce their demand and associated demand charges, which are based on the customer's highest level of consumption during peak demand periods.[46]

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[38] Ibid.

[39] Ibid.

[40] Ibid.

[41] Tesla at slide 6.

[42] Ibid.

[43] Tesla at slide 2.

[44] Tesla at slide 6.

[45] Mark LeBel, Jessica Shipley, Carl Linvill, Camille Kadoch, Regulatory Assistance Project for the Michigan Public Service Commission, "Smart Rate Design for Distributed Energy Resources," November 2021, p.4. Available at https://www.michigan.gov/-/media/Project/Websites/mpsc/workgroups/der/rap-lebel-shipley-linvill-kadoch-smart-rate-design-distributed-energy-resources-2021-novem.pdf.

[46] Energy Information Administration, Energy Storage for Electricity Generation.

From a utility perspective, BTM energy storage can also generate cost savings through reductions to overall load. As customers charge BTM energy storage during periods of low demand and discharge energy storage during higher demand, this can help to flatten daily load or net load shapes.[47] Changes to the timing of grid electricity use, through the use of BTM energy storage, can also reduce electricity prices. According to the Energy Information Administration, "Shifting some or all of electricity use from peak demand periods to other times of a day can reduce the amount of higher-cost or seldom-used reserve generation capacity, which can result in overall lower wholesale electricity prices."[48]

Utilities may also benefit from BTM energy storage through cost savings due to deferring or avoiding grid investment. BTM energy storage sited at strategic locations on the grid can support utilities in managing growing demand in ways that cost less than upgrading or expanding grid infrastructure.[49] For example, Green Mountain Power (GMP), a Vermont-based electric utility, has been providing utility-subsidized Tesla Powerwalls for customers to improve grid reliability metrics and balance energy demand events for the last several years.[50] GMP, in balancing the need to update aging infrastructure while dealing with increasing weather severity, continues to expand the Tesla Powerwall program, stating that incenting the connection to existing customers' Tesla Powerwalls, or offering rebates to customers installing new Tesla Powerwalls, helps to reduce GMP's overall expenditures.[51] As an alternative to investing in new infrastructure, such as new lines or new power plants, GMP customers enrolled in the Tesla Powerwall program provide a fee to the utility to host a Powerwall, allowing GMP to pull power in exchange for credits to their electricity bill. During the winter of 2022, 4800 Tesla Powerwalls provided power during multiple major events, saving residents $3 million in peak costs.[52]

Overall, when utilities develop programs to compensate customers for the value provided by their BTM energy storage systems, the cost benefits of BTM energy storage are shared between the consumer, the utility, and non-participants.[53]

Customer Engagement

BTM energy storage creates an opportunity for utilities to offer a tangible customer experience, particularly in regions with challenging service reliability or a high risk of outage.[54] Utilities have relatively few opportunities to engage customers and earn their trust that the utility is working to maintain continuity of service at the lowest cost to the customer. When utilities create a BTM energy storage program, they create a new avenue to engage customers and raise awareness of grid stress. Customers are then engaged in a way that makes them part of the reliability effort. In doing so, customers have a better appreciation for the challenges utilities face as owners, operators, managers

[47] Ibid.
[48] Ibid.
[49] Ibid.
[50] Tesla at slide 4.
[51] Ibid. See also https://www.nytimes.com/2023/10/09/business/energy-environment/green-mountain-home-batteries.html.
[52] Tesla at slide 4. See also https://electrek.co/2022/08/22/small-vermont-utility-builds-fleet-4000-tesla-powerwalls/.
[53] PG&E at slide 1. See also Tesla at slide 6.
[54] Tesla at slide 2.

and stewards of consistent reliable low-cost service.[55] When utilities make the investment in customer education and provide timely information about the grid, the utility is providing the customer a richer customer experience overall.[56]

The Tesla App is an example of a customer engagement technology that educates and makes these connections for customers.[57] The Tesla App provides the customer the opportunity to enroll in a program, such as the Virtual Power Plant program, opt-in or opt-out of an emergency response event, observe their device participate in this event, observe the financial benefit, observe real-time home load, solar generation, and battery dispatch. The customer can also see and observe grid needs in times of scarcity.[58]

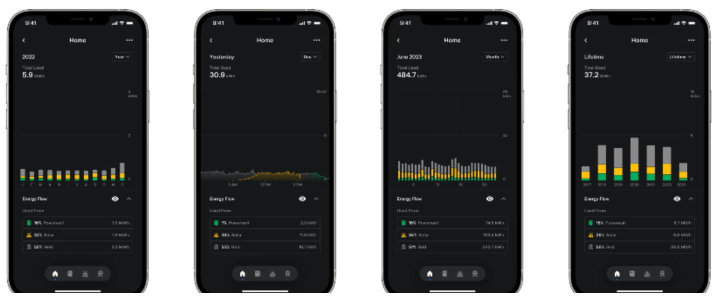

Figure 3: Tesla App for Powerwall. Source: Tesla.

BTM energy storage programs may also help to facilitate customer participation in related programs, such as demand response and other load management programs, to try to get as much value out of BTM energy storage systems as possible. At PG&E, when participating in the utility's BTM energy storage incentive programs, customers are required to participate in Power Saver rewards, which is an incentive program encouraging customers to reduce load when electric demand is at its highest. This approach streamlines incentive programs and encourages the adoption of multiple DERs to make them more efficient for customers while also lowering unit costs.[59]

Costs of BTM Energy Storage

Utilities are continually looking for opportunities to reduce the per unit cost of programs, including renewable energy and energy storage programs.[60] Utilities are often particularly mindful of the need to

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[55] Tesla at slide 8.
[56] Ibid.
[57] Ibid.
[58] Ibid.
[59] PG&E at slide 1.
[60] *See, e.g.,* Tim Woolf and Erin Malone, Synapse Energy Economics and Lisa Schwartz and John Shenot, Regulatory Assistance Project, "A Framework for Evaluating the Cost-Effectiveness of Demand Response: Prepared for the National Forum on the National Action Plan on Demand Response: Cost-effectiveness Working Group," February 2013, at p. 23. Available at https://www.ferc.gov/sites/default/files/2020-04/napdr-cost-effectiveness.pdf.

reduce costs for non-participants.[61] While programs to encourage BTM energy storage have proven valuable in providing grid resiliency and reliability, stacking different sources of value or the use of BTM energy storage in combination with multiple DERs creates even more efficient use for the customer while also lowering unit costs for the utility.[62] According to the National Renewable Energy Laboratory, "[A] BTM battery energy storage system is often paired with DG [distributed generation] to reduce energy bills and/or enhance compensation."[63] Utilities may also pull in external or third-party capital to reduce rate impacts, explore service models through structures like tariffs on the customer bill, and/or include a service charge on the monthly bill where the customer gets the benefit of resiliency.[64]

Compensation and Rate Design for BTM Energy Storage

A motivating factor for customers installing a BTM energy storage system is the opportunity to lower their electricity bills. For customers with BTM energy storage, this is mainly accomplished through a reduction in demand charges by lowering the maximum power consumed in a given month, and through energy arbitrage or shifting the customer's consumption from high- to low-cost time periods.[65] The customer's potential bill reduction depends on the tariff rate and what the customer is paid for exporting electricity when they discharge their BTM energy storage system.[66] Customers may also earn compensation by granting others, such as a utility or third party, access to their BTM energy storage systems in exchange for payments.[67]

The economics of owning a BTM energy storage system are heavily influenced by rate design. From a public policy perspective, the overarching goals of rate design are to encourage efficient competition, control monopoly pricing, and provide for reliable service, equity, environmental and public health requirements.[68] With these goals in mind, public utility commissions should take into account effective recovery of the revenue requirement, allocation of costs, efficient forward-looking price signals, and customer understanding.[69] In terms of operating BTM energy storage, rates should reflect the choices that the customer makes to minimize their own bill, consistent with the choices they would make to optimize system costs.[70]

Traditionally, rate design for residential customers has contained a customer charge, or a flat fee per month, and a volumetric per kWh charge.[71] For business customers, there is often a larger customer charge, a significant demand charge per month based on a customer's peak demand, and a smaller volumetric per kWh charge.[72] Traditional rate design price signals for the residential customer

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[61] PG&E at slide 1.
[62] Ibid.
[63] NREL Behind-The-Meter Battery Energy Storage: FAQ at p. 2.
[64] PG&E at slide 1.
[65] NREL Behind-The-Meter Battery Energy Storage: FAQ at p. 2.
[66] Ibid.
[67] Ibid.
[68] RAP at slide 3.
[69] RAP at slide 2.
[70] RAP at slide 4.
[71] RAP at slide 5.
[72] RAP at slide 5.

encourage the use of energy storage backup power in case of a power outage.[73] For commercial and industrial customers, the demand charge encourages customers to use energy storage to levelize their load and minimize the demand charge.[74] For customers with relatively flat demand, this does not necessarily provide much benefit, but peaky customers with a lower load factor[75] can save a lot of money by introducing storage to clip the peak.[76]

Traditional rate designs are evolving into smarter rate designs due to changes in the electric system overall. Technology changes over the last couple of decades are shifting the power system paradigm, with renewable energy, BTM energy storage, energy efficiency, demand response, smart grid technologies, advanced metering, electrification of transportation and heating, and customer load management technologies changing the way the grid operates for the future.[77]

While smart rate designs differ from traditional rate designs in important ways, there are some similarities. For example, smart rate designs still differentiate between residential and business rate customers. Notably, for smart rate designs to succeed, the use of advanced metering infrastructure (AMI) is required.[78] Generally, a smart rate design contains a three-period time of use (TOU) rate: off-peak, mid-peak, and on-peak. For residential customers, there is a tiered customer charge. For business customers, there is a smaller demand charge than under a traditional rate design, and some of those costs that would otherwise show up in the per kW demand charge are shifted to the time varying kWh portion of the rate.[79] For peak times, when the grid really needs those resources for residential customers, there is a peak time rebate that encourages customers to reduce their usage or even export energy to the grid in those crucial times of need.[80] For commercial and industrial customers, a more traditional critical peak price would be appropriate (Figure 4).[81]

	Residential	Medium C&I
Customer charge ($/month)	Multifamily: $7 Small single-family: $12 Large single-family: $17	$40
Site infrastructure ($/kW)	N/A	$2
Off-peak (cents/kWh)	8 cents	7 cents
Mid-peak (cents/kWh)	14 cents	13 cents
On-peak (cents/kWh)	22 cents	21 cents
Critical peak (cents/kWh)	75 cents (peak-time rebate)	75 cents

Figure 4: Smart Rate Design for BTM Energy Storage. Source: RAP.

[73] Ibid.

[74] Ibid.

[75] According to NREL, load factor is defined as "the average electrical demand divided by the peak electrical demand."[75] NREL, Procedure for Measuring and Reporting Commercial Building Energy Performance (October 2005), at p. 14. Available at https://www.nrel.gov/docs/fy06osti/38601.pdf.

[76] RAP at slide 5.

[77] RAP at slide 8.

[78] RAP at slide 9.

[79] Ibid.

[80] Ibid.

[81] Ibid.

Over the long term, whether the customer is charging or discharging the battery in a BTM energy storage system, it is not cost-free to cycle the battery in terms of degradation.[82] As the BTM energy storage system degrades, it becomes less efficient, affecting the customer's ability to fully take advantage of cost-saving opportunities. Federal tax credits and other programs and initiatives, in combination with better rate designs and compensation structures, can help encourage adoption of BTM energy storage, taking into account all of the economic aspects of owning such a system.[83]

Customer Understanding and Satisfaction

Energy storage can be confusing. In order to effectively evaluate whether a BTM energy storage system is a good fit for a home or facility requires an understanding of utility charges and how they are applied.[84] As rates evolve from traditional structures to smarter designs, achieving customer understanding and satisfaction with more complex rates will be a significant undertaking. Utilities, public utility commissions, and state governments can provide basic explanations and educational materials to aid in this endeavor.[85] Data provision and online tools can also help customers better understand rates.[86] When transitioning to new rate designs, a gradual transition is crucial. For example, a utility may start with an opt-in model and move to an opt-out or mandatory model later on.[87] A utility may consider offering more complex rates for more sophisticated customers, such as commercial or industrial customers.[88] Shadow billing,[89] hold harmless protections,[90] and/or companion programs can be important as well.[91] Cost effective energy management technology programs can help with customer response and minimize negative bill impacts.[92]

What's Next?

Looking into the future, net metering reform will continue to impact the deployment of BTM energy storage by altering project economics. Through a focus on narrower netting periods[93] that incorporate

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[82] RAP at slide 2.

[83] Ibid.

[84] NREL, "When Does Energy Storage Make Sense? It Depends," February 25, 2018. Available at https://www.nrel.gov/state-local-tribal/blog/posts/when-does-energy-storage-make-sense-it-depends.html.

[85] RAP at slide 10.

[86] Ibid.

[87] Ibid.

[88] Ibid.

[89] According to RAP, "Under shadow billing, customers get a utility bill with two sections: one part of the bill that shows what they currently owe, and a second that's for informational purposes only—showing what the customer would have paid for the same electricity usage under a different rate structure, such as a TOU rate or critical peak rate." Janine Migden-Ostrander, RAP, "Utility 'Shadow Billing' Can Shed Light on Rate Options" (August 2017). Available at https://www.raponline.org/blog/utility-shadow-billing-can-shed-light-on-rate-options/.

[90] According to RAP, hold harmless protections ensure that customers can only benefit from new rate structures, and will not be harmed. Hold harmless protections can be useful when instituting TOU rates by insulating customers from unexpected and potentially unaffordable increases in utility bills. See RAP at slide 10.

[91] RAP at slide 10.

[92] Ibid.

[93] The netting period is the time period over which the utility measures the energy being imported to or exported from the grid. See U.S. DOE, Grid-Connected Renewable Energy Systems, Net Metering. Available at https://www.energy.gov/energysaver/grid-connected-renewable-energy-systems.

time-of-use, along with changes to import rates and export credits, there is an opportunity to improve compensation of BTM energy storage resources.[94] Additionally, public utility commissions are starting to see more transactive energy structures being proposed. Several years ago, New York adopted a value of distributed energy resources tariff. In California, there have recently been net metering reforms, moving toward a much more transactive and granular price structure for their net metering credits.[95]

Additionally, regarding the distribution flow charge, many commissions are contemplating whether customers should contribute to administrative and distribution system costs when they export energy to the grid. With the energy system transitioning to a two-way highway, there have been proposals to charge customers for distribution flow going both ways.[96]

Virtual Power Plants (VPPs) are also on the rise. For example, PG&E launched a VPP pilot program in California in which owners of Tesla Powerwalls could opt in and allow the utility to pull power from their batteries if necessary. On August 18, 2022, PG&E released a Flex Alert Request to participating Tesla Powerwall owners, warning them of an emergency response event and giving them the option to opt out if they decided not to allow the utility to pull their power. Almost 2,500 PG&E customers participated in what is being referred to as the largest distributed battery so far, delivering as much as 16.5 MW during the outage.[97]

The electric system of the future is certainly going to be different than in the past. A wide range of regulatory innovations will be needed to achieve the best results when it comes to the integration of renewable energy and BTM energy storage systems.[98] While rate design and net metering reforms can provide improved incentives for the use of BTM energy storage and other DERs, it will likely take significant work to implement these measures. In addition, we will likely need new analytical processes to guide these substantive ratemaking reforms.[99]

[94] RAP at slide 11.
[95] Ibid.
[96] Ibid.
[97] Tesla at slide 3.
[98] RAP at slide 12.
[99] Ibid.

Resources for More Detailed Information

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Summary of Webinar Q&A

As you were describing the concept of smart rate design, how specifically does behind-the-meter storage fit into this design? How necessary is customer education to seeing the benefits of storage?

Mark LeBel, RAP: People are installing storage for a wide variety of their own personal purposes. They are buying big pickup trucks with enormous batteries that serve a variety of the exact same purposes. There's a lot of things happening that regulators can't directly control. At the same time, these rate designs are justified on their own economic grounds. We've been talking about them for 50 or 100 years and couldn't implement them in the past, but now are enabled by new technologies. Decisions that commissions make on rate design and other related issues help encourage customer adoption of these resources and influence how they get operated.

That's just one of many feedback loops that we have going on here. The existence of energy storage as a resource helps make time varying rates worthwhile, and time varying rates improve the operation of those new resources as people adopt them. Any time we're making a change, customers get nervous. It is important to do it slowly. Gradualism is important. Education by the utilities, state agencies and other trusted groups help to smooth that process.

I have colleagues that have been asking for better rate designs for longer than I've been alive. We're finally starting to see some of those designs implemented across the country on a default basis. Michigan's been doing that rather slowly in a way that's been sensitive to customer concerns. All these things fit together - smarter economic rate designs and more flexible customers with storage and other resources that can help the system and provide value to all customers. Having all those things work together as a sort of a unified whole is the holy grail of what we're looking for here.

What are some things that you think about when you're trying to scale these storage programs?

Ryan Chan, PG&E: I mentioned previously in my presentation that we think a lot about not just the participants but the non-participants in the program. The money that funds our resiliency programs is funded through other ratepayers. We're really focused on lowering the pre-unit costs to really try to minimize that rate impact. When it comes to scaling specifically, we always try to pick up whatever economies of scale we can move from a pilot to a full program. There are those flat administrative costs that don't necessarily scale with volume. For example, you need a contract in place, you need some staff labor in place. This is what I call the wedding principle. Whether you have 10 people or 1000 people at a wedding, you need a DJ, you need a caterer, like there's like basic things that you need, regardless of how big the program is. We try to pick up those sorts of economies of scale, looking at things like bulk purchasing to try to drive better per unit costs. On the flip side, there are also things that need to be built in a pilot or smaller program. There's a lot of things that you can do manually because it's the cost to automate it and aren't necessarily justified when the quantities are really small.

But as you start scaling into hundreds or thousands of customers, there's too many risks or error by going through manual processes. So you have IT projects then which are very long and expensive. And other automation starts to become necessary when you start scaling into the thousands.

I think the other thing we think about with regards to scaling is just what is the messaging. A lot of what we've currently done right is really targeted certain circuits and areas of need, geographies, customer types and profiles. When we start to scale, a lot of that targeting is going to be diluted a little bit necessarily because there will just be a much larger customer base to draw from. So one of the challenges that we're thinking about is how do you speak directly to those customers' needs based on where they are and how they're wired?

You mentioned PG&E being one of the largest utilities. We have a very diverse customer set and our territory is very large, covering the Central Valley to the very mountainous areas. So there's a lot of different conditions, a lot of different customers, and those are the things that we think about when programs start expanding.

Are there any key utility policies that have helped BTM storage that PUCs across the country should be paying attention to or looking for in utility programs and rate design proposals that you have seen be successful?

Greg Thurnher, Tesla: Rate design that is sensitive to charging and discharging is always helpful. Time-of-use is probably the most vanilla flavor, but of course, net energy metering is not conducive to a program that encourages storage to proliferate or participate in grid programs.

Arushi Sharma Frank, Tesla: In terms of market incentives, the most success comes from a pretty short but very effective list. One is any rate design, whether it's a rate or a program that recognizes the value stack of storage. There's value and resiliency behind the meter for the customer. What does that mean? That the customer is able to manage their own home electricity needs in an outage, which means it's one less customer for the utility to be concerned about when there are issues on the distribution system. In storage programs, the first and most important incentive to get buy-in is with dollar incentives, or an upfront rebate to the customer at a value that is reflective of the value to the system and is useful to the customer given how much storage costs average to install.

There are also other elements of the value stack that become important. Greg alluded to this, but policies that acknowledge that when you add storage to a solar system and create a new and different value in a product that you can suddenly provide because you're not just on 24/7 energy. Now you have the ability as a residential customer to provide a resiliency capacity product, creating a value that is a piece of the value stack. That is important because it is something that can be leveraged by the utility system or by the grid operator to create the correct price signal for the customer to make a choice between using certain amounts of reserve power for themselves or exporting it to the system to help the community grid. That is exactly the value proposition of the PG&E ELRP program, for example.

Last but not least, kind of the third or most sophisticated version is emergency capacity events, Virtual Power Plant (VPP) events, essentially creating an additional value in the program design that will compensate the customer for being available when all other resources are exhausted or close to being exhausted. You're seeing this right now in ERCOT, in Texas, and you're seeing this in Puerto Rico, with constrained grids around the world where people are trying to figure out how to motivate a customer who has extra capacity and their storage system to sell some of the energy back to the electric grid to provide that emergency condition restoration. In addition to those policies, I think one of the most important pieces we're still facing around the country is a lack of education among homeowner associations around the requirements for behind the meter interconnection and typical inspection and permitting processes. Labor issues can also be an issue. It's hard sometimes to find the install crews you need to be able to accomplish the huge demand we have on a regional basis for residential behind-the-meter projects. One of the key pieces that has really helped in getting basic customer adoption is an interconnection ombudsman so that there can be one single point of accountability to handle the customer's interest in adopting storage all the way to the commissioning of the resource, and then enrolling them in whatever incentive programs or grid services programs are available.

This question is from Texas. How can we help local co-ops realize the benefits of residential storage? What is the best approach for getting utilities to agree to use the backup switch?

Greg Thurnher, Tesla: I think the co-op experience is unique to their service territory. The breadth and depth of their organization in a traditional T&D utility in a cooperative territory doesn't always have the same services available to them in terms of being able to aggregate. Having a supplier available to monetize that capacity, having a network of installers to rely upon, and there's a spectrum. Notice that the entity was from Texas and there's a spectrum of capabilities. I do believe that cooperatives when aggregated themselves tend to be more capable of responding to these opportunities and standardizing how they might implement them.

In terms of using the backup switch, that's always a challenge. I've found that device to be both expedient at installs, but also another way to make distributed storage grow more quickly. I didn't know that there was much reluctance to use it outside of the general utility mantra that is, for those of you that aren't familiar with the backup switch, you pull the meter and install what we refer to as a collar that sits in the customer's meter pan and then accepts the utility meter. There's always a reluctance to removing and reinstalling a utility asset by anyone other than a utility employee or their designated contractors. I do think that education around the capabilities and the expedience of that installation are critical to its adoption.

Arushi Sharma Frank, Tesla: Just for context, the backup switch one of many meter collar devices that have the impact of essentially avoiding rip out, up to 60 wire terminations don't have to be ripped out when a whole home backup installation is performed. These are being used by companies like Tesla. We have the backup switch. Other entities are using the ConnectDER device, which is also a meter collar. Solar transfer switches operate similarly to disconnect devices and meter collars like the Tesla backup switch. On average, we are saving hours, sometimes a day of install time and install effort from labor crews, and we are eliminating truck rolls.

PG&E is one of the primary adopters of the Tesla backup switch. It went through extensive testing as part of the approval process. And the savings for customers are immense. Install costs remain one of the largest components of adopting behind-the-meter storage.

With co-ops, with municipal entities, with cities, I think citizen leadership and advocacy about what customers want is really important because when it comes to coming up with the innovation needed to push something new forward, this is just time and time again with any new product, any new technology, it all starts with what customers want. In that space OEMs are completely aligned with utilities and trying to figure out what the least-cost solution is and having awareness of that all the way to the regulatory level, whether it's a co-op board, whether it's the city government, or for an IOU it's the state regulatory entity, that's just absolutely critical. I think it's really important for utilities to have these educational opportunities and also be able to communicate that yes, they are working on these incredibly innovative projects to save customers money on their installs, and just to support resiliency in their communities. I think the partnerships of the kind that we've had with utilities like PG&E have been role models.

Can you address the challenge of deploying BTM energy storage for multifamily housing?

Mark LeBel, RAP: At a high level, this is a notorious problem across all energy technologies, where the landlord owns the asset. It is at best a collective action problem where everyone has to agree to do something, or at worst, you have transient renters who don't care about the long-term energy profile of the building and a landlord who doesn't care because their renter pays the energy bills. Some changes to how federal tax credits work are supposed to start helping some of these problems with transferability and monetization by different types of entities.

With solar, there's been a lot of attention to community solar and other slightly different regulatory frameworks. One hard thing in this context is that you've encouraged the elimination of master metering. You have one meter for each department, or each housing unit, which makes it much harder to install storage assets for individual entities in the common space near the meter. Multifamily housing basements are not super roomy where there's lots of room to install new things. I would encourage people to start to look into this, but this is a notorious regulatory and public policy issue.

Ryan Chan, PG&E: As I was thinking about this question, I was thinking there's nothing specific to storage that makes it any more or less difficult than any other DERs in multifamily. It's the age old question of who pays and who benefits?

Greg Thurnher, Tesla: This is a tough question to go third on, but I'll just say I agree with the other panelists and that somebody's got to make that investment. It's either the owner, the occupant, or the utility. And we've had a unique challenge in the competitive retail space where that relationship with the customer is potentially transient. Some retailers and competitive areas of Texas made the election to subsidize thermostats as a way to retain that customer. That's a different value proposition for a $100 Google Nest than it is for a $10,000 Tesla Powerwall. We've been shifting some of our focus to the vertically integrated utility, where at least the utility decides to subsidize that device, like a Green Mountain Power or a PG&E, can follow the value stream between transient occupants, which lends itself a little bit more to multifamily than then to single family, perhaps realizing value from the benefit of rolling one truck or multiple trucks to one site.

Arushi Sharma Frank, Tesla: I totally agree. I think this is a really ripe area. Multifamily poses all of those practical challenges. Utility ownership and rate-based solutions that are targeted around primary use case for the utility to be able to serve its peak needs and then providing additional resiliency benefits to the property owner that can be spread among tenants is really ripe for exploration as a business model. Companies like PearlX and Armada have been working with low-income housing projects around the country and really in Texas to try to make those work, and I think there's a ton of room for innovation there.

Mark LeBel, RAP: One thing to add is that there's lots of room in rate design to pay attention to multifamily housing in general. There are actually good cost reasons to think per customer, they're cheaper to serve because they all share a service job.