A Qualitative Study of EMaaS Performance in California Schools

by

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ABSTRACT

In recent years, many school districts, community colleges, and universities in California have implemented energy management-as-a-service (EMaaS). The purpose of this study was to analyzes how EMaaS has been realized in California schools, including how performance expectations and service guarantees have been met, how value is created and captured, and which trends are emerging in the pay-for-performance models. This study used a qualitative research design to identify patterns in the collected data and allow theories to be drawn from the emergent categories and themes. Ten in-depth interviews were conducted with a diverse pool of facility managers, energy practitioners, superintendents, and associate superintendents working with EMaaS. Four themes emerged (1) peak shaving overperformance, (2) low risk/reward, (3) performance exactly as expected, and (4) hope in future flexibility. This study reveals medium to high levels of performance satisfaction from the customers of cloud-enabled and battery-based EMaaS in California schools. Value has been captured primarily through peak shaving and intelligent bill management. Large campuses with higher peaks are especially good at delivering energy savings, and in some instances without pairing batteries and solar. Where demand response participation is permitted by the utility companies, the quality of demand response performance is mixed, with performance being exactly as expected to slightly less than expected. The EMaaS business model is positioned to help California schools implement and achieve many of their future sustainability goals in a cost-effective way.

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CHAPTER 1

BACKGROUND

Introduction

Educational institutions in California are increasingly adopting new energy efficiency technologies, including solar photovoltaics (PV) and on-site battery energy storage. Innovative business models have allowed school districts, community colleges, and universities to implement advanced technologies at low risk. In this study, the service performance of cloud-enabled and battery-based energy management-as-a-service (EMaaS) is explored. By gathering information from the school faculty, the quality of service and the suitability of the technologies in the education sector can be better understood.

In this chapter, the technology and its applications are introduced. Next, the EMaaS business model is explained. The purpose of this study and the research questions are presented. Then the demographics are determined, and the limitations and assumptions of the study are presented.

About intelligent battery storage

Distributed energy resource (DER) systems are decentralized, small-scale power generation and storage technologies. They typically include solar PV, behind-the-meter battery energy storage systems, and microgrids. Behind-the-meter battery systems are controllable energy storage systems that sit on the end user’s side of a building’s energy meter. Microgrids are local, interconnected energy systems in clearly defined electricity boundaries that can act as a single controllable entity (Berkeley Lab, 2019). Microgrids enable cooperation between distributed energy resources, providing shared objectives and strategies to optimally operate and manage interconnected systems (Boutin et al., 2017). Microgrids enable subsystems to act in coordination through a network infrastructure that includes sensors, meters, and network protections; controls at the DER level; controls at the microgrid management level aiming to optimize the entire system; supervisory control and data acquisition systems to interface with microgrid operators; and cloud-based decision capabilities (Boutin et al., 2017). Microgrids can operate off-grid in remote locations or can be connected to the wider grid and operate in networks. The technology that this research study focuses on are grid-tied behind-the-meter battery systems and networked microgrids with intelligent controls.

The foundational components that enable intelligent controls are the edge platform, cloud platform, and data analytics. Edge computing is a kind of distributed computing that moves the computer workload closer to the consumer to reduces latency, bandwidth, and overhead for the centralized data center (Hamilton, 2019). Cloud computing is the on-demand availability of computer system resources, especially data storage and computing power, without direct active management by the user (Wikipedia, "Cloud Computing"). And lastly, data analytics recognizes patters and correlations in large amounts of data. Software updates are performed over the cloud, enabling new features and functionality on a regular basis (Xul et al., 2018).

Together these technologies allow behind-the-meter battery systems and microgrids to forecast, monitor, optimize, and automate energy control capabilities in the following applications:

a) *Demand reduction*: Dispatched stored energy is used to cover the building electricity load during peak demand (peak shaving). Time-of-use bill management is able to track peak hours and avoid high cost consumption rates.

b) *Demand response*: System controls help stabilize the grid by immediately and automatically responding to system-level spikes or dips in power, frequency, or power (Fitzgerald, G. et al, 2015). Distributed batteries can automatically bid energy storage capacity into real-time and day-ahead electricity markets managed by independent system operators. Batteries can simultaneously perform demand reduction and adjust load capacity in response to market schedules and dispatches.

c) *Solar self-consumption optimization*: Solar plus storage maximizes renewable energy integration into buildings by charging the batteries and minimizing the amount of energy drawn from the grid.

d) *Intelligent bill management*: The energy service providers factor in utility, state, and federal incentives and rebates to maximize savings.

e) *Backup power*: System controls are optimized to cover critical loads during brownouts and blackouts.

The asset value of DERs is increased when multiple, stacked services are provided by the same device or fleet of devices (Fitzgerald et al., 2015). For example, a grid-tied, stand-alone battery system can perform energy arbitrage; that is, charge the battery during off-peak hours and discharge during peak-hours. Such batteries may operate 50 percent of their useful life. However, batteries in microgrid networks can perform demand response (e.g., frequency regulation and resource adequacy) the remaining 50–90 percent of the time, thereby extending the value of the storage asset (Fitzgerald et al., 2015). Moreover, batteries extend solar PV assets by storing available energy for future use rather than net metering or curtailment, and batteries can firm the intermittent generation of solar PV.

Market drivers of DER adoption. Three market factors are primarily driving the shift away from the centralized grid model to distributed resources and microgrids: the falling cost of solar PV and batteries, the rising demand charges, and the state and federal incentives and grants. First, solar PV costs have fallen every quarter since 2010 (coronavirus notwithstanding). Without incentives or subsidies, the average levelized cost of solar PV has fallen from $7.24 in 2010 to an average between $0.13 and $0.17 per kWh in 2018 (Fu et al., 2017). After incentives and subsidies, the cost drops further to $0.08 to $0.11 per kWh. For rate payers in California, investing in solar PV can cost significantly less than electricity from their utilities. Furthermore, the cost of lithium-ion batteries fell 87 percent, from $1,100/kWh to $156/kWh, between 2010 and 2019 (Bloomberg NEF, 2019). 2023 prices are projected to be around $100/kWh. Economies of scale and advancements in manufacturing are largely responsible for the price reductions seen in distributed energy technologies.

Second, utility companies' rates have increased. Consumption charges reflect the volume (kWh) of electricity consumed and demand charges reflect the highest rate (kW) of electricity consumed (McCrea, 2017). Demand charges are typically based on the highest average electricity usage within a 15-minute time interval during a billing period. California has some of the highest maximum demand charges in the U.S., at $47.08 per kw across all utilities in the state.

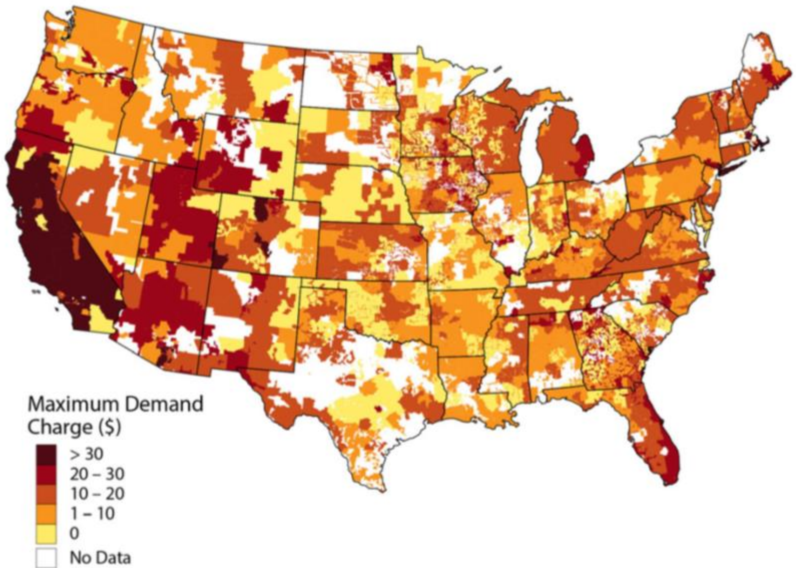


Image 1: Maximum demand charge rates by utility service territory (source: McLaren, 2017)

High demand charges in California are due in part to the increasing penetration of rooftop solar onto the grid. As the sun sets, utility companies face a sharp increase in electricity demand that requires large ramping capacity. “The duck curve” refers to the timing imbalance between peak demand and renewable energy generation over the course of a day (Wikipedia, “Duck Curve”). In Image 2, the orange curve has a steep ramping event from 17:00 to 19:30 p.m., requiring about 7 gigawatts of generating capacity within 1.5 hours:

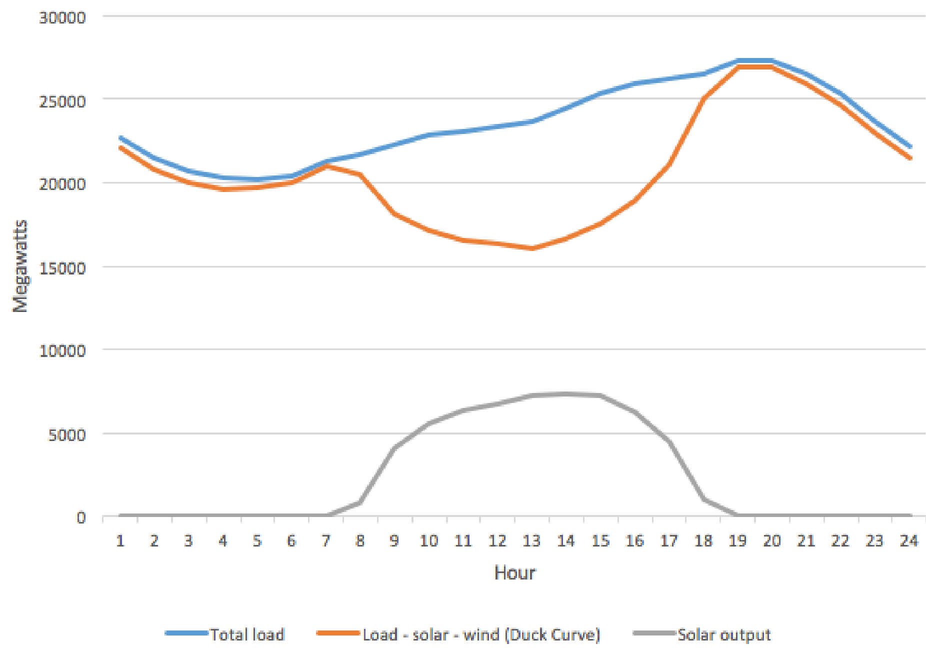


Image 2: California hourly electric load vs. load less solar and wind for October 22, 2016 (source: CAISO, 2018)

Increased peaking capacity and higher transmission and distribution costs results in higher demand charges: in California, demand charges increased an average of 40 percent between 2009 and 2019 (McLaren et al., 2017).

Third, incentives, credits and grants have driven the adoption of DERs. California's policies to reduce greenhouse gas emissions also promotes the decentralization of the grid through more autonomous production from DERs (Hanna et al., 2017). California has mandates for renewable energy, some of which favor DERs, as well as deployment quotas for distributed generation (2000 MW of distributed solar through the California Solar Initiative program, 4000 MW of combined heat and power per AB-32), 1325 MW of storage (through AB-2514), and an array of subsidy schemes such as California's Self-Generation Incentive Program (Hanna et al., 2017).

Energy Service Agreements

Innovative business models have emerged in California that offer energy efficiency services using batteries behind the meter. Energy service agreements allow customers to implement energy efficiency projects with zero upfront capital expenditures (IMT, 2019). One such service, energy management-as-a-service (EMaaS), is a business model that provides an intermediate energy efficiency service between the utilities and the customers. The model shifts the burden of financing, owning, installing, operating, and maintaining energy assets from the customer to the service provider (Amann, 2019). The service provider manages the generation, storage, consumption, and trading of renewable energy, and the customer pays a monthly fee (Chen, 2015). The fee is typically based on either a percentage of the customer’s utility rate, a percentage of the bill savings, or a fixed amount per kWh saved. Contract durations are typically 5-15 years, with 10 years being the most common. At the end of the contract period, the customer can purchase the equipment at the fair market price, have the provider remove it, or extend the contract (ACEEE a., 2019).

EMaaS is marketed as providing organizations with the following opportunities:

1. *First cost savings*: The energy service provider secures third-party funding to finance all project costs.
2. *Off-balance-sheet financing*: The energy service becomes an operating expense similar to a utility bill or a power purchase agreement. The provider owns the energy equipment, and the customer has no debt on their balance

sheet. The provider assumes the risk for achieving the energy efficiency savings.

3. *Operational and maintenance services*: The energy agreement is a pay-for-performance model in which the provider does all of the operational and maintenance duties.
4. *Flexible services*: The energy service structure allows flexibility by adding new energy efficient measures over time, often within the same contract terms or rate. Measures include pairing solar plus storage and EV charging infrastructure.
5. *Scalable service*: New opportunities for efficiency and savings can be funded and rolled into additional buildings (IMT, 2019). Campus-wide systems and EV charging infrastructure can be integrated under one service (ACEEE b., 2019).

The EMaaS model is advertised as lowering operational and financial risk for the customer and growing in its efficiency and scope over time.

The three largest EMaaS companies in California are Stem, Inc., Green Charge, and Advanced Microgrid Solutions. Stem's software platform has over 10 million runtime hours operating in 1,000 distributed systems (Stem, 2019). Green Charge has over 100 systems in K-12 schools and claims to have delivered over $30 million in demand charge savings (Kelley, 2018). And AMS has over 100 projects and 360 MWh of battery storage capacity currently under deployment (AMS, 2020).

Schools in California have low cash flow, high demand charges, and future sustainability goals (Bradford et al, 2019). EMaaS has been adopted in the commercial, industrial, and residential sectors, and the educational sector in California is now experiencing its first wave of cloud-enabled and battery-based energy efficiency services. At the same time, many schools have ambitious sustainability goals, both in their buildings and in transportation. In the U.S., within the top 10 schools for EVs, one study showed that over 60 percent of their campus-owned vehicles have been switched to EVs (Bradford et al., 2019). Vehicle-to-grid (V2G) bi-directional charging allows fleets of EVs to charge solar energy during the day, perform peak shaving for campus buildings, and perform demand response services for local grids. Induction charging allows vehicles in fixed routes, such as campus busses, to remained charge throughout the day (Bradford et al., 2019). The sustainability goals of many California schools are tending in the digital direction.

Purpose statement

The purpose of this study is to analyzes how EMaaS has been realized in California schools, how performance expectations and service guarantees have been met, how value is created and captured, and which trends are emerging in the pay-for-performance models. This study can expand the limited research on the user's perspectives of the performance of EMaaS in California schools by conducting a qualitative research study with school faculty. Ten in-depth interviews were conducted with faculty from eight educational institutions who work alongside EMaaS systems. The findings can provide the preliminary research needed to build a unified explanation of how value is created and captured with EMaaS in the California market.

Research Questions. The following research questions guided this study:

1. In what ways has EMaaS been realized in California schools?
2. How well have performance expectations and service guarantees been met?
3. How is value created and captured with EMaaS?
4. What trends are emerging with EMaaS?

Limitations and Assumptions

The limitations in this study have been identified as the following:

Research instrument. The primary data collection tool in this research is a questionnaire. Participants are all faculty members in California schools, including facility managers, energy managers, sustainability managers, superintendents, and assistant superintendents. This is a qualitative study, and as such, the structure and content of the questions developed as the process unfolded. Qualitative research depends on how the researcher forms the questions, poses the questions, and draws out implications. The research process is managed and carried out by the researcher. The questions presented to the participants were novel and have not been presented in other research. Some of the participants may have preferred written questionnaires over telephone interviews, however, ten in-depth telephone interviews were conducted.

Demographics. This research study was limited to faculty members in California schools with EMaaS. The schools in this study are customers of three utility companies: San Diego Gas and Electric (SDG&E), Southern California Edison (SCE), and Pacific Gas and Electric (PG&E). The utility- and climate-environment in California may not reflect those of other states and regions; that is, demand charges, renewable energy credits and incentives, and seasonal climate shifts, may vary state-by-state and utility-by-utility.

The following assumptions were accepted:

1. The responses from participants reasonably represented the data the researcher attempted to collect and were offered honestly and without bias.
2. Any presumptions of the researcher about the participants expectations of the performance of the services did not significantly influence the outcome of the research.
3. The researcher’s role in the collecting and analyzing of data reflected the standards of acceptable practice of qualitative research (Maxwell, 2013).

Summary

In Chapter One, the background of the study was explained, including the technology under investigation, its foundational components and applications, the driving forces of DERs, the structure of the EMaaS business model, and the energy efficiency opportunities marketed by EMaaS providers. The purpose of this study is to explore the performance characteristics of EMaaS in the education sector in California. Four research questions for this study were proposed, and limitations and assumptions were stated. In Chapter Two, the literature will be explored, and research gaps will be identified.

CHAPTER 2

LITERATURE REVIEW

The goal of facility management is to maintain efficiency and streamline operating expenses (Lind & Muyingo, 2012). In education, facility managers are tasked with maintaining overall sustainability and attractiveness of campuses (Parsons, 2015), as well as maintaining campus productivity, satisfaction, and efficiency (Kelly et al, 2013). Preventative maintenance and inspection of mechanical equipment and hardware is routine for facility managers (Lind & Muyingo, 2012).

Distributed energy resources, cloud-enabled microgrids, and EV charging are new technologies emerging in the built environment (Schneider Electric, 2019). When compared with 2014 levels of investment, all major segments of the microgrid market are expected to grow by 2020, for example small microgrids in commercial buildings (94%), medium sized microgrids such as those in communities (199%), and in public institutions with special requirements for reliability (228%), and large microgrids at military installations (142%) and universities (115%) (Hanna et al., 2017). CEC (2018) reports on 26 case studies of microgrids, showing the most common value propositions that hosts choose. Several value streams emerge from solar plus storage and solar microgrids (Eller & Gauntlett, 2017; Rahman, 2012; Farrelly, 2020). Optimization has been well documented (Kezunovic et al., 2012; Lundkvist, 2013; Jiang, 2013; Raju et al., 2016), including optimization for peak shaving in a university (Prasatsap et al., 2017), battery optimization criteria (Yanga, 2018), and cloud-based microgrids (Chang et al., 2015; Chen, 2017; Bera, 2015). Many school districts, community colleges, and universities are investing in alternative energy generation and EV charging stations (Bradford et al., 2019; Kelley, 2018). Campus facility managers seek to reduce energy bills by mitigating demand charges and provide clean energy for students and faculty (Bradford et al, 2019). The success of DER projects in California largely reflects the state mandates for carbon emission reduction and renewable energy integration, as well as the growing need for energy reliability and resiliency (CEC, 2018).

Energy management-as-a-service (EMaaS) is an innovated business model. The roles of providers include developing the project scope with the customer, financing, installing, operating, and maintaining project equipment, verifying savings, and identifying new savings opportunities (ACEEE a., 2019). High demand charges are cited as a critical factor in battery project economics (McLaren et al., 2017). Energy storage markets are growing (ACEEE b., 2019), and new forms of financing and services are becoming available; e.g., energy efficiency services offering zero up-front costs (ACEEE c, 2019). As far as I can tell, there exists no qualitative studies of performance expectations of EMaaS, and few qualitative studies have been done in facility management in schools (Parr, 2017).

Gaps in the Literature

Chen (2017) highlights the lack of research into EMaaS customers' behavior and the realizations for the cloud-based energy management services. The American Council for an Energy Efficient Economy (ACEEE a., 2019) suggests that in-depth evaluations and customer satisfaction assessments are needed to help further build the value proposition for the energy-as-a-service model. In particular, the authors suggest the need to evaluate the suitability of the service model for specialty sectors, including in education. More generally, there is a gap in business model research with energy efficiency services that use smart grids (Xu et al., 2018). This thesis will offer insights into how EMaaS has been realized in California schools, how performance expectations and service guarantees have been met, how value is created and captured, and which trends are emerging in the pay-for-performance models. This study can provide the preliminary research needed to build a unified explanation of how value is created and captured in the California market.

Summary

In Chapter Two, the literature was explored, and research gaps were identified. In Chapter Three, methodology will be established.

CHAPTER 3

METHODOLOGY

This study uses a qualitative research methodology to organize and identify patterns among categories in the collected data (McMillan & Schumacher, 1993). Grounded theory is used, allowing theories to emerge from the collected data. Grounded theory uses comparative analysis to discover and construct theory from data in a systematic way (Chun et al, 2019). The researcher does not begin with a predetermined explanation in mind; rather explanations are formed from the data and the data are used to ground explanations. The explanations that emerge is new knowledge that can help inform or develop new theories about EMaaS.

A questionnaire was given to ten faculty members in eight California educational institutions, including facility managers, energy managers, sustainability managers, superintendents, and assistant superintendents. Participant were selected on the basis of their familiarity with the energy services and service agreements on their campuses. This study extends previous research on the challenges and opportunities of cloud enabled and networked microgrids and their performance in the educational sector in California.

Participants were identified through publicly available information sources, as being critical faculty members at schools working alongside microgrids and battery storage systems. Requests for interviews were sent via email, and ten interviews were conducted over the phone. During the interviews, a questionnaire was followed and filled out by the researcher. The interviews were audio recorded and transcribed soon thereafter. Triangulation was used to verify information about the battery storage systems, by cross checking the information provided by the service providers, news articles, and school faculty. The trustworthiness of the research was improved by sharing the findings with several of the participants. There was no involvement from the service providers, and none were contacted before or during the course of the study.

Data Analysis

The data analysis process began by transcribing and processing the interview data. Responses were grouped according to the research questions (Elo et al., 2014). The research objectives were revisited, and potential coding categories were considered. Data from the interview questions were then coded and contextualized by the researcher (Maxwell et al., 2013). Each recording was coded with labels to attach to text segments that appeared to indicate important user perspective (Peng, et al., 2016). A coding framework emerged giving structure to the data and providing themes of the research. Following the coding, the findings were used to answer the research questions (Parr, 2017; Maxwell et al., 2013).

Ethical Considerations

This study was voluntary, and each participant was provided the opportunity to choose not to participate with no ill will or recourse. Participants were not directly benefitted or compensated for their involvement in this study. All participants were guaranteed anonymity in the final version. No names or educational institutions are disclosed. Hard copies of the completed questionnaires are securely locked, and audio recordings of interviews are stored on a personal laptop with password protection. All recordings, records, and documents will be destroyed one year after the research is complete.

Summary

In Chapter Three, a qualitative methodology was connected to the gaps identified in the research in Chapter Two. A questionnaire will guide in-depth interview to explore the service performance of EMaaS in California schools. Chapter Four will analyze the data from the interviews.

CHAPTER 4

DATA ANALYSIS

Educational institutions in California are experiencing increasing electricity demand charges and seek to mitigate their energy use; however, they typically do not have the additional capital or knowhow to invest and operate energy efficient technologies such as behind-the-meter batteries and microgrids. EMaaS presents an opportunity to lower demand charges through advanced technologies, while providing services with no up-front costs, no burden of owning and operating the equipment, and a promise of future energy reliability. This study fills a gap in the literature with an assessment in EMaaS customers' performance expectations and the realizations for the cloud-based energy management services (Chen, 2017) and the suitability of EMaaS in the educational sector (ACEEE a., 2019). In-depth interviews were conducted to identify how value is captured in customer-oriented energy efficiency services (Xu et al., 2018).

Demographic analysis

Interviewees include facility managers, energy managers, sustainability managers, superintendents, and assistant superintendents working in California schools, colleges, and universities. Interviewees were selected on the basis of their familiarity with the energy services and service agreements on their campuses. Ten interviewees were interviewed over the telephone.

All ten interviewees in this study use EMaaS with battery energy storage capacity. Six have "shared savings agreements" and four have "guaranteed savings agreements." Nine have systems with 10-year service contracts and one has a 5-year contract. Of the ten interviewees, three have systems commissioned in 2016, four in 2017, and three in

2019. Six of the ten interviewees have prior work experience with battery energy storage systems and four do not. All ten of the interviewees' projects received funding in the form of grants, incentives, or subsidies from the utilities, the state of California, or the federal government.

Preliminary Questions

Preliminary question 1*: Did your school/college pay up-front costs for the energy management service?* The interviewees unanimously reported 'No.' Both the shared savings agreements and guaranteed savings agreements are pay-for-performance and come with no up-front costs. Financing for all projects were secured by the energy service provider through third-party funding.

Preliminary question 2*: Does the project use off-balance sheet financing?* The interviewees unanimously reported 'Yes.' The EMaaS companies either own or lease the hardware and own the software, and thus the districts, colleges, and universities assume no liability and include no debt on their balance sheets. Service payments become an operating expense similar to a utility bill or power purchase agreement.

Preliminary question 3*: Does the service provider offer an online energy dashboard to monitor building electricity usage?* Nine participants reported 'Yes,' and one participant reported 'No.' Online energy dashboards are typically provided to allow facility managers to monitor their energy use in real-time, to better understand the variables affecting their bill, and to forecast and budget their electricity use. The one interviewee who reported having no access to an energy dashboard expressed the desire to get one soon.

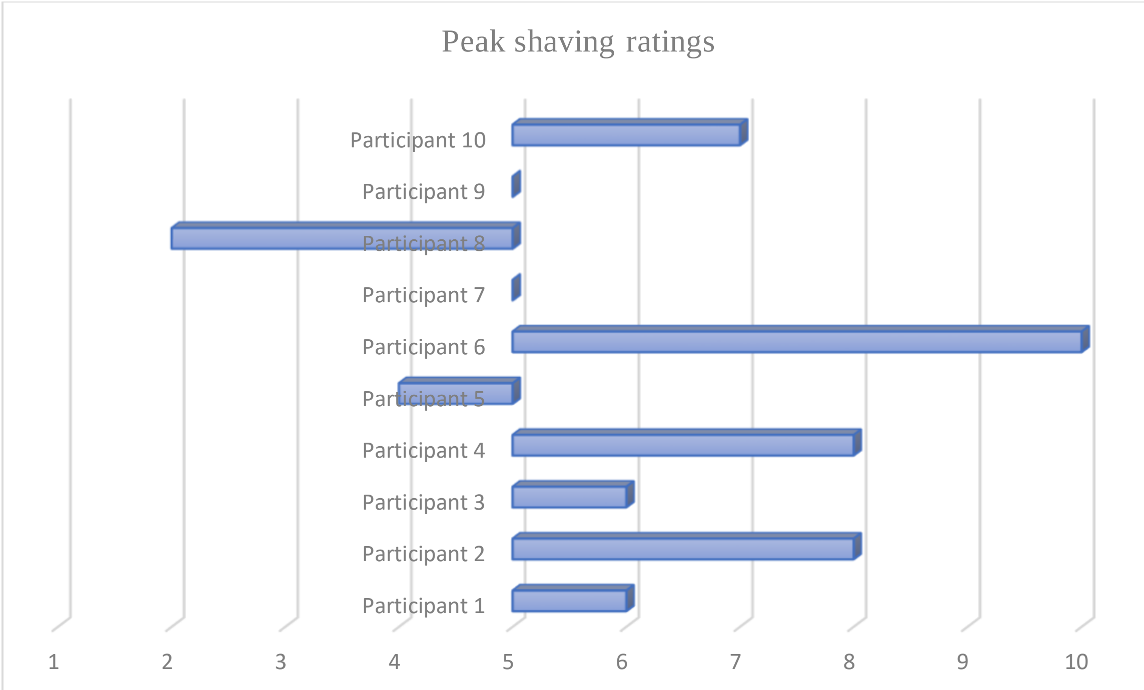
Preliminary question 4*: What was the primary intended function of the battery storage system or microgrid?* The interviewees unanimously reported ‘peak shaving.’ Peak demand charges can make up 50 percent or more of a school’s electricity bill, so reducing the peaks is the top priority.

Performance Ratings

This study of EMaaS presents customer ratings in five areas of battery system performance: peak shaving, demand response, operations and maintenance, cyber security, and overall performance. The performance ratings are given on a 1-10 scale, with 1 = far lower than expected; 5 = exactly as expected; and 10 = far greater than expected. Here “expected” refers to the performance specifications as stated in the contract; that is, how well the performance has met that which is stated in the contract documents, as opposed to the desires or hopes of the participants themselves. The mid-point rating of “5” was stressed by the researcher during the interviews as being “exactly as contractually expected.”

1. Peak shaving ratings

In this study, demand reduction through peak shaving is the primary function of all ten of the participants’ behind-the-meter battery storage projects. The performance rating question was asked: “On a scale from 1 to 10, with 1 being far lower than expected, 5 being exactly as expected, and 10 being far greater than expected, how well has the demand reduction performance met the performance specifications in the contract?” The various responses are plotted in Graph 1.



Graph 1: Peak shaving performance ratings

The interviewees' responses could be categorized into four areas: underperformance during the first 6 months; improved performance over time; overperformance; and underperformance. Each area is discussed in the following sections.

Underperformance during the first 6 months. Participants who reported peak shaving performance as being "less than expected," "exactly as expected," and "greater than expected" shared the response of beginning with a 6-month learning curve. Interviewee #8 reported that their early missed peaks occurred for a number of reasons, including the software learning the building patters, when systems are rebooted, and when sensors and meters are being replaced. Interviewee #9 reported that their system "had a few missed months in the beginning," but that the issues were addressed soon thereafter. Interviewee #7 reported performance improvements after the first 6-months. Interviewee #2, who gave a performance rating of "8," reported their system was "slow in the beginning, but good now."

Improved performance over time. Several interviewees reported improved performance over time. As the learning software continues to collect data and systems are interconnected and equipped with the appropriate sensors, peak shaving performance typically improves after the first 6 months as battery systems adapt to track the building energy habits and mitigate peaks according to the utility's time-of-use rates. Interviewee #7 reported improvements after the first 6 months: "The system is [now] very good at tracking time-of-use times and discharging to avoid high peaks." Interviewee #7 predicts that after 3-5 years of collecting data, the algorithms will perform even better.

Interviewee #8 reported underperformance early in the project, citing "tech issues and not being set up correctly to the meter." One problem with their system was that their campus meter was back-feeding into the local grid due to the wrong kind of meter being installed. Replacing the meter required shutting down the entire load, and thus, all operations. This posed a challenge, since finding a window of time on a campus that is typically busy 7 days per week is difficult. However, #8 reported, as time passed, "the technology has finally caught up with what we are trying to do, and the savings are slowly starting to come in." #8 quipped it is the "wild-wild west for batteries," meaning these technologies and services are still in their experimental phase and there is a perceived lack of established norms and standards.

Overperformance. Six of the ten interviewees reported systems that have overperformed expectations. One notable example, Interviewee #6 reported that the battery systems' second-by-second interval data revealed a more efficient way to use their two chiller systems together. The school was using two chillers systems one after the next to help ramp loads up and down, and one system is equipped with a variable frequency drive while the other is not. With the battery system, they discovered that reversing the order of the chillers was more energy efficient. Interviewee #6 cited this discovery as one of the reasons for their maximum performance rating ("10").

The use of an online energy dashboard was cited as a contributing factor to higher levels of demand reduction performance. Interviewee #2 reported that their energy dashboard was able to pinpoint a malfunctioning air-conditioner condenser as the cause of some unexpected peaks. Interviewee #6 also reported that the second-by-second dashboard was able to reveal previously unknown spikes. New peaks and their source can be more easily identified, for example, fixing the seal around an exterior door or moving the stadium lights to a different submeter.

Interviewee #1 reported higher levels of peak shaving performance in their larger systems. Their larger campuses tend to have higher peaks, and shaving those peaks often results in greater financial savings. On the other hand, their smaller elementary school campus doesn't have such high peaks and thus doesn't perform as well. According to Interviewee #1, the "overall" performance rating was slightly higher than expected ("6").

Generally, peak shaving performance was rated higher than expected by the participants. Interviewee #2 lost the use of a solar system on their campus after the battery system was installed, yet the battery system was still able to perform "very well." In fact, Interviewee #2 reported their school's average monthly savings of $6,500 has jumped as high as $9,000 per month. Interviewee #6 reported, “Once the system was offline for three weeks to fix the batteries and we still met the guaranteed savings.”

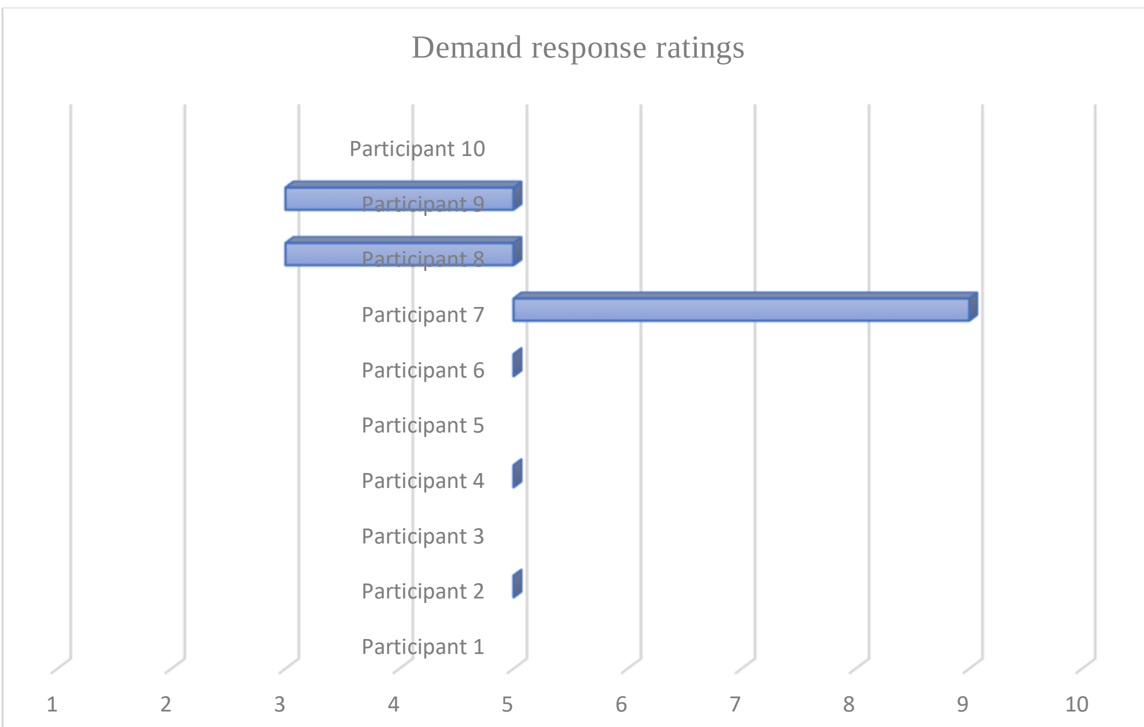
Underperformance. Interviewee #8, who gave a peak shaving reporting of “2,” said that the battery has a split second to catch the peaks, and if the software isn’t there, then just one second can throw off a whole billing cycle. In other words, consistent peak shaving performance can be ruined in a moment’s time, and for #8, their system has not been able to function as expected.

Interviewee #5 reported that the batteries “sometime discharge when they don’t need to.” For example, a battery system may consistently cover peaks 250 kw and greater, resulting in demand charge savings. However, when the system misses a peak and allows a spike of 275 kw, that becomes the new demand charge for the billing period. After that new spike, the system will not benefit from continuing to shave all peaks to 250 kw. When the battery continues to discharge more than it has to, the capacity of the battery is not being maximized. Interviewee #5 suggested that after a new peak has been set, the provider should conserve battery capacity by powering only what is necessary for the remainder of the billing period.

An issue raised by Interviewee #5 was that “there needs to be more user input to help control or mitigate the maximum demand.” In particular, there is a lack of a reliable method of communication between the user and the provider. A more reliable method to quickly inform the provider of a schedule change is suggested. Schools occasionally need to use their gymnasium and fields at random times, which requires additional hours of air-conditioning and lighting. When unplanned events occur, the algorithm won’t know to conserve capacity, thereby creating new peaks. These kinds of peaks can be avoided with the proper communication channels, according to Interviewee #5.

2. Demand response ratings:

Six interviewees reported that their battery systems performed demand response services and four reported no demand response function. The performance rating question was the following: “On a scale from 1 to 10, with 1 being far lower than expected, 5 being exactly as expected, and 10 being far greater than expected, how well has the demand response performance met the performance specifications in the contract?” The various responses are plotted in Graph 2.



Graph 2: Demand response performance ratings

The interviewees' responses could be categorized into four areas: no demand response service; performance exactly as expected; overperformance; and optimistic underperformance. Each area is discussed in the following sections.

No demand response feature. Four interviewees reported no demand response service. Local capacity reserve programs were either not available from the customer's utility or the service providers simply did not offer the service in the contract.

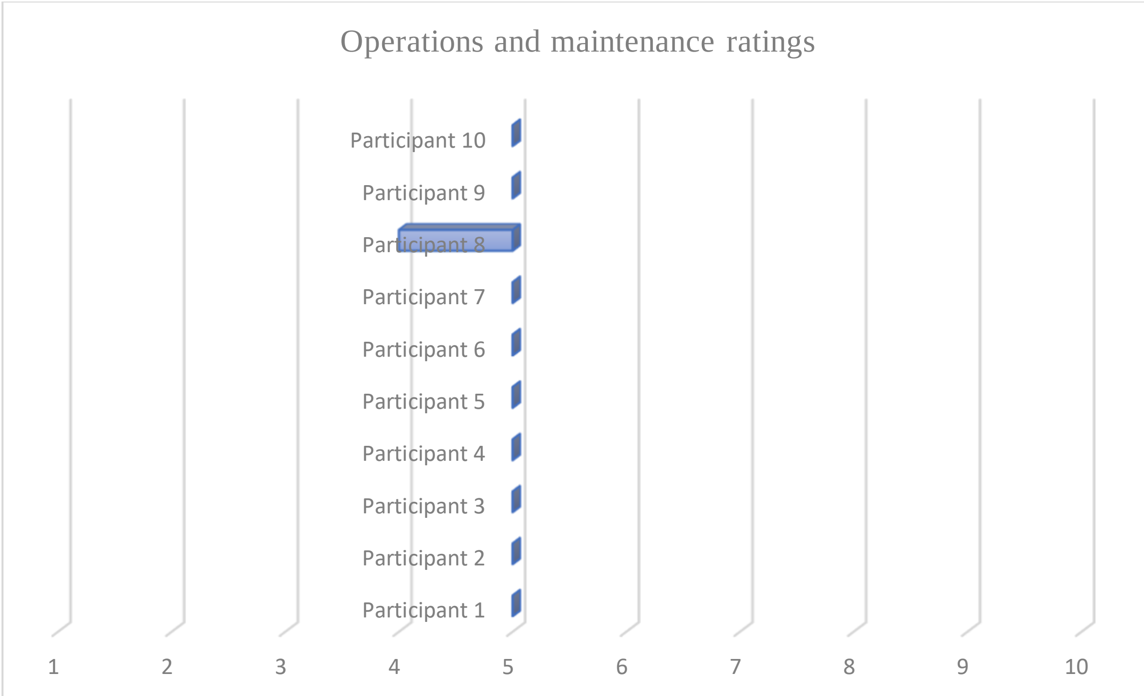
Performance exactly as expected. Three of the interviewees reported demand response performance to be exactly as expected. Interviewee #2 said that their provider contracted storage with the utility to create a virtual demand response system. All of the work has been done by the provider and the school has experienced no interruptions. The savings were acquired by the customer, and the battery functioned out of sight and exactly as expected. Interviewee #6 said, "I think it's fine, it's done everything," with their rating of "5." And Interviewee #4 reported, "we do [demand response] to a limited extent and the batteries take care of it."

Overperformance. Interviewee #7 reported demand response overperformance. Interviewee #7 reported, "[The provider] will coordinate the peak times and demand response and can still meet the capacity of the battery." #7 expressed a high level of assurance that the service provider had a good understanding of the utility rates and programs and has been able to take advantage of the demand response programs in such a way that delivers additional savings. #7 also cites their "hands off" approach on the facility side and experiencing no interruptions as the reasons for their high performance-rating ("9").

Optimistic underperformance. The two participants who reported underperformance with demand response also said they were hopeful the service would improve with time. Interviewee #8 reported a performance level that is "just not at what was promised" and had difficulties with the service provider balancing peak shaving with demand response. However, according to #8, "years down the road, demand response will be better… 3 to 5 years of collecting data and the algorithm will perform much better." Interviewee #9 reported demand response underperformance "so far," but also predicted future improvements.

3. Operations and maintenance ratings

The operations and maintenance (O&M) performance ratings were mostly uniform. Ratings questions were asked individually of both operations and maintenance service performance (see Appendix A); no variation occurred between the two of responses, so the two questions are presented here as one: "On a scale from 1 to 10, with 1 being far lower than expected, 5 being exactly as expected, and 10 being far greater than expected, how well has the operational and maintenance performance met the performance specifications in the contract?" The various responses are plotted in Graph 3.



Graph 3: Operations and maintenance service performance ratings

The participants' responses could be categorized into three areas: performance exactly as expected; no negative impact on school functions; and negative impact on school functions. Each area is discussed in the following sections.

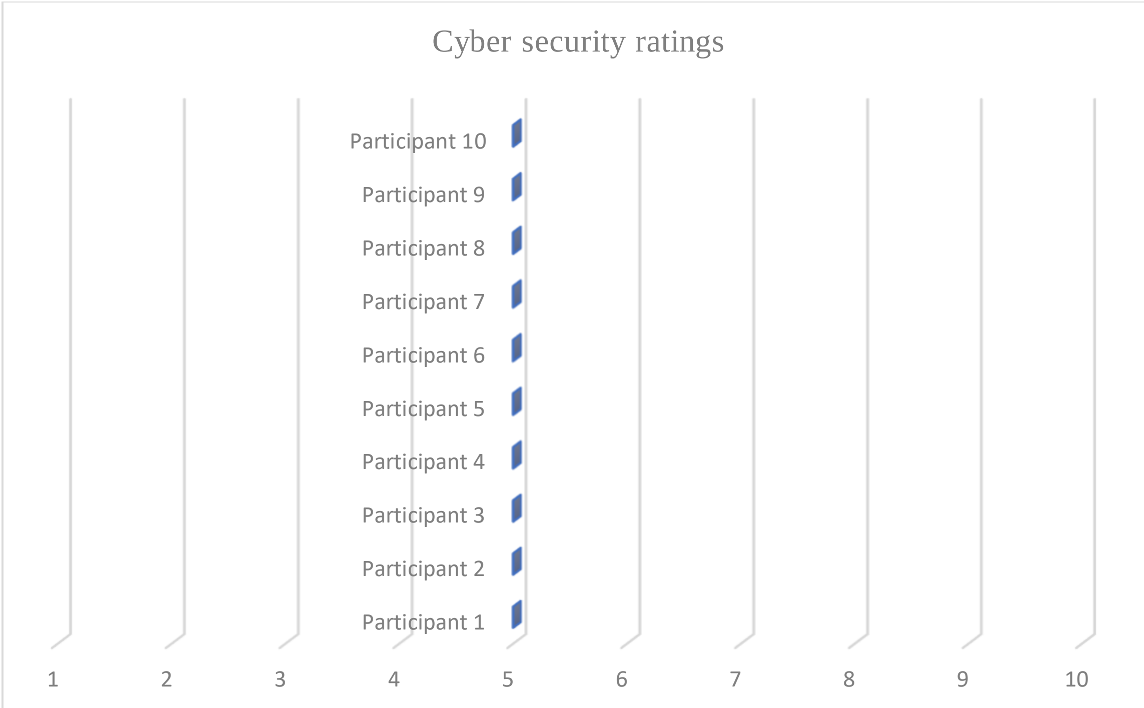
Performance exactly as expected. In most cases, interviewees reported O&M service performance to be exactly as expected. Interviewee #3 reported "the few times we've had [O&M] issues they've been very responsive," and, "we don't have to call or prompt them for the regularly scheduled maintenance." Interviewees #7 and #6 likewise reported no work at their facility. "I don't wrench on it or touch it or anything," said Interviewee #6, who gave a rating of "5" (exactly as expected). Interviewee #1 reported that the provider actively monitors the equipment, saying, "it's in their best interest to maintain and manage the system."

No negative impact on school functions. Several participants reported that the O&M services have not interrupted school functions. For instance, Interviewee #7 reported no interruptions despite having to reboot their system twice. #7 said the service providers were able to repair the systems during downtime without school interruptions. #6 reported not having to shut down any of their equipment or operations for scheduled maintenance: “It doesn’t affect any of our operation ever.”

School disruption. Interviewee #8 reported the “less than expected” O&M rating (“4”). The unsatisfactory performance rating from #8 was due to the issues caused by the shutdowns. Replacing component parts like sensors and meters requires shutting down entire loads. Doing so can require rebooting the fire and security systems. School function dictates that this sort of maintenance can only happens on the weekends. Weekend work can require overtime work for the facility and any events must be moved or canceled.

4. Cyber security ratings

All ten of the interviewees reported no cybersecurity threats or harm, and all ten gave a performance rating “exactly as expected” (“5”). The rating question was asked: “On a scale from 1 to 10, with 1 being far lower than expected, 5 being exactly as expected, and 10 being far greater than expected, how well has the cyber security performance met the performance specifications in the contract?” The various responses are plotted in Graph 4.



Graph 4: Cyber security performance ratings

The interviewees' responses could be categorized into two areas that overlap: no threats; and service providers have the own incentive to safeguard their services. Both are discussed in the following sections.

No threats. In the case of cyber security, all ten interviewees reported no incidences and no threats. Interviewee #3 reported, "Absolutely no problems" and both Interviewees #6 and #7 said, "No issues." The service providers have provided a level of cyber security that has met contractual expectations.

Service providers have their own incentive to safeguard their services. A second category that overlaps the first is the response that the providers have their own financial incentive to keep their systems secure. Interviewee #7 reported that the cyber security of the systems is important to the providers since they need them to function to make money. Several others mentioned that the providers actively monitor their equipment.

Equipment security. The following question was asked, "*Have you had any security issues with the equipment onsite?*" All ten interviewees reported no issues with physical security. Participants reported that the equipment is securely locked behind fencing or within their facilities. Interviewee #6 reported that their equipment was installed in a storage and transformer room where it is safely locked up. The provider and utility company workers have keys, to access the systems as needed and perform scheduled maintenance. Interviewee #5 reported, "the batteries are not visible from the street . . . they are in enclosures." #5 reported that most people on campus have no idea that the batteries are there.

5. Overall ratings

The final performance rating question was asked: "On a scale from 1 to 10, with 1 being far lower than expected, 5 being exactly as expected, and 10 being far greater than expected, overall, how well has the energy service met contractual expectations?" The various responses are plotted in Graph 5.

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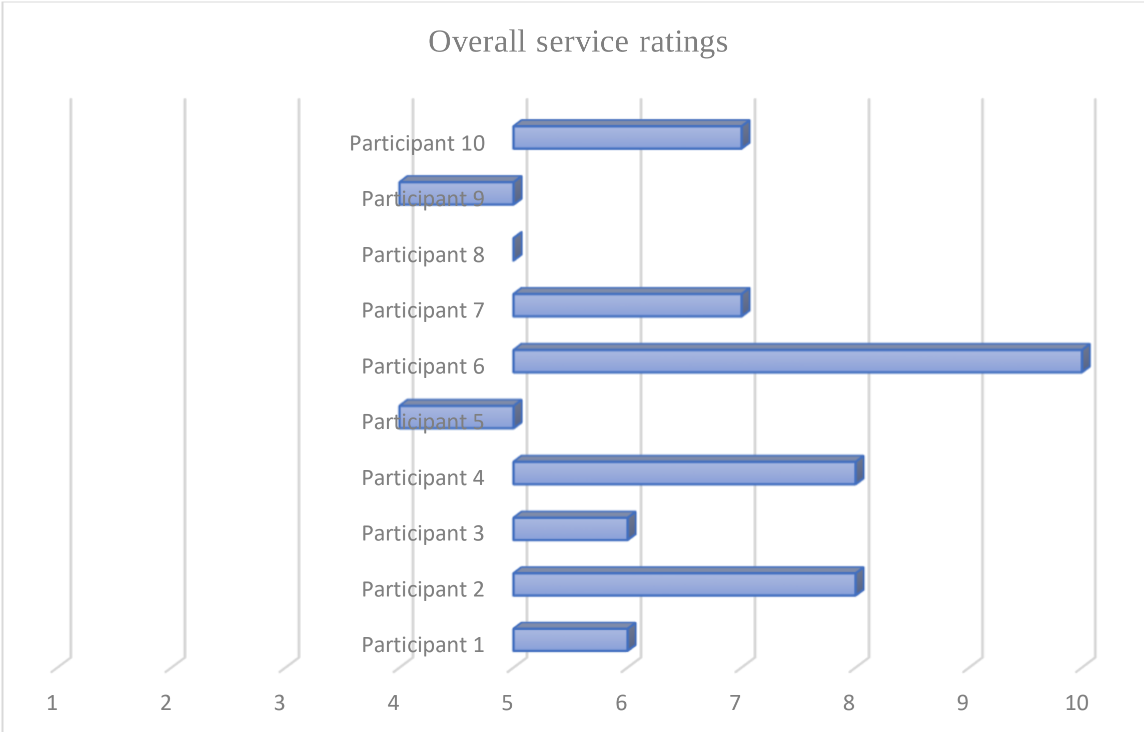

Graph 5: Overall service performance ratings

The interviewees' responses could be categorized into three areas: low risk for the school; performance exceeding expectations; and optimistic underperformance. Each area is discussed in the following sections.

Low risk for the school. Interviewee #1 reported successful peak shaving with very low capital risk for their school. #1 cited no up-front costs for the project, third-party equipment ownership, and regular monthly bill savings as the reasons for their positive rating ("6"). Interviewee # 2 reported the low risk with having battery storage technology that is guaranteed to perform for the life of the contract.

Performance exceeding expectations. Seven of the ten interviewees expressed that the overall performance of the energy systems exceeded expectations. Interviewee #7 said, “We are very satisfied with [the battery system] . . . I was actually impressed,” and, “[The system] is still improving, and once it learns our habits here, I think it can only get better.” Interviewee #10 reported performance that is “better than expected because there’s been a lot of positive feedback, and we haven’t had any issues . . . or concerns related to the units being on the schools.” Interviewee #6, who gave the highest overall performance rating of “10,” said that the battery system “exceeded expectations,” due to the additional savings and acuity of the controls system. Interviewee #2 also reported “better than expected” performance, despite having lost 500 kw of solar capacity.

Underperformance with optimism. Two of the ten interviewees expressed an overall performance rating as being slightly less than expected (both “4”). Interviewee #9 gave two reasons. First, while bill savings have “definitely been delivered,” issues with the meter have resulted in a lack of transparency with the actual savings that was achieved. Second, Interviewee #9 reported that the service provider has taken the utility incentives from the school, and yet the returns from the “guaranteed savings” have not matched what the school would otherwise have seen. #9 is hopeful, however, that the savings will be enhanced in the future, since “[the contract] is structured to our benefit.”

Interviewee #5 said, “My struggle with it is that it’s a learning software and, in my opinion, it’s taking too long to learn.” #5 reported that the battery system will discharge to cover small loads that don’t need to be covered, such an irrigation pump on a weekend. However, #5 reported optimism about future performance and future savings: “I’m expecting to see improved performance.”

Closing Questions

The researcher asked two closing questions to inquire into the scalability and flexibility of the technologies and services from EMaaS. Responses are also grouped into categories.

Closing question 1*: Is your energy service scalable? Does the service structure allow you to scale the technologies campus wide?* Nine of the ten participants responded 'Yes.' The one 'No' respondent, Interviewee #9, was late to their project and was not involved in the contract formation. They reported that their provider would likely not be adding to their project. The remaining nine interviewees shared an interest in scaling the technologies and services from EMaaS. Responses fell into two partially overlapping categories: scaling demand response and scaling solar and storage capacity.

Scaling demand response. Interviewee #8 also said they would like to scale demand response services "years down the road," however, they noted that SDG&E has recently put a cap on their school's demand response capabilities. Interviewee #7 wants to add a battery in a gymnasium that can perform demand response.

Scaling solar and storage capacity. Several of the interviewees shared the interest to add solar and storage capacity in the future. Interviewee #2 wants to add 1.5 MW of rooftop solar to seven buildings, and 250 kw of battery storage paired with 300 kw of solar and to an administration building. In addition to a lighting retrofit, #2 expects the administration building will be able to go off-grid for 30 days. Interviewee #3 wants to add solar and storage in four of their new buildings, to perform peak shaving and to increase solar-self consumption. Interviewee #6 wants to add solar and storage to their new campus buildings. And Interviewee #1 expressed an interest to add more solar and storage the future but is uncertain at the moment.

Closing question 2*: Is your energy service flexible? Does the energy service structure allow you to integrate new energy efficient measures over time?* The responses fell into three categories: integrating demand response; solar plus storage; and integrating EV charging.

Integrating demand response. Four interviewees had not received demand response services, and three reported an interest in integrating demand response in the future. Interviewee #1 said, “As we move forward . . . there are opportunities to integrate demand response.” #1 said they have the battery capacity to perform demand response but it’s not being used. #1’s main concern is to provide power and HVAC during the day, and if demand response services can be included without interruptions, there is flexibility. They noted their level of participation largely depends on SDG&E. Interviewee #3 expressed an interest in integrating demand response but said it “depends on PG&E and their rates and issues.” Interviewee #5 cited SCE’s demand response programs and said that any future expansion at their facilities would “depend on how the rules and regulations shake out on it.”

Solar plus storage. Interviewee #10 reported that their batteries are not paired with solar but charge off the grid and “integrating the two is a plan for the future.” #10 said that if there are identifiable energy efficient measures that they can take, they are open to expanding on their campus. Interviewee #1 also reports having no solar-battery integration but that their new rooftop projects will integrate solar with battery systems.

Integrating EV charging. Interviewee #7 reported to have twelve Level 2 charging stations on their campuses and is "working on getting more installed." Interviewee #2 affirmed that they would "eventually increase the number of EV charging [stations]," and Interviewee #6 said, "we're actually putting four more [Level 2 charging stations] in right now." Their plan in is to include Level 2 and 3 charging infrastructure and invest in electric school buses. Interviewee #3 also expressed an interest in electric fleets for their campuses. Interviewee #1 wants to add EV charging but says that right now it's not economically cost effective.

Emerging Themes

Qualitative research yields raw data which are categorized into themes (Parr, 2017; Creswell, 2014). Themes are designed to reflect the nature of the responses. Four themes emerged in the data analysis. The four themes are presented in the following section.

Emerging theme: Peak shaving overperformance. Six of the ten interviewees reported systems that have overperformed peak shaving expectations. One notable example, Interviewee #6, was able to use the systems' second-by-second interval data to discover a more energy efficient way to ramp their two chillers to avoid peaks. Or Interviewee #2, who lost 500 kw of solar capacity, still reported "better than expected" peak shaving performance. Interviewee #2 was able to take advantage of their energy dashboard to pinpoint equipment failure that was causing new peaks. Interviewee #10 reported performance that is "better than expected" and positive economic returns. Interviewee #1 reported higher levels of peak shaving performance in their larger systems. And Interviewee #2 reported significant jumps in their average monthly savings.

Emerging theme: Low risk/reward. Several interviewees connected the concepts of low risk and reward. Energy service with no up-front cost and off-balance-sheet financing is seen by the consumer as low risk, and capital savings and future energy flexibility are among the rewards. For instance, Interviewee #1 reported successful peak shaving and positive results with very low capital risk. #1 seeks to expand their energy efficiency measures across campuses. Interviewee # 2 said that having batteries that are guaranteed to perform for the life of the contract makes for a rewarding deal. For some, the greater visibility of being seen as 'sustainable' and 'green' is also a reward. Interviewee #3 said, "Going green is part of the heartbeat of this area," and Interviewee #10 reported positive feedback on the energy system from the faculty and community. All six of the ten interviewees who reported systems that overperformed expectations gave answers that reflected the theme of low risk and reward.

Emerging theme: Performance exactly as expected. 25 out of the 50 ratings question responses were rated "exactly as expected." All ten interviewees responded that the cyber security performance has been exactly as expected. Nine of the ten interviewees responded that the operations and maintenance service performance has been exactly as expected. There were "5's" reported within all five questions.

Emerging theme: Hope in future flexibility. Nine of the ten interviewees expressed a desire to expand their technologies and services. Those who have solar and battery storage capacity want to scale up. Those without demand response capability want to integrate more. Some seek to achieve backup power ("island mode") capabilities; others want to retrofit and add more solar plus storage. Nine of the ten interviewees responded positively to EV charging integration, and many hope to expand their charging infrastructure. Several participants reported a school goal of having all electric fleets including busses, and two participants mentioned vehicle-to-grid integration possibilities. Despite the utilities' rules and regulations against demand response participation, several interviewees reported the desire to implement demand response in the future. The participants' desire to expand their technology and services was a reoccurring theme.

Summary

In Chapter Four, the findings from the interview data were coded, categorized, and presented. The demographic section stated the processes of participant selection and the anonymity of the ten participants who contributed. The preliminary questions set the focus on EMaaS with cloud-enabled and intelligent battery systems. The performance ratings were presented and categorized into areas. The closing questions revealed the energy goals of the participants. The data revels four themes: peak shaving overperformance, low risk/reward, performance exactly as expected, and hope in future flexibility. Chapter Five will discuss the findings and answer the research questions.

CHAPTER 5

DISCUSSION

This qualitative study was designed to explore EMaaS customers' expectations of performance and the realizations for the cloud-based energy management services (Chen, 2017). This study used in-depth evaluations to assess service performance to help further build the value proposition for the energy-as-a-service model (ACEEE a., 2019). The suitability of the EMaaS model in the education sector is explored in this section. Data was gathered and categorized from a diverse pool of facility managers, energy practitioners, superintendents, and associate superintendents working with EMaaS. The data is utilized to better understand the performance from the point of view of the customers. In the following sections, the research questions are answered, and the findings are summarized. Implications from this study are drawn, and future research is suggested.

Findings

In this study, faculty members in educational institutions in California were interviewed about the performance of cloud-enabled behind-the-meter battery storage systems in their schools. Interview data is used to answer the research questions.

Research question one. *How has EMaaS been realized in California schools?* (Realized, *df*: "To bring into concrete existence, or to gain by effort, sale, or investment.") The EMaaS providers have designed the scope of each project according to the customer's energy needs. Schools have entered into energy service agreements and paid no up-front expenses or internal capital outlay. The service providers have financed all project costs and assumed all risk of operating and maintaining the equipment.

Demand charge savings have been actualized and peak shaving has largely driven the success of the service. Demand response programs have received positive feedback and many schools seek to expand their ancillary service participation. Cyber security performance has been "exactly as expected" and the physical equipment has been secure. A majority of the participants involved in this research study have enjoyed higher levels of overall performance.

Aspects of underperformance have also been realized. In two cases, participants cited communication issues with providers. They suggested the need for a faster or more reliable method of communication with the provider. Unplanned events can cause new peaks and greater savings can be achieved by mitigating peaks. The battery systems also can have a 6-month learning curve, which typically improves with time. Many participants showed a level of sympathy for early missteps, citing that the technology is still being developed and that improvements were seen with time. Cases of ongoing underperformance may be related to the nature of the deal, its management, or any number of operational factors.

Many schools in California have goals to reduce their carbon emissions, and EMaaS presents an avenue to reach those goals. Maximizing solar self-consumption and installing EV charging, for instance, can be used to reduce a school's carbon footprint. The pay-for-performance model is serving as a steppingstone to a more sustainable energy future.

Lastly, the EMaaS model allows schools to procure valuable energy efficiency services from experts. Schools are able to utilize advanced technologies that they couldn't otherwise attain by outsourcing the task of owning and operating the equipment to a third party with expertise. The nature of the model allows the profitability of expert service to attain with high overall performance quality. The higher levels of expertise required to design, optimize, operate, and maintain the technology are made accessible to schools with EMaaS. EMaaS has divided the role of facility management into two clearly defined roles involving the service provider and the customer such that both parties are able to realize benefits.

Research question two. *How well have performance expectations and service guarantees been met?* Participants reported peak shaving performance on average higher than expected. Overperformance with peak shaving emerged as a reoccurring theme. However, issues were apparent with cases of lower performance during the first 6-months of service. In a couple of cases the service was able to adapt to unfavorable circumstances and still achieve bill savings, for example, dealing with lost solar PV capacity and experiencing system shutdowns. EMaaS has been reported to have delivered monthly savings increases of up to 30 percent. The quality of operations and maintenance service performance has been effective and simple. Cyber security performance has been exactly as expected and has instilled confidence in all ten participants. And finally, overall performance ratings reflected a medium to high level of customer satisfaction.

Research question three. *How is value created and capture with EMaaS?* EMaaS has successfully created value by implementing new technologies into the energy infrastructure of school buildings to reduce energy costs and add new value streams. By integrating distributed solar and storage with machine learning software, data analytics, cloud-computing, and smart meters and sensors, EMaaS creates a financial opportunity for the service provider and the customers. The service provider receives monthly payments and shares in the additional savings with the customer. The customer avoids shouldering the risk of owning and operating the equipment while achieving bill savings.

This research study shows that value is captured through peak shaving, demand reduction, maximizing solar self-consumption, and intelligent bill management. Large campuses with spikey loads are especially good at delivering energy savings, and in some instances without pairing batteries and solar. Access to online energy dashboards have assisting school faculty in capturing additional bill savings. New value streams have emerged with demand response programs and EV charging integration. It appears that some programs and services are not offered if they fail to deliver profit. Some customers may not be fully satisfied with a limited number of performance options; however, in doing so the service provider is able to capture the most value that it creates.

The overperformance seen in this study is likely caused by a number of factors. First, EMaaS companies either lease or own the hardware so it is in their best interest to maintain and secure their systems. This is seen in the results of graphs 3 and 4. Second, the shared savings agreements incentivize greater energy efficiency – the more efficiency achieved, the greater the savings for both parties. And third, providers want to please their stakeholders and investors, so additional savings are often sought out. Value is created with the business model incentivizing innovation and efficiency.

Research question four. *What trends are emerging with EMaaS?* There is movement in the direction of higher levels of renewable energy integration and energy autonomy. The most apparent trend emerging in this research study is demand charge savings from peak shaving. The larger campuses with the highest demand charges are the first being tapped into. As the technology matures and becomes more cost-effective, participants seek to expand their energy efficient measures across their campuses. The EMaaS providers are moving in the direction of the technology and services that are most cost-effective. There is pressure growing on utility companies to expand their demand response programs. Many schools have set sustainability goals, with higher levels of building efficiency and the integration of EV charging infrastructure. Integrating vehicle-to-grid services was a concept on the minds of a few of the participants.

Implications

Energy efficient measures like peak shaving, load shifting, and demand response can operate in a variety of ways to deliver value. Intelligent energy storage allows schools the flexibility to work around their habits. For instance, an administration building can reduce peak demand charges while reserving power for an outage, and a community college campus can store solar power during the day and load shift to maximize revenue through participation in wholesale electricity markets. EMaaS provides an opportunity in the education sector for expert-delivered energy efficiency services with low capital risk. For many schools, energy is among their biggest non-discretionary expenses. EMaaS creates an opportunity for schools to mitigate demand charges and expand their renewable energy portfolios. EMaaS opens a path for schools to replace their aging energy infrastructure with adaptive and intelligent infrastructure.

Conclusion

This qualitative research study has shown medium to high levels of performance satisfaction from the customers of cloud-based energy management services in California schools. The themes reflected categories of performance quality, low financial risk, and future growth. The data shows that value is captured through peak shaving, demand reduction, maximizing solar self-consumption, and intelligent bill management. Large campuses with spikey loads are especially good at delivering energy savings, and in some instances without pairing batteries and solar. Demand response performance largely depends on the utility rules and regulations. Where demand response participation is allowed, the quality of performance is mixed with performance exactly as expected and slightly less than expected. The EMaaS business model is positioned to help schools implement and achieve many of their future sustainability goals in a cost-effective way, and schools are especially suited to take advantage of EMaaS benefits.

Future Research

More research is needed in EMaaS to develop a unified explanation of how value created and how such value is captured in specific sectors that are transitioning to a decentralized and customer-oriented business model. Quantitative data would help identify key value streams and allow for a long-term assessment of EMaaS. Emissions reduction studies will further elaborate the effectiveness of battery-based technologies as a sustainable energy option. And lastly, electric vehicle fleet integration and vehicle-to-grid technology studies will aid the integration of EVs and the built environment.

Summary

In Chapter 5, the findings were discussed, and research questions were answered. Implications were drawn, and future research was suggested.

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APPENDIX A

INTERVIEW QUESTIONNAIRE

1. What kind of service agreement do you have?
2. When was the battery system installed?
3. Do you have prior battery storage or microgrid experience?
4. What was the primary intended function of the battery storage system or microgrid?
5. On a scale from 1-10: if 1 = much less than expected, 5 = exactly as expected, and 10 = far greater than expected: How well has the demand reduction performance met the performance specifications in the contract?

1	2	3	4	5	6	7	8	9	10

6. Does the system participate in a demand response program?
7. On a scale from 1-10: with 1 = much less than expected, 5 = exactly as expected, and 10 = far greater than expected: How well has the demand response performance met the performance specifications in the contract?

1	2	3	4	5	6	7	8	9	10

8. Are there operational duties on the facility side?
9. On a scale from 1-10: if 1 = much less than expected, 5 = exactly as expected, and 10 = far greater than expected: How well has the operational performance met the performance specifications in the contract?

1	2	3	4	5	6	7	8	9	10

10. Are there any maintenance duties on the facility side?

11. On a scale from 1-10: if 1 = much less than expected, 5 = exactly as expected, and 10 = far greater than expected: How well has the maintenance performance met the performance specifications in the contract?

1	2	3	4	5	6	7	8	9	10

12. Does your facility have EV charging stations?
13. Does your facility plan to integrate more EV charging in the future?
14. Has cyber security ever been an issue?
15. On a scale from 1-10: with 1 = much less than expected, 5 = exactly as expected, and 10 = far greater than expected: How well has the cyber security performance met the performance specifications in the contract?

1	2	3	4	5	6	7	8	9	10

16. Has the security of the physical equipment on-site ever been an issue?
17. On a scale from 1-10: with 1 = much less than expected, 5 = exactly as expected, and 10 = far greater than expected: Overall, how well has the energy service met contractual expectations?

1	2	3	4	5	6	7	8	9	10

18. Is your energy service scalable? Does the service structure allow you to scale the technologies campus wide?
19. Is your energy service flexible? Does the energy service structure allow you to integrate new energy efficient measures over time?