**SCE Findings**
August 2016

# DR15.13: COMMERCIAL AND INDUSTRIAL ADR WITH STATIONARY BATTERY STORAGE

## BATTERY STORAGE IN DEMAND RESPONSE EVENTS

The goal of this project is to quantify the Demand Response (DR) performance of energy storage systems while monitoring power quality characteristics at the participating customer facilities to determine whether battery storage dispatch resulted in any power quality issues for the customer. Three customers with existing battery energy storage systems, with battery capacities of 2.6 megawatts (MW), 800 kilowatts (kW) and 600 kilowatts (kW), participated in the project and the SCE Capacity Bidding Program (CBP) was utilized to dispatch the test events. The standard Capacity Bidding Program (CBP) bid from each customer site was 200 kW for Customers 1 and 2 and 100 kW for Customer 3.

A total of 13 DR events were called to test the various scenarios laid out in the study. Results from the test events indicate that in some instances, the SCE meter records usage does not indicate that the battery responded as expected while the battery ALCS data indicates demand response in line with expectations. Similarly, sometimes the SCE meter records indicates what might be a response to a dispatch signal that is in line with expectations, but the battery ALCS indicates that the response was not in line with expectations.

The observations in this project suggest that further refinement is needed with regards to dispatch instructions in order to derive expected consistent and predictable battery response. It is recommend to explore refining the dispatch signal to request a specific amount of net load (MW) or energy usage (MWh) change at the customer site. Demand response baseline techniques can then utilize the SCE meter data relative to the measure and verify requested quantities. Essentially, the net load change defines the performance and a lack of prior scheduling ensures that the usage behavior does not change from what is typical in anticipation of the DR event.

# INTRODUCTION

## What Is This Technology?

### BATTERY STORAGE

Battery energy storage is an emerging technology as a distributed energy resource (DER). The U.S. deployed 221 MW of energy storage in 2015 which was an increase of 243% over 2014. When combined with intermittent renewable resources, including solar photovoltaic, batteries can be a shock absorber for the intermittent generation output by storing excess generation for later use and/or discharging to meet consumer electricity demand. The ability to both absorb excess energy and discharge as needed make batteries a key component in the evolution of DER. Other than pumped hydroelectric energy storage at hydroelectric plants, the concept of megawatt scale distributed energy storage is new.

While battery energy storage technology does not save energy per say, the advantages and capabilities of a flexible resource are very promising given the challenges of proliferating intermittent distributed renewable resources. Battery energy storage can help the overall system function more efficiently and resiliently. This is especially true at scale where curtailing base-load generation or renewable generation output during periods of minimum demand can be costly and batteries can charge with the resulting excess generation. Additionally, the off-peak energy storage (from less costly generation sources) can help lower the on-peak usage and help avoid the more costly peak generation options.

## What We Did?

### MONITORED THREE EXISTING BATTERY STORAGE SYSTEMS

Three customer sites with pre-existing stationary battery systems participated in the demonstration. In addition to DR measurement and evaluation (M&V), power quality was monitored at all three sites for the duration of the project.

SCE conducted a total of 13 events with the stationary storage devices available and receiving signals to participate. Each dispatch evet included a corresponding criticality level intended to direct storage performance to either charge, discharge, or turn-off charging.

For this project, power quality monitoring equipment was installed at the three customer sites and provided M&V for the DR dispatch performance utilizing SCE revenue meter data. This data was compared to the SCE meter data and the battery Advanced Load Control System (ALCS) data to analyze the demand reduction and power quality performance from each dispatch event.

#### DEMAND RESPONSE OBSERVATION SUMMARY LEGEND

| Icon | Description |
|---|---|
| | Green indicates that the response was in line with expectations. |
| | A green outline with yellow center indicates that the battery was in compliance with the dispatch instruction but there was not the expected change in demand or usage. |
| | Yellow indicates that the meter data does not indicate a change in usage in line with expectations. |
| | Red represents a test where that the meter data indicates a response was the opposite of the expected response. |
| % | The percentage indicates "Performance Relative To CBP Energy Baseline" which may or may not align with the observed test event usage change on the SCE, ALCS, and PQ meter. |
| -% | A negative percentage indicates that the "Performance Relative To CBP Energy Baseline" was opposite of intended performance. |
| ***Note: The colored icons indicate whether the observed test event usage change on the SCE, ALCS and PQ meter align with expectations for the test event.*** | |

**CUSTOMER 1: DR OBSERVATIONS AND PQ RESULTS** Customer 1 is an aerospace industrial manufacturing company. The facility includes multiple mills, and rigs associated with the production of forged rings using a variety of metals, including titanium, iron, carbon steels, and lead. Customer 1 has a 5200 kWh battery system with a maximum output of 2600 kW.

Evaluation of the power quality levels at this site showed acceptable levels during the monitoring. The voltage, voltage variations, harmonic distortion, and higher frequency harmonic distortion were within acceptable limits. Comparison of the power quality levels during the mill outage and during the battery system outage reveals that neither system has a significant impact on the power quality levels.

**CUSTOMER 2: DR OBSERVATIONS AND PQ RESULTS** The battery controller at Customer 2 only monitors and responds to a portion of the total facility load. The interconnection agreement with SCE does not allow net export of electricity. Therefore, Customer 2 battery system is effectively blind to a large portion of the facility load and must limit its capacity to the portion of the facility load it is monitoring. Customer 2 has a 1600 kWh battery system with a maximum output of 800 kW.

Evaluation of the harmonic distortion, voltage flicker, and voltage waveform information shows that the battery energy storage system at Customer 2 does not affect the power quality of the 480V system to which it is connected.

**CUSTOMER 3: DR OBSERVATIONS AND PQ RESULTS** The battery system at Customer 3 only supports the electric vehicle charging stations and "supercharger" at the facility. Because of this unique load, drastic and rapid fluctuations in the usage profile for the site meter data appear. Usage characteristics are dependent on the timing and number of vehicles charging which may not follow regular usage patterns. Customer 3 has a 1200 kWh battery system with a maximum output of 600 kW.

Evaluation of the harmonic distortion, voltage flicker, and voltage waveform information has shown that the energy storage system at Customer 3 does not affect the power quality of the 480V system to which it is connected.

| | | Customer 1 | | | | Customer 2 | | | | Customer 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Event Start Time | Event Type | SCE | Performance Relative to CPB Energy | Battery ALCS | PQ Meter[4] | SCE | Performance Relative to CPB Energy | Battery ALCS | PQ Meter | SCE | Performance Relative to CPB Energy | Battery ALCS | PQ Meter |
| 4/5/16 22:00 | Turn Off Charging | 🟢 | 516% | 🟢 | - | 🟡 | 109% | 🟡 | 🟡 | - | | - | - |
| 4/12/16 14:00 | Discharge | 🟢 | 703% | 🟢 | - | 🟡 | 75% | 🟢 | 🟢 | 🟢 | 266% | 🟢 | 🟢 |
| 4/19/16 22:00 | Turn Off Charging | 🟡 | 540% | 🟡 | - | 🟢 | 119% | 🟡 | 🟡 | 🟢 | 106% | 🟡 | - |
| 4/22/16 14:00 | Discharge | 🟢 | 1225% | 🟢 | - | 🟡 | 224% | 🔴 | 🟡 | 🟢 | 324% | 🟢 | 🟢 |
| 4/29/16 22:00 | Turn Off Charging | 🟡 | 1740% | 🟡 | - | 🟡 | 8% | 🟡 | 🟡 | 🟡 | 244% | 🔴 | 🟡 |
| 5/2/16 14:00 | Discharge | 🟢 | 450% | 🟢 | - | 🟢 | 91% | 🟢 | 🟢 | 🟢 | 313% | 🟢 | 🟢 |
| 5/6/16 3:00 | Start Charging | 🟢 | 529% | 🟢 | - | 🟢 | 83% | 🟢 | 🟢 | 🟢 | 64% | 🟢 | 🟢 |
| 5/10/16 22:00 | Turn Off Charging | 🟢 | 643% | 🟡 | - | 🟡 | 77% | 🟡 | - | 🟡 | 189% | 🟡 | 🟡 |
| 5/13/16 14:00 | Discharge | 🟢 | 1193% | 🟢 | - | 🟢 | 117% | 🟢 | 🟢 | 🟢 | 249% | 🟢 | 🟢 |
| 5/17/16 3:00 | Start Charging | 🟡 | -404% | 🟡 | - | 🟡 | -147% | 🟡 | 🟡 | 🔴 | 45% | 🔴 | 🔴 |
| 5/20/16 3:00 | Start Charging | 🟢 | 215% | 🟢 | - | 🟡 | 54% | 🟡 | 🟡 | 🟢 | 78% | 🟢 | 🟢 |
| 5/24/16 3:00 | Start Charging | 🟢 | 97% | 🟢 | - | 🟢 | 48% | 🟢 | 🟢 | 🟢 | 70% | 🟢 | 🟢 |
| 6/8/16 3:00 | Start Charging | 🟡 | 69% | 🟡 | - | 🔴 | 69% | 🔴 | 🟡 | 🔴 | -81% | 🔴 | 🔴 |

# CONCLUSIONS

## What We Concluded?

### DISPATCH SIGNALS, DEVIATION AND POWER QUALITY

The standard CBP bid from each customer site was 200 kW for Customers 1 and 2 and 100 kW for Customer 3. However,

- Customer 1 over-performed delivering an average of 578% of the requested demand response.
- Customer 2 under-performed delivering an average of 71% of the requested demand response.
- Customer 3 over-performed delivering an average of 156% of the requested demand response.

Therefore, the imprecision of the high, medium and low dispatch signals necessitated by CBP program constraints resulted in imprecise and inconsistent results. A dispatch signal indicating the exact amount of demand increase or reduction will likely yield more consistent performance.

Essentially, the battery system should not deviate from the normal schedule until receiving the dispatch signal and should return to the normal schedule after termination of the DR (test) event. A majority of test events showed event day usage that varied from the range of usage (maximum, minimum, and average) encountered during the 10 day baseline period.

Over three months of PQ data was collected from the customers' battery storage systems in order to analyze voltage flicker and harmonic voltage distortion. This analysis found that the flicker Pst as a 10-minute measure of the steadiness of the system voltage conforms to IEEE Standard 1453 with the system maintaining variations less than Pst < 1.0. Additionally, the harmonic voltage distortion trends show that the voltage distortion is within a good range, easily meeting the IEEE Standard 519 recommended limit of 5%.

## Recommendations

Battery energy storage is still an emerging technology and the results of this project demonstrate that the technology is not yet mature in terms of providing predictable and consistent demand response performance.

### ADJUSTMENT OF DR DISPATCH SIGNAL

As with many DR resources, some are suited for quick response but not prolonged dispatch. Others are more suited for scheduled and longer dispatch periods. In the case of battery energy storage, they can potentially respond very quickly but have limited-use restrictions for both capacity and duration of dispatch. It is likely that battery energy storage align with quick response distributed real-time ancillary services where the dispatch notification occurs approximately 10 minutes prior to dispatch and the quantity (MW) of dispatch can vary every 5 minutes with an average dispatch lasting approximately 20 minutes. This type of resource interaction is also consistent with what is expected in a future trans-active energy market.

As a follow-up to this study, it is recommend that adjustments are made to the DR dispatch signal such that a specific amount of energy is dispatched which results in the battery making net facility load adjustments to align with the requested quantity (MW) for the duration needed. Simulating the CAISO dispatch signal through an OpenADR26 interface and adjusting the quantity of energy requested during a dispatch will provide insight into the dispatch performance precision that the current battery energy storage systems can provide.

These Findings are based on the report "Commercial and Industrial ADR with Stationary Battery Storage" which is available from the ETCC program website, https://www.etcc-ca.com/reports.