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FINAL PROJECT REPORT

Irvine Ranch Water District Load Shifting and Demand Response Pilot Project

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PREFACE

The California Energy Commission's (CEC) Energy Research and Development Division supports energy research and development programs to spur innovation in energy efficiency, renewable energy and advanced clean generation, energy-related environmental protection, energy transmission, and distribution and transportation.

In 2012, the Electric Program Investment Charge (EPIC) was established by the California Public Utilities Commission to fund public investments in research to create and advance new energy solutions, foster regional innovation, and bring ideas from the lab to the marketplace. The EPIC Program is funded by California utility customers under the auspices of the California Public Utilities Commission. The CEC and the state's three largest investor-owned utilities—Pacific Gas and Electric Company, San Diego Gas and Electric Company, and Southern California Edison Company—were selected to administer the EPIC funds and advance novel technologies, tools, and strategies that provide benefits to their electric ratepayers.

The CEC is committed to ensuring public participation in its research and development programs that promote greater reliability, lower costs, and increase safety for the California electric ratepayer and include:

- Providing societal benefits.
- Reducing greenhouse gas emission in the electricity sector at the lowest possible cost.
- Supporting California's loading order to meet energy needs first with energy efficiency and demand response, next with renewable energy (distributed generation and utility scale), and finally with clean, conventional electricity supply.
- Supporting low-emission vehicles and transportation.
- Providing economic development.
- Using ratepayer funds efficiently.

The *Irvine Ranch Water District Load Shifting and Demand Response Pilot Project* is the final report for Contract Number EPC-16-028, conducted by Advanced Microgrid Solutions and Guidehouse. The information from this project contributes to the Energy Research and Development Division's EPIC Program.

For more information about the Energy Research and Development Division, please visit the CEC's research website (www.energy.ca.gov/research/) or contact the Energy Research and Development Division at ERDD@energy.ca.gov.

ABSTRACT

The Irvine Ranch Water District load shifting and demand response pilot project sought to advance, test, and validate a novel technology platform that could contribute considerably to achieving California's energy goals and reducing costs at industrial water treatment, pumping, and recycling facilities. The project aimed to automate load shifting and demand response at various water treatment and pumping facilities located throughout the Irvine Ranch Water District to reduce on-peak energy demand and use, enable site participation in demand response programs, and reduce energy bills and greenhouse gas emissions. The ultimate intent was to validate an approach that water agencies could use to achieve savings by reducing or shifting electricity load, with the prospect of using such strategies in water facilities throughout California and elsewhere.

This report documents the process, results, and findings from the project. The project demonstrated the load reduction and shifting benefits for sites through installing a battery energy storage system, and it highlighted the challenges associated with baseline-related demand response performance calculations with a battery energy storage system. The project also documented difficulties with implementing operating changes at water sites to achieve load reduction. As a result, this report provides valuable lessons learned on load reduction and shifting prospects using storage at water utilities and possibilities/challenges with demand response participation.

Keywords: demand response, water-energy nexus, water district, battery energy storage system, load shift

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Background

The water industry faces energy challenges from the increased use of energy-intensive technologies, population growth, higher energy prices, and limited options to optimize costs under current electricity rates. The water sector has shown limited improvement in energy use because of insufficient modernization, a lack of financial resources, and a lack of integration between energy and water policy issues. Public water agencies operate within strict health, safety, reliability, and ratemaking constraints. These regulatory priorities and operational constraints drive agencies to focus on water quality, reliability, and conservation rather than on systems to optimize energy use. Operational constraints make it challenging for water agencies to respond to price signals or utility demand response (DR) events (in which utilities ask customers to reduce or shift their energy use in response to changes in available supply), except for occasional participation in day-ahead DR events. Meaningfully reducing energy demand and use in the water sector requires testing and validating technologies, along with best practices for peak reduction, DR program participation, and customer cost optimization under available tariff structures.

Project Purpose

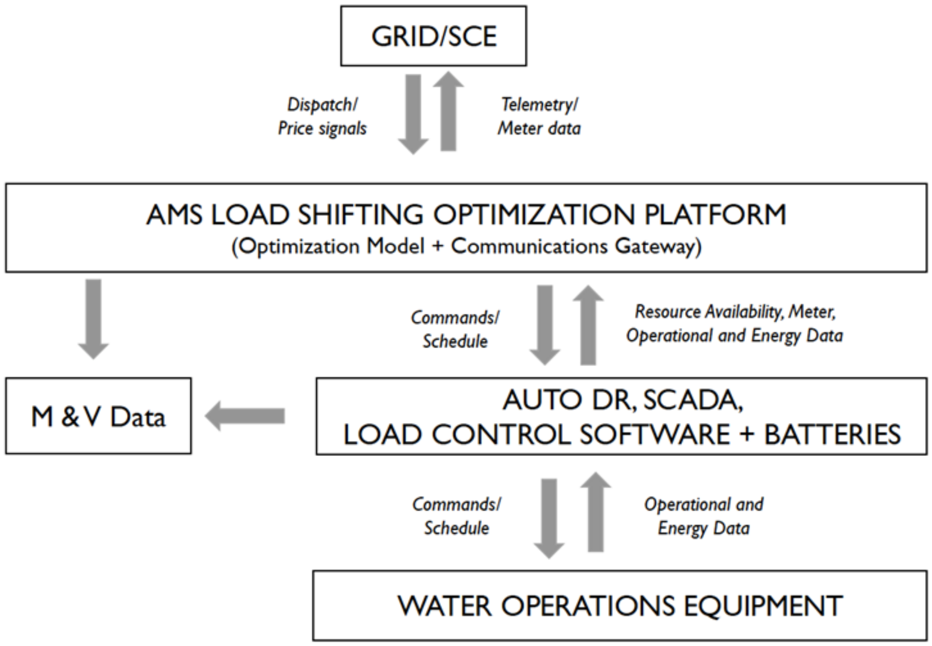
The purpose of the Irvine Ranch Water District Load Shifting and Demand Response Pilot Project was to advance, test, and validate a computer platform developed by Advanced Microgrid Solutions that can optimize electricity load shifting. The platform combines advanced data monitoring, automated load control, energy storage, and cost optimization software. The project goals were to: reduce on-peak energy demand and use at the district sites where the platform was installed, enable site participation in DR programs and enhance DR performance, reduce energy bills for the sites, reduce greenhouse gas (GHG) emissions, and analyze alternative electricity tariffs for each site to identify the most beneficial one.

The researchers used the data generated by the project to validate the load shifting approach, identify best practices for increasing the participation of industrial water customers in utility DR programs, and draw lessons learned from the pilot experience to inform similar future projects deployed at other water industry facilities in California and elsewhere.

Project Approach and Implementation Findings

The project involved multiple steps, including selecting the sites, assessing suitability of sites to participate in the pilot, installing the Advanced Microgrid Solutions optimization platform, and measuring site performance. Figure ES-1 shows how the different systems and project components integrated and interacted with each other. The figure highlights the central role played by the platform in optimizing site operations while using meter data and DR event and price signals from Southern California Edison Company and integrating site operations with battery energy storage system and automated DR strategies, ultimately providing data to measure and verify performance. Although the project originally contemplated leveraging automated DR, supervisory control and data acquisition systems, and load control software to achieve savings, these elements were ultimately irrelevant when the project scope was limited to batteries participating in the Local Capacity Requirements (LCR) program.

Figure ES-1: Project Implementation Diagram



The Advanced Microgrid Solutions platform links with Southern California Edison Company to collect data and receive DR signals, links with water system controls to automate control of batteries and loads, and provides data used in the verification process.

Source: Advanced Microgrid Solutions

Project implementation began by screening 81 potential sites and narrowing the field to the 11 best pilot candidates. The project team conducted a more detailed review of the potential sites with onsite visits and detailed energy audits to further narrow the field to six sites. The researchers presented plans to the Irvine Ranch Water District for implementing battery energy storage systems and operational load control for all six sites. The researchers envisioned operational load control involving shutting off facility pumps during selected times or installing variable frequency drive pumps capable of adjusting water flow. After receiving feedback from the Irvine Ranch Water District, however, the project team determined that none of the sites were suitable for operational load control due to operational constraints, noise and aesthetic concerns, and financial risks associated with dual DR program enrollment.

The researchers installed the battery energy storage systems at the six sites and enrolled in the LCR program with a total capacity of roughly 6.5 megawatts per 35 megawatt-hours. The LCR program is a DR program where the customer earns capacity and energy payments when reducing load in response to a call by the local utility. The platform controlled the systems and optimized the operation of the storage systems to get the highest total value of multiple revenue streams for each site from demand charge management and DR programs. Finally, the team used performance data collected from all six sites during the operating period

(August 1, 2019, to December 31, 2019) to evaluate program performance according to the key performance indicators discussed below.

Measurement and Verification Results and Conclusions

To assess the effectiveness of the battery energy storage systems, the project team evaluated six key performance indicators for each site.

1. Peak demand reduction: The percent reduction in maximum power draw; it includes both on-peak demand reduction (reduction during time-of-use on-peak periods) and global peak reduction (reduction in peak during utility billing cycles).
2. Peak usage reduction: The percent reduction in electricity consumption; it includes both on-peak usage reduction (reduction in energy use during time-of-use on-peak periods) and global usage reduction (reduction in energy use during utility billing cycles).
3. DR performance: The reduction in demand during DR events (in this case, LCR program events) as a percentage of the nominated capacity value in the program.
4. Bill reduction: The percent reduction in bills due to battery energy storage system optimization.
5. GHG reductions: The percent reduction in the marginal carbon emissions post-battery energy storage system.
6. Tariff impact: An impact assessment of potential alternative tariffs to identify the ones that could provide the greatest benefits.

The results showed that, across sites, the battery energy storage systems effectively reduced on-peak energy usage and curbed consumption during LCR program events. However, these reductions did not translate into lower operating costs; bills consistently increased by around 1 percent to 2 percent. Also, GHG emissions and total electricity consumption were consistently higher post-battery energy storage system, likely due to battery roundtrip inefficiencies (roundtrip refers to the fraction of energy put into a battery energy storage system that can be retrieved). The varied performance around the remaining metrics (on-peak demand reduction and global peak demand reduction) reflected the complexity of co-optimizing battery energy storage systems for demand charge management and DR participation. Each site's performance is described in greater detail in the report.

This pilot project fulfilled its purpose of advancing, testing, and validating a load shifting optimization platform; it had mixed results in achieving the goals, as shown in Table ES-1.

Table ES-1: Performance Summary for All Sites With Battery Energy Storage Systems Installed

Site	On-Peak Demand Reduction	Global Peak Demand Reduction	On-Peak Usage Reduction	Global Usage Reduction	LCR Performance (Reduction)	Bill Reduction	GHG Reduction
Baker	-1.8%	-11.0%	38%	-1.2%	57.6%	-2.5%	-0.6%
DATS	-1.9%	-32.0%	71%	-2.2%	14.7%	-3.4%	-1.1%
LAWRP	-10.1%	-19.6%	63%	-1%	29.7%	0.7%	-0.4%
MWRP	3.3%	-16.8%	40%	-0.9%	79.3%	-1.6%	-0.3%
PTP	3.5%	-10.0%	65%	-0.9%	26.6%	0.4%	-0.1%
Tustin Wells	10.7%	-0.02%	78%	-1.3%	32.6%	4%	-2.9%

Negative values indicate an increase in the metric.

Sources: Advanced Microgrid Solutions, Guidehouse.

Three of the six sites experienced a decrease in the average on-peak demand, while the remaining three experienced an increase in the average on-peak demand. The total on-peak energy use decreased at all sites. Despite decreases in demand and energy use, only three of the sites achieved positive bill savings; the other three saw an increase in the total utility bills. A variety of factors contributed to this bill increase, including relatively flat load profiles and charge window constraints. The Irvine Ranch Water District sites have relatively flat load profiles, which does not leave much headroom to charge the batteries fully without setting a new peak (resulting in an increase in global peak demand in all cases). This issue was exacerbated by limited charging windows because the battery may need to charge at a higher rate to fill to capacity in a shorter time.

The total GHG emissions increased at all sites, so the project did not achieve the goal of reducing emissions. The two primary factors contributing to the increase in GHG emissions were: (1) roundtrip efficiency losses, and (2) the GHG emissions factor not being necessarily higher during on-peak hours. The battery cycling efficiency was less than 100 percent, so each battery cycle drew slightly more energy from the grid than it consumed (resulting in global usage reduction, shown in Table ES-1), thus emitting more GHGs. Table ES-1 shows that battery energy storage systems were effective at reducing total energy consumption during on-peak hours and at shifting energy to be consumed in off-peak hours. If the GHG emissions factor is higher during on-peak hours, this could be an effective strategy to reduce overall GHG emissions. However, the grid mix in the district did not follow this trend; the GHG emission factor is not necessarily higher during on-peak hours and, therefore, shifting energy consumption to different times of the day does not decrease GHG emissions.

Based on the project results, the project team drew the following conclusions:

- Water and wastewater treatment facilities can shift electric load using battery energy storage systems. However, the load shift varies widely, depending on the site operations and load characteristics. Even for a particular site, the on-peak demand reduction can vary over a wide range within a certain timeframe. Due to the nature of demand charges — when even a single 15-minute interval of nonperformance results in lost savings — the ability to capture on-peak demand charges is challenging and subject to battery energy storage system and operational load control execution and uptime. This is further complicated when additional revenue streams like DR are available to a facility, because high-value DR programs may not allow a battery energy storage system unit to capture on-peak demand charges every month.
- Water agencies can participate in DR programs such as LCRs by using battery energy storage systems. All participating sites reduced load during LCR events, indicating that sites can reduce load during DR events using battery energy storage systems. The DR performance also varies widely, depending on facility operations, load characteristics, and battery energy storage system operations. Even for a particular site, the average monthly DR performance can vary widely, depending on the month. This variability stems primarily from seasonal changes in facility operations (increased treatment loads due to rainfall, for example) and from battery energy storage system operational performance.
- Batteries can help provide bill savings by reducing on-peak usage, on-peak demand, and global peak demand in a billing cycle. The potential savings depend highly on the baseline load profile of a site (lower savings for a flatter load profile versus higher savings for a site with a "spikier" load) and the level of demand charge (dollars per kilowatt) and energy charge (dollars per kilowatt-hour) in the applicable tariff for the site. Balancing on-peak reductions and global peak increases when load and dispatch conditions change requires sophisticated real-time optimization and, at some facilities, the cost (in the form of increased global peak demand) is approximately equal to the savings (in the form of reduced on-peak usage and demand).
- Batteries can help the stack value of demand change management and DR. However, significant barriers exist, including the use of baseline methodologies designed for load-control DR to measure battery energy storage system performance. With baseline methods, discharging the storage system for demand charge management for bill savings on a non-DR event dispatch day lowers the baseline that DR performance is measured against. Lowering the baseline essentially penalizes energy storage unit behavior during non-DR event hours, making value stacking risky and highly dependent on DR dispatch frequency and timing.
- Battery energy storage systems have a minimal impact on GHG emission reductions at facilities because there is not yet a GHG-related price signal for these systems to optimize against and realize revenue through. This is partly due to the roundtrip efficiency of the energy storage unit itself, which naturally increases electricity consumption. The primary reason, however, is the imperfect alignment of utility rate structures

with marginal grid emissions. If the price of electricity perfectly matched the marginal GHG emissions of the grid, energy storage units would have a financial incentive to minimize GHG emissions via electricity arbitrage.

Technology/Knowledge/Market Transfer Activities

This report is the first and primary method for communicating the lessons learned from this project. Summary presentations at conferences, to regulators, and to utility DR program managers can further disseminate study findings. Possible venues for presentations include:

- California Public Utilities Commission Demand Response Measurement and Evaluation Committee workshops
- Southern California Edison Company annual water conference
- California Efficiency Demand Management Council symposiums or webinars
- Peak Load Management Alliance conferences or events

Benefits to California

The findings from the project can be used to help water agencies understand the benefits and risks of deploying battery energy storage systems at their facilities. The report also documents the magnitude of costs and benefits of some common operational load control measures at water agency facilities, including both energy and financial benefits. Finally, it highlights the challenges of dual enrollment in programs that seek to engage controllable loads like traditional DR and newer battery energy storage system technologies.

Lastly, as California makes progress towards the 100 percent clean energy requirements of Senate Bill 100 (De León, Chapter 312, Statutes of 2018), effectively and predictably engaging customer-sited load control, electricity generation, and energy storage units will be critical to achieving these goals cost effectively. This project’s findings regarding the GHG impacts of battery energy storage systems, given current tariff structures and the barriers to engaging multiple customer-sited resources effectively, are important issues to resolve.

CHAPTER 1: Introduction

Background

The water industry has growing energy challenges due to the increased use of energy-intensive technologies, population growth, higher energy prices, and limited options to optimize costs under current tariff schedules (Badruzzaman et al. 2015). A 2013 study conducted by the Electric Power Research Institute estimated a 74 percent increase in energy usage in municipal wastewater treatment since 1996 and a 39 percent increase in energy usage for public drinking water systems (EPRI 2013). The water sector has shown limited improvement in energy use due to insufficient modernization, a lack of financial resources, and a lack of integration of energy issues with water policy (Badruzzaman et al. 2015). A study for the California Public Utilities Commission (CPUC) estimated that the scale of this problem is significant, with electricity use in water infrastructure accounting for approximately 8 percent of statewide use (GEI Consultants 2010). Given California's recent commitment to deeper cuts in greenhouse gas (GHG) emissions in Senate Bill (SB) 32 (Pavley, Chapter 249, Statutes of 2016) and SB 350 (De León, Chapter 547, Statutes of 2015), energy use for water operations is a critical and urgent problem for California.

Public water agencies operate within strict health, safety, reliability, and ratemaking constraints. These regulatory priorities and operational constraints drive agencies to focus on water quality, reliability, and conservation rather than on systems to optimize energy use. Operational constraints make it challenging for water agencies to respond to price signals or utility demand response (DR) events, except for occasional participation in day-ahead DR events. Even sophisticated water agencies with supervisory control and data acquisition (SCADA) systems do not use time-of-use (TOU) controls in many large facilities and instead rely on traditional energy management measures such as manually shutting down or using gravity flow from storage reservoirs to reduce demand charges. To significantly reduce energy demand and use in the water sector, there is a need to test and validate technologies and best practices for peak reduction, DR program participation, and customer cost optimization under available tariff structures.

Project Purpose

The purpose of the Irvine Ranch Water District (IRWD) load shifting and DR pilot project was to advance, test, and validate a novel technology platform that has the potential to contribute significantly to achieving the state's energy goals and reducing costs at industrial water treatment, pumping, and recycling facilities. The project integrated several innovative technologies into a load shifting optimization platform: advanced data monitoring, automated load control, energy storage, and cost optimization software.

The platform optimized and automated load shifting and DR at multiple water treatment and pumping facilities located throughout IRWD.

The goals of the project were to:

- Advance and validate a pre-commercial, optimized load shifting platform and DR system for water and wastewater treatment, pumping, and recycling facilities.
- Reduce peak demand and peak usage and associated costs in the water sector.
- Increase water sector participation in DR programs.
- Optimize water sector energy costs under available tariff structures.
- Demonstrate that load shifting and DR can be accomplished without impacting water agency operations.
- Provide direct benefits to California investor-owned utility ratepayers by reducing the cost of energy, increasing grid reliability and safety, improving air quality, reducing GHG emissions, and advancing technology to meet California's statutory energy goals.

The specific project objectives were to achieve the following for the project sites:

- Reduce on-peak demand by 22 percent or more.
- Reduce on-peak usage by 32 percent or more.
- Increase water sector participation in utility DR programs to 90 percent.
- Reduce overall energy bills by 5 percent.
- Reduce 224 tons of GHG emissions annually from reducing energy demand to carry out the State's climate change goals, including Assembly Bill No. 32 (AB 32, Nunez. Air pollution: greenhouse gases: California Global Warming Solutions Act of 2006), SB 32, SB 350, and the Governor's Executive Order B-30-15.
- Measure, quantify, and compare the effect of price signals within existing tariffs on reducing peak demand and usage, participation in DR programs, and customer cost optimization.

The project plan was to use the data generated by the project to validate the approach, identify best practices for increasing the participation of industrial water customers in utility DR programs, and draw lessons learned from the pilot experience to inform similar future projects deployed at other water industry facilities in California and elsewhere.

Chapter 2 describes the project implementation approach and findings. Chapter 3 presents the measurement and verification (M&V) results on key performance metrics and the conclusions from the project based on implementation findings and these results. Chapter 4 suggests technology/knowledge transfer activities, and Chapter 5 concludes with benefits to California.

CHAPTER 2: Project Approach and Implementation Findings

This chapter describes the project team, including roles and responsibilities of the different parties, the approach for site selection and load shifting optimization platform operations at the selected sites, and findings from implementation of the load shifting and DR program participation strategies. The chapter also describes the M&V approach for quantifying the performance metrics listed in the previous chapter.

Project Team

Table 1 lists project team members and their roles and responsibilities.

Table 1: Project Team Roles and Responsibilities

Name	Role	Responsibilities
Advanced Microgrid Solutions (AMS)	Recipient	• Manage project timeline, budget, subcontractors • Account for all California Energy Commission (CEC) deliverables and meetings • Manage all subcontractors • Work with host customer on project design, site selection and coordination, project implementation, and on-going M&V • Install battery energy storage systems (BESS) on selected sites • DR participation of BESS • Ongoing operations and maintenance of BESS • Advanced analysis of integration of BESS and operational load control (OLC) measures • Data collection and analysis for load shifting and DR performance of BESS • Tariff analysis
Irvine Ranch Water District (IRWD)	Host Customer	• Provide site access and data • Review proposed scope of work for BESS and OLC measures • Assist with BESS and OLC measure installation • Enroll in at least one Southern California Edison Company (SCE) DR program
Guidehouse	Subcontractor	• Develop M&V plan • Verify data and analysis • Baseline energy and water report • Post-implementation energy and water report • Validate project impact

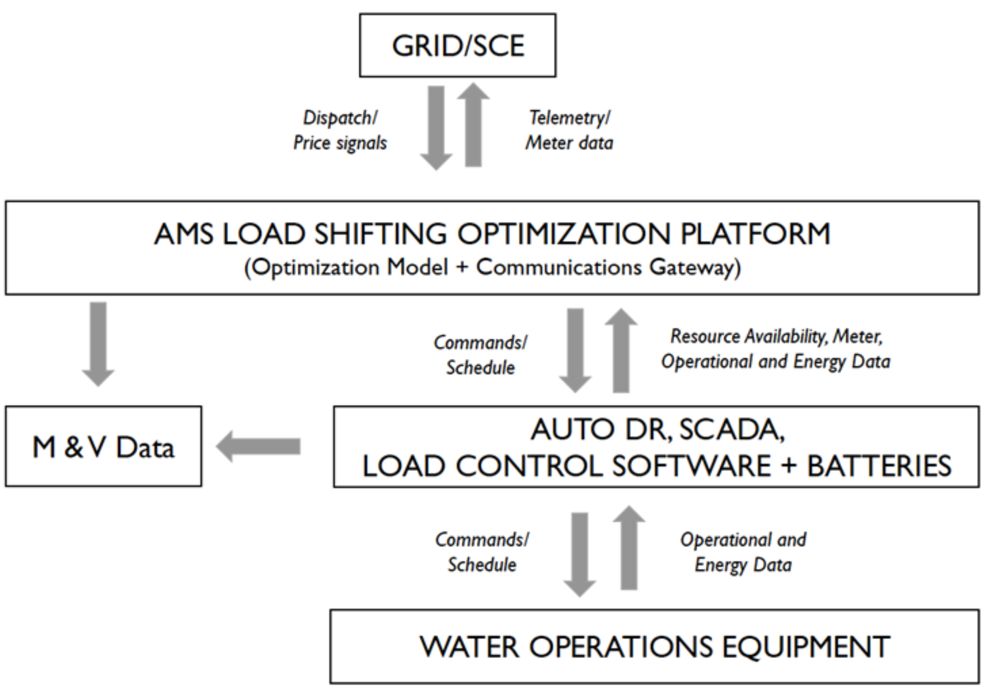
Name	Role	Responsibilities
		• California Energy Commission (CEC) reporting and deliverables
Lockheed Martin	Subcontractor	• Perform site and data audit to identify OLC measures with load shifting and DR opportunities • Data analysis and reports for OLC measures • Oversee hardware installation, SCADA reprogramming, and DR participation • Develop training materials and provide training
Akbar Jazayeri	Subcontractor	• Advise on tariff design, analysis, and selection

Source: Advanced Microgrid Solutions.

Project Design and Approach

The project execution involved selecting sites and assessing their suitability to participate in the pilot, installing the Advanced Microgrid Solutions (AMS) optimization platform, and measuring the performance of the sites. Figure 1 represents how the different systems and project components integrate and interact with each other. The figure highlights the central role played by the AMS platform in optimizing site operations while using meter data and DR event and price signals from SCE and integrating site operations with BESS and automated demand response (Auto-DR) strategies, ultimately providing data for performance M&V.

Figure 1: Project Implementation Diagram



The AMS platform links with SCE to collect data and receive DR signals, links with water system controls to automate control of batteries and loads, and provides data used in the verification process.

Source: Advanced Microgrid Solutions

Following are the project implementation steps, which are described below.

1. Assessing and screening site load.
2. Selecting 11 sites with potential of peak shaving and DR.
3. Performing comprehensive analytics to determine feasible sites for BESS and potential BESS sizes.
4. Conducting site visits and detailed energy audits for each selected site to identify operational load control (OLC) opportunities to shift load and enroll in DR.
5. Conducting analysis to consolidate BESS and OLC measures to estimate demand reduction, energy savings, and payback period.
6. Proposing solutions, including BESS and OLC opportunities, to IRWD for review and approval.
7. Installing BESS and participating in utility DR programs.
8. Performing optimization of demand charge management (DCM) and DR using BESS.
9. Performing M&V and reporting.

Implementation Steps and Findings

Site Load Assessment and Screening

The project team screened 81 service accounts to assess site suitability for pilot participation based on the load profile and operations at these sites.

Select 11 Sites With Potential for Peak-shaving and DR

Of the 81 sites screened (Figure 2 shows the hourly load profiles of the 81 sites screened), the research team identified 11 sites as good candidates for pilot participation. These included:

1. Michelson Water Recycling Plant (MWRP): IRWD's largest energy-consuming facility, which takes in raw sewage and conducts primary treatment, secondary treatment, tertiary treatment, recycled water distribution pumping, and biosolids processing.
2. Deep Aquifer Treatment System (DATS): IRWD's second-largest energy-consuming facility, which includes two wells that pump water from approximately 2,000 feet below ground level. Water is treated using reverse osmosis before being blended with other groundwater.
3. Los Alisos Water Recycling Plant (LAWRP): IRWD's third-largest energy-consuming facility, which takes in raw sewage and conducts primary treatment, secondary treatment, tertiary treatment, recycled water distribution pumping, and biosolids processing.
4. Principle Treatment Plant (PTP): A plant that treats groundwater using reverse osmosis, decarbonation, and disinfection.

5. Tustin Wells 21/22 Desalter Facility: A facility that treats groundwater using reverse osmosis.
6. Dyer Road Well 10: A potable groundwater well.
7. Portola 3-5 & A-C Pump Station: A station that includes one SCE meter connected to two booster pump stations, one for potable water and the other for nonpotable water.
8. Baker Water Treatment Plant: A drinking water treatment plant with 28.1 million gallons per day capacity that is a shared facility across five water districts.
9. Dyer Road Well 15: A potable groundwater well.
10. Dyer Road Well 17: A potable groundwater well.
11. 17675 ¼ Harvard: Harvard Avenue Trunk Sewer, which is both a trunk line that is fed sewage from a distinct region and a facility that is used to divert (pump) sewage to IRWD's Michelson Water Reclamation Plant.

Figure 2: Hourly Load Profiles of Screened and Selected Sites

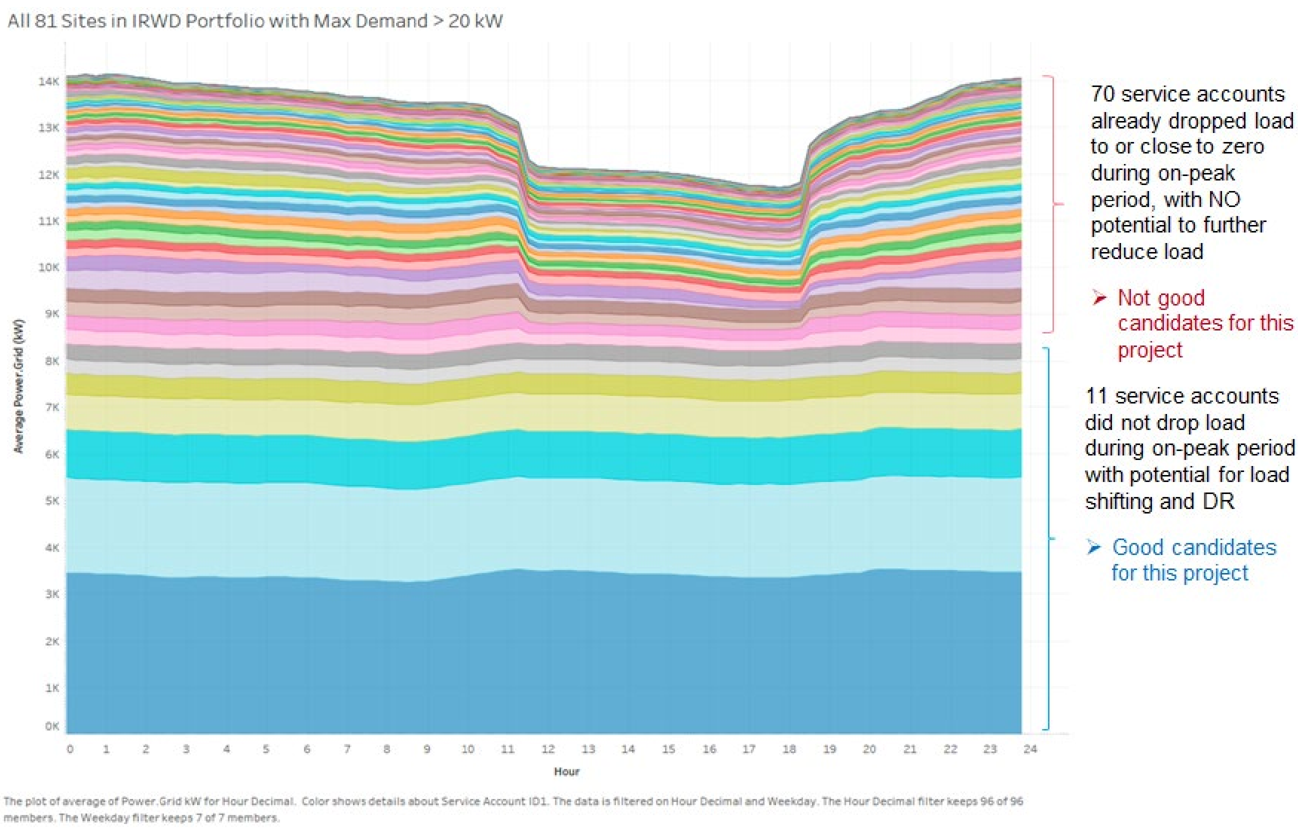


Figure 2 shows the hourly load profiles of 81 sites. Of these 81 sites, 70 sites were screened out as they were already reducing their load during the TOU on-peak period and had no further potential for reduction during DR events. These criteria can be observed visually in this figure as the sites with a noticeable drop in available load during TOU peak hours and the sites with a relatively small (less than100 kilowatts) available load. The 11 sites that did not drop load during the on-peak period were assessed to be good candidates for the pilot project.

Source: Advanced Microgrid Solutions

Perform Comprehensive Analytics to Determine Feasible Sites for Battery Energy Storage Systems and Potential Sizes

For the 11 selected sites, the project team assessed the financial feasibility of installing BESS and determined the potential BESS sizes that would be required. Financial feasibility was determined by assessing the potential revenues of a range of battery system sizes for each facility — incorporating available physical space for an installation, the available and appropriate rate schedules a facility was eligible for, and available DR programs — and comparing these with estimated project costs and third-party financing targets.

Of the 11 selected sites, the team selected 6 sites for BESS installation. Table 2 shows the sites where BESS was installed and the BESS sizes at these sites.

Table 2: Selected Sites and Sizes for BESS Installation

Site	BESS kW	BESS kWh
Michelson Water Recycling Plant (MWRP)	2,500	15,000
Los Alisos Water Recycling Plant (LAWRP)	1,040	5,040
Deep Aquifer Treatment System (DATS)	1,000	6,000
Principle Treatment Plant (PTP)	500	2,100
Baker Water Treatment Plant (Baker)	1,225	6,300
Tustin Well 21/22 Desalter Facility (Tustin Well)	250	1,260
Total	**6,515**	**35,700**

Source: Advanced Microgrid Solutions

By April 2019, BESS was successfully installed and operational at six sites, with a total capacity of 6,515 kilowatts (kW) per 35,700 kilowatt-hours (kWh).

Conduct Site Visit and Detailed Energy Audit for Each Site to Identify OLC Opportunities to Shift Load and Enroll in DR

For all 11 selected sites, the project team conducted site visits and performed detailed energy audits to identify OLC measures that these sites could undertake for load shifting and reduction during DR events.

The first step of this assessment was to document on-peak demand and energy use, total annual electricity use, and the annual marginal GHG emissions for these sites. Table 3 lists this data for the 11 selected sites.

Load shifting involves shifting load away from peak periods to other periods, based on the applicable TOU tariff for the sites. Appendix A includes the TOU tariff description. The on-peak period during summer months (June through September) was from 4 p.m. to 9 p.m. on weekdays under the applicable tariffs for these sites.

Table 3: Sites With Potential for Load Shifting and DR

Site	On-Peak Demand (kW)	Annual On-Peak Elec Use (kWh/yr.)	Annual Elec Use (kWh/yr.)	Annual Marginal GHG (ton-CO_2/yr.)
MWRP	5,738	2,786,653	32,335,495	9,976
DATS	1,114	616,597	8,518,529	2,652
LAWRP	982	438,660	6,757,092	2,104
PTP	405	109,523	2,755,011	839
Baker	5,382	1,071,104	17,987,096	5,382
Tustin Well	360	161,184	2,094,560	654
Portola 3-5 & A-C Pump Station	399	98,062	1,917,594	577
Harvard Avenue Trunk Sewer	72	21,391	366,024	161
Dyer Road Well 10	328	161,173	2,824,324	866
Dyer Road Well 15	375	184,306	2,789,181	844
Dyer Road Well 17*	334	140,452	2,330,494	N/A

Based on 2018 utility data.

*The team used 2017 data for Dyer Road Well 17, as the site was temporarily offline in 2018.
Source: Advanced Microgrid Solutions

The project team also researched the different types of DR programs (including dynamic rates) that these sites could participate in. Through these programs, sites could reduce load in response to the DR event and rate and could earn incentives and bill savings through load reduction during the DR event period. The three applicable DR programs and rates for these sites are summarized below and detailed in Appendix B.

- Local capacity requirement (LCR): Participating sites received a dollar per kilowatt incentive based on the load reduced during LCR events.
- Real-time pricing (RTP): Customers received hourly pricing and responded to price signals by shifting or reducing electricity usage during high price periods.
- Critical peak pricing (CPP): Customers received a discount on summer electricity rates in exchange for higher prices during the 12 CPP event days, which usually occurred on the hottest summer days.

Based on the energy audits of the 11 sites and assessment of the site load profile and operational patterns, the project team identified five sites with potential for on-peak load reduction using OLC measures and one site with potential for load shifting and participation in DR using OLC measures. The remaining five sites did not have practical OLC measures, given site and equipment conditions. Note that this assessment did not consider the presence or potential for BESS at these sites — this assessment was purely examining potential for OLC.

Table 4 shows the non-BESS OLC potential from five sites in terms of peak demand reduction potential, annual energy and bill savings, costs for implementing the OLC measures, and the payback period. Table 5 shows the potential from load shifting and DR participation from one site, Portola-AC. Of the 11 sites listed in Table 3, only the Portola A-C pump station could undertake continuous demand reductions by implementing OLC measures as part of its normal operations. The remaining 10 sites were unsuitable for additional load reduction in response to DR event triggers, due to site-specific conditions.

Table 4 shows the payback period of the sites with variable frequency drive (VFD) installation in pump motors. The payback period ranged from roughly 2 years to 7.5 years, depending on the peak demand reduction and energy savings potential of the sites. As mentioned, only Portola A-C (shown in Table 5) had potential for both DR participation and load shifting using OLC measures. The potential for load shifting from on-peak to off-peak periods and for load reduction during DR events led to very low payback of less than a year. The payback period in Table 5 is described as "best case" because the annual cost savings were based on optimistic assumptions, since performing both load shifting and demand response perfectly is unattainable.

Table 4: Non-battery Energy Storage System OLC Potential with Load Reduction Only

Site	OLC Measure	Peak Demand Reduction (kW)	Annual Energy Savings (kWh)	Annual Bill Savings ($)	Measure Cost ($)	Payback Period (yrs.)
Dyer Road Well 10	Install VFD on the 450 hp pump motor	17.4	145,872	$13,545	$112,500	7.52
Dyer Road Well 15	Install VFD on the 500 hp pump motor	19.9	167,542	$15,480	$125,000	7.34
Dyer Road Well 17	Install VFD on the 400 hp pump motor	30.0	236,477	$21,456	$100,000	4.66
Harvard Avenue Trunk Sewer	Install VFDs on two 75 hp pump motors	36.0	130,253	$18,989	$37,500	1.97
Tustin Well 21	Install VFD on the 300 hp pump motor	55.0	189,054	$18,404	$75,000	4.08

Source: Advanced Microgrid Solutions

Table 5: Non-battery Energy Storage System OLC Potential for Load Shifting and DR

Site	Measure Type (Load Shifting/DR)	DR Load Reduction (kW)	Annual Cost Savings ($)	Measure Cost ($)	Best Case Payback (yrs.)
Portola A-C	Load shifting: Limit operations to a single pump in all on-peak hours	190.0	$17,285	$5,000	0.29
Portola A-C	DR: Shut down all pumps and shift load to other hours during DR events	159.0	$9,540	$5,000	0.52

Source: Advanced Microgrid Solutions

Conduct Analytics to Consolidate Battery Energy Storage Systems and OLC Measures to Estimate Demand Reduction, Energy Savings, and Payback Period

Once the research team completed the BESS and OLC assessments, the next step was to consolidate BESS and OLC measures for all sites, analyze the combined demand reduction and energy savings potential, and estimate the payback period for these sites.

Table 6 shows the potential for load shifting and DR program participation using BESS and OLC in combination.[1] This table shows a range of bill savings values, a range that is due to the uncertainty of DR events and RTP price. If LCR events are called in the hours when RTP rates are high, bill savings are positive. If they happen in different hours in a day, bill savings are negative. Negative values for annual bill savings imply that annual energy bills could actually increase as a result of the measures.

One of the largest barriers to co-implementation of load shifting measures and DR programs is the baseline. To measure performance in a DR program, it is necessary to define a benchmark, or baseline, against which the participant's load drop will be measured. This baseline is typically a reflection of the site's "normal" load during eligible dispatch hours on undispatched days. If a site is participating only in the DR program, there should be no significant load drop on undispatched days, and the site's load drop during a dispatch event is measured relative to the site's typical load consumption. However, when a site co-implements load shifting measures with the DR program, the BESS will most likely perform load shifting on undispatched days with high RTP, which effectively lowers the baseline site load that DR performance is measured against.

As an example, consider two scenarios: (1) a site participates in a DR program, and (2) a site co-implements load shifting and DR participation. If the BESS discharges at exactly the same rate for the duration of a dispatch event for both scenarios, the performance for scenario (1)

[1] Note that this list does not include Tustin, where BESS was installed. The project team did not assess OLC potential for Tustin because IRWD strongly ruled out a VFD retrofit at the site due to noise concerns.

will be greater, since the baseline for scenario (2) will presumably include load shifting during previous non-dispatch days.

Table 6: Potential for Load Shifting and DR Participation Using BESS and OLC

Site	OLC Measure	Measure Type/DR Program	DR Load Reduction (kW)	Annual Bill Savings ($)(a)	Measure Cost ($)	Payback Period (yrs.)
PTP	Reduce reverse osmosis (RO) train pump speed by 5 percent and shift the load to other hours in high energy cost days.	LCR+RTP	36.1	($10,526) to $2,166	$5,000	2.31
Baker	Shut down one of the product water pumps and shift load to other hours in high energy cost days.	LCR+RTP	340.0	$15,005 to $20,400(b)	$5,000	0.25
DATS	Reduce nanofiltration (NF) train pump speeds by 5 percent in high energy cost days.	LCR+RTP	63.5	($68,068) to $3,180	$5,000	1.31
LAWRP	Shut down one of the three zone A product water pumps during all DR events and shift the load to cheap energy hours.	LCR+RTP	135.0	($90,641) to $8,100	$5,000	0.62
MWRP	Pre-cool and increase space temperatures in the control center building to 76°F in high energy cost days.	LCR+RTP	29.2	($46,536) to $1,752	$6,000	3.42

(a) Bills savings have a high and low range due to the uncertainty of DR events and RTP price. If LCR events are called in the hours with RTP, energy rates are high and bill savings are positive. If they happen in different hours in a day, the result is negative savings.

(b) Baker will have a new solar PV system in late 2020. Savings in the table are based on the solar PV system having been installed. If the OLC measure is installed before the new solar PV system is operational, bill savings will be negative.

Source: Advanced Microgrid Solutions

Propose Solutions Including Battery Energy Storage Systems and OLC Opportunities to IRWD for Review and Approval

Once the project team completed potential assessments outlined in the previous steps, the team presented these to the IRWD operations staff for consideration.

Based on the feedback from IRWD, none of the OLC measures were found suitable for implementing at the sites and none were approved for installation. IRWD cited multiple reasons for not approving OLC, including operational constraints at sites, noise and aesthetic reasons, and the financial risks associated with dual DR program enrollment. Operational and noise/aesthetic constraints are common reasons for not pursuing OLC measures at commercial and industrial facilities; however, dual participation risks are an area of growing concern. In this case, the benefits of installing OLC measures at some facilities with co-located BESS actually reduced the total value the facility could capture from available programs due to OLC measures reducing facility baselines. Table 7 indicates the reasons for which OLC measures were not approved at the selected sites.

Table 7: IRWD Feedback on OLC Measures at Selected Sites

Site	OLC Measure	Project Feedback
Dyer Road Well 10	Install VFD on the 450 hp pump motor.	No, due to operational constraint. Altering how the site is operated could have a negative impact on performance, so it is high risk to implement this OLC measure.
Dyer Road Well 15	Install VFD on the 500 hp pump motor.	No, due to operational constraint. Altering how the site is operated could have a negative impact on performance, so it is high risk to implement this OLC measure.
Dyer Road Well 17	Install VFD on the 400 hp pump motor.	No, due to operational constraint. Altering how the site is operated could have a negative impact on performance, so it is high risk to implement this OLC measure.
Harvard Avenue Trunk Sewer	Install VFDs to two 75 hp pump motors.	No, due to noise and aesthetic concerns. The site is located next to a residential area.
Tustin Well 21	Install VFD on the 300 hp pump motor.	No, due to noise concern. The site is located next to a residential area.
Portola A-C	Limit operations to a single pump in all on-peak hours. Shut down all pumps and shift load to other hours during DR events.	A decision was made by IRWD to ramp down the site in 2020.

Site	OLC Measure	Project Feedback
PTP	Reduce RO train pump speed by 5 percent and shift the load in high energy cost days to other hours.	No, due to downside of the financial risk for dual DR enrollment. Enrolling in dual DR programs would require a tariff switch, and the cost savings would not necessarily outweigh the incremental cost of the tariff switch.
Baker	Shut down one of the product water pumps and shift the load in high energy cost days to other hours.	No, due to downside of the financial risk for dual DR enrollment.
DATS	Reduce NF train pump speeds by 5 percent in high energy cost days.	No, due to downside of the financial risk for dual DR enrollment.
LAWRP	Shut down one of the three zone A product water pumps during all DR events and shift the load to cheap energy hours.	No, due to downside of the financial risk for dual DR enrollment.
MWRP	Pre-cool and increase space temperatures in the control center building to 76°F in high energy cost days.	No, due to downside of the financial risk for dual DR enrollment.

Source: Advanced Microgrid Solutions

Install Battery Energy Storage Systems and Participate in Utility DR Programs

IRWD approved implementation of BESS at the six sites and enrollment of these sites in the LCR program. As described previously, as of April 2019, BESS was installed and operating at six sites, with a total capacity of roughly 6.5 megawatts (MW) per 36 megawatt-hours (MWh).

Perform Optimization of Demand Charge Management and DR Using Battery Energy Storage Systems

Once the six sites with BESS were enrolled in the LCR program, the platform optimized the operations of the sites to maximize the total value of multiple revenue streams for each site from DCM and DR program participation.

Figure 3 represents the optimization process flow for conducting the combined analytics considering BESS and OLC.

Figure 3: Optimization of Demand Charge Management and DR Using BESS

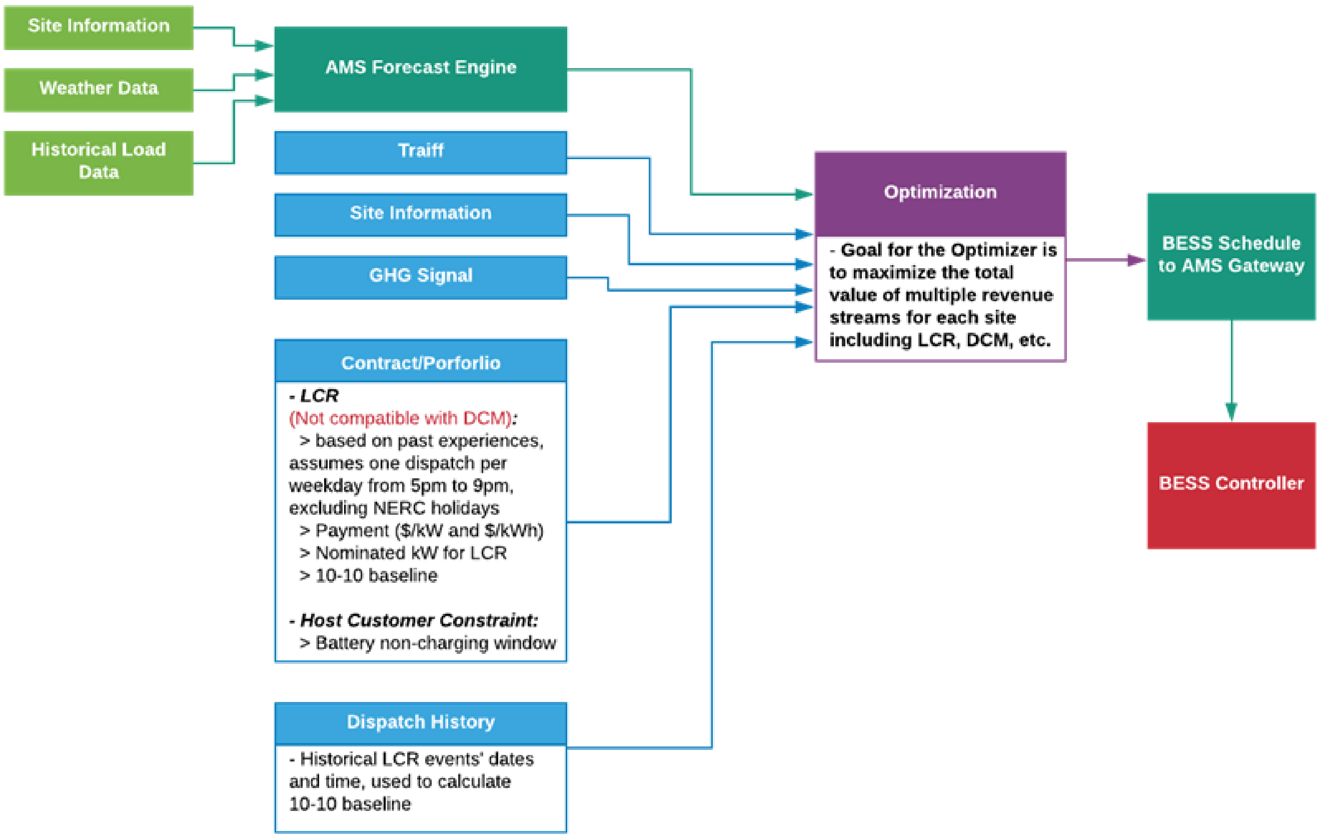


Figure 3 outlines how the AMS platform integrates site, weather, and load information into a forecasting engine. This forecasting engine is combined with tariff, GHG information, and DR program information as the input to a high frequency optimization layer, which maximizes the total revenue potential for a portfolio of sites. This optimization result is fed to the BESS controller through a set of instructions, a schedule, provided by the AMS gateway hardware.

Source: Advanced Microgrid Solutions

Performance Measurement and Verification and Reporting

During the operational phase of the project, from April 1, 2019, to December 31, 2019, the project collected performance data for all six sites participating in the pilot to calculate the performance metrics described below.

Figure 4 represents the meter placement and network communication diagram for measuring performance for a pilot site.

Figure 4: Meter Placement and Network Communication Diagram

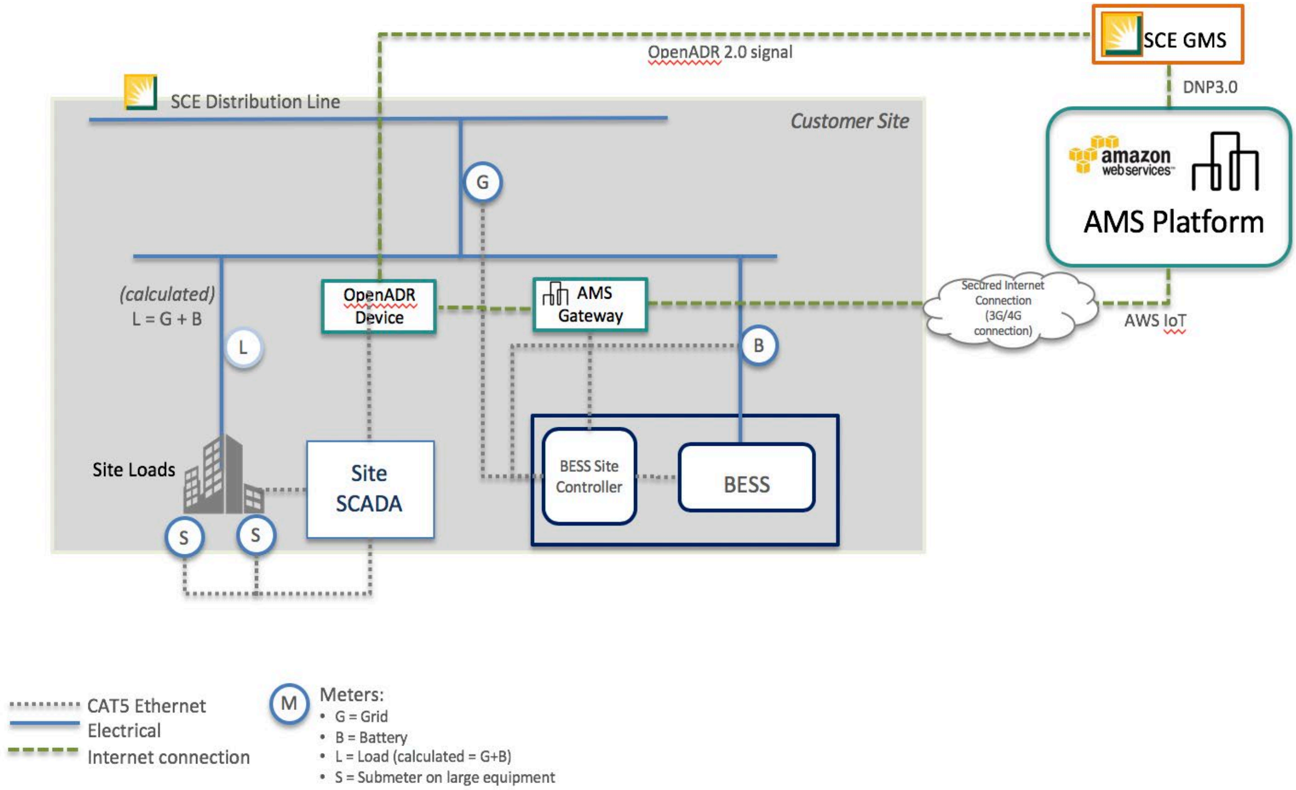


Figure 4 shows multiple points of electricity data collection throughout each site system. There is a meter at each site that measures the total load at the interconnection with the grid (grid meter, or G above). There is also a meter that measures and stores data on BESS charge and discharge (BESS meter, or B above). When charging, the B meter is negative; when discharging, it is positive. The total facility load (L) for a site with BESS is calculated as the sum of the load at the grid meter G and the BESS meter B.

Source: Advanced Microgrid Solutions

Following are the six performance metrics reported for this project.

1. Peak demand reduction percent (pre- and post-optimization of DCM and DR using the platform)
   - On-peak demand reduction: Reduction in maximum kW during TOU on-peak period in a utility billing cycle.
   - Global-peak reduction: Reduction in the maximum kW among all hours in a utility billing cycle.[2]
   - Chapter 3 reports the project findings on this metric and compares the AMS-reported values with Guidehouse-verified values.
   - The calculations are based on 15-minute grid meter data and BESS meter data for each site for each billing cycle.

[2] The global peak reduction was not specified as a performance metric in the project scope; however, the project team assessed it to be an important metric, as it impacts bill savings.

2. Peak usage reduction percent (pre- and post-optimization of DCM and DR using the platform)
    - On-peak usage reduction: Reduction in total kWh consumed during TOU on-peak period in a utility billing cycle.
    - Global usage reduction: Reduction in total kWh consumed in all hours in a utility billing cycle.[3]
    - Chapter 3 reports the project findings on this metric and presents Guidehouse-calculated values. AMS did not independently report this metric.
    - The calculations are based on 15-minute grid meter data and BESS meter data for each site for each billing cycle.
3. DR performance percent
    - DR load reduction percent: This metric calculates the site level demand reduction in response to LCR events as a percentage of the nominated capacity value for that site. The demand reduction for each event is calculated and then averaged over all events in a calendar month to report aggregate monthly load reduction percentage results.
    - Appendix C describes SCE's 10-in-10 methodology for estimating the baseline for calculating LCR event performance and the steps for calculating the demand reduction during DR events.
    - Chapter 3 reports the project findings on this metric and presents Guidehouse-calculated values. AMS did not independently report this metric.
    - The calculations are based on 15-minute grid meter data and BESS meter data for each site, DR event data from SCE, and the nominated value in LCR for each site.
4. Bill reduction percent
    - The baseline bill is determined based on what these charges would have been if the optimization using the platform was not operational. It is calculated by applying the tariff for a site to the total facility load profile, over the course of the monthly billing cycle, and it includes the sum of the on-peak and off-peak energy use charges plus the demand charges for the site. Similarly, these charges are calculated during the post BESS operational period and the difference between the two provides the bill savings for each site for each billing cycle during the effective period of the pilot.
    - Chapter 3 reports the project findings on this metric and presents AMS-calculated values. Guidehouse did not independently calculate this metric.

[3] The global usage reduction was not specified as a performance metric in the project scope; however, the project team assessed it to be an important metric, as it impacts bill savings.

- The calculations are based on 15-minute grid meter data and BESS meter data for each site and billing cycle, tariff details for each site, and utility bills for each site.

5. GHG reduction (kilograms [kg] of carbon dioxide [CO_2] per year)
   - Marginal carbon emissions intensity, in pounds of CO_2 per megawatt-hour, is used to calculate and evaluate the benefit of the project on GHG emissions. Marginal carbon emissions are the carbon emissions generated by the power plants that turn up or down in response to incremental changes in power demand (WattTime 2019b).
   - The baseline GHG measurement is determined using data from WattTime, a company specializing in measuring the carbon footprint of the grid (WattTime 2019a). The 24x7 annual marginal GHG emissions of each site are calculated by the AMS Armada platform based on the carbon emission intensity provided from WattTime and the measured facility energy consumption.
   - The post-implementation GHG emissions are calculated by the AMS Armada platform by applying the marginal carbon intensities from WattTime and the measured grid load (kWh).
   - The difference between the baseline and post-implementation GHG emissions is the GHG reduction amount.
   - Chapter 3 reports the project findings on this metric and presents AMS-provided values. Guidehouse did not independently calculate this metric.
   - The calculations are based on 15-minute grid meter data and BESS meter data for each site and billing cycle, and 15-minute WattTime data for marginal carbon emissions intensity.
6. Tariff impact
   - AMS analyzed energy costs and demand charges for each site under multiple tariffs (TOU, CPP, and RTP) to determine the impact of tariff price signals. AMS quantified the impact of each tariff by applying them to each site's load profile via the AMS Armada platform and calculating the peak energy costs, other energy costs, demand charges, and DR program savings or revenue.
   - Chapter 3 reports the project findings on this metric and presents AMS-provided values. Guidehouse did not independently calculate this metric.

CHAPTER 3: Measurement and Verification

Results and Conclusions

This chapter presents the project results for the performance metrics described in the previous chapter:

- Metric 1: Peak demand reduction (percent), which includes:
    - On-peak demand reduction
    - Global peak demand reduction
- Metric 2: Peak usage reduction (percent), which includes:
    - On-peak usage reduction
    - Global usage reduction
- Metric 3: DR program performance (percent)
- Metric 4: Bill reduction (percent)
- Metric 5: GHG reduction (kg CO_2/yr)

The performance on these metrics is reported below for each of the six selected sites.

In addition to these metrics, researchers also analyzed each site to assess the most suitable tariff, the findings of this analysis are included under the results discussion.

The end of the chapter presents overall conclusions based on the performance of the sites.

Performance Summary

Table 8 summarizes the performance for the six sites across the key performance indicators. These indicate:

- On-peak demand reduction: Sites experienced both on-peak demand reduction and increase, which varied over a wide range depending on the site and the billing month. Three of the six sites experienced average on-peak demand increases in the range of 2 percent to10 percent, while the remaining three sites experienced average on-peak demand reductions in the range of 3 percent to11 percent. This variation in performance stems from the complexity of co-optimizing BESS for both DCM and DR program participation.
- Global peak demand reduction: All six sites experienced increases in average global peak demand over the billing months. The increase in average global peak demand ranged from almost zero to 32 percent. This increase in global peak demand stemmed from the need to charge the batteries overnight and from the flat load profile at many water agency facilities.

- On-peak usage reduction: The usage reduction during the summer on-peak period over the entire timeframe for which post-BESS data was collected varied between 38 percent for Baker and 78 percent for Tustin Wells.

Table 8: Performance Summary for All Sites With BESS Installed

Site Name	On-peak Demand Reduction (%)	Global Peak Demand Reduction (%)	On-peak Usage Reduction (%)	Global Usage Reduction (%)	LCR Performance Reduction (%)	Bill Reduction	GHG Reduction
Baker	-1.8%	-11.0%	38%	-1.2%	57.6%	-2.5%	-0.6%
DATS	-1.9%	-32.0%	71%	-2.2%	14.7%	-3.4%	-1.1%
LAWRP	-10.1%	-19.6%	63%	-1%	29.7%	0.7%	-0.4%
MWRP	3.3%	-16.8%	40%	-0.9%	79.3%	-1.6%	-0.3%
PTP	3.5%	-10.0%	65%	-0.9%	26.6%	0.4%	-0.1%
Tustin Wells	10.7%	-0.02%	78%	-1.3%	32.6%	4%	-2.9%

Negative values indicate an increase in the metric.

Source: Advanced Microgrid Solutions, Guidehouse

- Global usage reduction: All sites experienced an increase in global usage in the range of 1 percent to2 percent.
- DR performance: The demand reduction in LCR events varied widely across sites and also by the month during which events were called. The average demand reduction as a percentage of the nominated amount ranged between 15 percent and 79 percent across the six sites.
- Bill reduction: Three of the six sites experienced an overall bill reduction for the measurement period. The bill reduction ranged from 0.4 percent to 4 percent. The remaining three sites experienced a bill increase ranging from 1.6 percent to 3.4 percent.
- GHG reduction: GHG emissions increased for all sites, in the range of less than 1 percent to around 3 percent.

Individual site performance is described in greater detail below.

Performance of Individual Sites

Baker

The Baker site is a drinking water treatment plant with a capacity of 28.1 million gallons per day. The facility is shared across five water districts. This site had a 1,225 kW/6,300 kWh capacity battery installed. During June 2019, this facility's BESS encountered a prolonged outage, and the results for this month — in particular demand measurements — should be understood in the context of only a partial performance from the BESS.

Metric 1: Peak Demand Reduction (Percent)

On-peak Demand Reduction

Table 9 shows Baker's on-peak demand reduction during the summer billing months due to BESS installation. The site experienced an average 2 percent increase in on-peak demand. As is evident from the results, the post-BESS on-peak demand was lower than the pre-BESS on-peak demand in two out of the five billing months; this translates into a 6.3 percent peak demand reduction in the May 2019 billing month and a 3.5 percent on-peak demand reduction in the September 2019 billing month. In the remaining three billing months, on-peak demand increased by between 0.7 percent and 16 percent.

Table 9: On-peak Demand Reduction for Baker

Billing Month	Verified Pre-BESS On-peak Demand (kW)	Verified Post-BESS On-peak Demand (kW)	Verified On-peak Demand Reduction (kW)	Reported On-peak Demand Reduction (kW)	Verified On-peak Demand Reduction (%)
2019-05	1,946	1,824	122	122	6.3%
2019-06*	2,144	2,144	-	-	-
2019-07	2,440	2,457	-17	-17	-0.7%
2019-08	2,434	2,834	-400	-400	-16.4%
2019-09	2,398	2,316	83	83	3.5%
Average					**-1.8%**

Billing month as defined in Appendix D.

* Prolonged BESS outage.
Sources: Advanced Microgrid Solutions, Guidehouse

Global Peak Reduction

Table 10 shows the global peak demand reduction due to BESS installation for Baker for the March to November 2019 billing months. Baker experienced an average 11 percent increase in global demand. The post-BESS global peak demand was higher than the pre-BESS peak demand for all months. The global peak demand increase varied over a wide range, from 0.2 percent in March 2019 to 22 percent in October 2019. This occurred because of the need to charge the BESS during nighttime hours and because of the site's load being very flat.

Table 10: Global Peak Demand Reduction for Baker

Billing Month	Verified Pre-BESS Global Demand (kW)	Verified Post-BESS Global Demand (kW)	Verified Global Demand Reduction (kW)	Reported Global Demand Reduction (kW)	Verified Global Demand Reduction (%)
2019-03	2,204	2,208	(4)	(4)	-0.2%
2019-04	2,356	2,784	(428)	(428)	-18.2%
2019-05	2,323	2,592	(269)	(269)	-11.6%
2019-06	2,624	2,656	(32)	(32)	-1.2%
2019-07	2,454	2,815	(360)	(360)	-14.7%
2019-08	2,455	2,876	(421)	(421)	-17.1%
2019-09	2,427	2,686	(260)	(260)	-10.7%
2019-10	2,213	2,706	(494)	(494)	-22.3%
2019-11	2,488	2,565	(78)	(78)	-3.1%
Average					**-11.0%**

Billing month as defined in Appendix D.

Sources: Advanced Microgrid Solutions, Guidehouse

Metric 2: Peak Usage Reduction (Percent)

On-peak Usage Reduction

Table 11 shows Baker's on-peak usage reduction during the summer billing months due to BESS installation. The overall on-peak usage reduced by 38 percent across all summer billing months. The on-peak usage reduction ranged from 28 percent to 48 percent.

Table 11: On-peak Usage Reduction for Baker

Billing Month	Verified Pre-BESS On-peak Usage (kWh)	Verified Post-BESS On-peak Usage (kWh)	Verified On-peak Usage Reduction (kWh)	Verified On-peak Usage Reduction (%)
2019-05	43,900	24,392	19,508	44%
2019-06*	197,550	143,096	54,454	28%
2019-07	158,323	82,768	75,554	48%
2019-08	230,494	139,074	91,419	40%
2019-09	136,846	80,776	56,069	41%
Total	**767,457**	**470,107**	**297,349**	**38%**

Billing month as defined in Appendix D.

* Prolonged BESS outage.
Source: Advanced Microgrid Solutions, Guidehouse

Global Usage Reduction

Table 12 shows the global usage reduction due to BESS installation for Baker for the March to November 2019 billing months. The total global usage increased by 1 percent over the entire timeframe. The post-BESS global usage was higher than the pre-BESS global usage for all billing months for which performance was measured, due to the roundtrip efficiency of the BESS. Put simply, the roundtrip efficiency is the fraction of energy put into a BESS that can be retrieved. Charging and discharging are not 100 percent efficient processes, so losses occur with each cycle of the battery.

Table 12: Global Usage Reduction for Baker

Billing Month	Verified Pre-BESS Global Usage (kWh)	Verified Post-BESS Global Usage (kWh)	Verified Global Usage Reduction (kWh)	Verified Global Usage Reduction (%)
2019-03	389,639	392,472	(2,833)	-0.7%
2019-04	1,474,093	1,486,480	(12,387)	-0.8%
2019-05	1,280,895	1,293,024	(12,129)	-1.0%
2019-06*	1,448,637	1,457,768	(9,131)	-0.8%
2019-07	1,059,372	1,080,566	(21,194)	-2.0%
2019-08	1,637,876	1,661,470	(23,595)	-1.4%
2019-09	1,225,467	1,239,682	(14,215)	-1.2%
2019-10	1,375,358	1,397,518	(22,160)	-1.6%
2019-11	1,650,894	1,667,853	(16,959)	-1.0%
Total	**11,542,231**	**11,676,835**	**(134,604)**	**-1.2%**

Billing month as defined in Appendix D.

* Prolonged BESS outage.
Sources: Advanced Microgrid Solutions, Guidehouse

Metric 3: DR Program Performance (Percent Demand Reduction)

Table 13 shows LCR event performance for Baker based on the definition of the metric in the previous chapter and the baseline and impact calculation methodology described in Appendix C. The average monthly demand reduction during LCR events ranged from a low of 25 percent in August 2019 to a high of 86 percent in July 2019, with an overall average of a 58 percent demand reduction for the June to September 2019 time period.

Table 13: LCR Performance for Baker

Month	Verified Average Monthly Reduction during LCR Events (kW)	Nominated Capacity for LCR (kW)	Verified Demand Reduction %
June 2019	769	1,225	60.9%
July 2019	1,071	1,225	85.9%
August 2019	269	1,225	24.7%
September 2019	722	1,225	59.0%
Average			**57.6%**

Sources: Advanced Microgrid Solutions, Guidehouse

Metric 4: Bill Reduction (Percent)

Table 14 shows an aggregate 2.5 percent increase in bills for Baker over the March to November 2019 billing months due to the increase in global peak demand and usage. Although there was an increase in bills during this time period, that was not necessarily reflective of the actual costs to the customer, as those costs were dictated by contracts between the customer and the BESS asset manager.

Table 14: Bill Reduction for Baker

Billing Month	Reported Pre-BESS Bill ($)	Reported Post-BESS Bill ($)	Bill Reduction ($)	Bill Reduction (%)
2019-03	$129,070	$129,609	($539)	-0.4%
2019-04	$132,200	$137,287	($5,087)	-3.8%
2019-05	$142,969	$145,265	($2,296)	-1.6%
2019-06	$153,739	$155,026	($1,287)	-0.8%
2019-07	$182,798	$186,466	($3,668)	-2.0%
2019-08	$222,740	$238,265	($15,525)	-7.0%
2019-09	$175,705	$175,104	$601	0.3%
2019-10	$135,496	$141,758	($6,261)	-4.6%
2019-11	$158,972	$160,143	($1,171)	-0.7%
Total	**$1,433,690**	**$1,468,922**	**($35,232)**	**-2.5%**

Billing month as defined in Appendix D.

Source: Advanced Microgrid Solutions

Metric 5: Greenhouse Gas Reduction

Table 15 shows a 0.65 percent increase in GHG emissions for Baker over the entire measurement period.

Table 15: Greenhouse Gas Emissions Reduction for Baker

Billing Month	Reported Pre-BESS GHG Emissions (kg of CO_2)	Reported Post-BESS GHG Emissions (kg of CO_2)	Emissions Reduction (kg of CO_2)	Emissions Reduction (%)
2019-03	1,187,861	1,193,969	(6,108)	-0.51%
2019-04	1,300,170	1,310,153	(9,983)	-0.77%
2019-05	1,127,666	1,136,741	(9,075)	-0.80%
2019-06	1,310,912	1,313,445	(2,533)	-0.19%
2019-07	1,004,440	1,013,899	(9,459)	-0.94%
2019-08	1,540,093	1,546,479	(6,386)	-0.41%
2019-09	1,105,953	1,111,703	(5,751)	-0.52%
2019-10	1,219,876	1,232,402	(12,526)	-1.03%
2019-11	1,440,035	1,450,942	(10,907)	-0.76%
Total	**11,237,007**	**11,309,733**	**(72,728)**	**-0.65%**

Billing month as defined in Appendix D.

Source: Advanced Microgrid Solutions

Tariff Impact

AMS analyzed the impact of alternative tariffs for Baker to assess which would be the most beneficial in terms of highest bill savings. This analysis leveraged a co-optimization of RTP and CPP tariffs with the LCR DR program, using the historical facility load and platform performance. The site was on a TOU rate and participated in LCR. AMS analyzed bill impacts as if the site were on an RTP or CPP tariff and participated in LCR events. Table 16 shows the tariff analysis results and highlights that the bill savings would be highest if the site were under RTP.

Table 16: Tariff Impact Analysis for Baker

Tariff	Reported On-peak kW Reduction (kW)	Reported On-peak kWh Reduction (kWh)	Reported Bill Savings ($)
LCR (TOU)	919	75,631	104,991
LCR+RTP	578	46,216	117,819
LCR+CPP	613	51,006	70,082

Source: Advanced Microgrid Solutions

Deep Aquifer Treatment System

DATS is IRWD's second-largest energy-consuming facility. It includes two wells that pump water from approximately 2,000 feet below ground level. It then treats that water using reverse osmosis before blending it with other groundwater. This site had a 1,000 kW/6,000 kWh capacity BESS installed.

Metric 1: Peak Demand Reduction (Percent)

On-peak Demand Reduction

Table 17 shows the on-peak demand reduction during the summer billing months due to BESS installation for DATS. DATS experienced an average 2 percent reduction in on-peak demand. As is evident from the results, the post-BESS on-peak demand was lower than the pre-BESS on-peak demand in four of the five billing months, ranging from 1.5 percent to 3.7 percent on-peak demand reduction. The on-peak demand increased by only 1.5 percent for the September 2019 billing month.

Table 17: On-peak Demand Reduction for Deep Aquifer Treatment System

Billing Month	Verified Pre-BESS On-peak Demand (kW)	Verified Post-BESS On-peak Demand (kW)	Verified On-peak Demand Reduction (kW)	Reported On-peak Demand Reduction (kW)	Verified On-peak Demand Reduction (%)
2019-06	1,089	1,073	16	16	1.5%
2019-07	1,147	1,105	42	42	3.7%
2019-08	1,122	1,092	30	30	2.7%
2019-09	1,122	1,139	(17)	(17)	-1.5%
2019-10	1,104	1,071	33	33	3.0%
Average					**1.9%**

Billing month as defined in Appendix D.

Sources: Advanced Microgrid Solutions, Guidehouse

Global Peak Demand Reduction

Table 18 shows the global peak demand reduction due to BESS installation for DATS for the April to December 2019 billing months. The post-BESS global peak demand was higher than the pre-BESS peak demand over the entire timeframe, with an average 32 percent increase in global demand. The increase in global peak demand ranged between 2 percent in the October billing month and 75 percent in the May 2019 billing month. This occurred because of the need to charge the BESS during nighttime hours and because of the site's load being very flat.

Table 18: Global Peak Demand Reduction for Deep Aquifer Treatment System

Billing Month	Verified Pre-BESS Global Demand (kW)	Verified Post-BESS Global Demand (kW)	Verified Global Demand Reduction (kW)	Reported Global Demand Reduction (kW)	Verified Global Demand Reduction (%)
2019-04	1,215	1,426	(210)	(210)	-17.3%
2019-05	1,206	2,113	(907)	(907)	-75.2%

Billing Month	Verified Pre-BESS Global Demand (kW)	Verified Post-BESS Global Demand (kW)	Verified Global Demand Reduction (kW)	Reported Global Demand Reduction (kW)	Verified Global Demand Reduction (%)
2019-06	1,220	1,850	(630)	(630)	-51.7%
2019-07	1,261	1,643	(382)	(382)	-30.3%
2019-08	1,226	1,665	(438)	(438)	-35.7%
2019-09	1,178	1,488	(310)	(310)	-26.3%
2019-10	1,454	1,517	(34)	(34)	-2.3%
2019-11	1,212	1,500	(287)	(287)	-23.7%
2019-12	1,127	1,416	(289)	(289)	-25.7%
Average					**-32.0%**

Billing month as defined in Appendix D.

Sources: Advanced Microgrid Solutions, Guidehouse

Metric 2: Peak Usage Reduction (Percent)

On-peak Usage Reduction

Table 19 shows the on-peak usage reduction during the summer billing months due to BESS installation for DATS. The overall on-peak usage reduced significantly, by 71 percent during the summer billing months (ranging from a low of 55 percent in the October billing month to a high of 82 percent in the July billing month).

Table 19: On-peak Usage Reduction for Deep Aquifer Treatment System

Billing Month	Verified Pre-BESS On-peak Usage (kWh)	Verified Post-BESS On-peak Usage (kWh)	Verified On-peak Usage Reduction (kWh)	Verified On-peak Usage Reduction (%)
2019-06	68,007	18,410	49,597	73%
2019-07	115,683	20,684	94,998	82%
2019-08	115,207	30,079	85,128	74%
2019-09	115,291	45,874	69,417	60%
2019-10	43,415	19,537	23,878	55%
Total	**457,604**	**134,585**	**323,019**	**71%**

Billing month as defined in Appendix D.

Sources: Advanced Microgrid Solutions, Guidehouse

Global Usage Reduction

Table 20 shows the change in global usage due to BESS installation for DATS for the April to December 2019 billing months. The total global usage increased by 2.2 percent over the entire timeframe. The post-BESS global usage was higher than the pre-BESS global usage for all billing months for which performance was measured, due to the roundtrip efficiency of the BESS.

Table 20: Global Usage Reduction for Deep Aquifer Treatment System

Billing Month	Verified Pre-BESS Global Usage (kWh)	Verified Post-BESS Global Usage (kWh)	Verified Global Usage Reduction (kWh)	Verified Global Usage Reduction (%)
2019-04	549,917	563,153	(13,236)	-2.4%
2019-05	759,936	771,517	(11,581)	-1.5%
2019-06	778,874	787,907	(9,033)	-1.2%
2019-07	851,659	876,098	(24,439)	-2.9%
2019-08	720,390	735,649	(15,259)	-2.1%
2019-09	783,923	800,183	(16,260)	-2.1%
2019-10	815,967	836,549	(20,581)	-2.5%
2019-11	746,983	762,494	(15,511)	-2.1%
2019-12	604,109	622,423	(18,314)	-3.0%
Total	**6,612,121**	**6,755,972**	**(143,851)**	**-2.2%**

Billing month as defined in Appendix D.

Source: Advanced Microgrid Solutions, Guidehouse

Metric 3: DR Program Performance (Percent Demand Reduction)

Table 21 shows LCR event performance for DATS based on the definition of the metric in the previous chapter and the baseline and impact calculation methodology described in Appendix C. The site had the highest reduction, of 45 percent, in June and the lowest, of 1 percent, in July, with an average performance of 15 percent.

Table 21: LCR Performance for Deep Aquifer Treatment System

Month	Verified Avg. Monthly Reduction During LCR Events (kW)	Nominated Capacity for LCR (kW)*	Verified Demand Reduction %
June 2019	435	1,000	44.2%
July 2019	(17)	1,000	0.8%
August 2019	85	1,000	8.9%
Sept. 2019	48	1,000	4.8%
Average			**14.7%**

*The nominated capacity was a fixed value for a site and did not vary by month.
** This was calculated as the average demand reduction during LCR events divided by the nominated capacity in LCR.
Source: Advanced Microgrid Solutions, Guidehouse

Metric 4: Bill Reduction (Percent)

Table 22 shows an aggregate 3.4 percent increase in bills for DATS over the April to December 2019 billing months due to increases in global peak demand and usage.

Table 22: Bill Reduction for Deep Aquifer Treatment System

Billing Month	Reported Pre-BESS Bill ($)	Reported Post-BESS Bill ($)	Bill Reduction ($)	Bill Reduction (%)
2019-04	$81,837	$81,466	$371	0.5%
2019-05	$76,044	$86,682	($10,638)	-14.0%
2019-06	$100,401	$105,518	($5,116)	-5.1%
2019-07	$121,458	$121,828	($370)	-0.3%
2019-08	$106,276	$108,495	($2,219)	-2.1%
2019-09	$113,346	$112,854	$492	0.4%
2019-10	$92,209	$96,336	($4,127)	-4.5%
2019-11	$77,065	$80,210	($3,145)	-4.1%
2019-12	$72,750	$76,858	($4,108)	-5.6%
Total	**$841,387**	**$870,246**	**($28,859)**	**-3.4%**

Billing month as defined in Appendix D.

Source: Advanced Microgrid Solutions

Metric 5: Greenhouse Gas Emissions Reduction

Table 23 shows a 1.1 percent increase in GHG emissions for DATS over the measurement period.

Table 23: Greenhouse Gas Emission Reduction for Deep Aquifer Treatment System

Billing Month	Reported Pre-BESS GHG Emissions (kg of CO_2)	Reported Post-BESS GHG Emissions (kg of CO_2)	Emissions Reduction (kg of CO_2)	Emission Reduction (%)
2019-04	733,766	742,745	(8,979)	-1.2%
2019-05	670,245	678,888	(8,643)	-1.3%
2019-06	695,492	698,387	(2,895)	-0.4%
2019-07	776,248	785,860	(9,612)	-1.2%
2019-08	682,722	683,176	(454)	-0.1%
2019-09	733,071	735,760	(2,689)	-0.4%
2019-10	727,325	740,257	(12,931)	-1.8%
2019-11	659,614	668,575	(8,961)	-1.4%
2019-12	539,471	553,255	(13,784)	-2.6%
Total	**6,217,953**	**6,286,902**	**(68,949)**	**-1.1%**

Billing month as defined in Appendix D.

Source: Advanced Microgrid Solutions

Tariff Impact

AMS analyzed the impact of alternative tariffs for DATS to assess which would be the most beneficial in terms of highest bill savings. This analysis leveraged a co-optimization of RTP and

CPP tariffs with the LCR DR program, using the historical facility load and platform performance. The site was on a TOU rate and participated in LCR. AMS analyzed bill impacts as if the site were on an RTP or CPP tariff and participated in LCR events. Table 24 shows the tariff analysis results and highlights that the bill savings would be highest for the site participating in LCR with a TOU tariff.

Table 24: Tariff Impact Analysis for Deep Aquifer Treatment System

Tariff	Reported On-peak kW Reduction (kW)	Reported On-peak kWh Reduction (kWh)	Reported Bill Savings ($)
LCR (TOU)	750	57,863	68,303
LCR+RTP	482	36,921	36,859
LCR+CPP	500	38,679	41,116

Source: Advanced Microgrid Solutions

Los Alisos Water Recycling Plant

The Los Alisos Water Recycling Plant (LAWRP) is IRWD's third-largest energy-consuming facility. It intakes raw sewage and conducts primary treatment, secondary treatment, tertiary treatment, recycled water distribution pumping, and biosolids processing. It has a 1,040 kW/ 5,040 kWh BESS installed at the site.

Metric 1: Peak Demand Reduction (Percent)

On-peak Demand Reduction

Table 25 shows the on-peak demand reduction during the summer billing months due to BESS installation for LAWRP. The site experienced a 10 percent increase in average on-peak demand. The post-BESS on-peak demand increase ranged from 1.3 percent in the August billing month to 29 percent in the July billing month.

Table 25: On-peak Demand Reduction for Los Alisos Water Recycling Plant

Billing Month	Verified Pre-BESS On-peak Demand (kW)	Verified Post-BESS On-peak Demand (kW)	Verified On-peak Demand Reduction (kW)	Reported On-peak Demand Reduction (kW)	Verified On-peak Demand Reduction (%)
2019-06	1,002	848	154	154	15.4%
2019-07	966	686	280	280	29.0%
2019-08	946	934	12	12	1.3%
2019-09	970	946	24	24	2.4%
2019-10	975	952	23	23	2.4%
Average					**10.1%**

Billing month as defined in Appendix D.

Sources: Advanced Microgrid Solutions, Guidehouse

Global Peak Reduction

Table 26 shows the global peak demand reduction due to BESS installation for LAWRP for the April to November 2019 billing months. The average post-BESS global peak demand increased by 20 percent. It increased for all billing months except April in that entire timeframe. This occurred because of the need to charge the BESS during nighttime hours and because of the site's load being very flat. The increase in global peak demand ranged from 9.6 percent in the July billing month to 36.6 percent in the June billing month.

Table 26: Global Peak Demand Reduction for Los Alisos Water Recycling Plant

Billing Month	Verified Pre-BESS Global Demand (kW)	Verified Post-BESS Global Demand (kW)	Verified Global Demand Reduction (kW)	Reported Global Demand Reduction (kW)	Verified Global Demand Reduction (%)
2019-04	974	848	126	126	13.0%
2019-05	1,010	1,360	-350	-350	-34.7%
2019-06	1,008	1,376	-368	-368	-36.6%
2019-07	1,227	1,345	-118	-118	-9.6%
2019-08	959	1,180	-222	-222	-23.1%
2019-09	976	1,193	-217	-217	-22.3%
2019-10	1,033	1,248	-216	-216	-20.9%
2019-11	969	1,189	-220	-220	-22.7%
Average					**-19.6%**

Billing month as defined in Appendix D.

Sources: Advanced Microgrid Solutions, Guidehouse

Metric 2: Peak Usage Reduction (Percent)

On-peak Usage Reduction

Table 27 shows the on-peak usage reduction during the summer billing months due to BESS installation for LAWRP. The overall on-peak usage reduced by 63 percent over the summer billing months. The on-peak usage reduction ranged from 42 percent in the October billing month to 80 percent in the June billing month.

Table 27: On-peak Usage Reduction for Los Alisos Water Recycling Plant

Billing Month	Verified Pre-BESS On-peak Usage (kWh)	Verified Post-BESS On-peak Usage (kWh)	Verified On-peak Usage Reduction (kWh)	Verified On-peak Usage Reduction (%)
2019-06	59,605	12,000	47,605	80%
2019-07	89,190	29,816	59,374	67%
2019-08	88,831	41,051	47,780	54%

Billing Month	Verified Pre-BESS On-peak Usage (kWh)	Verified Post-BESS On-peak Usage (kWh)	Verified On-peak Usage Reduction (kWh)	Verified On-peak Usage Reduction (%)
2019-09	90,416	33,685	56,731	63%
2019-10	30,970	17,965	13,005	42%
Total	**359,012**	**134,517**	**224,495**	**63%**

Billing month as defined in Appendix D.

Sources: Advanced Microgrid Solutions, Guidehouse

Global Usage Reduction

Table 28 shows the global usage reduction due to BESS installation for LAWRP for the April to November 2019 billing months. The total global usage increased by 1.1 percent over the entire timeframe. The post-BESS global usage was higher than the pre-BESS global usage for all billing months.

Table 28: Global Usage Reduction for Los Alisos Water Recycling Plant

Billing Month	Verified Pre-BESS Global Usage (kWh)	Verified Post-BESS Global Usage (kWh)	Verified Global Usage Reduction (kWh)	Verified Global Usage Reduction (%)
2019-04	375,657	377,064	(1,407)	-0.4%
2019-05	605,203	606,503	(1,300)	-0.2%
2019-06	611,884	617,347	(5,463)	-0.9%
2019-07	643,808	651,418	(7,610)	-1.2%
2019-08	581,393	586,453	(5,060)	-0.9%
2019-09	614,177	622,886	(8,709)	-1.4%
2019-10	672,547	684,123	(11,575)	-1.7%
2019-11	602,556	612,756	(10,200)	-1.7%
Total	**4,707,224**	**4,758,550**	**(51,326)**	**-1.1%**

Billing month as defined in Appendix D.

Sources: Advanced Microgrid Solutions, Guidehouse

Metric 3: DR Program Performance (Percent Demand Reduction)

Table 29 shows LCR event performance for LAWRP based on the definition of the metric in the previous chapter and the baseline and impact calculation methodology described in Appendix C. The average monthly demand reduction during LCR events ranged from 8 percent in the July billing month to 72 percent in the June 2019 billing month, with an overall 30 percent average performance.

Table 29: LCR Performance for Los Alisos Water Recycling Plant

Month	Verified Average Monthly Reduction During LCR Events (kW)	Nominated Capacity for LCR (kW)*	Verified Demand Reduction %**
June 2019	747	1,040	72.3%
July 2019	61	1,040	8.5%
August 2019	180	1,040	16.7%
Sept. 2019	223	1,040	21.5%
Average			**29.7%**

* The nominated capacity is a fixed value for a site and does not vary by month.
** This is calculated as the average demand reduction during LCR events divided by the nominated capacity in LCR.
Source: Advanced Microgrid Solutions, Guidehouse

Metric 4: Bill Reduction (Percent)

Table 30 shows an aggregate 0.7 percent decrease in bills for LAWRP over the March to November 2019 billing months, due to a decrease in demand charges.

Table 30: Bill Reduction for Los Alisos Water Recycling Plant

Billing Month	Reported Pre-BESS Bill ($)	Reported Post-BESS Bill ($)	Bill Reduction ($)	Bill Reduction (%)
2019-04	$57,411	$52,954	$4,457	7.8%
2019-05	$61,039	$65,052	($4,013)	-6.6%
2019-06	$81,923	$81,478	$446	0.5%
2019-07	$97,433	$88,381	$9,052	9.3%
2019-08	$86,692	$87,581	($890)	-1.0%
2019-09	$89,805	$90,097	($292)	-0.3%
2019-10	$77,648	$79,556	($1,908)	-2.5%
2019-11	$62,115	$64,889	($2,775)	-4.5%
Total	**$614,065**	**$609,987**	**$4,078**	**0.7%**

Billing month as defined in Appendix D.

Source: Advanced Microgrid Solutions

Metric 5: Greenhouse Gas Emissions Reduction

Table 31 shows a 0.39 percent increase in GHG emissions for LAWRP over the measurement period.

Table 31: Greenhouse Gas Emissions Reduction for Los Alisos Water Recycling Plant

Billing Month	Reported Pre-BESS GHG Emissions (kg of CO_2)	Reported Post-BESS GHG Emissions (kg of CO_2)	Emissions Reduction (kg of CO_2)	Emissions Reduction (%)
2019-04	483,681	485,500	(1,819)	-0.38%
2019-05	533,761	534,748	(987)	-0.18%

Billing Month	Reported Pre-BESS GHG Emissions (kg of CO_2)	Reported Post-BESS GHG Emissions (kg of CO_2)	Emissions Reduction (kg of CO_2)	Emissions Reduction (%)
2019-06	547,164	547,320	(156)	-0.03%
2019-07	588,327	589,141	(814)	-0.14%
2019-08	550,279	547,818	2,460	0.45%
2019-09	573,267	571,318	1,949	0.34%
2019-10	599,738	605,665	(5,927)	-0.99%
2019-11	531,378	536,354	(4,976)	-0.94%
2019-12	381,615	389,868	(8,253)	-2.16%
Total	**4,789,208**	**4,807,731**	**(18,523)**	**-0.39%**

Billing month as defined in Appendix D.

Source: Advanced Microgrid Solutions

Tariff Analysis

AMS analyzed the impact of alternative tariffs for LAWRP to assess which would be the most beneficial in terms of highest bill savings. The analysis was performed in a "perfect foresight" optimization environment, which means that the site load, RTP prices, and dispatch events are known for each interval in the optimization. This approach differs significantly from actual operations, since in real-time operations the site load, RTP prices, and dispatch event calls are all based on forecasts. Perfect foresight optimization results can be viewed as the best possible battery performance, or maximum achievable bill savings. This analysis leveraged a co-optimization of RTP and CPP tariffs with the LCR DR program, using the historical facility load and platform performance. The site was on a TOU rate and participated in LCR. AMS analyzed bill impacts as if the site were on an RTP or CPP tariff and participated in LCR events. Table 32 shows the tariff analysis results and highlights that the bill savings would be highest if the site were to continue to participate in LCR with the TOU rate.

Table 32: Tariff Impact Analysis for Los Alisos Water Recycling Plant

Tariff	On-peak kW Reduction (kW)	On-peak kWh Reduction (kWh)	Perfect Foresight Bill Savings ($)
LCR (TOU)	756	23,652	90,873
LCR+RTP	452	10,695	45,852
LCR+CPP	504	15,768	57,325

Source: Advanced Microgrid Solutions

Michaelson Water Recycling Plant

The Michaelson Water Recycling Plant (MWRP) is IRWD's largest energy consuming facility. It takes in raw sewage and conducts primary treatment, secondary treatment, tertiary treatment, recycled water distribution pumping, and biosolids processing. This facility has a 2,500 kW/15,000 kWh BESS installed.

Metric 1: Peak Demand Reduction (Percent)

On-peak Demand Reduction

Table 33 shows the summer on-peak demand reduction for MWRP due to BESS installation. The average on-peak demand reduction was 3 percent. The site reduced summer on-peak demand in all months. On-peak reduction ranged from 0.7 percent in the July billing month to 6.4 percent in the May billing month.

Table 33: On-peak Demand Reduction for Michaelson Water Recycling Plant

Billing Month	Verified Pre-BESS On-peak Demand (kW)	Verified Post-BESS On-peak Demand (kW)	Verified On-peak Demand Reduction (kW)	Reported On-peak Demand Reduction (kW)	Verified On-peak Demand Reduction (%)
2019-05	3,991	3,737	254	254	6.4%
2019-06	4,192	3,948	244	244	5.8%
2019-07	4,092	4,064	28	28	0.7%
2019-08	3,899	3,856	43	43	1.1%
2019-09	3,854	3,750	103	103	2.7%
Average					**3.3%**

Billing month as defined in Appendix D.

Sources: Advanced Microgrid Solutions, Guidehouse

Global Peak Reduction

Table 34 shows the global peak demand reduction due to BESS installation for MWRP for the April to November billing months. The post-BESS global peak demand was higher than the pre-BESS peak demand over the entire timeframe. This occurred because of the need to charge the BESS during nighttime hours and because of the site's load being very flat. The global peak demand increase varied from 11 percent to 25 percent, with an average increase of 17 percent.

Table 34: Global Peak Demand Reduction for Michaelson Water Recycling Plant

Billing Month	Verified Pre-BESS Global Demand (kW)	Verified Post-BESS Global Demand (kW)	Verified Global Demand Reduction (kW)	Reported Global Demand Reduction (kW)	Verified Global Demand Reduction (%)
2019-04	4,469	4,976	-507	-507	-11.3%
2019-05	4,311	4,784	-472	-472	-11.0%
2019-06	4,302	4,880	-578	-578	-13.4%
2019-07	4,345	5,004	-660	-660	-15.2%
2019-08	4,163	4,859	-696	-696	-16.7%
2019-09	3,976	4,975	-998	-998	-25.1%

Billing Month	Verified Pre-BESS Global Demand (kW)	Verified Post-BESS Global Demand (kW)	Verified Global Demand Reduction (kW)	Reported Global Demand Reduction (kW)	Verified Global Demand Reduction (%)
2019-10	4,073	4,960	-887	-887	-21.8%
2019-11	4,042	4,855	-813	-813	-20.1%
Average					**-16.8%**

Billing month as defined in Appendix D.

Sources: Advanced Microgrid Solutions, Guidehouse

Metric 2: Peak Usage Reduction (Percent)

On-peak Usage Reduction

Table 35 shows the on-peak usage reduction during the summer billing months due to BESS installation for MWRP. The overall on-peak usage reduced by 40 percent over all summer billing months.

Table 35: On-peak Usage Reduction for Michaelson Water Recycling Plant

Billing Month	Verified Pre-BESS On-peak Usage (kWh)	Verified Post-BESS On-peak Usage (kWh)	Verified On-peak Usage Reduction (kWh)	Verified On-peak Usage Reduction (%)
2019-05	56,691	28,383	28,308	50%
2019-06	391,998	287,383	104,615	27%
2019-07	392,256	260,512	131,745	34%
2019-08	378,353	196,647	181,706	48%
2019-09	324,231	149,353	174,877	54%
Total	**1,543,529**	**922,278**	**621,251**	**40%**

Billing month as defined in Appendix D.

Sources: Advanced Microgrid Solutions, Guidehouse

Global Usage Reduction

Table 36 shows the global usage reduction due to BESS installation for MWRP for the April to November 2019 billing months. The total global usage increased by 0.9 percent over the entire timeframe.

Table 36: Global Usage Reduction for Michaelson Water Recycling Plant

Billing Month	Verified Pre-BESS Global Usage (kWh)	Verified Post-BESS Global Usage (kWh)	Verified Global Usage Reduction (kWh)	Verified Global Usage Reduction (%)
2019-04	2,855,089	2,870,377	(15,288)	-0.5%
2019-05	2,698,375	2,688,208	10,167	0.4%
2019-06	2,820,289	2,854,607	(34,319)	-1.2%

Billing Month	Verified Pre-BESS Global Usage (kWh)	Verified Post-BESS Global Usage (kWh)	Verified Global Usage Reduction (kWh)	Verified Global Usage Reduction (%)
2019-07	2,508,074	2,528,546	(20,473)	-0.8%
2019-08	2,525,368	2,548,789	(23,421)	-0.9%
2019-09	2,445,046	2,482,126	(37,081)	-1.5%
2019-10	2,672,680	2,708,865	(36,185)	-1.4%
2019-11	2,532,328	2,567,408	(35,080)	-1.4%
Total	**21,057,249**	**21,248,927**	**(191,678)**	**-0.9%**

Billing month as defined in Appendix D.

Sources: Advanced Microgrid Solutions, Guidehouse

Metric 3: DR Program Performance (Percent Demand Reduction)

Table 37 shows LCR event performance for MWRP based on the definition of the metric in the previous chapter and the baseline and impact calculation methodology described in Appendix C. The average monthly demand reduction during LCR events ranged from 48 percent in July 2019 to around 100 percent in September 2019, implying that load reduction in September was almost the same as the total nominated amount. The average DR performance was 79 percent for the site.

Table 37: LCR Performance for Michaelson Water Recycling Plant

Month	Verified Average Monthly Reduction During LCR Events (kW)	Nominated Capacity for LCR (kW)	Verified Demand Reduction %
June 2019	2,004	2,500	83.1%
July 2019	1,070	2,500	47.5%
August 2019	2,138	2,500	86.9%
September 2019	2,488	2,500	99.7%
Average			**79.3%**

* The nominated capacity is a fixed value for a site and does not vary by month.
** This is calculated as the average demand reduction during LCR events divided by the nominated capacity in LCR.
Sources: Advanced Microgrid Solutions, Guidehouse

Metric 4: Bill Reduction (Percent)

Table 38 shows an aggregate 1.6 percent increase in bills for MWRP over the April to November 2019 billing months, due to increases in global peak demand and usage.

Table 38: Bill Reduction for Michaelson Water Recycling Plant

Billing Month	Reported Pre-BESS Bill ($)	Reported Post-BESS Bill ($)	Bill Reduction ($)	Bill Reduction (%)
2019-04	$261,649	$267,292	($5,643)	-2.2%
2019-05	$263,248	$263,958	($709)	-0.3%
2019-06	$370,804	$374,980	($4,176)	-1.1%

Billing Month	Reported Pre-BESS Bill ($)	Reported Post-BESS Bill ($)	Bill Reduction ($)	Bill Reduction (%)
2019-07	$348,154	$351,333	($3,178)	-0.9%
2019-08	$352,147	$354,301	($2,154)	-0.6%
2019-09	$332,508	$336,878	($4,370)	-1.3%
2019-10	$257,133	$267,289	($10,156)	-3.9%
2019-11	$247,849	$257,003	($9,154)	-3.7%
Total	**$2,433,493**	**$2,473,032**	**($39,540)**	**-1.6%**

Billing month as defined in Appendix D.

Source: Advanced Microgrid Solutions

Metric 5: Greenhouse Gas Emissions Reduction

Table 39 shows a 0.34 percent increase in GHG emissions for MWRP for the April 2019 to January 2020 billing months.

Table 39: Greenhouse Gas Emissions Reduction for Michaelson Water Recycling Plant

Billing Month	Reported Pre-BESS GHG Emissions (kg of CO_2)	Reported Post-BESS GHG Emissions (kg of CO_2)	Emissions Reduction (kg of CO_2)	Emissions Reduction (%)
2019-04	1,447,274	1,462,775	(15,501)	-1.07%
2019-05	2,517,813	2,530,140	(12,327)	-0.49%
2019-06	2,371,300	2,360,027	11,272	0.48%
2019-07	2,551,869	2,567,185	(15,315)	-0.60%
2019-08	2,376,163	2,370,395	5,768	0.24%
2019-09	2,377,526	2,367,413	10,113	0.43%
2019-10	2,224,316	2,231,601	(7,285)	-0.33%
2019-11	2,372,947	2,389,968	(17,021)	-0.72%
2019-12	2,215,382	2,234,462	(19,080)	-0.86%
2020-01	746,698	760,217	(13,519)	-1.81%
Total	**21,201,288**	**21,274,183**	**(72,894)**	**-0.34%**

Billing month as defined in Appendix D.

Source: Advanced Microgrid Solutions

Tariff Impact

AMS analyzed the impact of alternative tariffs for MWRP to assess which would be the most beneficial in terms of highest bill savings. The site was on a TOU rate and participated in LCR. AMS analyzed bill impacts as if the site were on an RTP or CPP tariff and participated in LCR events. Table 40 shows the tariff analysis results and highlights that the bill savings would be highest if the site were to remain in LCR with a TOU tariff. This tariff analysis was performed in a "perfect foresight" optimization environment, which means that the site load, RTP prices, and dispatch events are known for each interval in the optimization. This differs significantly from actual operations, since in real-time operations the site load, RTP prices, and dispatch event calls are all based upon forecasts. Perfect foresight optimization results can be viewed as the best possible battery performance, or maximum achievable bill savings.

Table 40: Tariff Impact Analysis for Michaelson Water Recycling Plant

Tariff	Reported On-peak kW Reduction (kW)	Reported On-peak kWh Reduction (kWh)	Reported Bill Savings ($)
LCR (TOU)	2,243	204,305	247,622
LCR+RTP	1,335	121,040	199,335
LCR+CPP	1,495	137,156	154,783

Source: Advanced Microgrid Solutions

Principle Treatment Plant

Principle Treatment Plant (PTP) treats groundwater using reverse osmosis, decarbonation, and disinfection. It has a 500 kW/2,100 kWh BESS installed at the site.

Metric 1: Peak Demand Reduction (Percent)

On-peak Demand Reduction

Table 41 shows the on-peak demand reduction during the summer billing months due to BESS installation for PTP. The on-peak demand reduction for PTP varied from 1.7 percent to 6.3 percent, with an average reduction of 3.5 percent.

Table 41: On-peak Demand Reduction for Principle Treatment Plant

Billing Month	Verified Pre-BESS On-peak Demand (kW)	Verified Post-BESS On-peak Demand (kW)	Verified On-peak Demand Reduction (kW)	Reported On-peak Demand Reduction (kW)	Verified On-peak Demand Reduction (%)
2019-06	477	447	30	30	6.3%
2019-07	477	456	21	21	4.4%
2019-08	478	463	15	15	3.1%
2019-09	486	478	8	8	1.7%
2019-10	451	442	8	8	1.9%
Average					**3.5%**

Billing month as defined in Appendix D.

Sources: Advanced Microgrid Solutions, Guidehouse

Global Peak Reduction

Table 42 shows the global peak demand reduction due to BESS installation for PTP for the April to November 2019 billing months. PTP experienced an average 10 percent increase in global peak demand. The post-BESS global peak demand was lower than the pre-BESS peak demand in only two months (the April and November billing months). The global peak demand increased in all remaining months and varied from 6.8 percent to 39 percent. This occurred because of the need to charge the BESS during nighttime hours and because of the site’s load being very flat.

Table 42: Global Peak Demand Reduction for Principle Treatment Plant

Billing Month	Verified Pre-BESS Global Demand (kW)	Verified Post-BESS Global Demand (kW)	Verified Global Demand Reduction (kW)	Reported Global Demand Reduction (kW)	Verified Global Demand Reduction (%)
2019-04	552	549	3	3	0.5%
2019-05	564	612	-47	-47	-8.3%
2019-06	746	727	19	19	2.6%
2019-07	565	685	-120	-120	-21.2%
2019-08	517	719	-202	-202	-39.0%
2019-09	568	607	-38	-38	-6.8%
2019-10	529	655	-126	-126	-23.7%
2019-11	741	621	120	120	16.2%
Average					**-10.0%**

Billing month as defined in Appendix D.

Sources: Advanced Microgrid Solutions, Guidehouse

Metric 2: Peak Usage Reduction (Percent)

On-peak Usage Reduction

Table 43 shows the on-peak usage reduction during the summer billing months due to BESS installation for PTP. The overall on-peak usage was reduced by 65 percent over the summer billing months.

Table 43: On-peak Usage Reduction for Principle Treatment Plant

Billing Month	Verified Pre-BESS On-peak Usage (kWh)	Verified Post-BESS On-peak Usage (kWh)	Verified On-peak Usage Reduction (kWh)	Verified On-peak Usage Reduction (%)
2019-06	38,005	10,937	27,068	71.2%
2019-07	47,103	12,429	34,674	73.6%
2019-08	46,261	17,413	28,848	62.4%
2019-09	47,382	20,921	26,461	55.8%
2019-10	5,646	3,228	2,418	42.8%
Total	**184,396**	**64,928**	**119,468**	**64.8%**

Billing month as defined in Appendix D.

Sources: Advanced Microgrid Solutions, Guidehouse

Global Usage Reduction

Table 44 shows the global usage reduction due to BESS installation for PTP for the April to November 2019 billing months. The total global usage increased slightly, by 1 percent, over this timeframe.

Table 44: Global Usage Reduction for Principle Treatment Plant

Billing Month	Verified Pre-BESS Global Usage (kWh)	Verified Post-BESS Global Usage (kWh)	Verified Global Usage Reduction (kWh)	Verified Global Usage Reduction (%)
2019-04	297,702	298,008	(306)	-0.1%
2019-05	316,909	317,269	(360)	-0.1%
2019-06	302,568	306,271	(3,703)	-1.2%
2019-07	340,052	344,365	(4,313)	-1.3%
2019-08	297,575	300,026	(2,451)	-0.8%
2019-09	321,605	324,505	(2,900)	-0.9%
2019-10	331,645	337,025	(5,380)	-1.6%
2019-11	241,775	244,623	(2,848)	-1.2%
Total	**2,449,830**	**2,472,092**	**(22,262)**	**-0.9%**

Billing month as defined in Appendix D.

Sources: Advanced Microgrid Solutions, Guidehouse

Metric 3: DR Program Performance (Percent Demand Reduction)

Table 45 shows LCR event performance for PTP based on the definition of the metric in the previous chapter and the baseline and impact calculation methodology described in Appendix C. The average monthly demand reduction during LCR events ranged from 9 percent in August 2019 to 60 percent in June 2019, with an average performance of 27 percent.

Table 45: LCR Performance for Principle Treatment Plant

Month	Verified Average Monthly Reduction During LCR Events (kW)	Nominated Capacity for LCR (kW)	Verified Demand Reduction %
2019-06	298	500	60.5%
2019-07	99	500	20.5%
2019-08	37	500	8.8%
2019-09	83	500	16.6%
Average			**26.6%**

* The nominated capacity is a fixed value for a site and does not vary by month.
** This is calculated as the average demand reduction during LCR events divided by the nominated capacity in LCR.
Sources: Advanced Microgrid Solutions, Guidehouse

Metric 4: Bill Reduction (Percent)

Table 46 shows an aggregate 0.4 percent decrease in bills for PTP over April-November 2019 billing months.

Table 46: Bill Reduction for Principle Treatment Plant

Billing Month	Reported Pre-BESS Bill ($)	Reported Post-BESS Bill ($)	Bill Reduction ($)	Bill Reduction (%)
2019-04	$33,817	$33,700	$117	0.3%
2019-05	$32,651	$33,189	($538)	-1.6%
2019-06	$47,200	$45,008	$2,192	4.6%
2019-07	$49,446	$49,309	$137	0.3%
2019-08	$44,561	$45,604	($1,043)	-2.3%
2019-09	$47,198	$46,684	$514	1.1%
2019-10	$35,766	$37,192	($1,426)	-4.0%
2019-11	$29,760	$28,341	$1,419	4.8%
Total	**$320,400**	**$319,027**	**$1,373**	**0.4%**

Billing month as defined in Appendix D.

Source: Advanced Microgrid Solutions

Metric 5: Greenhouse Gas Reduction

Table 47 shows an overall 0.1 percent increase in GHG emissions for PTP over the entire measurement period.

Table 47: Greenhouse Gas Emissions Reduction for Principle Treatment Plant

Billing Month	Reported Pre-BESS GHG Emissions (kg of CO_2)	Reported Post-BESS GHG Emissions (kg of CO_2)	Emissions Reduction (kg of CO_2)	Emissions Reduction (%)
2019-04	295,588	295,907	(319)	-0.11%
2019-05	277,871	278,103	(231)	-0.08%
2019-06	272,498	272,942	(444)	-0.16%
2019-07	315,918	315,442	476	0.15%
2019-08	279,440	277,537	1,903	0.68%
2019-09	298,884	297,528	1,356	0.45%
2019-10	294,502	297,054	(2,552)	-0.87%
2019-11	211,837	213,049	(1,213)	-0.57%
2019-12	153,475	154,575	(1,100)	-0.72%
Total	**2,400,013**	**2,402,136**	**(2,123)**	**-0.09%**

Billing month as defined in Appendix D.

Source: Advanced Microgrid Solutions

Tariff Impact

AMS analyzed the impact of alternative tariffs for PTP to assess which would be the most beneficial in terms of highest bill savings. The site was on a TOU rate and participated in LCR. AMS analyzed bill impacts as if the site were on an RTP or CPP tariff and participated in LCR events. Table 48 below shows the tariff analysis results and highlights that the bill savings would be highest for LCR participation with the applicable TOU tariff.

Table 48: Tariff Impact Analysis for Principle Treatment Plant

Tariff	Reported On-peak kW Reduction (kW)	Reported On-peak kWh Reduction (kWh)	Reported Bill Savings ($)
LCR (TOU)	254	16,091	42,468
LCR+RTP	140	8,311	25,992
LCR+CPP	170	10,728	27,743

Source: Advanced Microgrid Solutions

Tustin Well

The Tustin site has three facilities — a desalter plant, Well 21, and Well 22. Both of the groundwater wells feed the desalter, which uses reverse osmosis. This site has a 250 kW/ 1,250 kWh BESS installed.

Metric 1: Peak Demand Reduction (Percent)

On-peak Demand Reduction

Table 49 shows the on-peak demand reduction during the summer billing months due to BESS installation for Tustin Well. As is evident from the results, the post-BESS on-peak demand was lower than the pre-BESS on-peak demand in four of the five billing months, ranging from 2.5 percent to 45.6 percent on-peak demand reduction. The on-peak demand increased only in the September 2019 billing month, by 6.3 percent. As a result, the average on-peak demand reduction was at 11 percent.

Table 49: On-peak Demand Reduction for Tustin Well

Billing Month	Verified Pre-BESS On-peak Demand (kW)	Verified Post-BESS On-peak Demand (kW)	Verified On-peak Demand Reduction (kW)	Reported On-peak Demand Reduction (kW)	Verified On-peak Demand Reduction (%)
2019-06	219	209	10	0	4.6%
2019-07	284	154	129	129	45.6%
2019-08	217	202	15	15	7.0%
2019-09	208	222	-13	-13	-6.3%
2019-10	210	205	5	-81	2.5%
Average					**10.7%**

Billing month as defined in Appendix D.

Sources: Advanced Microgrid Solutions, Guidehouse

Global Peak Reduction

Table 50 shows the global peak demand reduction due to BESS installation for Tustin for the April to December 2019 billing months. The post-BESS global peak demand was lower than the pre-BESS peak demand in five months over that timeframe. The global peak reduction varied from 2.5 percent to 21.8 percent. The post-BESS global peak demand was higher than the pre-BESS global peak demand in the remaining four billing months in that timeframe. As a result, the site experienced an almost negligible change in global peak demand.

Table 50: Global Peak Demand Reduction for Tustin Well

Billing Month	Verified Pre-BESS Global Demand (kW)	Verified Post-BESS Global Demand (kW)	Verified Global Demand Reduction (kW)	Reported Global Demand Reduction (kW)	Verified Global Demand Reduction (%)
2019-04	241	235	6	6	2.5%
2019-05	274	276	-2	-2	-0.9%
2019-06	278	358	-79	-79	-28.4%
2019-07	433	346	87	87	20.1%
2019-08	373	328	45	45	12.0%
2019-09	419	328	91	91	21.8%
2019-10	258	299	-40	-40	-15.6%
2019-11	345	286	58	58	16.9%
2019-12	232	298	-66	-66	-28.6%
Average					**-0.02%**

Billing month as defined in Appendix D.

Sources: Advanced Microgrid Solutions, Guidehouse

Metric 2: Peak Usage Reduction (Percent)

On-peak Usage Reduction

Table 51 shows the on-peak usage reduction during the summer billing months due to BESS installation for Tustin Well. The overall on-peak usage reduced by 78 percent over the summer billing months.

Table 51: On-peak Usage Reduction for Tustin Well

Billing Month	Verified Pre-BESS On-peak Usage (kWh)	Verified Post-BESS On-peak Usage (kWh)	Verified On-peak Usage Reduction (kWh)	Verified On-peak Usage Reduction (%)
2019-06	9,258	2,101	7,157	77.3%
2019-07	21,588	2,303	19,285	89.3%
2019-08	20,081	3,942	16,139	80.4%

Billing Month	Verified Pre-BESS On-peak Usage (kWh)	Verified Post-BESS On-peak Usage (kWh)	Verified On-peak Usage Reduction (kWh)	Verified On-peak Usage Reduction (%)
2019-09	20,029	6,128	13,900	69.4%
2019-10	10,160	3,223	6,937	68.3%
Total	**81,115**	**17,697**	**63,418**	**78.2%**

Billing month as defined in Appendix D.

Sources: Advanced Microgrid Solutions, Guidehouse

Global Usage Reduction

Table 52 shows the global usage reduction due to BESS installation for Tustin Well for the April to December 2019 billing months. The total global usage increased by 1.3 percent over the entire timeframe.

Table 52: Global Usage Reduction for Tustin Well

Billing Month	Verified Pre-BESS Global Usage (kWh)	Verified Post-BESS Global Usage (kWh)	Verified Global Usage Reduction (kWh)	Verified Global Usage Reduction (%)
2019-04	65,360	65,381	(21)	0.0%
2019-05	146,617	147,105	(488)	-0.3%
2019-06	146,678	147,098	(421)	-0.3%
2019-07	157,131	159,611	(2,481)	-1.6%
2019-08	138,906	140,999	(2,093)	-1.5%
2019-09	142,841	144,820	(1,978)	-1.4%
2019-10	138,740	140,954	(2,214)	-1.6%
2019-11	139,475	141,718	(2,243)	-1.6%
2019-12	146,880	150,265	(3,385)	-2.3%
Total	**1,222,628**	**1,237,951**	**(15,323)**	**-1.3%**

Billing month as defined in Appendix D.

Sources: Advanced Microgrid Solutions, Guidehouse

Metric 3: DR Program Performance (Percent Demand Reduction)

Table 53 shows LCR event performance for Tustin Well based on the definition of the metric in the previous chapter and the baseline and impact calculation methodology described in Appendix C. The average monthly demand reduction during LCR events varied over a wide range, between 15 percent to 74 percent. The overall average DR performance was at 33 percent.

Table 53: LCR Performance for Tustin Well

Month	Verified Average Monthly Reduction During LCR Events (kW)	Nominated Capacity for LCR (kW)	Verified Demand Reduction %
June 2019	184	250	73.7%
July 2019	34	250	15.8%
August 2019	37	250	15.2%
September 2019	65	250	25.8%
Average			**32.6%**

* The nominated capacity is a fixed value for a site and does not vary by month.
** This is calculated as the average demand reduction during LCR events divided by the nominated capacity in LCR.
Sources: Advanced Microgrid Solutions, Guidehouse

Metric 4: Bill Reduction (Percent)

Table 54 shows an aggregate 3.8 percent decrease in bills for Tustin Well over the April to December 2019 billing months.

Table 54: Bill Reduction for Tustin Well

Billing Month	Reported Pre-BESS Bill ($)	Reported Post-BESS Bill ($)	Bill Reduction ($)	Bill Reduction (%)
2019-04	$12,773	$12,686	$87	0.7%
2019-05	$13,173	$13,187	($14)	-0.1%
2019-06	$14,462	$14,714	($252)	-1.7%
2019-07	$20,640	$17,177	$3,463	16.8%
2019-08	$17,366	$16,163	$1,203	6.9%
2019-09	$17,715	$16,682	$1,033	5.8%
2019-10	$14,699	$14,762	($62)	-0.4%
2019-11	$13,553	$13,098	$455	3.4%
2019-12	$13,192	$13,863	($672)	-5.1%
Total	**$137,574**	**$132,333**	**$5,241**	**3.8%**

Billing month as defined in Appendix D.

Source: Advanced Microgrid Solutions

Metric 5: Greenhouse Gas Emissions Reduction

Table 55 shows a 3 percent increase in aggregate GHG emissions for Tustin Well over the measurement period.

Table 55: Greenhouse Gas Emissions Reduction for Tustin Well

Billing Month	Reported Pre-BESS GHG Emissions (kg of CO_2)	Reported Post-BESS GHG Emissions (kg of CO_2)	Emissions Reduction (kg of CO_2)	Emissions Reduction (%)
2019-04	128,045	128,079	(34)	-0.03%
2019-05	129,408	129,767	(359)	-0.28%
2019-06	130,452	130,086	367	0.28%
2019-07	142,640	142,877	(237)	-0.17%
2019-08	130,890	130,527	364	0.28%
2019-09	134,013	133,662	351	0.26%
2019-10	124,331	125,150	(819)	-0.66%
2019-11	123,394	124,420	(1,026)	-0.83%
2019-12	127,919	130,212	(2,294)	-1.79%
Total	**1,171,092**	**1,174,780**	**(3,688)**	**-2.93%**

Billing month as defined in Appendix D.

Source: Advanced Microgrid Solutions

Tariff Impact

AMS analyzed the impact of alternative tariffs for Tustin Well to assess which would be the most beneficial in terms of highest bill savings. The site was on a TOU rate and participated in LCR. AMS analyzed bill impacts as if the site were on an RTP or CPP tariff and participated in LCR events. Table 56 below shows the tariff analysis results and highlights that the bill savings are highest for LCR participation with TOU.

Table 56: Tariff Impact Analysis for Tustin Well

Tariff	Reported On-peak kW Reduction (kW)	Reported On-peak kWh Reduction (kWh)	Reported Bill Savings ($)
LCR (TOU)	181	16,812	13,997
LCR+RTP	94	8,255	(5,344)
LCR+CPP	121	11,288	7,112

Source: Advanced Microgrid Solutions

CHAPTER 4: Conclusions

The goals of this project were to achieve reduction in on-peak demand and energy usage, enable site participation in DR programs and enhance DR performance, reduce energy bills for sites, achieve reductions in GHG emissions, and undertake alternative tariff analysis for each site to identify the optimal tariff. This pilot project fulfilled its purpose of advancing, testing, and validating a load shifting optimization platform, and it had mixed results in achieving the goals. Table 57 summarizes the performance at each site and shows the mixed results in achieving the goals.

Table 57: Summary of All Sites Performance

Site	On-peak Demand Reduction (%)	On-peak Energy Usage Reduction (%)	DR Performance (%)	Bill Reduction (%)	GHG Reduction (%)
Baker	- 1.8	38	58	- 2.5	- 0.6
DATS	- 1.9	71	15	- 3.4	- 1.1
LAWRP	- 10.1	63	30	0.7	- 0.4
MWRP	3.3	40	79	- 1.6	- 0.3
PTP	3.5	65	27	0.4	- 0.1
Tustin Well	10.7	78	33	3.8	- 2.9

Negative values represent increase in the metric.

Source: Advanced Microgrid Solutions

Three of the six sites experienced a decrease in the average on-peak demand, while the remaining three experienced an increase in the average on-peak demand. The total on-peak energy use decreased at all sites. Despite this, only half of the sites achieved positive bill savings, while the other half saw an increase in the total utility bill. There are a variety of contributing factors to this bill increase, including relatively flat load profiles and charge window constraints. The IRWD sites all have relatively flat load profiles, which does not leave much head room to charge the battery fully without setting a new peak. This issue is exacerbated by limited charging windows, since the battery may need to charge at a higher rate to fill to capacity in a shorter time.

The total GHG emissions increased at all sites, and this project did not achieve its goal of reducing emissions at the sites. There are two primary factors contributing to the increase in GHG emissions: (a) roundtrip efficiency losses, and (b) the GHG emissions factor is not necessarily higher during on-peak hours. The battery cycling efficiency is less than 100 percent, so each battery cycle draws slightly more energy from the grid than it consumes, thus emitting more GHGs. As shown in Table 57, the BESS was effective at reducing total energy consumption during on-peak hours and shifting this energy to be consumed in off-peak hours. If the

GHG emissions factor is higher during on-peak hours, this can be an effective strategy to reduce overall GHG emissions. However, the grid mix in Irvine does not follow this trend; therefore, shifting energy consumption to different times of the day does not result in decreased GHG emissions.

To conclude, following are some of the main take-aways from this study.

- Water agencies can shift load using BESS: Project results indicate that water and wastewater treatment facilities can shift load using BESS. However, the load shift varies over a wide range, depending on the site operations and load characteristics. Even for a particular site, the on-peak demand reduction can vary over a wide range within a certain timeframe. Due to the nature of demand charges — even one 15-minute interval of nonperformance results in lost savings — the ability to capture on-peak demand charges is challenging and subject to BESS and OLC execution and uptime. This is further complicated when additional revenue streams like DR are available to a facility, as high-value DR programs may not allow a BESS unit to capture on-peak demand charges every month.
- Water agencies can participate in DR programs such as LCR using BESS: All participating sites achieved load reduction during LCR events, indicating that sites are able to reduce load during DR events using BESS. The DR performance too varies over a wide range, depending on the site operations and load characteristics. Even for a particular site, the average monthly DR performance can vary widely, depending on the month. This variation is due to a combination of factors, such as load variability and dispatch timing and duration; however, the most significant cause of variable DR performance is activity that occurs during baseline-setting days. If batteries are actively meeting facility load during non-dispatch days, they reduce their measured performance during DR events.
- Batteries can help realize bill savings through DCM and load shifting: BESS can help sites reduce on-peak usage and lower the global peak demand in a billing cycle (demand charge management), thereby helping realize bill savings. The savings potential is highly dependent on the baseline load profile of a site (lower savings for a flatter load profile versus higher savings for a site with a spikier load) and the level of demand charge ($/kW) in the applicable tariff for the site. Balancing on-peak reductions and global peak increases as load and dispatch conditions change requires sophisticated real-time optimization. While some sites are not conducive to bill savings, the customer may still realize an overall reduction in energy costs by sharing in some of the value creation through BESS participation in LCR or other available programs.
- Batteries can help stack value of DCM and DR; however, significant barriers exist: One of the most significant barriers is the use of baseline methodologies designed for load-control DR to measure BESS performance. With baseline methodologies, if the BESS is discharged for demand charge management for bill savings on a non-DR event dispatch day, it lowers the site's baseline that DR performance is measured against. This essentially penalizes energy storage unit behavior during non-DR event hours, making value stacking risky and highly dependent on DR dispatch frequency and timing.

In addition to baseline methodologies, existing dual participation rules often prevent BESS systems from enrolling in multiple programs simultaneously and thus systems are unable to capture additional value through the provision of multiple grid services. For BESS to fully capture this stacked value, there is a need to make additional modifications to the California Independent System Operator market design as well as regulatory changes at the CPUC.

- Batteries have minimal impact on GHG emissions reduction: As there is not yet a GHG-related price signal for BESSs to optimize against and realize revenue through, most energy storage systems will have a negligible impact on facility GHG emissions. Partially, this is due to the roundtrip efficiency of the energy storage unit itself — it will increase electricity consumption naturally — however, it is primarily due to the imperfect alignment of utility rate structures with marginal grid emissions. If the price of electricity perfectly matched the marginal GHG emissions of the grid, energy storage units would be financially incentivized to arbitrage GHG emissions.

CHAPTER 5: Technology/Knowledge/Market Transfer Activities

This report represents the first and primary method for communicating the lessons learned from this project. Derivative summary presentations at conferences, to regulators, or to utility DR program managers can further disseminate the findings of this study. Possible venues for presentations include:

- Presentations at CPUC Demand Response Measurement and Evaluation Committee workshops. This would socialize results with utility regulators and the associated stakeholders and parties that follow DR issues and proceedings at the CPUC.
- Presentation at the SCE annual water conference. This event is held each year by SCE with a primary target audience of water utilities that are served by SCE. This would socialize results with public water agencies in Southern California.
- Presentations at California Efficiency Demand Management Council symposiums or to members via webinars. This would socialize results with policy advocates, implementors of DR programs, load-serving entities, and regulators.
- Presentations at Peak Load Management Alliance conferences or events. This would socialize results with the broader nationwide DR industry outside of California.

Further publicizing this information will present decision makers, customers, and utilities with the opportunities and challenges of implementing similar DR technologies throughout California.

CHAPTER 6: Benefits to California

The findings from the project can be used to help water agencies understand the benefits and risks of deploying BESS at their facilities. The project also documented the magnitude of costs and benefits of some common OLC measures at water agency facilities, including both energy and financial benefits. Finally, the project highlights the challenges of dual enrollment in programs that seek to engage controllable loads like traditional DR and newer BESS technologies. The complexities of meeting program requirements, financial implications of difficult-to-forecast baselines, and the punishing nature of high-cost demand charges require sophisticated software and program management, which are barriers to delivering and capturing value.

As water utilities pursue projects to reduce the energy and financial costs of operation, identifying those projects with a high rate of return could allow the utilities to pass on the benefits of reduced costs to ratepayers through future rate changes. This report documents OLC measures that are potential candidates for water agencies across California to deliver high-return projects, and it identifies tariffs and DR programs that, in some circumstances, can deliver additional value to OLC and BESS projects in SCE territory (though similar programs exist in other utility service territories in many cases).

As California makes progress on meeting the 100 percent clean energy electricity requirements of SB 100, effectively and predictably engaging customer-sited load control, electricity generation, and energy storage units will be critical to achieving these goals cost effectively. This project's findings regarding BESS's GHG impacts, given current tariff structures and the barriers to engaging multiple customer-sited resources effectively, are important issues to resolve.

GLOSSARY AND LIST OF ACRONYMS

Term	Definition
AMS	Advanced Microgrid Solutions
Auto-DR	automated demand response
Baker	Baker Water Treatment Plant
BESS	battery energy storage system
CEC	California Energy Commission
CO_2	carbon dioxide
CPP	critical peak pricing
CPUC	California Public Utilities Commission
DATS	Deep Aquifer Treatment System
DCM	demand charge management
DR	demand response
EPIC	Electric Program Investment Charge
GHG	greenhouse gas
IRWD	Irvine Ranch Water District
kg	kilogram
kVAR	kilo volt ampere reactive
kW	kilowatt
kWh	kilowatt-hour
LCR	local capacity requirements
LF	load factor
LAWRP	Los Alisos Water Recycling Plant
M&V	measurement and verification
MW	megawatts
MWh	megawatt-hour
MWRP	Michelson Water Recycling Plant
OLC	operational load control
PTP	Principle Treatment Plant
RO	reverse osmosis
RTP	real-time pricing
SB	Senate Bill
SCADA	supervisory control and data acquisition
SCE	Southern California Edison Company
TOU	time-of-use

Term	Definition
Tustin Well	Tustin Well 21/22 Desalter Facility
VFD	variable frequency drive
yr	year

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Appendix A: Time-of-use Tariff Descriptions

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APPENDIX A:
Time-of-use Tariff Descriptions

All sites are on a time-of-use (TOU) tariff, in which electricity rates vary by time of day. Typically, energy is more expensive when electricity is in high demand or when the energy price is high in the wholesale market.

There are multiple components in a TOU tariff:

- TOU energy rates: $/kWh of energy used in each TOU period. TOU periods vary by time of day, day of week, and season.
    - On-peak (summer)
    - Mid-peak (summer and winter)
    - Off-peak (summer and winter)
    - Super-off-peak (winter)
- Facility-related demand charges: $/kW apply year-round and are calculated per kW according to the highest recorded demand during each monthly bill period, regardless of season, day of week, or time of day.
- Time-related demand charges: $/kW apply year-round and are calculated per kW according to the highest recorded demand during summer on-peak and winter mid-peak TOU periods on weekdays, excluding weekends and holidays.
- Customer charge: $/meter/month, a fixed charge to the customer per month
- Other charges
    - Power factor adjustment: $/kVAR (kilo volt ampere reactive)
    - Voltage discount, demand: $/kW

Table A-1 presents the tariffs for the six sites with BESS and for which performance data was analyzed and presented in this report. The on-peak, mid-peak, off-peak, and super-off-peak time periods under these tariffs are noted in Table A-2 and Table A-3.

Table A-1: Applicable Tariffs for Sites

Site Name	Applicable Tariff
Baker	TOU-8-D
DATS	TOU-8-D
LAWRP	TOU-8-D
MWRP	TOU-8-D
PTP	TOU-8-D
Tustin	TOU-PA-3-D

Source: SCE 2020a, SCE 2020b

Time Period Definitions

Table A-2: TOU-8-D Tariff

TOU Period	Weekdays	Weekdays	Weekends and Holidays	Weekends and Holidays
Season	Summer	Winter	Summer	Winter
On-Peak	4 p.m.-9 p.m.	N/A	N/A	N/A
Mid-Peak	N/A	4 p.m.-9 p.m.	4 p.m.-9 p.m.	4 p.m.-9 p.m.
Off-Peak	All other hours	9 p.m.-8 a.m.	All other hours	9 p.m.-8 a.m.
Super Off-Peak	N/A	8 a.m.-4 p.m.	N/A	8 a.m.-4 p.m.

Source: SCE 2020a

Table A-3: TOU-PA-3-D Tariff

TOU Period	Weekdays	Weekdays	Weekends and Holidays	Weekends and Holidays
Season	Summer	Winter	Summer	Winter
On-Peak	4 p.m.-9 p.m.	N/A	N/A	N/A
Mid-Peak	N/A	4 p.m.-9 p.m.	4 p.m.-9 p.m.	4 p.m.-9 p.m.
Off-Peak	All other hours	9 p.m.-8 a.m.	All other hours	9 p.m.-8 a.m.
Super Off-Peak	N/A	8 a.m.-4 p.m.	N/A	8 a.m.-4 p.m.

Source: SCE 2020b

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Appendix B: Demand Response Program and Tariff Descriptions

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APPENDIX B: Demand Response Program and Tariff Descriptions

The three programs/rates for which the six demonstration sites with BESS sites are eligible include:

- Local capacity requirement (LCR)
- Real-time pricing (RTP) rate
- Critical peak pricing (CPP) rate

Table B-1 lists the salient features of these programs.

Table B-1: Demand Response Program and Rate Features

	LCR	RTP	CPP
Main Features	• Reduce load when called by SCE • Get capacity and energy payment • Potential penalty for low performance	• Hourly energy rate applied to bill calculation, depending on temperature and season • 7-day types with different energy rates	• CPP offers a discount on summer electricity rates in exchange for higher prices during 12 CPP event days per year, usually occurring on the hottest summer days.
Event	• Window: 8 a.m.-9 p.m., non-holiday weekdays • Duration: Anywhere from 15 minutes to 4 hours • Season: Year round • Limitation: Max 80 hrs./ month, 800 hrs./yr. • Notification: 20 minutes in advance	• None • SCE announces day type one day ahead, based on weather forecast	• 12 CPP events are called every year between 4 p.m. and 9 p.m. • CPP events can be called year-round on non-holiday weekdays. • Day-ahead notification provided.
Payment	• Capacity payment ($/kW reduced), and • Energy payment ($/kWh reduced) – bundled customer only • Penalty applied for low performance	• Calculated based on day type, tariff, and energy use in the day	• Bill credits are applied to reduce power costs during the summer months (June 1-September 30). • Energy used during a CPP event is charged at a higher rate for the duration of the event.

Source: SCE 2020.

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Appendix C: Local Capacity Requirement Performance Calculation Method

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APPENDIX C: Local Capacity Requirement Performance Calculation Method

The steps for LCR performance calculation, from baseline estimation to average monthly LCR performance calculation, are listed below:

1. Step 1: Calculate the baseline grid kW for each hour using the 10-10 rule — that is, calculating the average for each hour over the previous 10 non-event, non-holiday weekdays, represented as:
2. LCR_Baseline_kW_Hour = Average (BaselineDay_GridkW_Hour)
3. Step 2: Find the average grid kW for each hour during each event, represented as:
4. LCR_Event_kW_Hour = Average (EventDay_GridkW_Hour)
5. Step 3: Calculate the reduced kW at each hour in one event, represented as: LCR_Event_kW_Reduction_Hour = (LCR_Baseline kW_Hour – LCR_Event_kW_Hour)
6. Step 4: Find the lowest performing hour in each event, represented as: LCR_Event_kW_Reduction = Min (LCR_Event_kW_Reduction_Hour)
7. Step 5: Calculate the event performance in percent, represented as: LCR_Event_Performance_% =LCR_Event_kW_Reduction/Nominated kW
8. Step 6: Calculate the monthly performance in percent, represented as:
9. LCR_Monthly _Performance_% = Average (LCR_Event_Performance_%)

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Appendix D: Billing Month Definitions

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APPENDIX D: Billing Month Definitions

Table D-1 provides the billing month definitions.

Table D-1: Billing Month Definitions

Site	Billing Month	Start Day	End Day (Not Included in Cycle)
Baker	2019-03	3/11/2019	4/9/2019
Baker	2019-04	4/9/2019	5/9/2019
Baker	2019-05	5/9/2019	6/10/2019
Baker	2019-06	6/10/2019	7/10/2019
Baker	2019-07	7/10/2019	8/8/2019
Baker	2019-08	8/8/2019	9/9/2019
Baker	2019-09	9/9/2019	10/8/2019
Baker	2019-10	10/8/2019	11/7/2019
Baker	2019-11	11/7/2019	12/10/2019
DATS	2019-04	3/21/2019	4/22/2019
DATS	2019-05	4/22/2019	5/21/2019
DATS	2019-06	5/21/2019	6/20/2019
DATS	2019-07	6/20/2019	7/22/2019
DATS	2019-08	7/22/2019	8/20/2019
DATS	2019-09	8/20/2019	9/19/2019
DATS	2019-10	9/19/2019	10/21/2019
DATS	2019-11	10/21/2019	11/20/2019
DATS	2019-12	11/20/2019	12/20/2019
LAWRP	2019-04	3/22/2019	4/23/2019
LAWRP	2019-05	4/23/2019	5/22/2019
LAWRP	2019-06	5/22/2019	6/21/2019
LAWRP	2019-07	6/21/2019	7/23/2019
LAWRP	2019-08	7/23/2019	8/21/2019
LAWRP	2019-09	8/21/2019	9/20/2019
LAWRP	2019-10	9/20/2019	10/22/2019
LAWRP	2019-11	10/22/2019	11/21/2019

Site	Billing Month	Start Day	End Day (Not Included in Cycle)
MWRP	2019-04	4/5/2019	5/7/2019
MWRP	2019-05	5/7/2019	6/6/2019
MWRP	2019-06	6/6/2019	7/8/2019
MWRP	2019-07	7/8/2019	8/6/2019
MWRP	2019-08	8/6/2019	9/5/2019
MWRP	2019-09	9/5/2019	10/4/2019
MWRP	2019-10	10/4/2019	11/5/2019
MWRP	2019-11	11/5/2019	12/6/2019
PTP	2019-04	3/28/2019	4/29/2019
PTP	2019-05	4/29/2019	5/29/2019
PTP	2019-06	5/29/2019	6/27/2019
PTP	2019-07	6/27/2019	7/29/2019
PTP	2019-08	7/29/2019	8/27/2019
PTP	2019-09	8/27/2019	9/26/2019
PTP	2019-10	9/26/2019	10/28/2019
PTP	2019-11	10/28/2019	11/26/2019
Tustin Wells	2019-04	3/15/2019	4/15/2019
Tustin Wells	2019-05	4/15/2019	5/15/2019
Tustin Wells	2019-06	5/15/2019	6/14/2019
Tustin Wells	2019-07	6/14/2019	7/16/2019
Tustin Wells	2019-08	7/16/2019	8/14/2019
Tustin Wells	2019-09	8/14/2019	9/13/2019
Tustin Wells	2019-10	9/13/2019	10/15/2019
Tustin Wells	2019-11	10/15/2019	11/14/2019
Tustin Wells	2019-12	11/14/2019	12/16/2019

Source: SCE 2020