Maximizing the Grid Benefits of Behind-the-Meter Energy Storage

Four financial signals can unlock the value of distributed energy storage systems

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The CPUC determined that utilities should procure a total of 1,325 megawatts (MW) of energy storage systems by 2020 and that systems funded through California's Self-Generation Incentive Program would count toward this goal.

California became the first state to mandate energy storage procurement targets with approval of Assembly Bill (AB) 2514 in 2010. It required the California Public Utilities Commission (CPUC) to determine appropriate energy storage procurement targets for each load-serving entity, or utility, with the objectives that energy storage would either reduce greenhouse gas (GHG) emissions, reduce peak electric demand, defer or substitute investments in generation or grid assets, or improve grid reliability.

Subsequently, the CPUC determined that utilities should procure a total of 1,325 megawatts (MW) of energy storage systems by 2020 and that systems funded through California's Self-Generation Incentive Program would count toward this goal. Since 2011, the program has funded more than 71 MW of behind-the-meter energy storage projects, with an additional 40 MW in the queue, all of which will count toward California's energy storage procurement goals.

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However, due to the nascent nature of the energy storage industry and the policies governing energy storage operation, behind-the-meter energy storage systems have experienced challenges in maximizing their value to the grid. Regulatory reforms, such as tariff design, expanded utility demand response programs and procurement contracts, as well as increased access to wholesale markets could allow these systems to better accomplish the desired environmental and grid objectives outlined in AB 2514.

We investigate four broad regulatory changes that may allow behind-the-meter storage systems to better achieve AB 2514's objectives. Our intent is to inform and assist policymakers, utilities and other stakeholders in establishing clear expectations and goals for behind-the-meter energy storage, which would allow these technologies to play a more effective role in decarbonizing our electricity system and increasing the efficiency and reliability of the grid. The policy recommendations are meant to be applicable not only within California but to any entities seeking to integrate behind-the-meter energy storage into their energy system, whether at the local, state or national level.

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Introduction

California's Self-Generation Incentive Program (SGIP) is the nation's longest running incentive program to support existing, new and emerging distributed energy resources (DERs). The SGIP provides incentives for qualifying DER systems installed on the customer's side of the utility meter (behind-the-meter), including wind turbines, waste heat to power technologies, pressure reduction turbines, internal combustion engines, microturbines, gas turbines, fuel cells and advanced energy storage. Two primary goals of the program are to reduce peak demand and greenhouse gas (GHG) emissions.

Each year, the SGIP conducts an impact evaluation report of the performance of projects in accomplishing program goals. The most recent report for 2014-15 (released late 2016) found that certain energy storage systems funded through the program had increased both GHG emissions and peak demand in the state, thus indicating that energy storage systems overall did not accomplish the SGIP goals during the evaluated period. While various data methodologies and analyses might yield different results, this evaluation raises important questions that must be answered if behind-the-meter storage is to provide maximum benefits. This paper specifically addresses why behind-the-meter storage systems might not operate in ways that are beneficial to the grid and what policy reforms are needed and most integral to maximize their value to both customers and the grid.

Current Operation of Behind-the-Meter Energy Storage

To address the effectiveness of behind-the-meter storage systems, it is necessary to understand the primary motivation for energy storage operation: maximum financial return. To accomplish this goal, energy storage management systems are designed to operate on financial signals. A project developer's top priority, which is typically contractually binding, is to maximize the financial benefits of the system to the customer based on the customer's utility tariff and/or other financial signals, such as participation in demand

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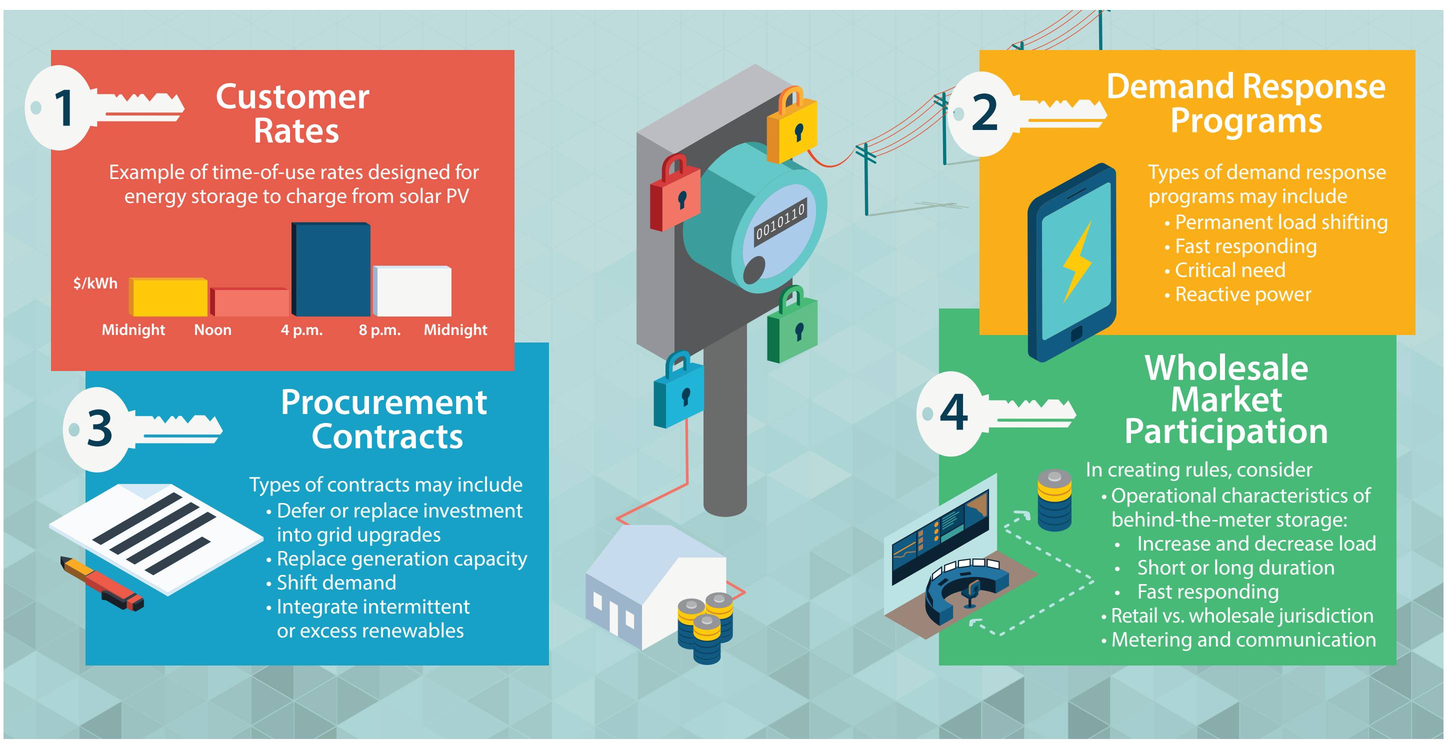
response programs or operational contracts with a utility, if available. If these financial signals are available, then the storage management system will consider them in its operation and respond to the signal that yields the highest financial return.

For example, if a utility calls on a storage system to charge during the peak hours of the customer's tariff, the storage management system will weigh the financial return of the utility payment versus the costs incurred by charging at peak hours and respond to the signal with the most financial gain. Thus, energy storage management systems are designed to operate in ways that will result in the customer's highest financial return, which may or may not coincide with ways that are beneficial to the grid. Consequently, when the financial signals are either not in place or are not lucrative enough to encourage behind-the-meter storage systems to operate in ways, places or at times that provide the most benefit to the grid, then these storage systems will not be operated to provide these benefits. Conversely, when financial signals that encourage efficient operation of storage systems are in place, then behind-the-meter storage can provide numerous benefits to the grid while maintaining their value to host customers.

Accordingly, this paper investigates four principal financial signals – tariffs, utility demand response programs, utility procurement contracts and direct wholesale market participation – that can be developed and implemented by local, state and national entities to promote more efficient uses of behind-the-meter energy storage systems. While these four financial signals are not the only possibilities, they are readily available in many jurisdictions and could be implemented in the near term.

Fig. 1 Unlocking the Value of Behind-the-Meter Energy Storage to the Customer and the Grid



Financial Signal #1: Tariffs

Tariffs, or utility rates, are the most widely used and perhaps most effective methods to incentivize customers to manage the timing of their energy consumption. Properly designed tariffs send price signals to customers letting them know when and how they should use electricity.

As energy storage systems are designed to operate according to price signals, utility tariffs can be designed to allow energy storage systems to accomplish specific functions. For example, if a utility experiences daily or seasonal peaks in electricity demand, tariffs such as coincident peak demand charges or peak energy prices can be designed to encourage energy storage systems to shift peak demand to off-peak hours. Properly designed tariffs will send price signals to energy storage systems, indicating how and when these systems should be operated to produce the most benefit for the grid and, consequently, the customer.

Additionally, tariffs should give customers and energy storage project developers certainty as to near-term future rates. Most behind-the-meter storage systems installed in California have warranties for ten years, so host customers must be certain they will achieve financial payback for the system over the ten years. If rates change drastically every couple of years, they will not provide project developers or customers the financial assurance required to install projects. Thus, tariffs should be designed to be stable to give project developers and customers insight into the future economics of the systems they install.

Financial Signal #2: Utility Demand Response Programs

Demand response programs provide opportunities for energy storage to offer significant value to the grid. Demand response programs have the advantage over tariffs of being much more dynamic and specific to the needs of the grid, especially in critical locations. For example, customers participating in demand response programs in critical areas might receive a higher payment for responding to demand response events, or programs might be designed specifically to address certain areas of the grid. Because energy storage can both increase and decrease load, storage could be called upon to charge if there is excess generation on a specific feeder and then discharge the energy later when needed. Further, many behind-the-meter project developers maintain operation of the storage systems they install, so they can aggregate multiple systems located at different customer properties and operate them as a fleet. The result is many smaller systems acting as a single large system, increasing their effect of participating in demand response programs. Moreover, demand response programs can be created for both real and reactive power, leveraging energy storage systems installed with smart inverters capable of providing and absorbing reactive power.

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Demand response programs must consider the type of communication and metering that will be allowed or required to participate. Additional meters or communication protocols might not pose a financial burden for large energy storage systems but can be expensive and cost-prohibitive for smaller energy storage systems. While each system should be able to accurately meter and provide data, programs must find a balance between the type and cost of metering required so that this does not become a barrier to participation in the program.

> Storage management systems are designed to respond to the financial signal that will yield the greatest return for the customer, so the actions that are most needed, whether charging during peak hours or other actions, should receive the highest payment.

All demand response programs should consider the customer's tariff when sending signals to program participants and should offer enough financial reward to make participation in the demand response program plausible if the demand response signal is contrary to the customer's utility tariff. For example, if storage systems located on a specific feeder are asked to charge during a customer's on-peak hours, payment for participation in the event should compensate any additional energy or demand charges incurred due to participating in the event. Storage management systems are designed to respond to the financial signal that will yield the greatest return for the customer, so the actions that are most needed, whether charging during peak hours or other actions, should receive the highest payment.

Energy storage could participate in different types of demand response programs. Following are brief descriptions of demand response designed for permanent load shifting, fast responding, critical need and reactive power.

Permanent Load Shifting

In this paper, permanent load shifting is defined as shifting hours of peak demand to off-peak hours on a regular basis. These programs may have more definite expectations of when the systems should be operating, how much load will be shifted and how much the systems will be paid for participation. Depending on the needs of the grid, permanent load shifting programs can be designed to shift load every day or only during certain seasons, such as shifting seasonal peak demand. Long-duration storage technologies can be used in demand response programs that seek to shift hours of peak energy to off-peak hours. Permanent load shifting programs can be especially beneficial to the grid in areas that experience very high seasonal peaks and require building peaker plants to provide additional generation. Energy storage systems capable of flattening out the load by shifting hours of peak demand to off-peak hours reduce the need to build and operate peaker plants and greatly increase the efficiency of the grid.

Fast Responding

Fast-responding demand response programs can fluctuate in the times and durations of demand response events. These types of programs can call upon energy storage systems to respond to a demand response event with short notice, such as a day, hours or minutes before the event. Many types of energy storage systems have nearly instantaneous response time to signals and are especially well suited for these types of demand response programs. These types of programs can be used to help mitigate unexpected variance in electricity supply and demand or other unexpected changes to the grid. These programs may be designed more around providing ancillary services to the grid rather than bulk energy shifting.

Critical Need

Critical need demand response programs can be designed for specific parts of the grid that face unique challenges or for times when the grid needs additional support. For example, certain feeders might house large amounts of behind-the-meter solar photovoltaics (PV) and experience high amounts of overgeneration during early afternoon hours, compromising the efficiency and reliability of the grid in that area. Conversely, parts of the grid might be chronically congested and need relief. Behind-the-meter storage systems located in critical areas can be called upon to charge or discharge during times that will increase the reliability and efficiency of the grid. Critical peak pricing programs can also be created for days forecasted to have abnormally high demand. During such days, the utility could offer lower than normal off-peak prices and higher than normal on-peak prices to encourage storage systems to shift demand from on- to off-peak.

Reactive Power

Energy storage systems that use smart inverters capable of producing and absorbing reactive power could be called upon to assist the traditional methods of maintaining and controlling reactive power on the grid. Such systems could support and increase the reliability and resiliency of the distribution grid.

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Financial Signal #3: Procurement Contracts

Utility contracts can be used to procure energy storage systems that will operate to achieve specific purposes. Looking at the near- and long-term needs of the grid, utility contracts can be designed to procure cost-effective behind-the-meter energy storage systems that meet these needs. Similarly, with projects participating in demand response programs, individual storage projects located at different customer sites can be aggregated and controlled as a fleet when participating in procurement contracts. These contracts are typically very attractive for project developers as they offer specific terms and conditions and bankable financial return, whereas tariffs or demand response programs might not offer such features. Additionally, contracts offer a firm commitment from storage system operators to utilities so that utilities can depend on these resources.

Contracts for energy storage procurement may be used to accomplish numerous goals.

- Defer or replace investment into grid upgrades
- Replace peak generation capacity
- Shift peak demand to off-peak
- Provide load reduction when called upon by the utility
- Integrate excess renewable generation

Contracts must be long-term to provide financial assurance to project developers. Given that most behind-the-meter storage projects are expected to operate for ten years, contracts with a ten-year term will provide much more financial reassurance than contracts with shorter terms. Due to the dynamic nature of energy storage, there are many types of use cases that energy storage can provide through contracts.

Procurement contracts are sporadically offered and typically not available to all customers but only to those that are awarded. Thus, procurement contracts do not offer as wide of participation as tariffs or demand response programs. Additionally, depending on the services the energy storage system is providing or as part of the contract design, these systems may not be able to provide other additional services to the grid beyond what the contract specifies. As much as possible, procurement contracts should be designed so that energy storage systems can still provide other services that add incremental value to the grid, such as participating in demand response programs or in the wholesale market, beyond simply meeting the requirements of the procurement contract.

Financial Signal #4: Participation in Wholesale Markets

Many energy storage technologies can respond almost instantly to signals to charge or discharge energy, making these technologies good candidates to provide ancillary services such as frequency regulation.

Where available, wholesale market participation is another opportunity for behind-the-meter energy storage to provide value to the grid. Wholesale markets send price signals that can be roughly equated to the needs of the grid; low prices can signal low electrical demand while high prices can signal high electrical demand and the need to bring new generation resources online to meet demand. Energy storage can take advantage of these opportunities by charging when prices are low and generation is relatively abundant and discharging when prices are higher, thus reducing the need to generate additional energy. Furthermore, many energy storage technologies can respond almost instantly to signals to charge or discharge energy, making these technologies good candidates to provide ancillary services such as frequency regulation.

Regrettably, many wholesale rules regarding operation, metering and communication were designed for large generators that can produce but cannot absorb energy. Wholesale resources must typically use wholesale-grade meters and communication software, which might be cost-prohibitive for individual behind-the-meter resources. Consequently, some wholesale market rules may not apply to energy storage systems or may in fact prevent these technologies from wholesale market participation. Furthermore, given that behind-the-meter resources are subject to retail jurisdiction, jurisdictional lines between retail and wholesale jurisdiction may become blurred when these projects participate in wholesale markets. Thus, incorporating behind-the-meter storage technologies into wholesale markets presents a unique set of challenges that wholesale markets and state agencies must consider and resolve.

Wholesale market rules should consider the technical capabilities and differences between behind-the-meter storage systems and large, central generators. For example, behind-the-meter energy storage technologies typically do not discharge energy to the distribution grid but rather discharge to the on-site load.[1] Thus, their participation in wholesale markets is typically seen in the form of load reduction rather than exporting electricity to the grid. Additionally, not all energy storage technologies discharge energy in the form

1 If solar PV is located on site, the solar PV might export to the grid; therefore, the site where the storage is located might discharge to the grid. But storage systems are typically designed to discharge when on-site load is high, not when it is low or nonexistent.

of electricity. Thermal energy storage technologies can discharge thermal energy to provide hot water, hot air, cool air, refrigeration or other services that offset the need to consume electricity to provide those same services. These few examples highlight the fact that behind-the-meter energy storage operates much differently than large, transmission-tied generators, and these characteristics should be considered in developing rules for energy storage technologies.

Wholesale markets should coordinate with state agencies so that questions regarding jurisdiction, interconnection or wholesale and retail rates can be resolved efficiently.

Final Considerations

Customer tariffs, demand response programs, procurement contracts and wholesale market participation are not independent of each other. A single resource can participate and be affected by several, if not all, of these financial signals, and payments for services should be made accordingly for any additional value that storage systems provide. The overarching goal should be to grant storage systems more opportunities to provide their value and compensate them for doing so. "Double payment," or paying storage systems through multiple value streams for the same services already provided, should be given higher consideration in payment design. Accurate metering and clear communication protocols could be used to measure and verify which services are provided and which payments are therefore needed.

Moreover, data access and communication are imperative to successfully implementing these measures. The better the data and information accessibility and the more streamlined and practical the communication protocols, the more successful each measure will be. Data access and streamlined communication protocols can let project developers know exactly where in the grid projects should be located, what functions storage systems should be performing (such as amount and duration of charge or discharge) and the exact timing of these functions in order to provide the most value to the grid.

Behind-the-meter storage systems will respond to the signals that provide the highest financial return. Thus, the financial return should be highest for the services that are most needed to encourage systems to provide these services. In implementing price signals that encourage behind-the-meter storage systems to respond to grid needs, these systems can be used to provide the greatest value at places and times that most need it to the benefit of host customers, the grid and all ratepayers.

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