Title

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Authors

Kramer, Hannah

Tang, Rui

Brown, Richard

et al.

Publication Date

2024-01-04

Peer reviewed

Lawrence Berkeley National Laboratory

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Hannah Kramer, Rui Tang, Richard Brown, Jessica Granderson, Claire Curtin

Lawrence Berkeley National Laboratory

Energy Technologies Area
March 2020

Market Brief: Customer-sited Distributed Energy Resources

Building Technology and Urban Systems Division

Lawrence Berkeley National Laboratory

Prepared by:

Hannah Kramer, Rui Tang, Richard Brown, Jessica Granderson, Claire Curtin

Prepared for:

Heather Goetsch, U.S. Department of Energy

March 2020

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Acknowledgement

This work was supported by the Assistant Secretary for Energy Efficiency and Renewable Energy, Building Technologies Office, of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231. The authors thank Eliot Crowe, Andrew Satchwell, and Gerald Robinson of Lawrence Berkeley National Laboratory and each of the vendors and building owners who were interviewed for this market brief.

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1. Introduction

Building owners are becoming increasingly aware of opportunities to install distributed energy resources (DERs) on their properties, also frequently referred to as *behind-the-meter distributed energy resources*. DER technologies are primarily used to help owners manage building electric loads. Customer-sited DERs may include on-site generation, such as solar photovoltaics (PV) and combined heat and power (CHP) plants, as well as battery or thermal storage. The use of flexible building loads—such as shedding or shifting heating, ventilation, and air conditioning (HVAC) or lighting loads to manage demand—is also considered a type of DER. Further, it is common for DERs to include energy efficiency as a primary way to reduce loads, even though the reductions in load are not usually dispatchable. Electric vehicle charging is an emerging DER; flexible, "smart" charging will become more necessary as electric vehicles gain market share.

To clarify the features of evolving DER systems, this market brief presents an introductory landscape of customer-sited DER solutions. Its primary audience is building owners and facility managers in the commercial buildings sector who are looking to understand the currently available market associated with customer-sited DER products and services. The market brief is a snapshot of the current landscape and does not cover all potential customer-sited DER solutions or providers.

The advent of DERs is changing the way power is generated and transmitted to the electric grid [1]. Distributed energy resources utilize "small, modular, energy generation and storage technologies that provide electric capacity or energy where you need it" [2]. These resources can either reduce demand or provide supply to satisfy the energy, capacity, and other balancing needs of the distribution grid [3]. All grid-tied DER systems are situated either "in-front-of-the-meter" or "behind-the-meter" [4].

- A behind-the-meter (BTM) DER system provides power that can be used on site and is typically tied into the electric grid. In this document, BTM DER systems will be referred to as *customer-sited DERs*.
- In-front-of-the-meter DER systems are assets generally owned by a utility or large-scale DER provider, and the control systems for these assets are referred to as *distributed energy management systems* (DERMS) [5].

DER systems are starting to proliferate in many regions of the United States and around the world. In 2016, DERs accounted for about 2 percent of the installed generation capacity in the United States [6]. By 2015, California had more than 7,000 megawatts (MW) of installed DER capacity [7, 8] and had set a target to integrate more than 12,000 MW of DERs by 2020 [6]. Numerous technology, policy, and customer-driven factors contribute to this growth. In addition to declining costs of DER technologies and increasingly available incentives, factors such as customer desire for self-supply, price certainty, and environmental stewardship point to ongoing DER growth.

As DER deployment grows, there is a need to manage the power dispatch of DER systems effectively, to avoid detrimental effects on the grid, such as steep load ramps during midday due to increasing solar generation. Grid-interactive efficient buildings (GEB) provide distributed generation, dispatchable battery/thermal storage, and building load management when needed to minimize utility costs for owners and support overall electric grid function.

This market brief summarizes key takeaways from interviews with vendors and service providers in one or more areas of the DER market: DER controls, battery storage, solar photovoltaic, thermal energy storage, combined heat and power, flexible building loads, and electric vehicle charging. Back-up generators used only in emergencies are not in the scope of this market brief.

2. Background on value streams and market incentives

The value of DERs to customers depends on the market opportunities available in their region, as well as the DERs selected and their configuration. There are four main categories of value streams [9]:

- **Energy bill savings:** DERs can be utilized to reduce peak demand charges by "clipping" the peaks or to save energy costs by using stored energy when prices are high. Energy efficiency measures also result in energy cost savings.
- **Resiliency and reliability:** The stored energy and distributed generation can be used for back-up power for critical loads during grid outages.
- **Revenue opportunities:** Owners can earn revenue through participation in demand response programs and wholesale capacity and ancillary products using their DERs.
- **Carbon reduction:** DERs can support the integration of intermittent renewables, so more renewable energy can be utilized on site. The size of a PV installation can be increased when batteries are used to store the excess renewable energy, which is especially desirable when customers are not allowed to export excess power to the grid.

The level of importance of these value streams depends on an owner's utility tariff and the wholesale market rules in their area which determine how these value streams are monetized for the customer. Additional monetary value may come from utility programs and avoided business losses upon a grid outage. Some value streams, like carbon reduction and reliability value are not explicitly compensated.

Value streams can compete when a DER can be used for multiple purposes [10]. For instance, when battery storage is used to manage a customer's demand charges and the battery is also used to participate in other revenue opportunities like demand response or ancillary services, a portion of the battery capacity must be reserved for each function. The relative cost savings or revenue benefits of any competing value streams should be considered.

Table 1 shows customer benefits related to various DER investments. Combining DERs can sometimes result in greater than additive benefits. In a recent study, demand savings were modeled for solar-only installations, battery-only installations, and combined solar PV and battery storage installations. The combined solar PV and battery storage models resulted in a greater reduction in demand than the sum of demand savings that solar and battery storage each achieved alone [11]. There are also combinations of DERs that compete. For example, adding energy efficiency can reduce the amount of shiftable and sheddable load available as a demand response resource. Incentives and tariffs dictate a customer's strategy and the resulting benefits, especially for solar + storage combinations. The most common financial benefits from shifting or shedding load include peak demand cost reduction, energy arbitrage (shift energy to lower time-of-use rates), and payments from demand response programs.

Table 1. Opportunities for owners with DER investments

DER Investment	Opportunities
Solar PV	• Offset the need for grid power during the day • Zero carbon emission renewable energy generation
Battery Storage	• Dispatch battery storage to reduce facility peak demand • Charge battery with solar or when utility rates are low • Store energy from solar to use when energy rates are high • Provide back-up power for resiliency when the grid is down
Thermal Energy Storage	• Make ice or cold water when utility rates are low, to serve thermal loads when rates are high • Pre-cool thermal mass (building mass or refrigerated product)
Combined Heat and Power (CHP)	• Supply electric base load with on-site generation • Serve heating loads with waste heat from power production • Typically uses gas turbines, although fuel cells are becoming more prevalent as a lower-carbon alternative • Provide back-up power for resiliency when the grid is down
Flexible Building HVAC and Lighting Loads	• Automated or semi-automated building controls to shed or shift loads, reducing facility peak demand charges • Revenue through participation in utility demand response programs
EV Charging	• Customer/building occupant need for access to EV charging • Charge during low electric rates or during excess solar production on site • DER optimization may control the timing of EV charging to reduce demand

Three main areas for DER financial value streams include retail markets, wholesale markets, and utility programs.

Retail markets

The purchase and sale of electricity from utilities to commercial business owners occurs in the retail electricity market. In retail markets, demand management is typically accomplished in response to retail electricity rates and tariffs using peak demand charges, energy charges based on the time of day, and net energy metering regulations.

- **Peak demand reduction:** This is limiting peak demand to reduce utility demand charges. High peak demand charges (typically charged at the highest 15- or 30-minute average demand for the month) incent owners to reduce peaks.
- **Energy arbitrage:** In the case of DERs, *energy arbitrage* refers to charging battery or thermal storage when time-of-use (TOU) electricity prices are low, and discharging when prices are high, to reduce energy costs. High TOU energy charges encourage owners to shift energy use from high- to low-price time periods.

- **Net energy metering:** This metering policy allows owners with DERs to use the energy at any time by exporting it to the grid when they produce excess energy and importing it from the grid when they cannot meet on-site energy needs. On-site generation compensation rules are evolving; for example, whether or not net export to the grid is allowed, and how much the utility will pay for net export of energy (i.e., a retail rate or a designated grid-export rate). Net metering may be allowed at different time intervals. Some net metering rules require the energy to be used on site within the month it was generated, and others within the year. These rules have important financial and system sizing implications. Net energy metering an evolving and contentious area of retail rate design [12].

Wholesale markets

Wholesale markets include capacity markets, energy markets, and ancillary services. Currently, use of DERs in wholesale markets are emerging as specific rules for use of DERs are developed.

- **Capacity markets:** Capacity markets (or *forward markets*) ensure that power will be available to meet demand in the future. Capacity providers are paid for the power that they will make available, whether this power is in fact dispatched by the utility. Capacity providers include power plants, battery storage, and capacity provided by demand reduction.
- **Energy markets:** Electricity is sold as a commodity in energy markets to load serving entities.
- **Ancillary services:** Ancillary services help maintain the balance between real-time supply and demand. These services may include frequency regulation and operating reserves, which support the stability and reliability of the grid.

Grid operators want to ensure that DERs can meet the desired response rate for load reduction when dispatched. Rules around availability of the resource may also apply (e.g., year-round versus seasonal), which can affect which DERs are allowed. The level of visibility of distribution system operations to the utility also affects DER use. For example, the utility needs to maintain voltage within the distribution system, and the level of monitoring in place will affect its ability to reliably integrate DERs into the distribution grid and/or use DERs for ancillary services.

Utility programs

Revenue from utility program incentives are a value stream available to owners based on their utility territory's offerings. Demand response programs and virtual power plant programs are evolving to allow for DER participation. Additional incentives from programs that support energy efficiency or renewable generation can significantly boost the business case for DER implementation.

- **Demand response programs:** Building owners are asked to reduce demand based on event-based requests from utilities or grid operators**.** Owners receive payments through price- or incentive-based programs depending on the level of curtailment of building loads during peak event times. Traditional demand response and emergency load relief programs may allow DERs to participate if response criteria are met.
- **Virtual power plant programs:** Virtual power plants are an emerging market mechanism in which customer-sited DERs are aggregated from several different customers and operated by a third party that responds to utility calls for demand reductions, generally using a centralized control for battery storage discharge across their fleet. Virtual power plant programs are not widespread yet in the United States but are gaining traction in Southern California. These types of programs will provide an additional financial value stream for DERs that qualify.

The ideal environment for favorable DER economics includes utilities that have high peak demand charges [13], or locations that offer time-of-use and critical peak pricing rates for commercial customers. Peak demand reduction heavily depends on a customer's load profile, their utility tariff, and the combination of DERs employed. Opportunities for DERs to benefit from additional financial value streams, such as participation in wholesale markets and utility programs, are also important factors in determining the financial feasibility of customer-sited DERs.

3. Methodology

This market brief was created based on a literature review of research reports, vendor information, and interviews with 15 DER solutions providers and 5 commercial building facility managers. DER solutions providers were identified based on the following factors:

- Diversity across defining characteristics to illustrate market breadth
- Demonstrated use in commercial buildings, with emphasis on selecting providers that focus on battery storage solutions, due to the rapid growth of this technology
- Willingness and ability to share information necessary for a full characterization

Selection of DER solutions providers for interview does not constitute an endorsement or recommendation. The vendors interviewed are not intended to be a comprehensive view of the market, and the absence of a given product does not imply a negative assessment.

The interviews were conducted to provide a general overview of products and services (including product delivery models), how the DERs are controlled, which DERs are typically integrated, most common owner use-cases, and the benefits and barriers to implementation. The vendors interviewed and the survey questions used are found in the Appendix.

4. Customer-sited DER market findings

This section provides a current snapshot of an evolving customer-sited DER market. The market characterization focuses on the following areas:

- Coordinated optimization of DERs
- Project phases and contracting
- DER solution providers
- Additional providers in the customer-sited DER market
- DER optimization software products
- Integrating building loads into DER optimization

4.1 Coordinated optimization of DERs

During this research, we did not find consistent terminology used for the software that manages and optimizes customer-sited DER systems; however, the terms *DER optimization, DER optimization controls,* and *DER co-optimization* were most often used. In this report, the term *DER optimization* will be used to describe the control system used to monitor and/or control energy production, charge and discharge storage, and send signals to curtail building loads.

DER optimization strategies may incorporate data inputs such as:

- Energy price and demand charge per the customer's rate schedule, and forecasted energy prices when participating in real-time hourly energy markets
- Building load models: forecasts based on historical weather and building load data and projected future weather and other building events
- Solar production forecast
- CHP plant production forecast
- Equipment performance curves based on historical data
- DER resource availability: planned equipment maintenance schedules and constraints to building load shedding
- Market participation rules and incentive requirements, including investment tax credits (ITC)[1]
- Value of the back-up reserve (the cost to the business if the grid went down)
- Grid operator or aggregator dispatch signal for demand response
- Real-time carbon emission intensity from the customer's grid-sourced energy provider

Using these inputs, the software analyzes an optimal charge or discharge for battery or thermal storage, may dispatch or curtail EV charging stations, and may send signals to the building to shed or shift loads. The approaches that are employed in DER optimization control algorithms are generally proprietary.

4.2 Project phases and contracting

Many parties are involved in a successful customer-sited DER implementation, including the owner, project developer, financier, software developer, engineering/EPC (engineering, procurement, and construction) contractor, system integrator, operations and maintenance (O&M) service provider, software provider, and utility. Each participant has a role in the phases of design, financing, construction/commissioning (Cx), and operations. Table 2 shows the actions and responsibilities generally assigned to each role. The owner of the system in many cases is the project financier, as is the case with power purchase agreements and energy-as-a-service contracts.

In practice, the DER project roles in Table 2 are often combined to allow the customer to work with a single integrated DER solution provider. DER solution providers are responsible for project development (including financing), hiring the EPC and systems integrator, and often operating and maintaining the DERs. Some DER solution providers also own the DER systems and sell the energy produced to their customers. DER optimization software may be developed by the DER solutions provider or another software provider.

Utilities can drive customer-sited DER investment through incentive programs and adoption of market mechanisms that increase DER value. Utilities are also key in the interconnection process and any required grid upgrades that the owner is responsible for installing, along with the customer-sited DER,

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[1] The investment tax credit can be applied to renewable generation as well as storage. Energy storage can receive a 30 percent tax credit of the cost of the system if the storage is charged more than 75 percent of the time using renewable energy.

which can greatly affect project timelines cost effectiveness. The time frame for planning and installing a DER system varies from six months to well over a year, depending on the size and complexity of the installation and interconnection timelines.

Table 2. Roles in the DER project phases

	Design	Financing	Construction/Cx	Operations
Owner	Define desired DER investments and location on site	Determine desired financing approach	Identify appropriate tie-ins to existing electrical and mechanical systems	Participation in markets and utility programs with DERs
Project Developer	Bring together all parties; hire engineers	Provide financing and contracting; financier may own the DER system	Oversee construction and execution of design intent	Guarantee savings and performance; may own, operate, and maintain DERs
Engineering Procurement & Construction	Determine grid tie-in and interconnection agreement with the utility. Obtain building permits.	Perform cost estimation	Help procure and construct DER equipment	Warranty phase system analysis
Systems Integrator	Develop controls and integration design documents for optimization of DERs	*N/A*	Commission (Cx) the control sequences and make sure DERs are working together	Control and monitoring services. Portal for owners to visualize and analyze system operation
O&M Service Provider	*N/A*	*N/A*	Oversee Cx of DERs	O&M services for DER system
DER Optimization Software Developer	Work with engineering to incorporate specs for DER equipment; simulate results	*N/A*	Implement control algorithms for DER optimization	Warranty phase analysis; software maintenance/technical support
Utility	Publish rules regarding generation export to grid	Offer incentives; offset first costs	Interconnection process and potential grid upgrades	Price signals (peak demand charges, TOU pricing); incentives for DR; wholesale markets (utility dispatch of BTM resources)

Table 3 lists contracting structures that currently exist for DER implementation. The contract structures are classified based on who owns the system and which party controls the system. There are five models available in the market, however, power purchase agreements (PPA) and energy-as-a-service (or holistic energy management) have become common since the owner does not need to make a capital investment. Energy-as-a-service covers multiple aspects of services to customers, spanning from energy audits and efficiency to system control and cost savings.

Table 3. Potential contract structures for DER projects

Model	Ownership	Control	Notes
Sale/Lease	Customer	Customer/Developer	Gives the customer the control over the system, but the customer assumes most of the technical and business risk.
Power Purchase Agreement (PPA) or Shared Savings	Third-Party Owner (TPO)	Customer/ Developer	Customer is charged based on services (kilowatts [kW], kilowatt-hours [kWh], reactive power) or based on a percentage of the bill savings. Generally, no or low money down, and transfers most risks to the vendor. May limit the cost-effectiveness of future energy efficiency upgrades.
Holistic Energy Management/Energy-as-a-Service	TPO	Developer	Complete energy management solutions, including energy audits, energy efficiency, bill management, distributed generation, and load control.
Sale/Lease + Utility Tariff	Customer	Utility or Aggregator	Customer purchases the system but "shares" it with the utility. Customer receives lower bills but may have restrictions on when or how they operate the system.
Utility Procurement	TPO	Utility or Aggregator	Utility purchases the system and locates it at the customer's facility. Customer receives lower bills but may have restrictions on when or how they operate the system.

Source: U.S. Department of Energy. *On-site Energy Storage Decision Guide.* 2017 [14].

4.3 DER solution providers

Through the interviews, we found two main categories of DER solutions providers for customer-sited DERs, often employing turnkey development for owners: (1) solar PV + battery storage providers and (2) multiple DER providers. These broad categories are described, and the DER solutions providers interviewed as a part of this market brief were placed into these categories based on their *primary* area of focus.

- **Solar PV + battery storage providers** generally finance solar + battery storage systems, and help owners operate and maintain them. Often these systems have no upfront cost to the owner and are paid for through their cost savings and utility incentives. All solar + battery storage providers offer a grid-tied solution in which there is no islanding mode when grid outages occur, and some providers also offer microgrid configurations.
- **Multiple DER providers** provide integrated control for DERs in addition to solar PV and battery storage such CHP, thermal energy storage, and flexible building loads. Often these providers help building owners operate large campus-scale systems with central plants, and they offer either grid-tied or microgrid configurations.

A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected and island mode. Unless a DER provider offers a microgrid configuration, when the grid is down, the DER systems are not available to be used due to the hazards of potential power backfeed to the grid.

Most DER systems currently installed cannot operate during a grid outage because they are not built and configured as a microgrid.

However, owners may implement microgrids with the primary objective of resilience and avoidance of downtime when power grid outages occur. Microgrid controls disconnect the site from the grid with appropriate switchgear, and these control dispatch generation and storage to meet building electrical loads. Like traditional backup generator systems, DER systems only provide backup power if they have the appropriate switchgear to island from the grid.

Table 4 lists some solutions providers for commercial buildings behind-the-meter DER installations and indicates the DERs for which integrated control has been implemented. The table lists providers with integrated solutions that simultaneously optimize across each of the DERs indicated. For example, flexible building loads would be indicated with a dot if load shedding or shifting were coordinated through the DER optimization software with other DERs, such as battery storage. Note that these DER solutions providers may have different levels of technology integration for residential or industrial market sectors.

Table 4. DER solution provider technology integration for commercial buildings

Category	DER Solution Provider	Solar	Battery storage	Thermal storage	CHP	Flexible building loads	Microgrid
Solar + storage	Advanced Microgrid Solutions	●	●				
	Enel X	●	●				●
	ENGIE Storage	●	●				
	Forefront Power	●	●				
	NantEnergy	●	●				●
	STEM	●	●			●	●
	Tesla	●	●				●
Multiple DERs	Go Electric	●	●		●		●
	Johnson Controls	●	●	●	●	●	
	Schneider Electric	●	●	●	●	●	●
	Siemens	●	●		●	●	●

The solar + storage companies specialize in providing a combined project of battery with solar PV installation, or battery storage add-on kits where PV already exists. Solar + storage companies can also provide stand-alone storage installation (with no solar on site). Recently, solar + storage system installation has grown significantly with decreasing battery costs and utility incentive programs. With peak demand periods moving later in the day as solar PV meets midday power needs, battery storage is discharged during late afternoon/early evening to reduce the new peak demand periods.

Microgrids are an emerging market for solar + storage installations, as more customers want to utilize their systems when the grid is down. For DER solutions providers that also control HVAC equipment (such as Johnson Controls, Schneider Electric, and Siemens), the DER optimization algorithms can be a part of a single control platform.

Currently, most DER optimization algorithms view EV charging as a load rather than a controllable DER, even though the capability to control EV charging is available in current smart charging technology. With smart charging technology, EV charging may be allowed only during off-peak TOU rates or outside of the typical peak demand time period, to avoid setting a new peak demand. Currently many DER solutions providers offer visualization of EV charging loads in their DER optimization dashboard. As with any load, the DER optimization algorithms will react to EV charging loads by dispatching DERs so that demand and energy charges are minimized for customers. Controlling EV loads is likely to become more prevalent with the increased penetration of EVs in the market and further development of smart charging capabilities and applications.

4.4 Additional providers in the customer-sited DER market

Alongside the DER energy solution providers, there are additional players in the customer-sited DER market. We interviewed a sample of providers in the following areas:

- **DER consulting/owner's representative:** This type of company helps building owners with their DER implementation strategy, feasibility analysis, Request for Proposal or other procurement process, project management oversight, and commissioning and monitoring over time. One example is Terra Verde Energy, which acts as an owner's representative for DER projects.
- **DER equipment and software providers:** DER equipment includes PV panels and inverters, battery storage, thermal storage, and CHP systems. Axiom Exergy is an example of a thermal storage provider for commercial refrigeration systems. Autogrid and Enbala are two examples of companies that deliver DER optimization software to DER project developers and utilities but do not develop DER projects. Section 4.5 below describes DER optimization software products developed by DER software-only providers, as well as turnkey DER solutions providers.
- **Curtailment service providers:** Curtailment service providers or ancillary service providers help owners engage with capacity and ancillary services markets and programs. These companies facilitate dispatch of building load reduction into demand response and other ancillary services programs. Examples of curtailment service providers include Enel X (also a DER solutions provider) and CPower.

Most often the DER solutions providers rely on an array of equipment and technology providers rather than developing all the pieces of a DER project on their own.

4.5 DER optimization software products

Table 5 shows the customer-sited-DER optimization product for each provider interviewed. These optimization controls work at the customer site level for demand charge reduction. Some of the vendors also participate in virtual power plant programs in which they control a fleet of batteries at multiple customer sites.

Some DER optimization controls include human-in-the-loop optimization, in which operator inputs can influence the automated optimization routines. For instance, an operator can input that the building load will be higher than forecast, such as during an event. The software adjusts to account for this upcoming schedule change, which could otherwise cause a demand peak. DER optimization providers also have a visualization component of their software so customers can view how DERs are managed in real time in response to the loads.

Table 5. Customer-sited-DER optimization

Company	DER Optimization Software Product
Advanced Microgrid Solutions (AMS)	Armada
AutoGrid	AutoGrid Distributed Energy Resource Management System (DERMS) AutoGrid Virtual Power Plant (VPP)
Enbala	Concerto
Enel X	DER.OS
ENGIE Storage	GridSynergy software
Forefront Power	Data acquisition system (only for solar); uses other vendors for battery optimization
Go Electric	AutoLYNC® microgrid controller
Johnson Controls	Central plant optimization
NantEnergy	NantEnergy SmartStorage™ systems
Schneider Electric	EcoStruxure Microgrid Advisor
Siemens	SICAM; Spectrum Power 7; Energy IP DEOP; Energy IP E-car OC; Navigator
Stem	Athena optimization with PowerScope data visualization
Tesla	Autobidder (operating storage in wholesale markets); Tesla commercial dashboard (energy manager view)

Figure 1 shows an example of one vendor's DER optimization user interface. As previously described in Section 4.1, DER optimization strategies may have many data inputs and various approaches to optimization. The example in Figure 1 shows optimization across PV and battery storage.

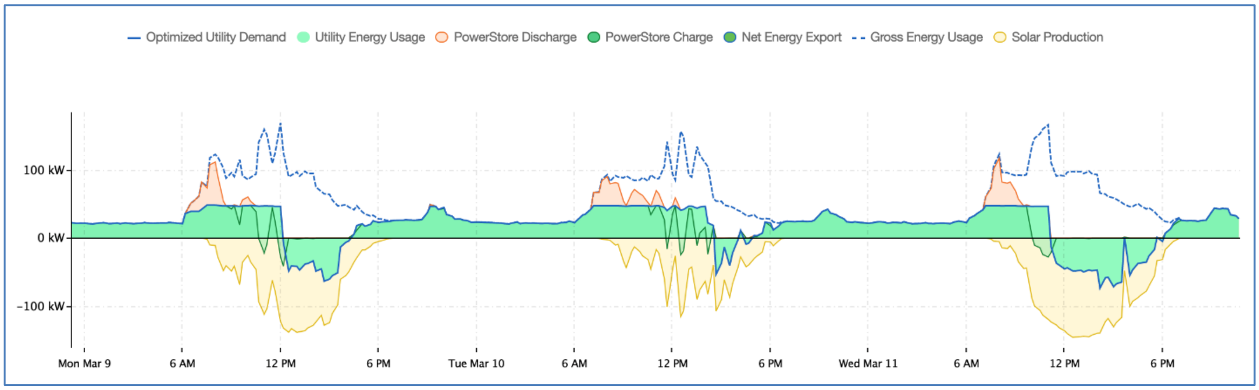

Figure 1. DER optimization user interface (Source: Stem's PowerScope data visualization)

In this example, the battery discharge is set to limit peak demand to a 40 kW threshold. The green area above the x-axis is energy from the utility which is reduced due to the discharge or storage (orange) and solar production (yellow). The green area below the x-axis indicates that solar energy is being used to charge the battery.

4.6 Integrating building loads into DER optimization

In the research for this market brief, the integration of building loads and DER systems were investigated to get a sense of the level of integration occurring in the market today. Building load and DER integration has the following main benefits:

- It may reduce the first cost of batteries, since smaller batteries are needed when part of the peak load is curtailed through a building load shed (typically HVAC and/or lighting loads).
- It provides a single interface and platform for facility engineers to manage, rather than multiple interfaces for each control system.
- It maximizes revenue from market programs, with deeper demand reductions possible when utilizing both storage and building loads.

The multiple DER solution providers generally can manage the building load by controlling the HVAC system using commands such as global temperature reset and AHU fan speed limiting and can perform this control in coordination with other DERs. This capability was indicated during the DER provider interviews as technically possible, and although it is not typical, its use is emerging. Many of the multiple DER solution providers historically have offered building HVAC control and central plant management (chilled water/steam/hot water) as a part of their core business, and integration with DERs is an extension of these functions.

Building owners most commonly manage their DER systems and building loads separately using software that does not communicate. Among the owners interviewed, most said that they did not see enough value in coordinating their DERs and building loads. The reasons that the owners had not integrated their building loads with their DER systems included the following:

- Occupant comfort can be affected by building load shed and shift, although demand response control routines minimize impacts. When customers have battery storage installed, they prefer to use the battery systems to provide demand management instead of altering their building loads, since managing demand using battery storage can be invisible to building operations (set it and forget it).

- Integration can be complex with disparate systems that may not communicate easily. Not all DER vendors controls products can control building loads.
- The financial drivers for incremental revenue that DER and building load integration provides may not be large enough to justify the cost.
- Shifting BAS control from manual or simple automation logic to more advanced methods such as model-based optimization takes time to build operator trust that new control strategies are reliable.

Currently, even with limited integration of building loads and DERs, most DER solutions providers shared that integration of DERs with building loads is necessary to fully optimize for cost savings and battery sizing, and this optimization will occur as the industry matures. A flexible and grid-interactive building requires integration at this level.

Beyond controls integration, the use of energy management and information systems (EMIS) as an integration layer for data visualization, analytics, and fault detection across all DERs is a development area, as vendors embed diagnostics to ensure DER system performance within their software. Diagnostics for CHP and thermal storage, technologies that have been commercialized for decades, may be more available to owners than diagnostics for solar PV and battery storage. Having diagnostics to ensure proper PV inverter function and battery health helps owners determine if products are meeting appropriate performance levels relative to warranties.

5. Conclusion

Customer-sited distributed energy systems are rapidly gaining attention from commercial building owners and operators. This document investigates the evolving market of customer-sited DERs and the diversity of available products and services for owners, providing a market landscape of owner-facing DER solutions providers based on fifteen interviews and literature review.

This market brief is intended to help building owners and facility managers in the commercial sector who are seeking to understand the benefits and market associated with DER products and services. It is a snapshot of the current landscape and does not cover all potential customer-sited DER solutions or providers. Customer-sited DERs are growing in adoption, with the multiple streams of benefits available to building owners: energy bill reduction, system resilience during grid outages, economic revenue, and carbon reduction. Load flexibility achieved through DER implementation also supports electric grid stability. While these value streams are described in the literature and through interviews, documenting the return on investment for various types of customer-sited DER systems requires additional research.

According to interviews, most DER solutions providers felt that the integration of DERs with building loads would be necessary in the future to fully optimize for cost savings and battery sizing, although there has been limited integration to date. Such an integration can provide a single interface for a full picture of system operations and management across multiple systems. Similarly, the development and application of EMIS within integrated DER solutions would provide a single interface for analytics and fault detection.

The market landscape for DERs is becoming more mature as owners expand implementation of DERs at their sites. Some owners are interested in the development of microgrids at the building and community scale to address grid resiliency and risk of severe financial impacts from grid outages. As the implementation of customer-sited DERs continues to expand in the commercial building sector, integration across DER solutions is needed to achieve the deepest impact and benefit.

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7. Appendix

Companies interviewed

DER Solutions Providers
Advanced Microgrid Solutions
ENGIE Storage
Enel X
Forefront Power
Go Electric
Johnson Controls
NantEnergy
Schneider Electric
Siemens
Stem
Tesla

DER Equipment and Technology Providers
AutoGrid Systems
Axiom Exergy
CPower
Enbala
TerraVerde Energy

Interview questions

- What are the functions/capabilities of your software products (such as demand response, bill savings, etc.)?
- What services do you provide (such as design, installation, configuration, etc.)?
- Can you show us a demo of your products?
- Do you have case studies and owner references?
- What is the most common use case for owners installing DERs in their buildings (What are the biggest drivers of cost-effectiveness?)?
- How do you control the DERs?
- Are your products capable of integrating with building automation systems (BAS)? Do you have examples of this? What are the benefits and drawbacks of integration DERs and building loads?

- If they manage demand automatically using battery storage, would they also participate in DR programs using their BAS? Would they also manage demand using their HVAC BAS? Do they coordinate these demand management activities, or do they keep them separate?
- Are there any barriers to integration between building load and BTM-DERs?
- New applications and future directions?