COMMERCIAL AND INDUSTRIAL ADR WITH STATIONARY BATTERY STORAGE

DR15.13

Prepared by:

Engineering Services
Customer Service
Southern California Edison

August 2016

Acknowledgements

Southern California Edison's Emerging Products (EP) group is responsible for this project. It was developed as part of Southern California Edison's Emerging Technologies Program under internal project number DR15.13. Neha Arora, a project manager in EPM organization at SCE conducted this technology evaluation with overall guidance and management from David Rivers. Contact Neha.Arora@sce.com for more information on this project. .

Disclaimer

This report was prepared by EnerNex LLC (team of Jeremy Laundergan, Dave Mueller and Sean Morash performed technology evaluation with contributions from Erich Gunther) for Southern California Edison (SCE) and funded by California utility customers under the auspices of the California Public Utilities Commission. Reproduction or distribution of the whole or any part of the contents of this document without the express written permission of SCE is prohibited. This work was performed with reasonable care and in accordance with professional standards. However, neither SCE nor any entity performing the work pursuant to SCE's authority make any warranty or representation, expressed or implied, with regard to this report, the merchantability or fitness for a particular purpose of the results of the work, or any analyses, or conclusions contained in this report. The results reflected in the work are generally representative of operating conditions; however, the results in any other situation may vary depending upon particular operating conditions.

EXECUTIVE SUMMARY

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)[1] was utilized to dispatch the test events[2]. The standard Capacity Bidding Program (CBP) bid from each customer site was 200kW for Customers 1 and 2 and 100kW for Customer 3.

Measurement and Verification (M&V) for the dispatch performance was performed utilizing the following three data sources:

- SCE revenue meter data used for billing and other functions.
- Advanced Load Control System (ALCS) data from the installed battery system providing the battery controller's measurement or estimation of site power usage.
- Power Quality (PQ) data from the PQ monitoring equipment was used to provide independent verification and insight into event responses and data for PQ analysis.

Three dispatch instructions were utilized to initiate demand response test events utilizing OpenADR 2.0 communication protocol. The following signals were dispatched from SCE's Demand Response Automation Server (DRAS) to the manufacturer's server that served as an interface to initiate DR at the three test sites:

- High: Turn off Battery charging
- Medium: Battery Discharge
- Low: Start Battery charging

A total of 13 DR events were called to test the scenarios listed above. 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 what might be 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. Test event alignment with expectations are summarized in Table 2 and a description of the colored icons, as well as the percentage performance information, is included in Table 1.

[1] SCE Capacity Bidding Program - https://www.sce.com/wps/wcm/connect/06f06444-92dd-4ca4-a32d-2454f09fb321/SCE_Capacity+Bidding+Program_NR-2232-V1-0513.pdf?MOD=AJPERES.

[2] Some teste events were run outside of standard CBP hours (11am-7pm) through the Experimental Schedule UCLT: Utility-Controlled Load Tests - https://www.sce.com/NR/sc3/tm2/pdf/ce60-12.pdf

TABLE 1. 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.

TABLE 2. BATTERY DEMAND RESPONSE OBSERVATION SUMMARY

Event Start Time	Event Type	Customer 1				Customer 2				Customer 3			
		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	green	516%	green	-	yellow	109%	yellow (green outline)	yellow	-		-	-
4/12/16 14:00	Discharge	green	703%	green	-	yellow	75%	green	green	green	266%	green	green
4/19/16 22:00	Turn Off Charging	yellow (green outline)	540%	yellow (green outline)	-	green	119%	yellow (green outline)	yellow (green outline)	green	106%	yellow (green outline)	-
4/22/16 14:00	Discharge	green	1225%	green	-	yellow	224%	red	yellow (green outline)	green	324%	green	green
4/29/16 22:00	Turn Off Charging	yellow (green outline)	1740%	yellow (green outline)	-	yellow (green outline)	8%	yellow (green outline)	yellow (green outline)	yellow	244%	red	yellow
5/2/16 14:00	Discharge	green	450%	green	-	green	91%	green	green	green	313%	green	green
5/6/16 3:00	Start Charging	green	529%	green	-	green	83%	green	green	green	64%	green	green
5/10/16 22:00	Turn Off Charging	green	643%	yellow	-	yellow (green outline)	77%	yellow (green outline)	-	yellow (green outline)	189%	yellow (green outline)	yellow (green outline)
5/13/16 14:00	Discharge	green	1193%	green	-	green	117%	green	green	green	249%	green	green
5/17/16 3:00	Start Charging	yellow	-404%	yellow	-	yellow	-147%	yellow	yellow	red	45%	red	red
5/20/16 3:00	Start Charging	green	215%	green	-	yellow	54%	yellow (green outline)	yellow (green outline)	green	78%	green	green
5/24/16 3:00	Start Charging	green	97%	green	-	green	48%	green	green	green	70%	green	green
6/8/16 3:00	Start Charging	yellow	69%	yellow (green outline)	-	red	69%	red	yellow (green outline)	red	-81%	red	red

[3] For purposes of this project the 10-in-10 baseline is equivalent to the CBP Energy Baseline used for performance calculation and settlement with the customers participating in this project.

[4] Because of the configuration of how the Customer 1 PQ device was monitoring the battery and facility load, the device was monitoring the net result of a portion of the facility load and the battery output. As such, we have omitted categorization of the performance from this table. Results are presented in the RESULTS section of this report

Demand response is the perceived change in electricity demand or usage both upon dispatch of a DR resource and again upon termination of the DR event. This project found that perceiving a change in demand or usage was complicated because:

- Turn-off charging dispatches were issued when charging was not taking place.
- Turn-off charging dispatches were issued while discharging was taking place (and discharging continued during the turn-off charging test event).
- Start-charging events were dispatched when charging was already taking place.
- Discharge events were dispatched when discharging was already taking place.
- The requested dispatch initiating earlier and/or being terminated later than scheduled or dispatched.

These instances all resulted in the perceived electricity usage or demand not changing as anticipated.

Another complicating factor is that the test event day usage often varied from the baseline usage range (maximum to minimum) and pattern or shape. This may be due to the standard battery ALCS program (likely optimized to minimize energy (kWh) usage and demand (kW)) was manually overridden on test event days. Three different baselines were utilized to measure DR event performance[5]. Therefore, significant variation from the historical baseline prior to or subsequent to the test event results in an inaccurate quantification of performance.

Therefore, the two biggest barriers to integrating battery energy storage as a dispatchable distributed energy resource are:

- The perceived inconsistent performance based on current DR measurement and valuation baseline techniques; and
- The ability to perceive a change in usage or demand with the utility meter at the initiation and termination of a DR test event.

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 that 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 quantity[6]. 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.

In addition to DR performance, over three months of PQ data was collected from the battery storage systems in order to analyze voltage flicker and harmonic voltage distortion. This analysis found that the Perceptible Voltage Flicker (Pst) as a 10-minute measure of the steadiness of the system voltage conforms to IEEE Standard 1453 with the system

[5] Reference Section **Analysis Overview and 10-In-10 Baseline Methodology**

[6] CBP typically utilizes the high medium and low dispatch signals to dispatch different levels of customer elected capacity (kW). For this project, aligning high medium and low dispatch signals with turn off battery charging, battery discharge and start battery charging did not yield consistent 200 kW delivery performance

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%. Voltage and current waveform captures were also examined during various states of the battery energy storage system. No anomalies were found during the various operating modes of idle, charging, or discharging.

ABBREVIATIONS AND ACRONYMS

Battery ALCS	Battery Automatic Load Control System providing the battery control interface and battery meter data
Baseline	Calculated estimate for what the usage would have been in the absence of a DR test event. Methodologies include 10-in-10, ± 20% from baseline and Linearly Adjusted (LA) 10-in-10.
CAISO	California Independent System Operator – manages day-ahead and real-time wholesale energy market in California
CBP	SCE Capacity Bidding Program (CBP): https://www.sce.com/NR/sc3/tm2/pdf/ce293.pdf
CPP	Critical Peak Pricing
DER	Distributed Energy Resource
DR	Demand Response
EB	10-in-10 Energy Baseline (EB) specified by CBP. For purposes of this project the 10-in-10 baseline is equivalent to the CBP EB.
ESDER	Energy Storage and Distributed Energy Resources
HGO3	3rd Harmonic Volts
HGO5	5th Harmonic Volts
HGO7	7th Harmonic Volts
IRMS	Current Root Mean Square
kWh	Kilowatt Hour
kW	Kilowatt
LCR	Local Capacity Resource
LSE	Load Serving Entity

M&V	Measurement and Valuation
MWh	Megawatt Hour
MW	Megawatt
NEM	Net Energy Metering
NGR	Non-Generation Resource
Pst	Perceptible Voltage Flicker (Pst) is a measure of the variations in the line voltage, and is a common power quality characteristic that is monitored at steel and metal working facilities.
PQ	Power Quality
REGF	Renewable Electric Generating Facility
SCE	Southern California Edison
TOU	Time-of-Use Pricing
VRMS	Voltage Root Mean Square
VTHD	Voltage Total Harmonic Distortion - The summation of all harmonic components of the voltage or current waveform compared against the fundamental component of the voltage or current wave.

CONTENTS

EXECUTIVE SUMMARY _____ I

ABBREVIATIONS AND ACRONYMS _____ VI

INTRODUCTION _____ 1

BACKGROUND _____ 2

PROJECT OBJECTIVES _____ 4

TECHNOLOGY/PRODUCT EVALUATION _____ 5

PQ Instrumentation, Measurements and Analysis 6

ANALYSIS: DEMAND RESPONSE AND POWER QUALITY _____ 9

Analysis Overview and 10-In-10 Baseline Methodology 9

SCE Meter Baseline Analysis 10

Battery ALCS Baseline Analysis 11

RESULTS _____ 12

Customer 1: Demand Response Observations and Power Quality Results 12

Test Event 1: Tuesday April 5, 22:00-23:00 PDT – Turn Off Charging 12

Test Event 2: Tuesday April 12, 14:00-15:00 PDT – Discharge 18

Test Event 3: Tuesday April 19, 22:00-23:00 PDT – Turn Off Charging 24

Test Event 4: Friday April 22 14:00-15:00 PDT – Discharge 30

Test Event 5: Friday April 29, 22:00-23:00 PDT – Turn Off Charging 36

Test Event 6: Monday May 2, 14:00-15:00 PDT –Discharge 42

Test Event 7: Friday May 6, 3:00-4:00 PDT – Start Charging 49

Test Event 8: Tuesday May 10, 22:00-23:00 PDT – Turn Off Charging 55

Test Event 9: Friday May 13, 14:00-15:00 PDT – Discharge 61

Test Event 10: Tuesday May 17, 3:00-4:00 PDT – Start Charging 67

Test Event 11: Friday May 20, 3:00-4:00 PDT – Start Charging 74

Test Event 12: Tuesday May 24, 3:00-4:00 PDT – Start Charging 81

Event 13: Wednesday June 8, 3:00 -4:00 PDT – Start Charging 87
Power Quality Evaluation 94
Customer 2 Demand Response Observations and Power Quality Results 102
Test Event 1: Tuesday April 5, 22:00-23:00 PDT – Turn Off Charging 102
Test Event 2: Tuesday April 12, 14:00-15:00 PDT – Discharge 108
Test Event 3: Tuesday April 19, 22:00-23:00 PDT – Turn Off Charging 114
Test Event 4: Friday April 22 14:00-15:00 PDT – Discharge 121
Test Event 5: Friday April 29, 22:00-23:00 PDT – Turn Off Charging 127
Test Event 6: Monday May 2, 14:00-15:00 PDT –Discharge 134
Test Event 7: Friday May 6, 3:00-4:00 PDT – Start Charging 139
Test Event 8: Tuesday May 10, 22:00-23:00 PDT – Turn Off Charging 146
Test Event 9: Friday May 13, 14:00-15:00 PDT – Discharge 152
Test Event 10: Tuesday May 17, 3:00-4:00 PDT – Start Charging 158
Test Event 11: Friday May 20, 3:00-4:00 PDT – Start Charging 165
Test Event 12: Tuesday May 24, 3:00-4:00 PDT – Start Charging 172
Test Event 13: Wednesday June 8, 3:00 -4:00 PDT – Start Charging 178
Customer 2 Power Quality Evaluation 184
Customer 3 Demand Response Observations and Power Quality Results 196
Test Event 1: Tuesday April 5, 22:00-23:00 PDT – Turn Off Charging 196
Test Event 2: Tuesday April 12, 14:00-15:00 PDT – Discharge 196
Test Event 3: Tuesday April 19, 22:00-23:00 PDT – Turn Off Charging 202
Test Event 4: Friday April 22 14:00-15:00 PDT - Discharge 207
Test Event 5: Friday April 29, 22:00-23:00 PDT – Turn Off Charging 213
Test Event 6: Monday May 2, 14:00-15:00 PDT – Discharge 220
Test Event 7: Friday May 6, 3:00-4:00 PDT – Start Charging 226
Test Event 8: Tuesday May 10, 22:00-23:00 PDT – Turn Off Charging 233

Test Event 9: Friday May 13, 14:00-15:00 PDT – Discharge 240
Test Event 10: Tuesday May 17, 3:00-4:00 PDT – Start Charging 246
Test Event 11: Friday May 20, 3:00-4:00 PDT – Start Charging 252
Test Event 12: Tuesday May 24, 3:00-4:00 PDT – Start Charging 258
Test Event 13: Wednesday June 8, 3:00 -4:00 PDT – Start Charging 263
Customer 3 Power Quality Evaluation 270

DISCUSSION ____ 280
Confounding Factors to Analysis 283
Quantifying Performance 283
CAISO Wholesale Energy Market Integration 285
Inconsistency Across Metering 286

CONCLUSIONS ____ 291
Dispatch Signals 291
Deviation from typical usage 291
Power Quality 291

RECOMMENDATIONS ____ 293

APPENDIX 294
A. Linearly Adjusted 10-in-10 Computations 294
B. Temperature as a performance variable 294
C. PQ Meter Configuration 307
Customer 1 PQ Configuration 307
Customer 2 PQ Configuration 310
Customer 3 PQ Configuration 312

FIGURES

Figure 1. Customer 2 PQ Monitoring Installation 7
Figure 2. Customer 3 Current Probes 8
Figure 3. Customer 3 PQ Monitoring Installation 8
Figure 4. April 5 23:00-24:00 Customer 1 Turn Off Charging – SCE Meter Data 13
Figure 5. April 5 23:00-24:00 Customer 1 Turn Off Charging – DR Baseline Estimates 14
Figure 6. April 5 23:00-24:00 Customer 1 Turn Off Charging – Battery ALCS Net Meter Data 16
Figure 7. April 5 23:00-24:00 Customer 1 Turn Off Charging – Battery ALCS Import/Export Meter Data 17
Figure 8. April 5 22:00-24:00 Customer 1 Turn Off Charging – PQ Meter Data 18
Figure 9. April 12 14:00-15:00 Customer 1 Discharge – SCE Meter Data 19
Figure 10. April 12 14:00-15:00 Customer 1 Discharge – DR Baseline Estimates 20
Figure 11. April 12 14:00-15:00 Customer 1 Discharge – Battery ALCS Net Meter Data 22
Figure 12. April 12 14:00-15:00 Customer 1 Discharge – Battery ALCS Import/Export Meter Data 23
Figure 13. April 19 22:00-23:00 Customer 1 Turn Off Charging – SCE Meter Data ..25
Figure 14. April 19 22:00-23:00 Customer 1 Turn Off Charging – DR Baseline Estimates 26
Figure 15. April 19 22:00-23:00 Customer 1 Turn Off Charging – Battery ALCS Net Meter Data 28
Figure 16. April 19 22:00-23:00 Customer 1 Turn Off Charging – Battery ALCS Import/Export Meter Data 29
Figure 17. April 19 22:00-23:00 Customer 1 Turn Off Charging – PQ Meter Data....30
Figure 18. April 22 14:00-15:00 Customer 1 Discharge – SCE Meter Data 31
Figure 19. April 22 14:00-15:00 Customer 1 Discharge – DR Baseline Estimates 32
Figure 20. April 22 14:00-15:00 Customer 1 Discharge – Battery ALCS Net Meter Data 34
Figure 21. April 22 14:00-15:00 Customer 1 Discharge – Battery ALCS Import/Export Meter Data 35
Figure 22. April 22 14:00-15:00 Customer 1 Discharge – PQ Meter Data 36
Figure 23. April 29 22:00-23:00 Customer 1 Turn Off Charging – SCE Meter Data ..37
Figure 24. April 29 22:00-23:00 Customer 1 Turn Off Charging – DR Baseline Estimates 38
Figure 25. April 29 22:00-23:00 Customer 1 Turn Off Charging – Battery ALCS Net Meter Data 40
Figure 26. April 29 22:00-23:00 Customer 1 Turn Off Charging – Battery ALCS Import/Export Meter Data 41

Figure 27. April 29 22:00-23:00 Customer 1 Turn Off Charging –PQ Meter Data.....42
Figure 28. May 2 14:00-15:00 Customer 1 Discharge – SCE Meter Data 43
Figure 29. May 2 14:00-15:00 Customer 1 Discharge – DR Baseline Estimates 44
Figure 30. May 2 14:00-15:00 Customer 1 Discharge – Battery ALCS Net Meter Data 46
Figure 31. May 2 14:00-15:00 Customer 1 Discharge – Battery ALCS Import/Export Meter Data 47
Figure 32. May 2 14:00-15:00 Customer 1 Discharge–PQ Meter Data 48
Figure 33. May 6 03:00-04:00 Customer 1 Start Charging – SCE Meter Data 50
Figure 34. May 6 03:00-04:00 Customer 1 Start Charging – DR Baseline Estimates 51
Figure 35. May 6 03:00-04:00 Customer 1 Start Charging – Battery ALCS Net Meter Data 53
Figure 36 May 6 03:00-04:00 Customer 1 Start Charging – Battery ALCS Import/Export Meter Data 54
Figure 37. May 6 3:00-4:00 Customer 1 Start Charging –PQ Meter Data 55
Figure 38. May 10 22:00-23:00 Customer 1 Turn Off Charging – SCE Meter Data...56
Figure 39. May 10 22:00-23:00 Customer 1 Turn Off Charging – DR Baseline Estimates 57
Figure 40. May 10 22:00-23:00 Customer 1 Turn Off Charging – Battery ALCS Net Meter Data 59
Figure 41. May 10 22:00-23:00 Customer 1 Turn Off Charging – Battery ALCS Import / Export Meter Data..60
Figure 42. May 10 22:00-23:00 Customer 1 Turn Off Charging–PQ Meter Data 61
Figure 43. May 13 14:00-15:00 Customer 1 Discharge – SCE Meter Data.............62
Figure 44. May 13 14:00-15:00 Customer 1 Discharge – DR Baseline Estimates.....63
Figure 45. May 13 14:00-15:00 Customer 1 Discharge– Battery ALCS Net Meter Data 65
Figure 46. May 13 14:00-15:00 Customer 1 Discharge –Battery ALCS Import / Export Data 66
Figure 47. May 13 14:00-15:00 Customer 1 Discharge–PQ Meter Data 67
Figure 48. May 17 03:00-04:00 Customer 1 Start Charging – SCE Meter Data 68
Figure 49. May 17 03:00-04:00 Customer 1 Start Charging – DR Baseline Estimates 69
Figure 50. May 17 3:00-4:00 Customer 1 Start Charging – Battery ALCS Net Meter Data 71
Figure 51. May 17 3:00-4:00 Customer 1 Start Charging – Battery ALCS Import / Export Data 72
Figure 52. May 17 3:00-4:00 Customer 1 Start Charging –PQ Meter Data 73
Figure 53. May 20 03:00-04:00 Customer 1 Start Charging – SCE Meter Data 75

Figure 54. May 20 03:00-04:00 Customer 1 Start Charging – DR Baseline Estimates 76
Figure 55. May 20 3:00-4:00 Customer 1 Start Charging – Battery ALCS Net Meter Data 78
Figure 56. May 20 3:00-4:00 Customer 1 Start Charging – Battery ALCS Import / Export Data 79
Figure 57. May 20 3:00-4:00 Customer 1 Start Charging –PQ Meter Data 80
Figure 58. May 24 03:00-04:00 Customer 1 Start Charging – SCE Meter Data 82
Figure 59. May 24 03:00-04:00 Customer 1 Start Charging – DR Baseline Estimates 83
Figure 60. May 24 3:00-4:00 Customer 1 Start Charging – Battery ALCS Net Meter Data 85
Figure 61. May 24 3:00-4:00 Customer 1 Start Charging – Battery ALCS Import / Export Data 86
Figure 62. May 24 3:00-4:00 Customer 1 Start Charging –PQ Meter Data 87
Figure 63. June 8 3:00-4:00 Customer 1 Start Charging – SCE Meter Data 88
Figure 64. June 8 3:00-4:00Customer 1 Start Charging – DR Baseline Estimates 89
Figure 65. June 8 3:00-4:00 Customer 1 Start Charging – Battery ALCS Net Meter Data 91
Figure 66. 3:00-4:00 Customer 1 Start Charging – Battery ALCS Import / Export Meter Data 92
Figure 67. June 8 3:00-4:00 Customer 1 Start Charging –PQ Meter Data 93
Figure 68. Voltage (Vrms), Current (Irms), Power (kW), and Reactive Power (kVAR) 95
Figure 69. Voltage (Vrms), Power (kW), and Perceptible Voltage Flicker (Pst) 96
Figure 70. Power (kW), Harmonic Distortion (VThd), K-Factor Distortion (KFact) 96
Figure 71. Power (kW), Harmonic Distortion (VThd), 3rd Harmonic Volts (HG03), 5th Harmonic Volts (HG05), 7th Harmonic Volts (HG07) 97
Figure 72. Power (kW), Harmonic Distortion (VThd), 23rd Harmonic Volts (HG23), 25th Harmonic Volts (HG25), 35th Harmonic Volts (HG35) 97
Figure 73. Voltage (Vrms), Current (Irms), Power (kW), and Reactive Power (kVAR) 98
Figure 74. Voltage (Vrms), Power (kW), and Perceptible Voltage Flicker (Pst) 99
Figure 75. Power (kW), Harmonic Distortion (VThd), K-Factor Distortion (K-Fact) 100
Figure 76. Power (kW), Harmonic Distortion (VThd), 3rd Harmonic Volts (HG03), 5th Harmonic Volts (HG05), 7th Harmonic Volts (HG07) 100
Figure 77. Power (kW), Harmonic Distortion (VThd), 23rd Harmonic Volts (HG23), 25th Harmonic Volts (HG25), 35th Harmonic Volts (HG35) 101
Figure 78. April 5 22:00-23:00 Customer 2 Turn Off Charging – SCE Meter Data 103
Figure 79. April 5 22:00-23:00 Customer 2 Turn Off Charging – DR Baseline Estimates 104

Figure 80. April 5 22:00-23:00 Customer 2 Turn Off Charging – Battery ALCS Net Meter Data ... 105
Figure 81. April 5 22:00-23:00 Customer 2 Turn Off Charging – Battery ALCS Import/Export Meter Data ... 106
Figure 82. April 5 22:00-23:00 Customer 2 Turn Off Charging – PQ Meter Data ... 107
Figure 83. April 12 14:00-15:00 Customer 2 Discharge – SCE Meter Data ... 109
Figure 84. April 12 14:00-15:00 Customer 2 Discharge – DR Baseline Estimates ... 110
Figure 85. April 12 14:00-15:00 Customer 2 Discharge – Battery ALCS Net Meter Data ... 112
Figure 86. April 12 14:00-15:00 Customer 2 Discharge – Battery ALCS Import/Export Meter Data ... 113
Figure 87. April 12 14:00-15:00 Customer 2 Discharge – PQ Meter Data ... 114
Figure 88. April 19 22:00-23:00 Customer 2 Turn Off Charging – SCE Meter Data 115
Figure 89. April 19 22:00-23:00 Customer 2 Turn Off Charging – DR Baseline Estimates ... 116
Figure 90. April 19 22:00-23:00 Customer 2 Turn Off Charging – Battery ALCS Net Meter Data ... 118
Figure 91. April 19 22:00-23:00 Customer 2 Turn Off Charging – Battery ALCS Import/Export Meter Data ... 119
Figure 92. April 19 22:00-23:00 Customer 2 Turn Off Charging – PQ Meter Data ... 120
Figure 93. April 22 14:00-15:00 Customer 2 Discharge – SCE Meter Data ... 122
Figure 94. April 22 14:00-15:00 Customer 2 Discharge – DR Baseline Estimates ... 123
Figure 95. April 22 14:00-15:00 Customer 2 Discharge – Battery ALCS Net Meter Data ... 125
Figure 96. April 22 14:00-15:00 Customer 2 Discharge – Battery ALCS Import/Export Meter Data ... 126
Figure 97. April 22 14:00-15:00 Customer 2 Discharge – PQ Meter Data ... 127
Figure 98. April 29 22:00-23:00 Customer 2 Turn Off Charging – SCE Meter Data 128
Figure 99. April 29 22:00-23:00 Customer 2 Turn Off Charging – DR Baseline Estimates ... 129
Figure 100. April 29 22:00-23:00 Customer 2 Turn Off Charging – Battery ALCS Net Meter Data ... 131
Figure 101. April 29 22:00-23:00 Customer 2 Turn Off Charging – Battery ALCS Import/Export Meter Data ... 132
Figure 102. April 29 22:00-23:00 Customer 2 Turn Off Charging –PQ Meter Data ... 133
Figure 103. May 2 14:00-15:00 Customer 2 Discharge – SCE Meter Data ... 135
Figure 104. May 2 14:00-15:00 Customer 2 Discharge – DR Baseline Estimates ... 136
Figure 105. May 2 14:00-15:00 Customer 2 Discharge – Battery ALCS Net Meter Data ... 137
Figure 106. May 2 14:00-15:00 Customer 2 Discharge – Battery ALCS Import/Export Meter Data ... 138

Figure 107. May 2 14:00-15:00 Customer 2 Discharge–PQ Meter Data 139
Figure 108. May 6 03:00-04:00 Customer 2 Start Charging – SCE Meter Data 140
Figure 109. May 6 03:00-04:00 Customer 2 Start Charging – DR Baseline Estimates 141
Figure 110. May 6 03:00-04:00 Customer 2 Start Charging – Battery ALCS Net Meter Data 143
Figure 111. May 6 03:00-04:00 Customer 2 Start Charging – Battery ALCS Import/Export Meter Data 144
Figure 112. Friday May 6, 3:00-4:00 PDT – Start Charging– PQ Meter Data......... 145
Figure 113. May 10 22:00-23:00 Customer 2 Turn Off Charging – SCE Meter Data 147
Figure 114. May 10 22:00-23:00 Customer 2 Turn Off Charging – DR Baseline Estimates 148
Figure 115. May 10 22:00-23:00 Customer 2 Turn Off Charging – Battery ALCS Net Meter Data 150
Figure 116. May 10 22:00-23:00 Customer 2 Turn Off Charging – Battery ALCS Import/Export Meter Data 151
Figure 117. May 13 14:00-15:00 Customer 2 Discharge – SCE Meter Data 153
Figure 118. May 13 14:00-15:00 Customer 2 Discharge – DR Baseline Estimates . 154
Figure 119. May 13 14:00-15:00 Customer 2 Discharge– Battery ALCS Net Meter Data 155
Figure 120. May 13 14:00-15:00 Customer 2 Discharge– Battery ALCS Import/Export Meter Data 156
Figure 121. May 13 14:00 -15:00Customer 2 Discharge–PQ Meter Data............. 157
Figure 122. May 17 03:00-04:00 Customer 2 Start Charging – SCE Meter Data ... 159
Figure 123. May 17 03:00-04:00 Customer 2 Start Charging – DR Baseline Estimates 160
Figure 124. May 17 3:00-4:00 Customer 2 Start Charging – Battery ALCS Net Meter Data 162
Figure 125. May 17 3:00-4:00 Customer 2 Start Charging – Battery ALCS Import/Export Meter Data 163
Figure 126. May 17 3:00-4:00 Customer 2 Start Charging–PQ Meter Data........... 164
Figure 127. May 20 03:00-04:00 Customer 2 Start Charging – SCE Meter Data ... 166
Figure 128. May 20 03:00-04:00 Customer 2 Start Charging – DR Baseline Estimates 167
Figure 129. May 20 3:00-4:00 Customer 2 Start Charging – Battery ALCS Net Meter Data 169
Figure 130. May 20 3:00-4:00 Customer 2 Start Charging – Battery ALCS Import/Export Meter Data 170
Figure 131. May 20 3:00-4:00 Customer 2 Start Charging–PQ Meter Data........... 171
Figure 132. May 24 03:00-04:00 Customer 2 Start Charging – SCE Meter Data ... 173

Figure 133. May 24 03:00-04:00 Customer 2 Start Charging – DR Baseline Estimates 174
Figure 134. May 24 3:00-4:00 Customer 2 Start Charging – Battery ALCS Net Meter Data 176
Figure 135. May 24 3:00-4:00 Customer 2 Start Charging – Battery ALCS Net Meter Data 177
Figure 136. May 24 3:00-4:00 Customer 2 Start Charging–PQ Meter Data........ 178
Figure 137. June 8 03:00-04:00 Customer 2 Start Charging – SCE Meter Data 179
Figure 138. June 8 03:00-04:00 Customer 2 Start Charging – DR Baseline Estimates 180
Figure 139. June 8 3:00-4:00 Customer 2 Start Charging – Battery ALCS Net Meter Data 181
Figure 140. June 8 3:00-4:00 Customer 2 Start Charging – Battery ALCS Net Meter Data 182
Figure 141. June 8 3:00-4:00 Customer 2 Start Charging–PQ Meter Data........ 183
Figure 142. Voltage (Vrms), Current (Irms), Power (kW), and Reactive Power (kVAR)........ 186
Figure 143. Voltage (Vrms), Power (kW), and Perceptible Voltage Flicker (Pst)........ 186
Figure 144. Power (kW) and Harmonic Distortion (VThd) 187
Figure 145. Power (kW), Harmonic Distortion (VThd), 3rd Harmonic Volts (HG03), 5th Harmonic Volts (HG05), and 7th Harmonic Volts (HG07) 188
Figure 146. Power (kW), Harmonic Distortion (VThd), 23rd Harmonic Volts (HG23), 25th Harmonic Volts (HG25), and 35th Harmonic Volts (HG35) 188
Figure 147. Voltage and Current Waveforms with Phasor Diagram (Battery Off) 190
Figure 148. Harmonic Spectral Analysis (Battery Off) 191
Figure 149. Voltage and Current Waveforms with Phasor Diagram (Battery Charging)........ 192
Figure 150. Harmonic Spectral Analysis (Battery Charging) 193
Figure 151. Voltage and Current Wavforms with Phasor Diagram (Full Discharge) 194
Figure 152. Harmonic Spectral Analysis (Full Discharge) 195
Figure 153. April 12 14:00-15:00 Customer 3 Discharge – SCE Meter Data 197
Figure 154. April 12 14:00-15:00 Customer 3 Discharge – DR Baseline Estimates 198
Figure 155. April 12 14:00-15:00 Customer 3 Discharge – Battery ALCS Net Meter Data 200
Figure 156. April 12 14:00-15:00 Customer 3 Discharge – Battery ALCS Import/Export Meter Data 201
Figure 157. April 12 14:00-15:00 Customer 3 Discharge – PQ Meter Data 202
Figure 158. April 19 22:00-23:00 Customer 3 Turn Off Charging – SCE Meter Data........ 203
Figure 159. April 19 22:00-23:00 Customer 3 Turn Off Charging – DR Baseline Estimates 204

Figure 160. April 19 22:00-23:00 Customer 3 Turn Off Charging – Battery ALCS Net Meter Data 205
Figure 161. April 19 22:00-23:00 Customer 3 Turn Off Charging – Battery ALCS Import/Export Meter Data 206
Figure 162. April 22 14:00-15:00 Customer 3 Discharge – SCE Meter Data 208
Figure 163. April 22 14:00-15:00 Customer 3 Discharge – DR Baseline Estimates 209
Figure 164. April 22 14:00-15:00 Customer 3 Discharge – Battery ALCS Net Meter Data 210
Figure 165. April 22 14:00-15:00 Customer 3 Discharge – Battery ALCS Import/Export Meter Data 211
Figure 166. April 22 14:00-15:00 Customer 3 Discharge–PQ Meter Data 212
Figure 167. April 29 22:00-23:00 Customer 3 Turn Off Charging– SCE Meter Data214
Figure 168. April 29 22:00-23:00 Customer 3 Turn Off Charging- DR Baseline Estimates 215
Figure 169. April 29 22:00-23:00 Customer 3 Turn Off Charging– Battery ALCS Net Meter Data 217
Figure 170. April 29 22:00-23:00 Customer 3 Turn Off Charging– Battery ALCS Export Meter Data 218
Figure 171. April 29 22:00-23:00 Customer 3 urn Off Charging–PQ Meter Data.... 219
Figure 172. May 2 14:00-15:00 Customer 3 Discharge – SCE Meter Data 221
Figure 173. May 2 14:00-15:00 Customer 3 Discharge – DR Baseline Estimates... 222
Figure 174. May 2 14:00-15:00 Customer 3 Discharge – Battery ALCS Net Meter Data 223
Figure 175. May 2 14:00-15:00 Customer 3 Discharge – Battery ALCS Import/Export Meter Data 224
Figure 176. May 2 14:00-15:00 Customer 3 Discharge–PQ Meter Data 225
Figure 177. May 6 03:00-04:00 Customer 3 Start Charging – SCE Meter Data 227
Figure 178. May 6 03:00-04:00 Customer 3 Start Charging – DR Baseline Estimates 228
Figure 179. May 6 03:00-04:00 Customer 3 Start Charging – Battery ALCS Net Meter Data 230
Figure 180. May 6 03:00-04:00 Customer 3 Start Charging – Battery ALCS Import/Export Meter Data 231
Figure 181. May 6 3:00-4:00 Customer 3 Start Charging–PQ Meter Data 232
Figure 182. May 10 22:00-23:00 Customer 3 Turn Off Charging – SCE Meter Data 234
Figure 183. May 10 22:00-23:00 Customer 3 Turn Off Charging – DR Baseline Estimates 235
Figure 184. May 10 22:00-23:00 Customer 3 Turn Off Charging – Battery ALCS Net Meter Data 237
Figure 185. May 10 22:00-23:00 Customer 3 Turn Off Charging – Battery ALCS Import/Export Meter Data 238

Figure 186. May 10 22:00-23:00 Customer 3 Turn Off Charging–PQ Meter Data... 239
Figure 187. May 13 14:00-15:00 Customer 3 Discharge – SCE Meter Data 241
Figure 188. May 13 14:00-15:00 Customer 3 Discharge – DR Baseline Estimates . 242
Figure 189. May 13 14:00-15:00 Customer 3 Discharge – Battery ALCS Net Meter Data 243
Figure 190. May 13 14:00-15:00 Customer 3 Discharge– Battery ALCS Import/Export Meter Data 244
Figure 191. May 13 14:00-15:00 Customer 3 Discharge–PQ Meter Data............. 245
Figure 192. May 17 03:00-04:00 Customer 3 Start Charging – SCE Meter Data ... 247
Figure 193. May 17 03:00-04:00 Customer 3 Start Charging – DR Baseline Estimates 248
Figure 194. May 17 03:00-4:00 Customer 3 Start Charging – Battery ALCS Net Meter Data 250
Figure 195. May 17 3:00-4:00 Customer 3 Start Charging – Battery ALCS Import/Export Meter Data 251
Figure 196. May 17 3:00-4:00 Customer 3 Start Charging–PQ Meter Data........... 252
Figure 197. May 20 03:00-04:00 Customer 3 Start Charging – SCE Meter Data ... 253
Figure 198.. May 20 03:00-04:00 Customer 3 Start Charging – DR Baseline Estimates 254
Figure 199. May 20 03:00-4:00 Customer 3 Start Charging – Battery ALCS Net Meter Data 256
Figure 200. May 20 3:00-4:00 Customer 3 Start Charging – Battery ALCS Import/Export Meter Data 257
Figure 201. May 20 3:00-4:00 Customer 3 Start Charging–PQ Meter Data........... 258
Figure 202. May 24 03:00-04:00 Customer 3 Start Charging – SCE Meter Data ... 259
Figure 203. May 24 03:00-04:00 Customer 3 Start Charging – DR Baseline Estimates 260
Figure 204. May 24 03:00-4:00 Customer 3 Start Charging – Battery ALCS Net Meter Data 261
Figure 205. May 24 3:00-4:00 Customer 3 Start Charging – Battery ALCS Import/Export Meter Data 262
Figure 206. May 24 3:00-4:00 Customer 3 Start Charging–PQ Meter Data........... 263
Figure 207. June 8 03:00-04:00 Customer 3 Start Charging – SCE Meter Data 264
Figure 208. June 8 03:00-04:00 Customer 3 Start Charging – DR Baseline Estimates 265
Figure 209. June 8 03:00-4:00 Customer 3 Start Charging – Battery ALCS Net Meter Data 267
Figure 210. June 8 3:00-4:00 Customer 3 Start Charging – Battery ALCS Import/Export Meter Data 268
Figure 211. June 8 3:00-4:00 Customer 3 Start Charging–PQ Meter Data............ 269
Figure 212. Voltage (Vrms), Current (Irms), Power (kW), and Reactive Power (kVAR) 271

Figure 213. Voltage (Vrms), Power (kW), and Perceptible Voltage Flicker (Pst)..... 272
Figure 214. Power (kW) and Harmonic Distortion (VThd) 272
Figure 215. Power (kW), Harmonic Distortion (VThd), 3rd Harmonic Volts (HG03), 5th Harmonic Volts (HG05), and 7th Harmonic Volts (HG07) 273
Figure 216. Power (kW), Harmonic Distortion (VThd), 23rd Harmonic Volts (HG23), 25th Harmonic Volts (HG25), and 35th Harmonic Volts (HG35) 273
Figure 217. Voltage and Current Waveforms (Battery Off)................................. 274
Figure 218. Harmonic Spectral Analysis (Battery Off) 275
Figure 219. Voltage and Current Waveforms with Phasor Diagram (Battery Charging)... 276
Figure 220. Harmonic Spectral Analysis (Battery Charging) 277
Figure 221. Voltage and Current Waveforms with Phasor Diagram (Full Discharge) 278
Figure 222. Harmonic Spectral Analysis (Full Discharge) 279
Figure 223. Customer 1 Difference Between SCE meter and Battery Submetering on May 2.. 287
Figure 224. Customer 2 Difference Between SCE meter and Battery Submetering on May 2.. 287
Figure 225. Customer 3 Difference Between SCE meter and Battery Submetering 288
Figure 226. Cumulative Customer 1 Difference Between SCE meter and Battery Submetering.. 289
Figure 227. Cumulative Customer 2 Difference Between SCE meter and Battery Submetering.. 289
Figure 228. Cumulative Customer 3 Difference Between SCE meter and Battery Submetering.. 290
Figure 229. Temperature Analysis for April 5 Event Day..................................... 295
Figure 230. Temperature Analysis for April 12 Event Day 296
Figure 231. Temperature Analysis For April 19 Event Day 297
Figure 232. Temperature Analysis for April 22 Event Day 298
Figure 233. Temperature Analysis for April 29 Event Day 299
Figure 234. Temperature Analysis for May 2 Event Day 300
Figure 235. Temperature Analysis for May 6 Event Day 301
Figure 236. Temperature Analysis for May 10 Event Day.................................... 302
Figure 237. Temperature Analysis for May 13 Event Day.................................... 303
Figure 238. Temperature Analysis for May 17 Event Day.................................... 304
Figure 239. Temperature Analysis for May 20 Event Day.................................... 305
Figure 240. Temperature Analysis for May 24 Event Day.................................... 306
Figure 241. Temperature Analysis for June 8 Event Day..................................... 307

TABLES

Table 1. Demand Response Observation Summary Legend ii
Table 2. Battery Demand Response Observation Summary iii
Table 3. Test Event Dispatch Summary 5
Table 4. April 5 22:00-23:00 Customer 1 Turn Off Charging – Performance of Event 15
Table 5. April 12 14:00-15:00 Customer 1 Discharge – Performance of Event 21
Table 6. April 19 22:00-23:00 Customer 1 Turn Off Charging – Performance of Event 27
Table 7. April 22 14:00-15:00 Customer 1 Discharge – Performance of Event 33
Table 8. April 29 22:00-23:00 Customer 1 Turn Off Charging – Performance of Event 39
Table 9. May 2 14:00-15:00 Customer 1 Discharge – Performance of Event 45
Table 10. May 6 3:00-4:00 Customer 1 Start Charging – Performance of Event 52
Table 11. May 10 22:00-23:00 Customer 1 Turn Off Charging – Performance of Event 58
Table 12. May 13 14:00-15:00 Customer 1 Discharge – Performance of Event 64
Table 13. May 17 3:00-4:00 Customer 1 Start Charging – Performance of Event 70
Table 14. May 20 3:00-4:00 Customer 1 Start Charging – Performance of Event 77
Table 15. May 24 3:00-4:00 Customer 1 Start Charging – Performance of Event 84
Table 16. June 8 3:00-4:00 Customer 1 Start Charging – Performance of Event 90
Table 17. April 5 22:00-23:00 Customer 2 Turn Off Charging – Performance of Event 104
Table 18. April 12 14:00-15:00 Customer 2 Discharge – Performance of Event 111
Table 19. April 19 22:00-23:00 Customer 2 Turn Off Charging – Performance of Event 117
Table 20. April 22 14:00-15:00 Customer 2 Discharge – Performance of Event 124
Table 21. April 29 22:00-23:00 Customer 2 Turn Off Charging – Performance of Event 130
Table 22. May 2 14:00-15:00 Customer 2 Discharge – Performance of Event 136
Table 23. May 6 3:00-4:00 Customer 2 Start Charging – Performance of Event 142
Table 24. May 10 22:00-23:00 Customer 2 Turn Off Charging – Performance of Event 149
Table 25. May 13 14:00-15:00 Customer 2 Discharge – Performance of Event 154
Table 26. May 17 3:00-4:00 Customer 2 Start Charging – Performance of Event 161
Table 27. May 20 3:00-4:00 Customer 2 Start Charging – Performance of Event 168
Table 28. May 24 3:00-4:00 Customer 2 Start Charging – Performance of Event 175
Table 29. June 8 3:00-4:00 Customer 2 Start Charging – Performance of Event 180

Table 30. April 12 14:00-15:00 Customer 3 Discharge – Performance of Event 199
Table 31. April 19 22:00-23:00 Customer 3 Turn Off Charging – Performance of Event 204
Table 32. April 22 14:00-15:00 Customer 3 Discharge– Performance of Event 209
Table 33. April 29 22:00-23:00 Customer 3 Turn Off Charging – Performance of Event 216
Table 34. May 2 14:00-15:00 Customer 3 Discharge– Performance of Event........ 222
Table 35. May 6 3:00-4:00 Customer 3 Start Charging – Performance of Event.... 229
Table 36. May 10 22:00-23:00 Customer 3 Turn Off Charging– Performance of Event 236
Table 37. May 13 14:00-15:00 Customer 3 Discharge– Performance of Event 242
Table 38. May 17 3:00-4:00 Customer 3 Start Charging – Performance of Event .. 249
Table 39. May 20 3:00-4:00 Customer 3 Start Charging – Performance of Event .. 255
Table 40. May 24 3:00-4:00 Customer 3 Start Charging – Performance of Event .. 260
Table 41. June 8 3:00-4:00 Customer 3 Start Charging – Performance of Event ... 266
Table 42. Demand Response Observation Summary Legend 281
Table 43 Battery Demand Response Observation Summary 282
Table 44. Facility Temperature Correlation 294

EQUATIONS

Equation 1. Load Point Adjustment 294
Equation 2. Linear Adjustment 294

INTRODUCTION

Demand response (DR) has traditionally been used as a tool by the energy industry to ensure system stability and reliability. However, DR has evolved into demand limiting strategies that customers can utilize to minimize their consumption to limit demand charges and/or in response to time-of-use (TOU) rates (including critical peak pricing (CPP) or peak time rebate (PTR)). Additionally, DR is starting to become integrated into the CAISO wholesale electric power market. This transition may gain further momentum now that the Supreme Court has upheld FERC order 745[7] related to DR compensation in wholesale energy markets. Ideally, integration of DR into wholesale electricity markets will start to evolve electricity into a true commodity market where demand can respond to supply (generation) pricing or delivery constraints.

Many areas of the country are now utilizing DR programs to interact with customers to request demand reduction during specific days that are anticipated to be peak days of the year or to reduce demand when generation supply costs are expensive or there are infrastructure or capacity issues in the distribution system that can affect delivery reliability.

Dispatchable battery storage devices possess a unique ability as a grid resource to both import and export electricity throughout the day while participating in demand response programs. This ability, combined with the distributed location at customer sites, creates the potential for these grid resources to provide support at precise locations and times that provide the greatest value for system stability and reliability. CAISO has initiated several initiatives including Non-Generation Resource (NGR) and Energy Storage and Distributed Energy Resources (ESDER) to take advantage of distributed storage resources[8].

The demand response resources utilized in this project are large stationary battery energy storage devices performing a variety of simultaneous functions, including those mentioned above. These resources respond to various price signals, building usage data, and load curtailment algorithms in addition to dispatch signals from Southern California Edison (SCE).

[7] FERC, Order 745, March 2011; http://www.ferc.gov/EventCalendar/Files/20110315105757-RM10-17-000.pdf

[8] California ISO, Storage technologies provide flexible resources in the market: https://www.caiso.com/participate/Pages/Storage/Default.aspx

BACKGROUND

Battery energy storage is an emerging technology as a distributed energy resource (DER). The U.S. deployed 221 (Megawatts) MW of Energy Storage in 2015 which was an increase of 243% over 2014[9]. 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 levelize consumer electricity demand. The ability to both absorb excess energy and discharge as needed make batteries a key component in the evolving ecosystem of DER. Other than pumped hydroelectric energy storage at hydroelectric plants, the concept of megawatt scale distributed energy storage is new.

While the 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. For example, there are AC to DC and DC to AC conversion loss factors such that the battery output is less than the battery input. However, 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.

The state of California is continuing policy goals to integrate energy storage into the portfolio of energy resources being utilized. For example, the Local Capacity Resource (LCR) Request for Offer (RFO)[10] includes provisions for procuring multiple types of resources within the framework detailed in CPUC Decision 13-02-015 on February 13, 2013, authorizing Long-Term Procurement for Local Capacity Requirements[11] where at least 50 MW of capacity must be procured from energy storage resources.

Integrating DR with the California mandated energy storage procurement targets[12] is logical. A customer using electricity from the grid when a DR signal is dispatched can curtail energy usage by using electricity from a storage device. Similarly, a customer

---

[9] Greentech Media: https://forms.greentechmedia.com/Extranet/95679/forms.aspx?msgid=ebf411c6-5eb6-4c54-bae5-7707f94fc2a6&LinkID=CH00095679eR00000420AD&Source=launch1&caid=81619388

[10] Local Capacity Requirements ("LCR") RFO http://on.sce.com/1sL50cM

[11] CPUC Decision 13-02-015 Authorizing Long-Term Procurement For Local Capacity Requirements, February 13, 2013: https://www.sce.com/wps/wcm/connect/259e4c0f-14a9-4c11-af81-ec3d896843af/D1302015_AuthorizingLongTermProcurementforLocalCapacityRequirements.pdf?MOD=AJPERES

[12] R. 10-12-007, Order Instituting Rulemaking Pursuant to Assembly Bill 2514 to Consider the Adoption of Procurement Targets for Viable and Cost-Effective Energy Storage Systems, December 16, 2010: http://docs.cpuc.ca.gov/PublishedDocs/WORD_PDF/FINAL_DECISION/128658.PDF

using storage when a DR signal is dispatched to increase load can switch to utilizing energy from the grid and/or the battery can switch to charging mode.

PROJECT OBJECTIVES

The purpose of this project is to measure and evaluate the dispatch performance of storage devices for reliability and resource adequacy in response to the demand response signals from system operators at Southern California Edison. Energy savings performance will be calculated using a baseline approach from previous non-event days to determine demand in the absence of the battery storage technology.

In addition to the baseline analysis to evaluate the effectiveness of each event's response, this project intends to gain insight into any power quality issues that arise from DR dispatches to large stationary battery energy storage systems. In the future, dispatchable battery energy storage systems may provide another tool to dispatchers to mitigate some of the potential power quality issues that arise from a high penetration of distributed and renewable energy resources. This project captured transient waveform captures, harmonics and interharmonics trending to glean better insight into resource performance.

TECHNOLOGY/PRODUCT EVALUATION

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. The dispatch instructions utilized to initiate demand response test events were:

- High: Turn-Off Charging
  - Discharging from batteries to support facility load during turn-off charging test events. (The idea is that SCE/utility will see reduced demand.)
  - For *Turn Off Charging* events, it is expected that the customer demand will decrease.
  - However, the expected demand decrease will be mitigated if the battery was not charging at the time of dispatch.
  - Additionally, discharging during a *Turn-Off Charging* test event is allowed, so often the meter data does not vary from what would have happened during normal use.
- Medium: Discharge
  - For *Discharge* events, it is expected that the customer demand will decrease as the battery begins to provide some of the facility electricity demand.
  - However, if the battery was already in discharge mode, the expected decrease in demand will be mitigated.
- Low: Start Charging
  - Target early morning hours: Ideally the system will not be charging during those hours on non-event days.
  - For *Start Charging* events, it is expected that the total facility electricity demand increases.
  - However, if the battery was already in charging mode, the expected increase in demand will be mitigated.
  - Additionally, the expected response can be mitigated if a charge command is issued but the battery is already charged to capacity.

SCE conducted a total of 13 events with the stationary storage devices available and receiving signals to participate. Each dispatch event included a corresponding criticality level intended to direct storage performance to either charge, discharge, or turn-off charging. The final dispatch event plan is detailed in Table 3.

TABLE 3. TEST EVENT DISPATCH SUMMARY

EVENT START TIME	EVENT END TIME	CRITICALITY LEVEL	CRITICALITY LEVEL
2016-04-05 22:00:00	2016-04-05 23:00:00	High*	Turn-Off Charging
2016-04-12 14:00:00	2016-04-12 15:00:00	Medium**	Discharge
2016-04-19 22:00:00	2016-04-19 23:00:00	High*	Turn-Off Charging

EVENT START TIME	EVENT END TIME	CRITICALITY LEVEL	CRITICALITY LEVEL
2016-04-22 14:00:00	2016-04-22 15:00:00	Medium**	Discharge
2016-04-29 22:00:00	2016-04-29 23:00:00	High*	Turn-Off Charging
2016-05-02 14:00:00	2016-05-02 15:00:00	Medium**	Discharge
2016-05-06 03:00:00	2016-05-06 04:00:00	Low***	Start Charging
2016-05-10 22:00:00	2016-05-10 23:00:00	High*	Turn-Off Charging
2016-05-13 14:00:00	2016-05-13 15:00:00	Medium**	Discharge
2016-05-17 03:00:00	2016-05-17 04:00:00	Low***	Start Charging
2016-05-20 03:00:00	2016-05-20 04:00:00	Low***	Start Charging
2016-05-24 03:00:00	2016-05-24 04:00:00	Low***	Start Charging
2016-06-08 03:00:00	2016-06-08 04:00:00	Low***	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. The data sources utilized for this evaluation were:

- SCE revenue meter data used for billing and other functions.
- Battery energy data from the installed battery ALCS system providing the perceived battery performance and the battery controller's measurement or estimation of site power usage.
- Power quality data from power quality monitoring equipment to provide independent verification and insight into event responses.

Both the SCE and battery metering were in place prior to conducting this project and PQ monitoring equipment was installed at each of the sites for the purposes of this project as further detailed in the following section.

PQ INSTRUMENTATION, MEASUREMENTS AND ANALYSIS

To facilitate further evaluation of the power and power quality (PQ) characteristics of the battery energy storage systems, portable power quality analyzers were installed for three months on the battery energy storage systems at the three customer sites. The PQ was then analyzed during each DR test event.

At the Customer 1 site, access was only available at the plant 4160 V main breaker shown in Figure 1. Clip-on voltage probes were connected to the open delta potential transformer metering circuits, while 10 amp current probes were connected to secondary connections of the main breaker current transformers. At the request of Customer 1, additional PQ analysis was also performed when a large mill was down for maintenance as well as obtaining baseline PQ data on a day that the battery system was offline for 24 hours.

At the Customer 2 site, the PQ unit was installed at the 480 V main disconnect switch of the battery energy storage system, utilizing clip on voltage leads and flexible current probes. A picture of the installation is shown in Figure 1.

At the Customer 3 site, the PQ unit was installed at the 480 V combiner cabinet, where the entire battery energy storage system connects to the plant grid. Figure 3 shows the connection of the flexible current probes, while shows the installed setup. Further details on PQ meter configuration can be found in the Appendix Section I.C.

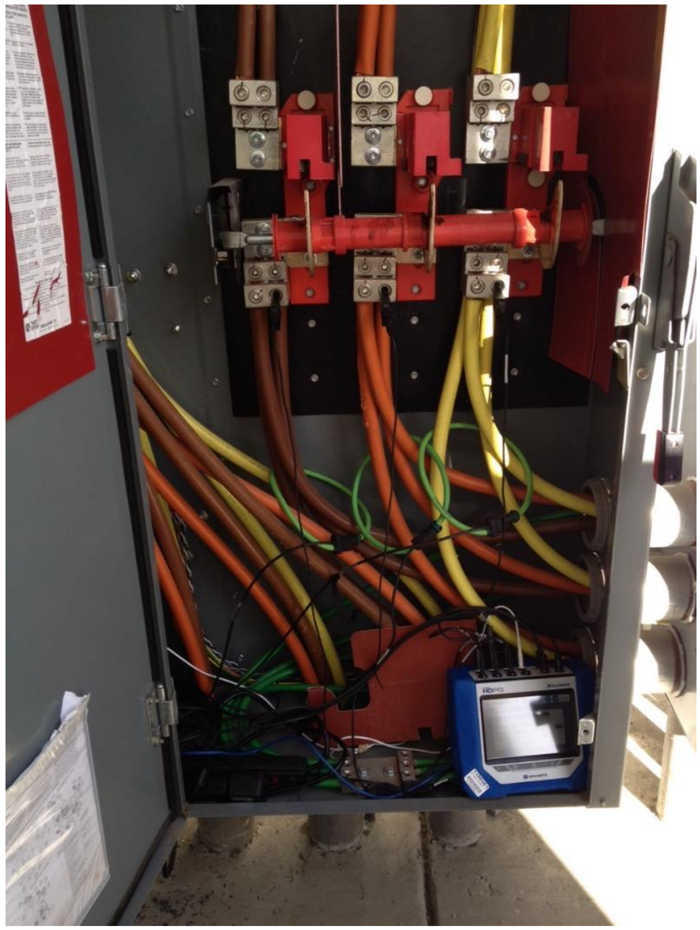


FIGURE 1. CUSTOMER 2 PQ MONITORING INSTALLATION

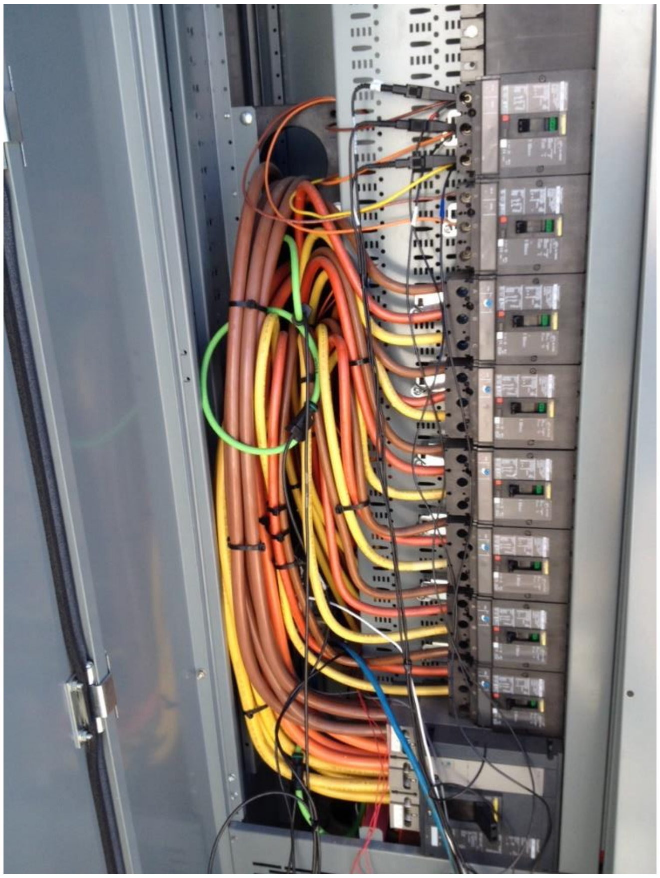


FIGURE 2. CUSTOMER 3 CURRENT PROBES

FIGURE 3. CUSTOMER 3 PQ MONITORING INSTALLATION

ANALYSIS: DEMAND RESPONSE AND POWER QUALITY

ANALYSIS OVERVIEW AND 10-IN-10 BASELINE METHODOLOGY

Throughout the analysis a 10-in-10 approach will be referenced. This approach to baselining is consistent with the CAISO Demand Response User Guide v3.1.1 instructions for calculating a baseline.[13] The 10-in-10 baseline process is further outlined on pages 94-96 of the Report on the Transition of SCE DR Programs into MRTU.[14]

Essentially, the baseline is an average of the 15-minute interval usage data for the ten most recent past days of the same type as the test event day being evaluated (non-holiday weekdays). Past DR event days are not included in the baseline.

Three different 10-in-10 baseline methodology variations were utilized for analysis and comparison of the battery storage systems during a DR test event. These variations are:

- 10-in-10: Average 15 minute usage from the past 10 non-holiday workdays. For purposes of this project the 10-in-10 baseline is equivalent to the CBP Energy Baseline used for performance calculation and settlement with the customers participating in this project.
- 10-in-10 ±20%: A 10-in-10 baseline that is shifted up or down by up to 20% based on the customer usage at the time of DR dispatch. This baseline aligns with the methodology utilized by CAISO for Proxy Demand Resources (PDR)[15].
- LA 10-in-10: a linear adjustment of the 10-in-10 baseline to align the baseline curve to the point 15 minutes prior to the test event and 15 minutes following the event.

These baselining techniques are applied to both the SCE metering and battery storage system metering data sources.

[13] Found on page 186 of the document

[14] http://www3.sce.com/sscc/law/dis/dbattach3e.nsf/0/0CB693A87C9BBD838825782D0082C428/$FILE/A.08-06-001_Report+on+the+Transition+of+SCE+DR+Programs+into+MRTU.pdf

[15] CAISO Proxy Demand Resource (PDR) https://www.caiso.com/23bc/23bc873456980.html

SCE METER BASELINE ANALYSIS

The "SCE Meter Baseline Analysis" sub-sections of the "Results" section consists of two charts and related analysis:

- Chart 1: The "Event Day" curve compared to the maximum, minimum, and average 10-in-10 usage baseline curve; and
- Chart 2: The "Event Day" curve compared to the 10-in-10, the 10-in-10 ±20% and the LA 10-in-10 baseline curves.

Chart 1 contains four lines which are described below:

- 10-in-10 Baseline = The 15-minute interval 10-in-10 baseline curve
- Max Baseline Period Usage = The maximum demand for any 15-minute interval during the 10-day baseline period.
- Min Baseline Period Usage = The minimum demand for any 15-minute interval during the 10-day baseline period.
- Event day Usage = The 15-minute interval usage from the event day.

Chart 2 contains four lines and which are described below:

- Event Day Usage = The 15-minute interval usage from the event day.
- 10-in-10 Baseline = The 15-minute interval 10-in-10 baseline curve.
- ± 20% from Baseline = The 10-in-10 Baseline curve shifted up or down with a maximum of 20% in order to match the usage profile of event day 15-minutes prior to the start of the event. This strategy is utilized to shift the 10-in-10 baseline to better coincide with event day usage immediately prior to the start of the event.
- LA 10-in-10 = Linearly Adjusted 10-in-10 is outlined in the Appendix A and on Pages 113-117 of the Report on the Transition of SCE DR Programs into MRTU.[16]

The general goal of the baseline illustrations is to understand what usage would have been in the absence of a DR test event. The kW and kWh impact of each event is based on the difference between the baselines and the event day curve as illustrated in the "Performance of Event" table for each test event. Each table includes 15-minute interval data for the event day load and the difference between the event day load and the three baseline methodologies (10-in-10, 10-in-10 20% cap, LA 10-in-10). The difference between the three baselines and the actual event day usage is the battery DR performance (demand kW and usage kWh) for each test event. For purposes of this project the 10-in-10 baseline is equivalent to the CBP Energy baseline used for performance calculation and settlement with the customers participating in this project.

[16] Report on the Transition of SCE DR Programs into MRTU http://www3.sce.com/sscc/law/dis/dbattach3e.nsf/0/0CB693A87C9BBD838825782D0082C428/$FILE/A.08-06-001_Report+on+the+Transition+of+SCE+DR+Programs+into+MRTU.pdf

BATTERY ALCS BASELINE ANALYSIS

The battery storage ALCS data gives insight into the actions of the battery ALCS at each customer site. Upon review of the data, it was clear that the battery was both charging and discharging at varying rates simultaneously. As such, it is important to look at the import (charging) and export (discharging) behavior at each site, along with the overall net (charge minus discharge) performance profile.

Each of these sections contains two graphs (Site Battery Net Profile, and Site Battery Import Export Chart) with baselining methodology identical to the SCE meter baseline methodology outlined above.

The Site Net Profile Chart includes the following:

- Net Battery Baseline Average: The 15-minute interval 10-in-10 baseline curve for the net effect of the battery.
- Net Battery Baseline Max: The maximum demand for any 15-minute interval during the 10-day baseline period.
- Net Battery Baseline Min: The minimum demand for any 15-minute interval during the 10-day baseline period.
- Event Day Battery Net: The 15-minute interval net battery performance for the event day.

The Site Battery Import Export Chart includes the following:[17]

- Baseline Battery Import Max: The maximum import demand during the 10-day baseline period.
- Baseline Battery Import Average: The 15-minute interval 10-in-10 baseline curve for the import of the battery.
- Event Day Battery Import: The 15-minute interval import battery performance for the event day.
- Baseline Battery Import Min: The minimum import demand during the 10-day baseline period.
- Baseline Battery Export Max: The maximum import demand during the 10-day baseline period.
- Event Day Battery Export: The 15-minute interval export battery performance for the event day.
- Baseline Battery Export Average: The 15-minute interval 10-in-10 baseline curve for the export of the battery.
- Baseline Battery Export Min: The minimum export demand during the 10-day baseline period.

[17] Battery exports are displayed as negative values. Therefore, the "Baseline Battery Export Min" curve typically shows more extreme values than the "Baseline Battery Export Max" curve.

RESULTS

This section includes detailed analysis of demand response and PQ performance for each test event day. The analysis is comprised of three parts: SCE Meter Baseline Analysis, Battery ALCS Baseline Analysis, and PQ measurements illustrating the data gathered from the PQ Instrumentation.

In the analysis, observations refer to usage patterns and shapes that can be seen in the different lines in the graphs illustrating both the event day usage as well as the reference baseline usage. The range of usage refers to the range in between the maximum baseline usage and the minimum baseline usage in the SCE Meter Data charts.

CUSTOMER 1: DEMAND RESPONSE OBSERVATIONS AND POWER QUALITY 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.

Because of site limitations, monitoring equipment at the test site was installed at a circuit that is essentially the net load between the battery interface and the connected loads. Therefore, data from may be influenced by the machinery and load at the facility, but still provides insight into the whole-building power quality both during events and under normal operating conditions.

The battery storage system at this test site is connected via a step-up transformer to the plant 4160 V system, where the monitoring was performed. The monitoring equipment captured approximately three months of data. In addition to the demand response PQ monitoring over this period, there was PQ monitoring during a mill shut down that occurred from May 10-18, and a battery system shutdown that occurred on May 25-26.

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.

TEST EVENT 1: TUESDAY APRIL 5, 22:00-23:00 PDT – TURN OFF CHARGING

a) SCE Meter Baseline Analysis

In Figure 4, it is interesting that the test day has peak demand periods in excess of the maximum baseline period usage. As a result, the different M&V approaches may not yield an accurate measurement of DR performance since the test day usage is so dissimilar to the baseline and the maximum baseline period usage.

The baseline pattern for the test event follows a typical demand response pattern with the major caveat that the usage reduction seems to have started 30 minutes prior to the test event initiation and continues through the end of the period before returning to usage similar to what is seen throughout the day. Effectively, it looks like this event lasts a full 2 hours, from 21:30-23:30, rather than the hour from 22:00-23:00 that was requested in the dispatch instruction.

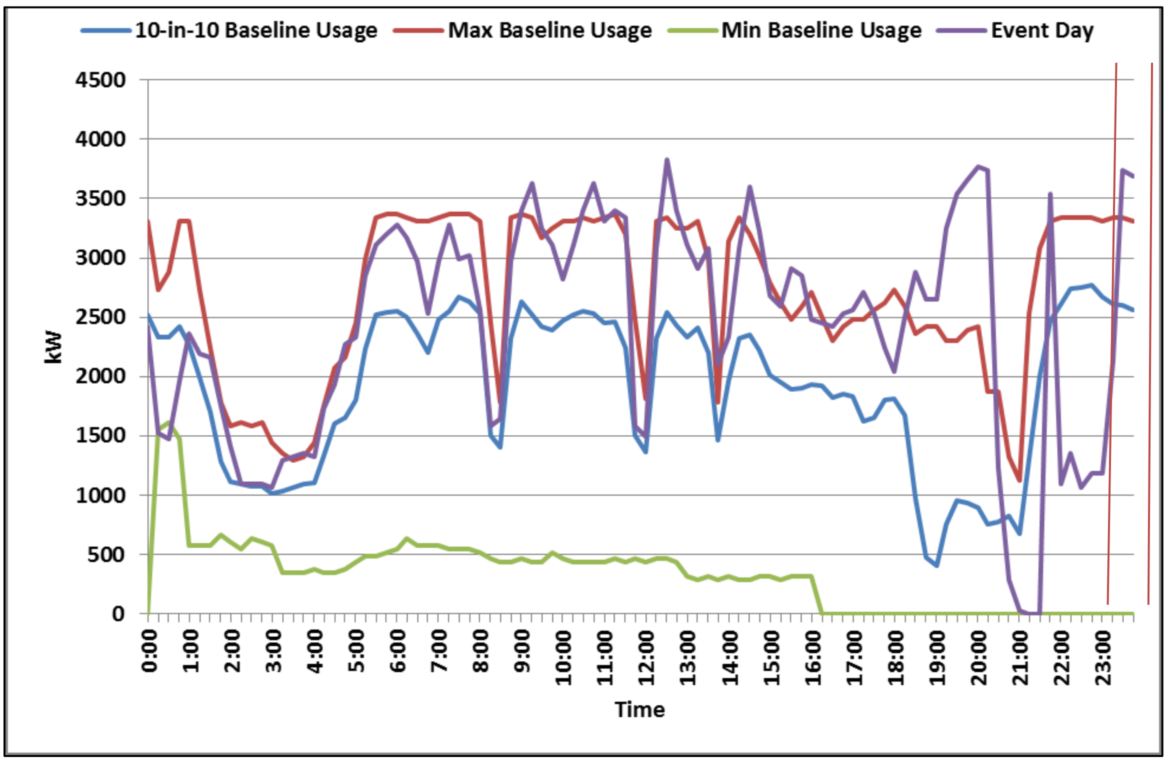


Figure 4. April 5 23:00-24:00 Customer 1 Turn Off Charging – SCE Meter Data

All three baseline models seem to indicate that there is some DR happening, but that information is confounded by the minimum usage of zero kW that was observed over the baseline period for the same timeframe.

Because the event appears to have started 30 minutes prior to the event start time and completed 30 minutes after event termination, it is noted that the linearly adjusted (LA) 10-in-10 estimate for what usage would have been in the absence of a test event does mirror the usage patterns (slopes) of the 10-in-10 Baseline Usage nor the 20% corrective model. The LA 10-in-10 estimate aligns with the usage 15 minutes before and 15 minutes after the test event period.

It is worth noting that the combination of premature start of the battery response and the usage being significantly higher than the range of usage prior to the battery response result in a negative rather than positive adjustment for the ±20% adjustment.

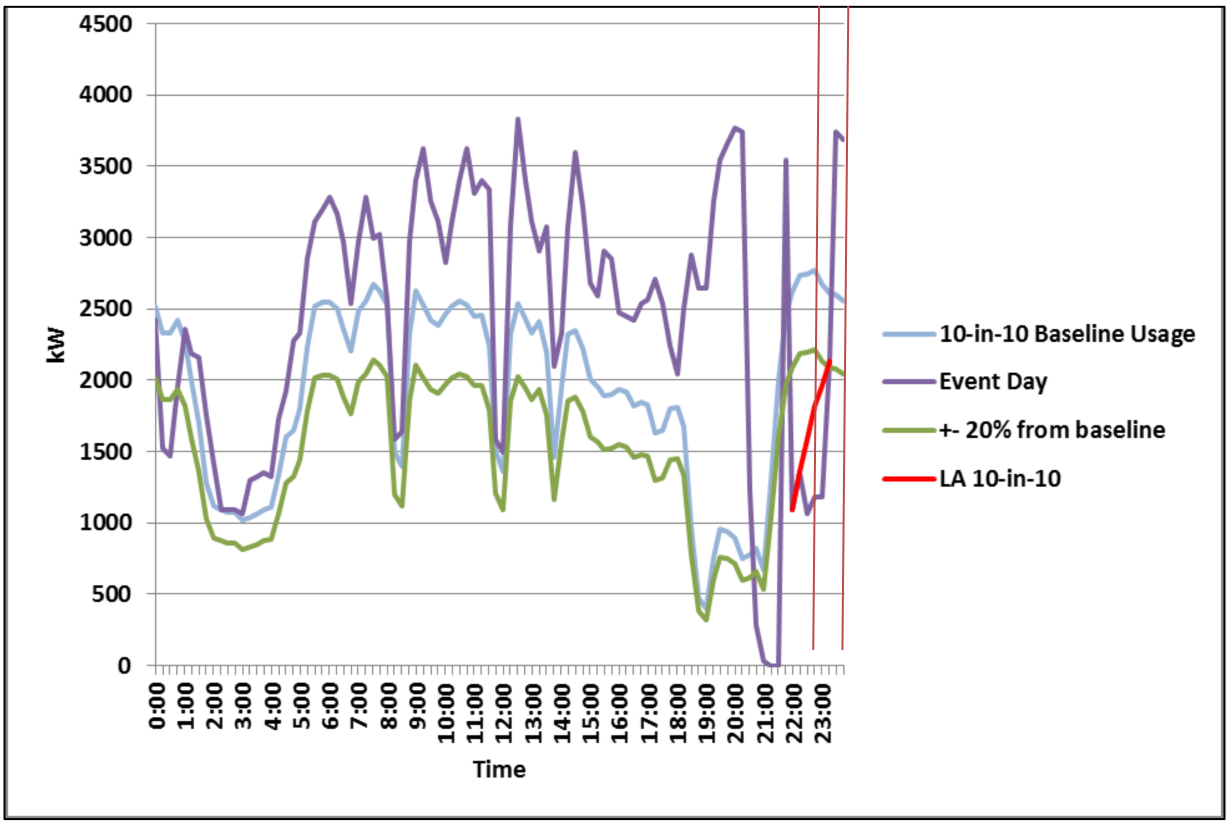


FIGURE 5. APRIL 5 23:00-24:00 CUSTOMER 1 TURN OFF CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis. Again, simply because all three estimates for what usage would have been agree with what would be expected with a proper response to the signal does not indicate that the signal was responded to. First, the perceived response started prematurely and ended late. Second, the usage pattern prior to the test event was both above the maximum baseline curve and below the minimum baseline curve. Furthermore, the estimates for average kW savings vary by threefold without a logical correct answer.

TABLE 4. APRIL 5 22:00-23:00 CUSTOMER 1 TURN OFF CHARGING – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CBP EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
21:45-22:00	1,094.40	-	-	-
22:00-22:15	1,353.60	(1,405.44)	(853.63)	(16.78)
22:15-22:30	1,065.60	(1,693.44)	(1,141.63)	(525.57)
22:30-22:45	1,180.80	(1,598.40)	(1,042.56)	(644.39)
22:45-23:00	1,180.80	(1,488.96)	(955.01)	(786.16)
23:00-23:15	2,131.20	-	-	-
Average kW	**1,195.20**	**(1,546.56)**	**(998.21)**	**(493.23)**
Average kWh	**1,195.20**	**(1,546.56)**	**(998.21)**	**(493.23)**
CBP Bid (kW)		(300)		
CBP Event Performance		**516%**		

For purposes of settlement for this project, the 10-in-10 baseline is being utilized for the CBP Energy Baseline settlement with participating customers.

b) Battery ALCS Baseline Analysis

In Figure 6, developed from the battery ALCS data, the same pattern as observed at the SCE meter is apparent, indicating that the battery system was at least partly responsible for the event day usage that was observed in the SCE Meter Baseline Analysis. Still, there is little indication as to why the event appears to start prematurely.

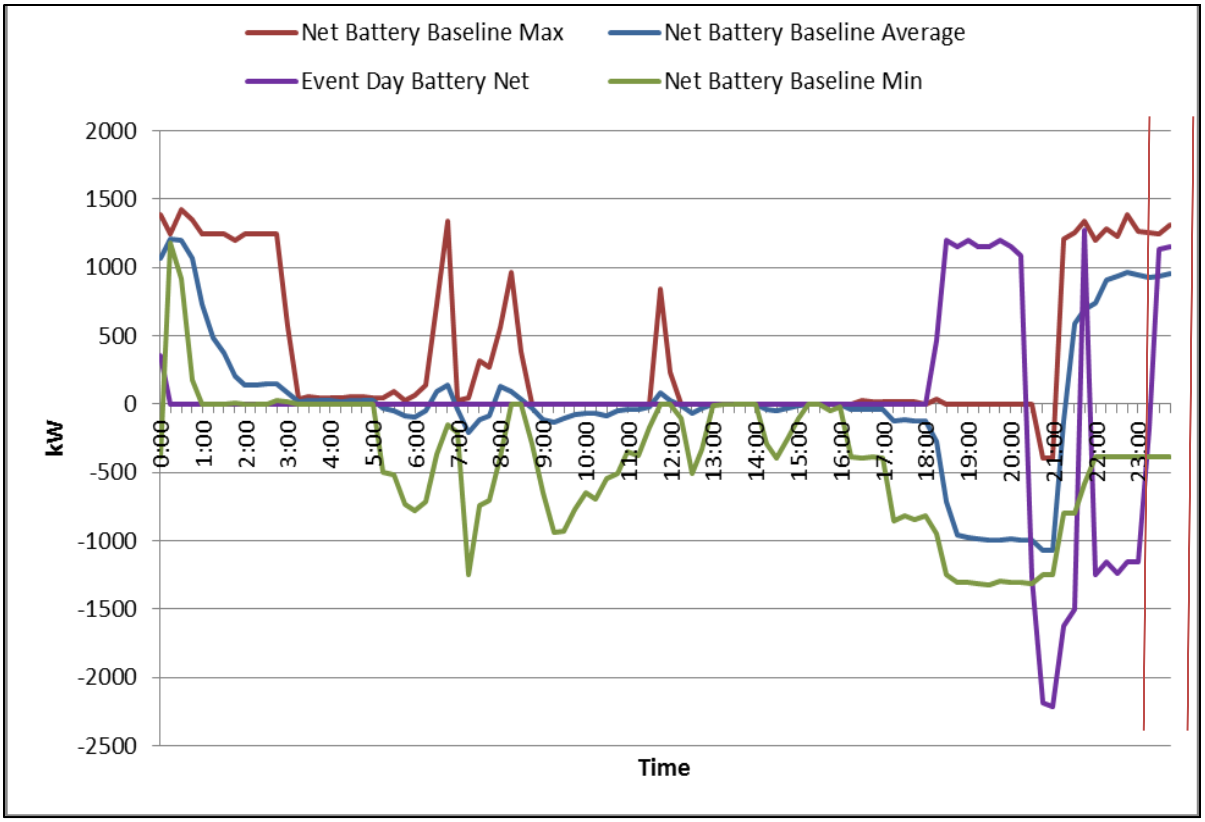


Figure 6. April 5 23:00-24:00 Customer 1 Turn Off Charging – Battery ALCS Net Meter Data

In Figure 7, typical battery behavior is apparent around the 22:00-23:00 hour. Typically, the battery exports electricity from roughly 15:00-21:00 before switching to importing electricity through the night. This behavior is typical in load shifting batteries. On event day, the battery imports from 18:00-20:15, then exports significantly, before cycling again and actually exports 22:00-23:00 despite this being a simple "Turn Off Charging" signal. The behavior in advance of the event is odd and the reason for the extended performance is still not clear.

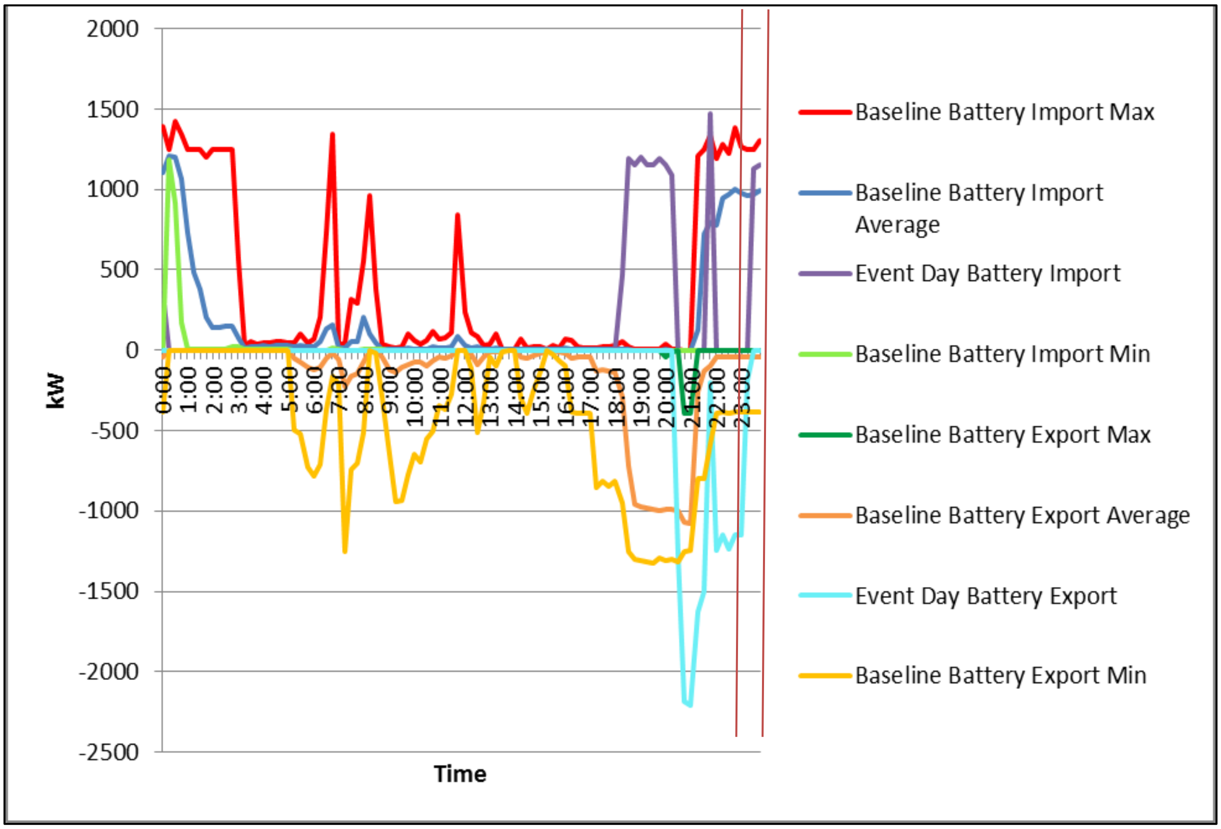


FIGURE 7. APRIL 5 23:00-24:00 CUSTOMER 1 TURN OFF CHARGING – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ Measurements

Because of the configuration of how the Customer 1 power monitoring device was set up to monitor facility load, the device recorded the net result of a portion of the facility load and the battery output. Therefore, the upper chart in Figure 8 does not align with the meter data from SCE or battery ALCS system shown in Figure 4 through Figure 7 above.

The lower chart in Figure 8 shows that the Voltage Total Harmonic Distortion (VThd) as a measurement of power quality was within the normal range (< 5%) prior to, during and after the test event period.

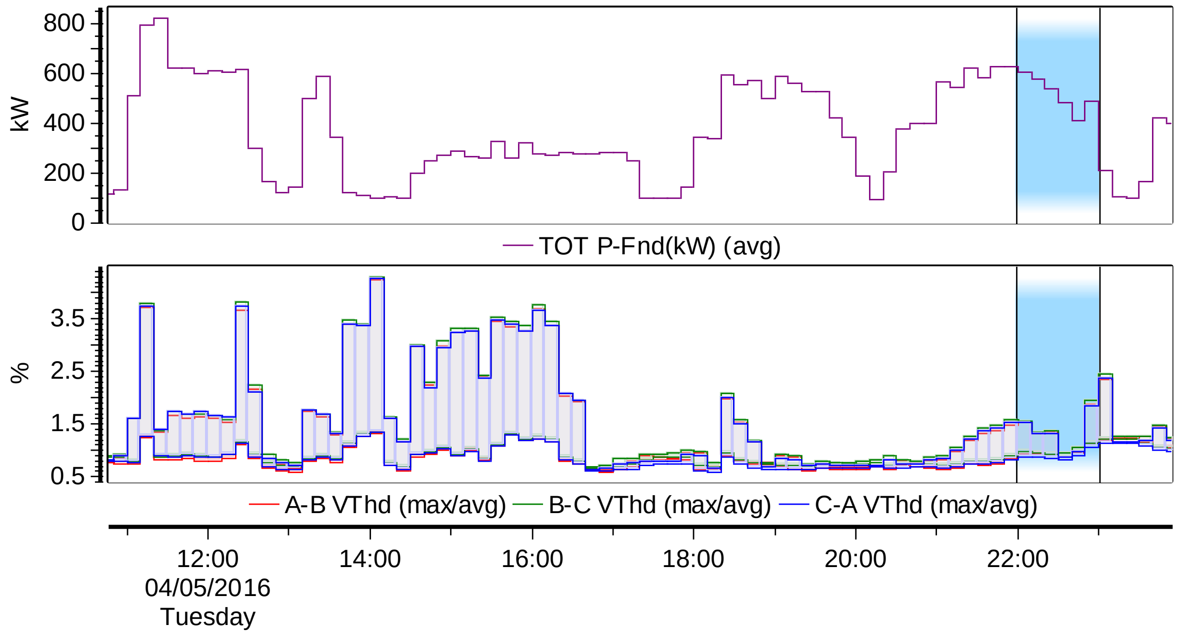


Figure 8. April 5 22:00-24:00 Customer 1 Turn Off Charging – PQ Meter Data

Test Event 2: Tuesday April 12, 14:00-15:00 PDT – Discharge

a) SCE Meter Baseline Analysis

In Figure 9, the event day curve matches the maximum baseline usage fairly closely. The event day usage drop aligns well with the discharge test dispatch instruction. Note the significant usage rebound after the test event has ended. This might be the battery recharging after discharge.

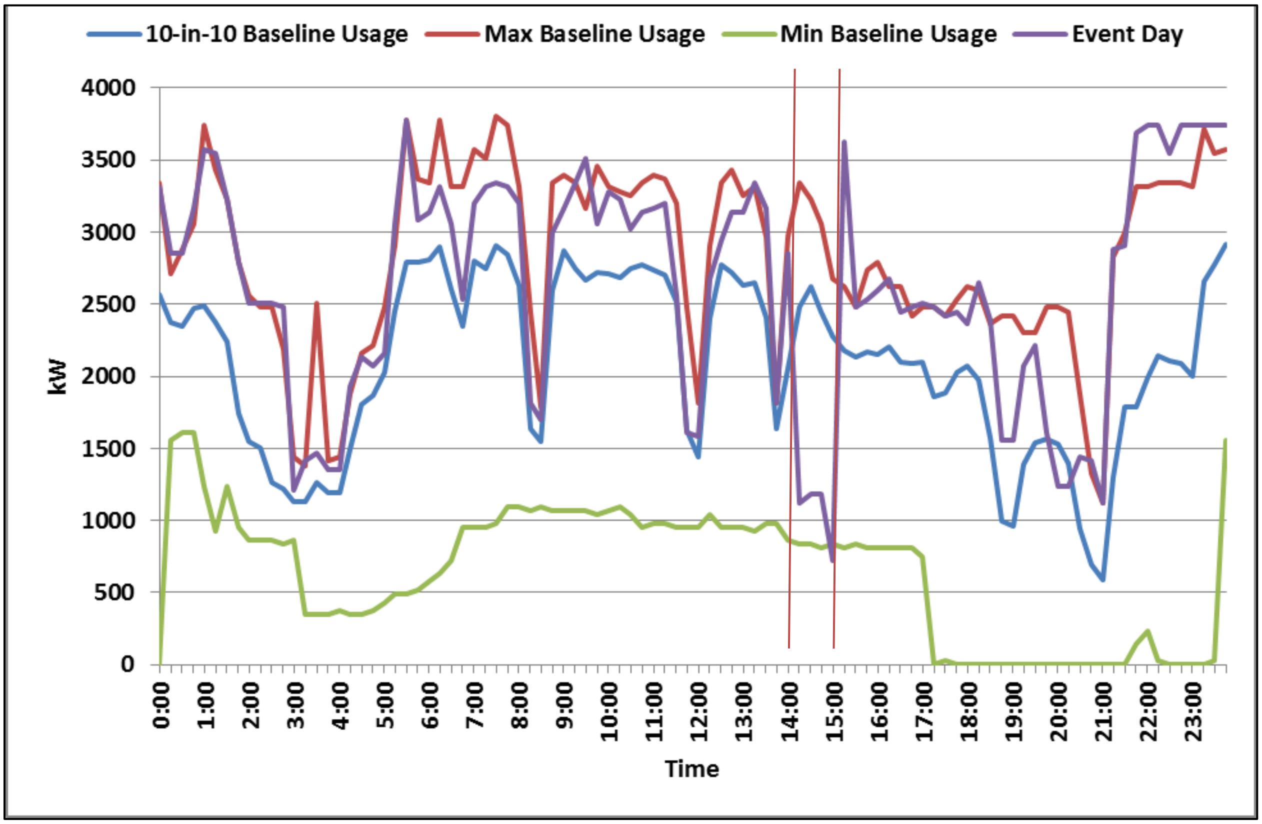


FIGURE 9. APRIL 12 14:00-15:00 CUSTOMER 1 DISCHARGE – SCE METER DATA

The three baseline curves in Figure 10 show significant power savings with the event. The LA 10-in-10 curve appears to be influenced by the spike immediately following the event. The other graphs also show significant savings. It is worth mentioning that the "± 20% from baseline graph" appears to align quite well with event day usage prior to the event.

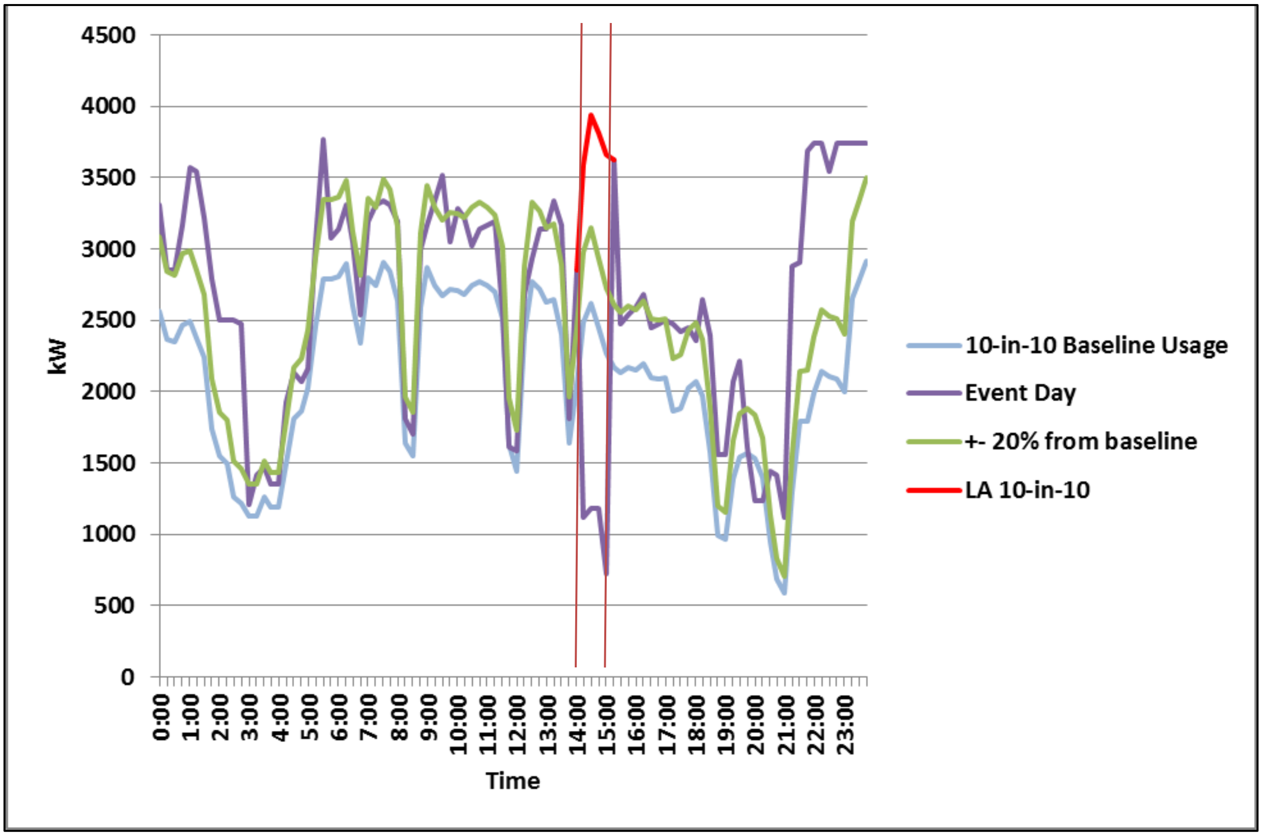


FIGURE 10. APRIL 12 14:00-15:00 CUSTOMER 1 DISCHARGE – DR BASELINE ESTIMATES

Error! Reference source not found. lists the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis. Significant savings across all three baseline methodologies are revealed. While not quantified in the table, event day usage at 14:00 was 39% higher than the 10-in-10 baseline average usage. The high event start usage is within the range of usage shown in Figure 9. However, the usage increases after the test event is significantly higher than the maximum baseline usage.

TABLE 5. APRIL 12 14:00-15:00 CUSTOMER 1 DISCHARGE – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CBP EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
13:45-14:00	2,851.20	-	-	-
14:00-14:15	1,123.20	(1,359.36)	(1,855.87)	(2,466.91)
14:15-14:30	1,180.80	(1,442.88)	(1,967.62)	(2,759.49)
14:30-14:45	1,180.80	(1,267.20)	(1,756.80)	(2,631.97)
14:45-15:00	720.00	(1,552.32)	(2,006.78)	(2,945.68)
15:00-15:15	3,628.80	-	-	-
Average kW	**1,051.20**	**(1,405.44)**	**(1,896.77)**	**(2,701.01)**
Average kWh	**1,051.20**	**(1,405.44)**	**(1,896.77)**	**(2,701.01)**
CBP Bid (kW)		(200)		
CBP Event Performance		**703%**		

b) Battery ALCS Baseline Analysis

This net battery profile supports what has been seen thus far. There is significant discharge during the event that is not normally observed, followed by a brief period of re-charging in the 15 minutes immediately following the event.

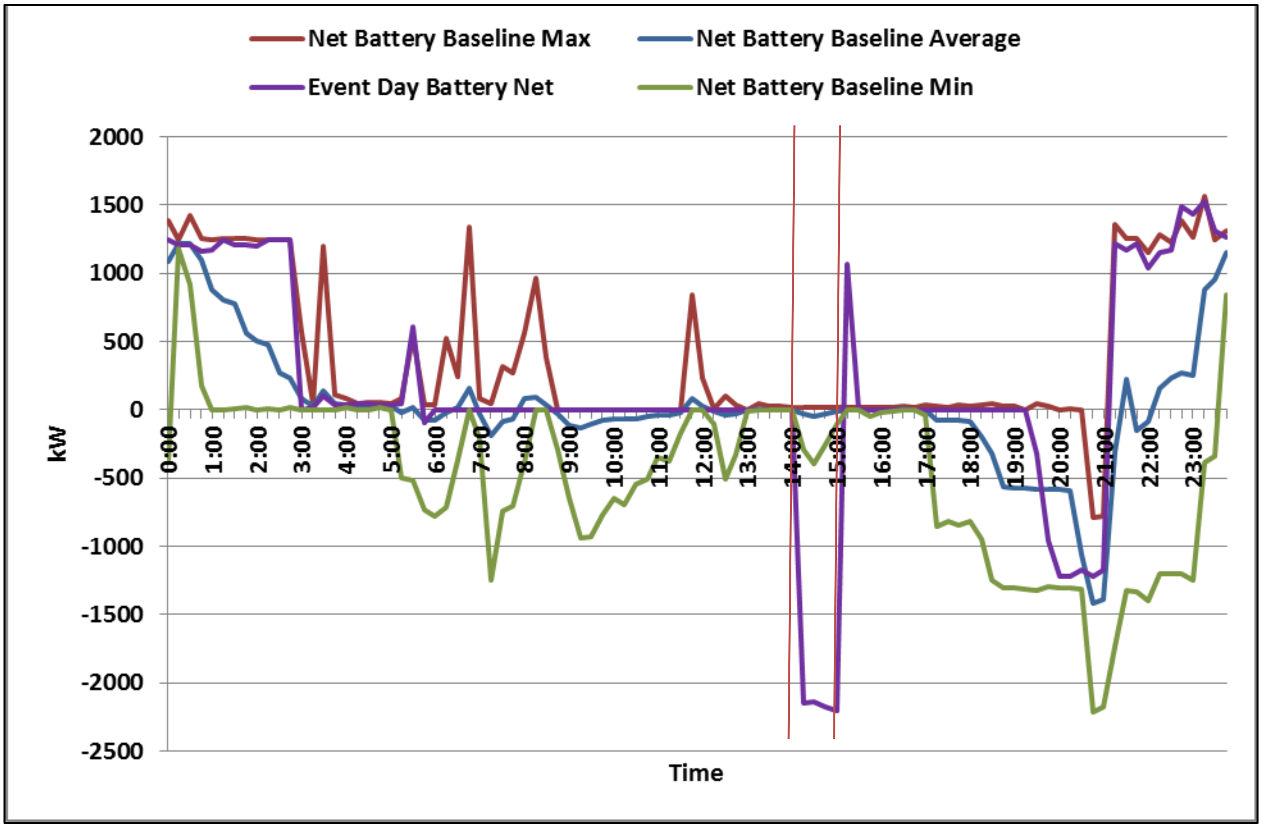


Figure 11. April 12 14:00-15:00 Customer 1 Discharge – Battery ALCS Net Meter Data

The Import/Export chart also indicates that there is significant discharge during the event that is not normally observed, followed by a brief period of re-charging in the 15 minutes immediately following the event.

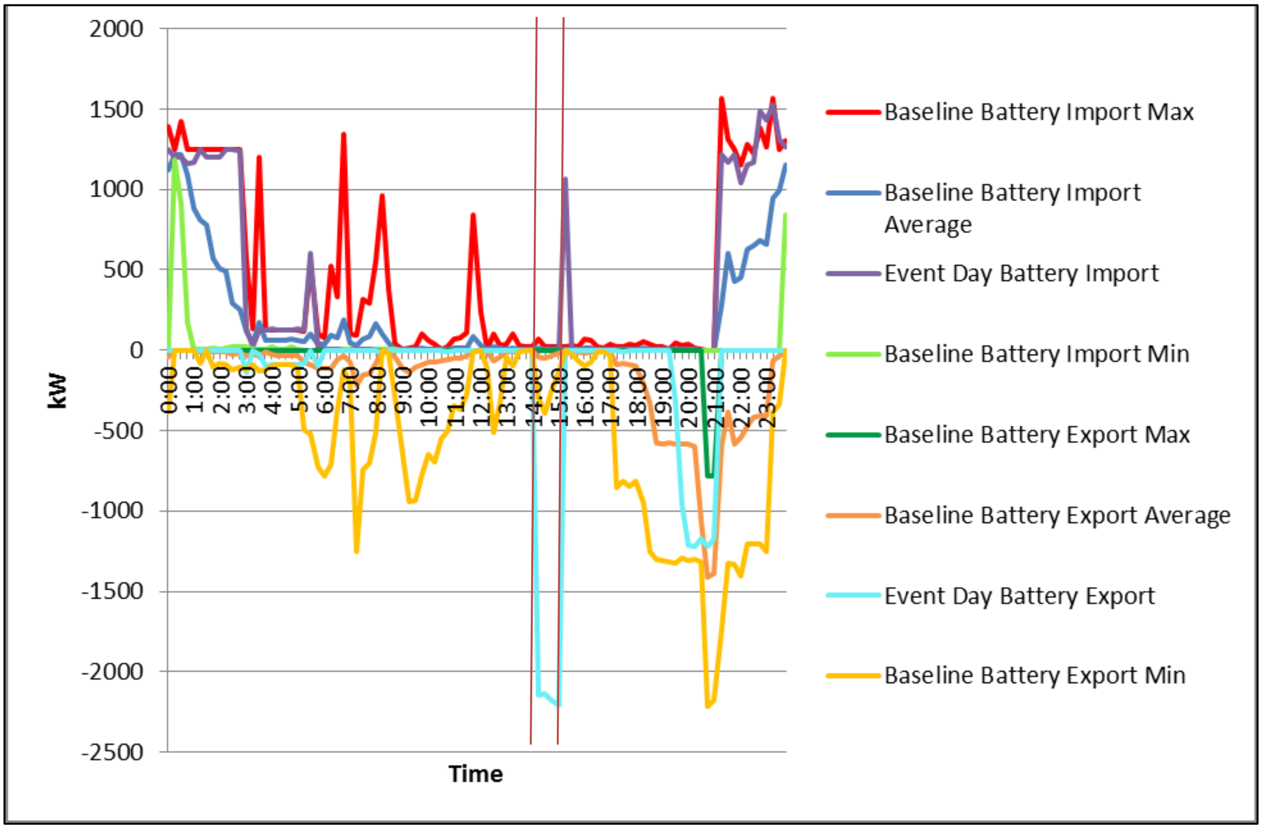


FIGURE 12. APRIL 12 14:00-15:00 CUSTOMER 1 DISCHARGE – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ Measurements

No data; The PQ instrument was reset.

Test Event 3: Tuesday April 19, 22:00-23:00 PDT – Turn Off Charging

a) SCE Meter Baseline Analysis

Test event day usage varies between the minimum and maximum baseline usage levels for most of the day before the test event. During the test event, a slight usage increase is revealed, followed by a gradual usage decrease for the remainder of the test event before a spike back to the baseline in the period following the test event. Usage during the event was below the baseline, which might indicate a response to the “Turn Off Charging” signal, but it is inconclusive based on the SCE meter data.

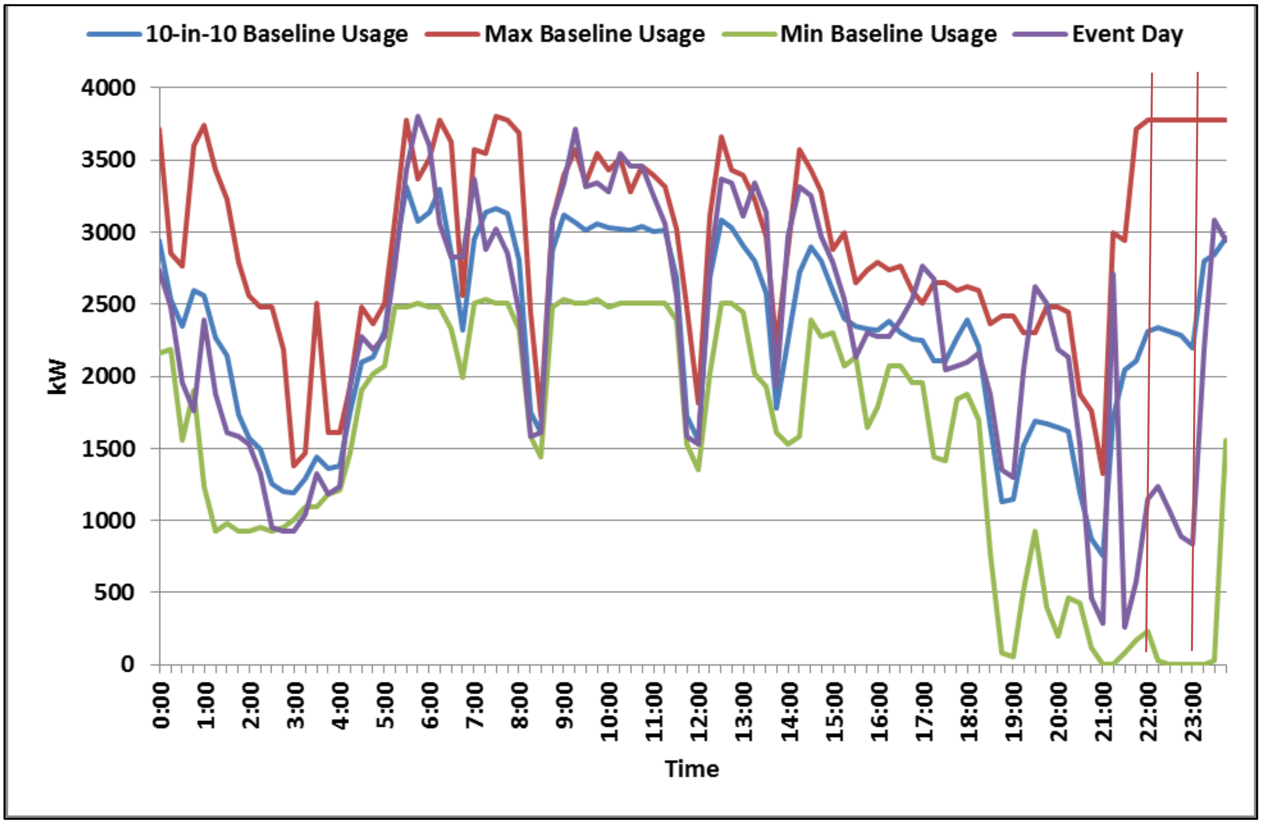


Figure 13. April 19 22:00-23:00 Customer 1 Turn Off Charging – SCE Meter Data

Because usage was below the 10-in-10 (average) baseline just prior to test event initiation, the estimates for what usage would have been are all higher than what was observed. Because usage started so much lower than average at the start of the event, the 10-in-10 and ± 20% estimates are inaccurate estimates for what usage would have been in the absence of the event signal. Even still, it is difficult to discern where the response to the signal begins and where the battery activity starts.

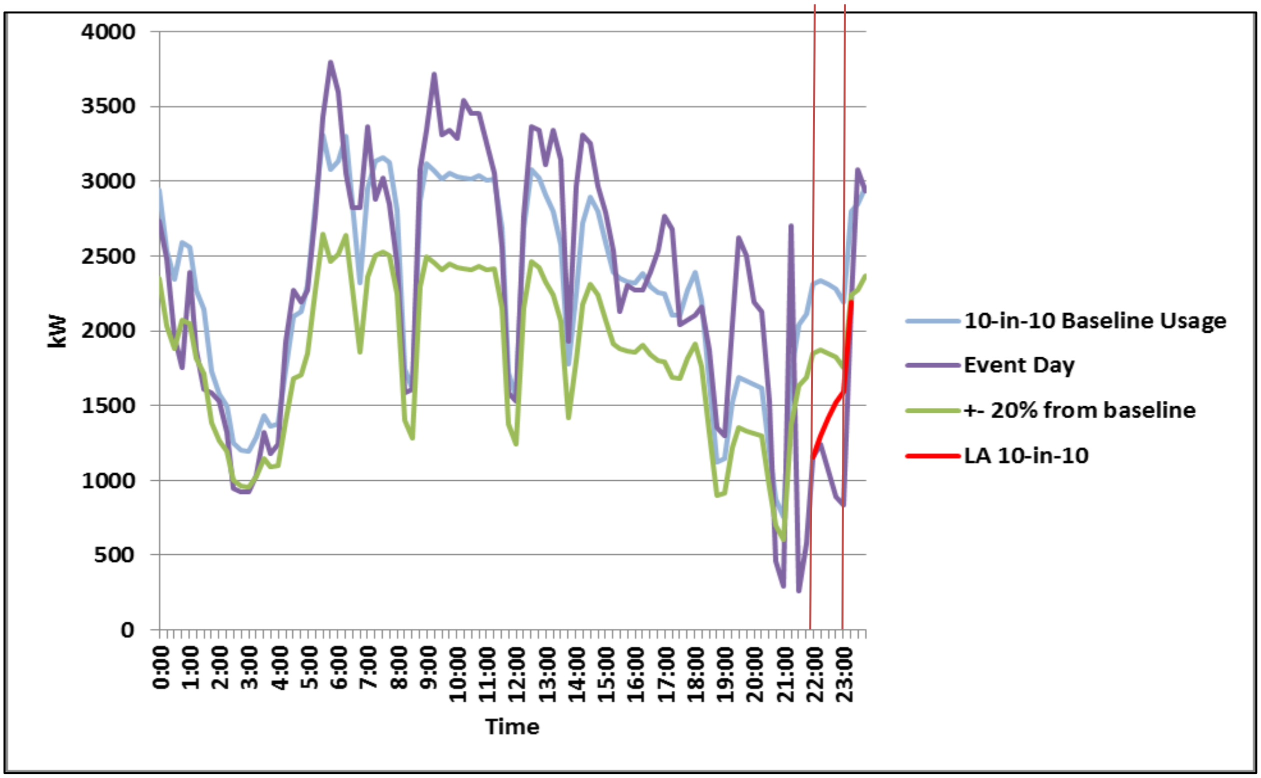


FIGURE 14. APRIL 19 22:00-23:00 CUSTOMER 1 TURN OFF CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 6. APRIL 19 22:00-23:00 CUSTOMER 1 TURN OFF CHARGING – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CBP EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
21:45-22:00	1,152.00	-	-	-
22:00-22:15	1,238.40	(1,100.16)	(632.45)	(58.85)
22:15-22:30	1,065.60	(1,249.92)	(786.82)	(349.91)
22:30-22:45	2,188.80	(613.44)	(52.99)	-
22:45-23:00	835.20	(1,359.36)	(920.45)	(754.75)
23:00-23:15	2,188.80	-	-	-
Average kW	**1,332.00**	**(1,080.72)**	**(598.18)**	**(290.88)**
Average kWh	**1,332.00**	**(1,080.72)**	**(598.18)**	**(290.88)**
CBP Bid (kW)		(200)		
CBP Event Performance		**540%**		

b) Battery ALCS Baseline Analysis

Figure 15 shows that the baseline battery profile for the 22:00-23:00 hour displays a wide range of typical behavior. The net average for that time period is between 0 and 500 kW, but with a range from nearly -1500 kW export to 2000 kW import. While event day is near that minimum, it is not possible to discern this profile from what is normally observed.

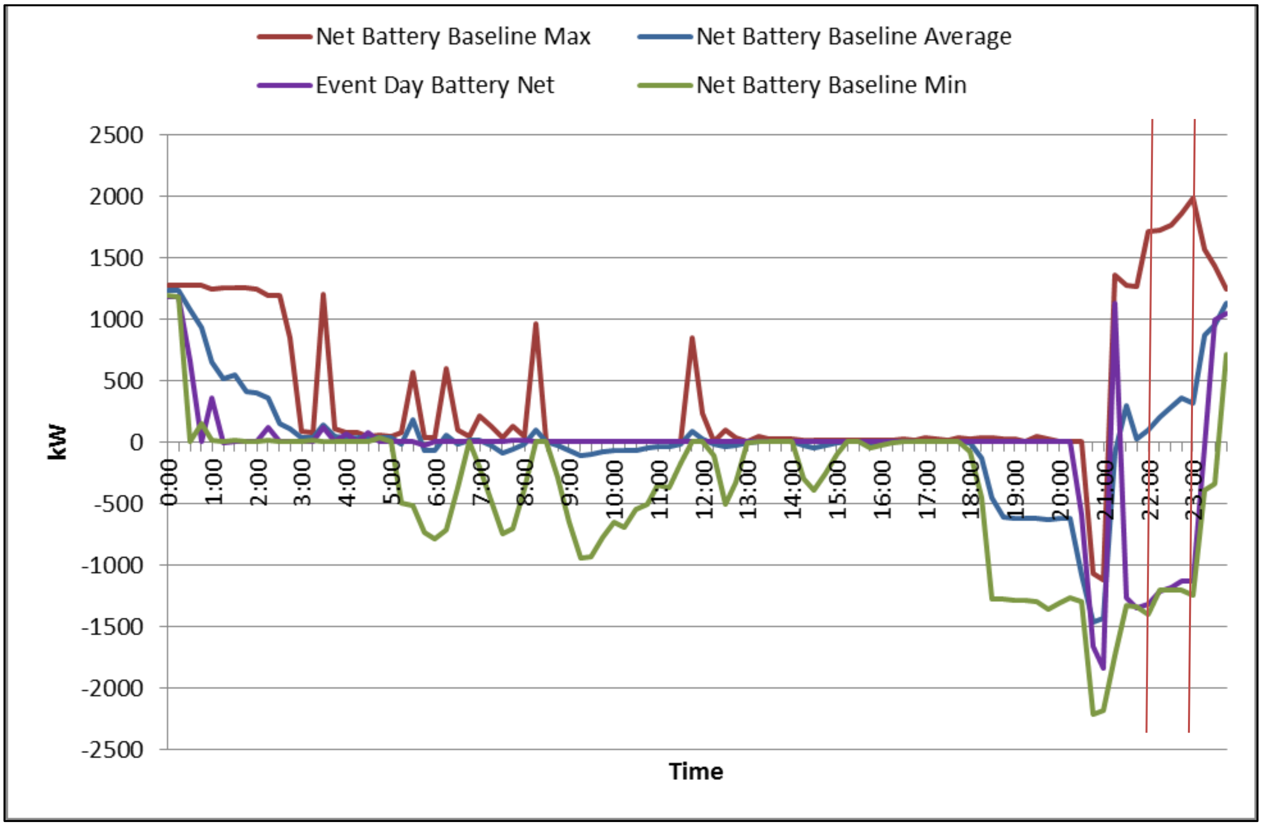


Figure 15. April 19 22:00-23:00 Customer 1 Turn Off Charging – Battery ALCS Net Meter Data

Figure 16 shows the wide range in battery activity during the baseline of the event period. However, this chart provides added insight that was otherwise missing. The average battery import over the baseline period (the blue line) starts at roughly 500 kW and increases over the 22:00-23:00 hour. On event day, the battery does not import (charge) at all during the event period. The event day import behavior is still within the observed baseline behavior, since the "Baseline Battery Import Min" (Lime Green) is also 0 during the event time period.

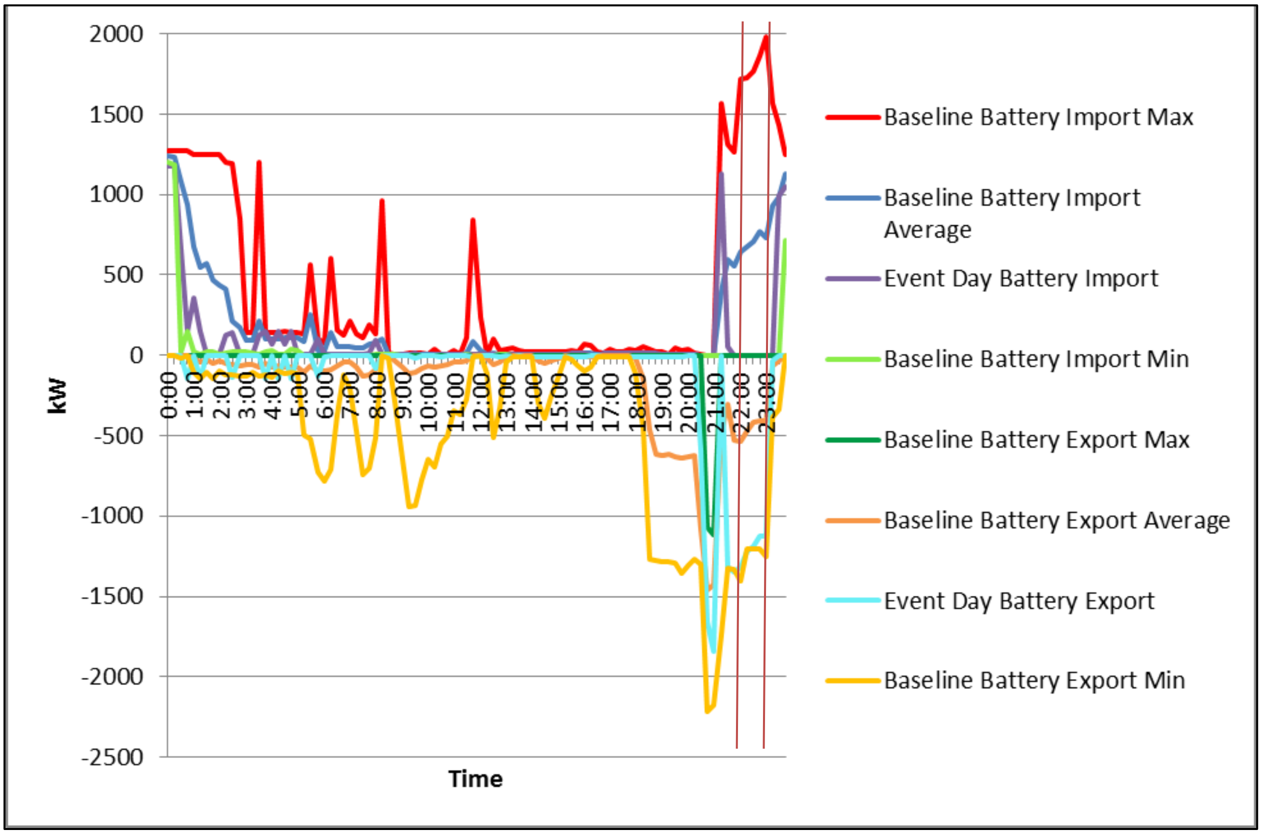


FIGURE 16. APRIL 19 22:00-23:00 CUSTOMER 1 TURN OFF CHARGING – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ Measurements

Because of the configuration of how the Customer 1 power monitoring device was monitoring the battery and facility load, the device was monitoring the net result of a portion of the facility load and the battery output. Therefore, the upper chart in Figure 17 does not align with the meter data from SCE or battery ALCS shown in Figure 13 through Figure 16 above.

The lower chart in Figure 17 shows that the voltage total harmonic distortion (VThd) as a measurement of power quality was within the normal range (< 5%) prior to, during, and after the test event period.

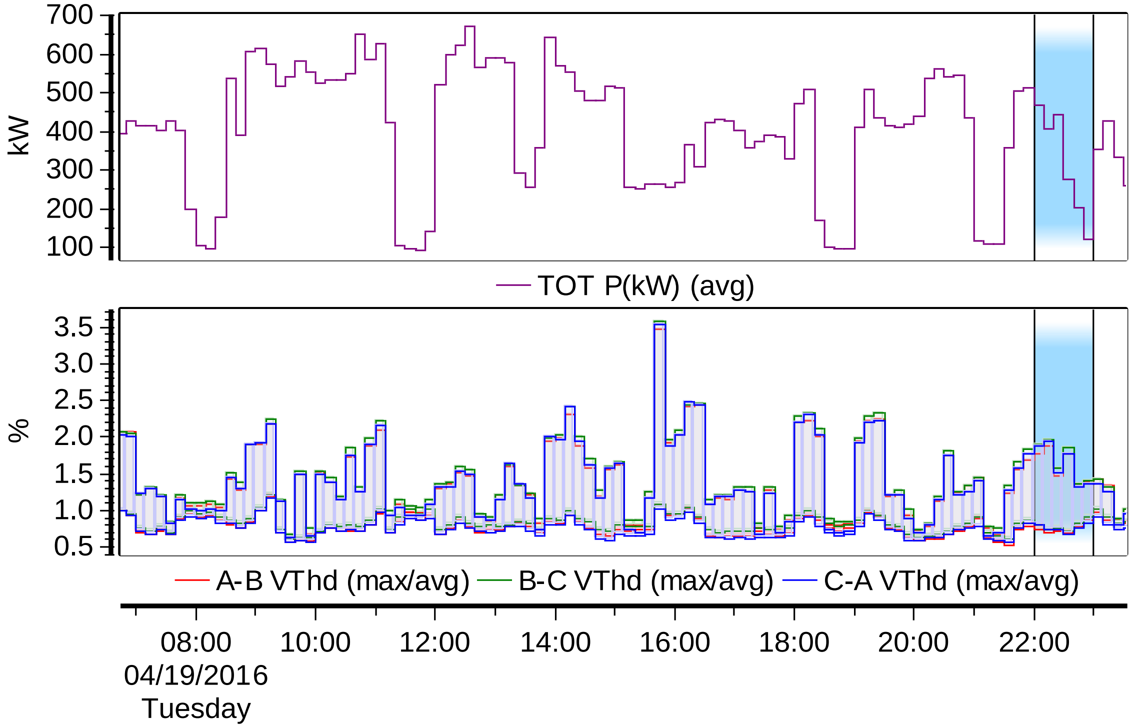


Figure 17. April 19 22:00-23:00 Customer 1 Turn Off Charging – PQ Meter Data

Test Event 4: Friday April 22 14:00-15:00 PDT – Discharge

a) SCE Meter Baseline Analysis

At first look, Figure 18 indicates a strong response to the "discharge" signal. However, usage actually drops significantly in the 30 minutes preceding the test event. Even from this lower start point for the event, the usage profile continued to drop in apparent response to the "discharge" signal before returning to minimum baseline levels in the period immediately following test event completion.

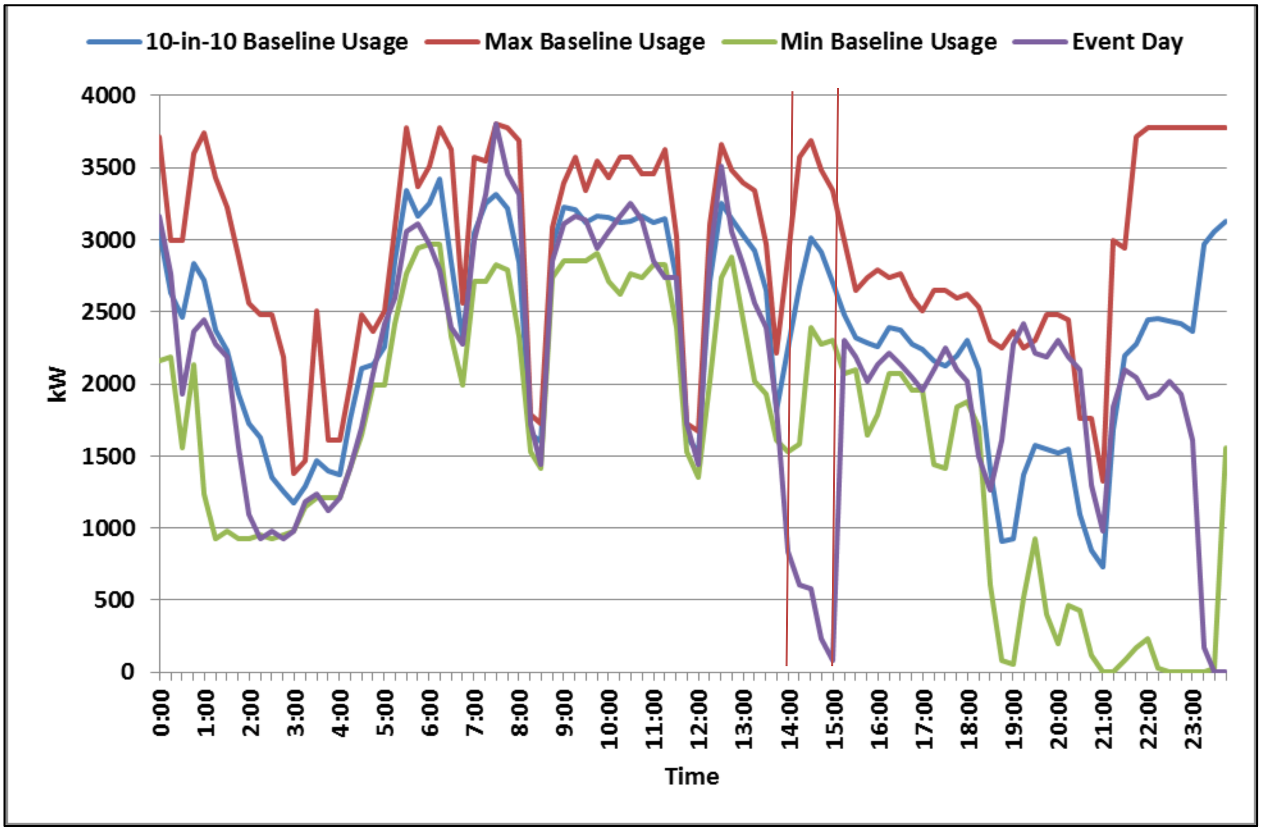


Figure 18. April 22 14:00-15:00 Customer 1 Discharge – SCE Meter Data

In Figure 19, as with the April 5 and April 19 events, the usage was so low at the start of the event that the baseline estimates for what usage would have been are relatively high. There is a discernable pattern of behavior similar to the April 12 event, where the batteries display some discharge response across the first 30 minutes of the event followed by an increased response during the final 30 minutes. Then, a return to more average usage is observed. Because the usage was so low at the start of the event, even the LA 10-in-10 taken from 15 minutes doesn't look quite right. If the LA 10-in-10 baseline methodology had been adjusted to start the baseline curve 30 minutes prior to event start, a typical DR pattern could have been observed. While this adjustment may look better on the graph, explanation as to why the battery would begin discharging 15 minutes prior to the start of the test event would still be necessary.

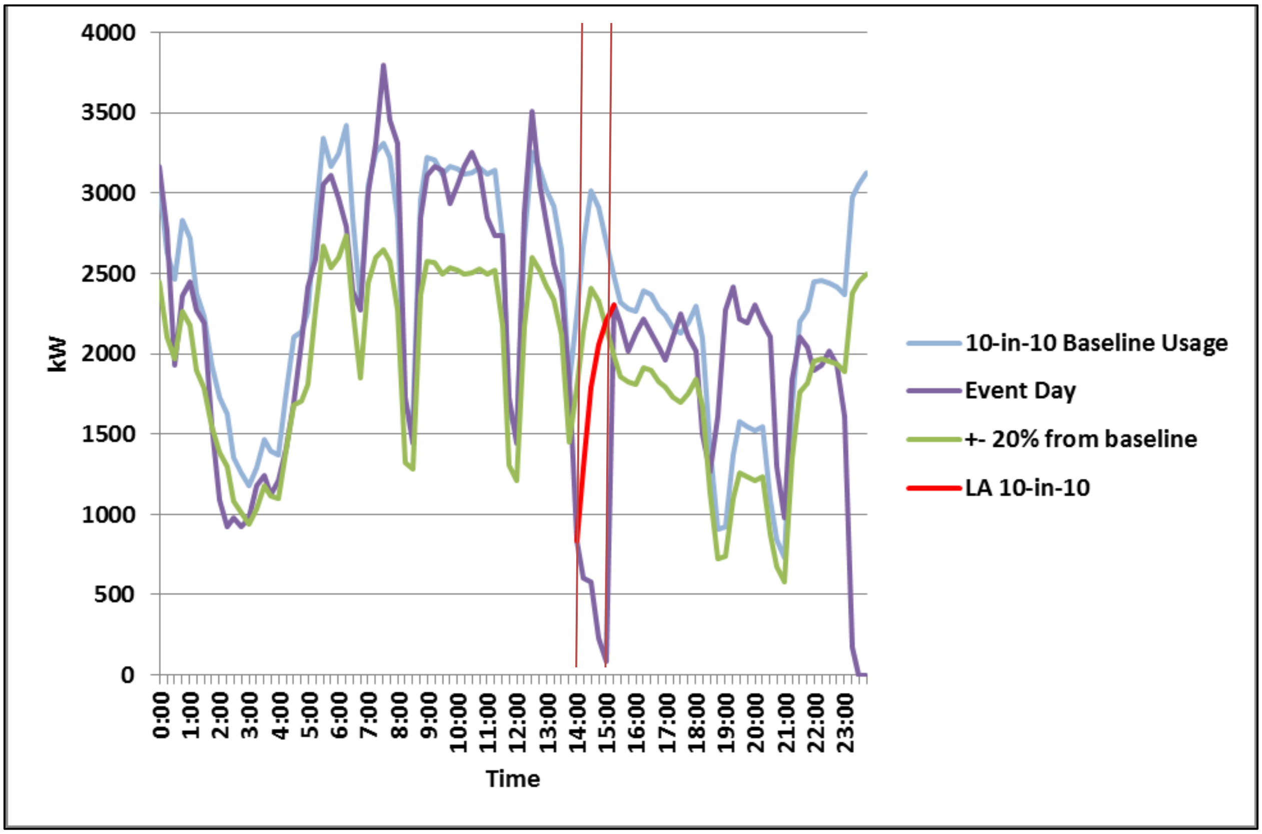


FIGURE 19. APRIL 22 14:00-15:00 CUSTOMER 1 DISCHARGE – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 7. APRIL 22 14:00-15:00 CUSTOMER 1 DISCHARGE – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CBP EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
13:45-14:00	835.20	-	-	-
14:00-14:15	604.80	(2,070.72)	(1,535.62)	(688.77)
14:15-14:30	576.00	(2,436.48)	(1,833.98)	(1,216.94)
14:30-14:45	230.40	(2,681.28)	(2,098.94)	(1,827.74)
14:45-15:00	86.40	(2,612.16)	(2,072.45)	(2,122.49)
15:00-15:15	2,304.00	-	-	-
Average kW	**374.40**	**(2,450.16)**	**(1,885.25)**	**(1,463.99)**
Average kWh	**374.40**	**(2,450.16)**	**(1,885.25)**	**(1,463.99)**
CBP Bid (kW)		(200)		
CBP Event Performance		**1225%**		

b) BATTERY ALCS BASELINE ANALYSIS

Figure 20 reveals that the event day usage profile shift is likely due to the battery discharge. The same problem is apparent here: the discharge behavior starts prematurely.

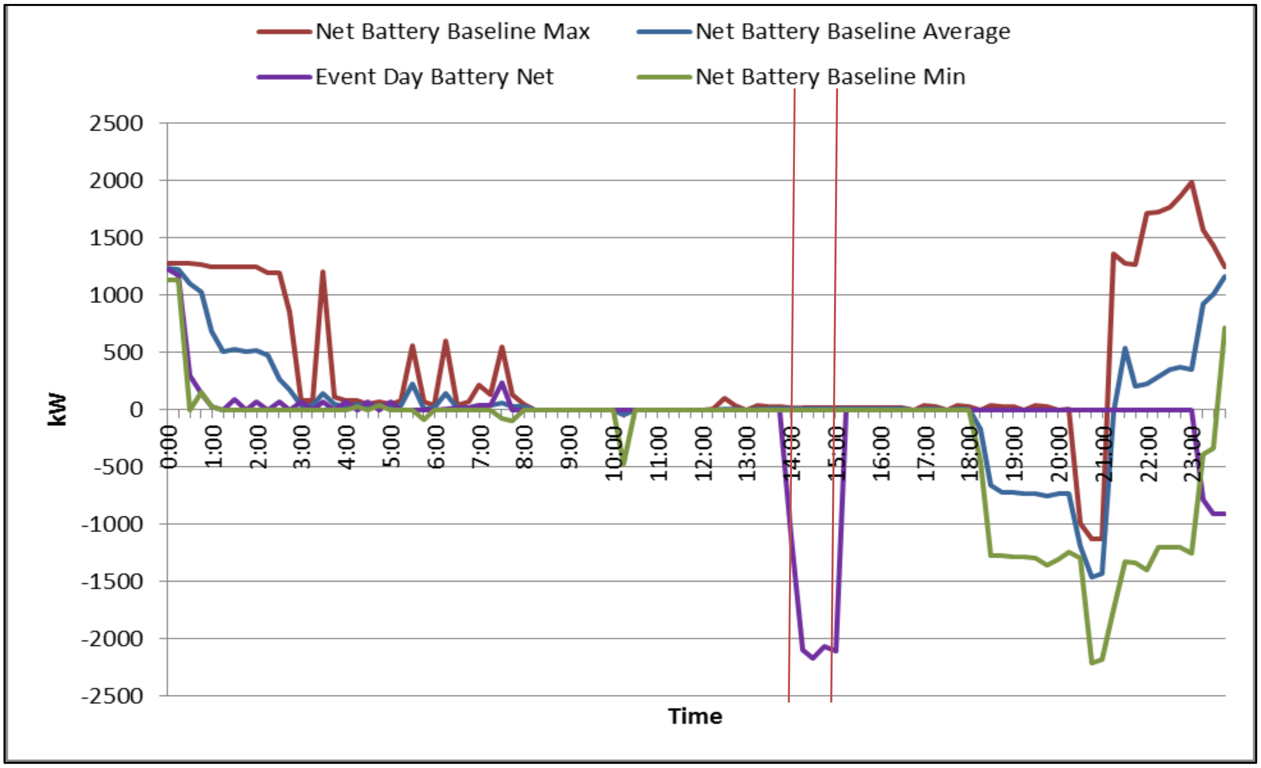


FIGURE 20. APRIL 22 14:00-15:00 CUSTOMER 1 DISCHARGE – BATTERY ALCS NET METER DATA

Figure 21, shows that the battery exported in seeming response to the “discharge” signal in a manner that was well outside of its baseline behavior pattern and in line with a discharge dispatch instruction.

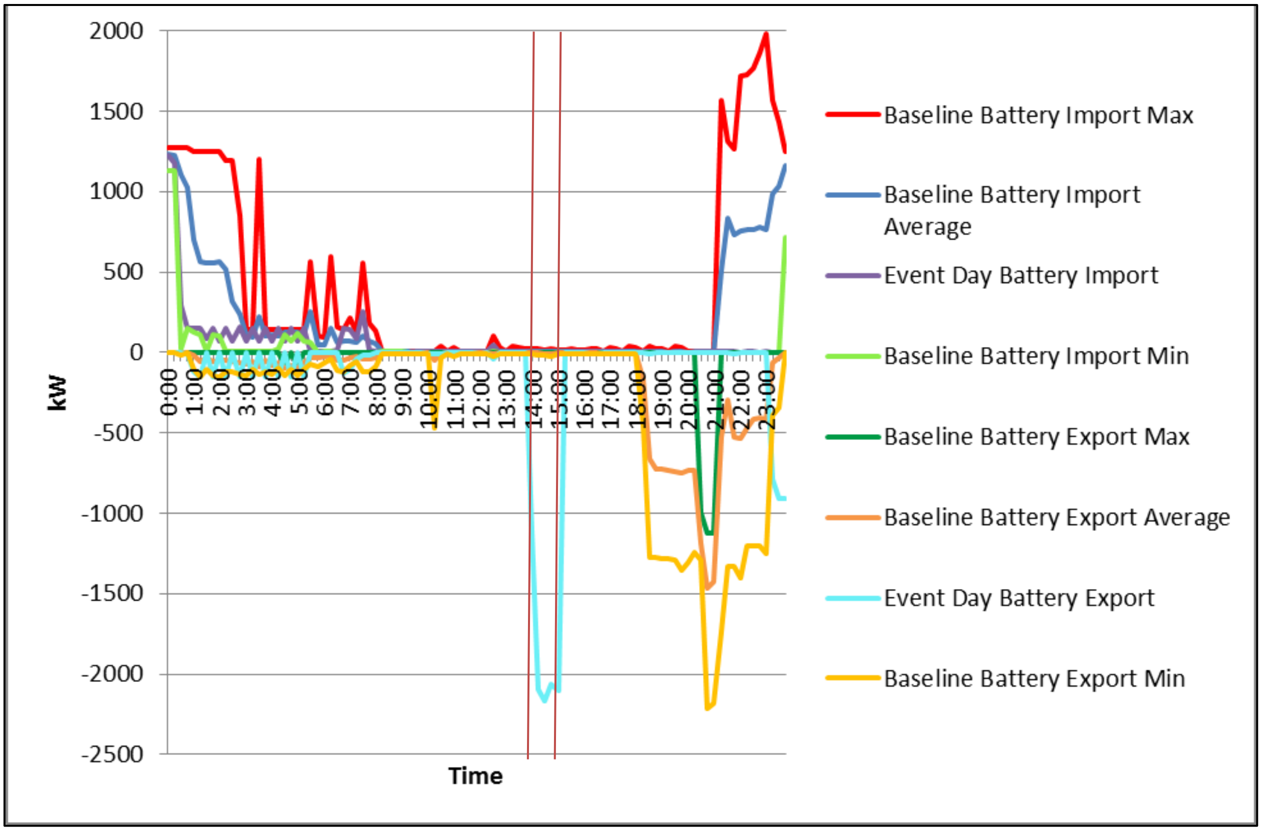


FIGURE 21. APRIL 22 14:00-15:00 CUSTOMER 1 DISCHARGE – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ Measurements

Because of the configuration of how the Customer 1 power monitoring device was monitoring the battery and facility load, the device was monitoring the net result of a portion of the facility load and the battery output. Therefore, the upper chart in Figure 22 does not align with the meter data from SCE or Battery ALCS shown in Figure 18 through Figure 21.

The lower chart in Figure 22 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during, and after the test event period.

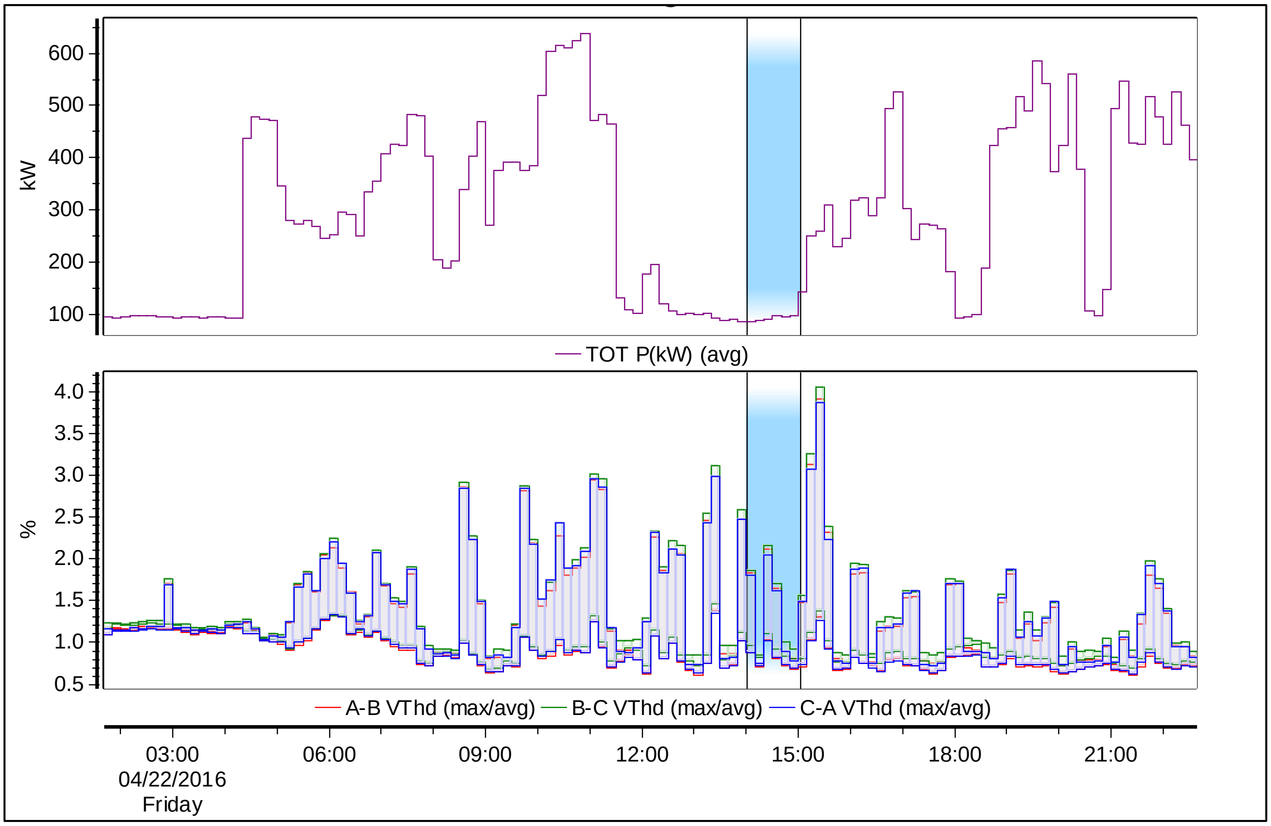


Figure 22. April 22 14:00-15:00 Customer 1 Discharge – PQ Meter Data

Test Event 5: Friday April 29, 22:00-23:00 PDT – Turn Off Charging

a) SCE Meter Baseline Analysis

In Figure 23, the event day usage is below the baseline minimum for the test period 22:00-23:00 PDT, before quickly ramping back up to near the baseline minimum over the next hour. There is no change in the usage profile across the 21:00-22:00 hour when compared with the event period. That the usage profile is so far below the minimum baseline usage, let alone at zero, indicates that the battery is likely in discharge mode and not charging, but that does not explain the usage from 21:00-22:00.

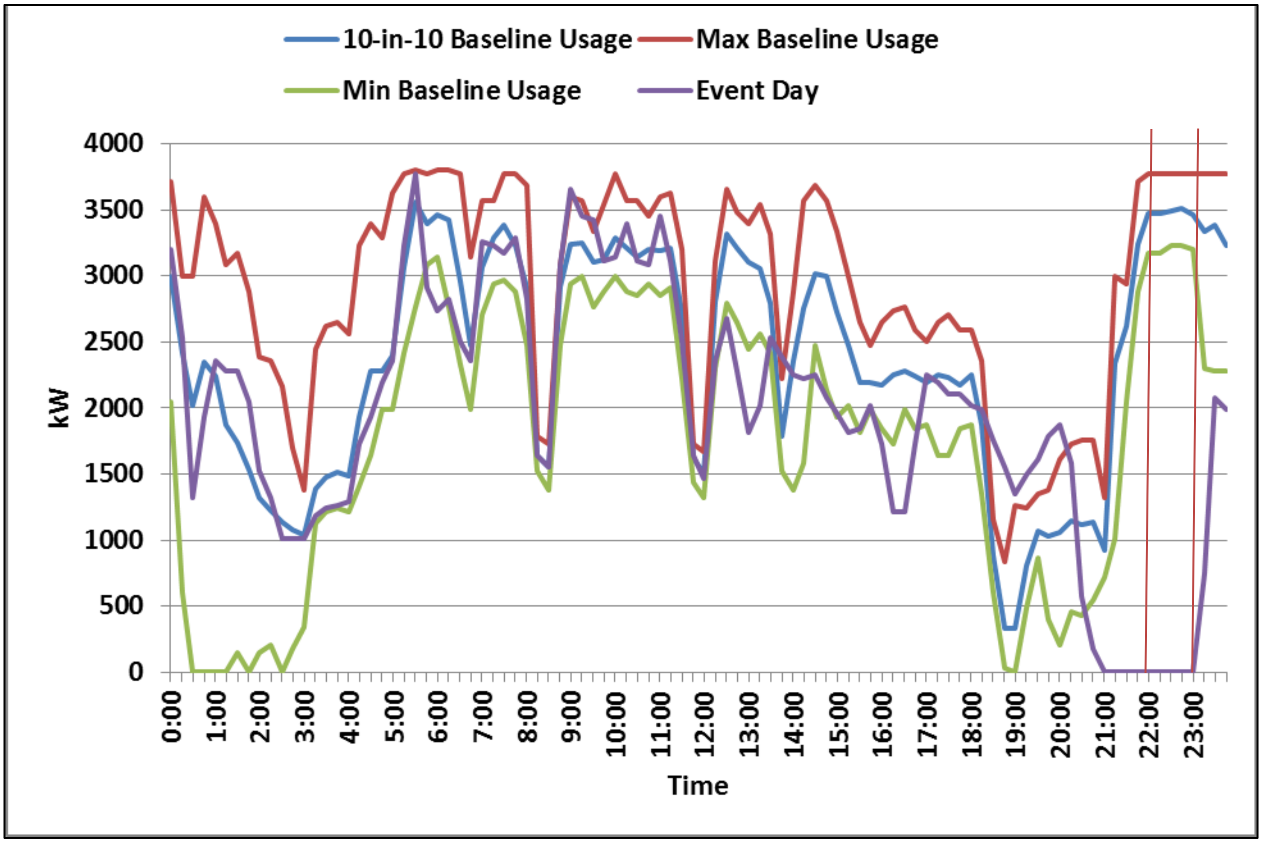


Figure 23. April 29 22:00-23:00 Customer 1 Turn Off Charging – SCE Meter Data

In Figure 24, as was the case with previous events, because usage was so low at the start of the event, the estimates for what usage would have been err on the high side. That the whole building usage is so close to zero is a strong indication that the net effect of the battery is negative.

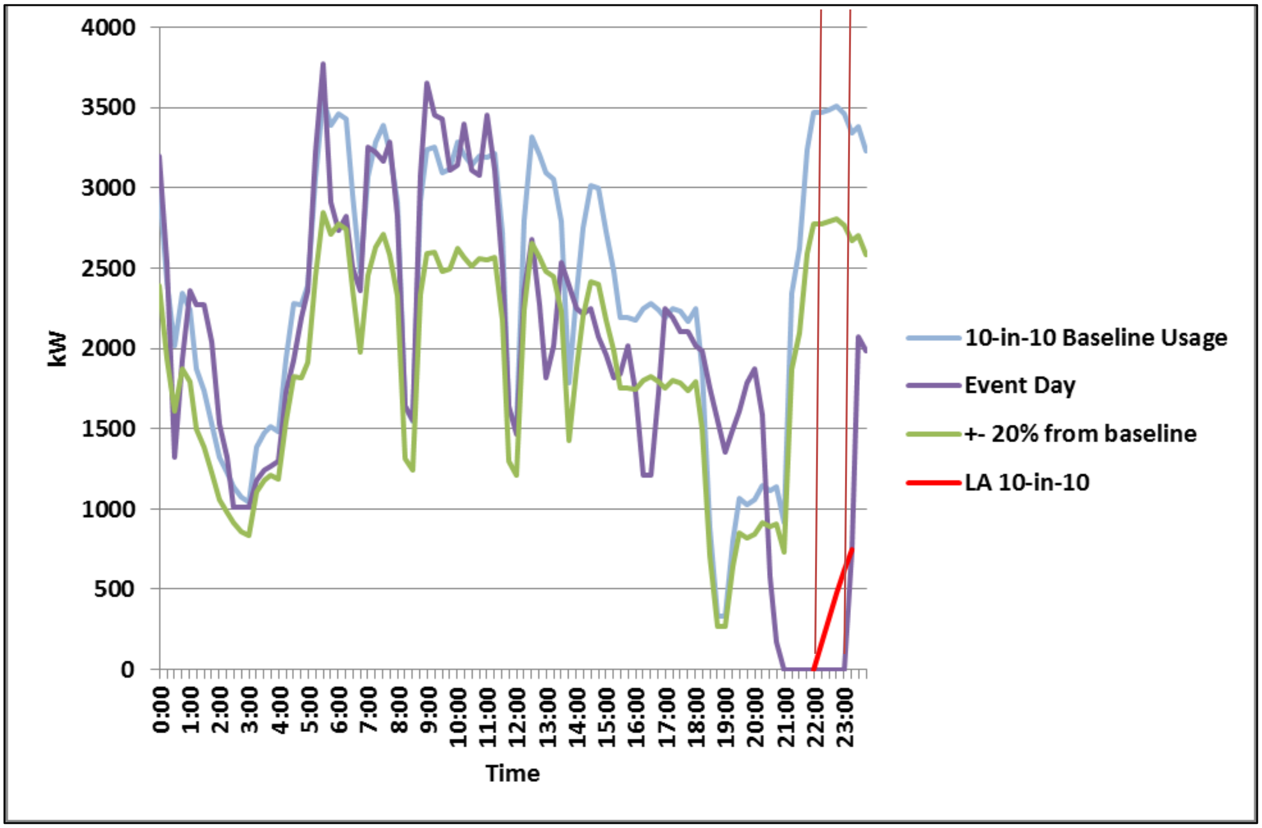


FIGURE 24. APRIL 29 22:00-23:00 CUSTOMER 1 TURN OFF CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 8. APRIL 29 22:00-23:00 CUSTOMER 1 TURN OFF CHARGING – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CBP EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
21:45-22:00	0.00	-	-	-
22:00-22:15	-	(3,467.52)	(2,774.02)	(155.44)
22:15-22:30	-	(3,487.68)	(2,790.14)	(312.69)
22:30-22:45	-	(3,507.84)	(2,806.27)	(471.74)
22:45-23:00	-	(3,458.88)	(2,767.10)	(620.21)
23:00-23:15	748.80	-	-	-
Average kW	**-**	**(3,480.48)**	**(2,784.38)**	**(390.02)**
Average kWh	**-**	**(3,480.48)**	**(2,784.38)**	**(390.02)**
CBP Bid (kW)		(200)		
CBP Event Performance		**1740%**		

b) Battery ALCS Baseline Analysis

Figure 25, reveals that there is a strong indication that the battery was effectively negative during the event period. While discharging the battery during a "Turn Off Charging" test event was allowed, it results in demand response observations that are not necessarily in line with the intended response to the "Turn Off Charging" dispatch signal.

It appears that a routine schedule has developed with the battery performance. The battery discharges from roughly 18:00-21:00, seemingly in line with the battery usage programming instructions, before recharging through the rest of the night. The event day profile is shifted two hours later in the day than any day in the baseline period. All of these factors are an indication that the site did respond to the "Turn Off Charging" signal, but that that pre-programmed response to the test event deviated the battery usage from the daily routine *prior to* initiation of the test event. This anticipatory response in advance of receiving the DR dispatch instruction significantly affects the M&V baselines which are used to estimate battery performance. In this case, the event day profile begins to vary significantly from the baseline 4 hours prior to the start of the event.

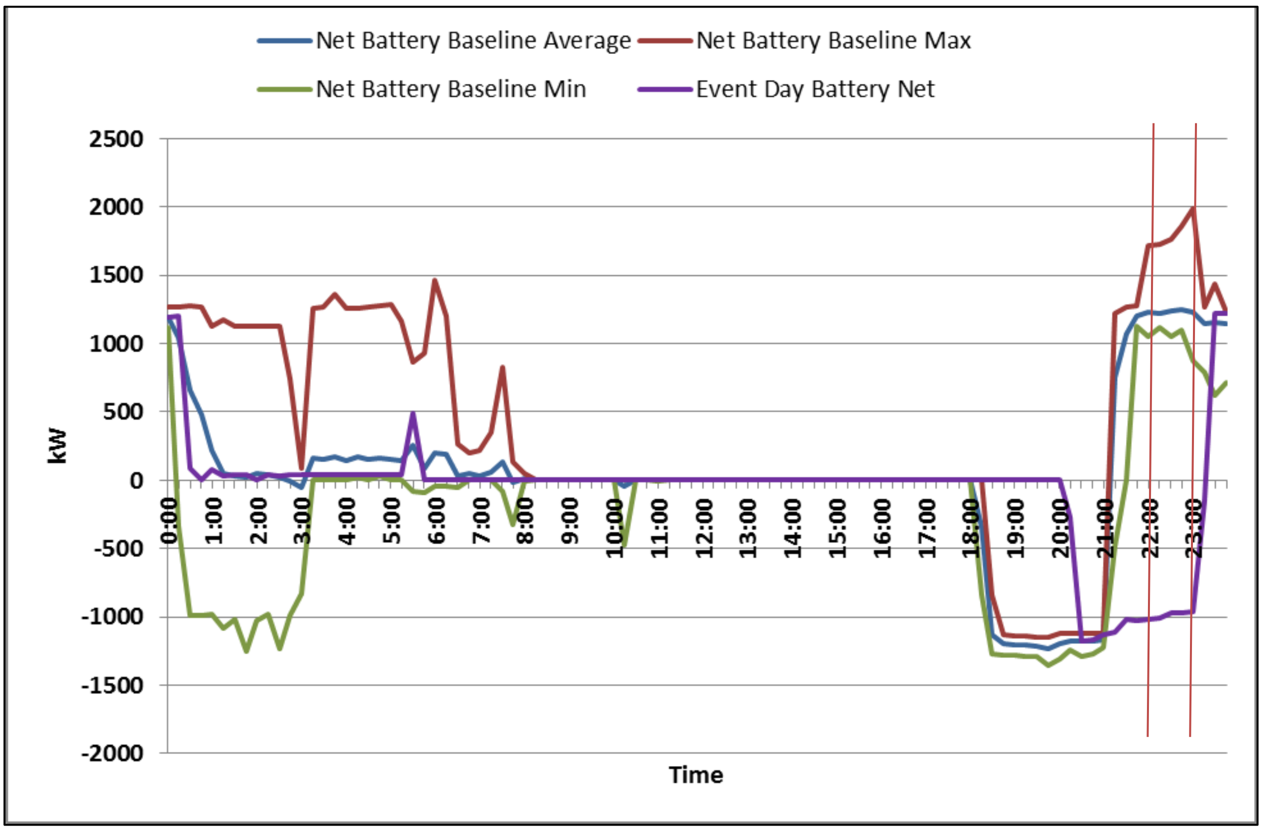


Figure 25. April 29 22:00-23:00 Customer 1 Turn Off Charging – Battery ALCS Net Meter Data

The Import/Export chart in Figure 26 supports the observations in the Net Profile, Figure 25. The battery system did not charge during the event period, but it did discharge when it had not previously discharged during that period.

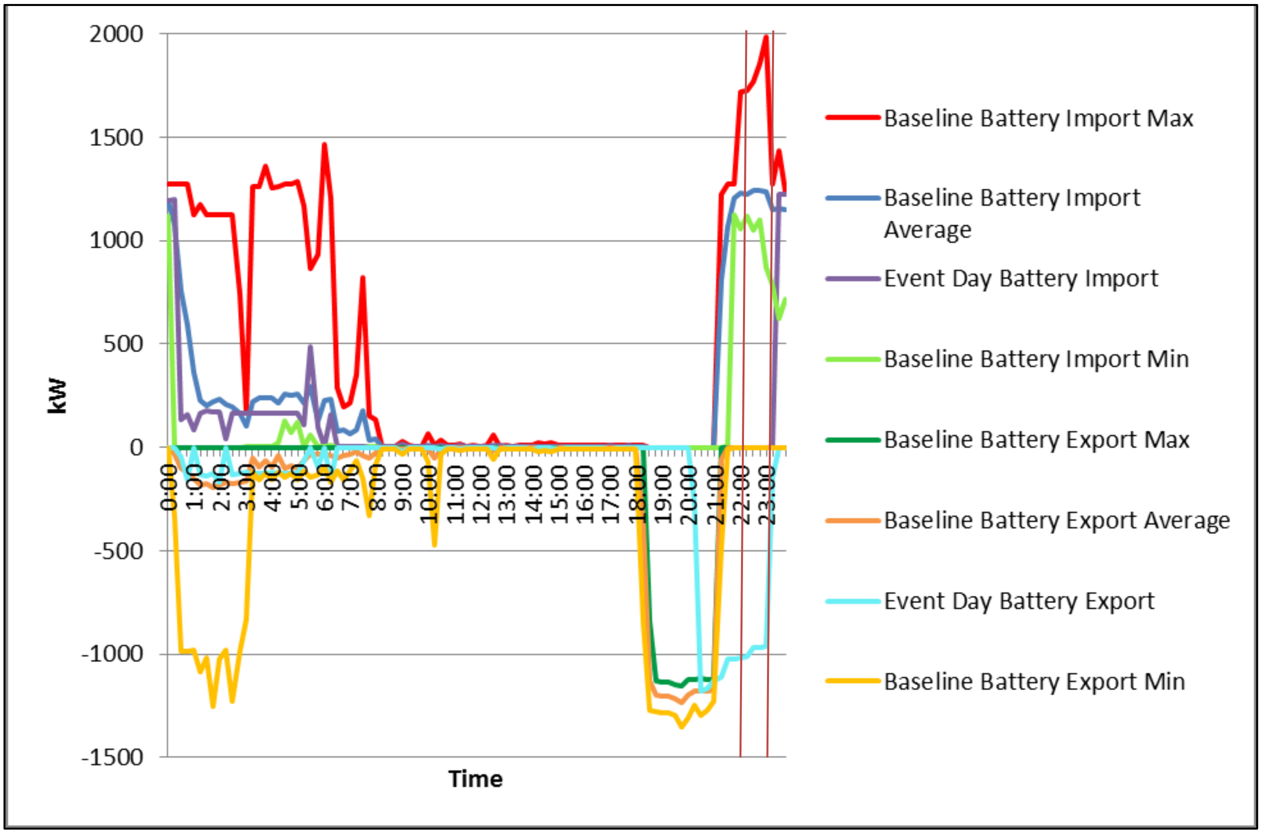


FIGURE 26. APRIL 29 22:00-23:00 CUSTOMER 1 TURN OFF CHARGING – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ Measurements

Because of the configuration of how the Customer 1 power monitoring device was recording the battery and facility load, the device was monitoring the net result of a portion of the facility load and the battery output. Therefore, the upper chart in Figure 27 does not align with the meter data from SCE or Battery ALCS shown in Figure 23 through Figure 26.

The lower chart in Figure 27 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during, and after the test event period.

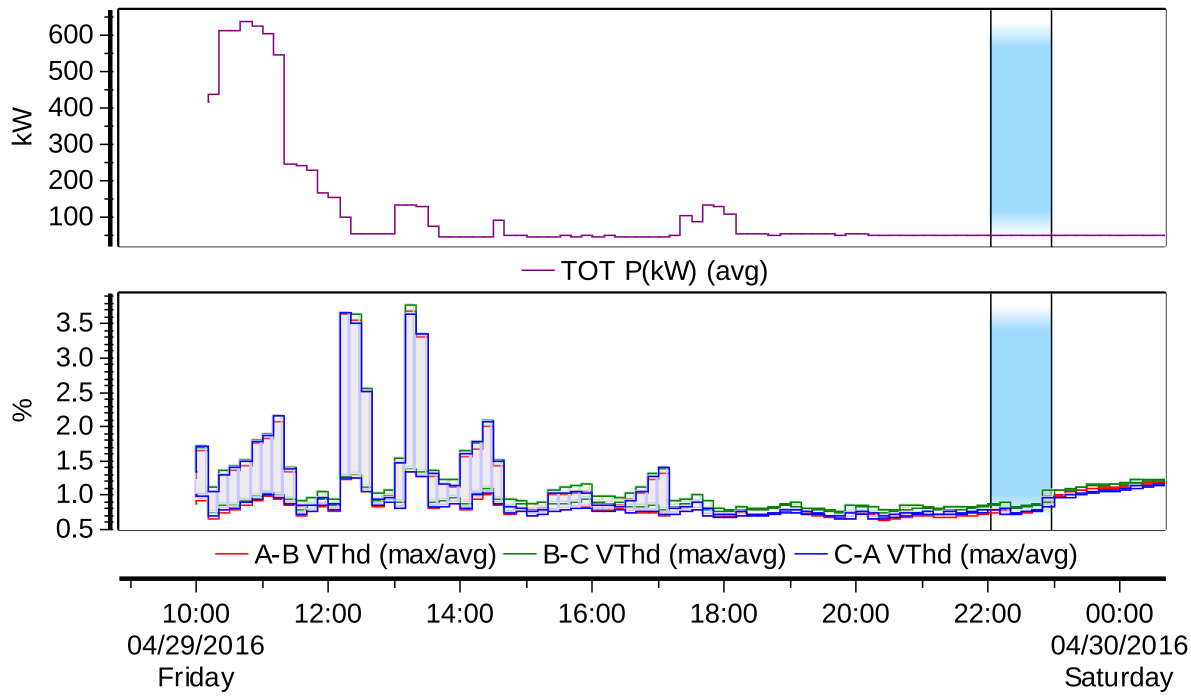


Figure 27. April 29 22:00-23:00 Customer 1 Turn Off Charging –PQ Meter Data

Test Event 6: Monday May 2, 14:00-15:00 PDT –Discharge

a) SCE METER BASELINE ANALYSIS

Figure 28 shows that actual day usage during the test event period indicates a good response to the "discharge" signal. Usage drops in each period from 14:00-15:00 before returning to a usage level more consistent with the baseline at 15:15. The event day appears to avoid the spike in usage around 14:30 which is apparent across all three baseline usage patterns. Usage following the event is slightly higher than observed usage during the baseline event. This may be due to battery recharge following the discharge during the event.

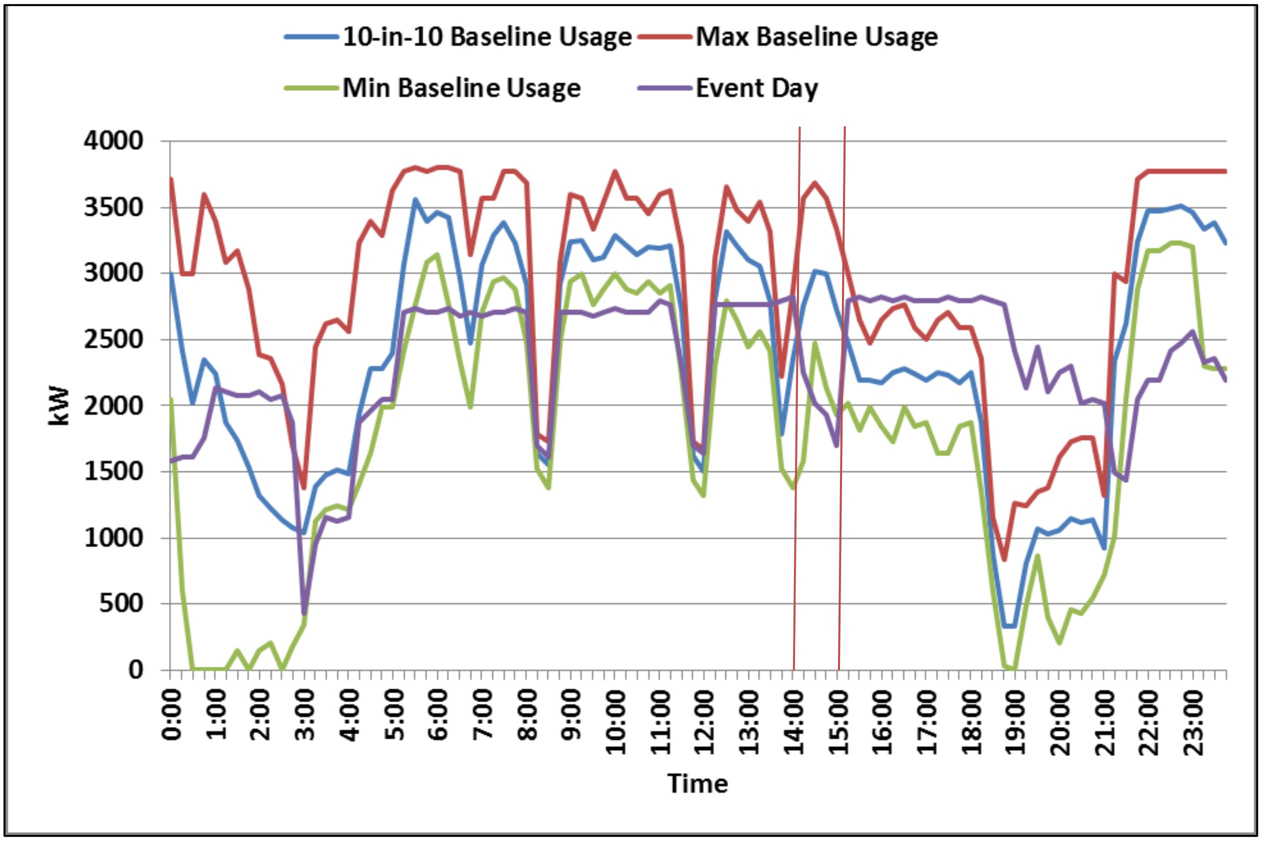


FIGURE 28. MAY 2 14:00-15:00 CUSTOMER 1 DISCHARGE – SCE METER DATA

Figure 29 shows that event day usage is much flatter when compared with the 10-in-10 baseline from 05:15-07:45, 8:30-10:00, and 12:15 through the event start at 14:00. The relatively flat usage from 12:15-14:00 deviates from the baseline pattern which shows a sharp decrease in usage between 13:00 and 13:45 before increasing to a peak at 14:15. This deviation from the baseline usage pattern influences both the ± *20% from baseline* and the LA 10-in-10 baseline. As a result, because the usage was higher than the baseline at the start of the test event, the ± *20% from baseline* and the LA 10-in-10 baseline show higher estimates of what usage might have been in the absence of a DR test event than the regular 10-in-10 baseline. This is despite the fact that event day usage was consistently below the 10-in-10 throughout the event day. However, the 10-in-10 baseline usage average shows a peak from 14:00-1500 compared to the event day usage decrease attributable to the "Discharge" event response. The battery likely helped to regulate building load on the event day based on the flat usage patterns with the regular dips in usage shown in the baselines.

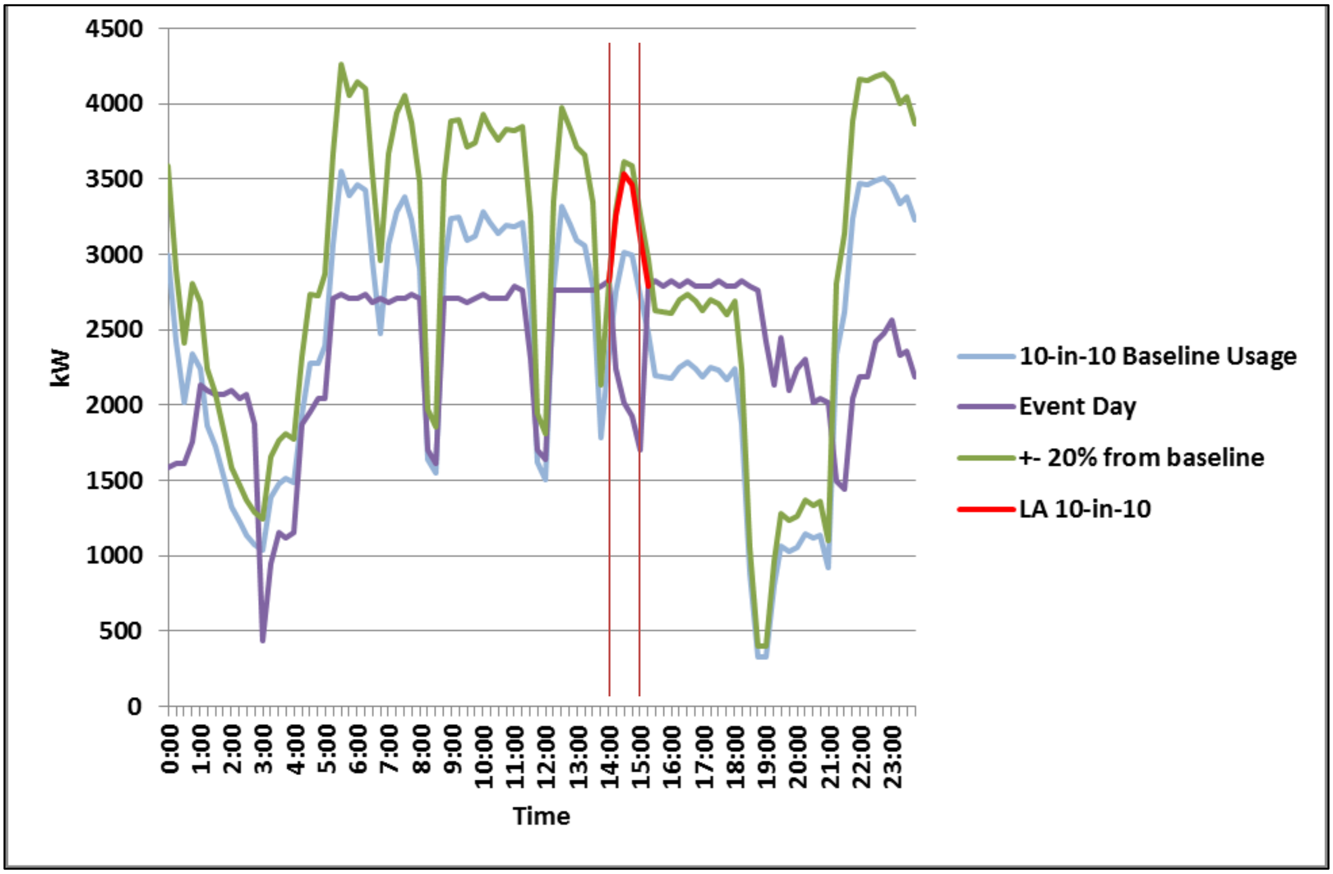


FIGURE 29. MAY 2 14:00-15:00 CUSTOMER 1 DISCHARGE – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 9. MAY 2 14:00-15:00 CUSTOMER 1 DISCHARGE – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CBP EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
13:45-14:00	2,822.40	466.56	-	-
14:00-14:15	2,246.40	(504.00)	(1,048.70)	(1,010.12)
14:15-14:30	2,016.00	(1,002.24)	(1,599.98)	(1,515.31)
14:30-14:45	1,929.60	(1,068.48)	(1,662.23)	(1,536.07)
14:45-15:00	1,699.20	(1,025.28)	(1,564.85)	(1,411.98)
15:00-15:15	2,793.60	316.80		-
Average kW	1,972.80	(900.00)	(1,468.94)	(1,368.37)
Average kWh	1,972.80	(900.00)	(1,468.94)	(1,368.37)
CBP Bid (kW)		(200)		
CBP Event Performance		**450%**		

b) Battery ALCS Baseline Analysis

In Figure 30, the impact of this DR event would best be measured by removing the battery charging peaks at 13:45 and the 15:15-15:30 shown in net battery impacts. These spikes artificially improve the perceived impact of the test event by inflating the usage profile against which the event performance is judged.

Additionally, the battery was discharged to regulate the peaks throughout the day prior to the start of the event. If this was the standard battery routine and reflected in the historical baseline, the M&V for the DR event would be more representative of actual battery performance. During this event, the battery system did not discharge from 18:00-21:00 in its usual fashion, but instead appears to be recovering from the discharge event by charging during portions of that evening period.

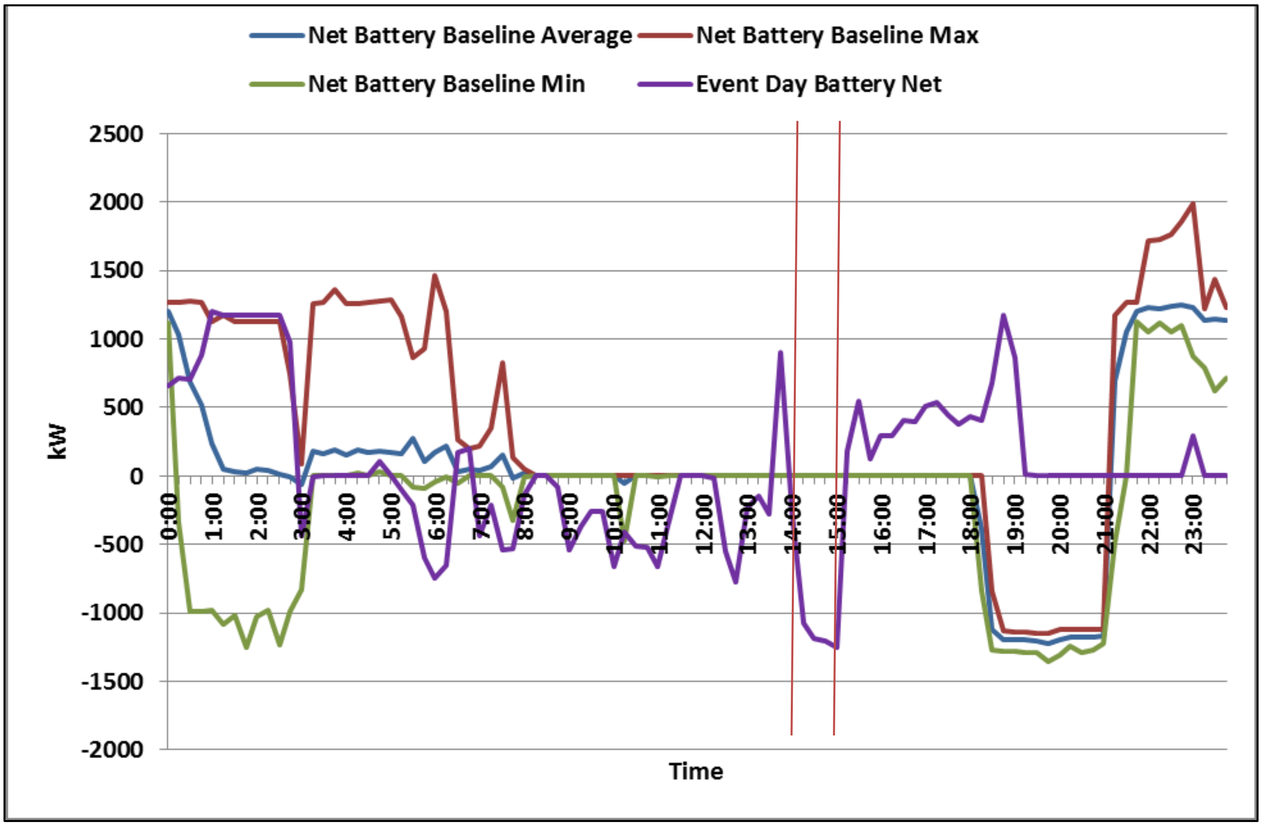


FIGURE 30. MAY 2 14:00-15:00 CUSTOMER 1 DISCHARGE – BATTERY ALCS NET METER DATA

The Import Export Chart in Figure 31 supports the findings outlined in the Net Battery Profile.

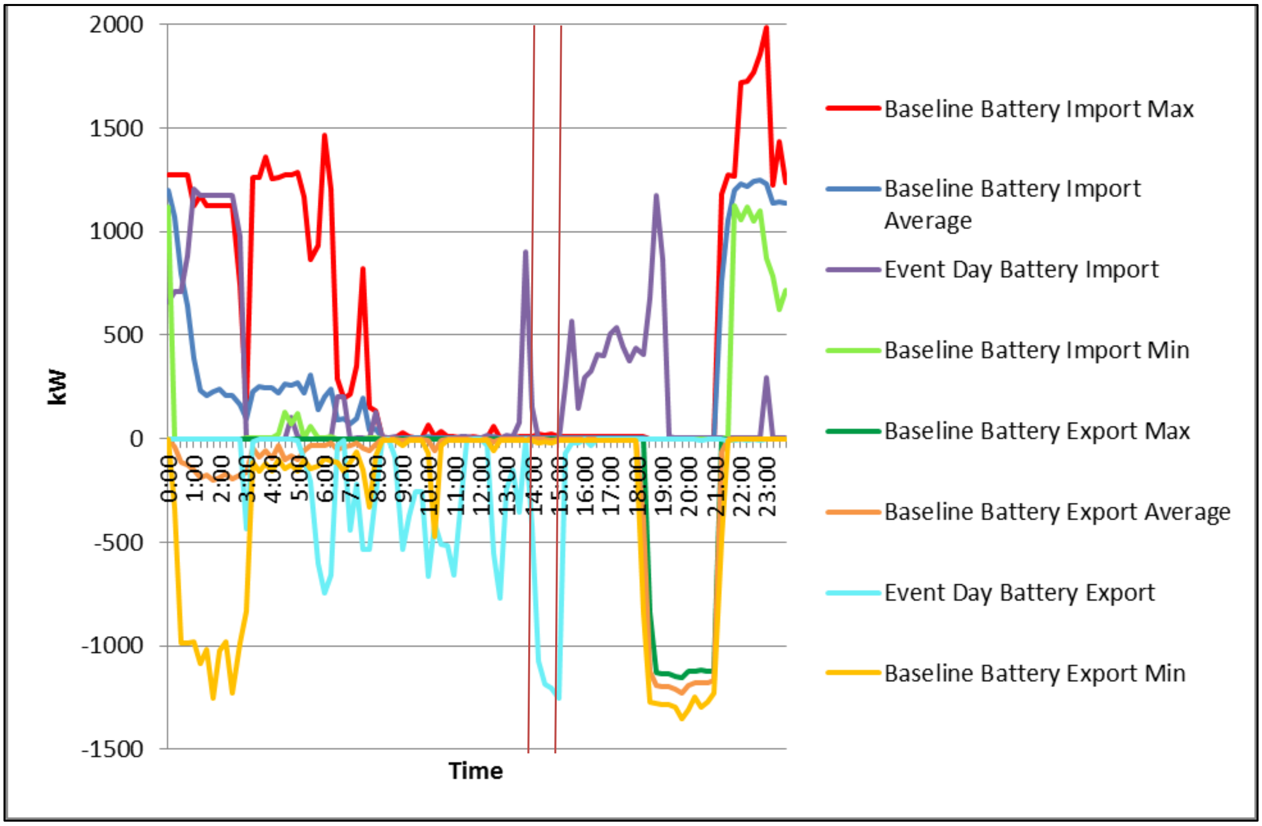


FIGURE 31. MAY 2 14:00-15:00 CUSTOMER 1 DISCHARGE – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ Measurements

Because of the configuration of how the Customer 1 power monitoring device was recording the battery and facility load, the device was monitoring the net result of a portion of the facility load and the battery output. Therefore, the upper chart in Figure 32 does not align with the meter data from SCE or Battery ALCS results shown in Figure 28 through Figure 31.

The lower chart in Figure 32 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during, and after the test event period.

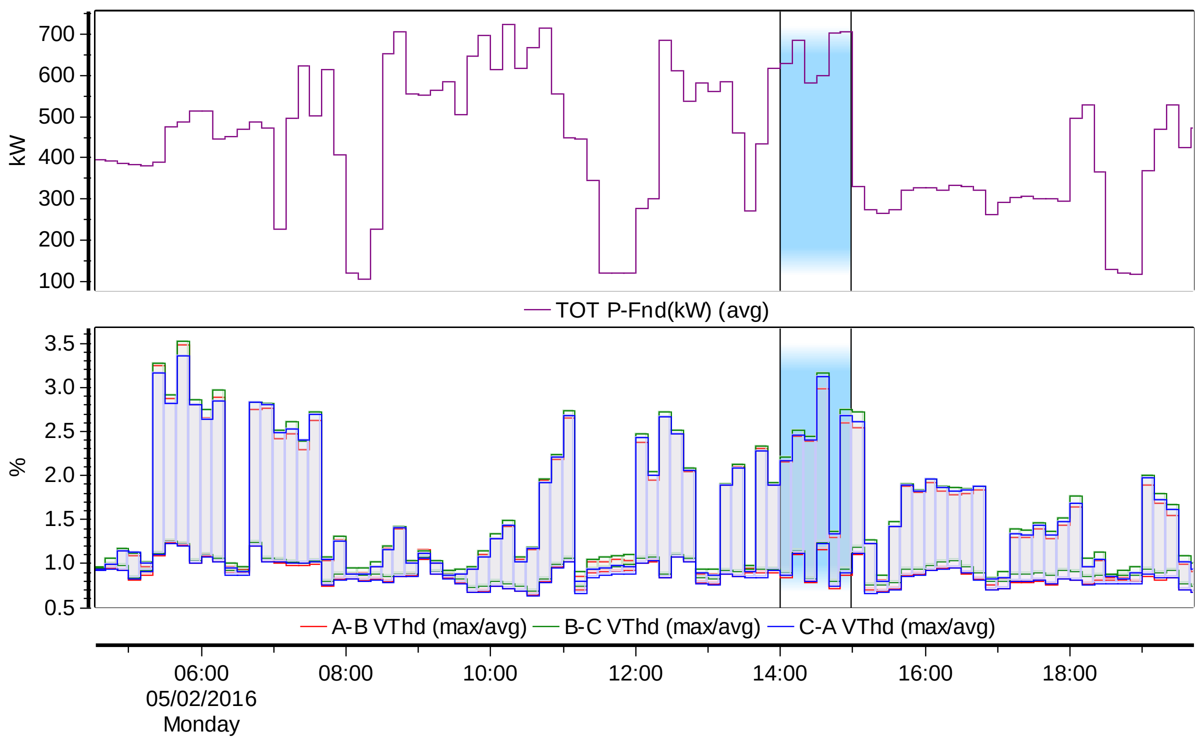


Figure 32. May 2 14:00-15:00 Customer 1 Discharge–PQ Meter Data

TEST EVENT 7: FRIDAY MAY 6, 3:00-4:00 PDT – START CHARGING

a) SCE METER BASELINE ANALYSIS

Figure 33 displays a dramatic increase in usage on event day across the 3:00-3:15 period which indicates a good response to the Start Charging signal. However, that usage pattern is similarly observed in the Max Baseline Usage curve and to a lesser extent in the 10-in-10 and Min Baseline Usage curves. All of the baseline curves reflect a sharp uptick in usage during this period, followed by relatively stable profiles from 3:15-4:00.

The event day usage deviates from the baseline patterns with the mostly flat usage immediately following the event. In the baseline curves, usage continued to increase until maximizing around 5:30; that was not the case on event day.

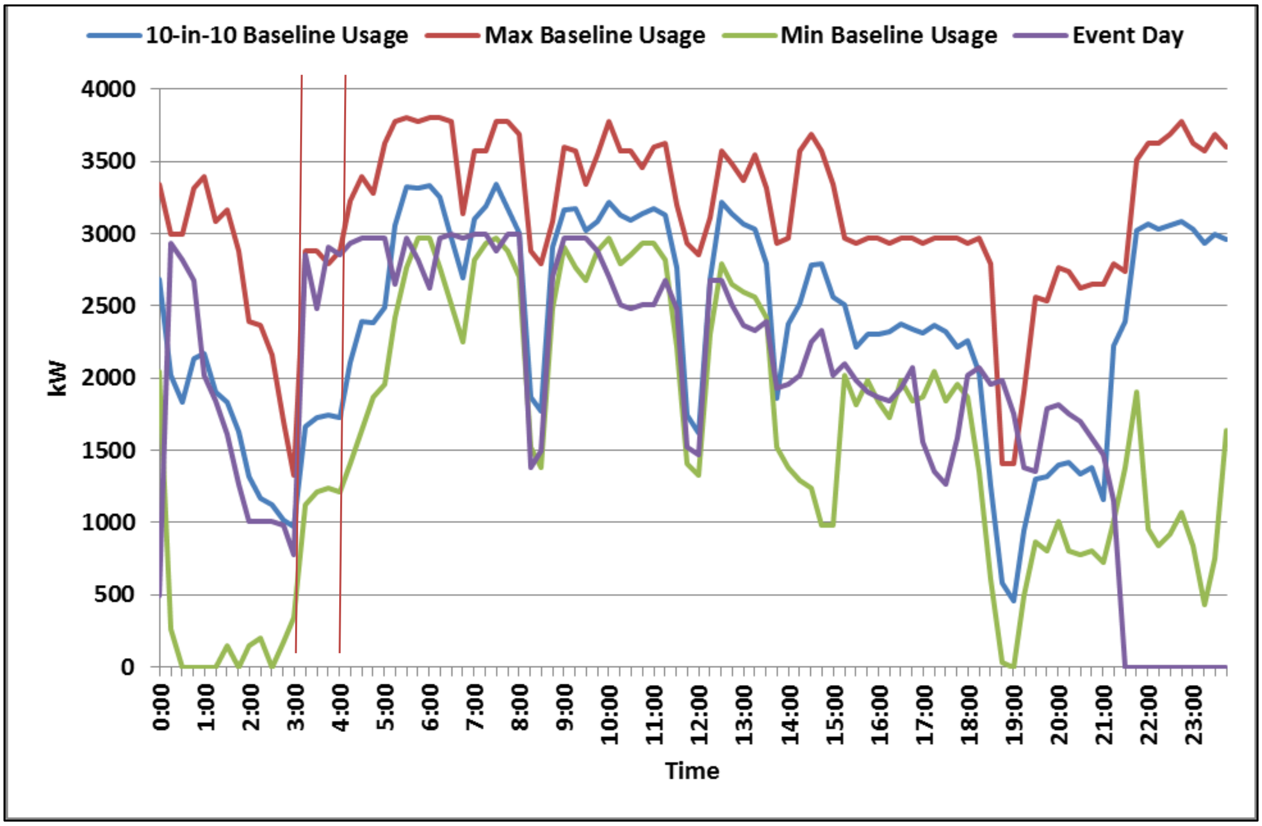


FIGURE 33. MAY 6 03:00-04:00 CUSTOMER 1 START CHARGING – SCE METER DATA

The desired impact of a Start Charging signal is to increase the energy consumption by the participating customer. Figure 34 illustrates that the event day usage increased above the 10-in-10 baseline for the test event despite beginning with lower usage. That increase was still within the maximum bound of what was observed during the baseline period. The other complication in assessing the performance of this event is the continuance of higher than baseline usage immediately following the test event. Without clear insight into the typical charging pattern of the battery, it is expected that the profile will return to the average 10-in-10 baseline following the completion of the event. Instead, usage remains high.

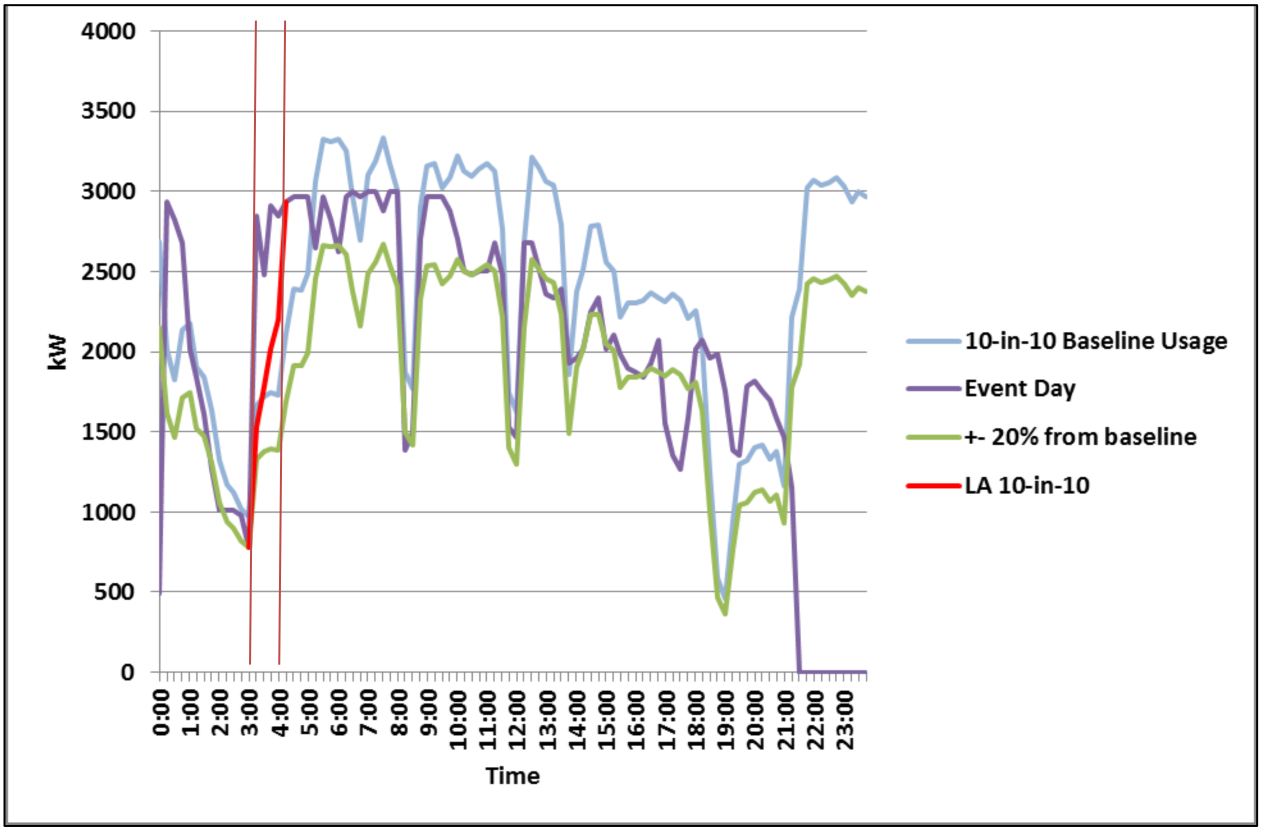


FIGURE 34. MAY 6 03:00-04:00 CUSTOMER 1 START CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 10. MAY 6 3:00-4:00 CUSTOMER 1 START CHARGING – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CBP EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
2:45-3:00	777.60	-	-	-
3:00-3:15	2,851.20	1,186.56	1,517.51	1,320.97
3:15-3:30	2,476.80	754.56	1,096.96	690.27
3:30-3:45	2,908.80	1,166.40	1,512.81	895.63
3:45-4:00	2,851.20	1,123.20	1,466.75	650.64
4:00-4:15	2,937.60	-		-
Average kW	**2,772.00**	**1,057.68**	**1,398.51**	**889.38**
Average kWh	**2,772.00**	**1,057.68**	**1,398.51**	**889.38**
CBP Bid (kW)		200		
CBP Event Performance		**529%**		

b) Battery ALCS Baseline Analysis

Figure 35 displays the results from Battery ALCS system across the test event day. The observation from indicates that the actual building usage stayed steady following the test event shown in the Event Day Battery Net curve with increased battery usage (Import) from 3:00-3:15 followed by a slow descent back to neutral around 5:30. However, the Net Battery Baseline Average and Max curves show a similar pattern. Since the actual test event day battery usage does not vary significantly over the event period compared to the Net Battery Baseline Max profile, it is difficult to differentiate the possible increase in performance of the battery in response to the Start Charging signal from the performance of the baseline max.

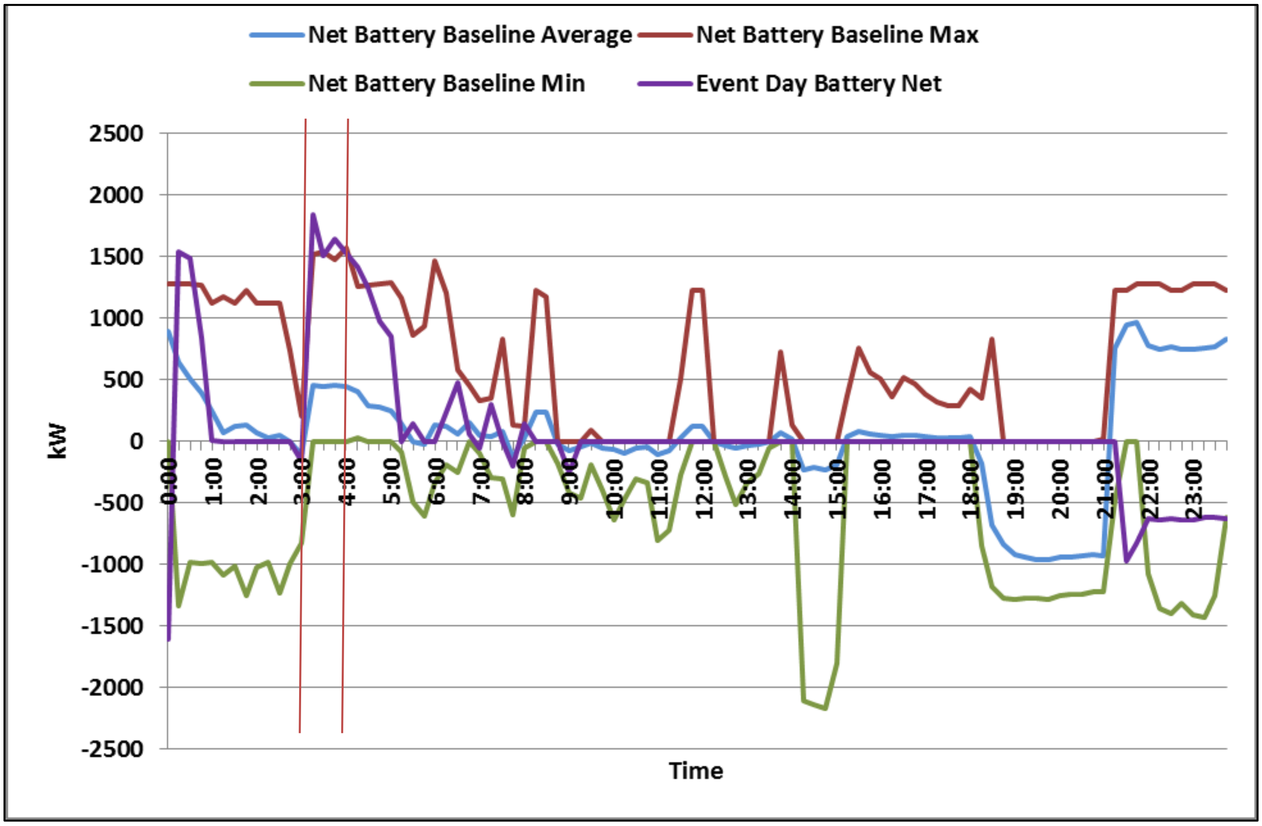


Figure 35. May 6 03:00-04:00 Customer 1 Start Charging – Battery ALCS Net Meter Data

The Import Export chart, Figure 36, supports the observations from the net battery profile in Figure 35.

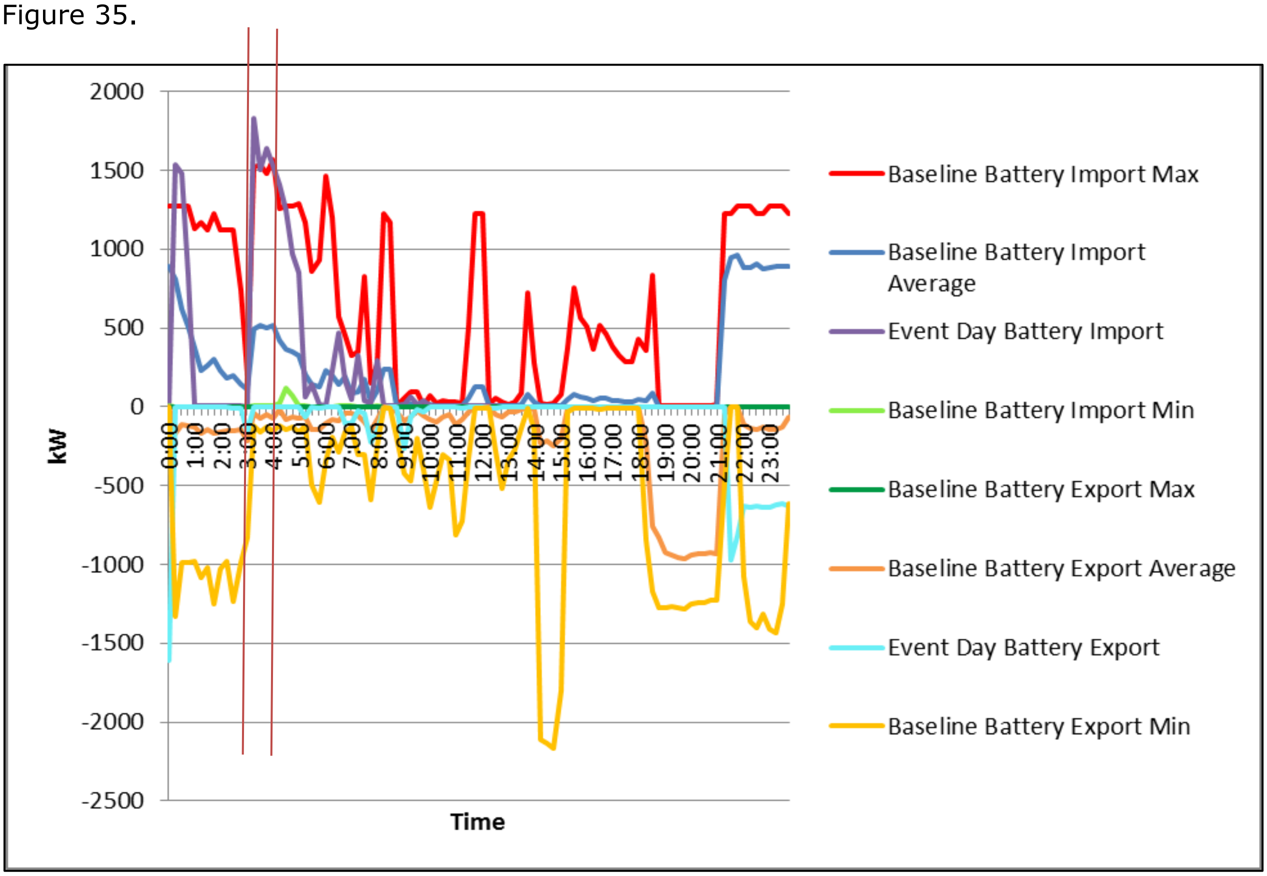


FIGURE 36 MAY 6 03:00-04:00 CUSTOMER 1 START CHARGING – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ Measurements

Because of the configuration of how the Customer 1 power monitoring device was recording the battery and facility load, the device was monitoring the net result of a portion of the facility load and the battery output. Therefore, the upper chart in Figure 37 does not align with the meter data from SCE or Battery ALCS system results shown in Figure 33 through Figure 36.

The lower chart in Figure 37 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during and after the test event period.

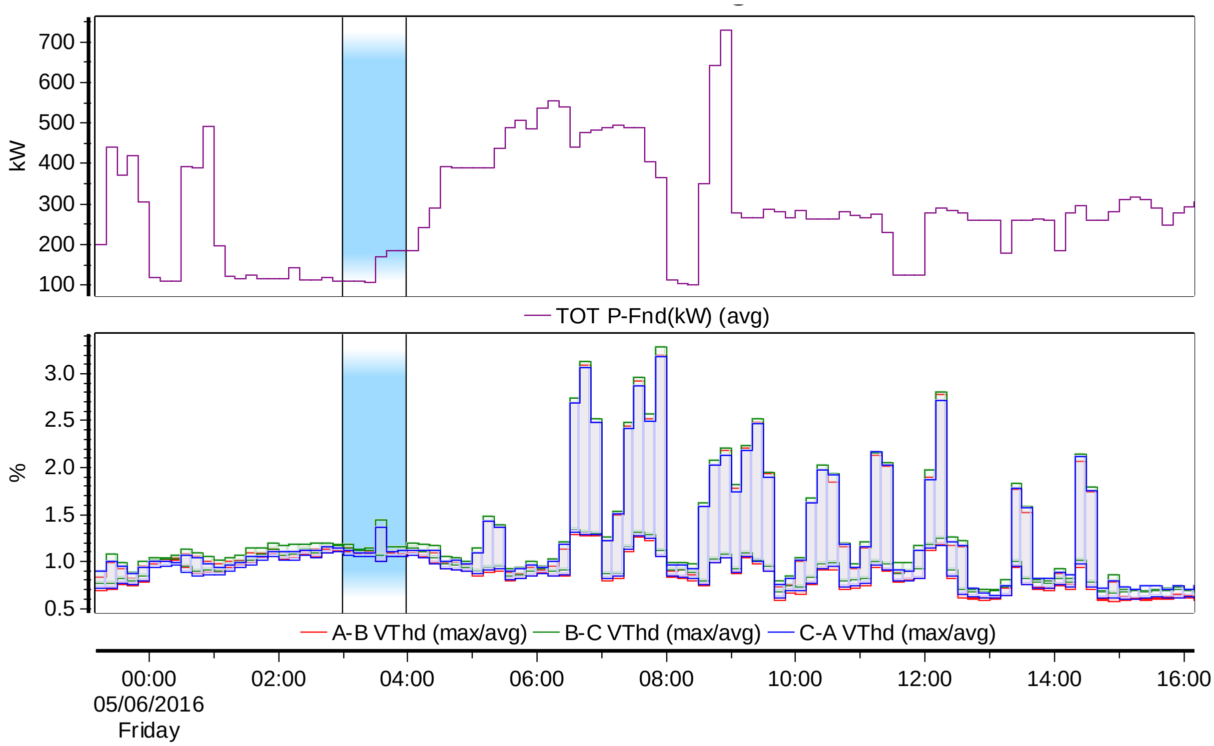


FIGURE 37. MAY 6 3:00-4:00 CUSTOMER 1 START CHARGING –PQ METER DATA

TEST EVENT 8: TUESDAY MAY 10, 22:00-23:00 PDT – TURN OFF CHARGING

a) SCE METER BASELINE ANALYSIS

Figure 38 shows usage steadily decreases during the event period from 22:00-23:00, although, usage is still between the average and minimum baseline usage throughout the event. Each 15-minute period during the event uses less energy than its preceding period. However, usage continues steadily drop even after the event concludes.

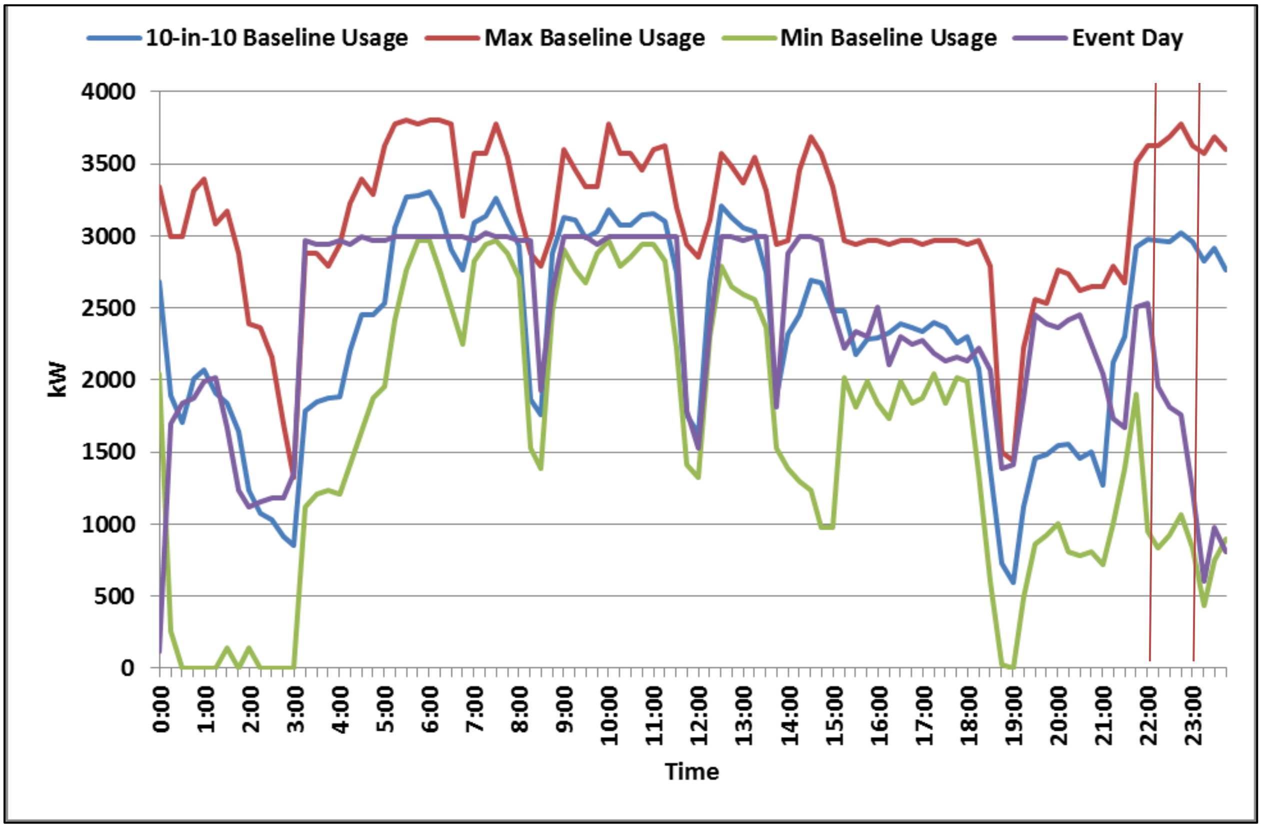


FIGURE 38. MAY 10 22:00-23:00 CUSTOMER 1 TURN OFF CHARGING – SCE METER DATA

Figure 39 illustrates the 10-in-10 baseline and the ±20% from baseline clearly showing a relatively flat usage profile across 22:00-23:00 and providing a choice of baseline options. However, due to the steady and continuing usage decrease during and after the test event, the LA 10-in-10 looks quite similar to the event day profile with a steady drop from 22:00-23:15.

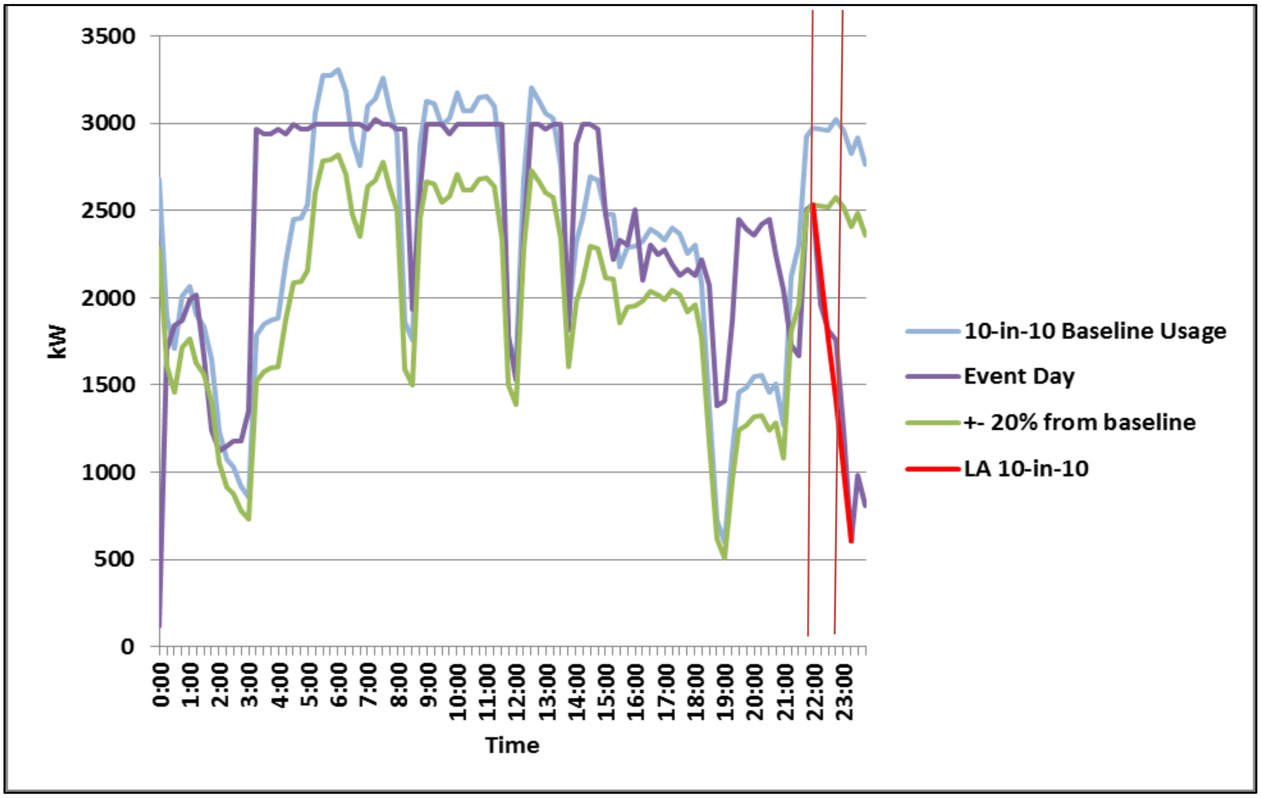


FIGURE 39. MAY 10 22:00-23:00 CUSTOMER 1 TURN OFF CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 11. MAY 10 22:00-23:00 CUSTOMER 1 TURN OFF CHARGING – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CBP EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
21:45-22:00	2,534.40	-	-	-
22:00-22:15	1,958.40	(1,008.00)	(568.64)	(190.23)
22:15-22:30	1,814.40	(1,146.24)	(707.73)	47.61
22:30-22:45	1,756.80	(1,267.20)	(819.31)	337.95
22:45-23:00	1,238.40	(1,719.36)	(1,281.28)	227.94
23:00-23:15	604.80	-	-	-
Average kW	**1,692.00**	**(1,285.20)**	**(844.24)**	**105.82**
Average kWh	**1,692.00**	**(1,285.20)**	**(844.24)**	**105.82**
CBP Bid (kW)		(200)		
CBP Event Performance		**643%**		

b) Battery ALCS Baseline Analysis

Figure 40 reveals that the battery was not charging prior to or during the event. Essentially, there was no load adjustment from a "Turn Off Charging" dispatch because the battery was not charging at the time. There is a slight charge at 22:15 that appears to be in contradiction to the "Turn Off Charging" signal. Additionally, the battery did not charge following the event as it did during the average baseline period. Instead, the battery enters a discharge period after the test event. While there is a precedent for the battery discharge at 23:00, it is unexpected.

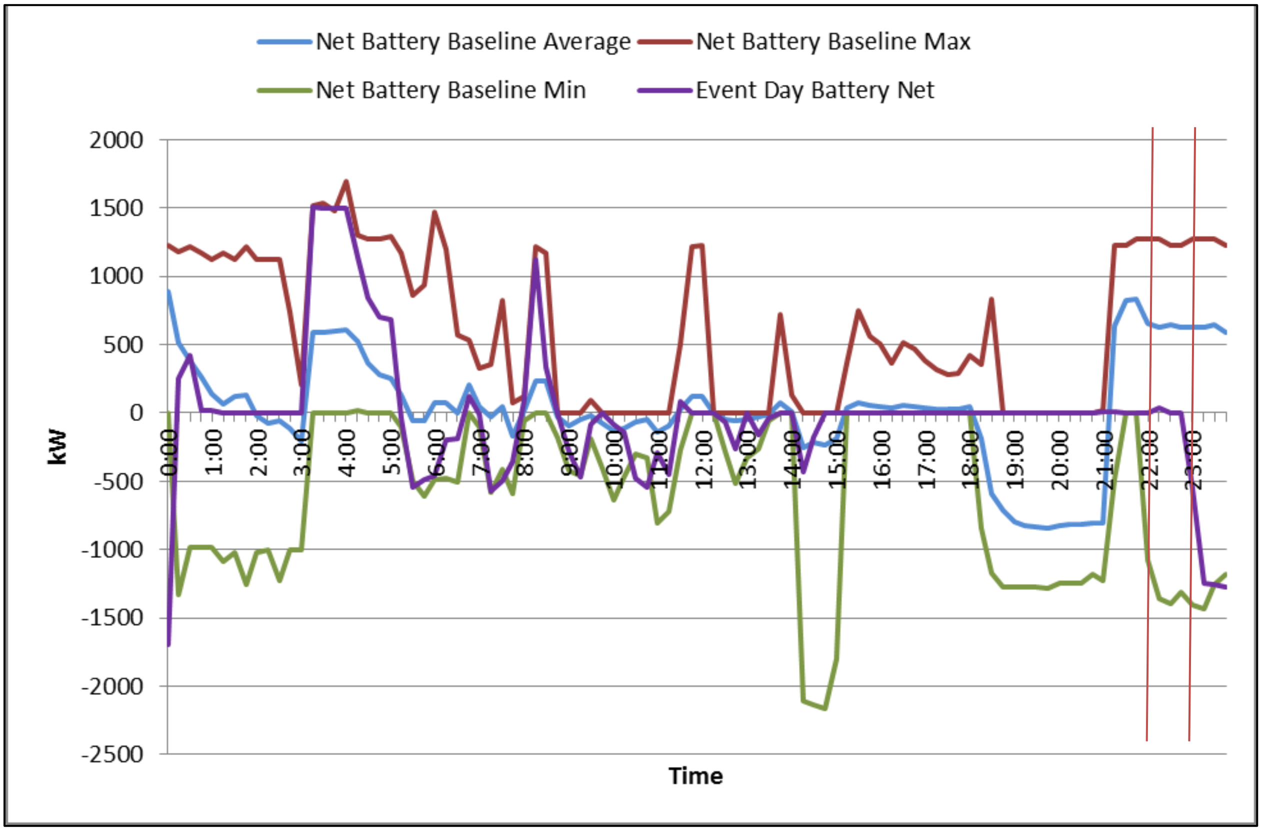


Figure 40. May 10 22:00-23:00 Customer 1 Turn Off Charging – Battery ALCS Net Meter Data

Figure 41 displays a slight bump in event day charge at 22:15 indicating that the battery charged a little bit during the "Turn Off Charging" event.

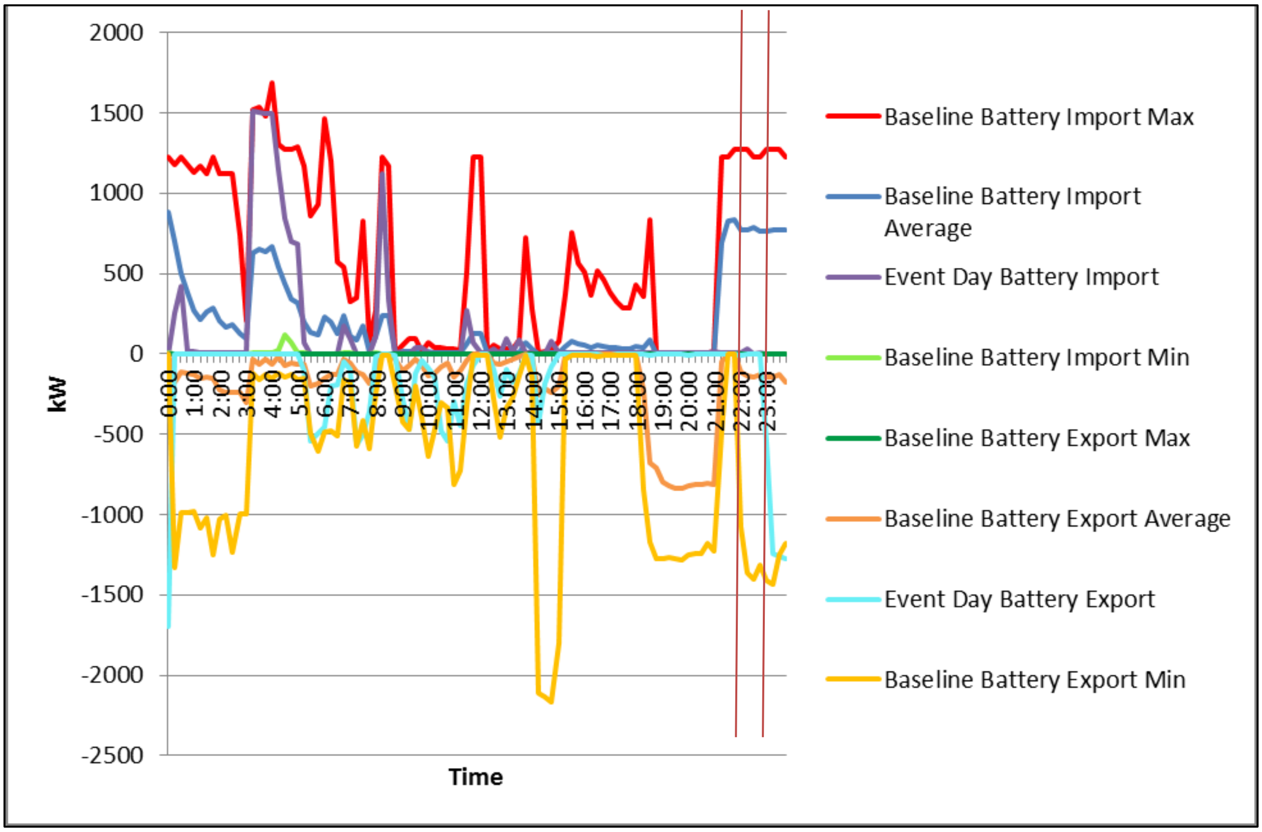


FIGURE 41. MAY 10 22:00-23:00 CUSTOMER 1 TURN OFF CHARGING – BATTERY ALCS IMPORT / EXPORT METER DATA

c) PQ MEASUREMENTS

Because of the configuration of how the Customer 1 power monitoring device was recording the battery and facility load, the device was monitoring the net result of a portion of the facility load and the battery output. Therefore, the upper chart in Figure 42 does not align with the meter data from SCE or Battery ALCS system results shown in Figure 38 through Figure 41.

The lower chart in Figure 42 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during and after the test event period.

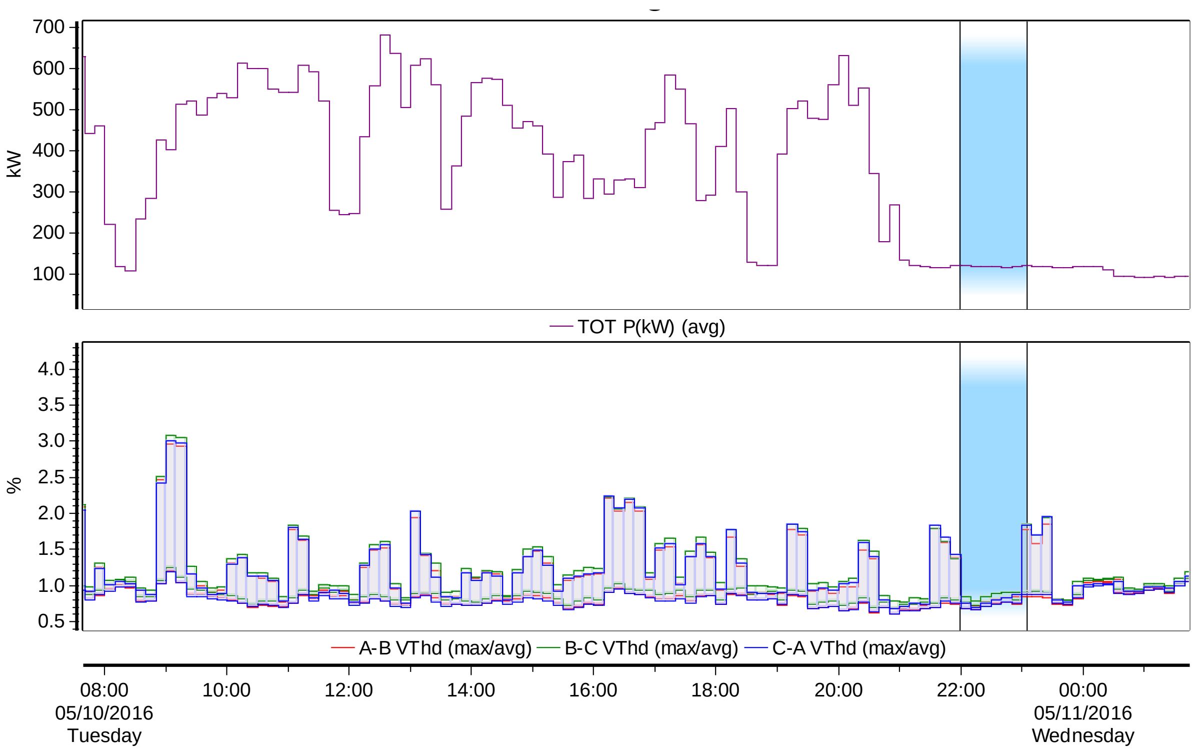


FIGURE 42. MAY 10 22:00-23:00 CUSTOMER 1 TURN OFF CHARGING–PQ METER DATA

TEST EVENT 9: FRIDAY MAY 13, 14:00-15:00 PDT – DISCHARGE

a) SCE Meter Baseline Analysis

Figure 43 is an example of the classic demand response pattern. Usage drops significantly across the first 15-minute period, remains low throughout the event, and returns to normal usage after the conclusion of the event. Customer 1 had a mill out due to maintenance from May 10 through May 18. This may explain why event day usage was slightly below the minimum baseline at periods throughout the day.

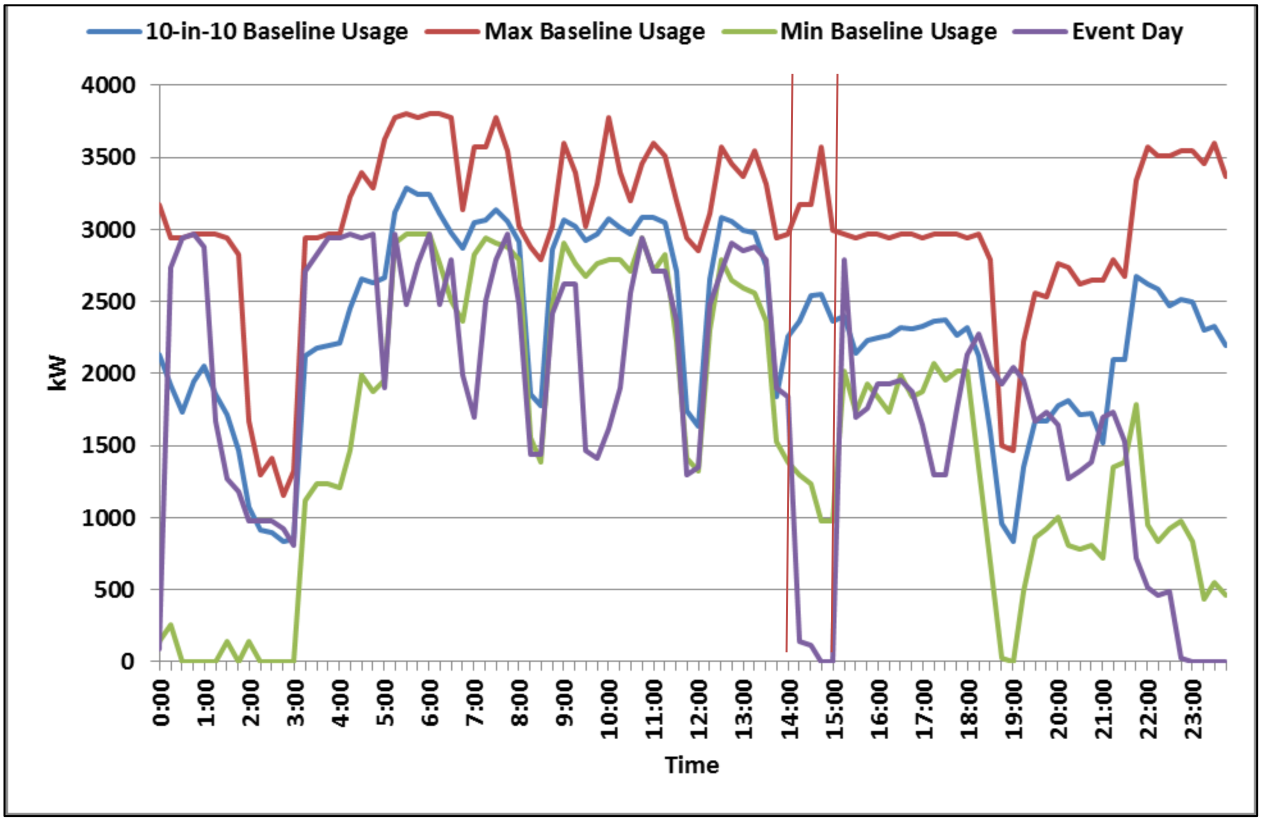


Figure 43. May 13 14:00-15:00 Customer 1 Discharge – SCE Meter Data

Figure 44 displays the classic demand response pattern, followed by an increase in usage in the 15 minutes following the event. Perhaps this increase in usage is battery charging to make up for the performance during the event period. Further evidence of that theory comes from the fact that event day usage was below the 10-in-10 baseline for much of the day prior to the event.

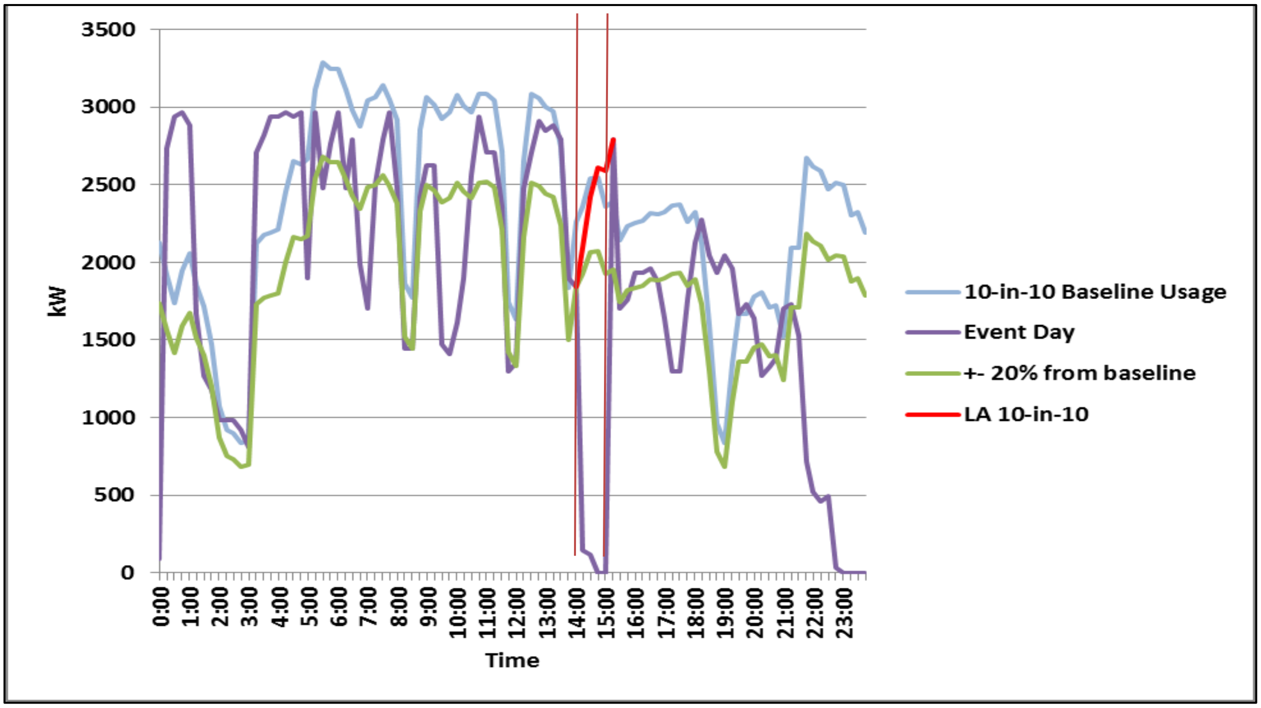


FIGURE 44. MAY 13 14:00-15:00 CUSTOMER 1 DISCHARGE – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 12. MAY 13 14:00-15:00 CUSTOMER 1 DISCHARGE – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CBP EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
13:45-14:00	1,843.20	-	-	-
14:00-14:15	144.00	(2,217.60)	(1,781.38)	(1,946.97)
14:15-14:30	115.20	(2,422.08)	(1,953.41)	(2,309.22)
14:30-14:45	-	(2,545.92)	(2,075.65)	(2,611.18)
14:45-15:00	-	(2,361.60)	(1,925.38)	(2,587.72)
15:00-15:15	2,793.60	-		-
Average kW	**64.80**	**(2,386.80)**	**(1,933.96)**	**(2,363.77)**
Average kWh	**64.80**	**(2,386.80)**	**(1,933.96)**	**(2,363.77)**
CBP Bid (kW)		(200)		
CBP Event Performance		**1193%**		

b) BATTERY ALCS BASELINE ANALYSIS

Figure 45 shows that the peak in usage following the event is due to battery performance. This peak is greater than the peak that was observed during the baseline period. Further, the event day usage being lower than average is not the result of the battery performing throughout the day. However, the Net Battery Baseline Min curve closely aligns with the Event Day Battery Net during the discharge test event.

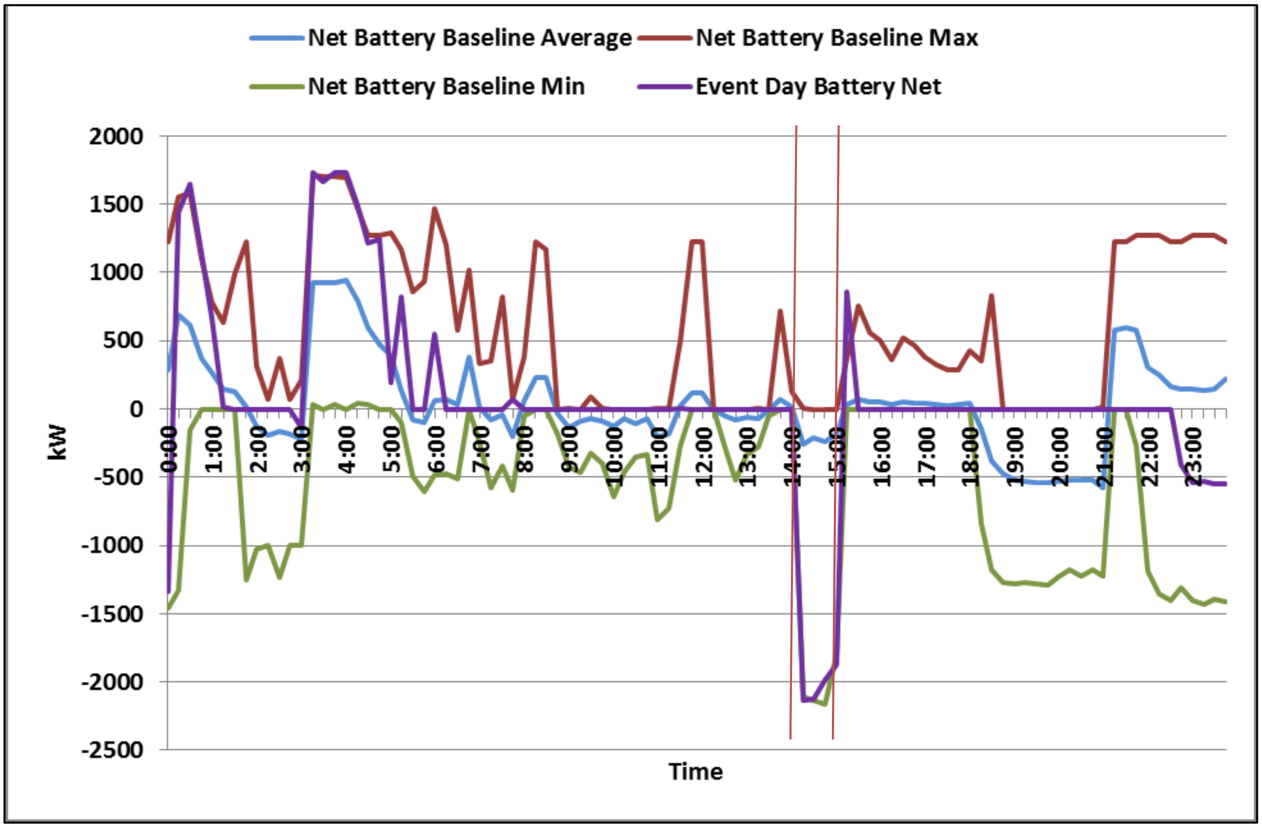


FIGURE 45. MAY 13 14:00-15:00 CUSTOMER 1 DISCHARGE– BATTERY ALCS NET METER DATA

The Import Export Chart in Figure 46 supports the observations outlined above, and also reinforces the observation that the baseline period appears to have a very similar DR event across the same timeframe. The Baseline Battery Export Min curve from 14:00-15:00 occurred on May 3, when no event for this was scheduled.

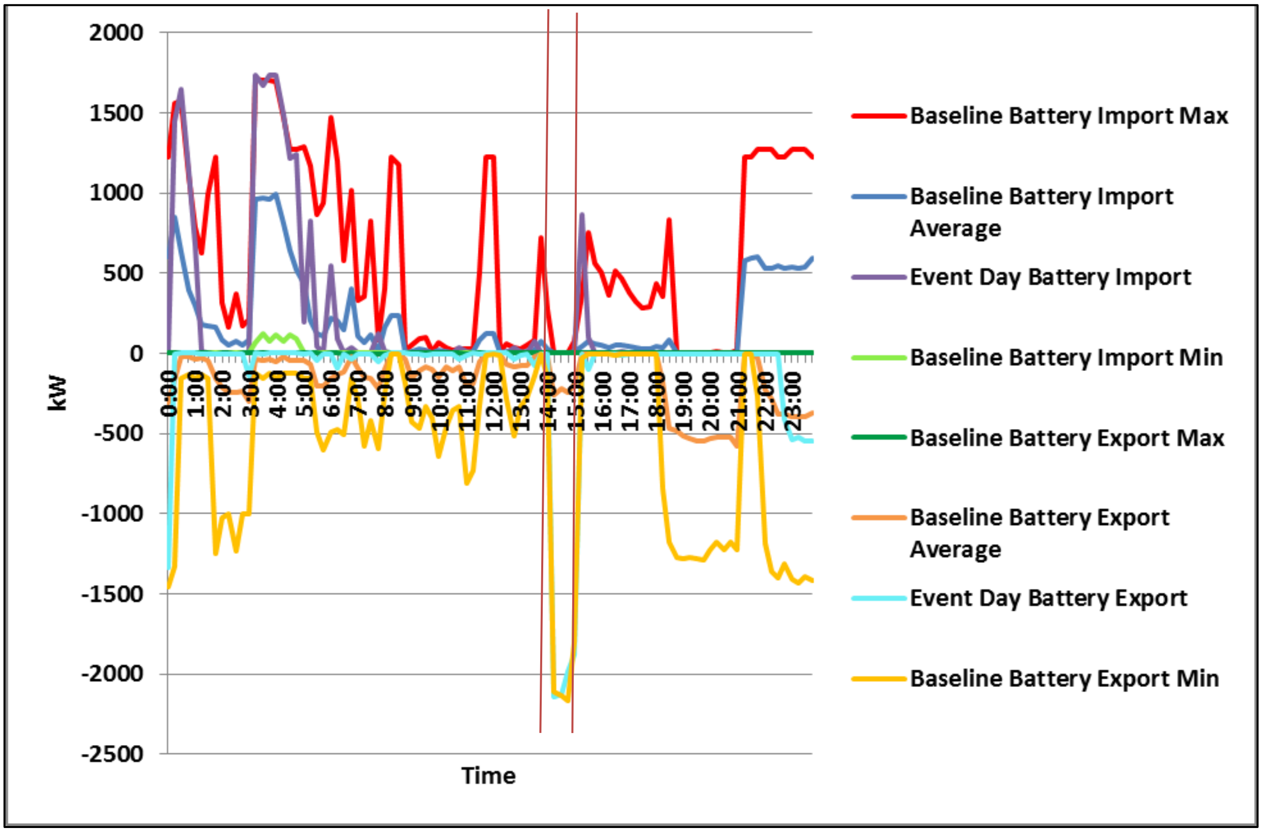


FIGURE 46. MAY 13 14:00-15:00 CUSTOMER 1 DISCHARGE –BATTERY ALCS IMPORT / EXPORT DATA

c) PQ Measurements

Because of the configuration of how the Customer 1 power monitoring device was recording the battery and facility load, the device was monitoring the net result of a portion of the facility load and the battery output. Therefore, the upper chart in Figure 47 does not align with the meter data from SCE or Battery ALCS system results shown in Figure 43 through Figure 46.

The lower chart in Figure 47 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during and after the test event period.

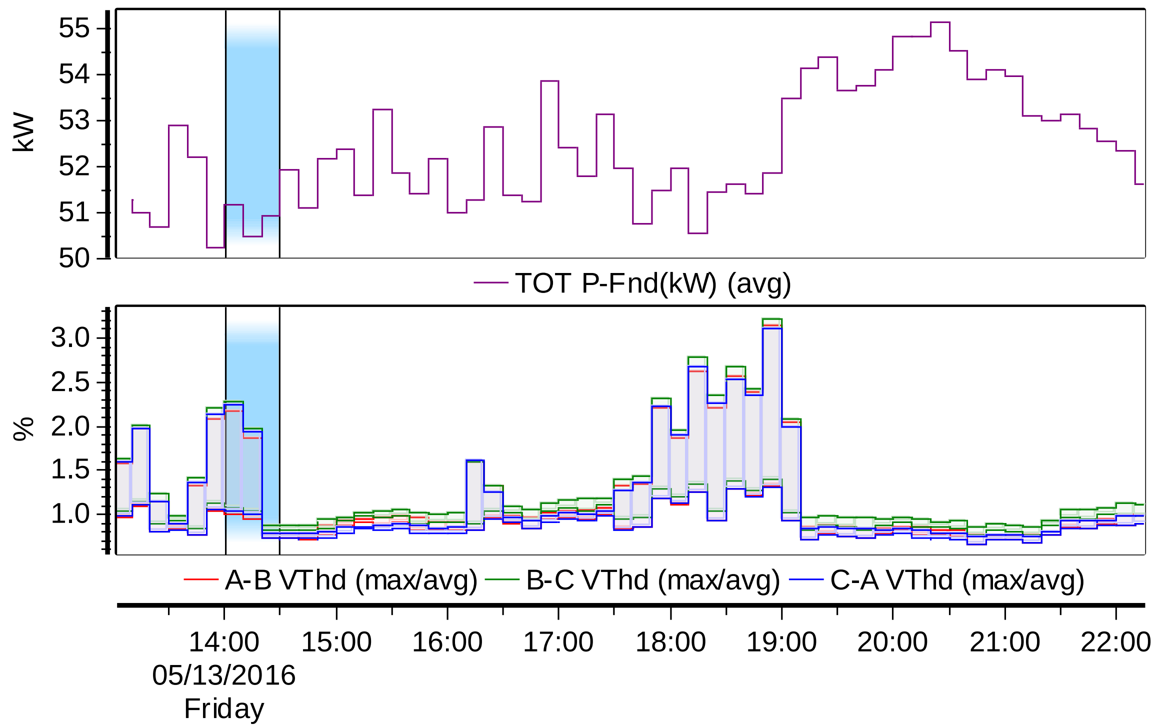


Figure 47. May 13 14:00-15:00 Customer 1 Discharge–PQ Meter Data

Test Event 10: Tuesday May 17, 3:00-4:00 PDT – Start Charging

a) SCE Meter Baseline Analysis

Figure 48 shows that the shape of the baseline range (max, min, and average) and the shape of the event day usage are similar from 2:00-4:00. The event day usage is similar to the minimum baseline usage indicating that the Start Charging event did not have the net effect of increasing the usage relative to the baseline.

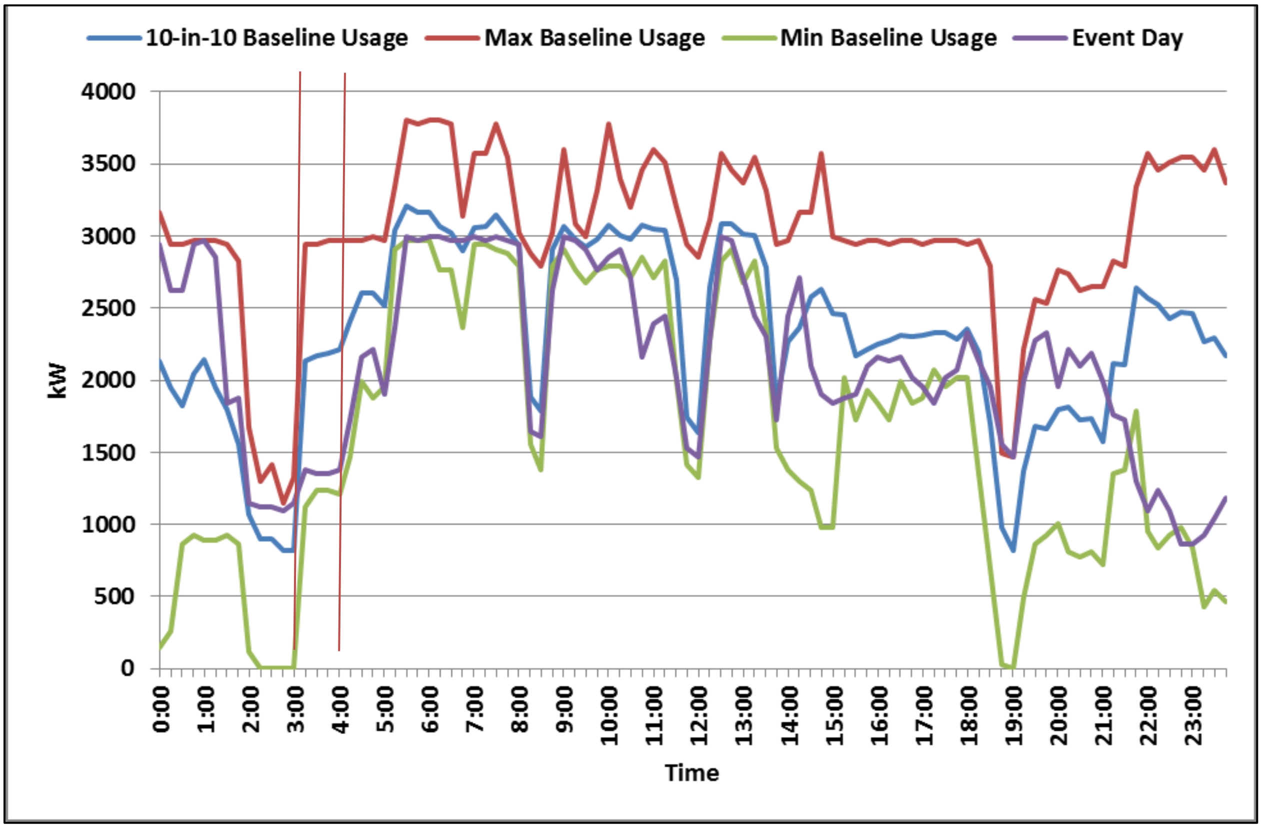


Figure 48. May 17 03:00-04:00 Customer 1 Start Charging – SCE Meter Data

Figure 49 illustrates that the event day usage was above the baseline leading up to the event. As a result, the ± 20% and LA modifications to the baseline curve make baseline adjustments to indicate higher rather than lower usage. In order to indicate a net increase in usage, the actual usage curve will need to be above the baseline curves. Therefore, the adjustments increasing the baseline usage make the Start Charging performance appear worse.

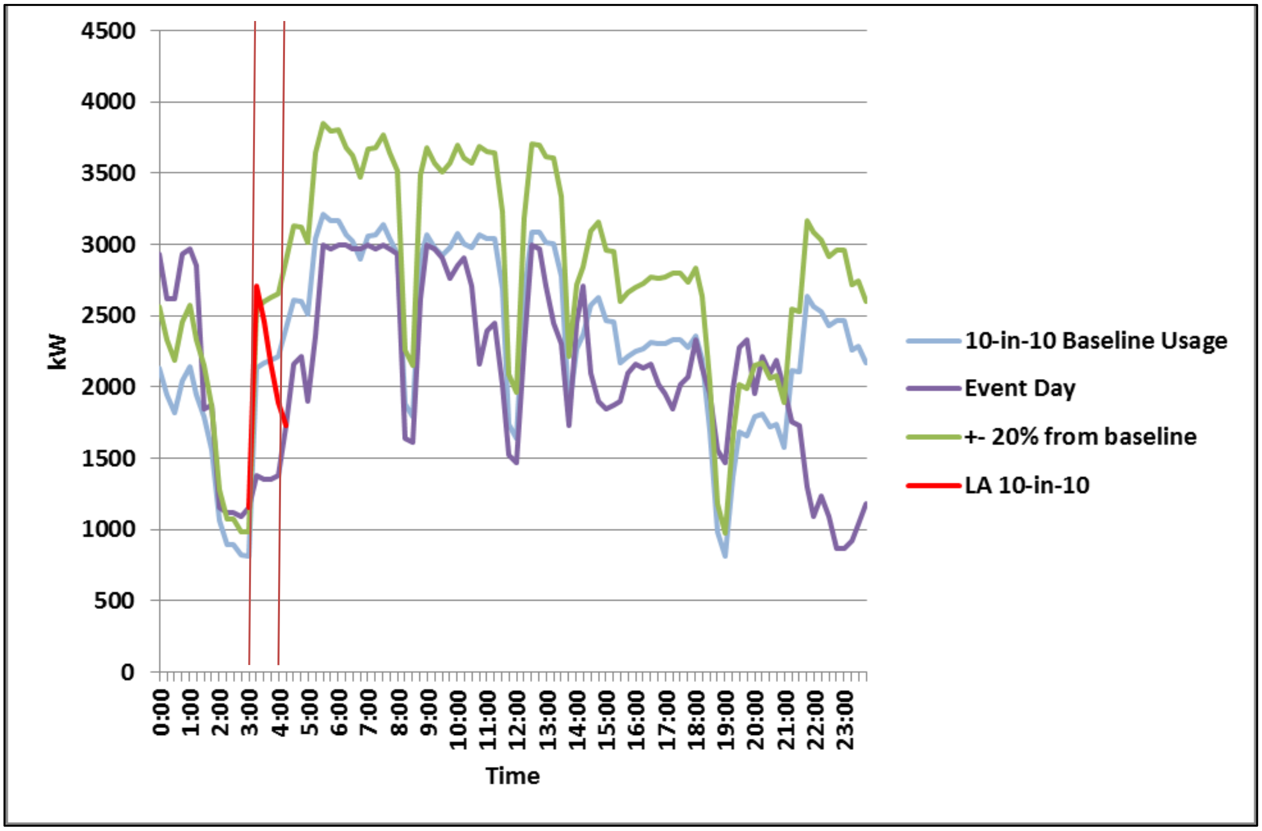


FIGURE 49. MAY 17 03:00-04:00 CUSTOMER 1 START CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis. The negative CBP event performance indicates that the battery response was opposite of what was expected. In this instance, rather than an increase in usage in response to the Start Charging dispatch, there was an average 808.56 kW decrease in demand.

TABLE 13. MAY 17 3:00-4:00 CUSTOMER 1 START CHARGING – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
2:45-3:00	1,152.00	-	-	-
3:00-3:15	1,382.40	(751.68)	(1,178.50)	(1,328.16)
3:15-3:30	1,353.60	(817.92)	(1,252.22)	(1,104.15)
3:30-3:45	1,353.60	(835.20)	(1,272.96)	(820.95)
3:45-4:00	1,382.40	(829.44)	(1,271.81)	(509.09)
4:00-4:15	1,728.00	-	-	-
Average kW	1,368.00	(808.56)	(1,243.87)	(940.59)
Average kWh	**1,368.00**	**(808.56)**	**(1,243.87)**	**(940.59)**
CBP Bid (kW)		200		
CBP Event Performance		**-404%**		

b) BATTERY ALCS BASELINE ANALYSIS

Each of the maximum, average, and minimum curves in Figure 50 include a sharp change in battery behavior towards more importing. Therefore, event day remains flat through this period and appears to not respond to the Start Charging signal.

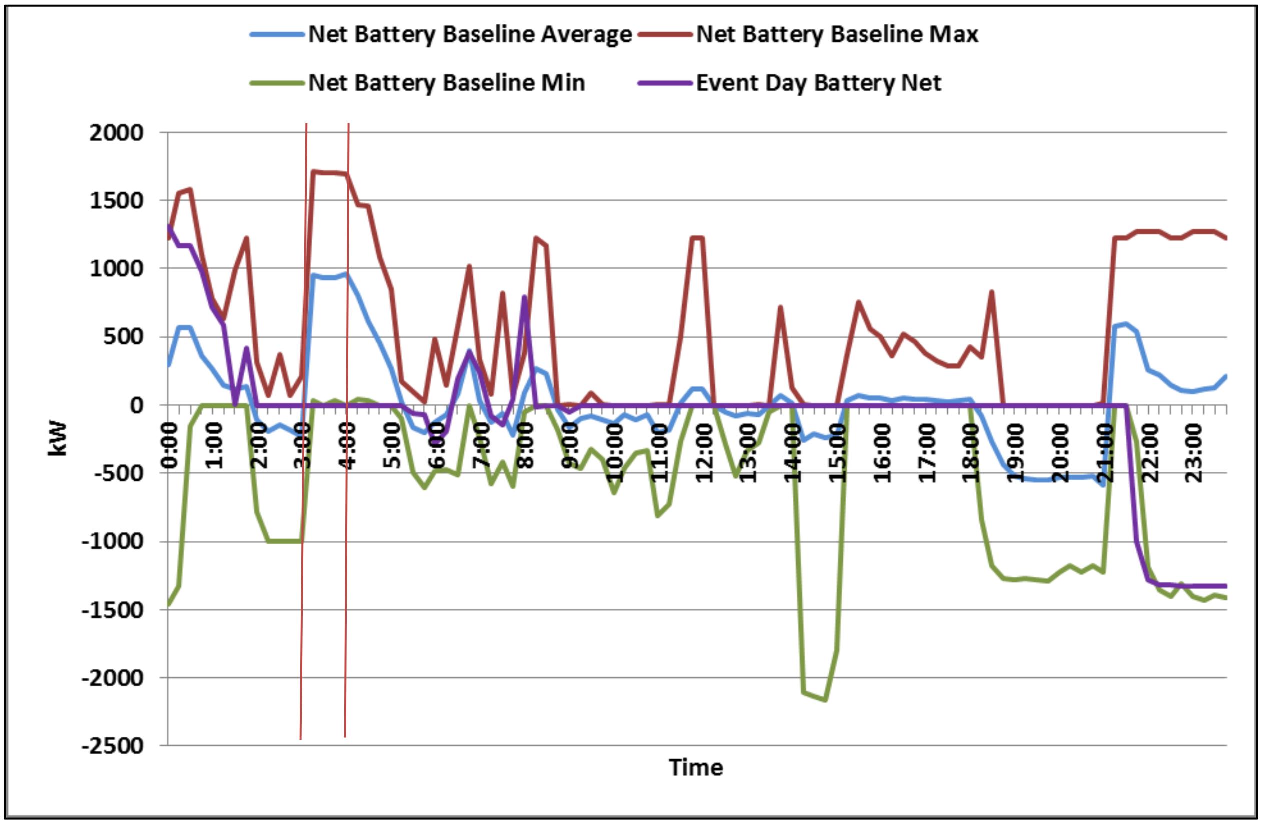


FIGURE 50. MAY 17 3:00-4:00 CUSTOMER 1 START CHARGING – BATTERY ALCS NET METER DATA

Although Figure 51 buries the purple *Event Day Battery Import* line underneath overlapping lines, the line trended to zero during the event. This indicates that it did not start charging in response to any signal. However, the battery also did not export during the event, meaning that it did not perform in opposition to the event signal.

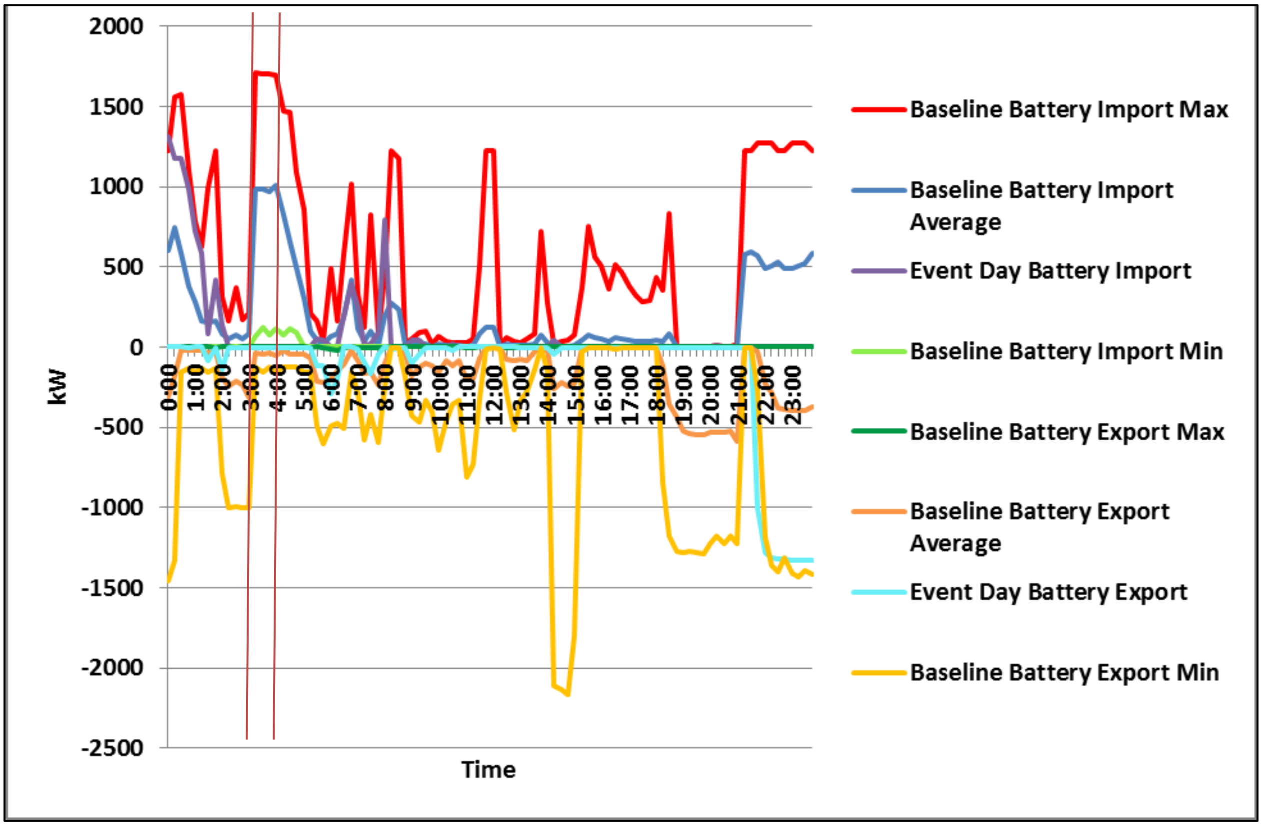


FIGURE 51. MAY 17 3:00-4:00 CUSTOMER 1 START CHARGING – BATTERY ALCS IMPORT / EXPORT DATA

c) PQ Measurements

Because of the configuration of how the Customer 1 power monitoring device was recording the battery and facility load, the device was monitoring the net result of a portion of the facility load and the battery output. Therefore, the upper chart in Figure 52 does not align with the meter data from SCE or Battery ALCS system results shown in Figure 48 through Figure 51.

The lower chart in Figure 52 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during, and after the test event period.

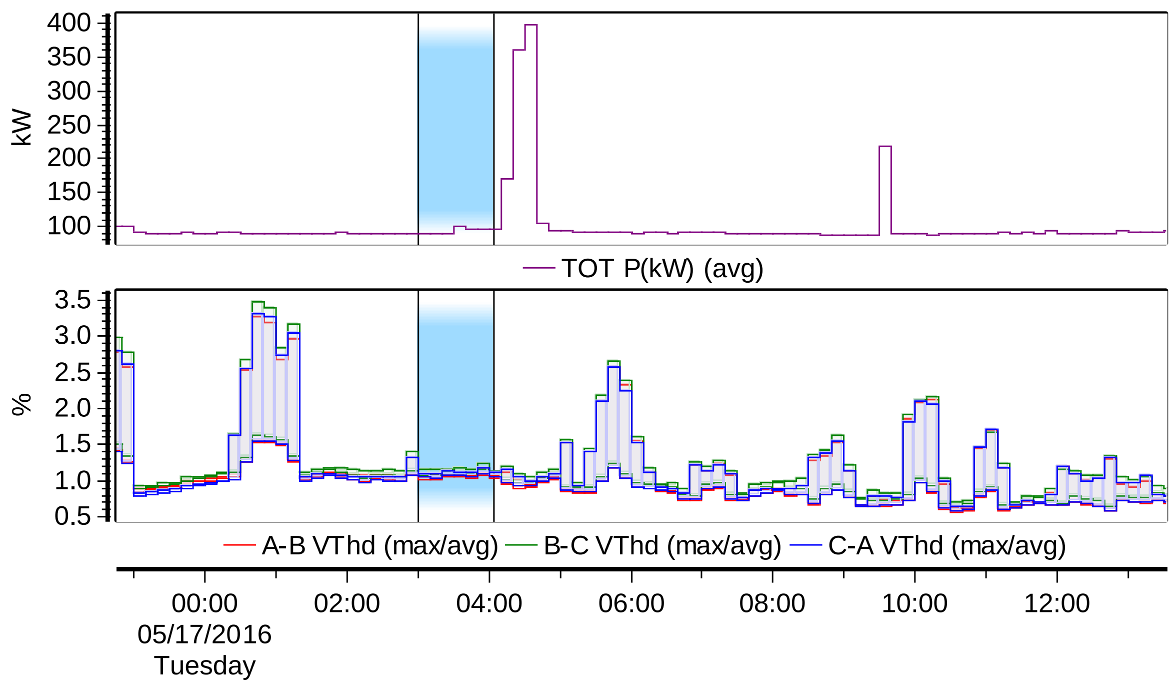


Figure 52. May 17 3:00-4:00 Customer 1 Start Charging –PQ Meter Data

TEST EVENT 11: FRIDAY MAY 20, 3:00-4:00 PDT – START CHARGING

a) SCE METER BASELINE ANALYSIS

Figure 53 shows that the baseline usage increases across the average, maximum, and minimum for the baseline period. This pattern of usage increase beginning at 3:00 complicates the Start Charging event at this same period. Event day usage "jumps" from roughly the minimum baseline to the maximum baseline usage from 3:00-3:15 and sustains that high level of usage for the remainder of the hour and through the next few hours. However, this large shift in usage is not vastly different from the usage profiles observed in the baseline period and looks very similar to the Max Baseline Usage.

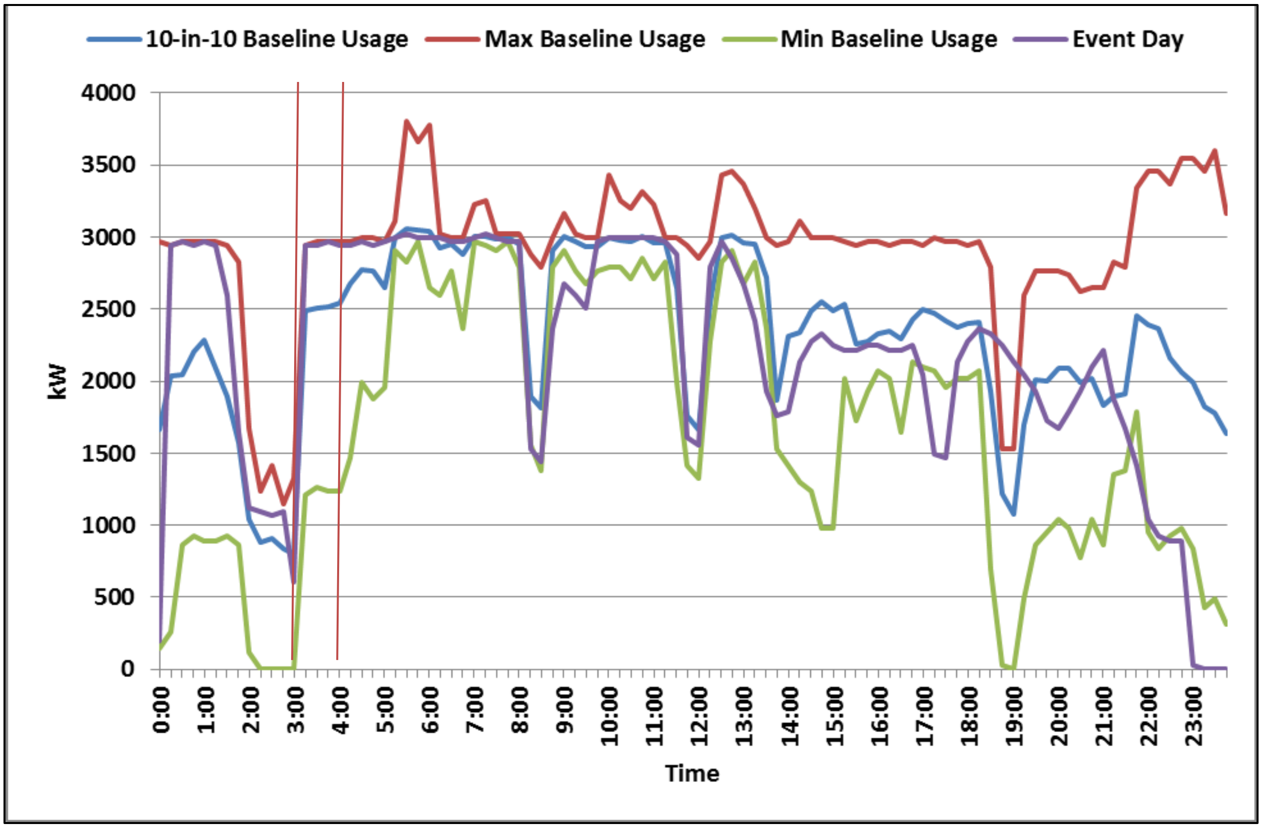


FIGURE 53. MAY 20 03:00-04:00 CUSTOMER 1 START CHARGING – SCE METER DATA

Figure 54 indicates that usage drops significantly immediately before the test event. The sharp decline immediately preceding the event influences the adjustments to the ±20% and LA baseline estimates for what usage would have been in the absence of a test event. In this instance, the average 10-in-10 Baseline is likely the best to compare the performance of the battery.

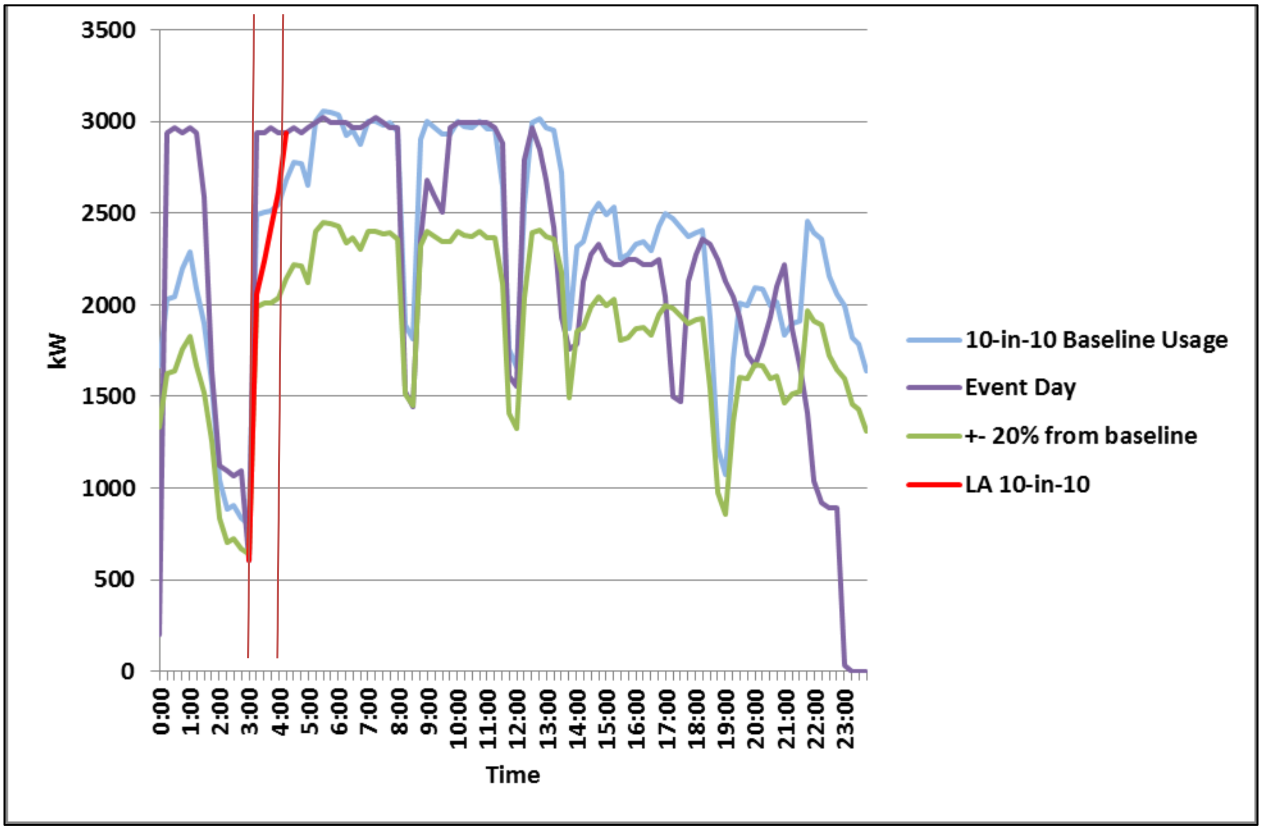


FIGURE 54. MAY 20 03:00-04:00 CUSTOMER 1 START CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 14. MAY 20 3:00-4:00 CUSTOMER 1 START CHARGING – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
2:45-3:00	604.80	-	-	-
3:00-3:15	2,937.60	449.28	946.94	882.61
3:15-3:30	2,937.60	429.12	930.82	696.06
3:30-3:45	2,966.40	452.16	955.01	549.43
3:45-4:00	2,937.60	391.68	900.86	317.74
4:00-4:15	2,937.60	-		-
Average kW	**2,944.80**	**430.56**	**933.41**	**611.46**
Average kWh	**2,944.80**	**430.56**	**933.41**	**611.46**
CBP Bid (kW)		200		
CBP Event Performance		**215%**		

b) BATTERY ALCS BASELINE ANALYSIS

Figure 55 displays that the sharp usage decrease leading up to the event start was the result of battery activity. Further, Figure 55 also shows that the event day battery was not even at the maximum of what was observed during the baseline period. These two facts likely make the ± 20% and LA adjusted DR Baselines in **Error! Reference source not found.** overestimate the performance of the event.

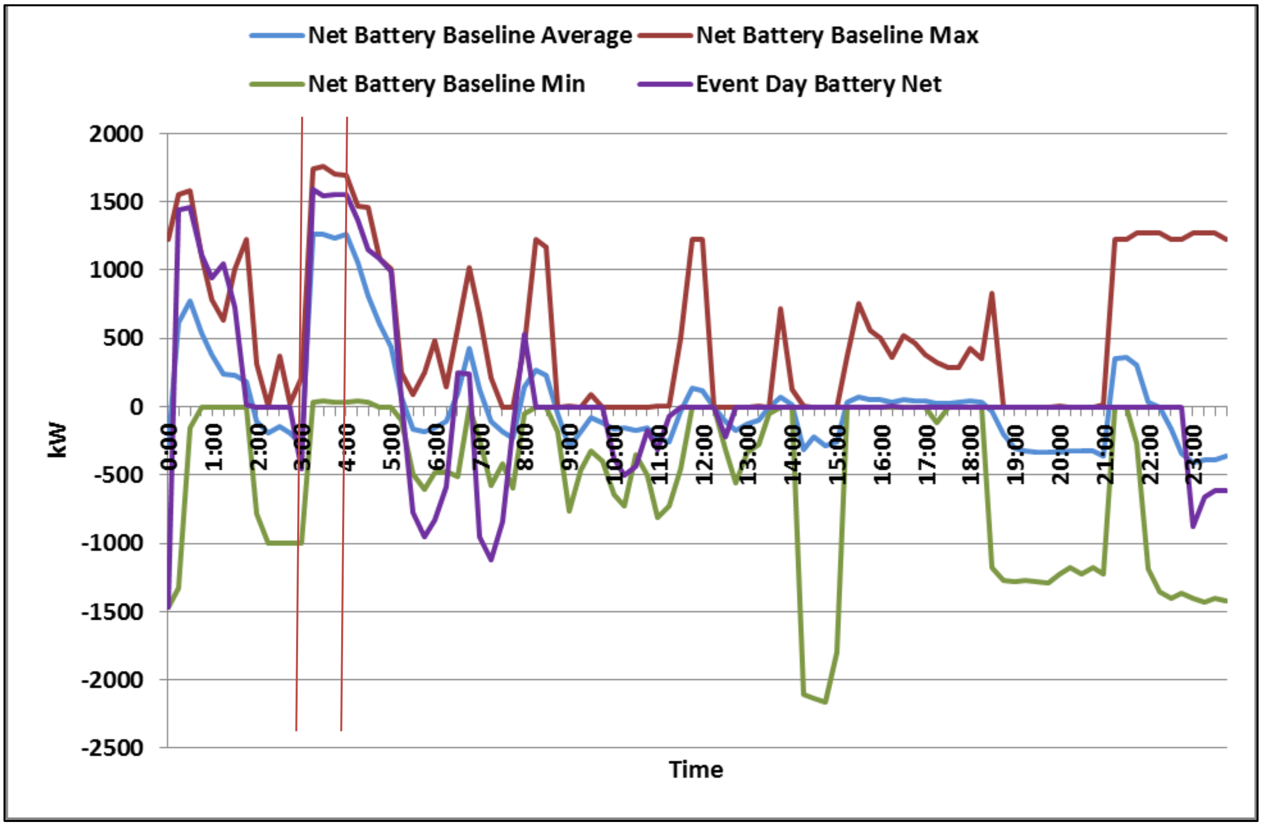


FIGURE 55. MAY 20 3:00-4:00 CUSTOMER 1 START CHARGING – BATTERY ALCS NET METER DATA

The Import Export chart in Figure 56 supports what was observed in the net battery profile.

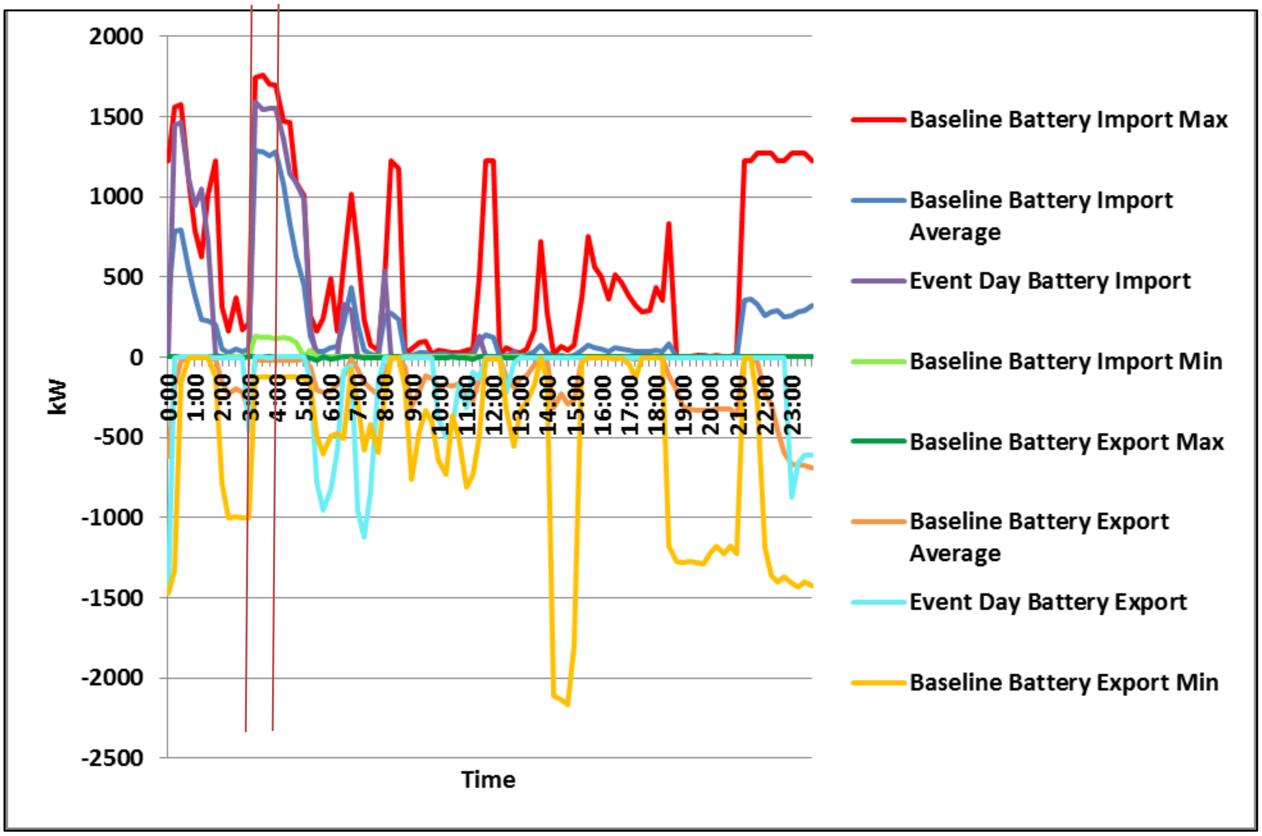


FIGURE 56. MAY 20 3:00-4:00 CUSTOMER 1 START CHARGING – BATTERY ALCS IMPORT / EXPORT DATA

c) PQ MEASUREMENTS

Because of the configuration of how the Customer 1 power monitoring device was recording the battery and facility load, the device was monitoring the net result of a portion of the facility load and the battery output. Therefore, the upper chart in Figure 57 does not align with the meter data from SCE or Battery ALCS system results shown in Figure 53 through Figure 56.

The lower chart in Figure 57 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during and after the test event period.

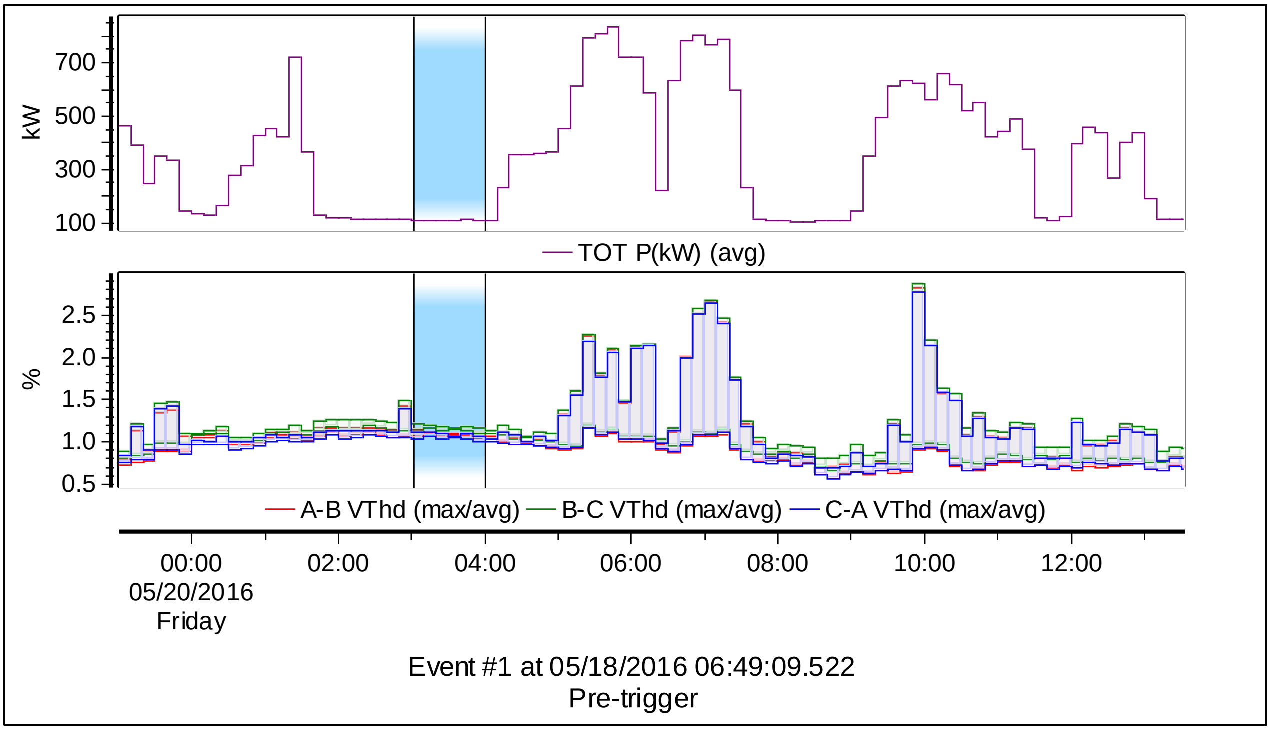


FIGURE 57. MAY 20 3:00-4:00 CUSTOMER 1 START CHARGING –PQ METER DATA

TEST EVENT 12: TUESDAY MAY 24, 3:00-4:00 PDT – START CHARGING

a) SCE Meter Baseline Analysis

Figure 58 shows that the baseline usage typically increases significantly just prior to the test event time of 3:00-4:00. This pattern suggests that the 3:00 Start Charging test aligns with the standard or daily battery charging routine. Event day usage "jumps" from roughly the 10-in-10 baseline to the maximum baseline usage from 3:00-3:15 and sustains that high level of usage for the remained of the hour and through the next few hours with a few dips in usage.

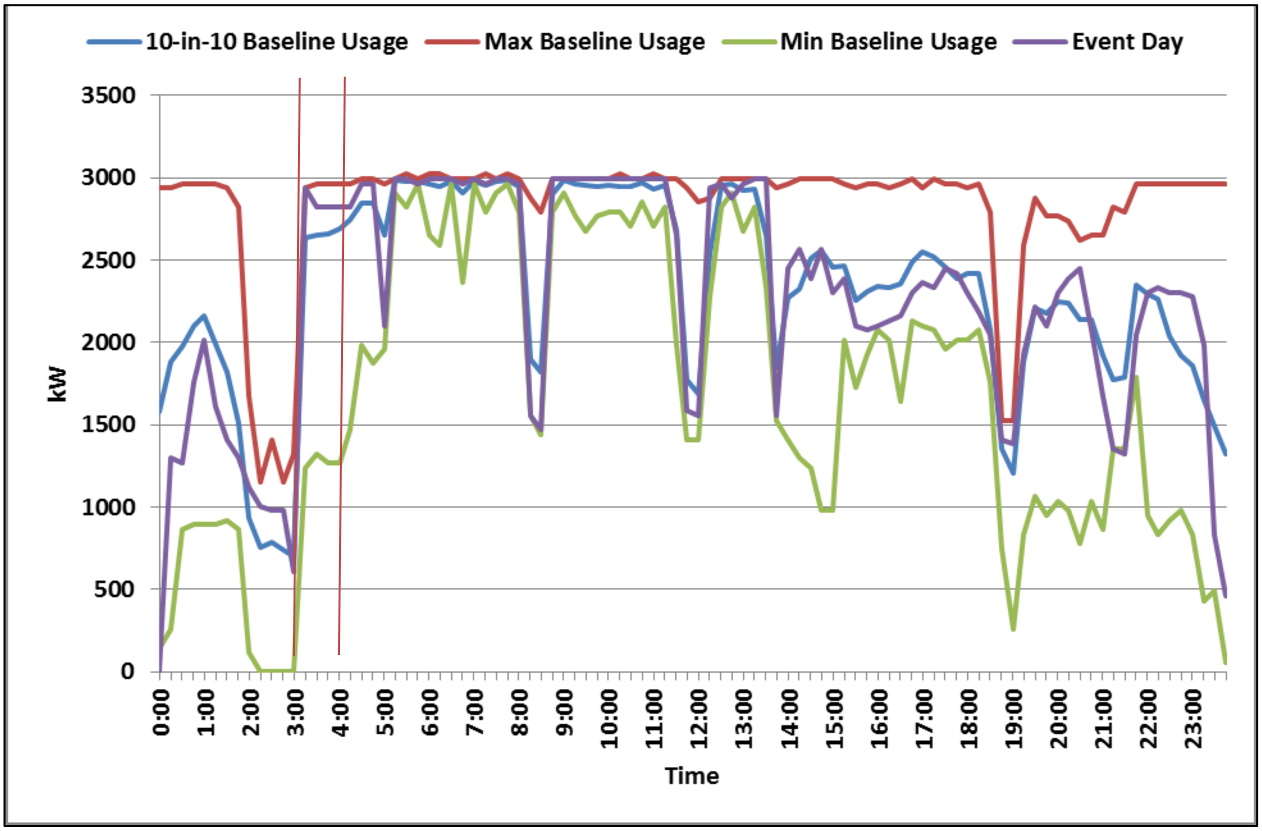


Figure 58. May 24 03:00-04:00 Customer 1 Start Charging – SCE Meter Data

Figure 59 illustrates that the event day usage was similar to non-event days. Prior to the test event, usage drops significantly. The sharp decline immediately preceding the event influences the adjusted ± 20% and LA 10-in-10 baseline estimates for what usage would have been in the absence of the test event.

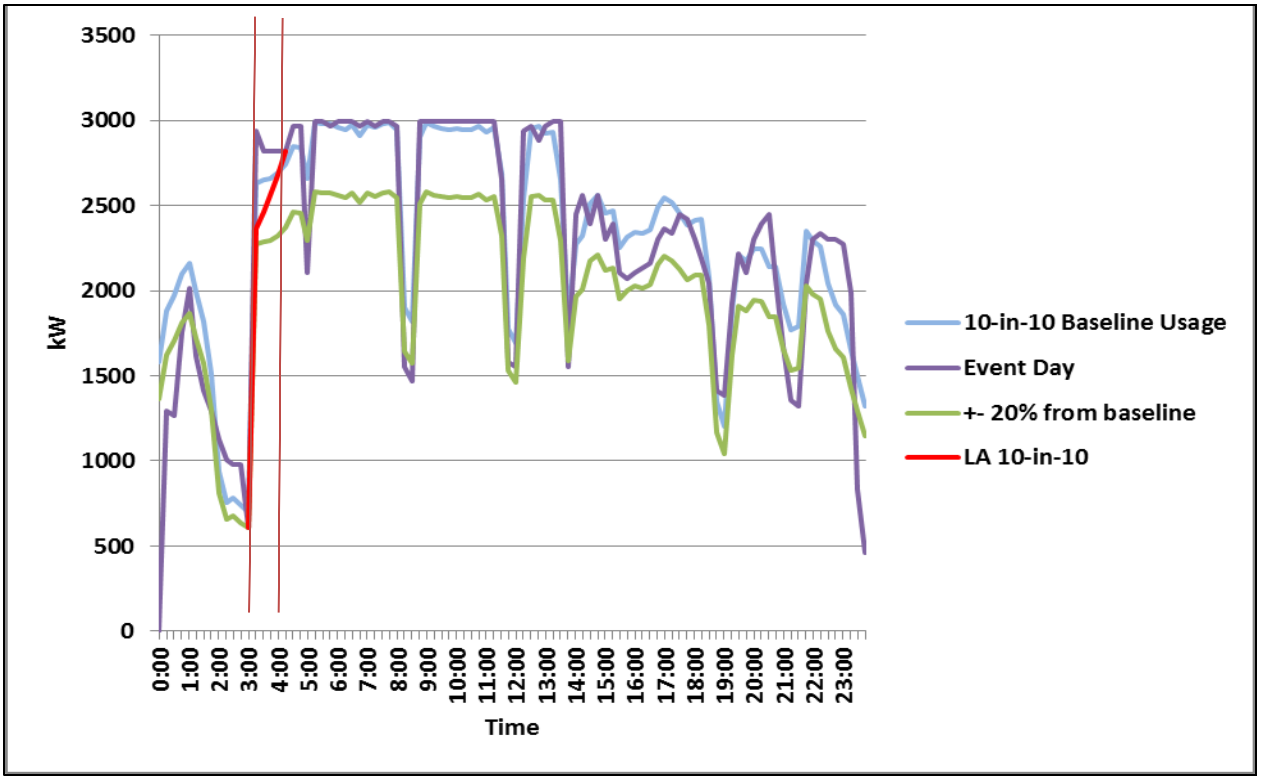


FIGURE 59. MAY 24 03:00-04:00 CUSTOMER 1 START CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 15. MAY 24 3:00-4:00 CUSTOMER 1 START CHARGING – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
2:45-3:00	604.80	-	-	-
3:00-3:15	2,937.60	305.28	662.76	575.78
3:15-3:30	2,822.40	172.80	532.62	357.52
3:30-3:45	2,822.40	164.16	525.16	261.65
3:45-4:00	2,822.40	132.48	497.78	142.25
4:00-4:15	2,822.40	80.64		-
Average kW	**2,851.20**	**193.68**	**554.58**	**334.30**
Average kWh	**2,851.20**	**193.68**	**554.58**	**334.30**
CBP Bid (kW)		200		
CBP Event Performance		**97%**		

b) BATTERY ALCS BASELINE ANALYSIS

Similar to the May 20 test event, Figure 60 shows that battery charging is responsible for the usage observed prior to and during the test event. However, the battery performance aligns very closely with the maximum baseline suggesting that performance was in line with the typical usage of battery.

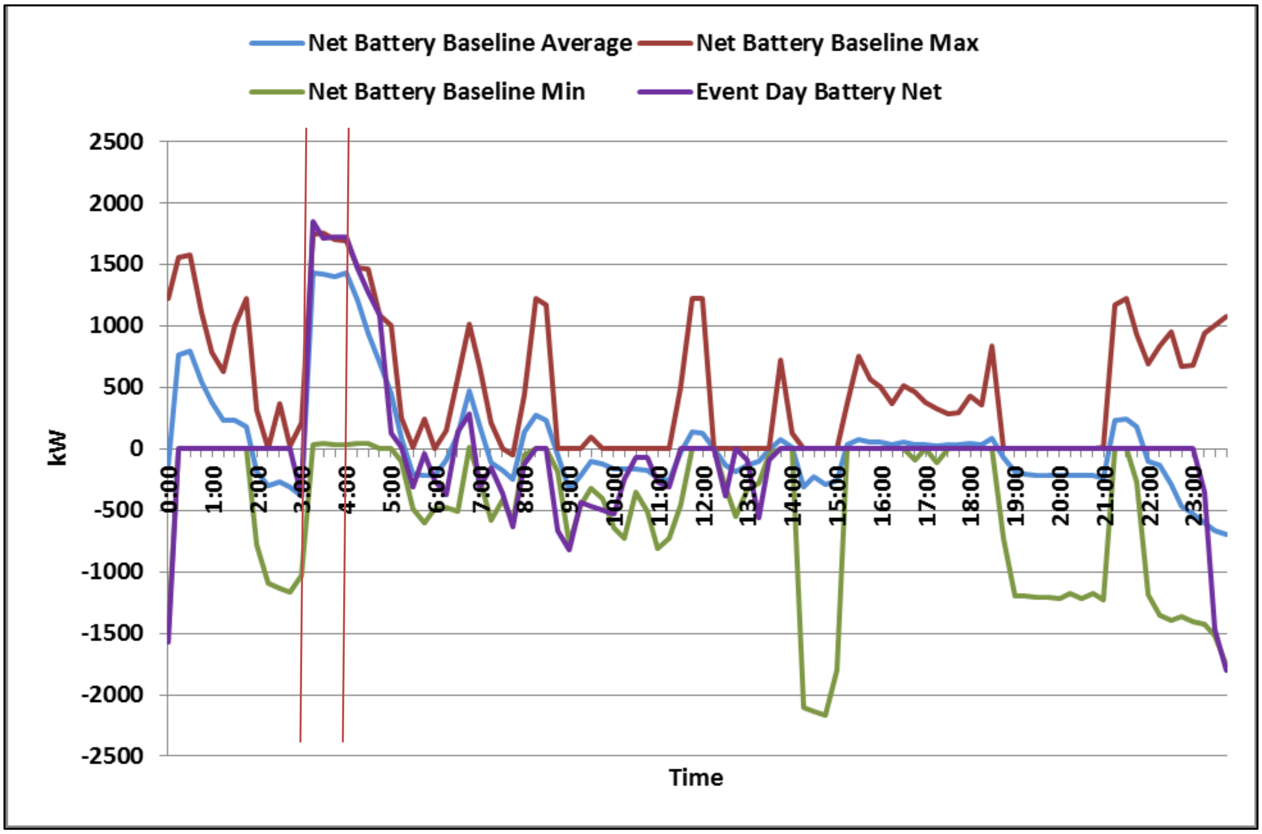


FIGURE 60. MAY 24 3:00-4:00 CUSTOMER 1 START CHARGING – BATTERY ALCS NET METER DATA

The Import Export chart in Figure 61 further supports the observations from the net battery profile above.

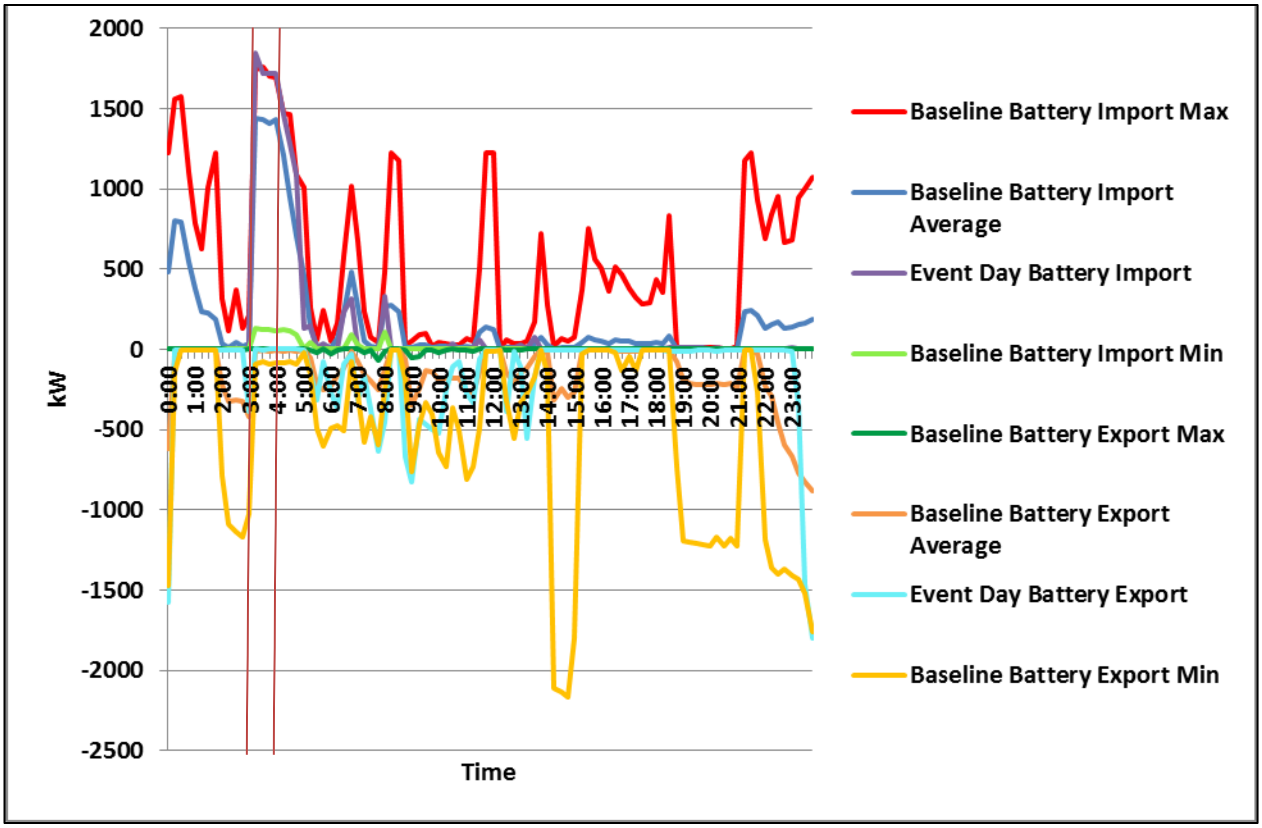


FIGURE 61. MAY 24 3:00-4:00 CUSTOMER 1 START CHARGING – BATTERY ALCS IMPORT / EXPORT DATA

c) PQ Measurements

Because of the configuration of how the Customer 1 power monitoring device was recording the battery and facility load, the device was monitoring the net result of a portion of the facility load and the battery output. Therefore, the upper chart in Figure 62 does not align with the meter data from SCE or Battery ALCS system results shown in Figure 58 through Figure 61 above.

The lower chart in Figure 62 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during and after the test event period.

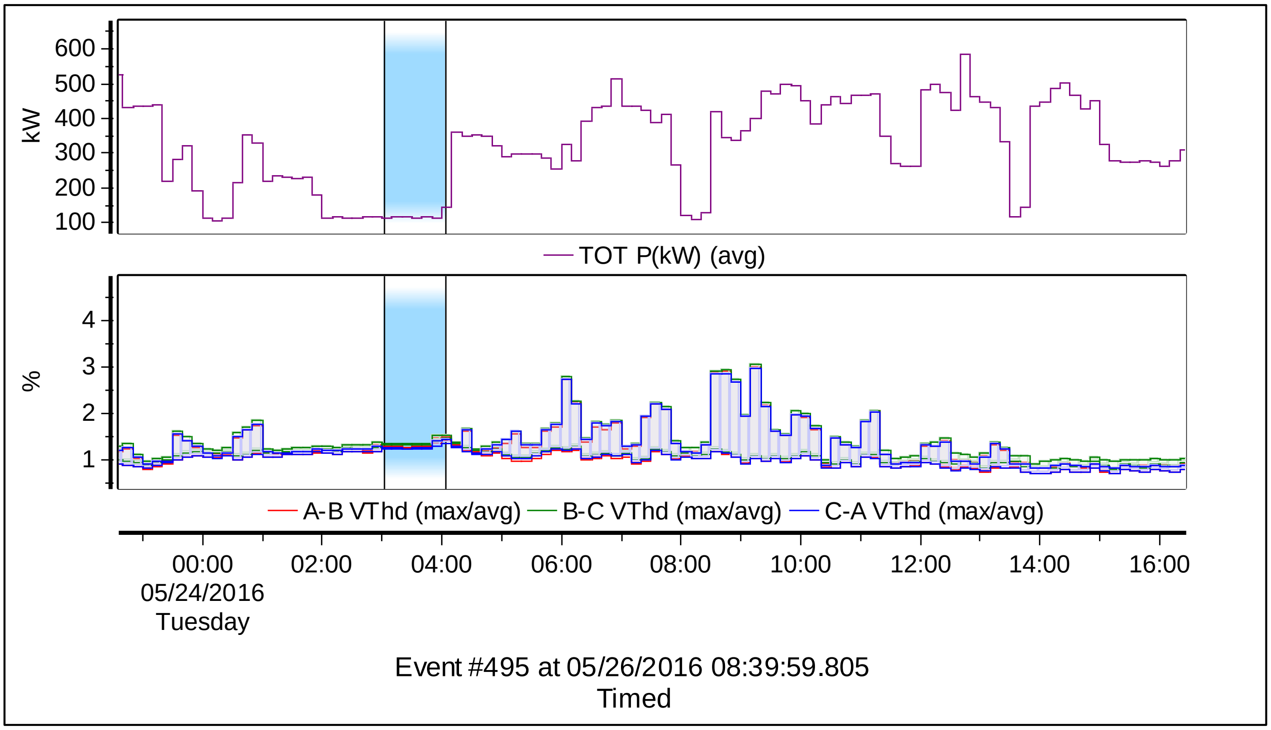


Figure 62. May 24 3:00-4:00 Customer 1 Start Charging –PQ Meter Data

Event 13: Wednesday June 8, 3:00 -4:00 PDT – Start Charging

a) SCE METER BASELINE ANALYSIS

Figure 63 shows the event day usage aligning with the max baseline usage prior to the 3:00-4:00 test event. After the Start Charging event dispatch, there is an increase in usage for the first 30 minutes of the test event followed by a decrease in usage. It is difficult to discern whether this usage behavior is attributable to a Start Charging dispatch or whether it is within the normal range of usage as illustrated by the max, min and 10-in-10 baseline usage curves.

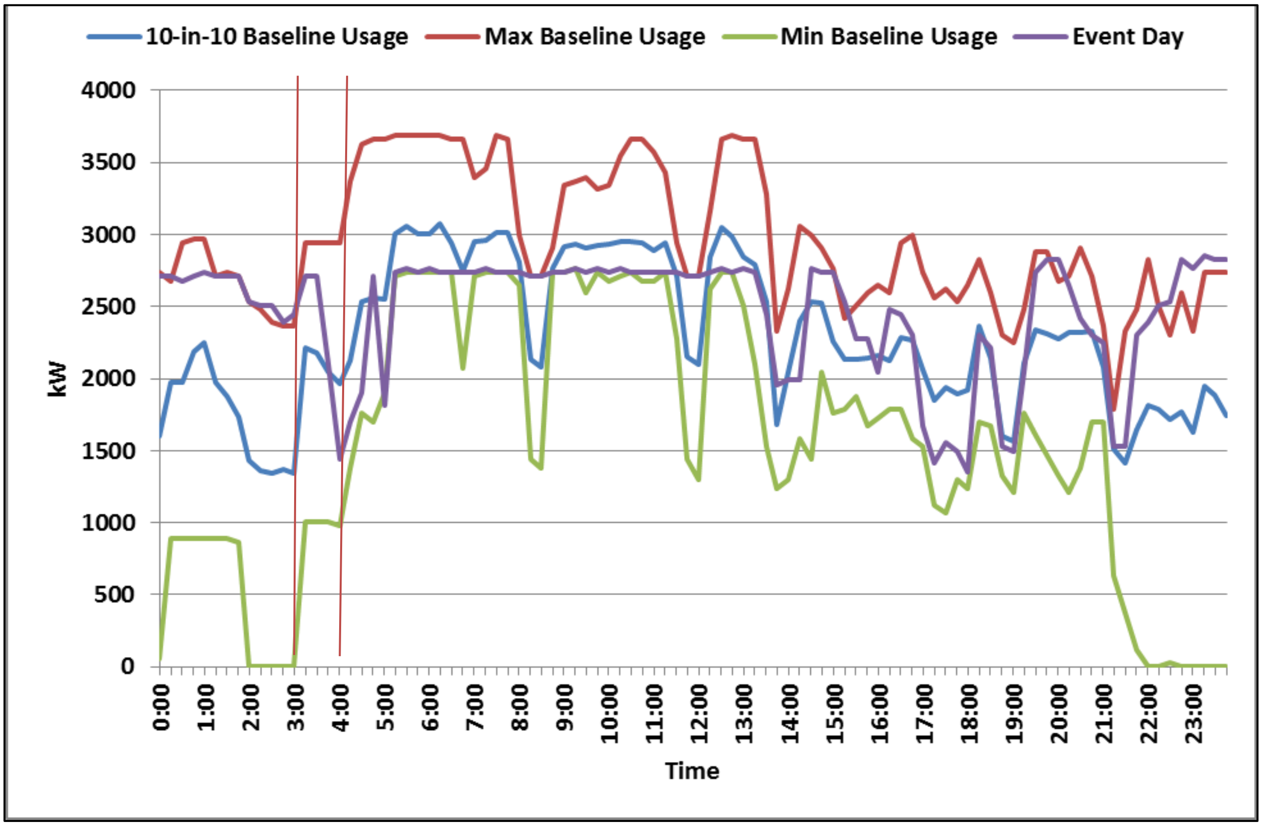


FIGURE 63. JUNE 8 3:00-4:00 CUSTOMER 1 START CHARGING – SCE METER DATA

With a start charging signal, it is expected that the event day usage be higher than the baseline estimates. While the *±20% from baseline* and the *10-in-10 Baseline Usage* estimates in Figure 64 appear to show a response, neither fully takes into account the high actual usage at the start of the test event. The LA 10-in-10 is exaggerated because of this high usage at the start of the test event and spikes upward in an attempt to reflect the 10-in-10 usage shape on a typical non-event day. Essentially, the standard baseline shape at 03:00 better reflects the Start Charging usage pattern better than the event.

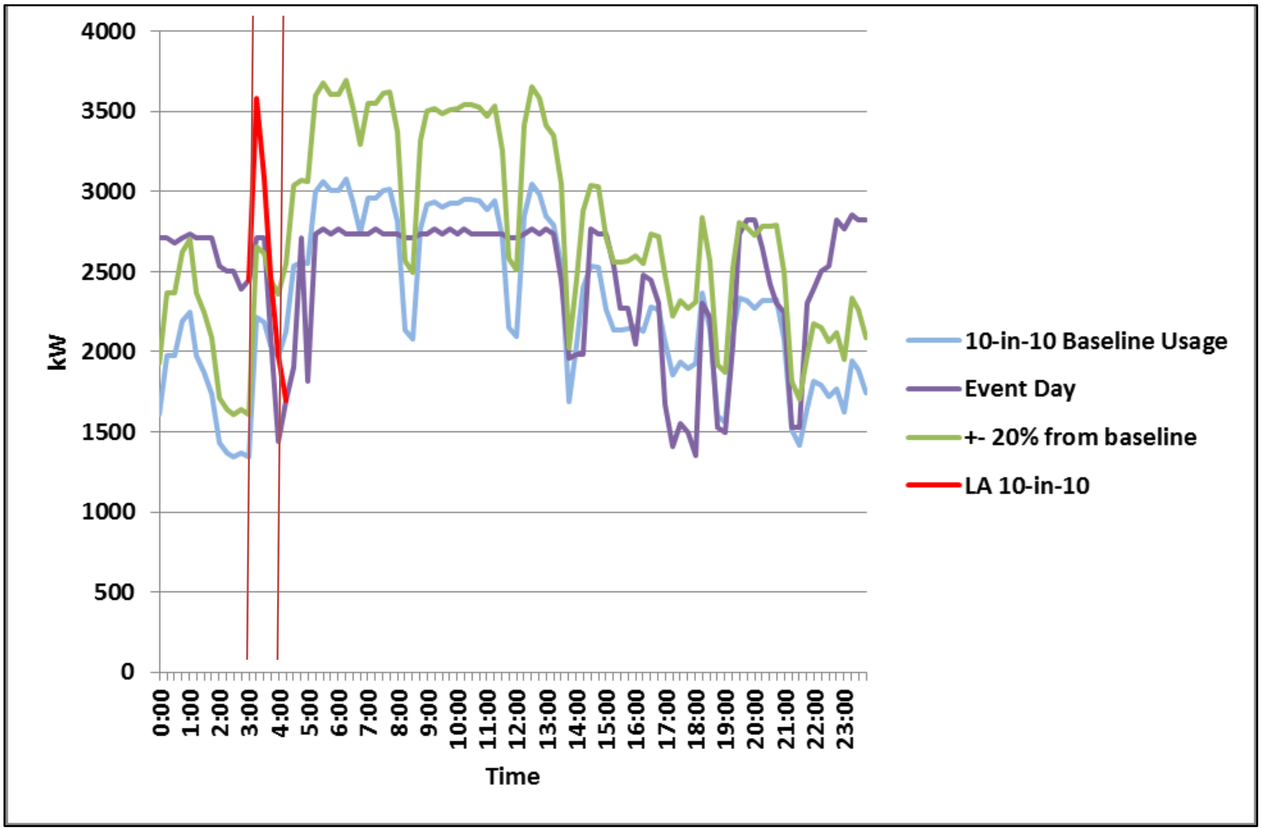


FIGURE 64. JUNE 8 3:00-4:00CUSTOMER 1 START CHARGING – DR BASELINE ESTIMATES

TABLE 16. JUNE 8 3:00-4:00 CUSTOMER 1 START CHARGING – PERFORMANCE OF EVENT

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
2:45-3:00	2,448.00	-	-	-
3:00-3:15	2,707.20	495.36	52.99	(873.55)
3:15-3:30	2,707.20	527.04	91.01	(375.05)
3:30-3:45	2,102.40	60.48	(347.90)	(365.55)
3:45-4:00	1,440.00	(527.04)	(920.45)	(533.94)
4:00-4:15	1,699.20	-	-	-
Average kW	2,239.20	138.96	(281.09)	(537.02)
Average kWh	**2,239.20**	**138.96**	**(281.09)**	**(537.02)**
CBP Bid (kW)		200		
CBP Event Performance		**69%**		

b) Battery ALCS Baseline Analysis

Figure 65 indicates that the battery was charging prior to and at the start of the event. As a result there is not a usage increase attributable to the Start Charging event dispatch at the start of the testing period. Additionally, the battery did not continue to charge through the event and looks to have completed charging at approximately 3:30.

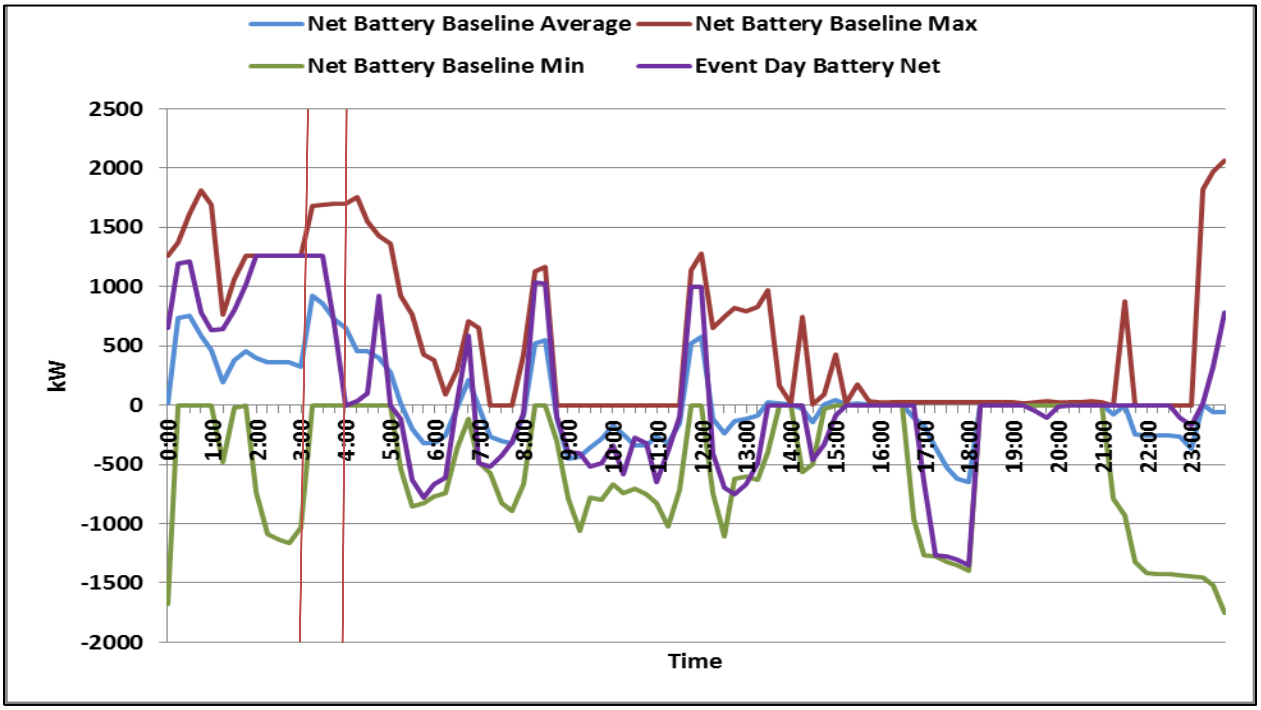


Figure 65. June 8 3:00-4:00 Customer 1 Start Charging – Battery ALCS Net Meter Data

Figure 66 supports the prior observations for this test event. It is also observed that the battery exported across the 3:45-4:00 timeframe. While that export was neutralized by an equal import, an export is in contradiction to the Start Charging signal.

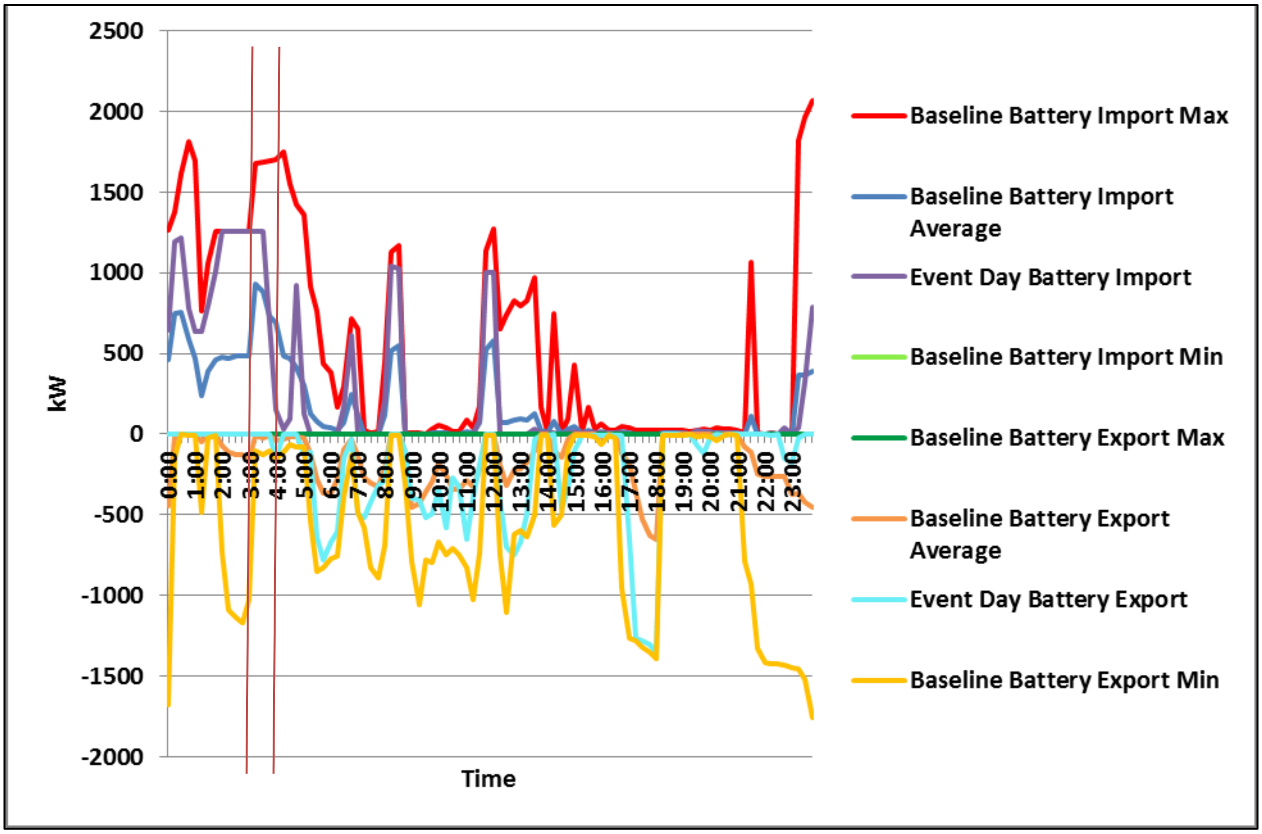


FIGURE 66. 3:00-4:00 CUSTOMER 1 START CHARGING – BATTERY ALCS IMPORT / EXPORT METER DATA

c) PQ MEASUREMENTS

Because of the configuration of how the Customer 1 power monitoring device was recording the battery and facility load, the device was monitoring the net result of a portion of the facility load and the battery output. Therefore, the upper chart in Figure 67 does not align with the meter data from SCE or Battery ALCS system results shown in Figure 63 through Figure 66.

The lower chart in Figure 67 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during and after the test event period.

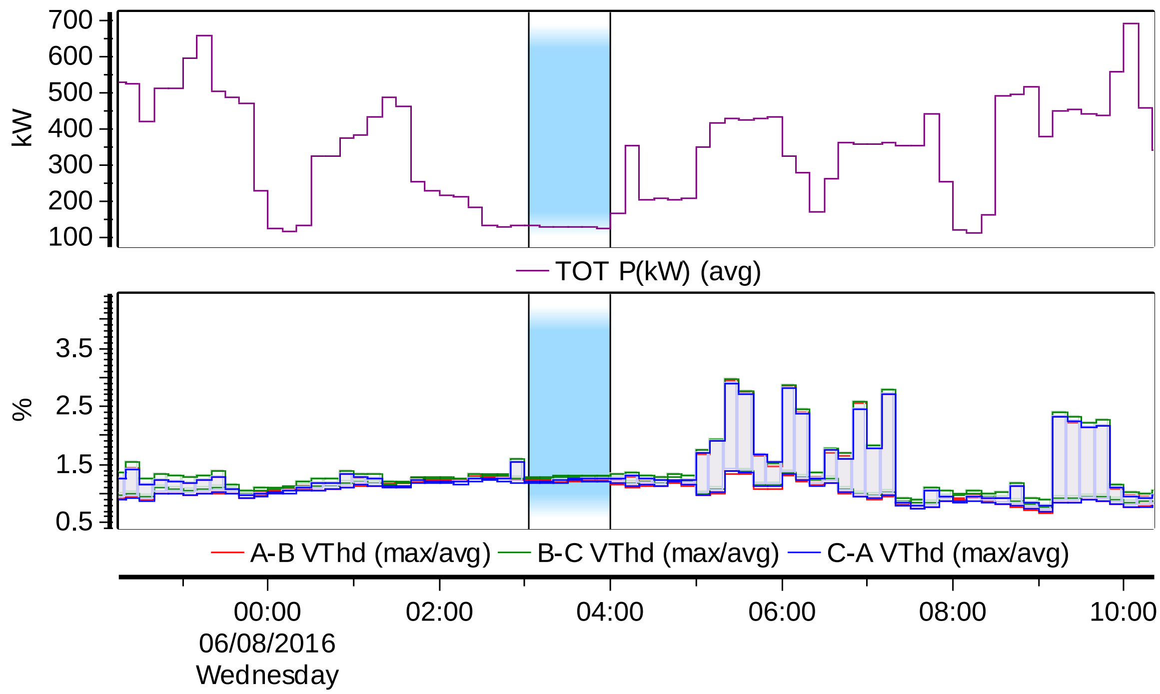


FIGURE 67. JUNE 8 3:00-4:00 CUSTOMER 1 START CHARGING –PQ METER DATA

POWER QUALITY EVALUATION

a) MILL MAINTENANCE: MAY 10-MAY 18

The Customer 1 test site was down for maintenance from May 10 – 18. As part of the power quality analysis, the PQ Meter Data was reviwed during this maintenance period and compared it to the PQ Meter Data collected when the mill was on line.

Figure 68 shows that the recordings at the substation showed slightly reduced load during the maintenance period, but the load still exceeded (1000 kW).

Figure 69 shows that the Pst was slightly higher when the site was in operation than when it was down for maintenance. This Pst is a measure of the variations in the line voltage.

Figure 70 shows the VThd and K-Factor distortion. Except for a couple of peaks in the K-Factor during switching transients, the VThd and K-Factor distortion were in a similar range during the time the site was in operation or offline for maintenance.

Figure 71 shows the 3rd, 5th, and 7th harmonic components, which are typical of industrial motor drive equipment. The levels of these low order harmonic components were acceptable, and did not vary much before, during, or after the site l shutdown.

Figure 72 shows the 23rd, 25th, and 35th harmonic components, which are typical of voltage source inverters (battery storage system). These levels were acceptable, and did not vary much before, during, or after the site shutdown.

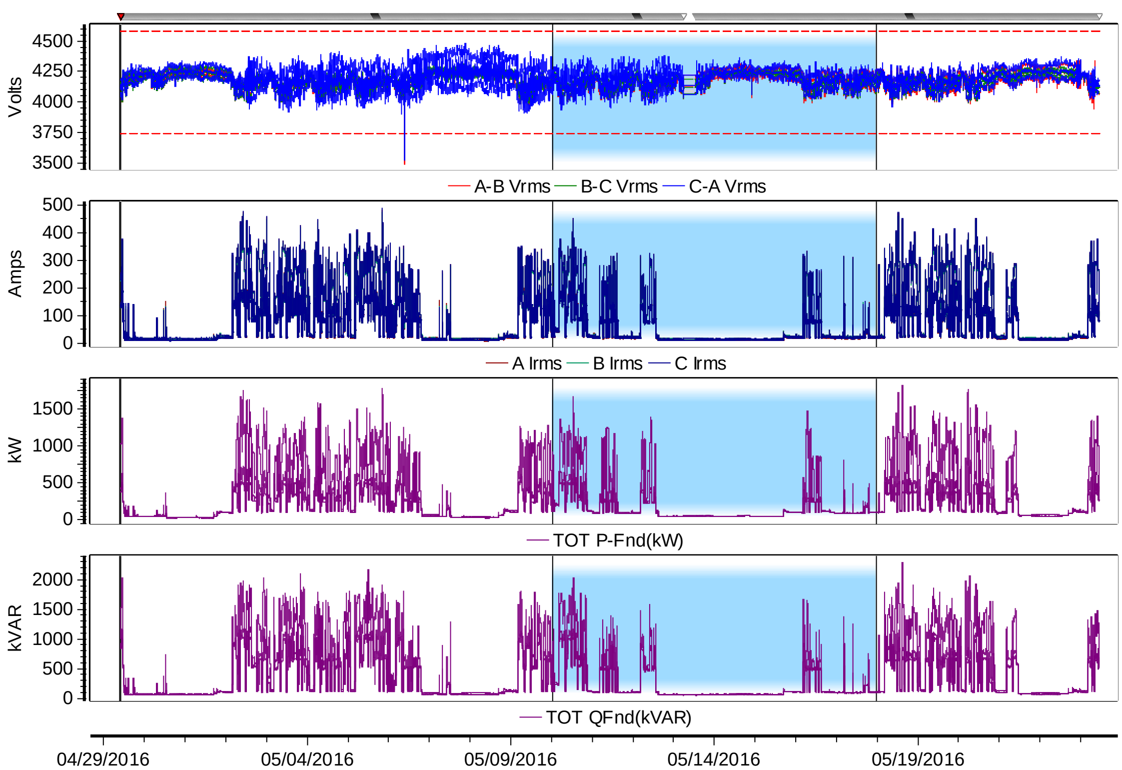


FIGURE 68. VOLTAGE (VRMS), CURRENT (IRMS), POWER (KW), AND REACTIVE POWER (KVAR)

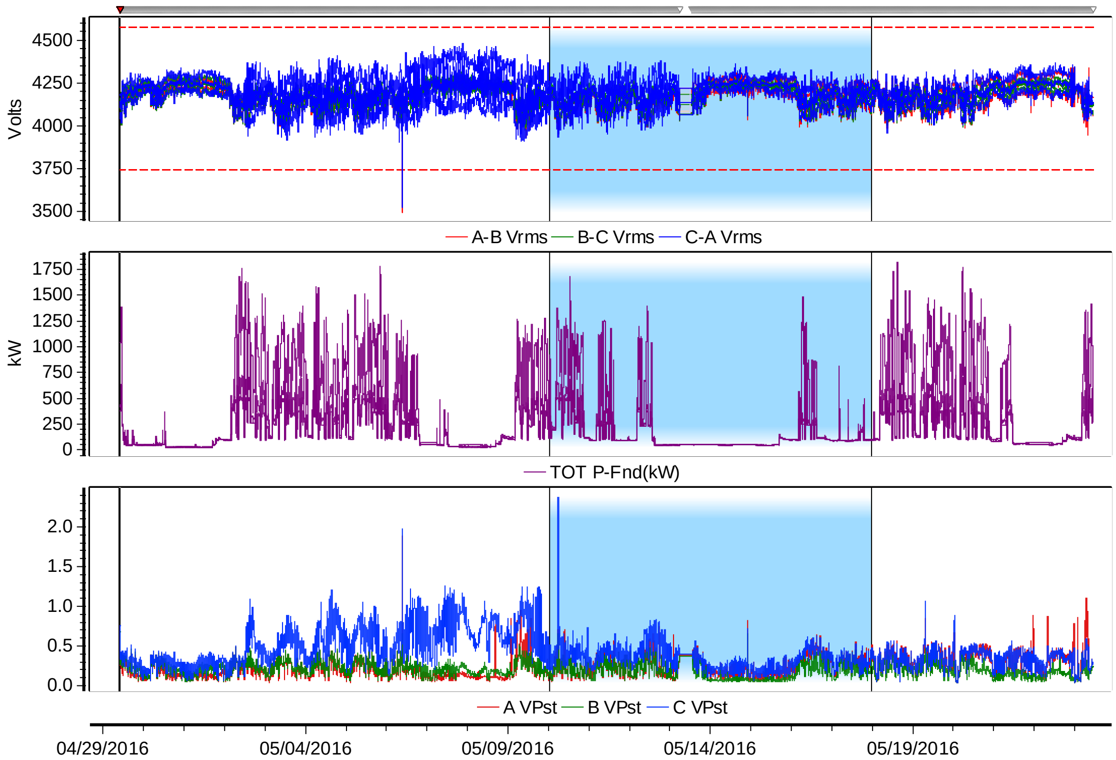


FIGURE 69. VOLTAGE (VRMS), POWER (KW), AND PERCEPTIBLE VOLTAGE FLICKER (PST)

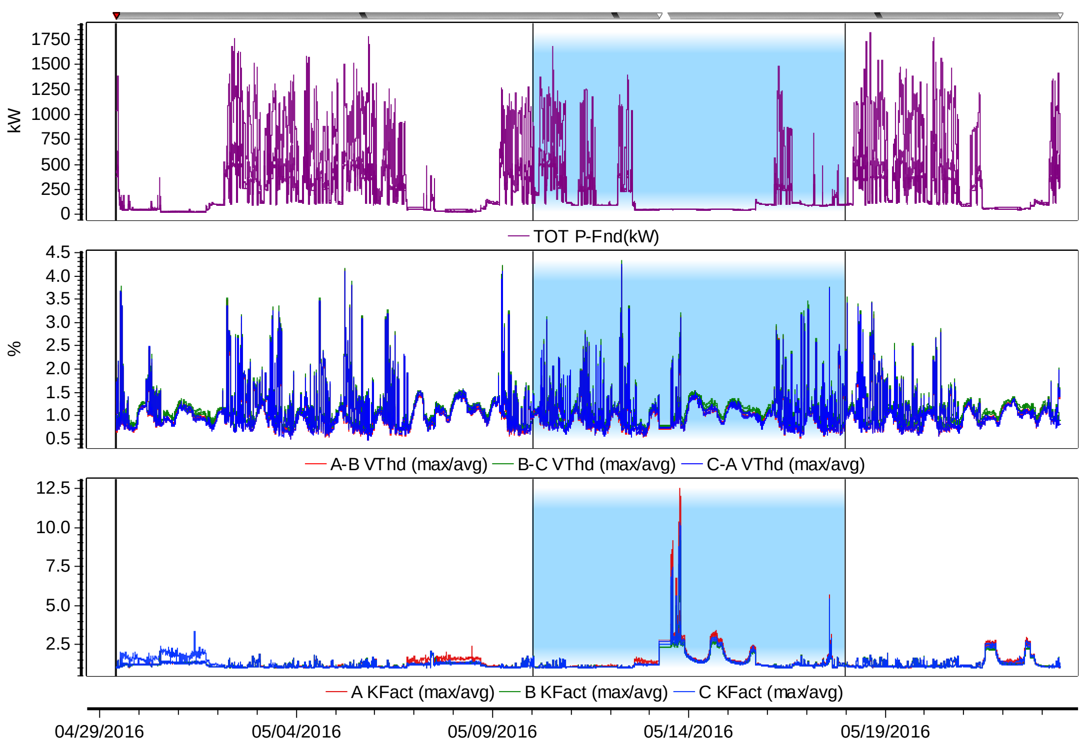


FIGURE 70. POWER (KW), HARMONIC DISTORTION (VTHD), K-FACTOR DISTORTION (KFACT)

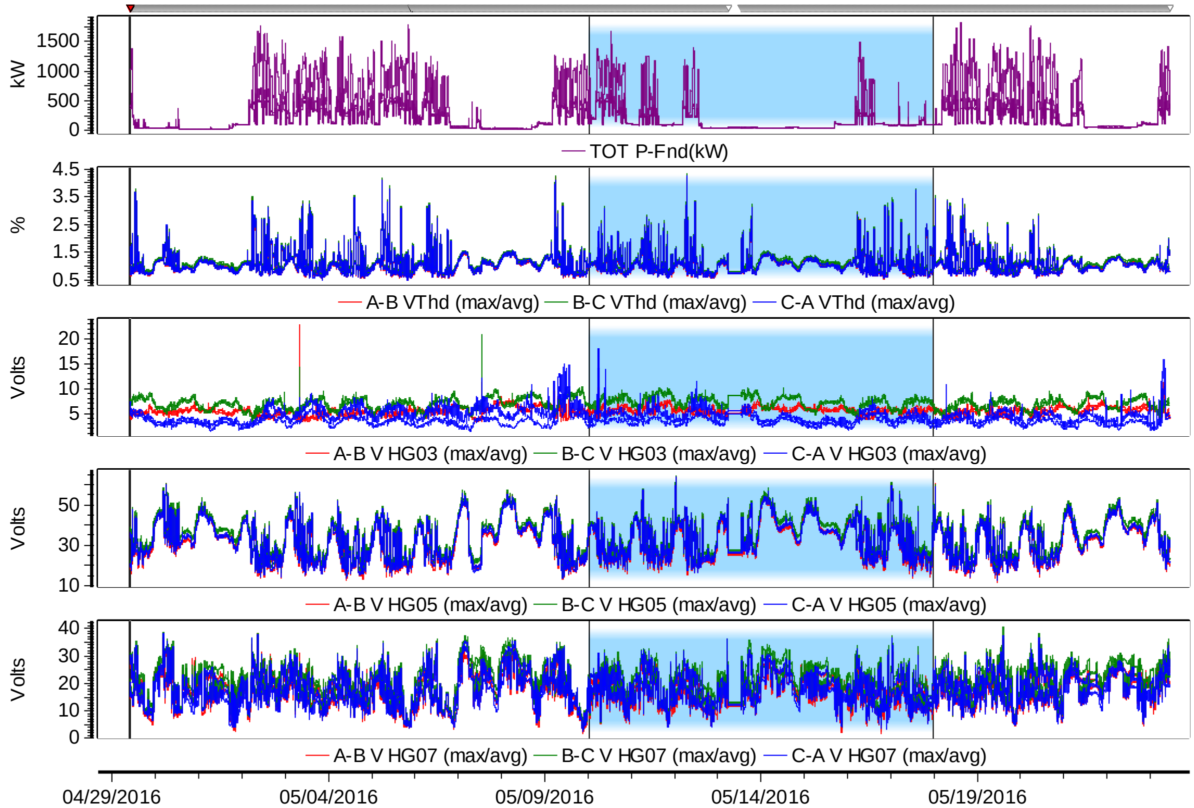


FIGURE 71. POWER (KW), HARMONIC DISTORTION (VTHD), 3RD HARMONIC VOLTS (HG03), 5TH HARMONIC VOLTS (HG05), 7TH HARMONIC VOLTS (HG07)

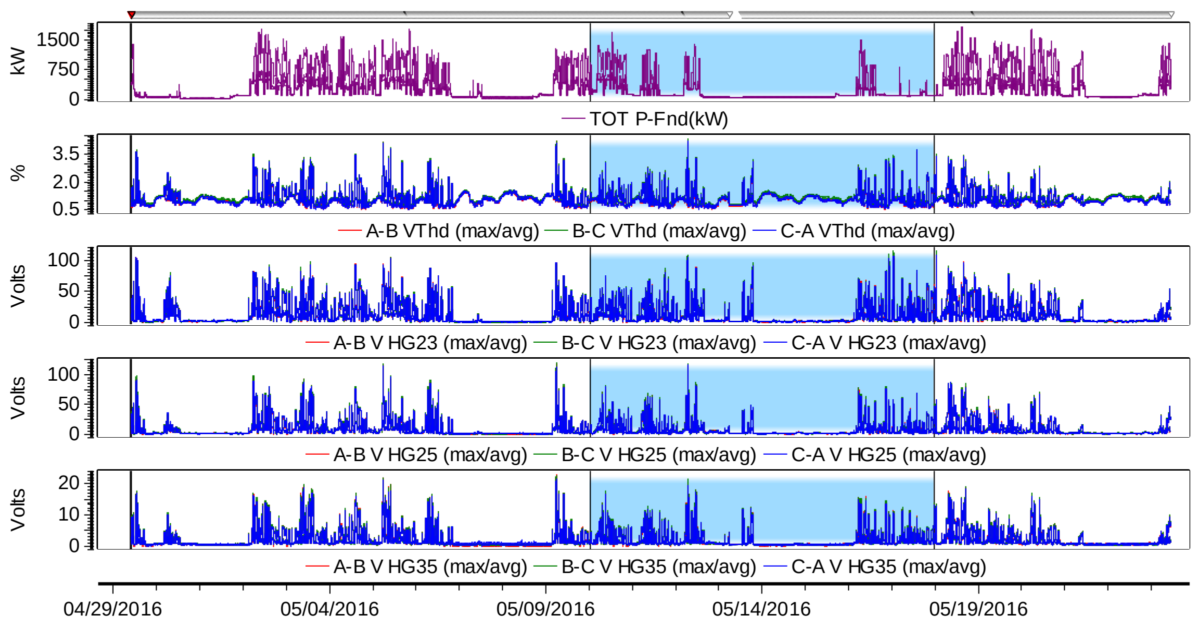


FIGURE 72. POWER (KW), HARMONIC DISTORTION (VTHD), 23RD HARMONIC VOLTS (HG23), 25TH HARMONIC VOLTS (HG25), 35TH HARMONIC VOLTS (HG35)

b) Wednesday May 25 12:00 (noon) PDT – 24 hour battery shutoff

At noon on Wednesday May 25, the battery system at Customer 1 was shut off for a period of 24 hours.

Figure 73 shows that the power readings (above 1000 kW) did not vary much before or after the shutdown.

Figure 74 shows that the Pst was slightly higher when the battery system was down, due to other load at the site. This Pst is a measure of the variations in the line voltage, and is a common power quality characteristic that is monitored at steel and metal working facilities.

Figure 75 shows the VThd and K-Factor distortion. The VThd was slightly higher (worse) with the battery storage system out of service, which is a result of a disturbing load elsewhere.

Figure 76 shows the 3rd, 5th, and 7th harmonic components, which are typical of industrial motor drive equipment. These levels of these low-order harmonic components were acceptable, and did not vary much before, during, or after the site shutdown.

Figure 77 shows the 23rd, 25th, and 35th harmonic components, which are typical of voltage source inverters (battery storage system). These levels were acceptable, and did not vary much before, during, or after the site shutdown.

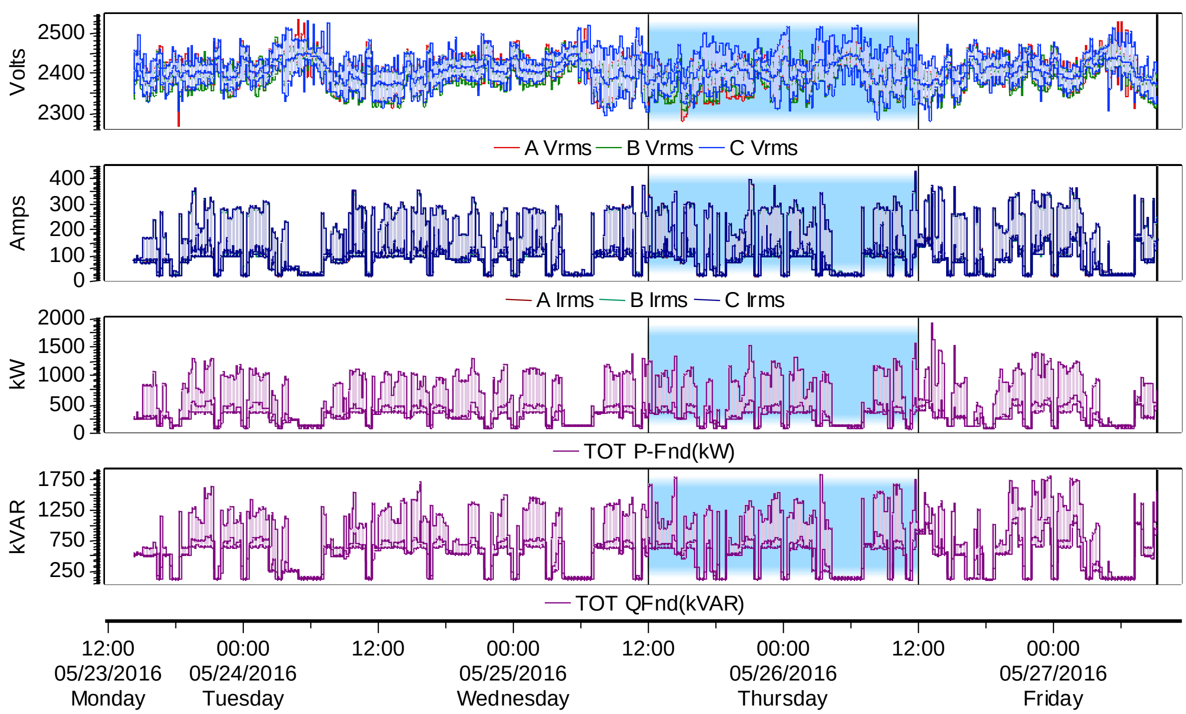


FIGURE 73. VOLTAGE (VRMS), CURRENT (IRMS), POWER (KW), AND REACTIVE POWER (KVAR)

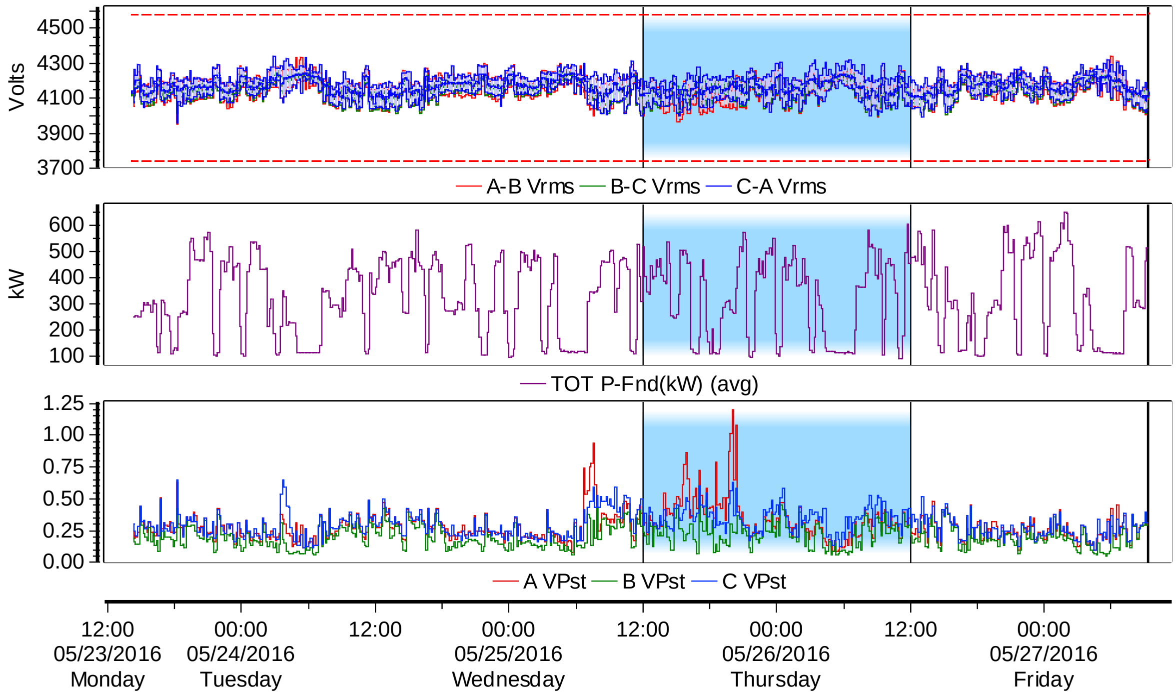


FIGURE 74. VOLTAGE (VRMS), POWER (KW), AND PERCEPTIBLE VOLTAGE FLICKER (PST)

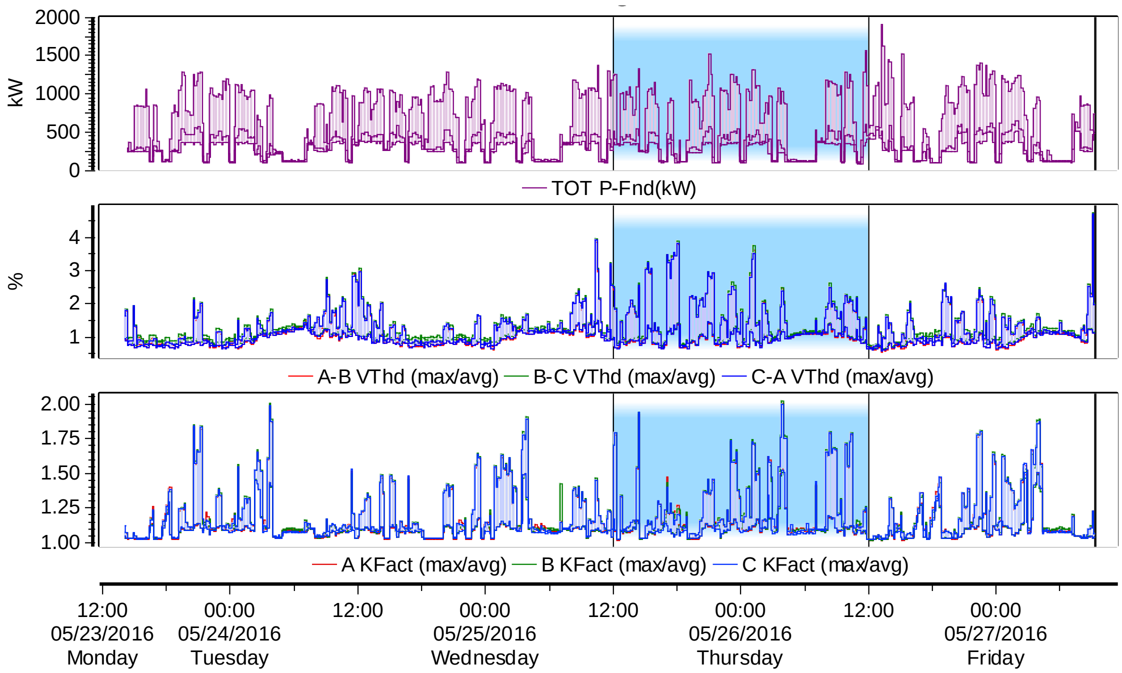


FIGURE 75. POWER (KW), HARMONIC DISTORTION (VTHD), K-FACTOR DISTORTION (K-FACT)

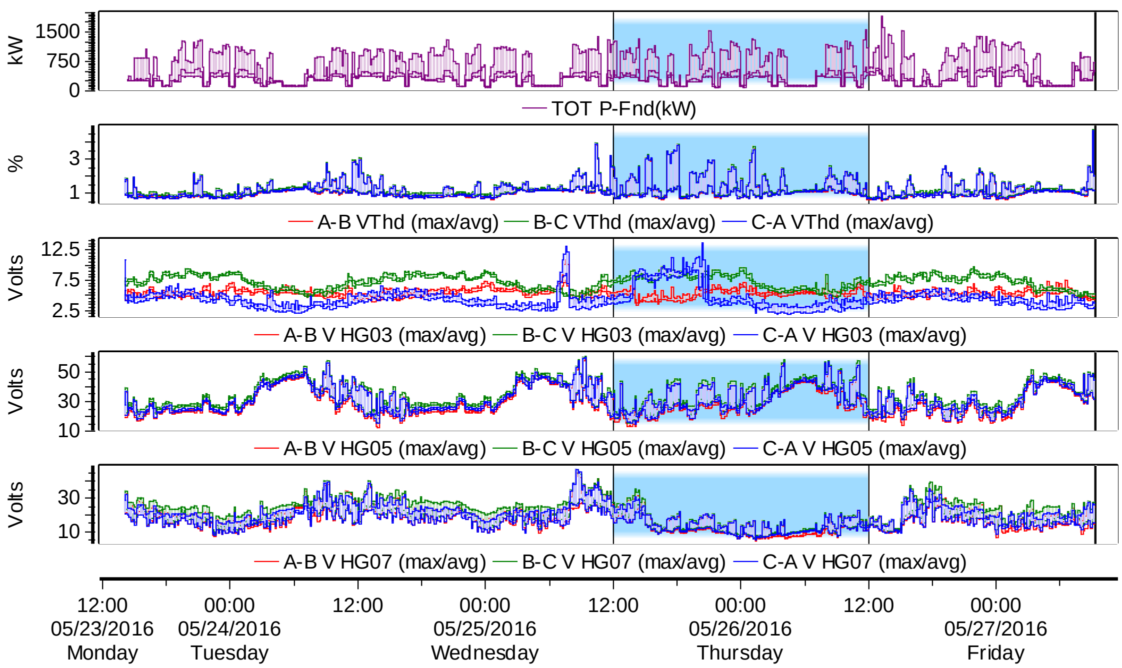


FIGURE 76. POWER (KW), HARMONIC DISTORTION (VTHD), 3RD HARMONIC VOLTS (HG03), 5TH HARMONIC VOLTS (HG05), 7TH HARMONIC VOLTS (HG07)

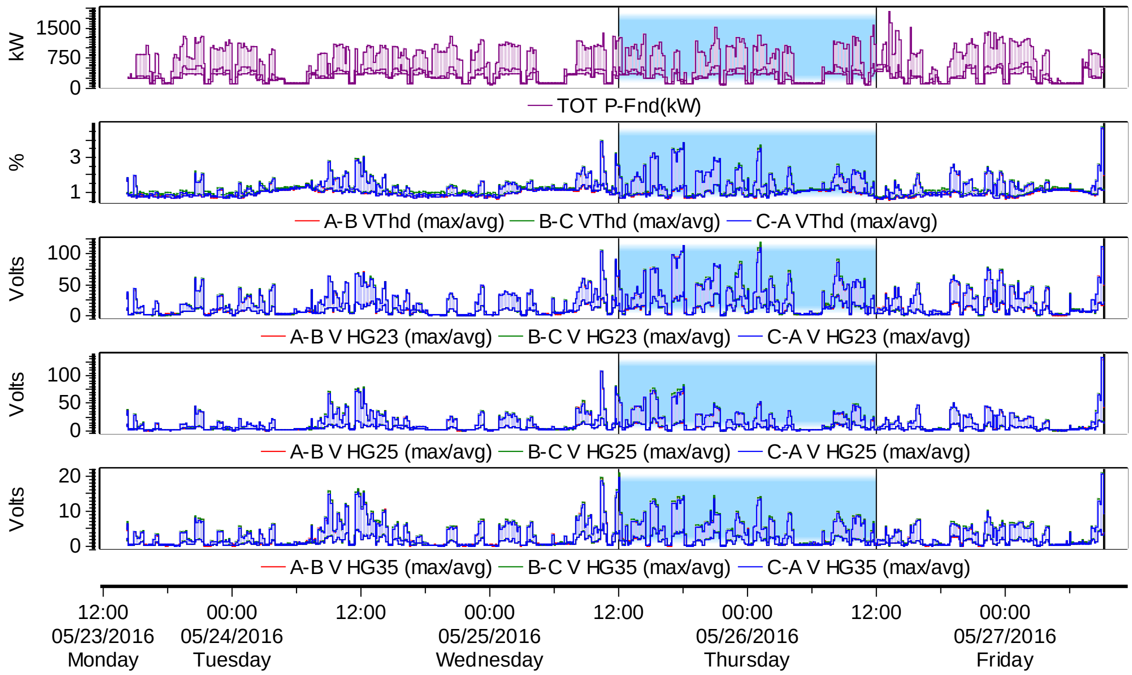


FIGURE 77. POWER (KW), HARMONIC DISTORTION (VTHD), 23RD HARMONIC VOLTS (HG23), 25TH HARMONIC VOLTS (HG25), 35TH HARMONIC VOLTS (HG35)

CUSTOMER 2 DEMAND RESPONSE OBSERVATIONS AND POWER QUALITY 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[18]. 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.

TEST EVENT 1: TUESDAY APRIL 5, 22:00-23:00 PDT – TURN OFF CHARGING

[18] SCE Net Energy Metering Interconnection Handbook: https://www.sce.com/wps/wcm/connect/69531af9-15f6-43e1-8368-a195c65fa249/NEM+Interconnection+Handbook.pdf?MOD=AJPERES

a) SCE METER BASELINE ANALYSIS

Figure 78 shows the test day has peak demand periods in excess of the maximum baseline period usage. During the test event, there is an increase of usage for the first 15 minutes, a decrease in usage for the next 15 minutes, a small increase in usage for the following 15 minutes and a significant usage increase over the final 15 minutes of the test period which results in a peak usage in excess of the maximum baseline period usage.

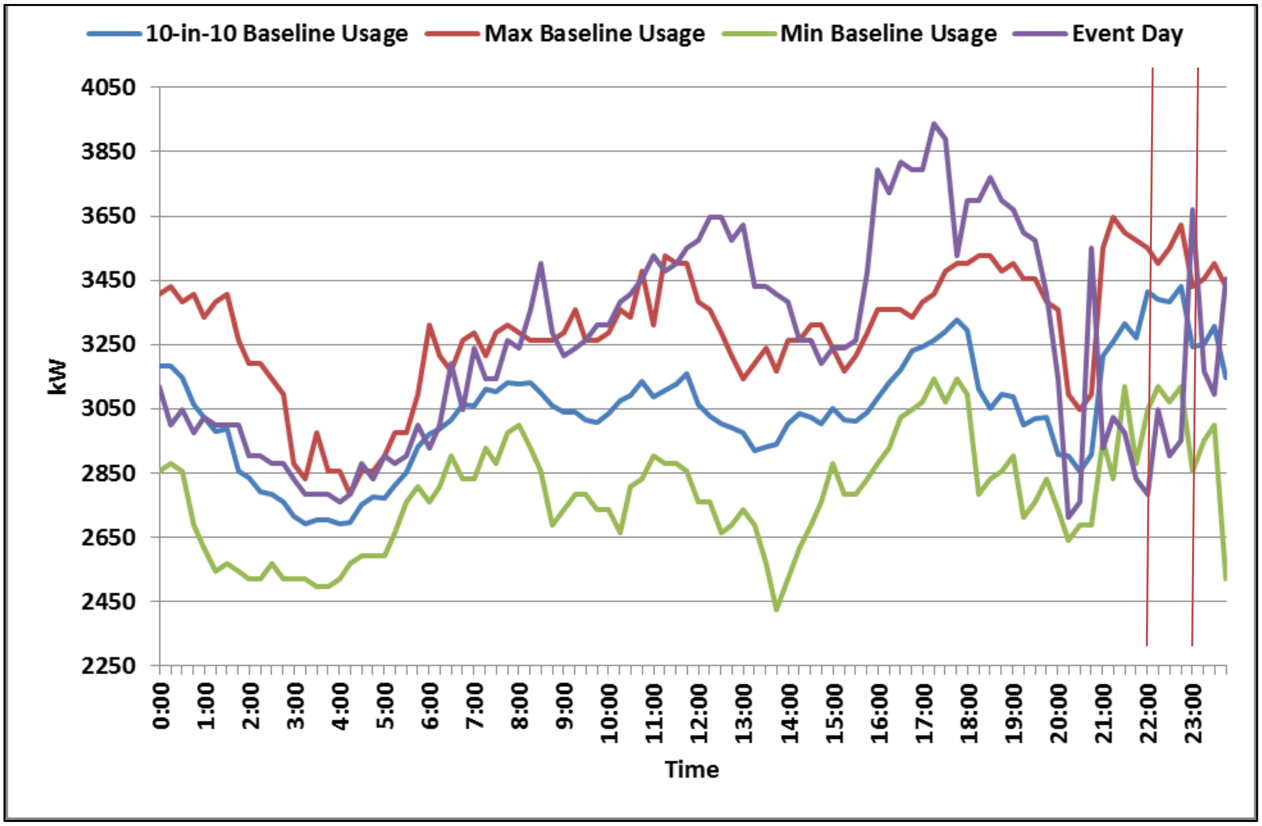


FIGURE 78. APRIL 5 22:00-23:00 CUSTOMER 2 TURN OFF CHARGING – SCE METER DATA

Because usage at the beginning of the event was lower than the minimum observed in the baseline period, the 10-in-10 Baseline estimate in Figure 79 is relatively high compared to the adjusted ±20% and LA 10-in-10 baselines. The 10-in-10 baseline is more representative of the average usage during the baseline period. The ± 20% and LA 10-in-10 baselines attempt to correct for the low usage prior to the test event, but neither methodology seem to accomplish this goal.

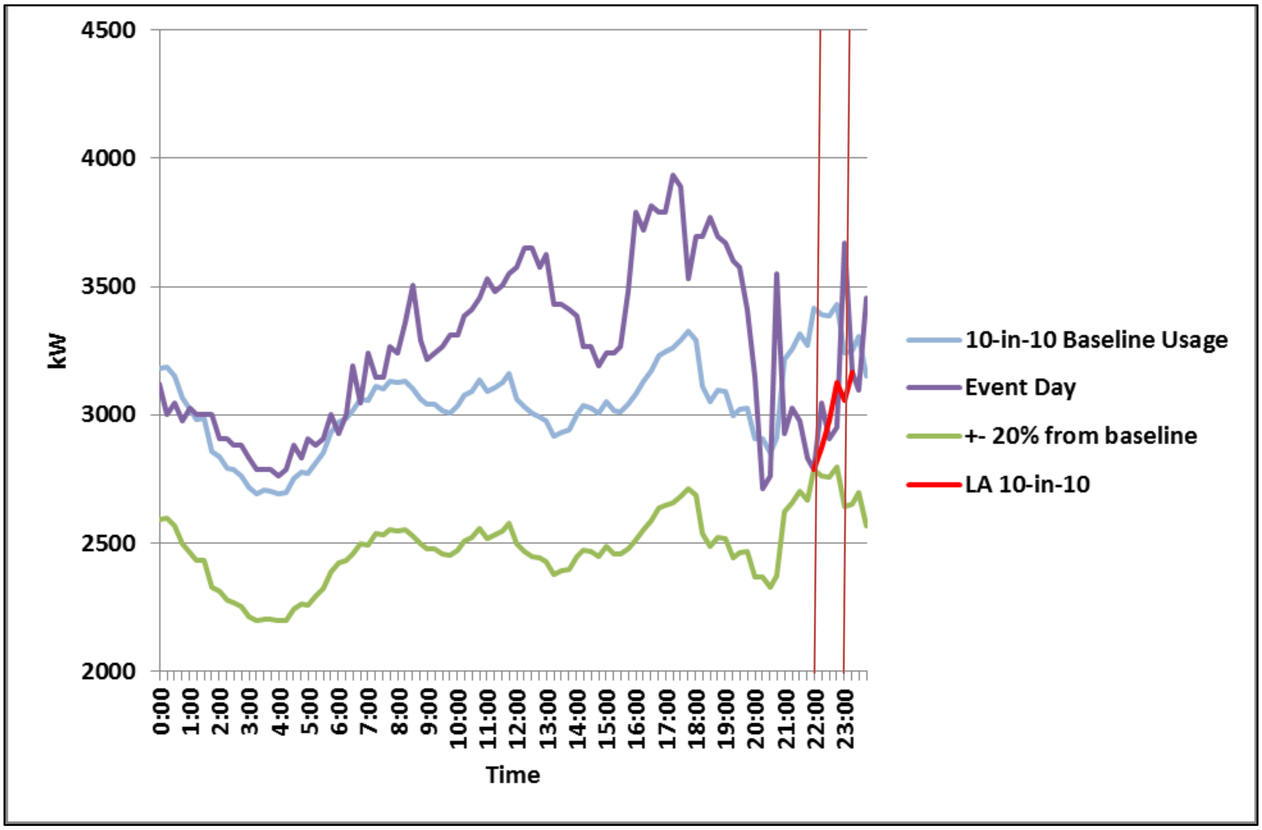


FIGURE 79. APRIL 5 22:00-23:00 CUSTOMER 2 TURN OFF CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 17. APRIL 5 22:00-23:00 CUSTOMER 2 TURN OFF CHARGING – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
21:45-22:00	2,784.00	-	-	-
22:00-22:15	3,048.00	(340.80)	285.52	177.76
22:15-22:30	2,904.00	(480.00)	145.43	(69.78)
22:30-22:45	2,952.00	(480.00)	154.30	(173.09)
22:45-23:00	3,672.00	429.60	1,028.86	616.45
23:00-23:15	3,168.00	-	-	-
Average kW	**3,144.00**	**(217.80)**	**403.53**	**137.84**
Average kWh	**3,144.00**	**(217.80)**	**403.53**	**137.84**
CBP Bid (kW)		(200)		
CBP Event Performance		**109%**		

b) Battery ALCS Baseline Analysis

Figure 80 shows that the battery was discharging prior to and during the "Turn Off Charging" event. Discharging is allowed for a "Turn Off Charging" test event, but results and response to the "Turn Off Charging" dispatch signal get lost since there was no actual change in usage as a result of the "Turn Off Charging" dispatch.

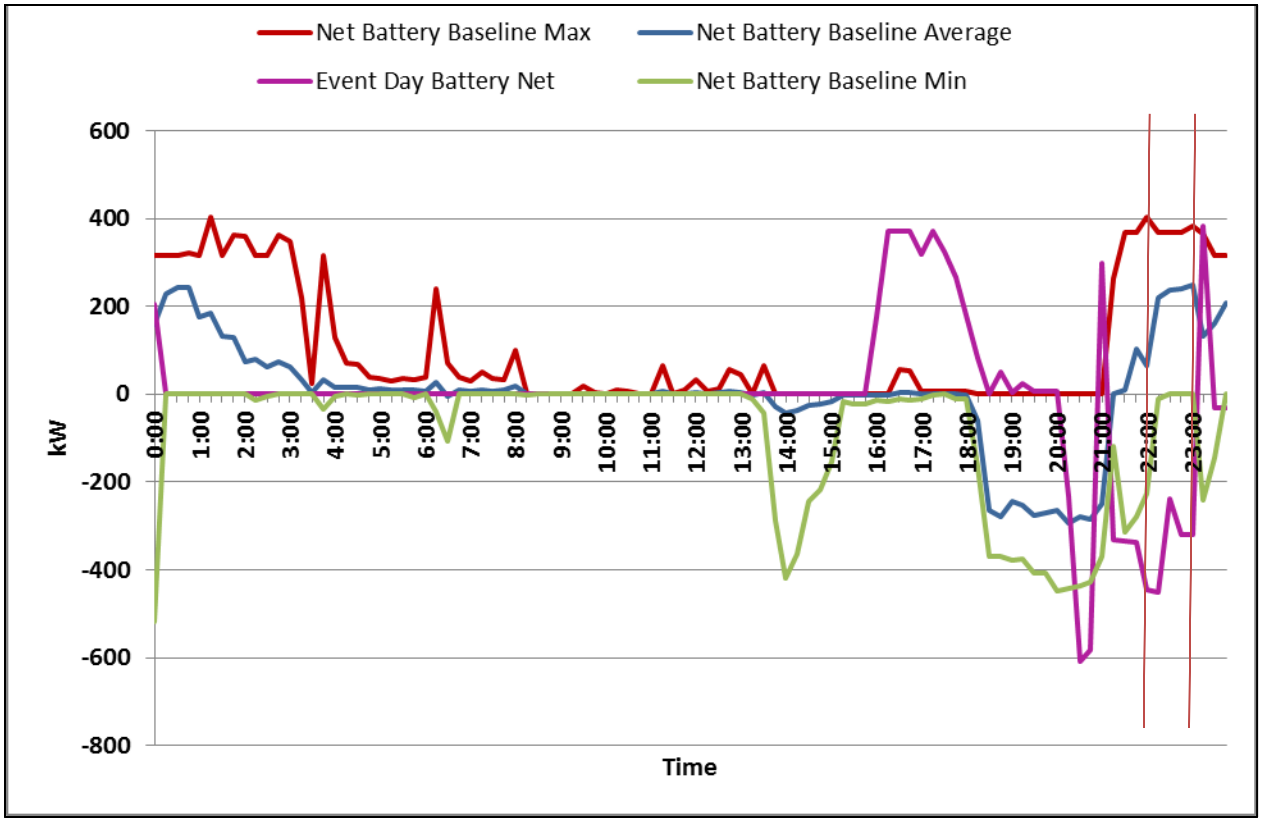


Figure 80. April 5 22:00-23:00 Customer 2 Turn Off Charging – Battery ALCS Net Meter Data

The battery was signaled to "Turn Off Charging" from 22:00-23:00 but Figure 81 shows that the battery was not charging at 22:00, so the expected response did not occur. The battery did discharge during the event giving a similar effect to a "Turn Off Charging" response. However, this response is similar to what is observed in the 21:00-22:00 hours and does not necessarily indicate a response to any "Turn Off Charging" signal.

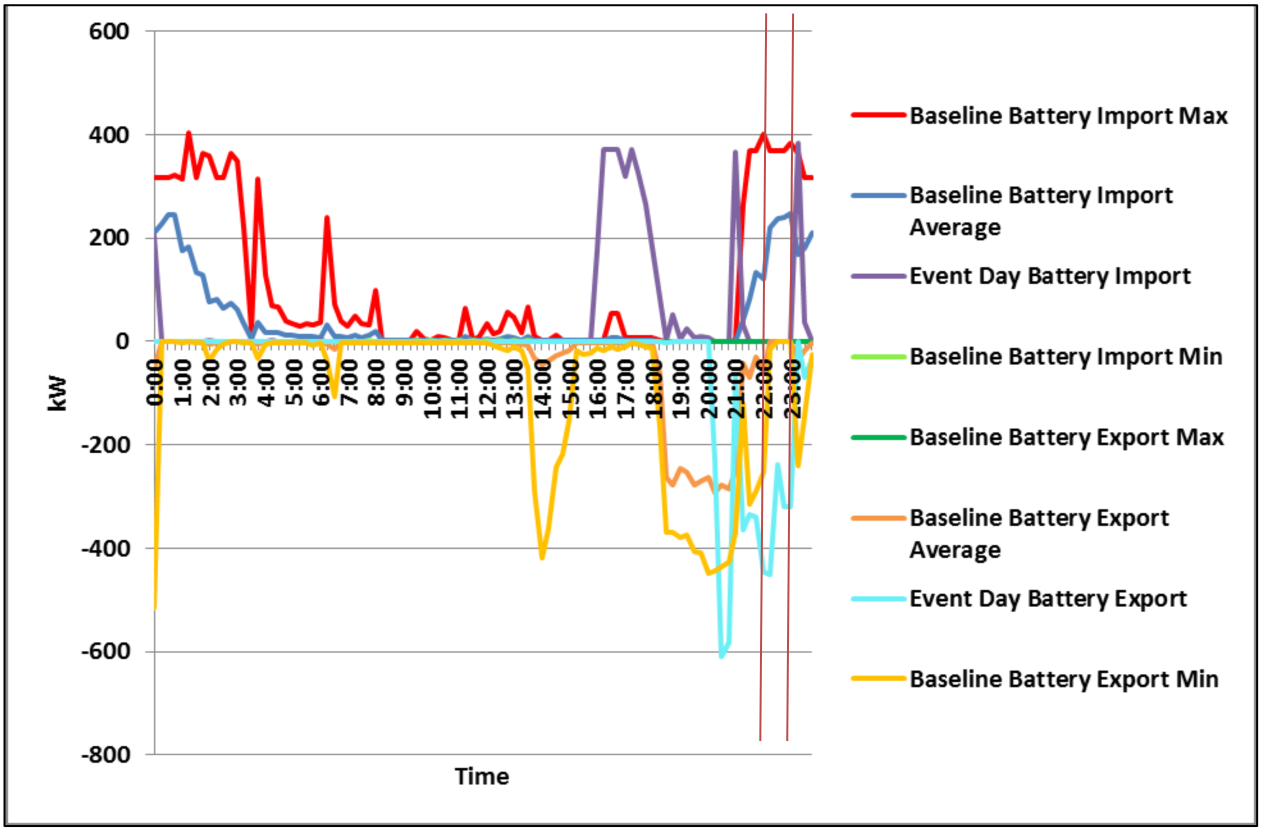


FIGURE 81. APRIL 5 22:00-23:00 CUSTOMER 2 TURN OFF CHARGING – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ MEASUREMENTS

The upper chart in Figure 82 aligns with both the Battery ALCS data shown in Figure 80 and Figure 81 as well as the SCE meter data shown in Figure 78 and Figure 79. The lower chart in Figure 82 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during, and after the test event period.

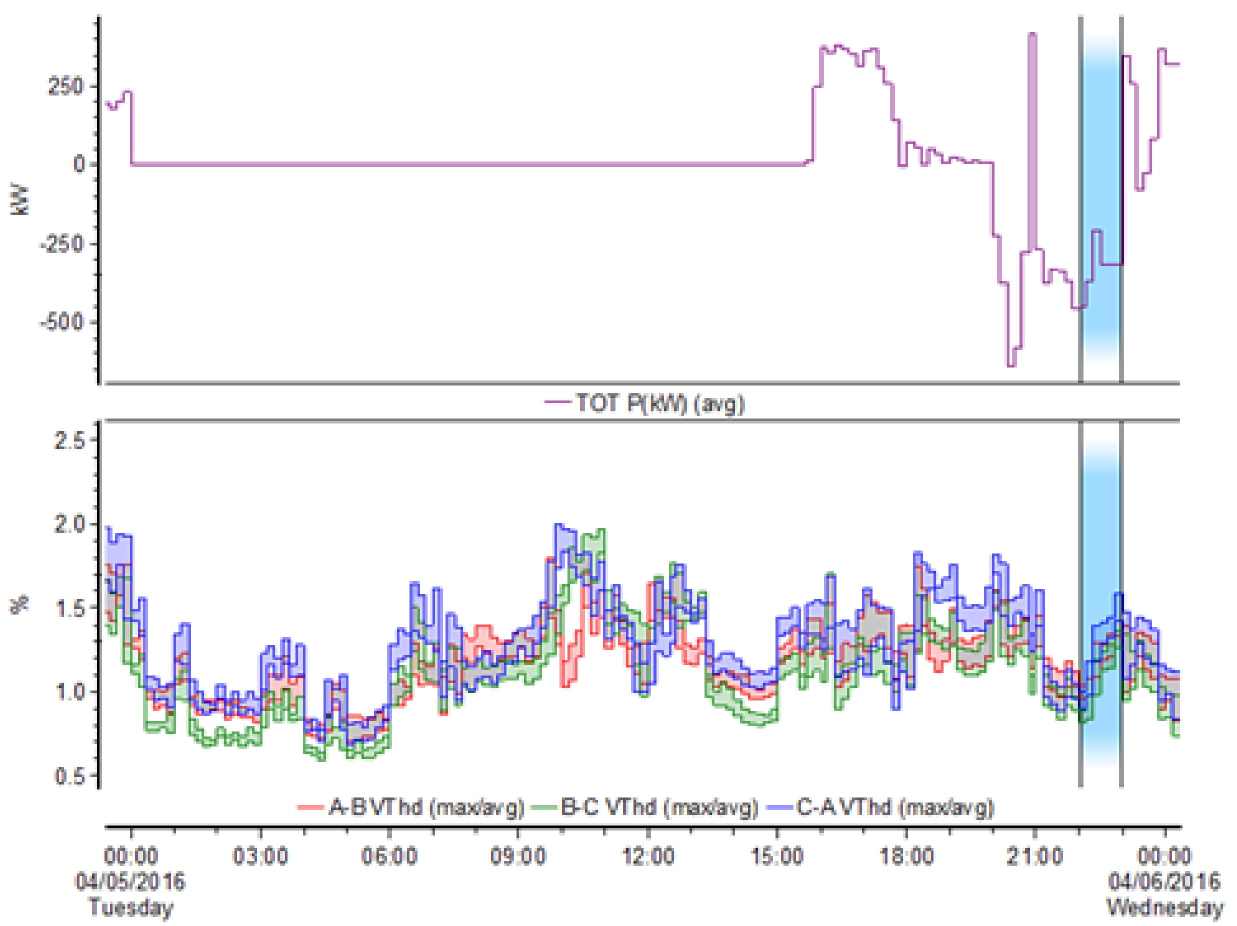


FIGURE 82. APRIL 5 22:00-23:00 CUSTOMER 2 TURN OFF CHARGING – PQ METER DATA

TEST EVENT 2: TUESDAY APRIL 12, 14:00-15:00 PDT – DISCHARGE

a) SCE Meter Baseline Analysis

Figure 83 shows that usage on the test event day varied between the maximum and minimum baseline usage, remaining relatively close to the average 10-in-10 throughout. During the test event period, usage increased for the first 30 minutes before a slight decrease for the next 15 minutes, and a larger increase across the final 15 minutes. This is not the anticipated profile for a successful "discharge" test event. There is no indication in the meter data that the batteries performed any discharge during the test event period.

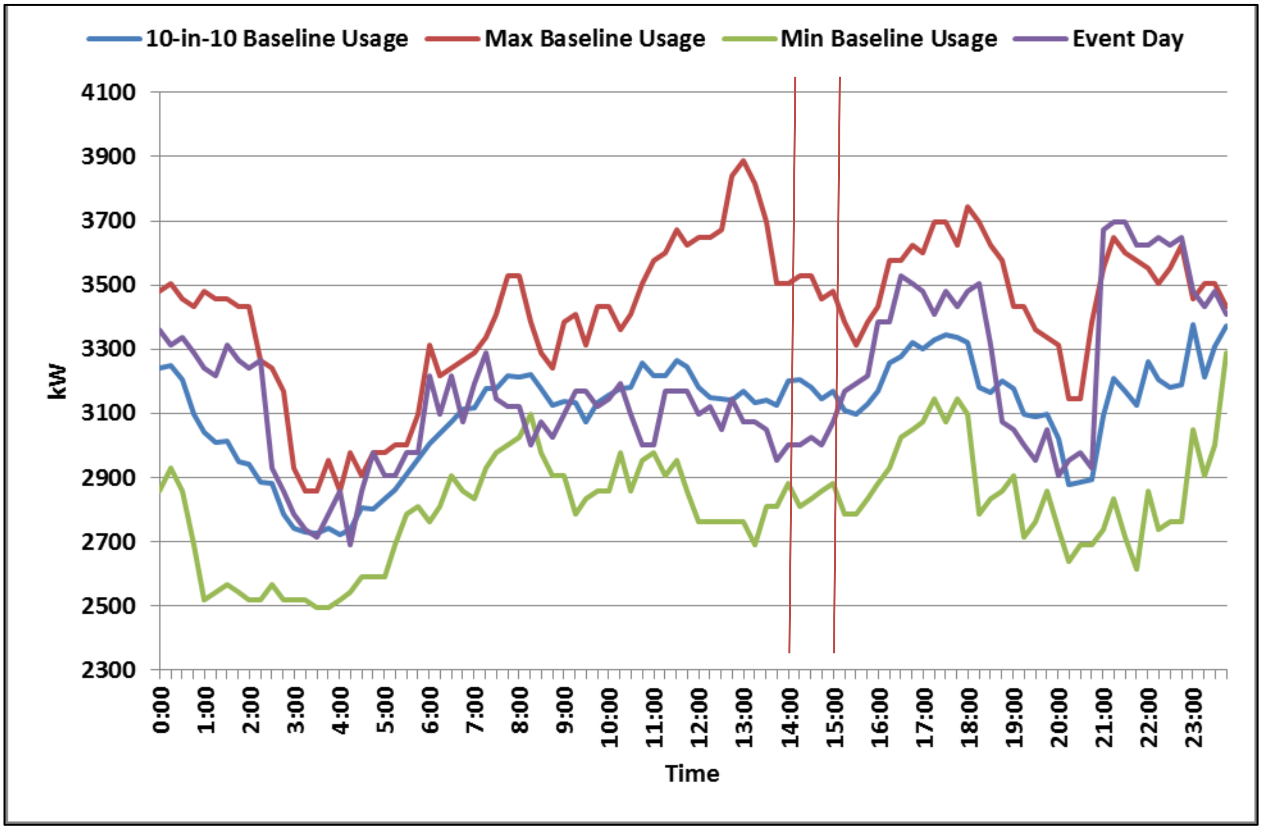


Figure 83. April 12 14:00-15:00 Customer 2 Discharge – SCE Meter Data

During a "discharge" event, it is expected that the event day load be significantly lower than the average load. While the event started at a point that was below the average load, it crept closer to that average rather than moving down. The lack of response is highlighted in Figure 84 by the ±*20% from baseline* graph, which shows that given the event's low starting point, it would have been expected to remain low.

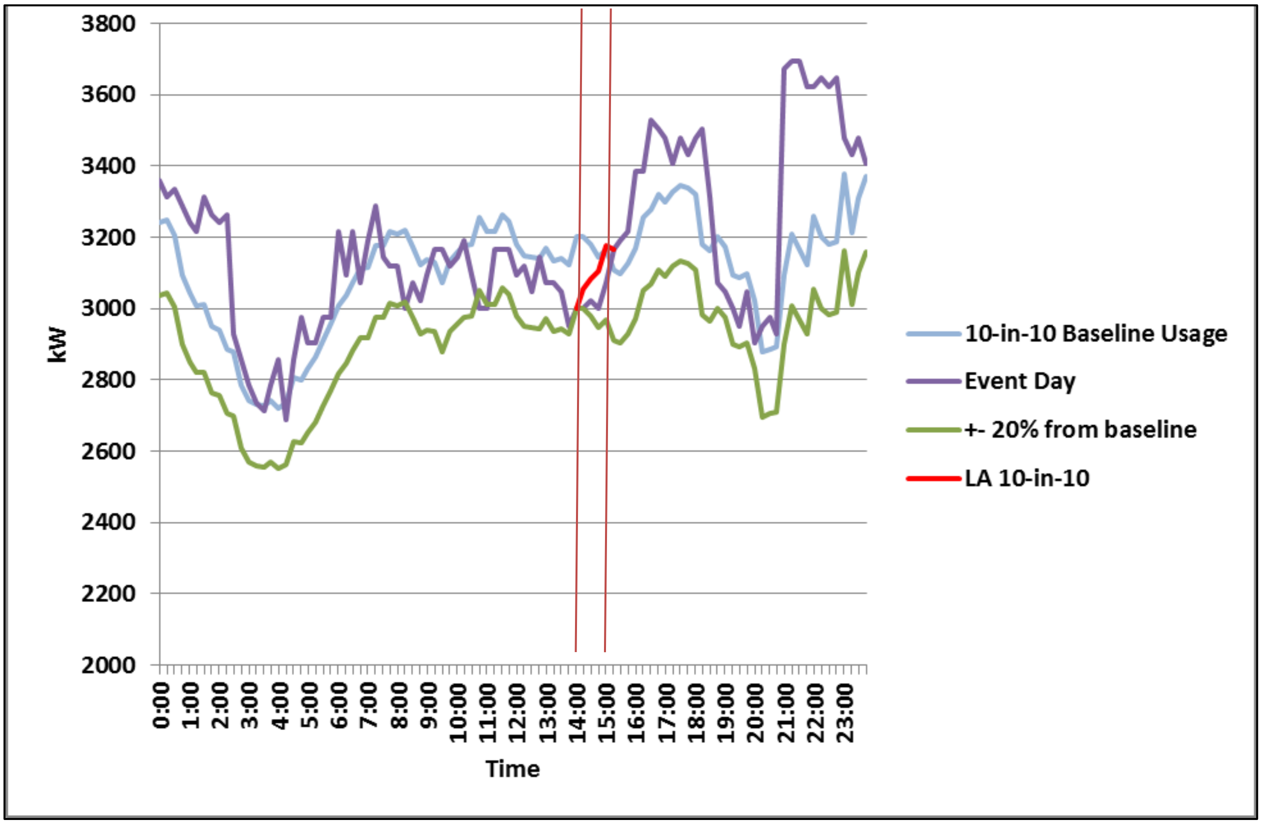


FIGURE 84. APRIL 12 14:00-15:00 CUSTOMER 2 DISCHARGE – DR BASELINE ESTIMATES

Error! Reference source not found. shows the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 18. APRIL 12 14:00-15:00 CUSTOMER 2 DISCHARGE – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
13:45-14:00	3,000.00	-	-	-
14:00-14:15	3,000.00	(204.00)	(2.25)	(54.97)
14:15-14:30	3,024.00	(156.00)	44.24	(60.41)
14:30-14:45	3,000.00	(146.40)	51.72	(103.60)
14:45-15:00	3,072.00	(96.00)	103.48	(105.03)
15:00-15:15	3,168.00	-	-	-
Average kW	**3,024.00**	**(150.60)**	**49.30**	**(81.00)**
Average kWh	**3,024.00**	**(150.60)**	**49.30**	**(81.00)**
CBP Bid (kW)		(200)		
CBP Event Performance		**75%**		

b) Battery ALCS Baseline Analysis

While the SCE meter data in Figure 83 indicates no perceivable change in demand, the battery ALCS system data in Figure 85 indicates that there was some export from the battery. The inconsistency may be attributable to the fact that the battery system is not allowed to export to the grid and the battery discharge was limited to the amount of load that is metered by the battery ALCS. Still, the magnitude of this discharge (roughly 200 kW) is roughly half of the greatest magnitude of discharge for the day and 40% of what was observed in the baseline period.

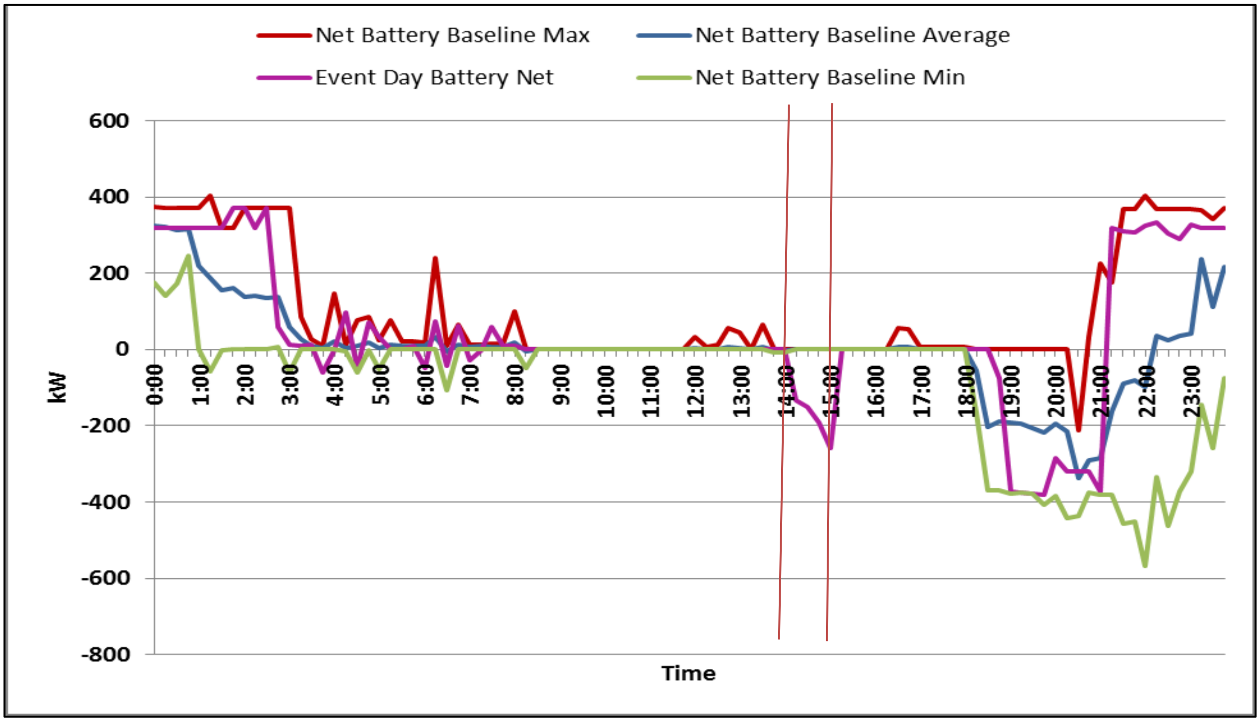


Figure 85. April 12 14:00-15:00 Customer 2 Discharge – Battery ALCS Net Meter Data

The Import Export chart in Figure 86 supports the observations from Figure 85.

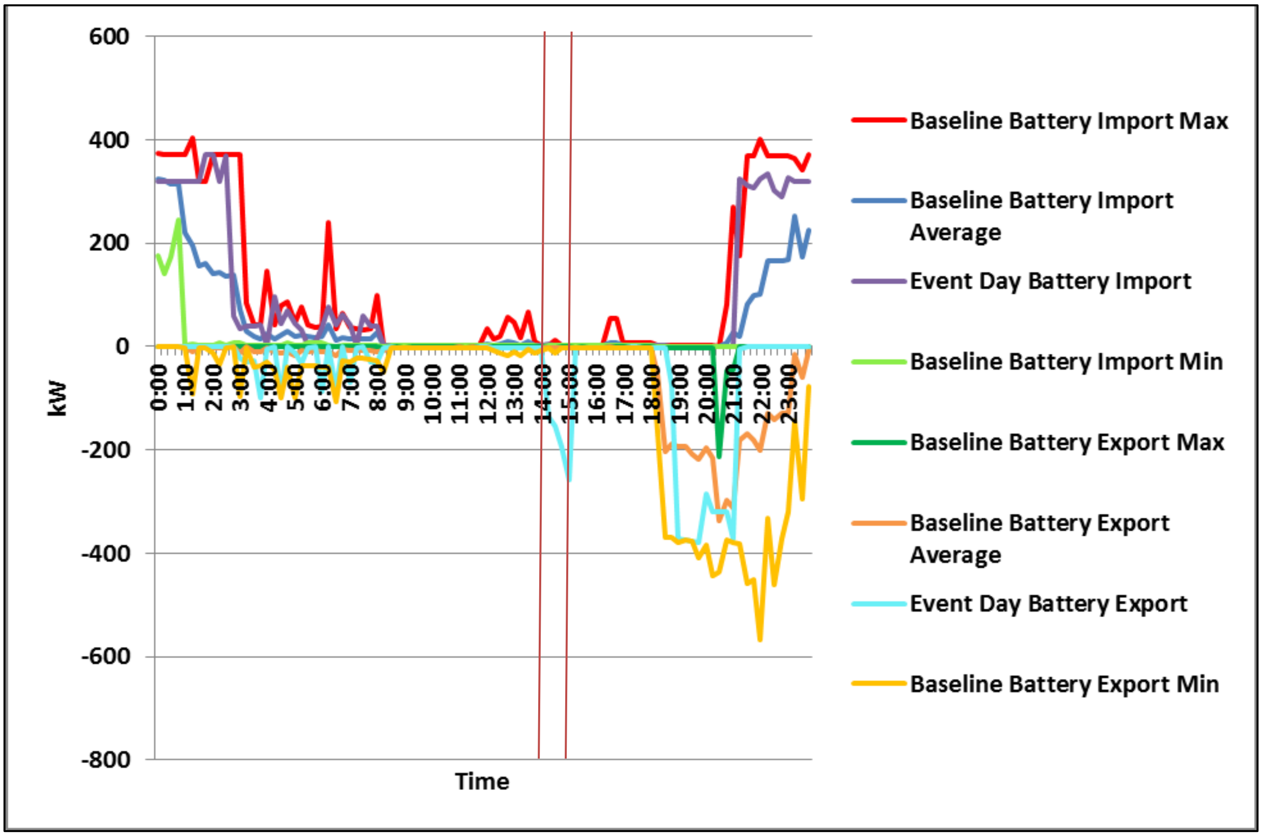


FIGURE 86. APRIL 12 14:00-15:00 CUSTOMER 2 DISCHARGE – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ MEASUREMENTS

The upper chart in Figure 87 aligns with the Battery ALCS data shown in Figure 85 and Figure 86 with the battery being offline until the start of the test event at 14:00 and discharging from 14:00-15:00. The actual discharge seems to get lost in the net facility load reflected in the SCE meter data shown in Figure 83 and Figure 84.

The lower chart in Figure 87 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during and after the test event period.

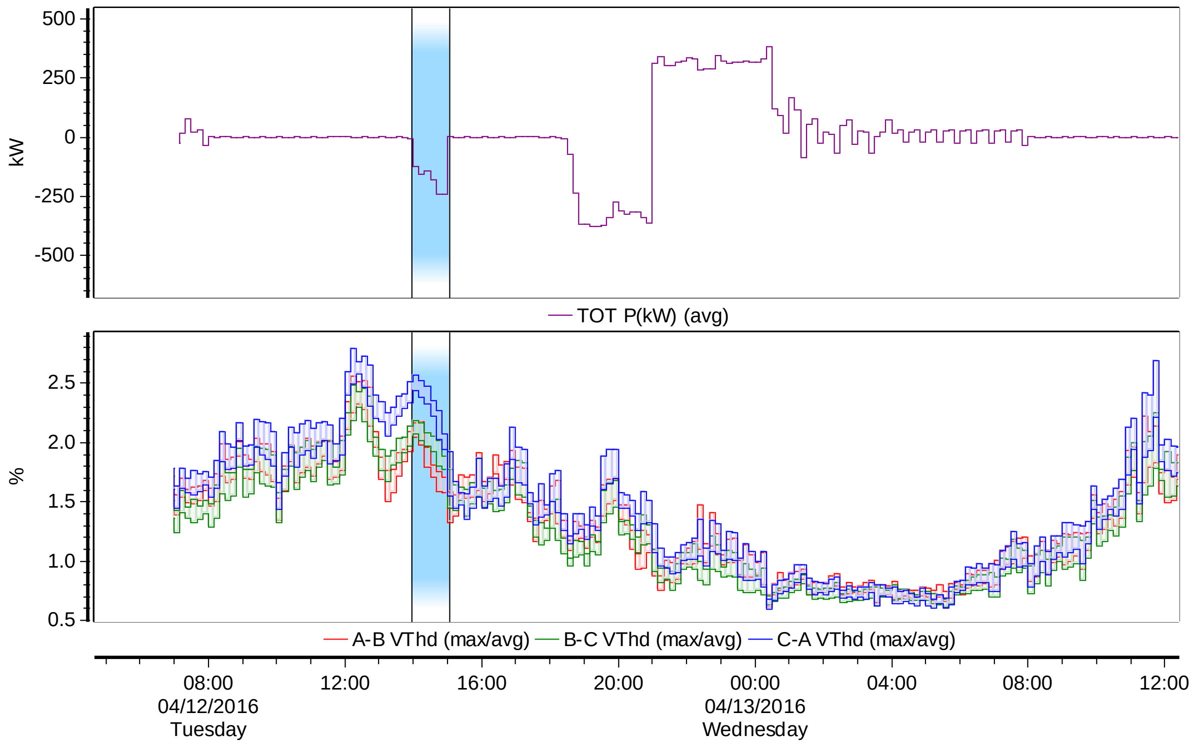


FIGURE 87. APRIL 12 14:00-15:00 CUSTOMER 2 DISCHARGE – PQ METER DATA

TEST EVENT 3: TUESDAY APRIL 19, 22:00-23:00 PDT – TURN OFF CHARGING

a) SCE METER BASELINE ANALYSIS

Figure 88 appears to show a decrease in usage during the first 15 minutes of the test event, followed by a gradual usage increase for the next 30 minutes, a slight usage decrease for the final 15 minutes followed by usage climbing back to 10-in-10 baseline levels after the test event completion. This test event is not a dramatic representation of a demand response profile, but is in line with decreased impact expectations for a "Turn Off Charging" signal.

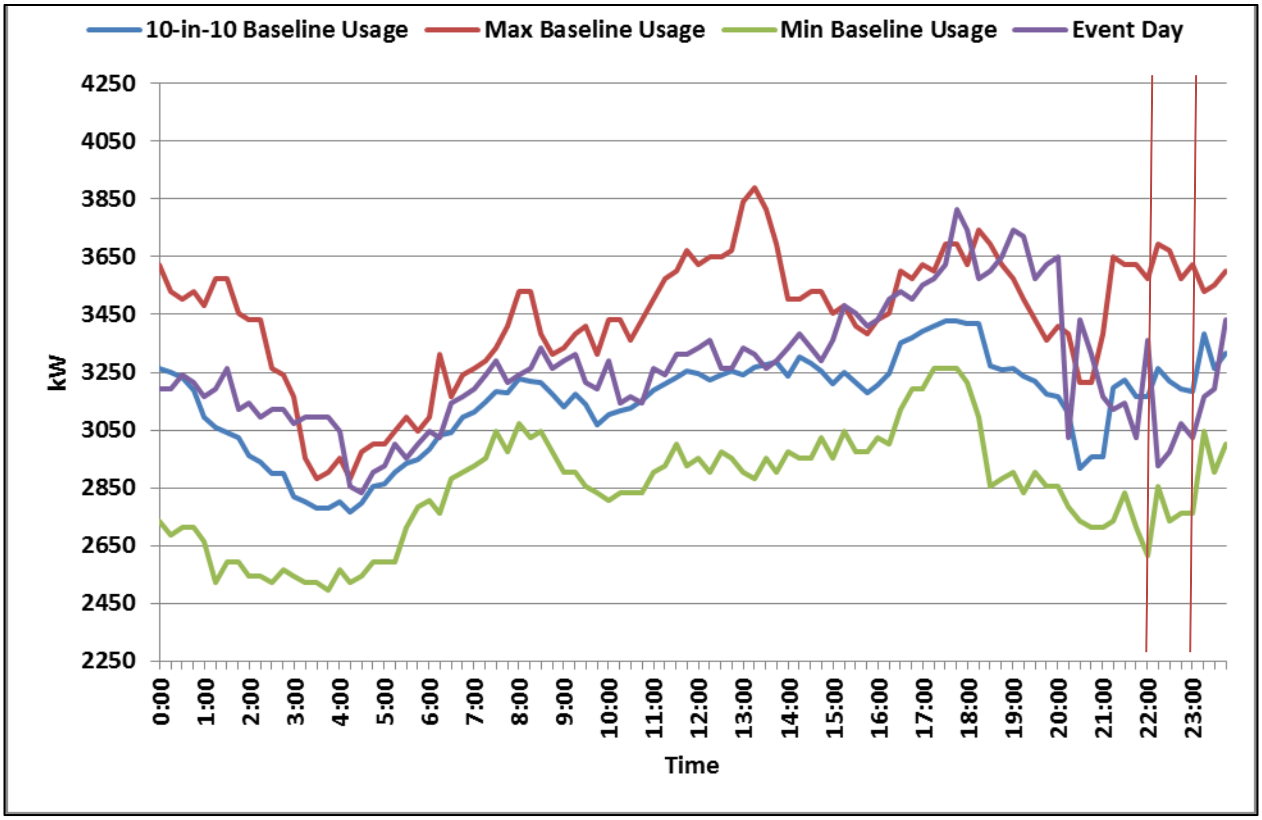


FIGURE 88. APRIL 19 22:00-23:00 CUSTOMER 2 TURN OFF CHARGING – SCE METER DATA

Figure 89 shows that all of the DR baseline estimates agree that some usage decrease occurred as a result of the "Turn Off Charging" test event. However, it is important to recognize that the 15 minutes prior to event start exhibit a large peak that is different from the preceding hour. While there is some difference between the readings at 21:45 and 22:15, the difference is much smaller than when the peak observed at 22:00 is compared with the 22:15. Put another way, the perceived impact of this event may have been influenced by a charge leading up to the event.

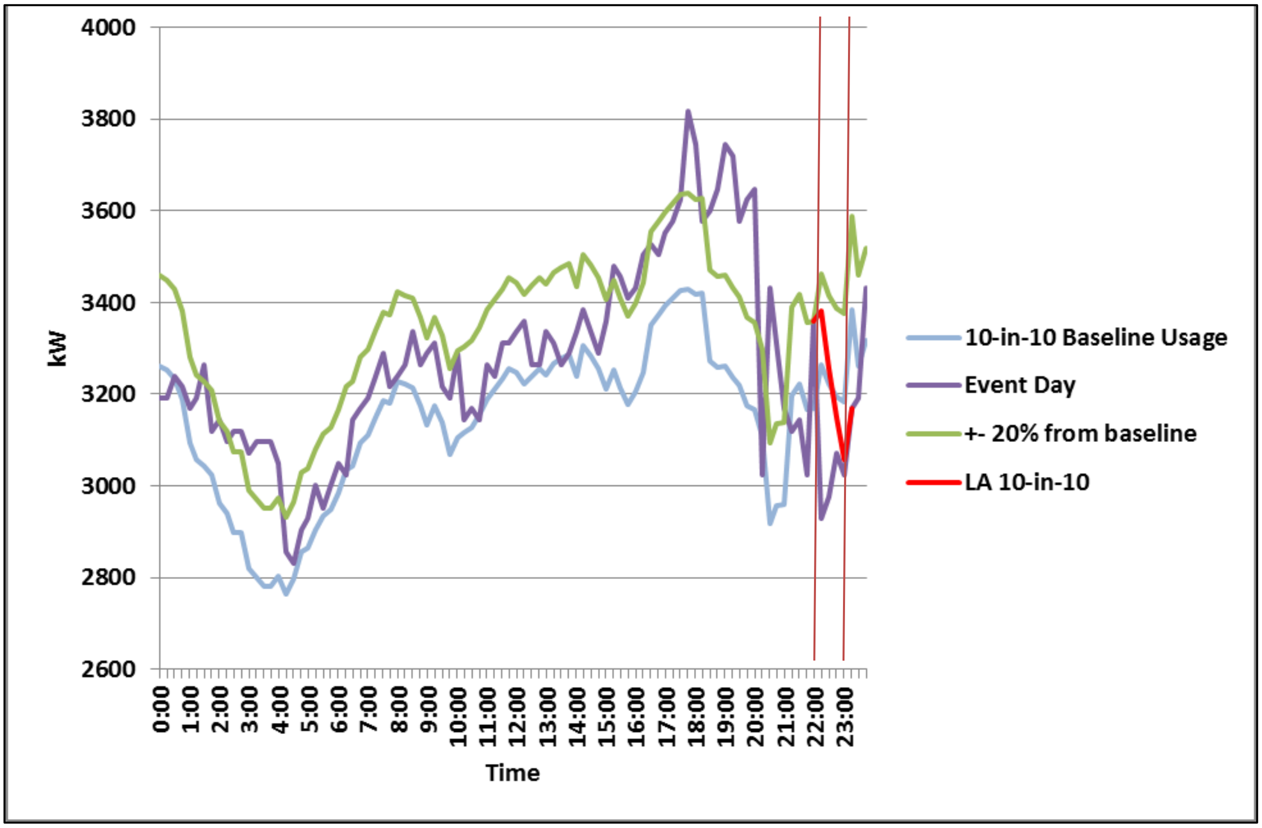


FIGURE 89. APRIL 19 22:00-23:00 CUSTOMER 2 TURN OFF CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 19. APRIL 19 22:00-23:00 CUSTOMER 2 TURN OFF CHARGING – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CBP EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
21:45-22:00	3,360.00	-	-	-
22:00-22:15	2,928.00	(336.00)	(533.82)	(452.59)
22:15-22:30	2,976.00	(244.80)	(440.00)	(279.69)
22:30-22:45	3,168.00	(216.00)	(421.09)	-
22:45-23:00	3,024.00	(158.40)	(351.27)	(34.47)
23:00-23:15	3,168.00	-	-	-
Average kW	**3,024.00**	**(238.80)**	**(436.55)**	**(191.69)**
Average kWh	**3,024.00**	**(238.80)**	**(436.55)**	**(191.69)**
CBP Bid (kW)		(200)		
CBP Event Performance		**119%**		

b) BATTERY ALCS BASELINE ANALYSIS

Figure 90 shows the battery was discharging prior to and during the “Turn Off Charging” event. Discharging was allowed for a “Turn Off Charging” event. The discharging that occurs during the “Turn Off Charging” test event from 22:00-23:00 increases the perceived performance of the “Turn Off Charging” test. In fact, no charging was taking place just prior to 22:00 and therefore the “Turn Off Charging” dispatch would not have resulted in any usage change if not for the discharging occurring concurrently. Additionally, Figure 20 shows that the baseline battery usage is roughly zero from 22:00-23:00, indicating that the battery does not usually charge during the event period. The importance of selecting appropriate signaling times is further discussed in the Discussion sections “Selecting the Appropriate Markets and Event Times to Maximize Results” portion of the report.

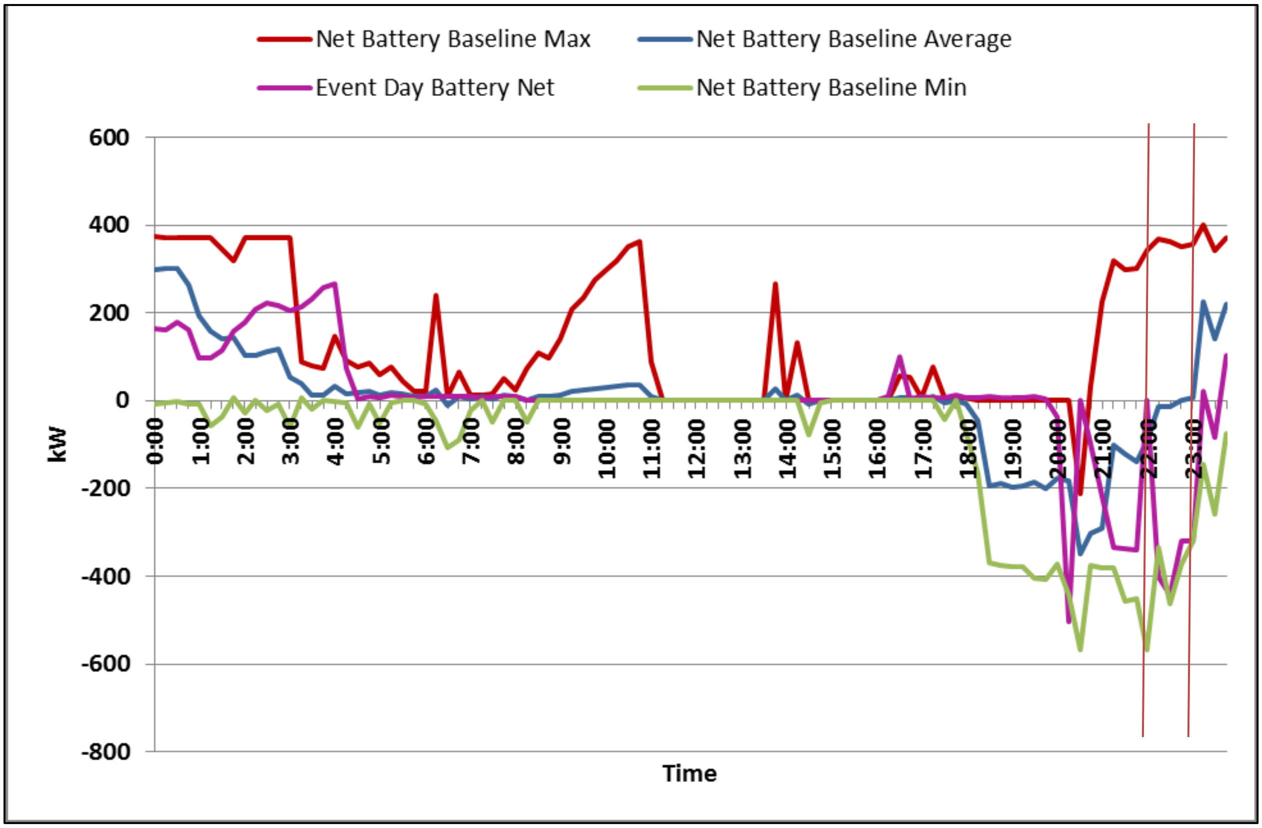


FIGURE 90. APRIL 19 22:00-23:00 CUSTOMER 2 TURN OFF CHARGING – BATTERY ALCS NET METER DATA

The Import Export chart in Figure 91 supports the event day observations outlined above. The blue *Baseline Battery Import Average* line is actually positive during the event period. However, the burnt orange *Baseline Battery Export Average* is of nearly equal magnitude negative. In effect, the average import behavior and average export behavior zero each other out, as evidenced in Figure 90. This nuance is important and further discussed in the Discussion section's "Selecting the Appropriate Markets and Event Times to Maximize Results" portion of the report.

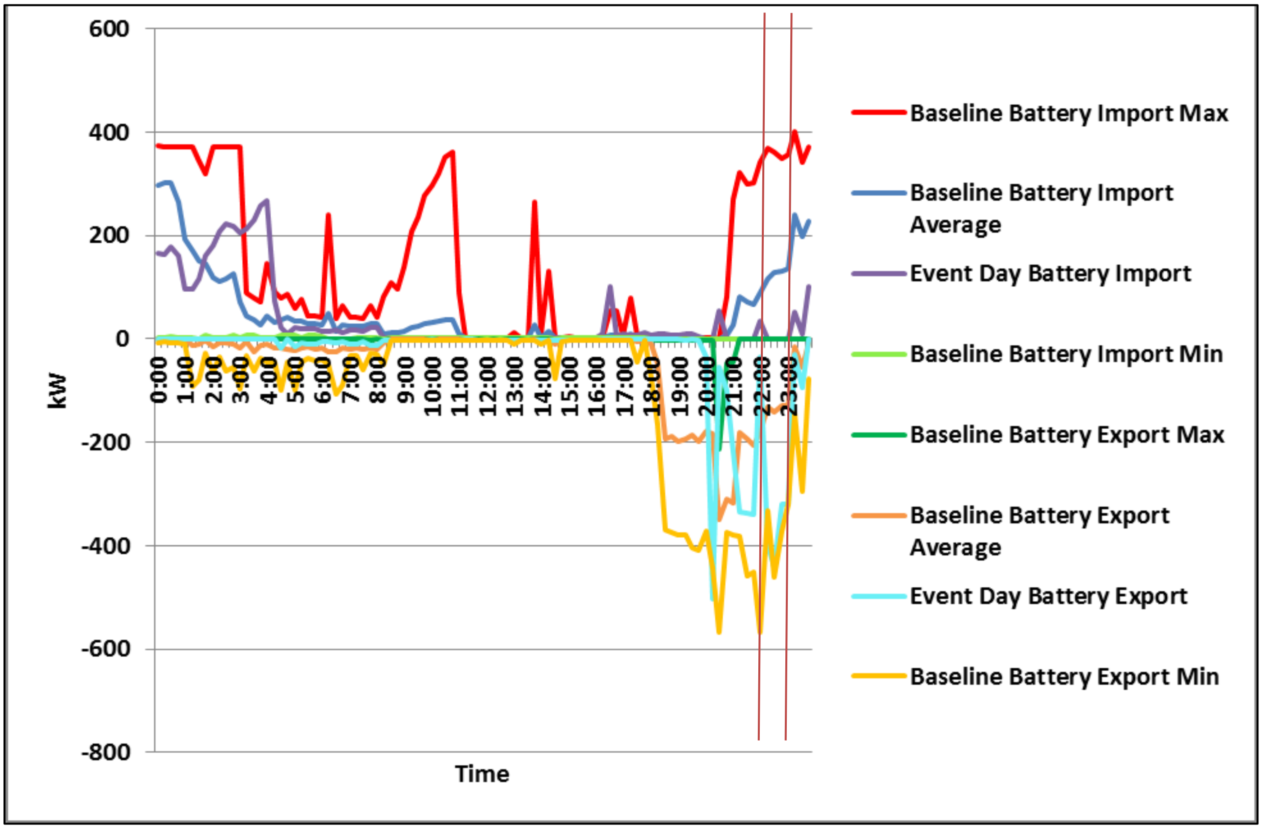


FIGURE 91. APRIL 19 22:00-23:00 CUSTOMER 2 TURN OFF CHARGING – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ Measurements

The upper chart in Figure 92 aligns with both the Battery ALCS data shown in Figure 90 and Figure 91 as well as the SCE meter data shown in Figure 88 and Figure 89. The lower chart in Figure 92 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during, and after the test event period.

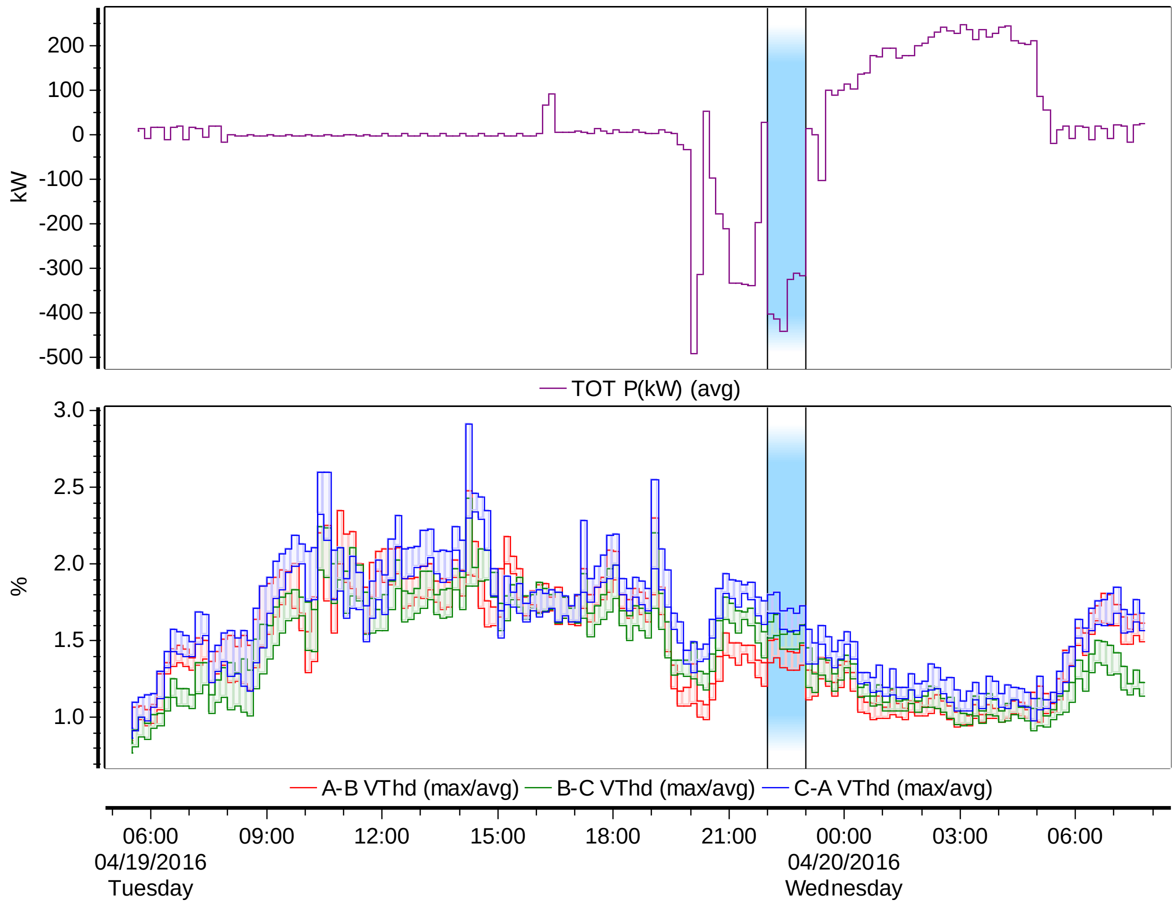


Figure 92. April 19 22:00-23:00 Customer 2 Turn Off Charging – PQ Meter Data

TEST EVENT 4: FRIDAY APRIL 22 14:00-15:00 PDT – DISCHARGE

a) SCE Meter Baseline Analysis

Figure 93 shows that usage drops in the hour prior to the start of the test event. Usage then increases during the first 30 minutes of the test event before decreasing during the last 30 minutes of the test. There is little indication that the batteries discharged as usage remained relatively similar to the profile prior to the test event. The increase in usage back to 10-in-10 baseline levels following the test event may indicate a response that is buried in with the other loads not monitored by the Customer 2 battery controller.

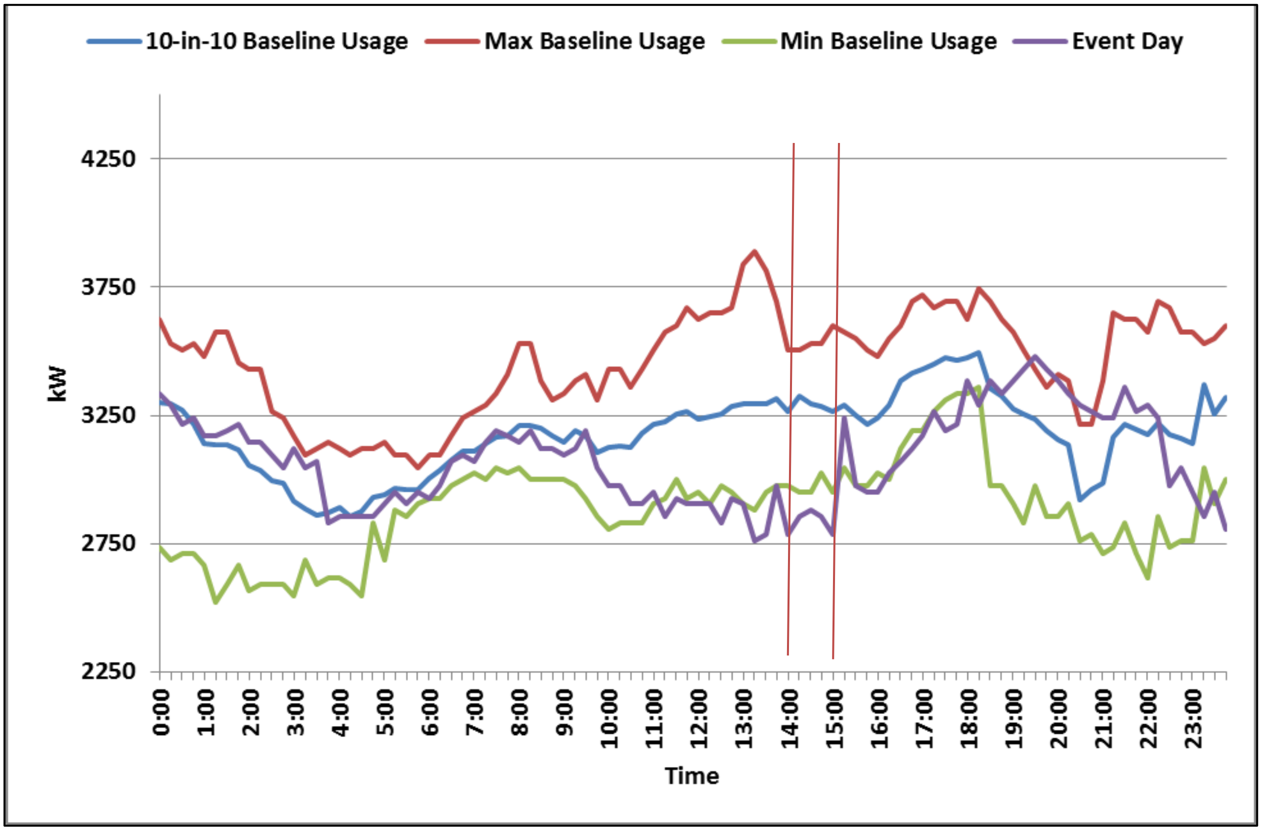


Figure 93. April 22 14:00-15:00 Customer 2 Discharge – SCE Meter Data

Figure 94 illustrates the influence of the drop in usage leading up to 14:00. Figure 94 also shows that the discharge event did not perform as expected when comparing the Event Day profile with the ±*20% from baseline* profile that begins from the same low usage. The LA 10-in-10 estimate was influenced by the sharp increase in usage following the event.

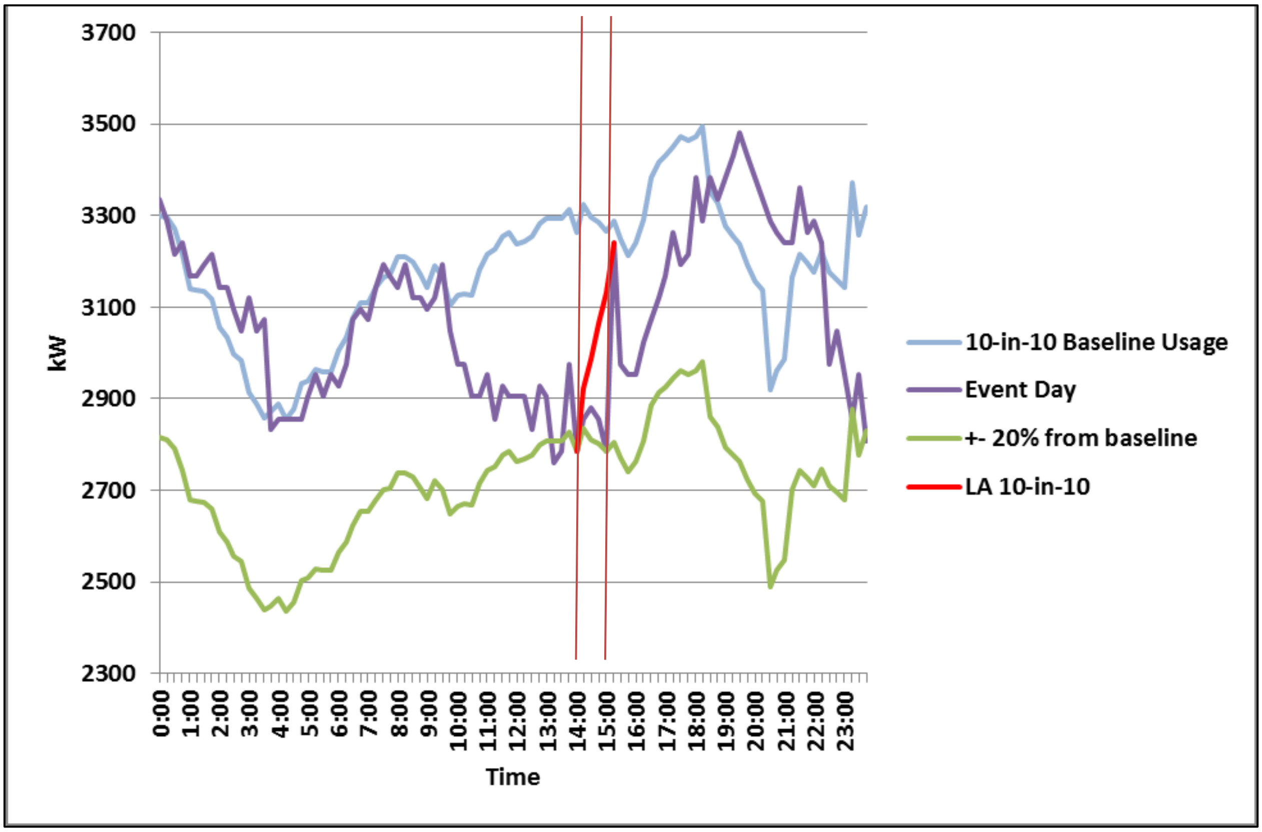


FIGURE 94. APRIL 22 14:00-15:00 CUSTOMER 2 DISCHARGE – DR BASELINE ESTIMATES

Error! Reference source not found. shows the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 20. APRIL 22 14:00-15:00 CUSTOMER 2 DISCHARGE – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
13:45-14:00	2,784.00	-	-	-
14:00-14:15	2,856.00	(468.00)	20.82	(67.24)
14:15-14:30	2,880.00	(415.20)	69.39	(105.21)
14:30-14:45	2,856.00	(429.60)	53.58	(207.55)
14:45-15:00	2,784.00	(482.40)	(2.05)	(348.18)
15:00-15:15	3,240.00	-	-	-
Average kW	**2,844.00**	**(448.80)**	**35.44**	**(182.04)**
Average kWh	**2,844.00**	**(448.80)**	**35.44**	**(182.04)**
CBP Bid (kW)		(200)		
CBP Event Performance		**224%**		

b) BATTERY ALCS BASELINE ANALYSIS

While the SCE meter data in Figure 93 indicates a small decrease in demand, the battery ALCS system in Figure 95 indicates that the system is showing no change in net or import/export on during the test event period.

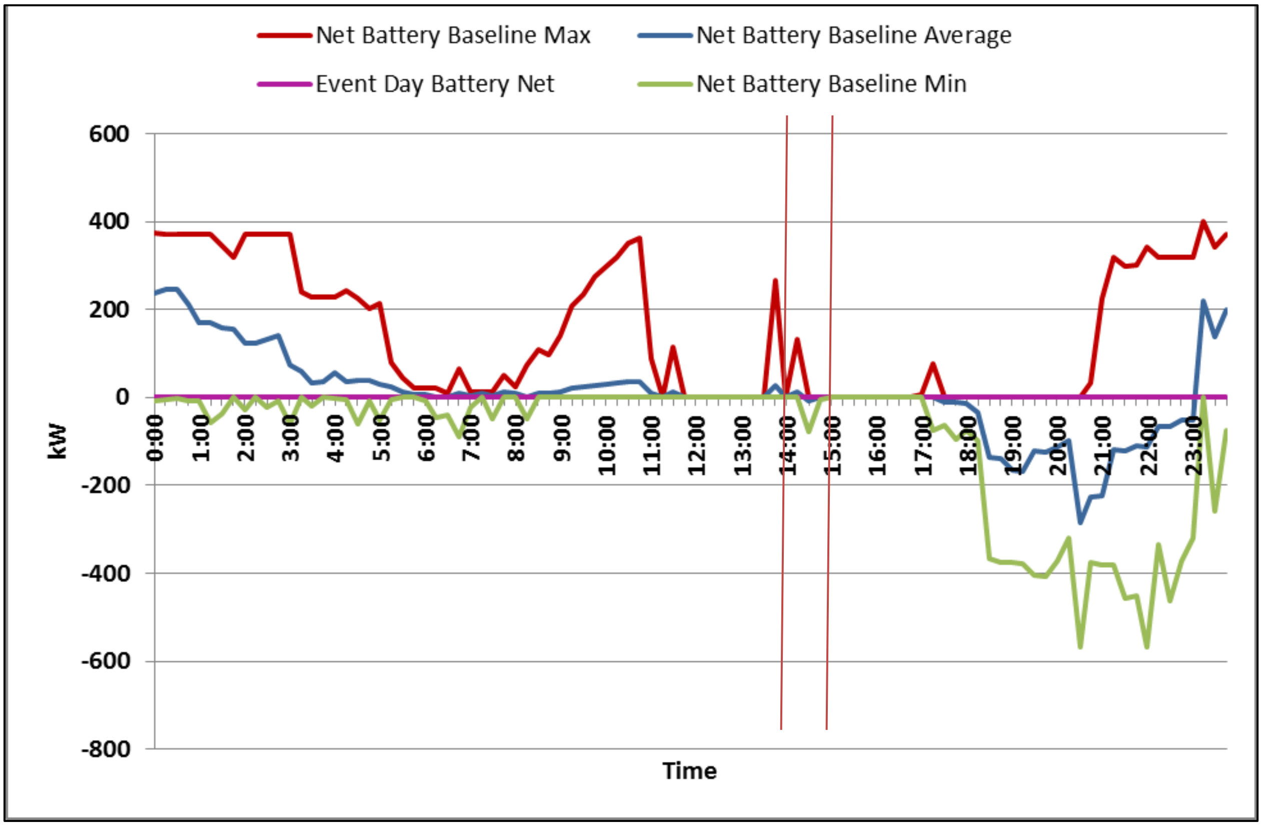


FIGURE 95. APRIL 22 14:00-15:00 CUSTOMER 2 DISCHARGE – BATTERY ALCS NET METER DATA

The Import Export chart in Figure 96 supports the event day observations outlined in Figure 95.

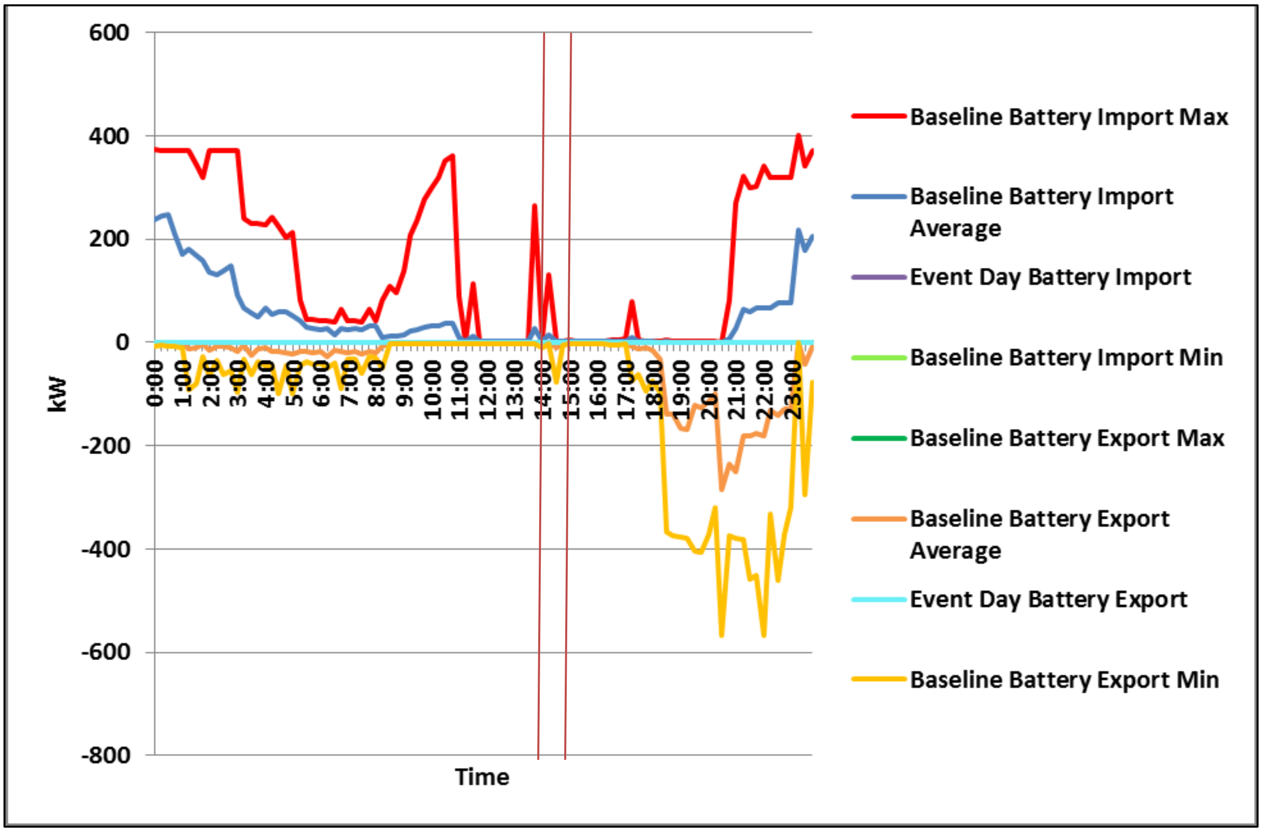


FIGURE 96. APRIL 22 14:00-15:00 CUSTOMER 2 DISCHARGE – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ Measurements

Figure 97 contrasts with the Battery ALCS graphs shown in Figure 95 and Figure 96. The Battery ALCS results indicate that the battery was offline for the event day with a flat event day battery net line in Figure 95 and a flat event day battery import and export lines in Figure 96. The PQ data shown in Figure 97 indicates that the battery was discharging from 13:30 – 15:00 followed by a spike in charging activity from 15:00-15:15.

The SCE data shown in Figure 93 and Figure 94 shows that the SCE data aligns with the PQ Meter Data in Figure 97.

The lower chart in Figure 97 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during, and after the test event period.

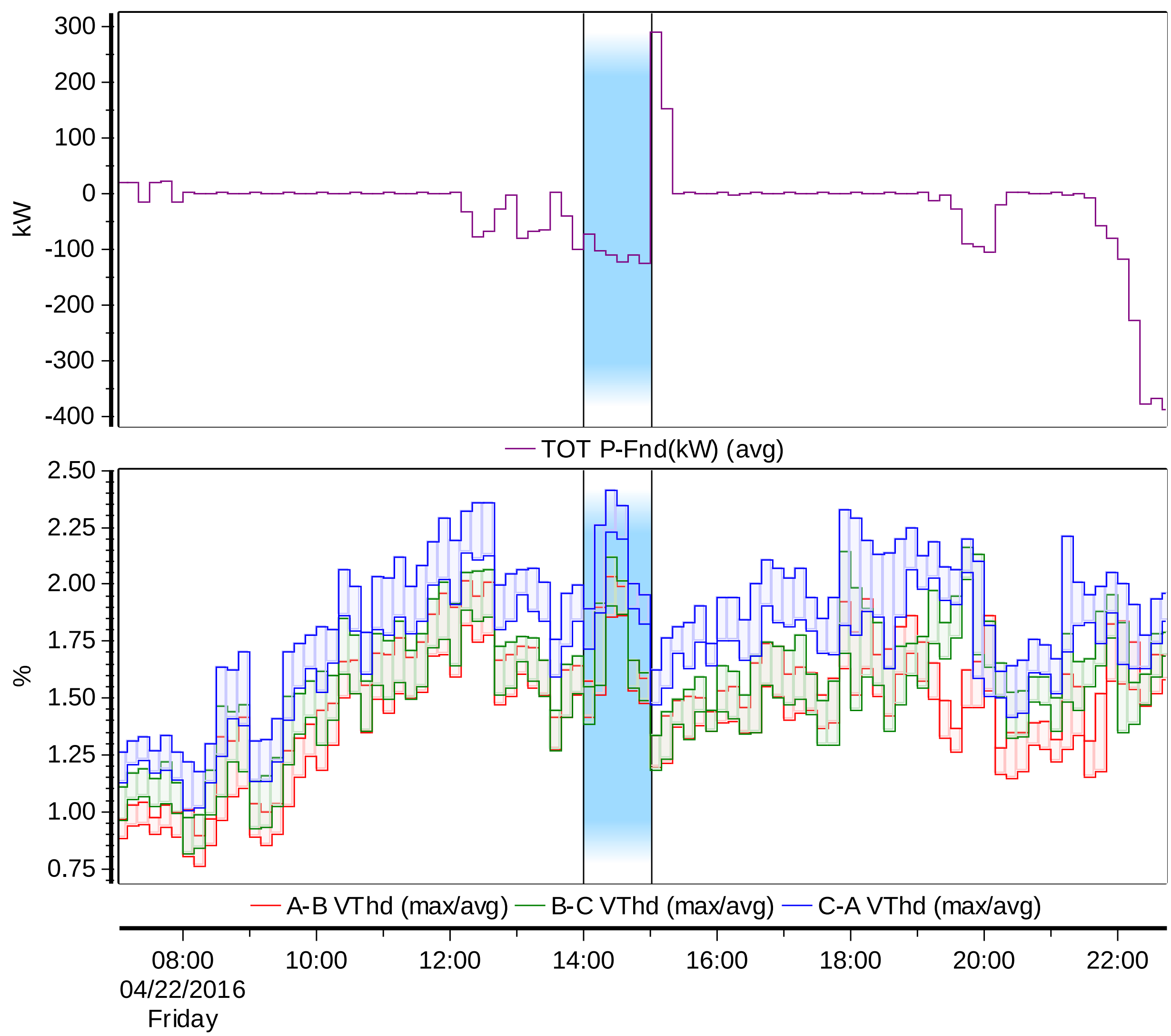


Figure 97. April 22 14:00-15:00 Customer 2 Discharge – PQ Meter Data

Test Event 5: Friday April 29, 22:00-23:00 PDT – Turn Off Charging

a) SCE Meter Baseline Analysis

Figure 98 shows the event day usage similar to the average baseline usage throughout the day, and closely aligns with the baseline usage through the event period. The event day usage trends downward for the first 45 minutes before a slight uptick in the last 15 minutes. The baseline follows a similar pattern across the 22:00-23:00 hour.

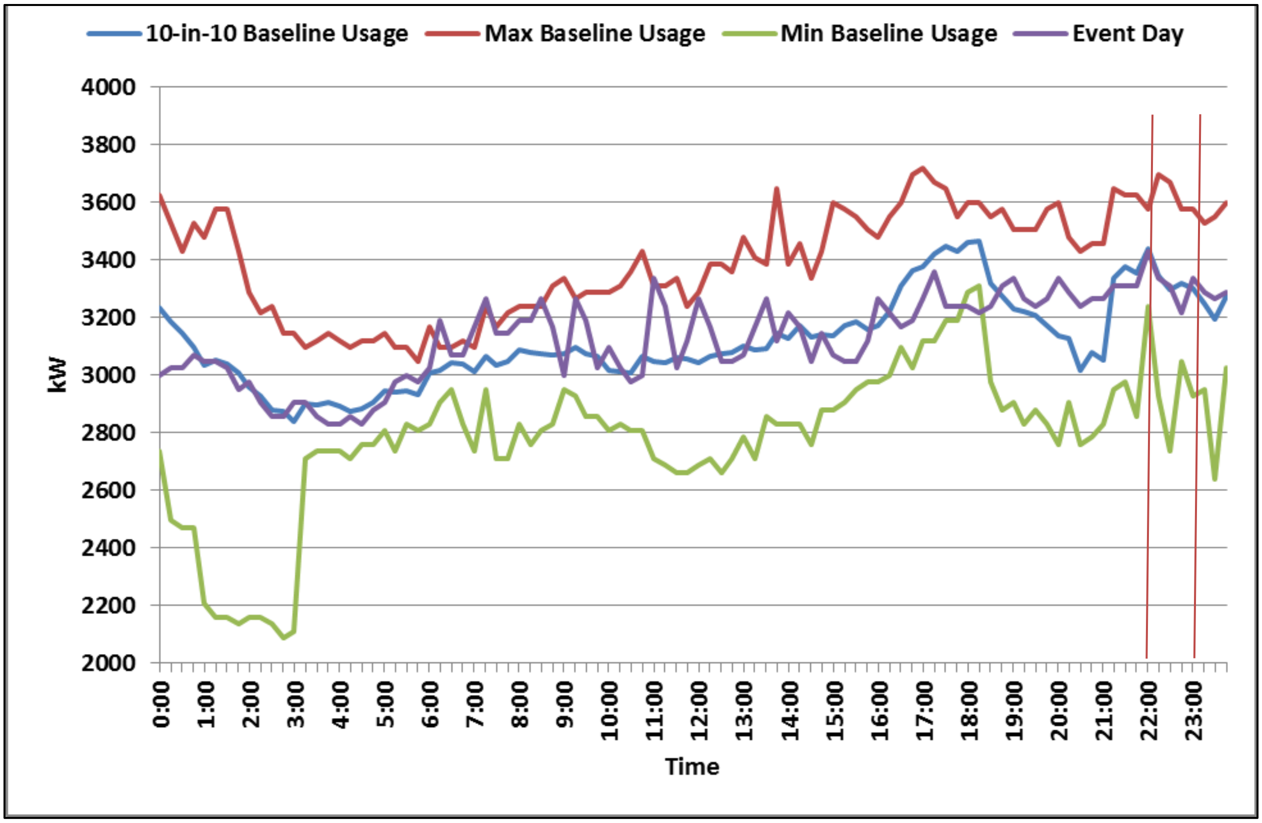


Figure 98. April 29 22:00-23:00 Customer 2 Turn Off Charging – SCE Meter Data

Because the event day follows a very similar pattern to the baseline through the event period, a significant overlap across the baselines and actual event day usage is shown in Figure 99. While slopes and magnitudes vary slightly, the overall point remains that the estimates show very little impact from the event.

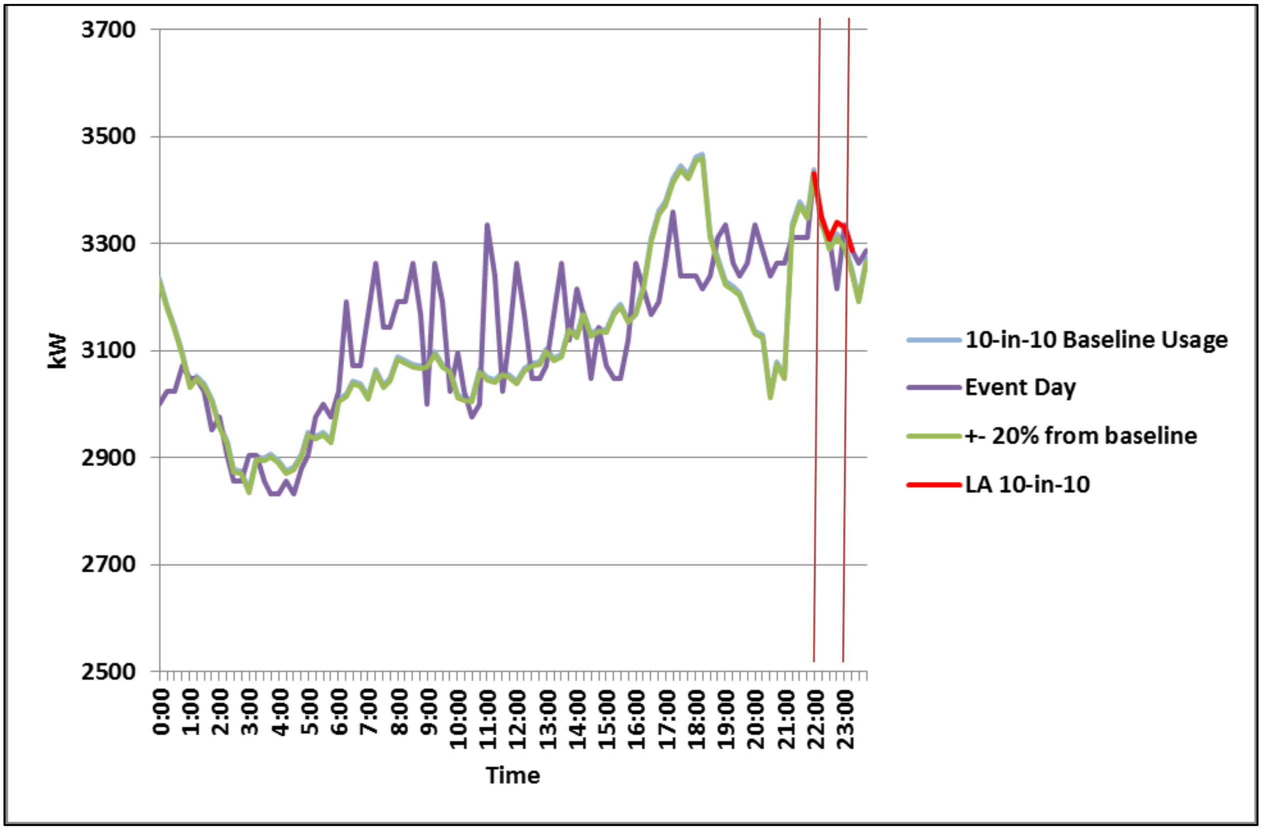


FIGURE 99. APRIL 29 22:00-23:00 CUSTOMER 2 TURN OFF CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 21. APRIL 29 22:00-23:00 CUSTOMER 2 TURN OFF CHARGING – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
21:45-22:00	3,432.00	-	-	-
22:00-22:15	3,336.00	(12.00)	(4.99)	(14.31)
22:15-22:30	3,312.00	14.40	21.30	2.96
22:30-22:45	3,216.00	(103.20)	(96.25)	(123.95)
22:45-23:00	3,336.00	36.00	42.91	6.19
23:00-23:15	3,288.00	-	-	-
Average kW	**3,300.00**	**(16.20)**	**(9.26)**	**(32.28)**
Average kWh	**3,300.00**	**(16.20)**	**(9.26)**	**(32.28)**
CBP Bid (kW)		(200)		
CBP Event Performance		**8%**		

b) BATTERY ALCS BASELINE ANALYSIS

While the SCE meter data indicates a small decrease in demand, Figure 100 indicates that the battery system is offline with no life in either the net or import/export on the test event day. The decreased demand observed by SCE meter may be the organic change in demand of the site during the test event hour.

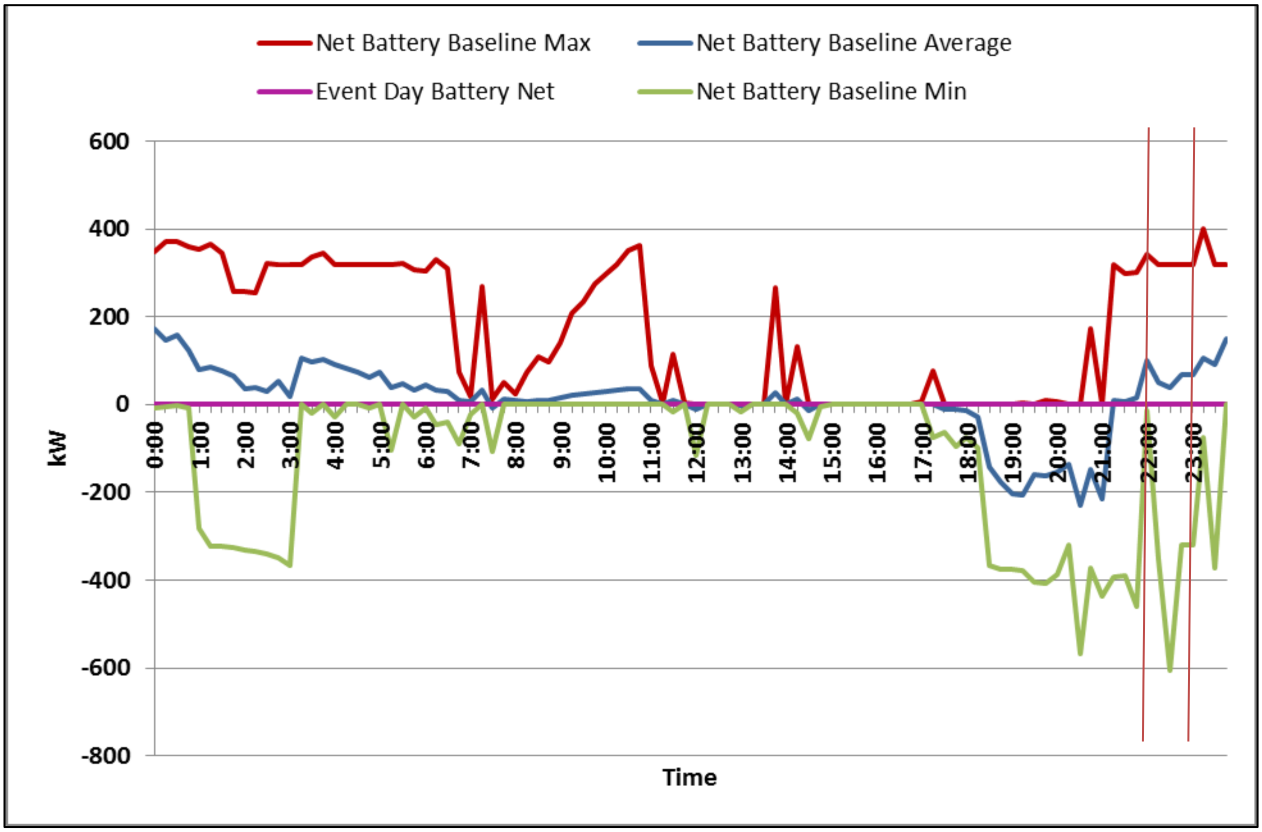


FIGURE 100. APRIL 29 22:00-23:00 CUSTOMER 2 TURN OFF CHARGING – BATTERY ALCS NET METER DATA

The Import Export chart in Figure 101 supports the event day observations outlined in Figure 100.

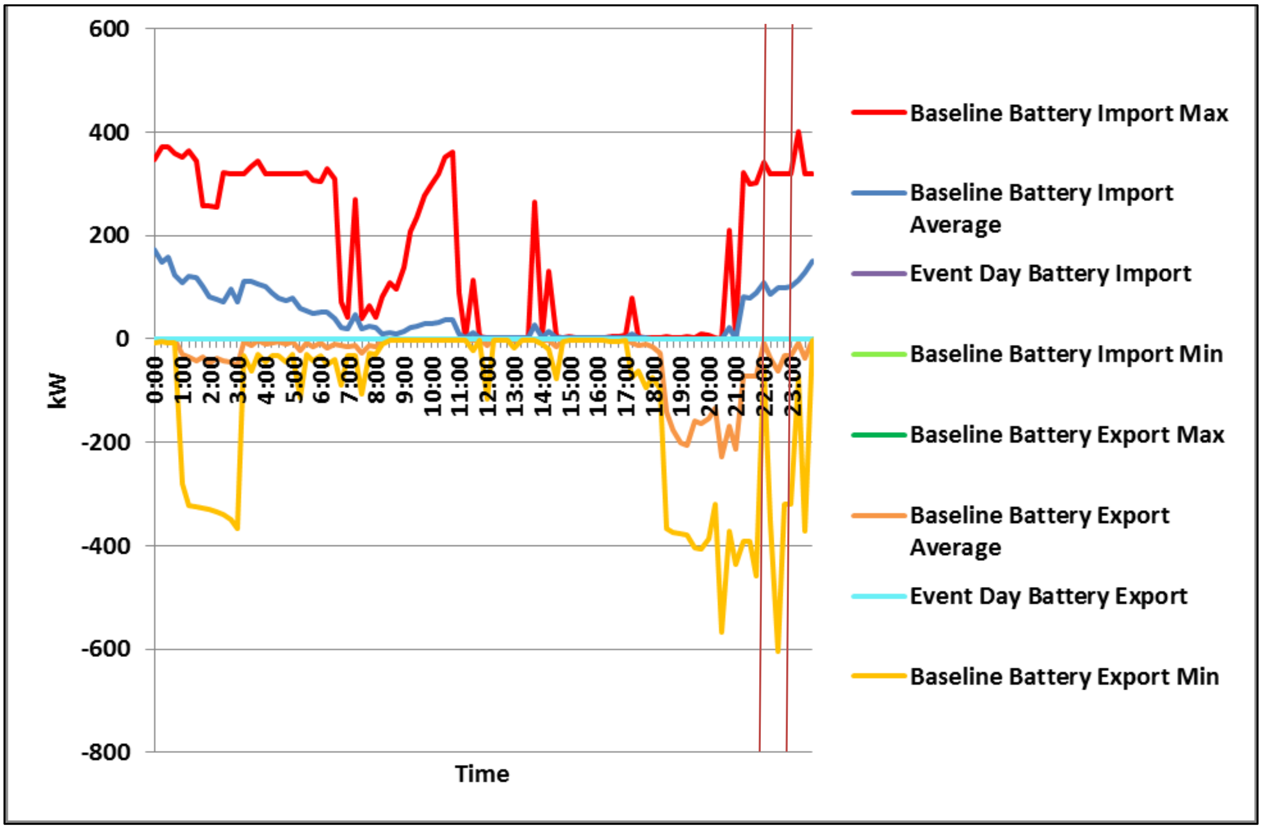


FIGURE 101. APRIL 29 22:00-23:00 CUSTOMER 2 TURN OFF CHARGING – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ Measurements

The upper chart in Figure 102 aligns with both the Battery ALCS data shown in Figure 100 and Figure 101 and indicates that the battery system was off line until approximately 16:30 the following day, April 30th.

While the battery was offline, the lower chart in Figure 102 shows that the VThd was within the normal range (< 5%) prior to, during, and after the test event period.

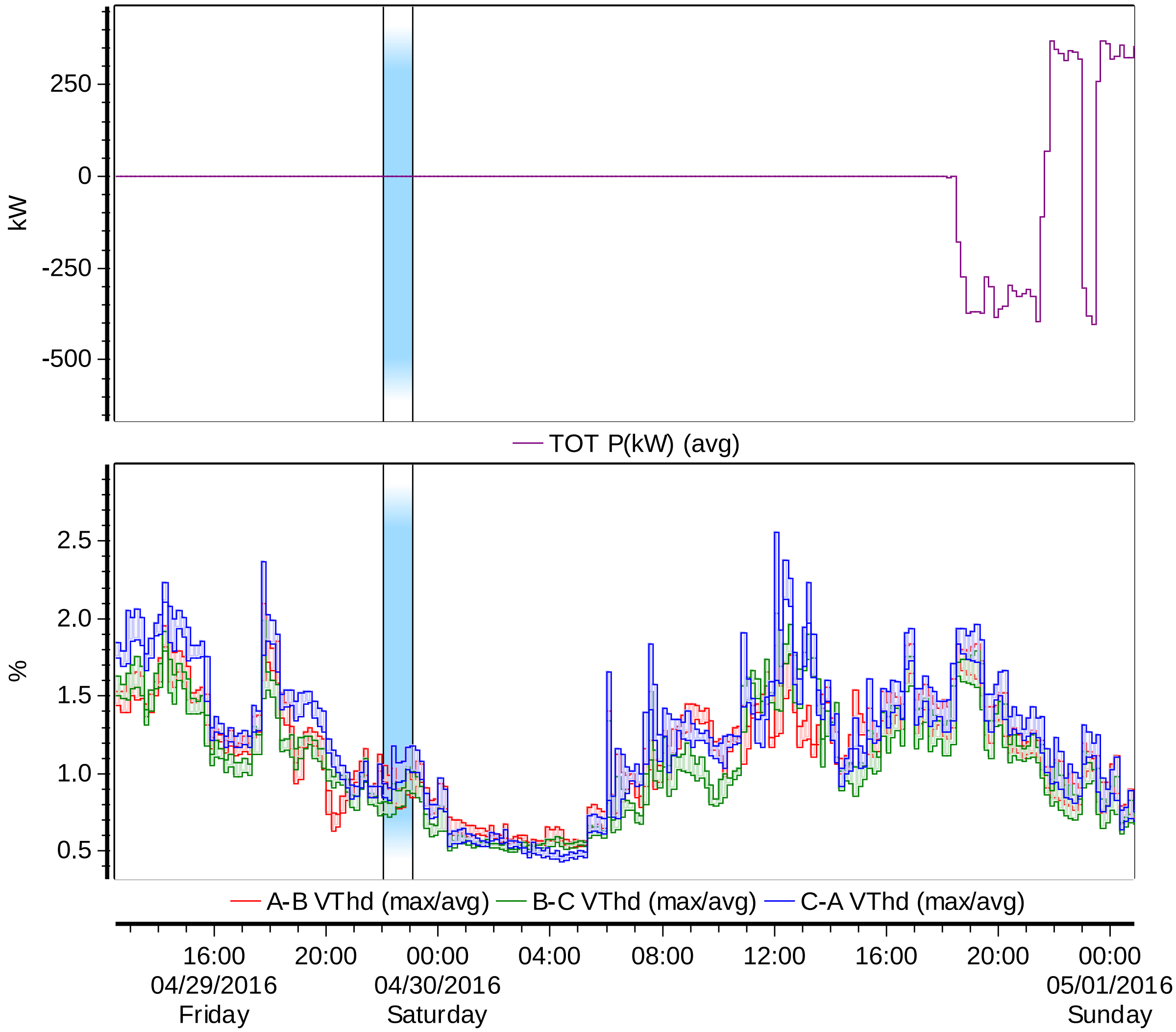


Figure 102. April 29 22:00-23:00 Customer 2 Turn Off Charging –PQ Meter Data

TEST EVENT 6: MONDAY MAY 2, 14:00-15:00 PDT –DISCHARGE

a) SCE METER BASELINE ANALYSIS

Figure 103 shows that event day usage appears to dip during the 14:00-15:00 hour, but is still relatively consistent with the observed baseline patterns. Usage increases after the event in a similar manner and is observed in other "Discharge" events.

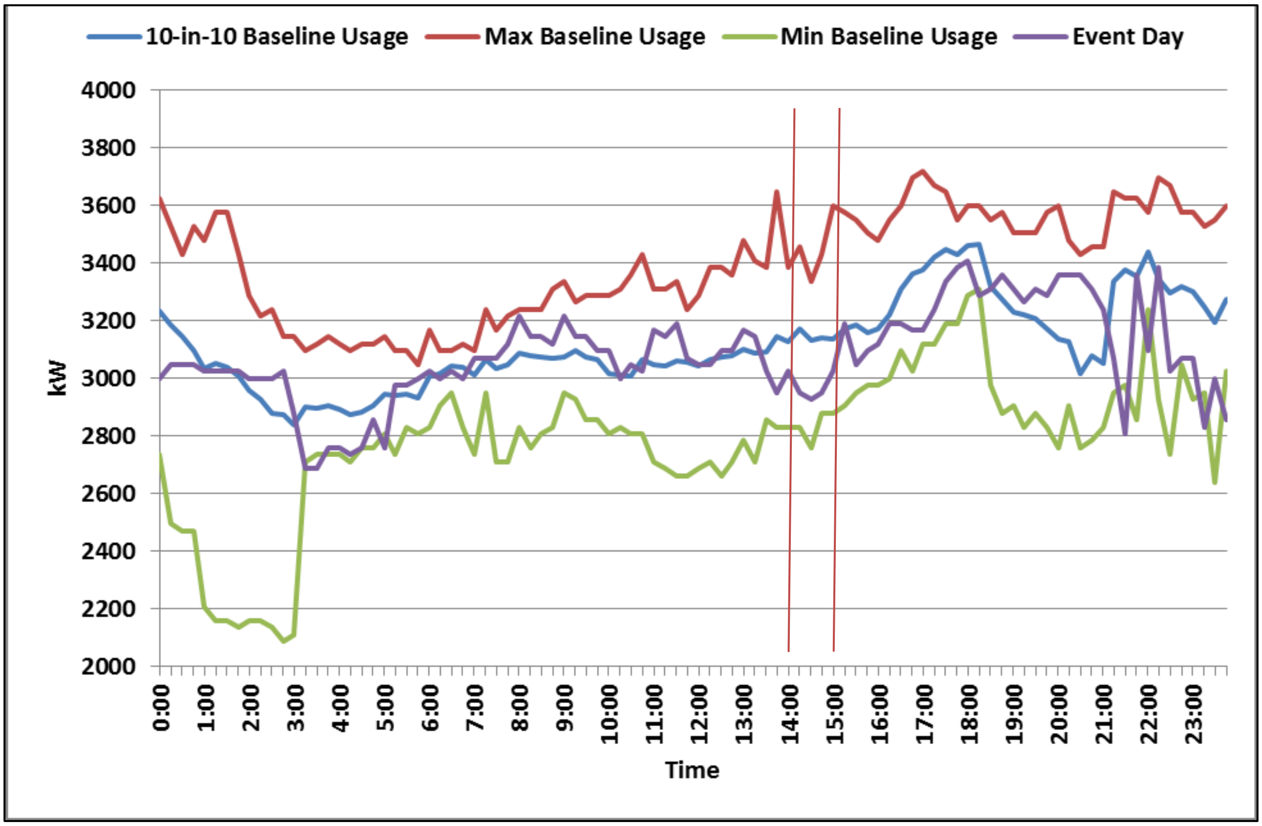


FIGURE 103. MAY 2 14:00-15:00 CUSTOMER 2 DISCHARGE – SCE METER DATA

Each of the DR baseline estimates in Figure 104 indicate that there was some performance correlating to a "discharge" signal during the event. The LA 10-in-10 again appears to be affected by the uptick in usage immediately following the event.

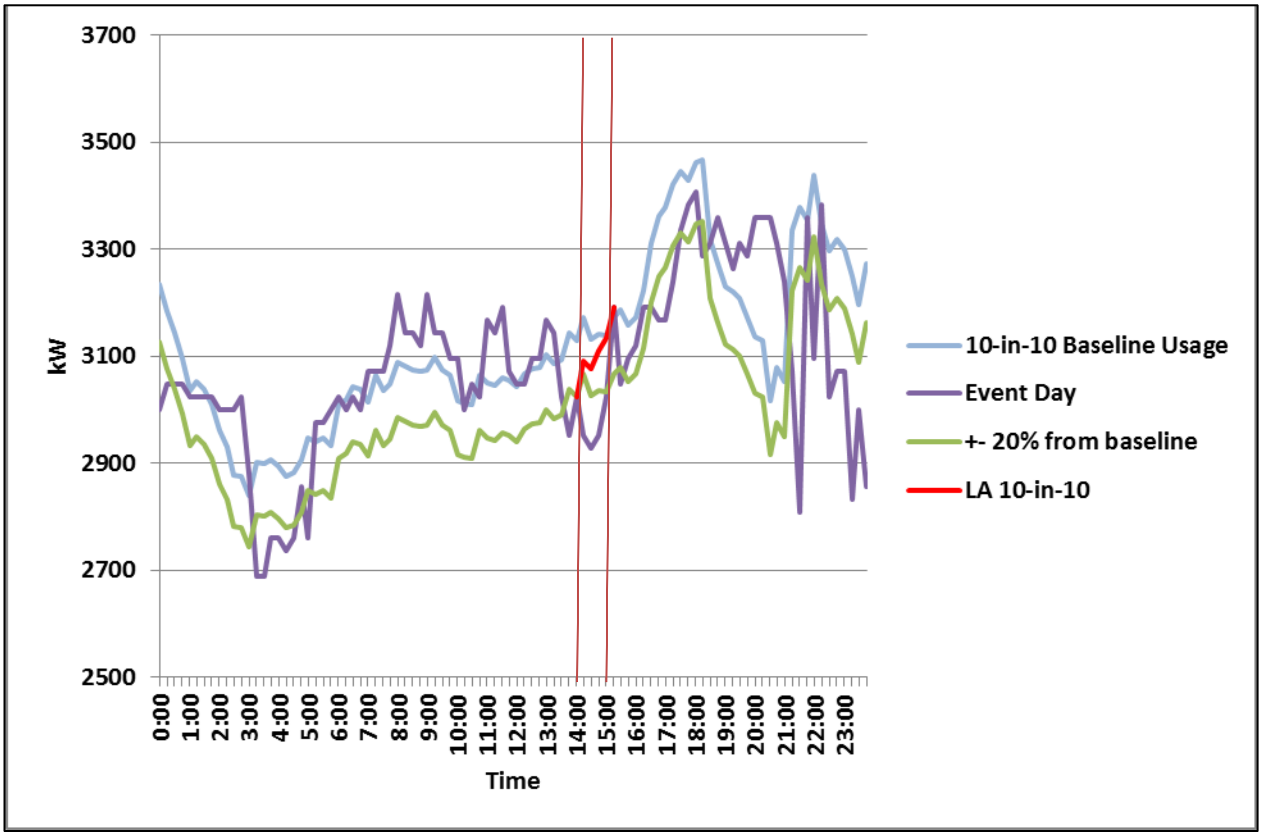


FIGURE 104. MAY 2 14:00-15:00 CUSTOMER 2 DISCHARGE – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 22. MAY 2 14:00-15:00 CUSTOMER 2 DISCHARGE – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
13:45-14:00	3,024.00	-	-	-
14:00-14:15	2,952.00	(220.80)	(113.74)	(138.99)
14:15-14:30	2,928.00	(204.00)	(98.32)	(148.17)
14:30-14:45	2,952.00	(189.60)	(83.60)	(158.60)
14:45-15:00	3,024.00	(115.20)	(9.28)	(109.21)
15:00-15:15	3,192.00	-	-	-
Average kW	2,964.00	(182.40)	(76.23)	(138.75)
Average kWh	2,964.00	(182.40)	(76.23)	(138.75)
CBP Bid (kW)		(200)		
CBP Event Performance		91%		

b) Battery ALCS Baseline Analysis

Figure 103 indicated a small decrease in demand, and Figure 105 supports that observation since there was some export from the battery. The small amount of discharge may be attributable to the battery system not being allowed to export more than its metered load. However, export was not at maximum during the event and the battery system exported significantly more electricity later in the event day.

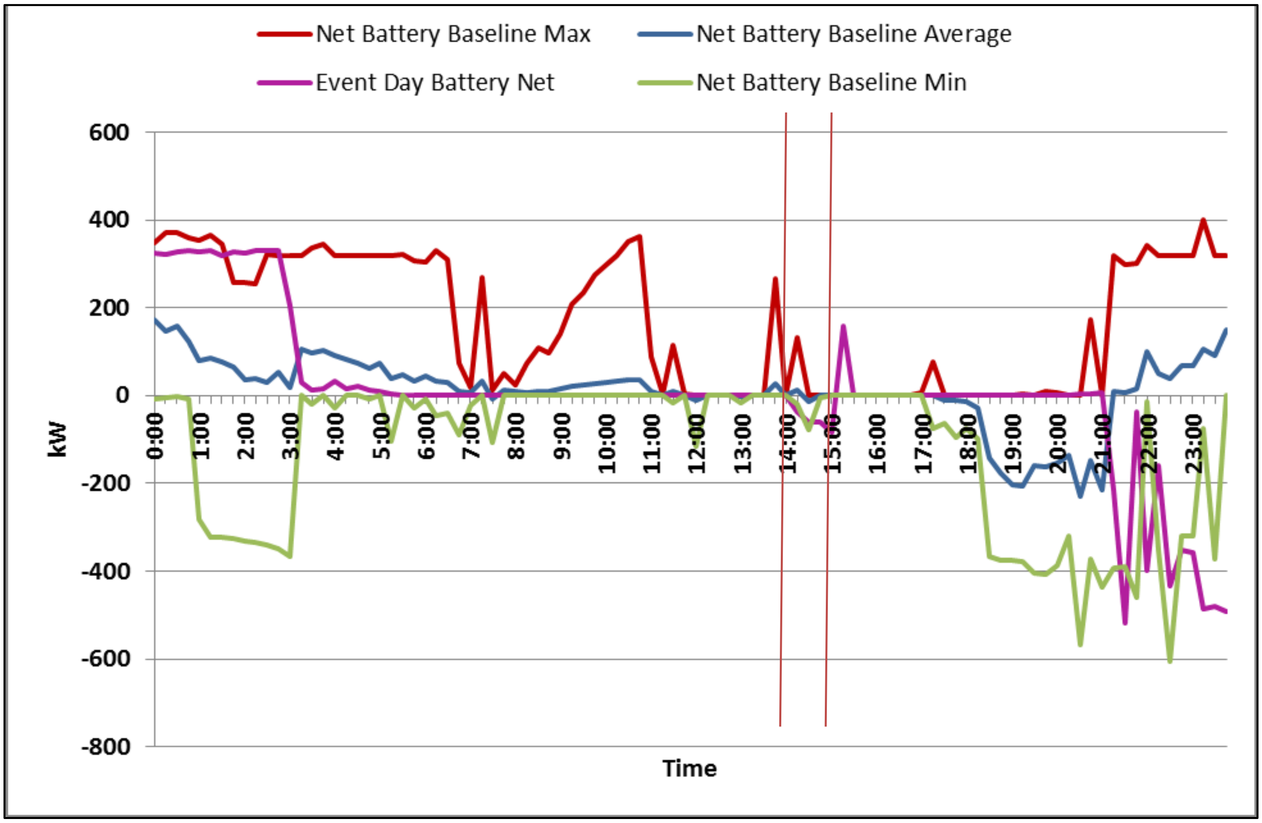


Figure 105. May 2 14:00-15:00 Customer 2 Discharge – Battery ALCS Net Meter Data

The Import Export chart, Figure 106, supports the event day observations outlined in Figure 105.

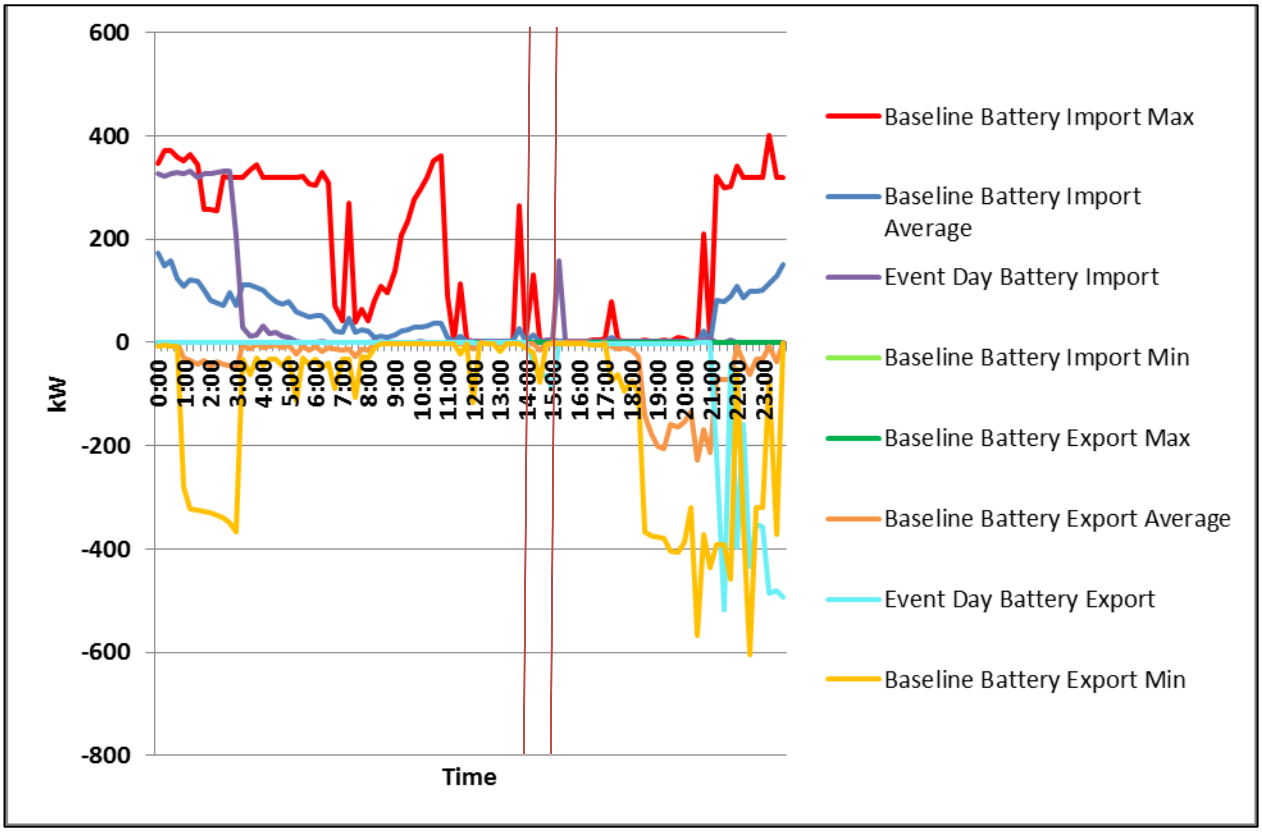


FIGURE 106. MAY 2 14:00-15:00 CUSTOMER 2 DISCHARGE – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ Measurements

The upper chart in Figure 107 aligns with the Battery ALCS data shown in Figure 105 and Figure 106 with the battery being offline until the start of the test event at 14:00 followed by a charging starting at 15:00. These observations are consistent with the SCE meter data shown in Figure 103 and Figure 104 although the 100kW charge is somewhat lost within the net facility load reflected in the SCE data.

The lower chart in Figure 107 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during, and after the test event period.

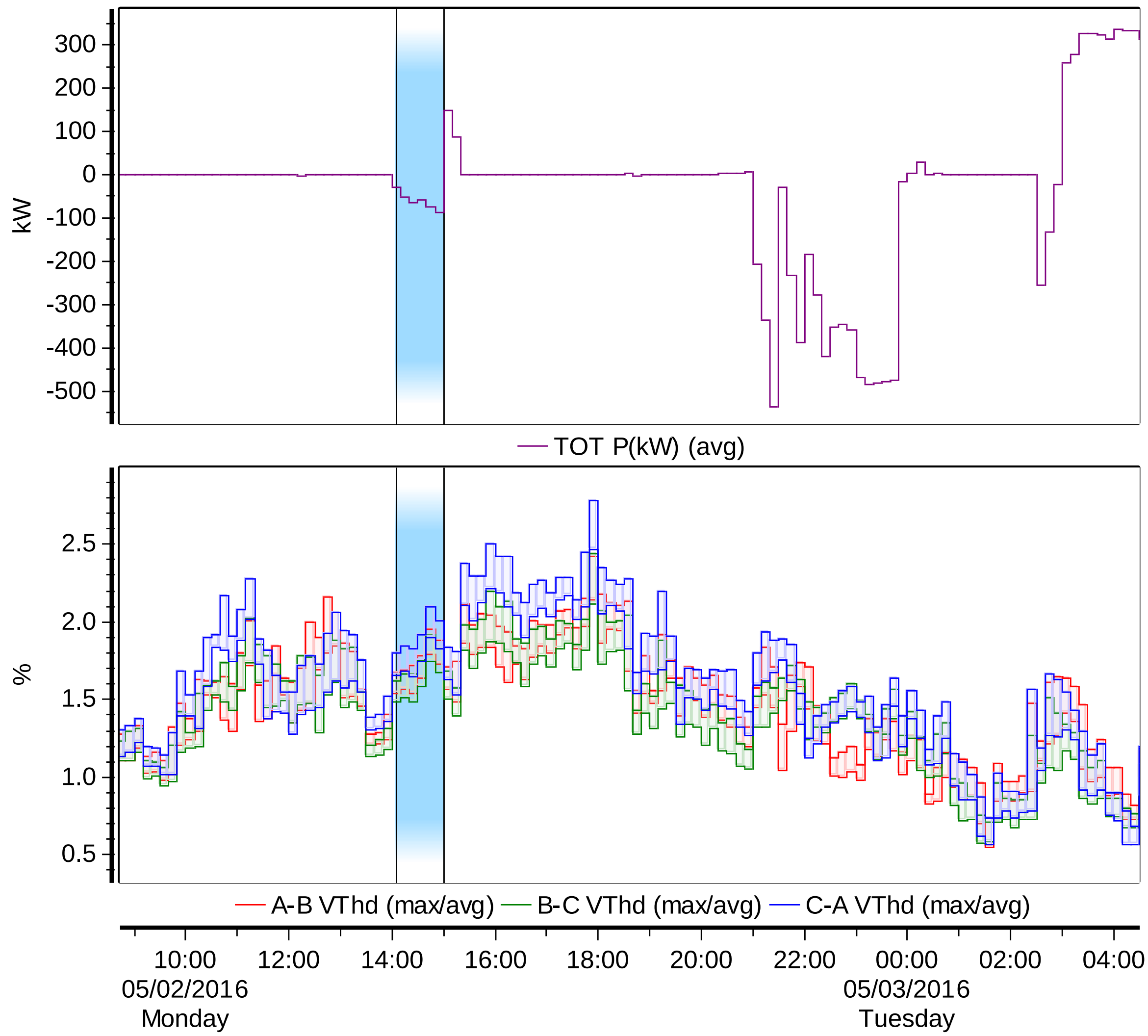


Figure 107. May 2 14:00-15:00 Customer 2 Discharge–PQ Meter Data

Test Event 7: Friday May 6, 3:00-4:00 PDT – Start Charging

a) SCE METER BASELINE ANALYSIS

Figure 108 shows a large increase in usage during the first 15 minutes of the test event window. This would normally indicate a strong response to the Start Charging signal. However, there was also an increase in usage in the 15-minute interval preceding the test event. Additionally, a similar increase is seen in the minimum baseline usage curve across that 2:45-3:15 timeframe. However, it is worth noting that test event usage at 3:15 was higher than the max baseline usage for that same period.

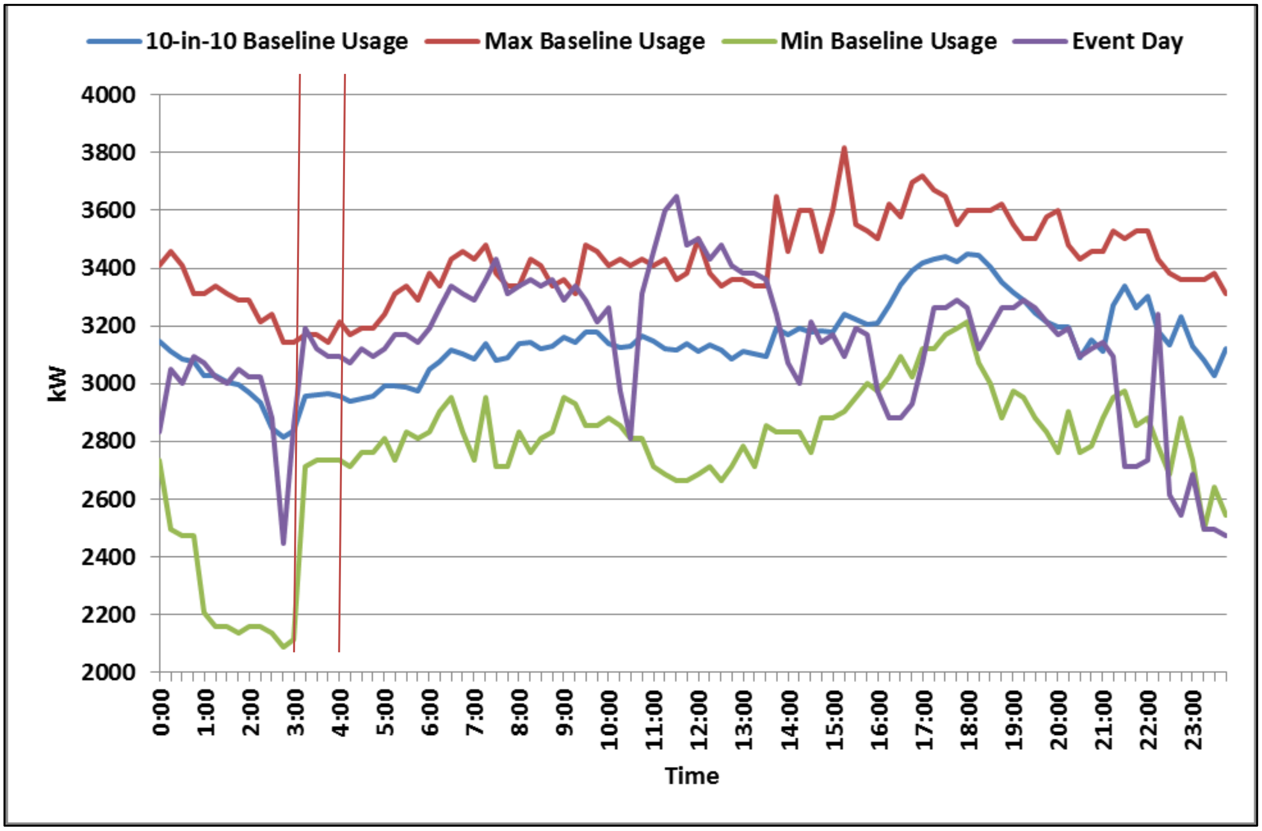


FIGURE 108. MAY 6 03:00-04:00 CUSTOMER 2 START CHARGING – SCE METER DATA

With a Start Charging event, the event day usage is expected to exceed baseline usage. According to all three of the baseline estimates in Figure 109, usage increases upon initiation of the Start Charging event. While there is some increase in charging expected from 3:00-3:15, the additional charging in that period represents the impact of the Start Charging signal.

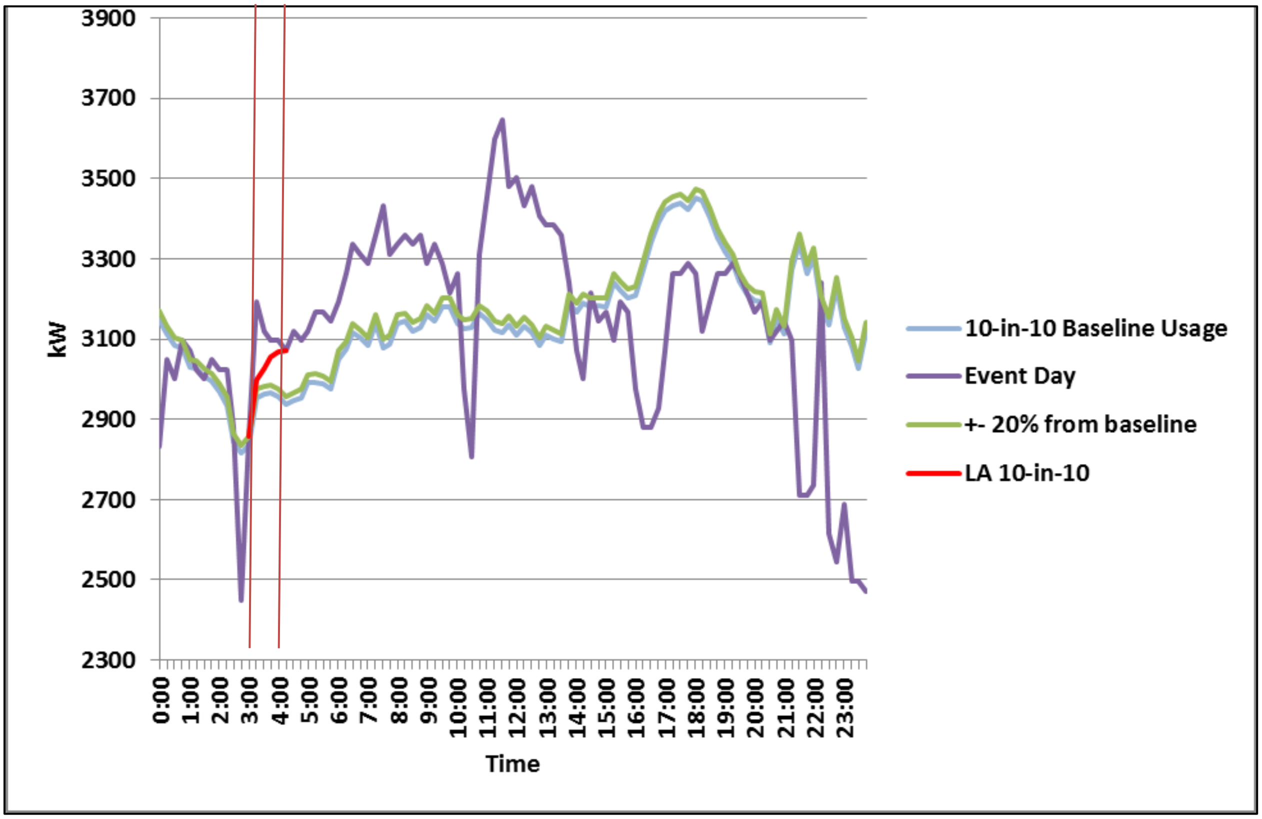


FIGURE 109. MAY 6 03:00-04:00 CUSTOMER 2 START CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. shows the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 23. MAY 6 3:00-4:00 CUSTOMER 2 START CHARGING – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
2:45-3:00	2,856.00	-	-	-
3:00-3:15	3,192.00	237.60	217.60	194.57
3:15-3:30	3,120.00	158.40	138.36	92.17
3:30-3:45	3,096.00	129.60	109.52	40.14
3:45-4:00	3,096.00	139.20	119.19	26.97
4:00-4:15	3,072.00	-	-	-
Average kW	**3,126.00**	**166.20**	**146.17**	**88.46**
Average kWh	**3,126.00**	**166.20**	**146.17**	**88.46**
CBP Bid (kW)		200		
CBP Event Performance		**83%**		

b) Battery ALCS Baseline Analysis

The trends outlined above are reflected in Figure 110. It is interesting to note the discharge in usage that occurs from 2:30-2:45, before returning to neutral at 3:00. This pattern is shifted 15 minutes earlier in advance of the event from what has been observed in previous events (e.g., April 19th at Customer 2).

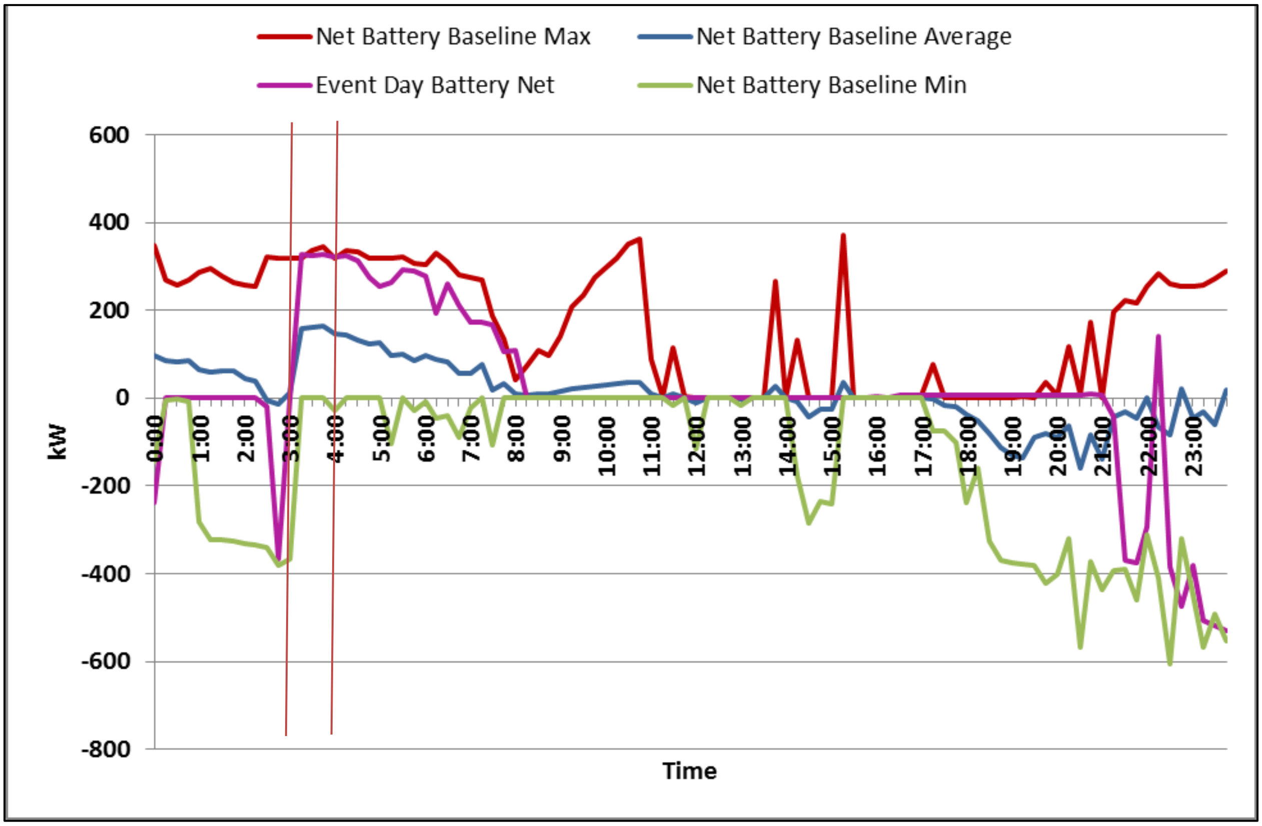


Figure 110. May 6 03:00-04:00 Customer 2 Start Charging – Battery ALCS Net Meter Data

The Import Export chart in Figure 111 supports the event day observations outlined in Figure 110.

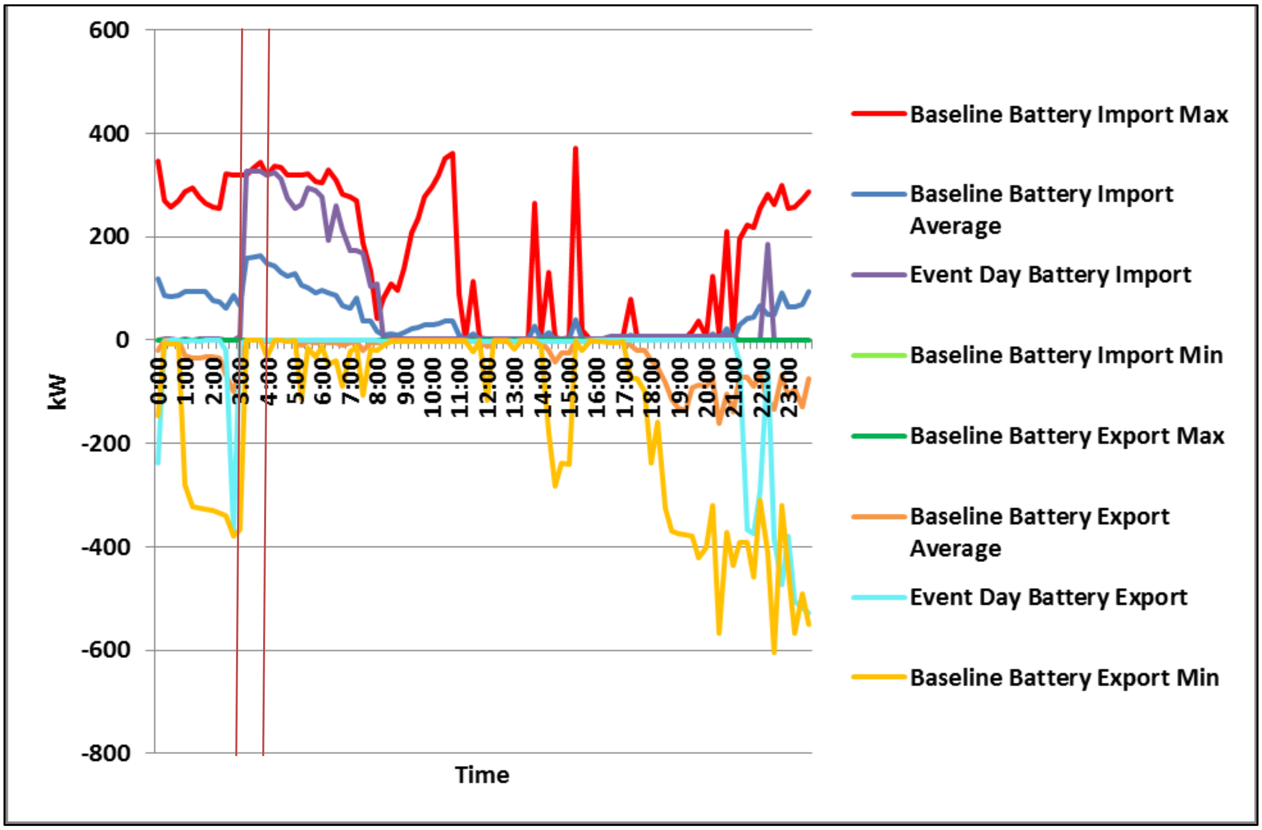


FIGURE 111. MAY 6 03:00-04:00 CUSTOMER 2 START CHARGING – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ MEASUREMENTS

The upper chart in Figure 112 aligns with both the Battery ALCS data shown in Figure 110 and Figure 111 as well as the SCE meter data shown in Figure 108 and Figure 109. The lower chart in Figure 112 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during, and after the test event period.

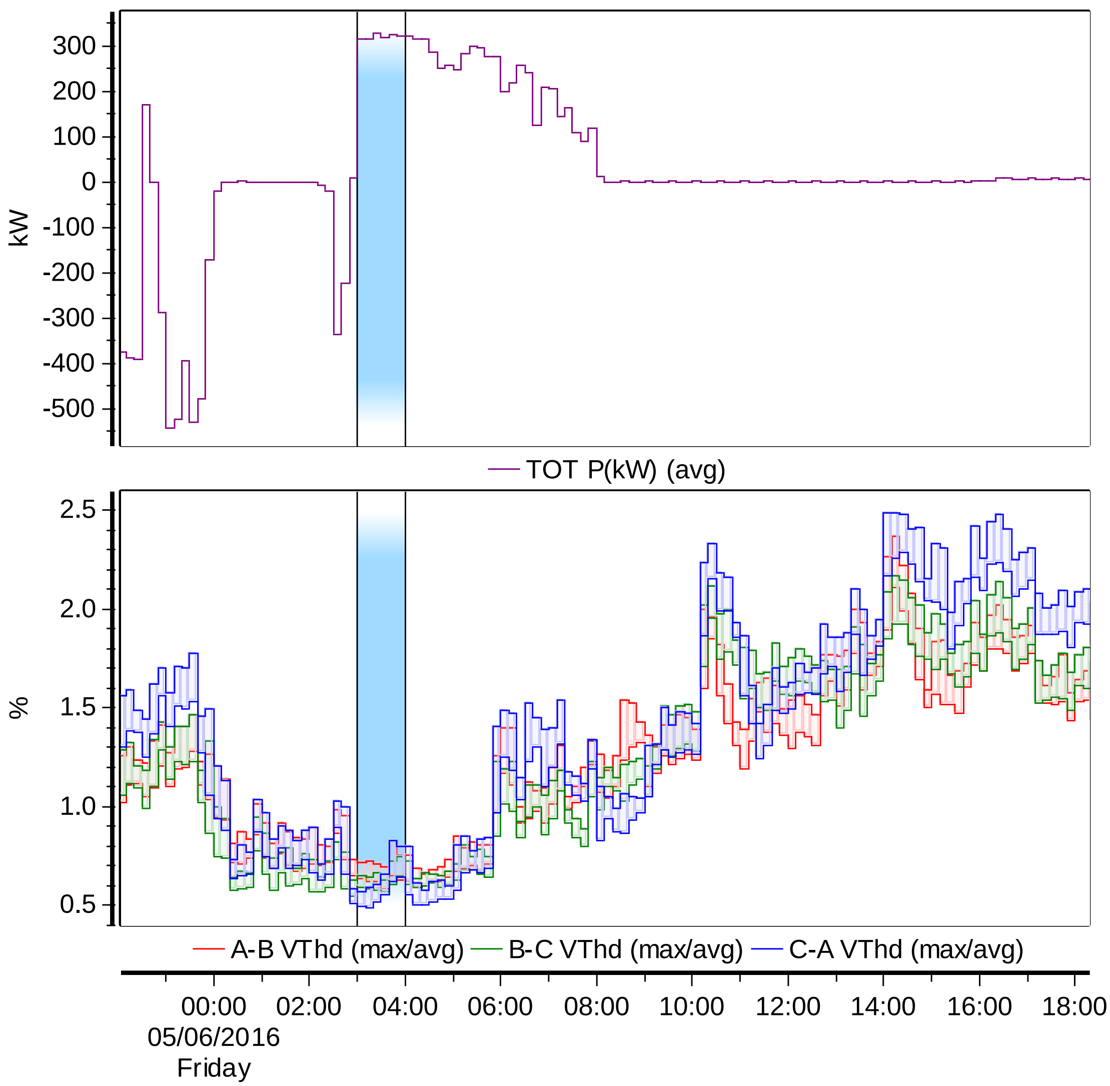


FIGURE 112. FRIDAY MAY 6, 3:00-4:00 PDT – START CHARGING– PQ METER DATA

TEST EVENT 8: TUESDAY MAY 10, 22:00-23:00 PDT – TURN OFF CHARGING

a) SCE METER BASELINE ANALYSIS

With a "Turn Off Charging" signal, it is expected that the demand be lower than the average baseline usage. That trend is not apparent across the 22:00-23:00 hour in Figure 113, but event day usage trends both above and below the average baseline appear outside of the event period. The overall downward slope across the event period is consistent with the baseline usage and the decrease in usage immediately following the event indicates that the battery may have been charging during the event period.

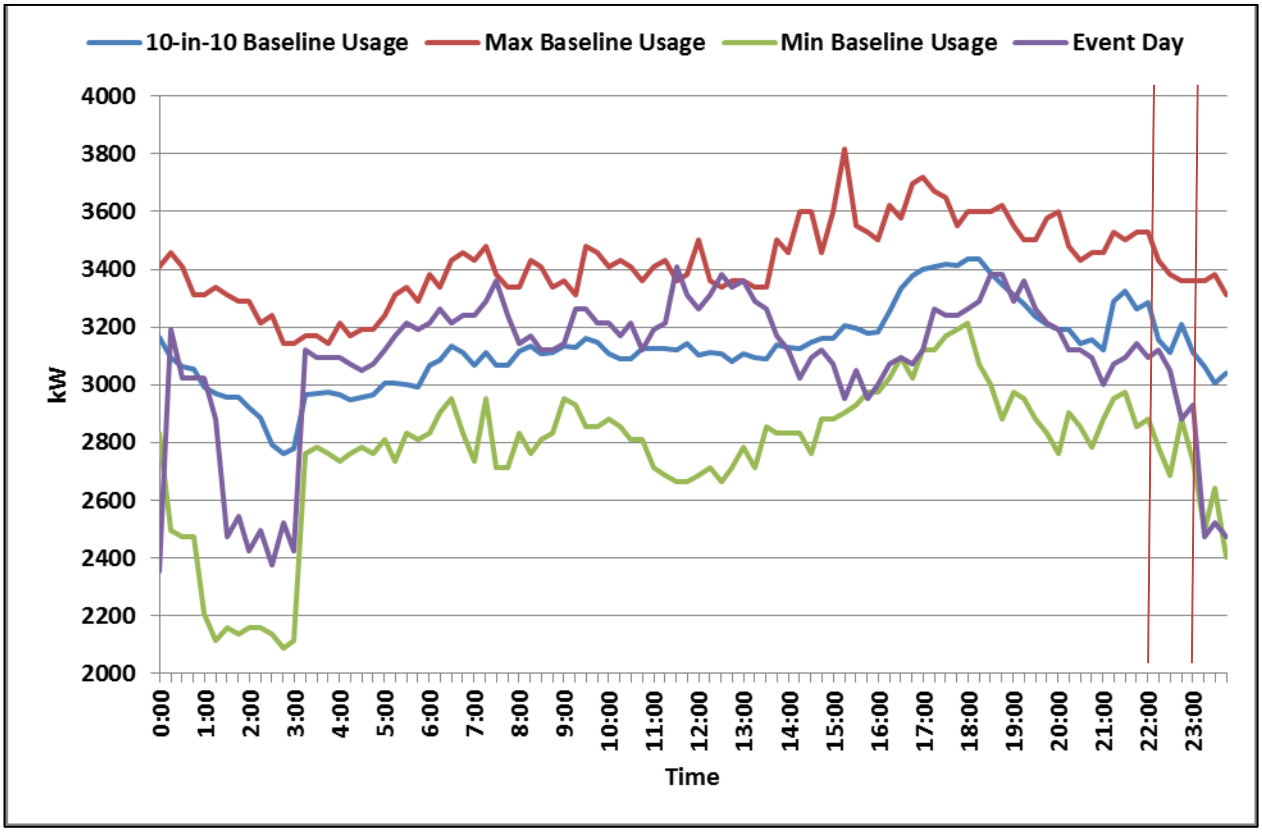


FIGURE 113. MAY 10 22:00-23:00 CUSTOMER 2 TURN OFF CHARGING – SCE METER DATA

The estimates for what usage would be in the absence of an event vary significantly as evidenced in Figure 114. The only baseline that provides the consistent negative kW that would be wanted when issuing a "Turn Off Charging" signal is the 10-in-10 baseline usage estimate that is roughly 190 kW more than the actual event day usage at the start of the test event. The LA 10-in-10 estimate is significantly influenced by the decrease in usage following the event.

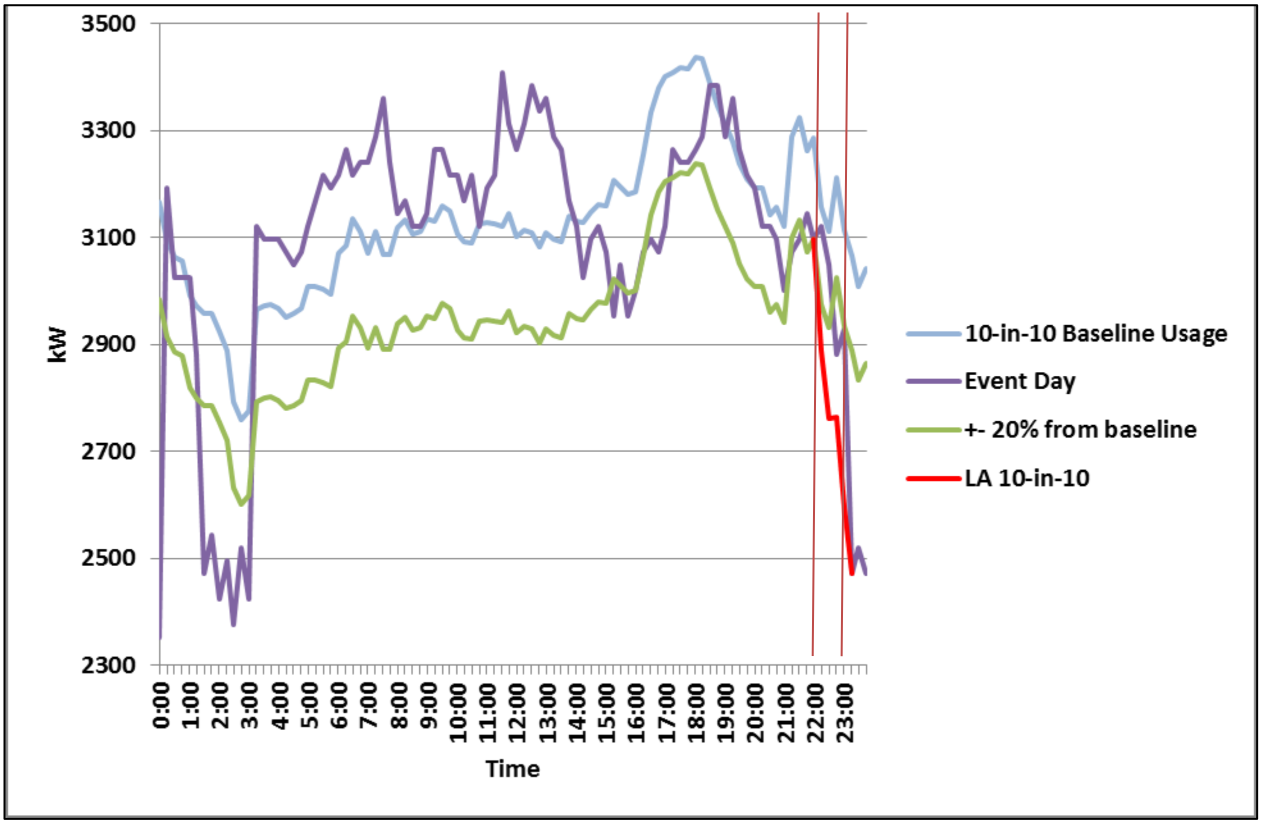


FIGURE 114. MAY 10 22:00-23:00 CUSTOMER 2 TURN OFF CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 24. MAY 10 22:00-23:00 CUSTOMER 2 TURN OFF CHARGING – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPC EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
21:45-22:00	3,096.00	-	-	-
22:00-22:15	3,120.00	(36.00)	146.12	231.79
22:15-22:30	3,048.00	(62.40)	117.09	285.94
22:30-22:45	2,880.00	(331.20)	(145.89)	115.59
22:45-23:00	2,928.00	(184.80)	(5.17)	332.79
23:00-23:15	2,472.00	-	-	-
Average kW	**2,994.00**	**(153.60)**	**28.04**	**241.53**
Average kWh	**2,994.00**	**(153.60)**	**28.04**	**241.53**
CBP Bid (kW)		(200)		
CBP Event Performance		**77%**		

b) BATTERY ALCS BASELINE ANALYSIS

Figure 115 shows that the battery was not charging prior the "Turn Off Charging" event. Therefore, there is no perceivable change in demand at the start of the event. Discharging was allowed for a "Turn Off Charging" test event and the battery started discharging for the second half of the test and continued discharging after the event.

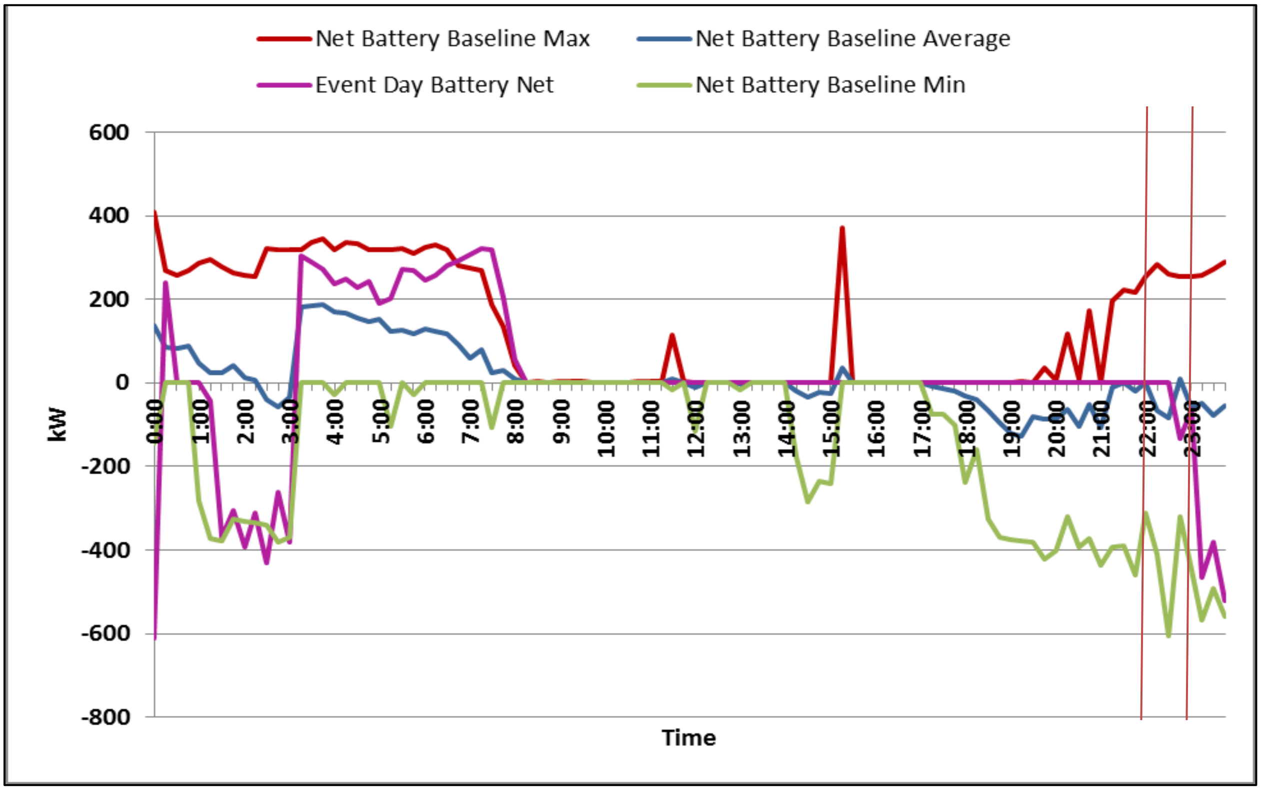


FIGURE 115. MAY 10 22:00-23:00 CUSTOMER 2 TURN OFF CHARGING – BATTERY ALCS NET METER DATA

The Import Export chart in Figure 116 supports the event day observations outlined in Figure 115.

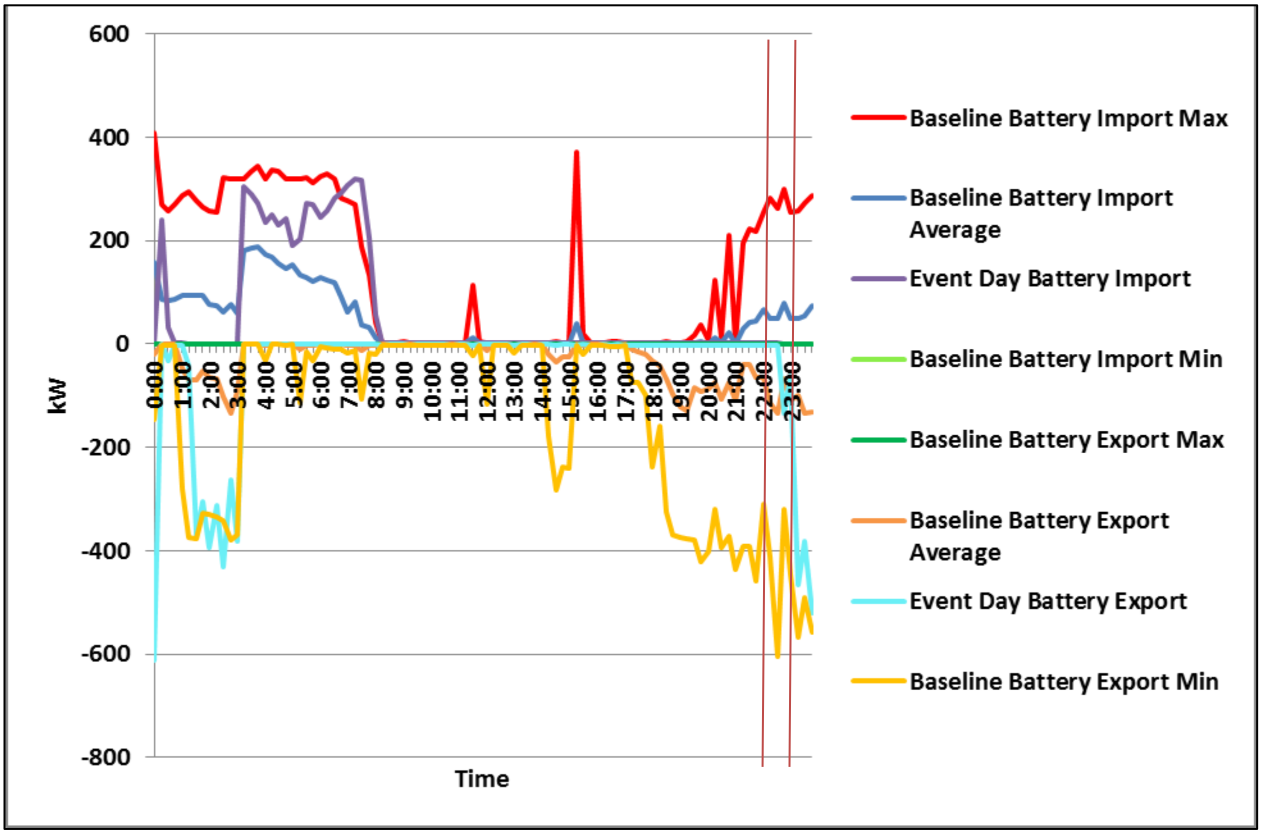


FIGURE 116. MAY 10 22:00-23:00 CUSTOMER 2 TURN OFF CHARGING – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ Measurements

No data was collected at Customer 2 from May 10-May 13. The instrument was reset and data collection continued.

Test Event 9: Friday May 13, 14:00-15:00 PDT – Discharge

a) SCE Meter Baseline Analysis

Figure 117 displays the SCE Meter data for the event and appears to show a response to the "discharge" event. While event day usage trends towards the minimum baseline usage and returns to a higher usage in the period after the event is over, the trend is not very pronounced relative to the rest of the event day usage. This small magnitude may be attributable to the Customer 2 battery being limiting the export to the portion of the facility load monitored by the battery system

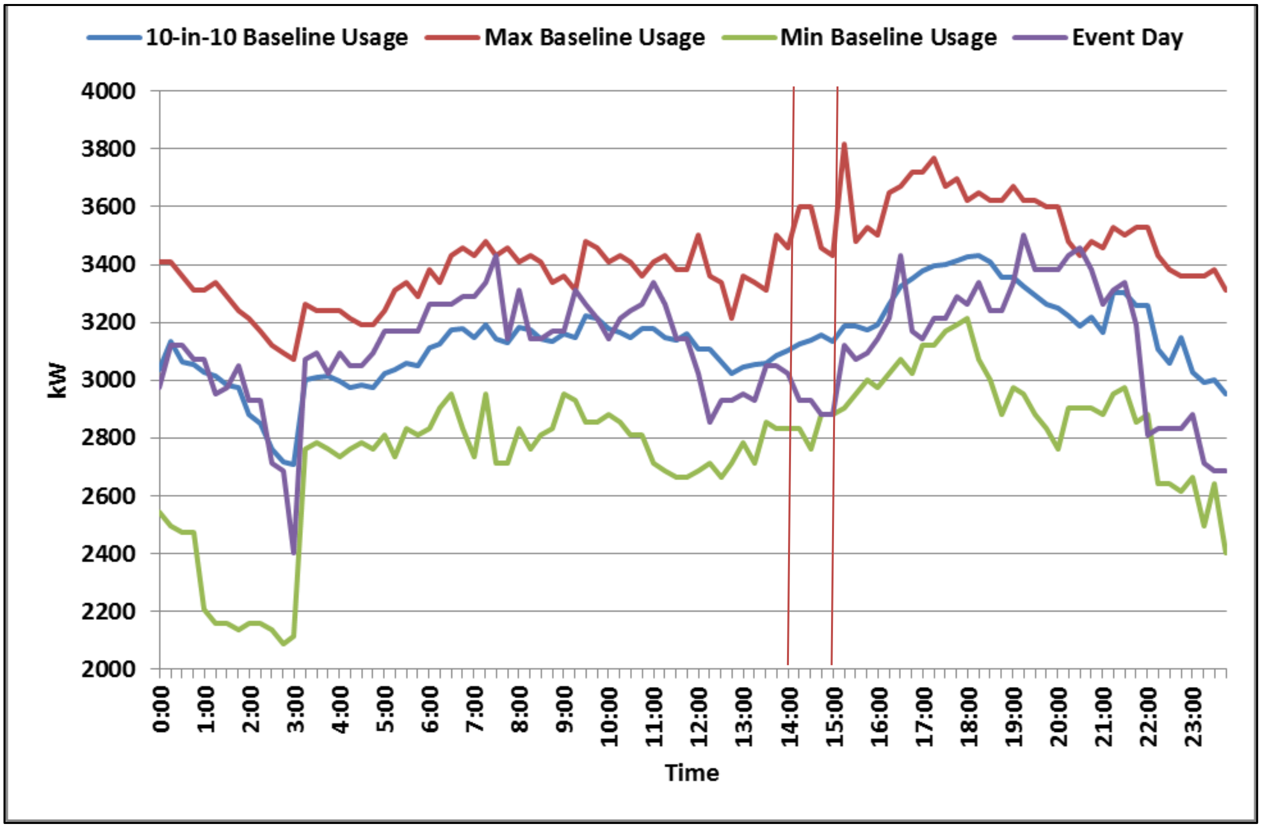


Figure 117. May 13 14:00-15:00 Customer 2 Discharge – SCE Meter Data

Figure 118, clearly illustrates that load might have been expected to climb through the event period, but instead drops off significantly. The LA 10-in-10 and the ±*20% from baseline* mirror each other very closely, with an average kW savings of 161 and 155, respectfully.

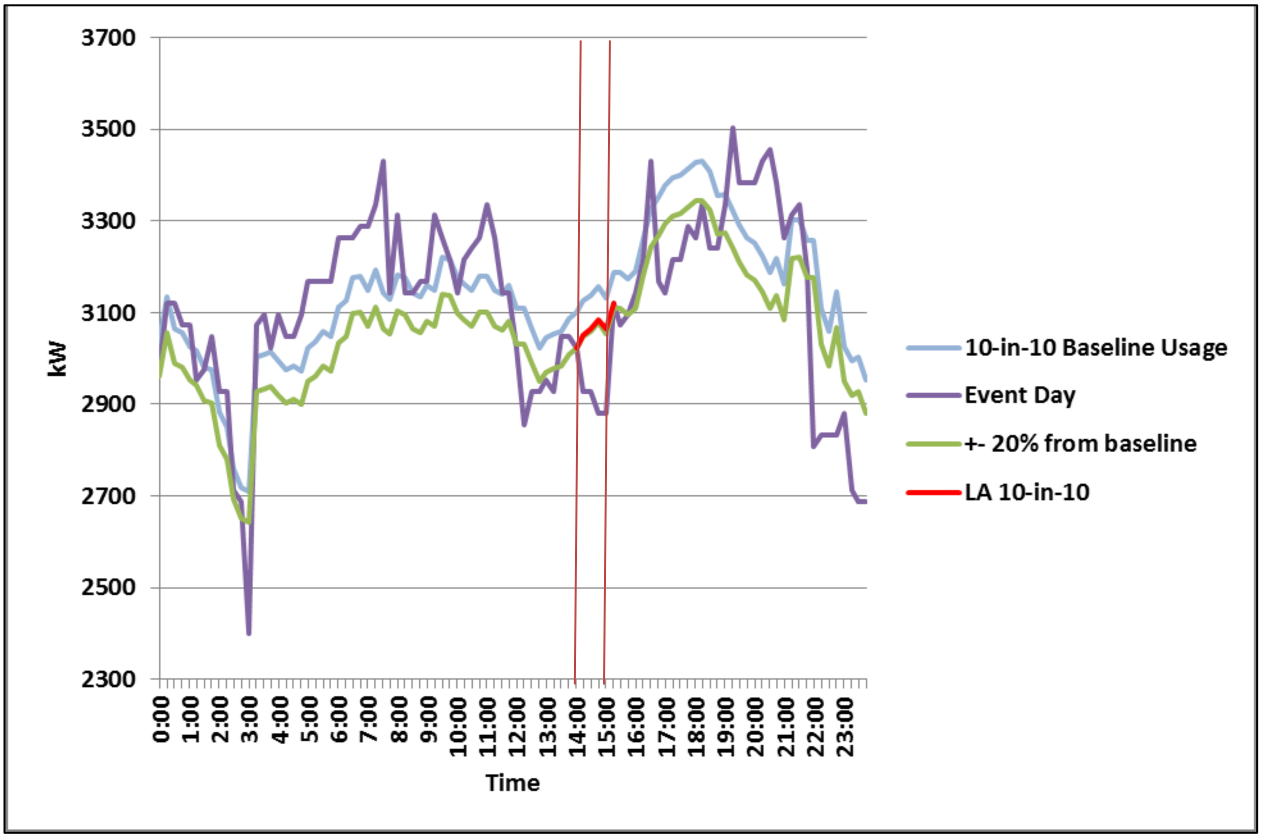


FIGURE 118. MAY 13 14:00-15:00 CUSTOMER 2 DISCHARGE – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 25. MAY 13 14:00-15:00 CUSTOMER 2 DISCHARGE – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
13:45-14:00	3,024.00	-	-	-
14:00-14:15	2,928.00	(196.80)	(119.41)	(121.71)
14:15-14:30	2,928.00	(208.80)	(131.11)	(135.73)
14:30-14:45	2,880.00	(276.00)	(197.83)	(204.81)
14:45-15:00	2,880.00	(252.00)	(174.43)	(183.66)
15:00-15:15	3,120.00	-		-
Average kW	**2,904.00**	**(233.40)**	**(155.69)**	**(161.48)**
Average kWh	**2,904.00**	**(233.40)**	**(155.69)**	**(161.48)**
CBP Bid (kW)		(200)		
CBP Event Performance		**117%**		

b) BATTERY ALCS BASELINE ANALYSIS

The net battery profile in Figure 119 mirrors the SCE meter data. The battery discharged from 14:00-15:00. In this event there is no activity in the periods immediately before and after the event, which assists in creating smooth baseline projections for non-event usage profiles.

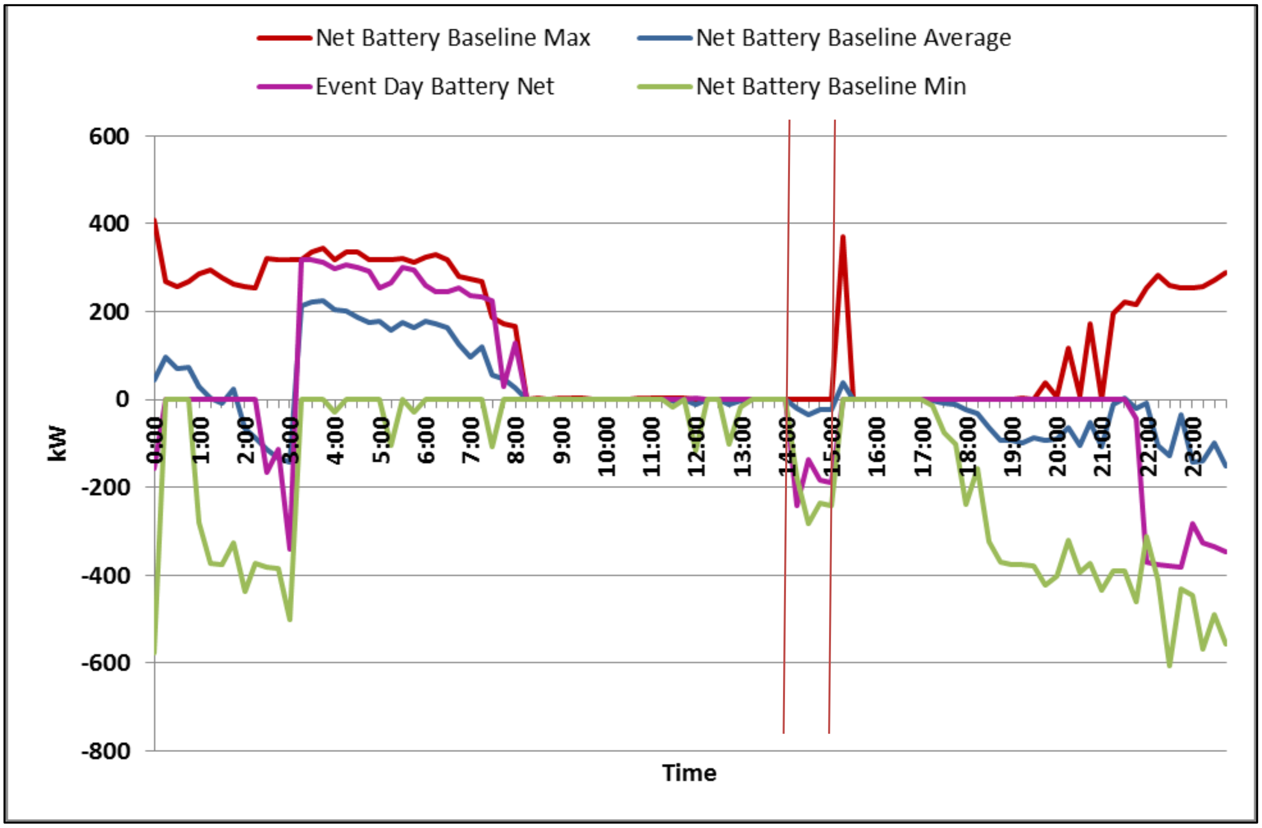


FIGURE 119. MAY 13 14:00-15:00 CUSTOMER 2 DISCHARGE– BATTERY ALCS NET METER DATA

The Import Export chart in Figure 120 supports the event day observations outlined in Figure 119.

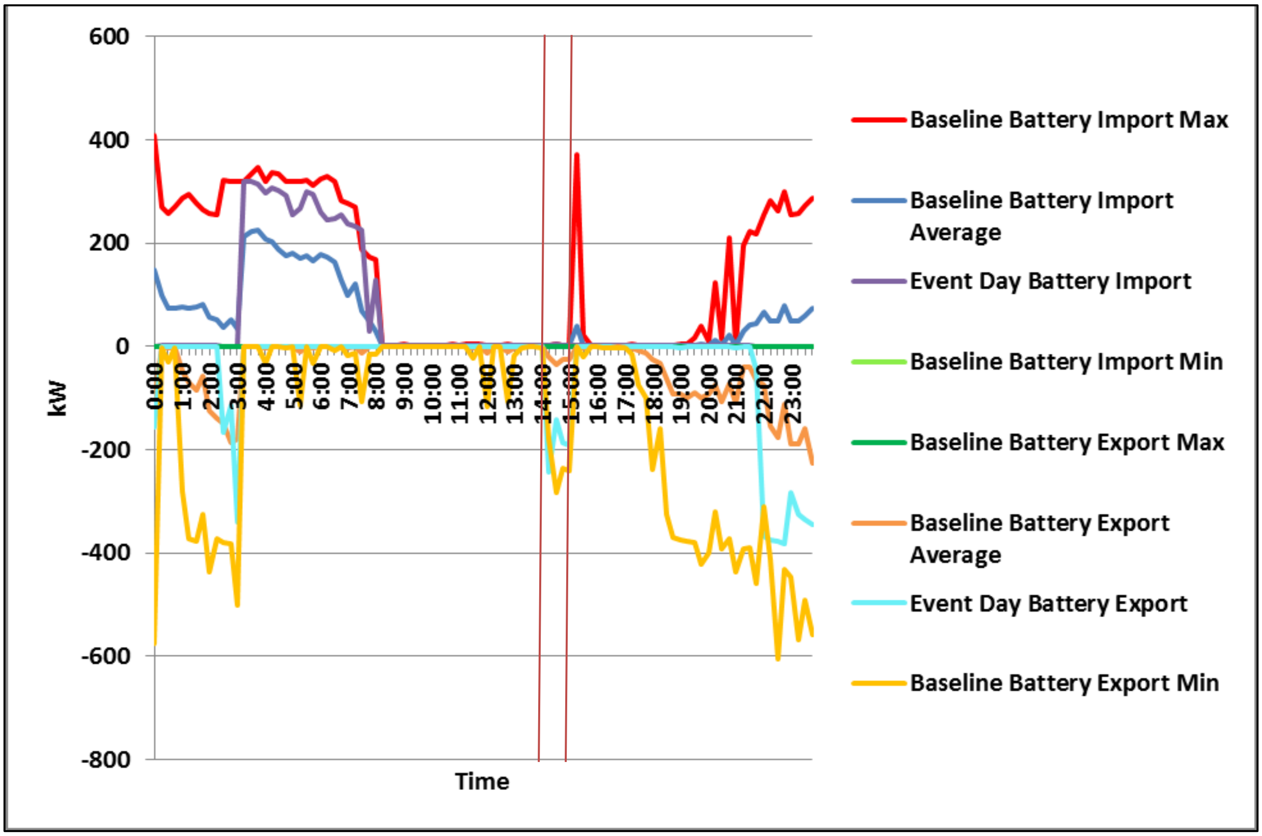


FIGURE 120. MAY 13 14:00-15:00 CUSTOMER 2 DISCHARGE– BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ Measurements

While only the second half of the test event period was captured, the upper chart in Figure 121 aligns with both the Battery ALCS data shown in Figure 119 and Figure 120 as well as the SCE meter data shown in Figure 117 and Figure 118. The lower chart in Figure 121 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during, and after the test event period.

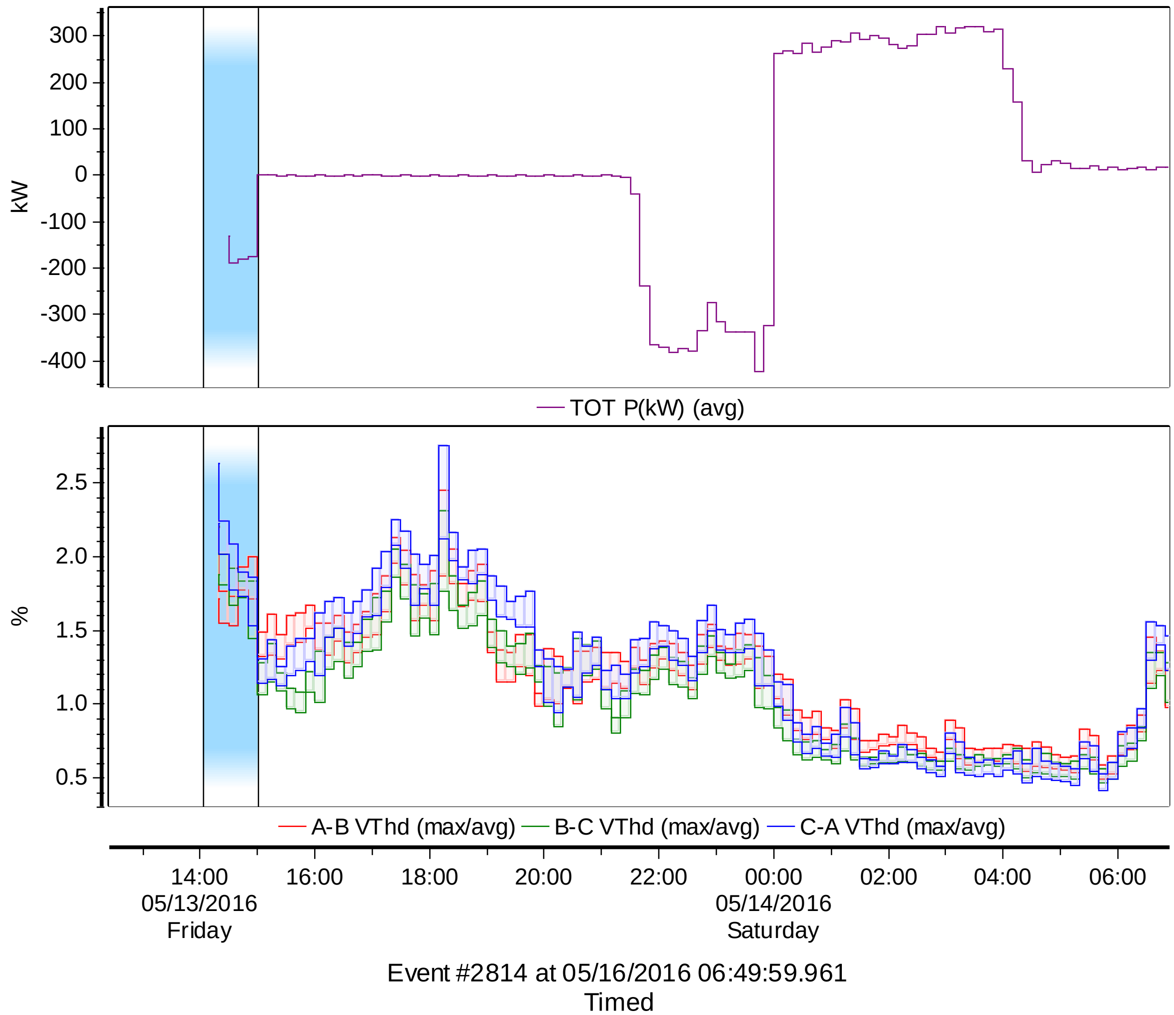


Figure 121. May 13 14:00 -15:00Customer 2 Discharge–PQ Meter Data

TEST EVENT 10: TUESDAY MAY 17, 3:00-4:00 PDT – START CHARGING

a) SCE METER BASELINE ANALYSIS

As shown in Figure 122, the baseline usage increases across the average, maximum, and minimum for the baseline period from 3:00-3:15. This pattern of usage increase beginning at 3:00 complicates baseline quantification for the Start Charging test at this same period. However, the event day usage from 3:00-4:00 actually decreases to lower levels than the minimum observed in the baseline period for the same time-frame. The decrease in usage indicates a lack of response to the Start Charging signal. Midday peaks are higher than the average observed during the baseline period, which may indicate that the battery system was offline on event day.

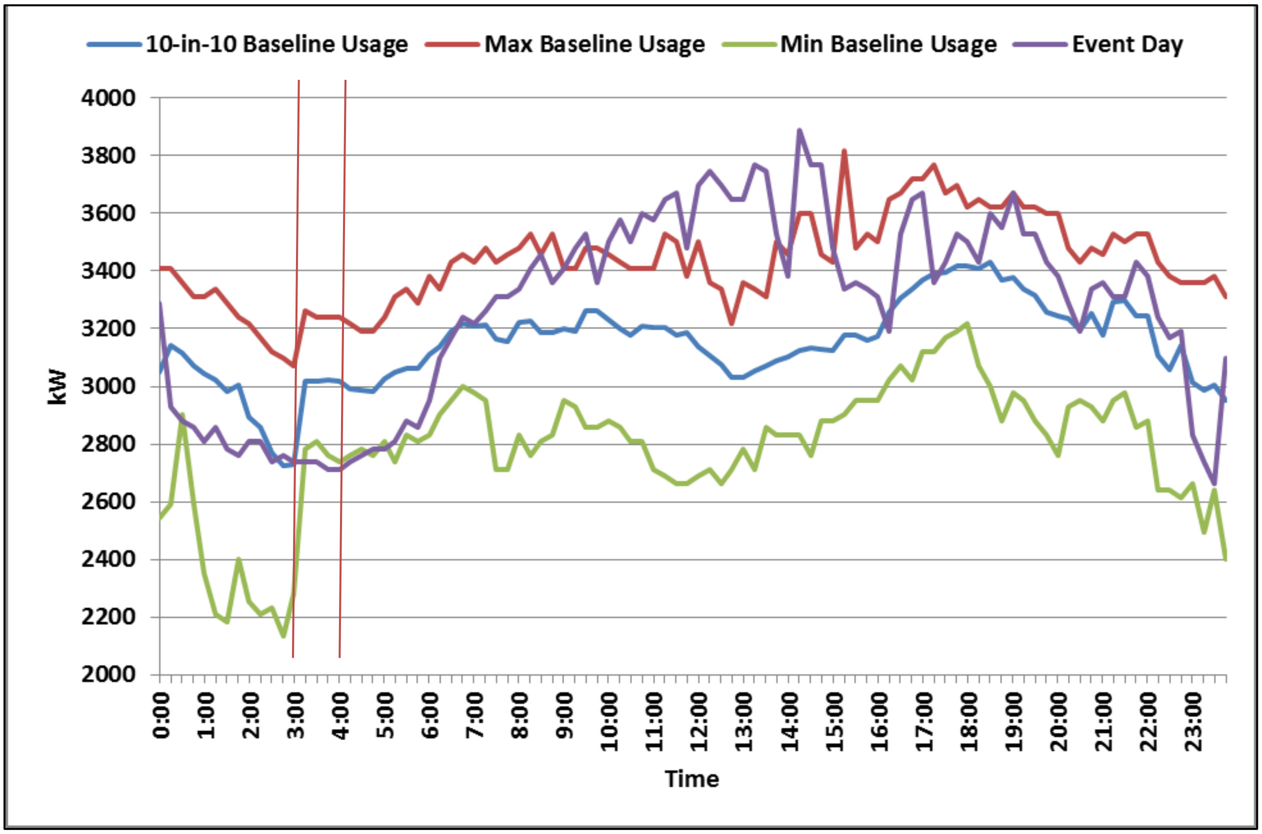


FIGURE 122. MAY 17 03:00-04:00 CUSTOMER 2 START CHARGING – SCE METER DATA

Figure 123 shows that the baseline usage estimates increase across the 3:00-3:15 period. The event day usage does not align with what might be expected from a Start Charging event. This lack of charging seems to manifest in the midday hours as usage exceeds the maximum baseline period.

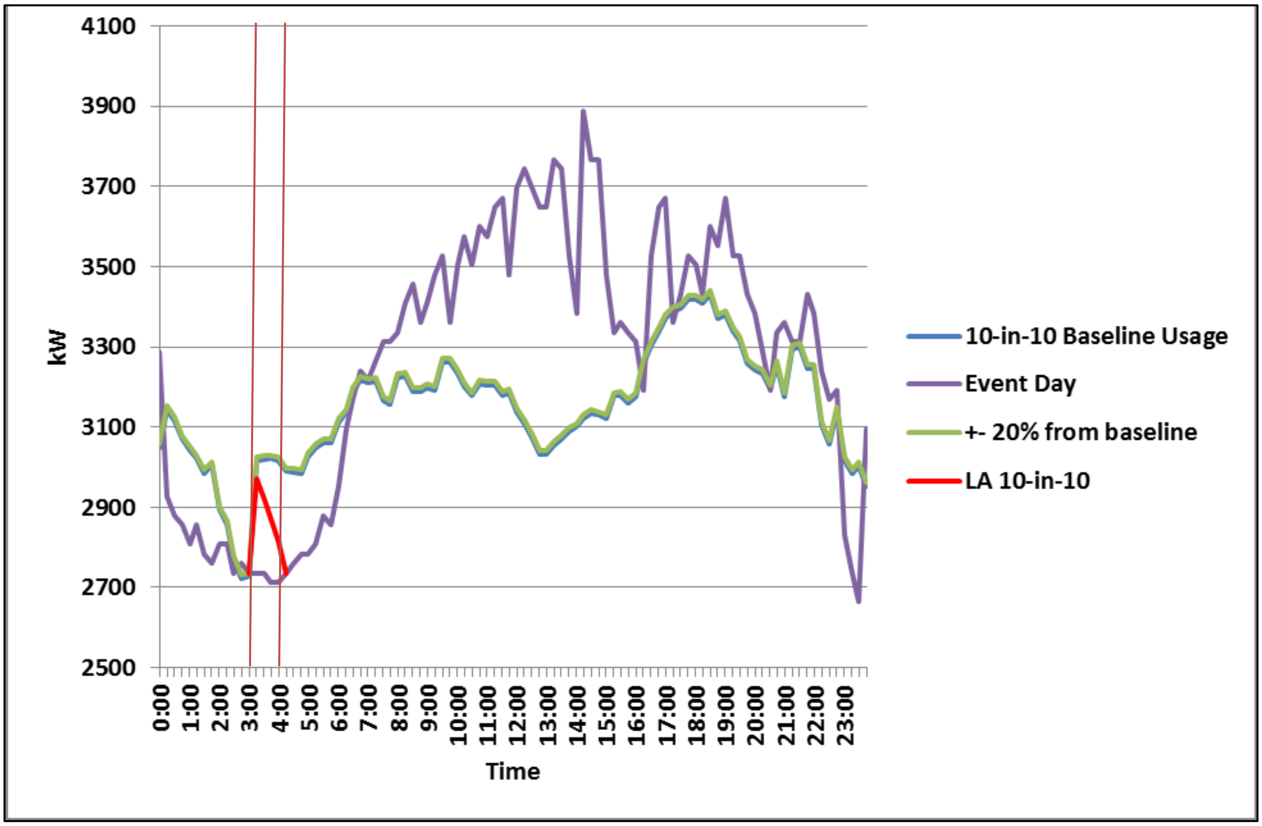


FIGURE 123. MAY 17 03:00-04:00 CUSTOMER 2 START CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis. The negative CBP event performance indicates that the battery response was opposite of what was expected. In this instance, rather than an increase in usage in response to the "Start Charging" dispatch, there was an average 294 kW decrease in demand.

TABLE 26. MAY 17 3:00-4:00 CUSTOMER 2 START CHARGING – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
2:45-3:00	2,736.00	-	-	-
3:00-3:15	2,736.00	(280.00)	(288.84)	(235.96)
3:15-3:30	2,736.00	(282.67)	(291.52)	(185.65)
3:30-3:45	2,712.00	(309.33)	(318.19)	(159.25)
3:45-4:00	2,712.00	(304.00)	(312.84)	(101.29)
4:00-4:15	2,736.00	-	-	-
Average kW	**2,724.00**	**(294.00)**	**(302.85)**	**(170.54)**
Average kWh	**2,724.00**	**(294.00)**	**(302.85)**	**(170.54)**
CBP Bid (kW)		200		
CBP Event Performance		**-147%**		

b) Battery ALCS Baseline Analysis

Figure 124 shows that the battery was not charging on event day in response to the “Start Charging” event even though the Net Battery Baseline Max and Net Battery Baseline Average both indicate that charging is typical at 3:00. Furthermore, the figure also shows that charging shifted to the afternoon. The peaks observed on the event day SCE meter graphs (Figure 122) are likely due to this increased battery load from charging in the midday hours. The theory that peaks were due to a lack of discharging in those hours due to non-charging in the morning does not hold with this new information.

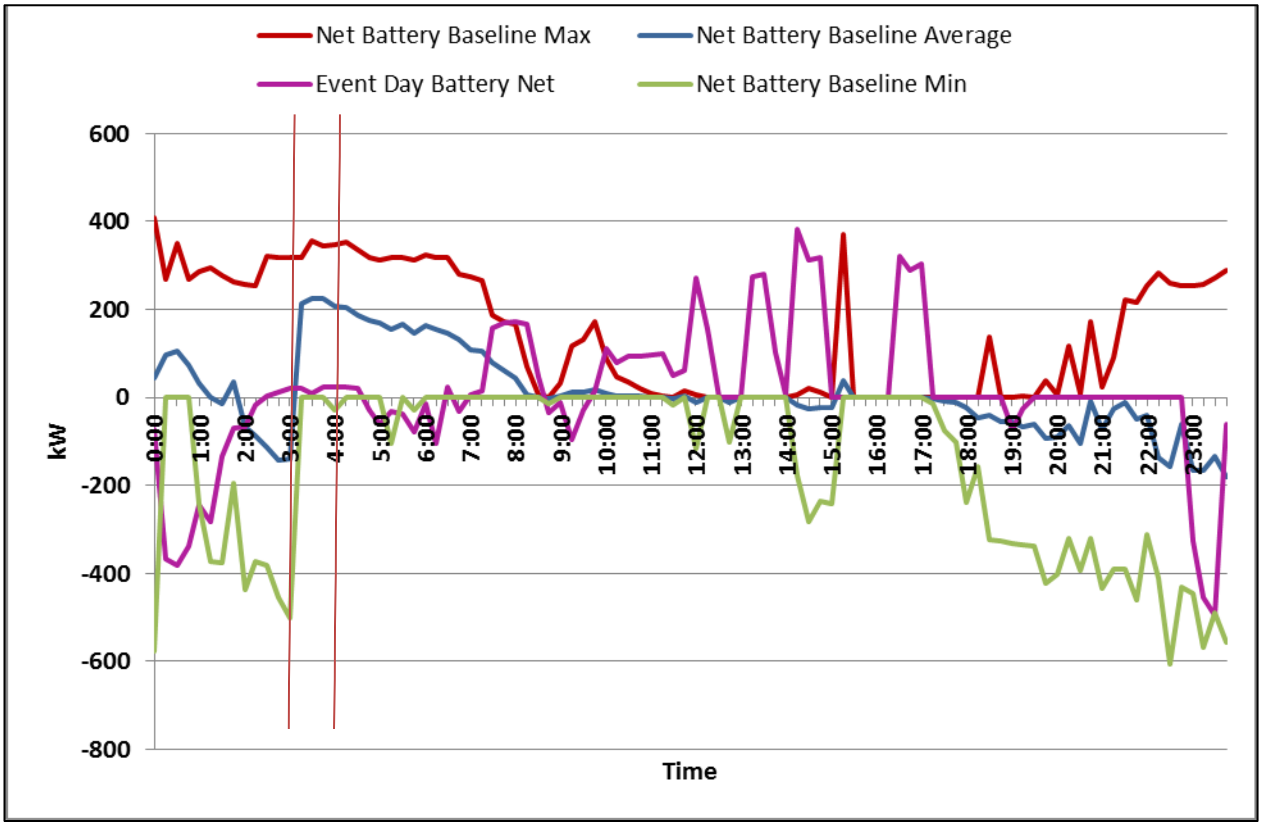


Figure 124. May 17 3:00-4:00 Customer 2 Start Charging – Battery ALCS Net Meter Data

The Import Export chart in Figure 125 supports the event day observations outlined in Figure 124.

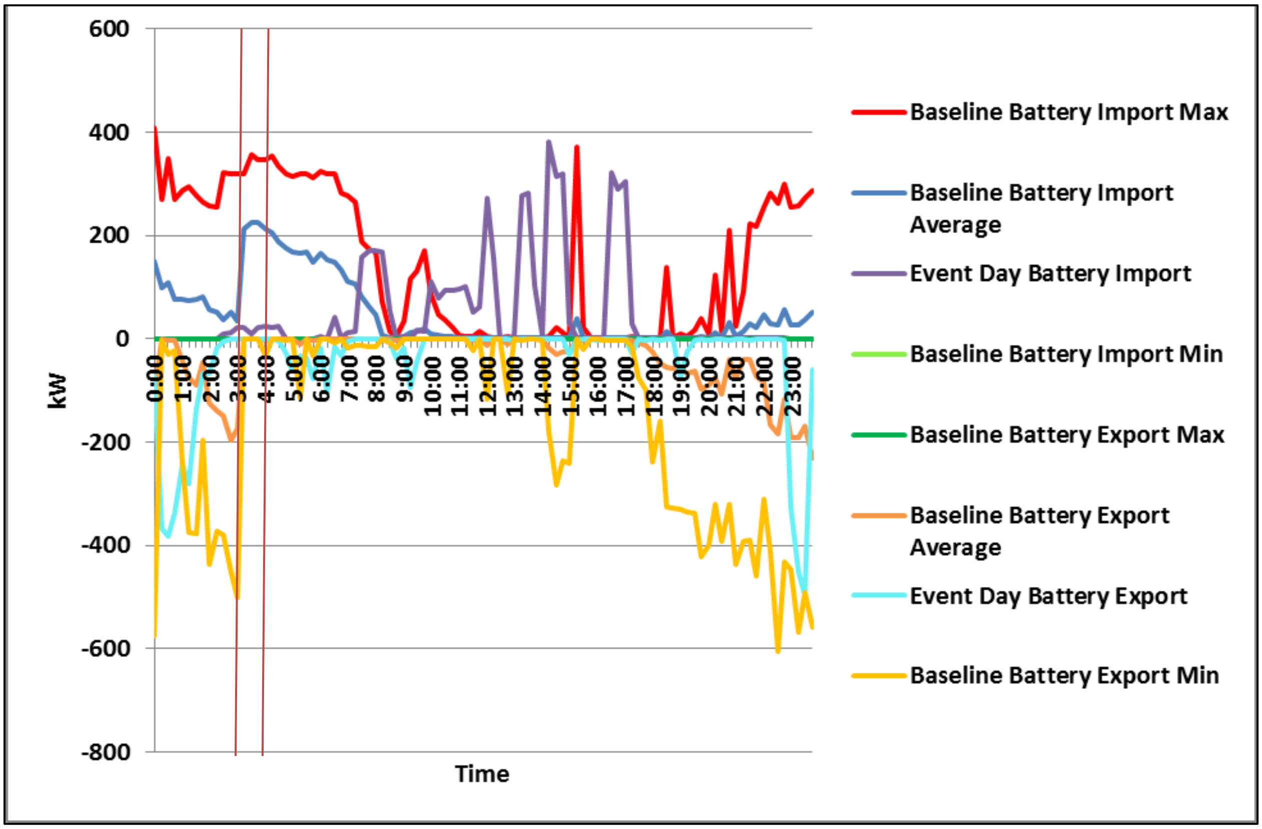


FIGURE 125. MAY 17 3:00-4:00 CUSTOMER 2 START CHARGING – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ MEASUREMENTS

The upper chart in Figure 126 aligns with both the Battery ALCS data shown in Figure 124 and Figure 125 as well as the SCE meter data shown in Figure 122 and Figure 123. The lower chart in Figure 126 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during, and after the test event period.

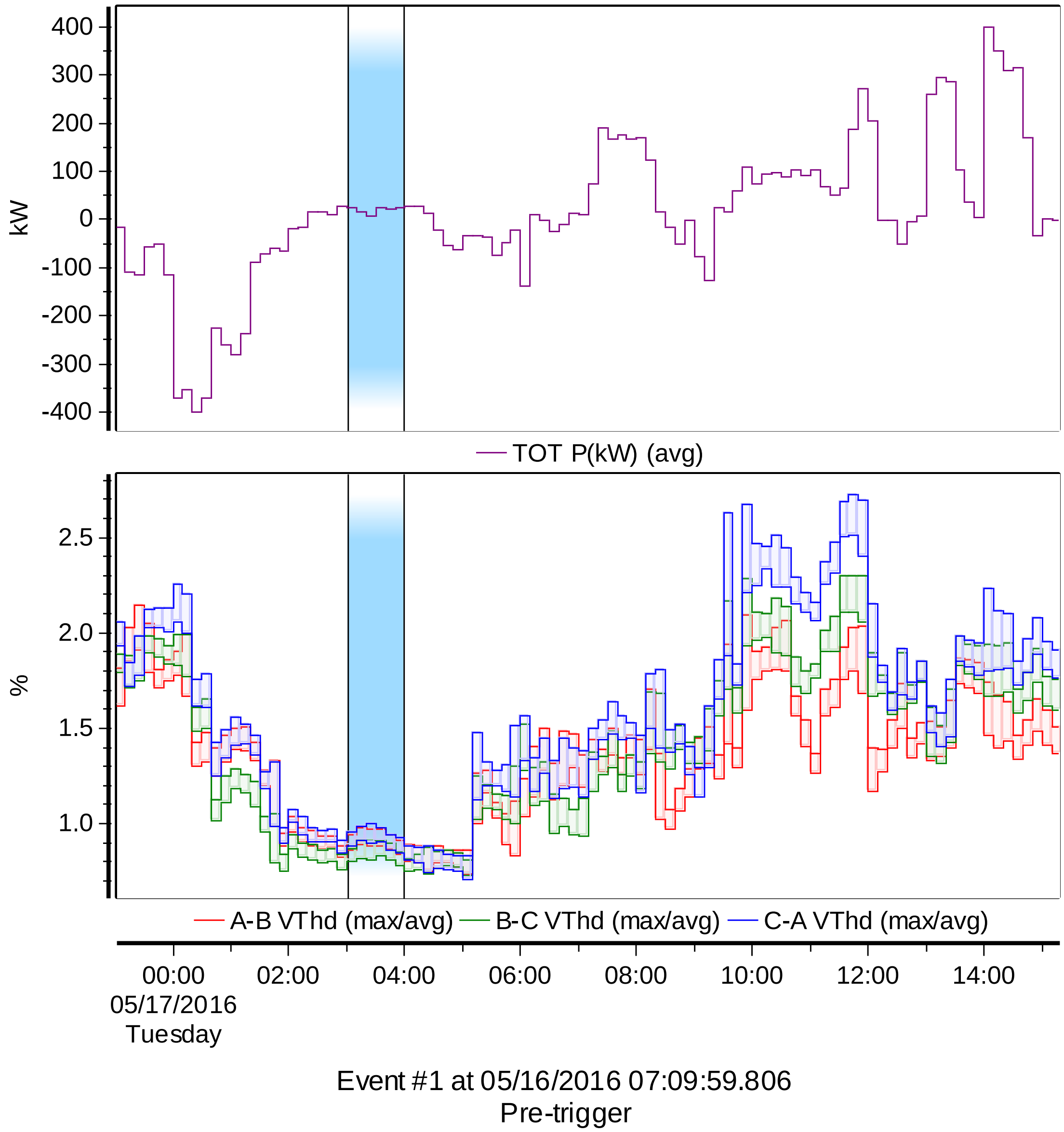


FIGURE 126. MAY 17 3:00-4:00 CUSTOMER 2 START CHARGING–PQ METER DATA

TEST EVENT 11: FRIDAY MAY 20, 3:00-4:00 PDT – START CHARGING

a) SCE Meter Baseline Analysis

Figure 127 shows that the baseline usage increases across the average, maximum and minimum for the baseline period from 3:00-3:15. This pattern of usage increase beginning at 3:00 complicates the baseline quantification for the Start Charging test at this same period. However, the event day usage profile does not demonstrate this same usage increase from 3:00-3:15. Event day usage is roughly at the maximum baseline period at the start of the event and maintained through the event.

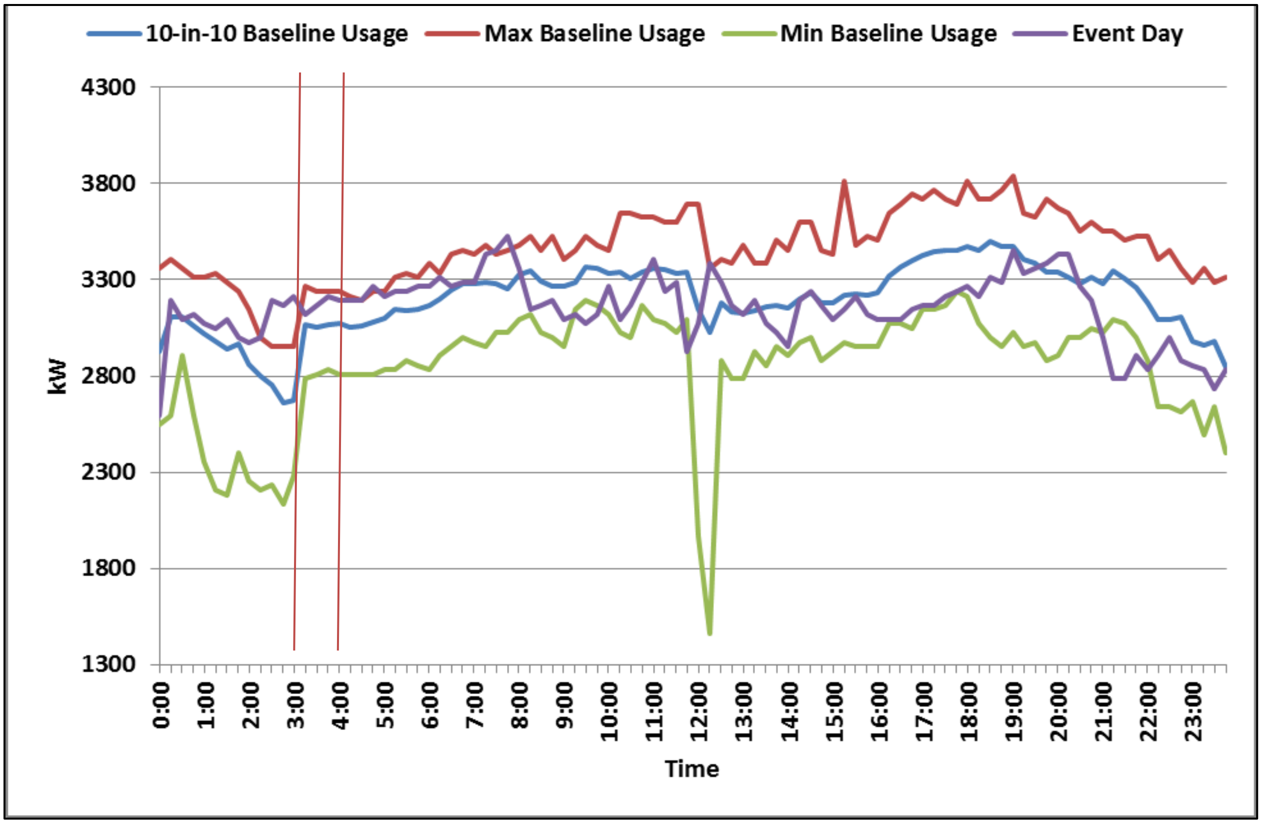


Figure 127. May 20 03:00-04:00 Customer 2 Start Charging – SCE Meter Data

In Figure 128, the actual event day usage displays higher usage levels than the 10-in-10 baseline. However, when the baseline profile is adjusted to the usage amount at the event start via the ±*20% from baseline* green line, it can be seen that the event did not perform to expectations compared to the baseline estimate for what would be expected in the absence Start Charging event signals.

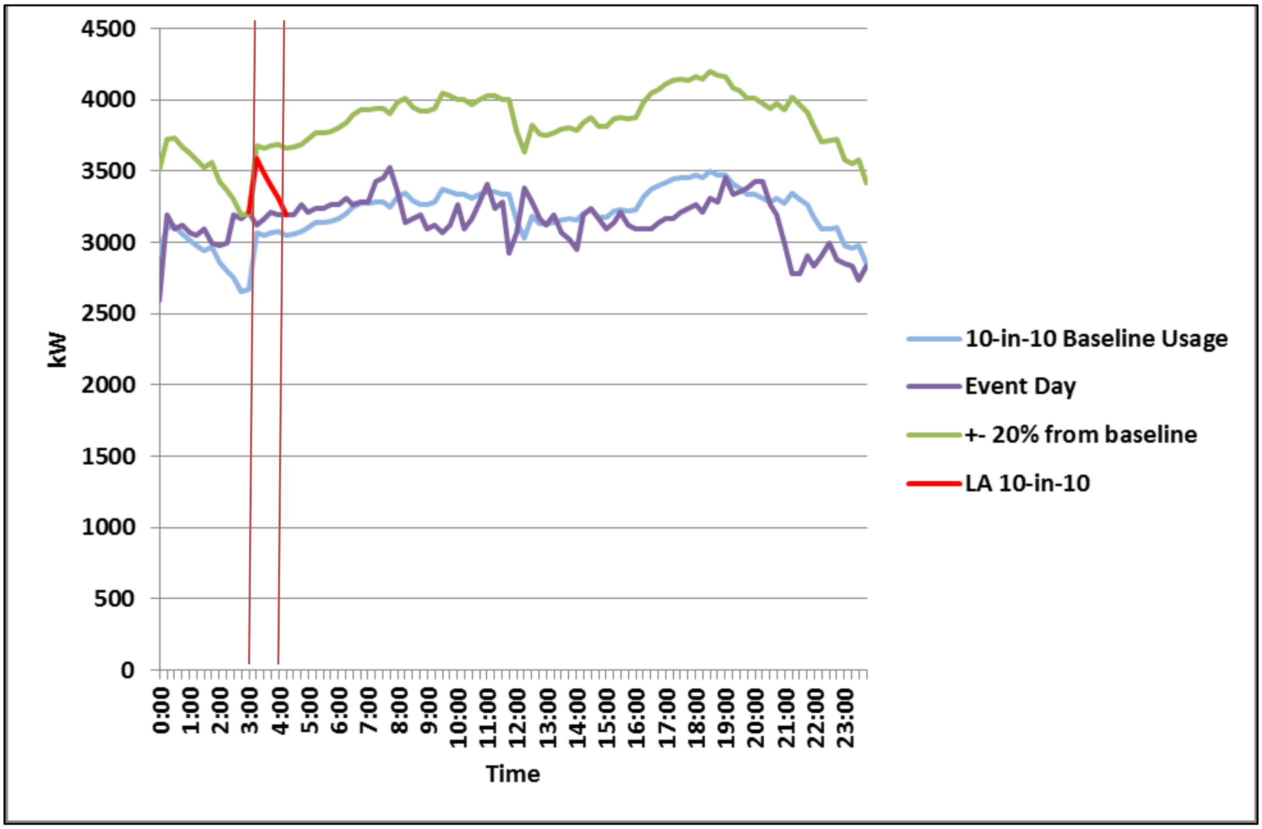


FIGURE 128. MAY 20 03:00-04:00 CUSTOMER 2 START CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. shows the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 27. MAY 20 3:00-4:00 CUSTOMER 2 START CHARGING – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
2:45-3:00	3,216.00	-	-	-
3:00-3:15	3,120.00	53.33	(560.00)	(474.00)
3:15-3:30	3,168.00	114.67	(496.00)	(313.78)
3:30-3:45	3,216.00	146.67	(467.20)	(186.93)
3:45-4:00	3,192.00	117.33	(497.60)	(119.57)
4:00-4:15	3,192.00	-	-	-
Average kW	**3,174.00**	**108.00**	**(505.20)**	**(273.57)**
Average kWh	**3,174.00**	**108.00**	**(505.20)**	**(273.57)**
CBP Bid (kW)		200		
CBP Event Performance		**54%**		

b) BATTERY ALCS BASELINE ANALYSIS

Figure 129 shows that the battery began charging on event day at 2:30 as opposed to its traditional 3:00. This premature start might be responsible for the lack of measurable impact during the event. The charging actually becomes less as the event continues, which is consistent with the baseline average. It is interesting to note the continued charging through 8:00. The 7:45-8:00 period charges with greater intensity than the event period, which indicates that the battery had more charging capacity to offer during the event.

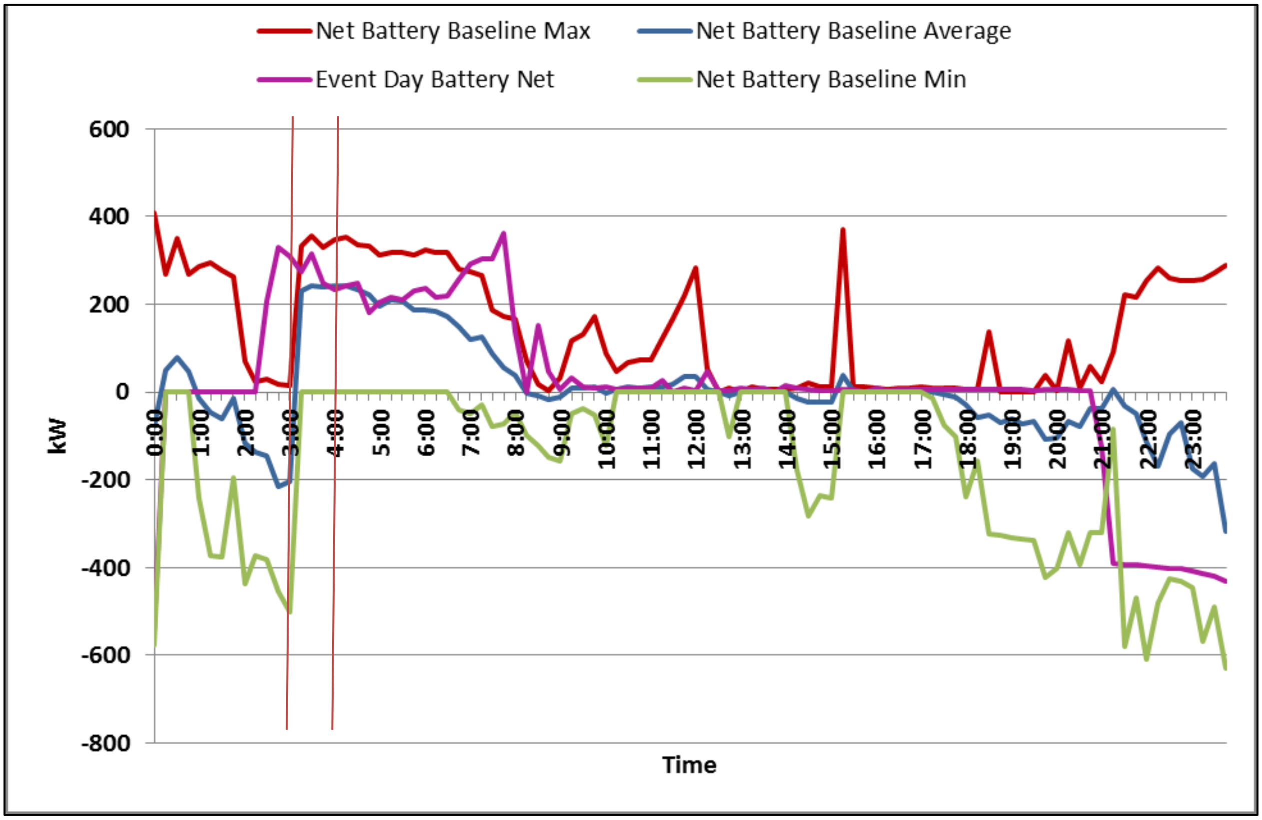


FIGURE 129. MAY 20 3:00-4:00 CUSTOMER 2 START CHARGING – BATTERY ALCS NET METER DATA

Figure 130 supports the event day observations outlined in Figure 129.

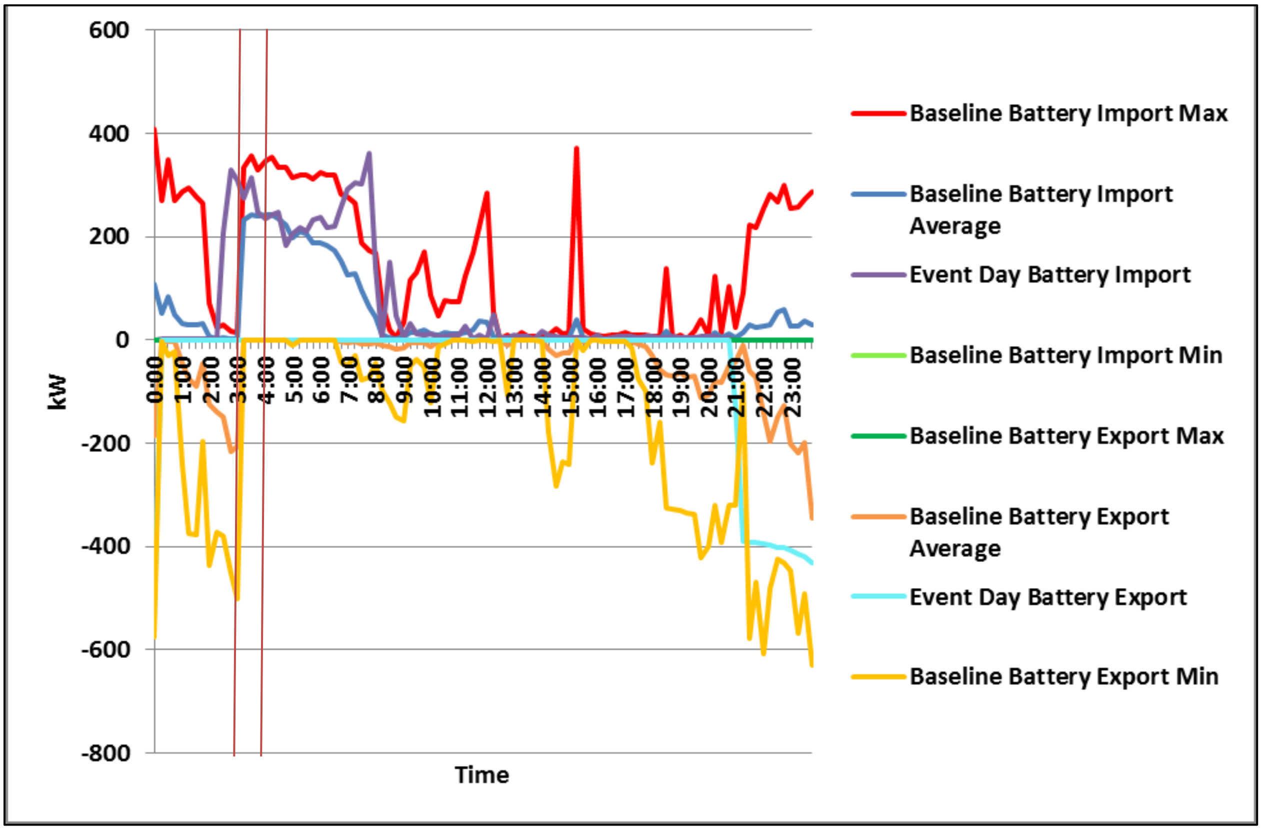


FIGURE 130. MAY 20 3:00-4:00 CUSTOMER 2 START CHARGING – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ MEASUREMENTS

The upper chart in Figure 131 aligns with both the Battery ALCS data shown in Figure 129 and Figure 130 indicating that the battery was already charging prior to as well as after the test event. Therefore the net effect of the "Start Charging" event is somewhat lost in the SCE meter data shown in Figure 127 and Figure 128. The lower chart in Figure 131 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during, and after the test event period.

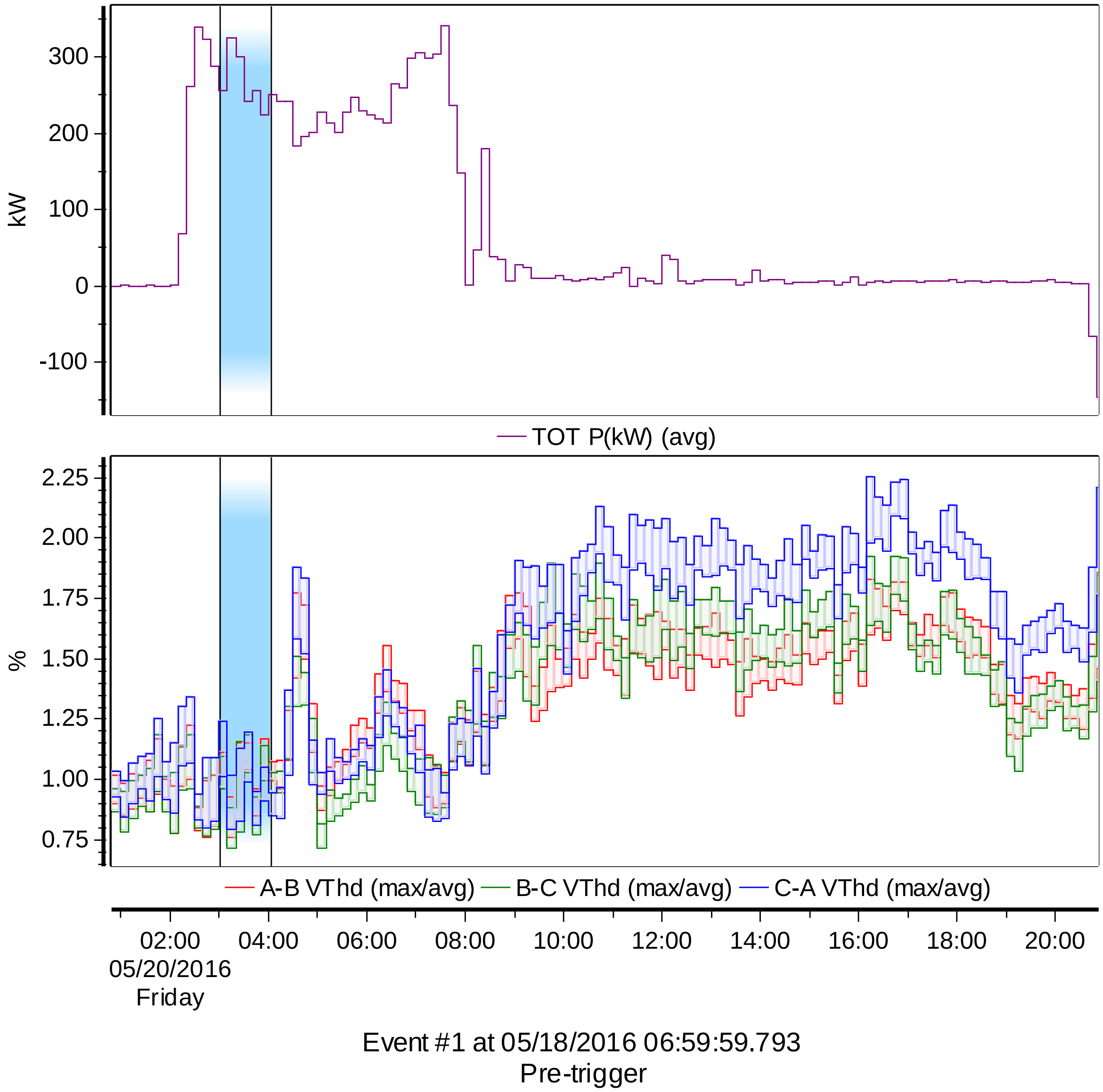


FIGURE 131. MAY 20 3:00-4:00 CUSTOMER 2 START CHARGING–PQ METER DATA

TEST EVENT 12: TUESDAY MAY 24, 3:00-4:00 PDT – START CHARGING

a) SCE Meter Baseline Analysis

Figure 132 shows that the baseline usage increases across the average, maximum, and minimum for the baseline period from 3:00-3:15. This pattern of usage increase beginning at 3:00 complicates the baseline analysis for the Start Charging test at this same period. Event day usage does increase across the 3:00-3:15 period, but the increase actually appears to start in advance of the event start (at 2:45).

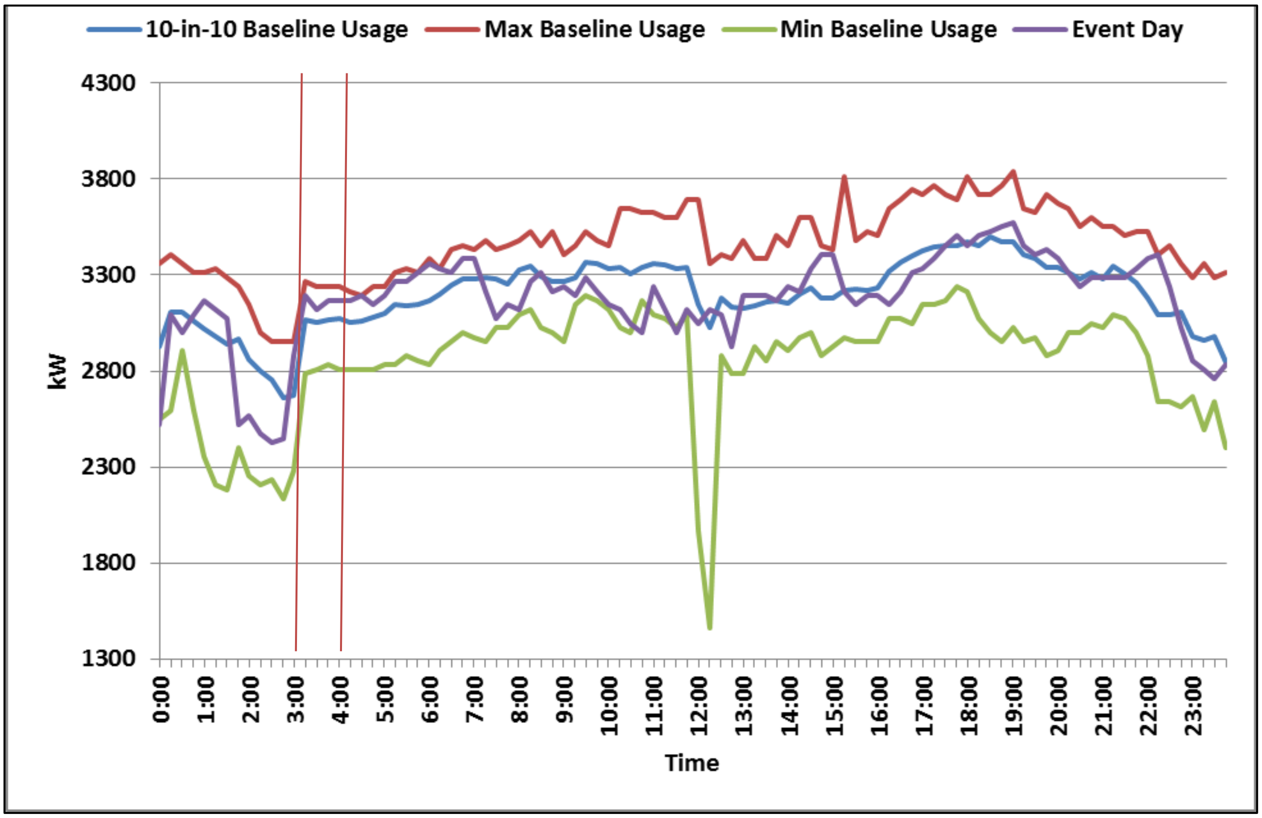


Figure 132. May 24 03:00-04:00 Customer 2 Start Charging – SCE Meter Data

Figure 133 shows that the two adjusted estimates for usage, the LA 10-in-10 and the *±20% from baseline*, indicate a lack of charging performance versus what might have been expected in the timeframe. This may be because usage increase immediately prior to the start of the event was the start of the response to the event or because there was limited event response.

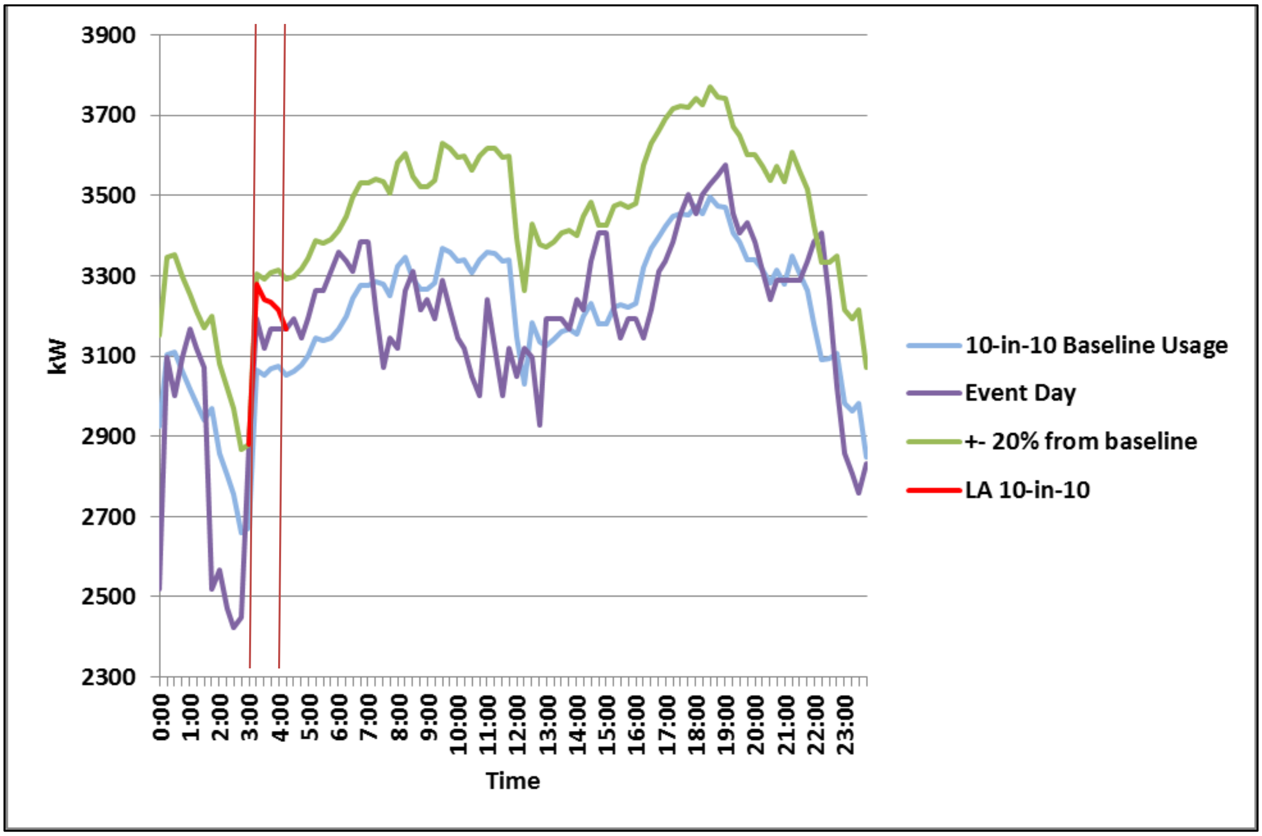


FIGURE 133. MAY 24 03:00-04:00 CUSTOMER 2 START CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 28. MAY 24 3:00-4:00 CUSTOMER 2 START CHARGING – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
2:45-3:00	2,880.00	-	-	-
3:00-3:15	3,192.00	125.33	(113.39)	(88.68)
3:15-3:30	3,120.00	66.67	(171.02)	(121.81)
3:30-3:45	3,168.00	98.67	(140.26)	(66.07)
3:45-4:00	3,168.00	93.33	(146.01)	(46.91)
4:00-4:15	3,168.00	-	-	-
Average kW	**3,162.00**	**96.00**	**(142.67)**	**(80.87)**
Average kWh	**3,162.00**	**96.00**	**(142.67)**	**(80.87)**
CBP Bid (kW)		200		
CBP Event Performance		**48%**		

b) BATTERY ALCS BASELINE ANALYSIS

Figure 134 shows that the minimum of the net battery profile occurs at 2:45 and that the battery performance is neutral at 3:00. This varies from the max, average, and minimum baseline battery profiles which all spike solely across the 3:00-3:15 timeframe, whereas the event day spike is carried out across the 30-minute timeframe from 2:45-3:15. This slower change in behavior is likely why there is little perceivable response in the SCE meter data.

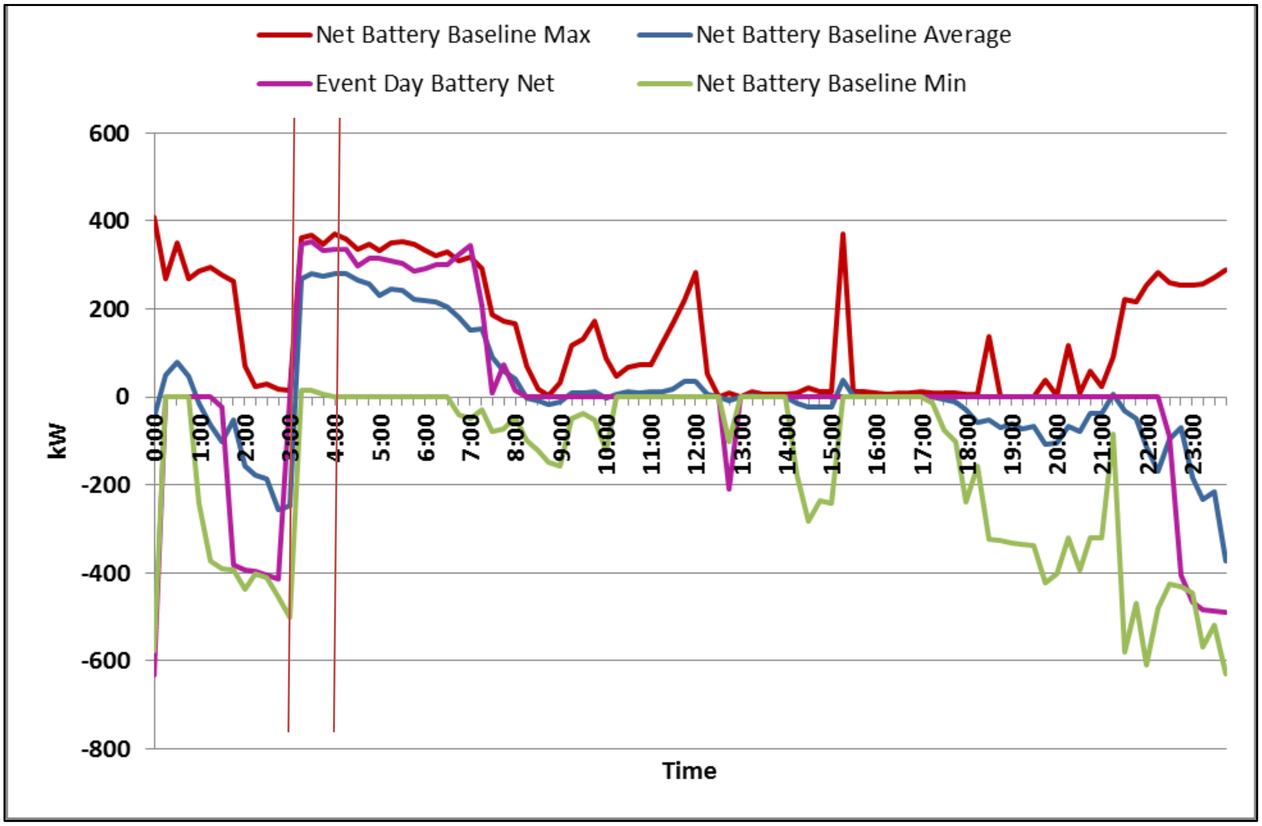


FIGURE 134. MAY 24 3:00-4:00 CUSTOMER 2 START CHARGING – BATTERY ALCS NET METER DATA

The Import Export chart in Figure 135 supports the event day observations outlined in Figure 134.

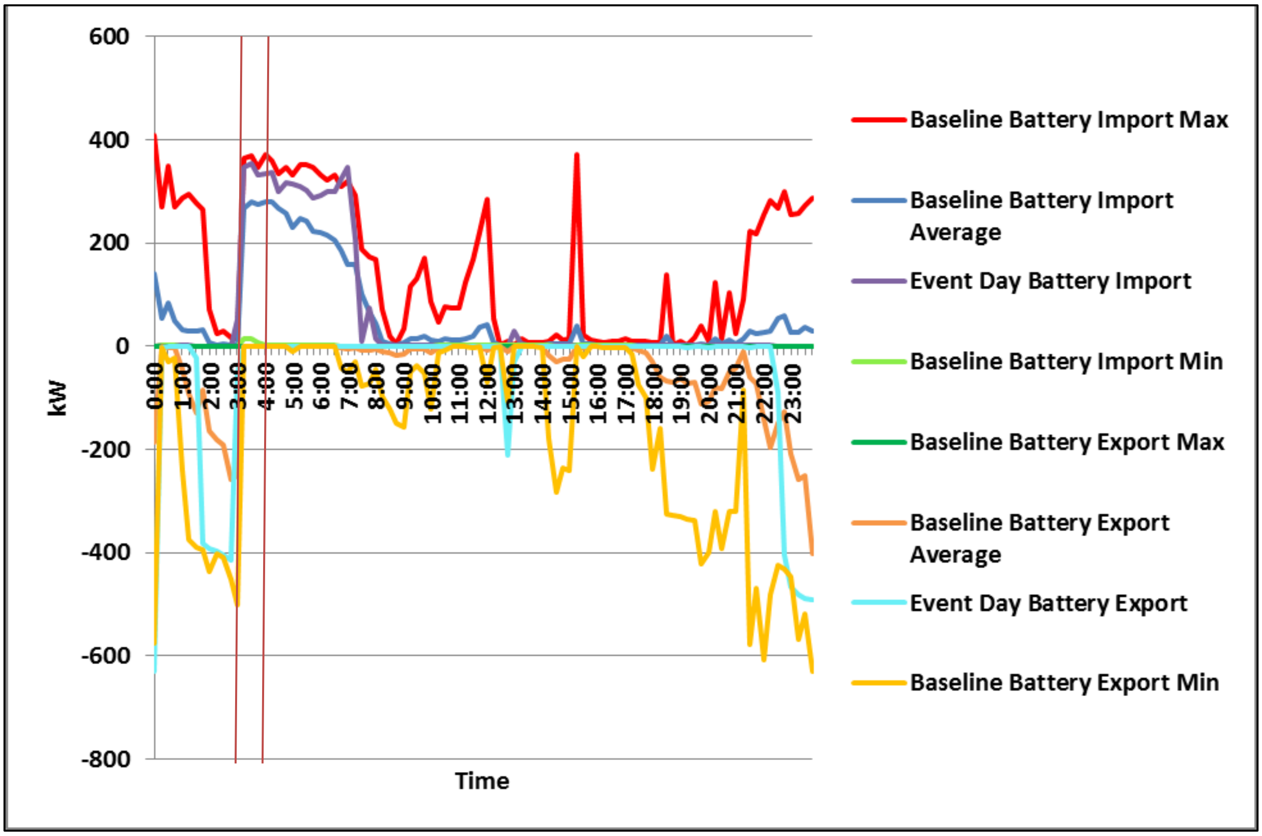


FIGURE 135. MAY 24 3:00-4:00 CUSTOMER 2 START CHARGING – BATTERY ALCS NET METER DATA

c) PQ Measurements

The upper chart in Figure 136 aligns with both the Battery ALCS data shown in Figure 134 and Figure 135 as well as the SCE meter data shown in Figure 132 and Figure 133 indicating that the battery started charging at the initiation of the test event and continued past test event termination. The lower chart in Figure 136 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during, and after the test event period.

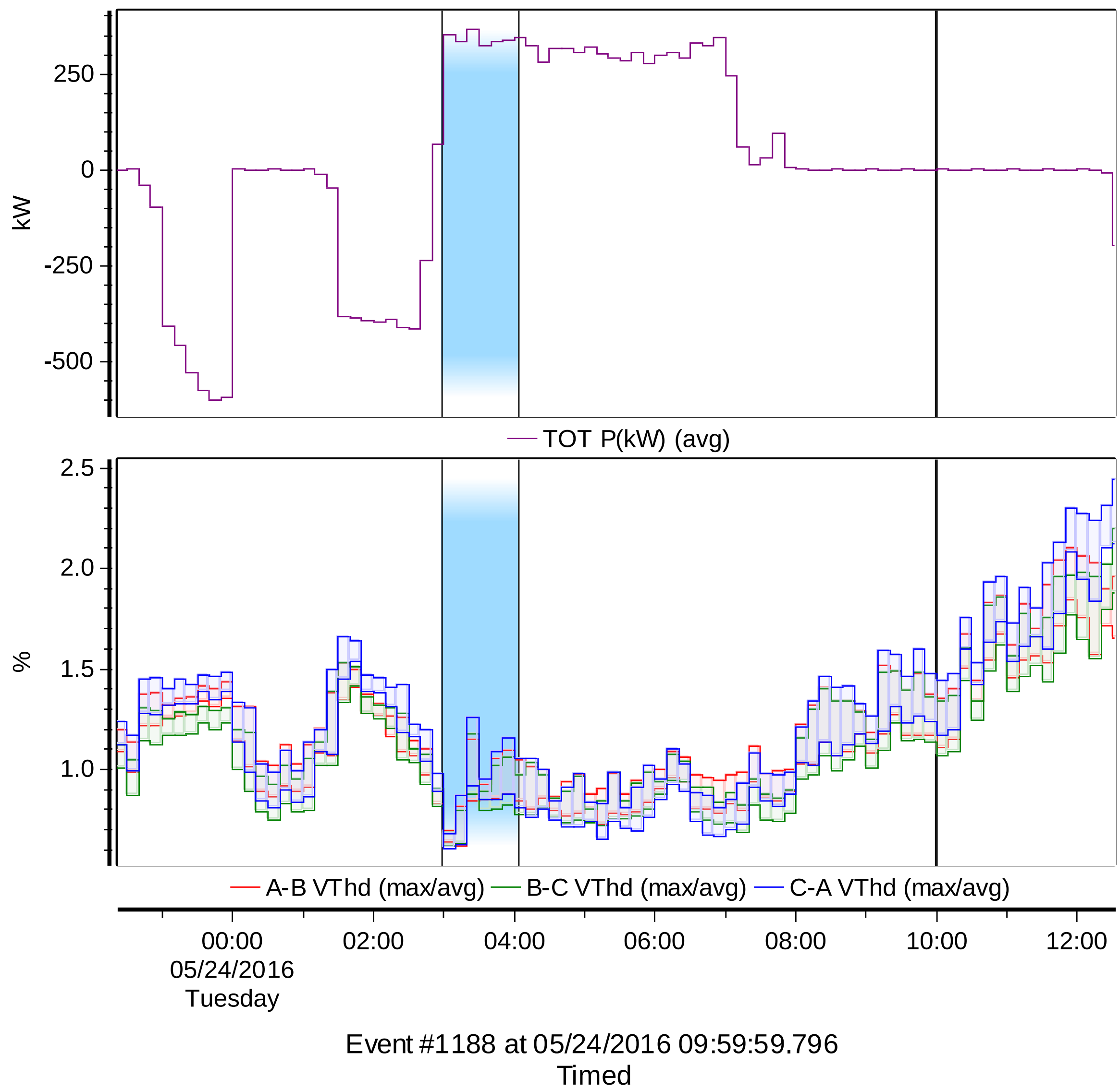


Figure 136. May 24 3:00-4:00 Customer 2 Start Charging–PQ Meter Data

Test Event 13: Wednesday June 8, 3:00 -4:00 PDT – Start Charging

a) SCE Meter Baseline Analysis

The minimum and average baseline usage curves in Figure 137 show a large increase in usage beginning at 3:00. That normal increase coincides with the normal charging time for the battery system. On event day, there is not a large increase in usage that would reflect the battery system starting to charge. Instead, the event day usage profile begins roughly in line with the maximum observed baseline usage before dipping below average by the end of the event. This slope is not in line with the expectations associated with a start charging command.

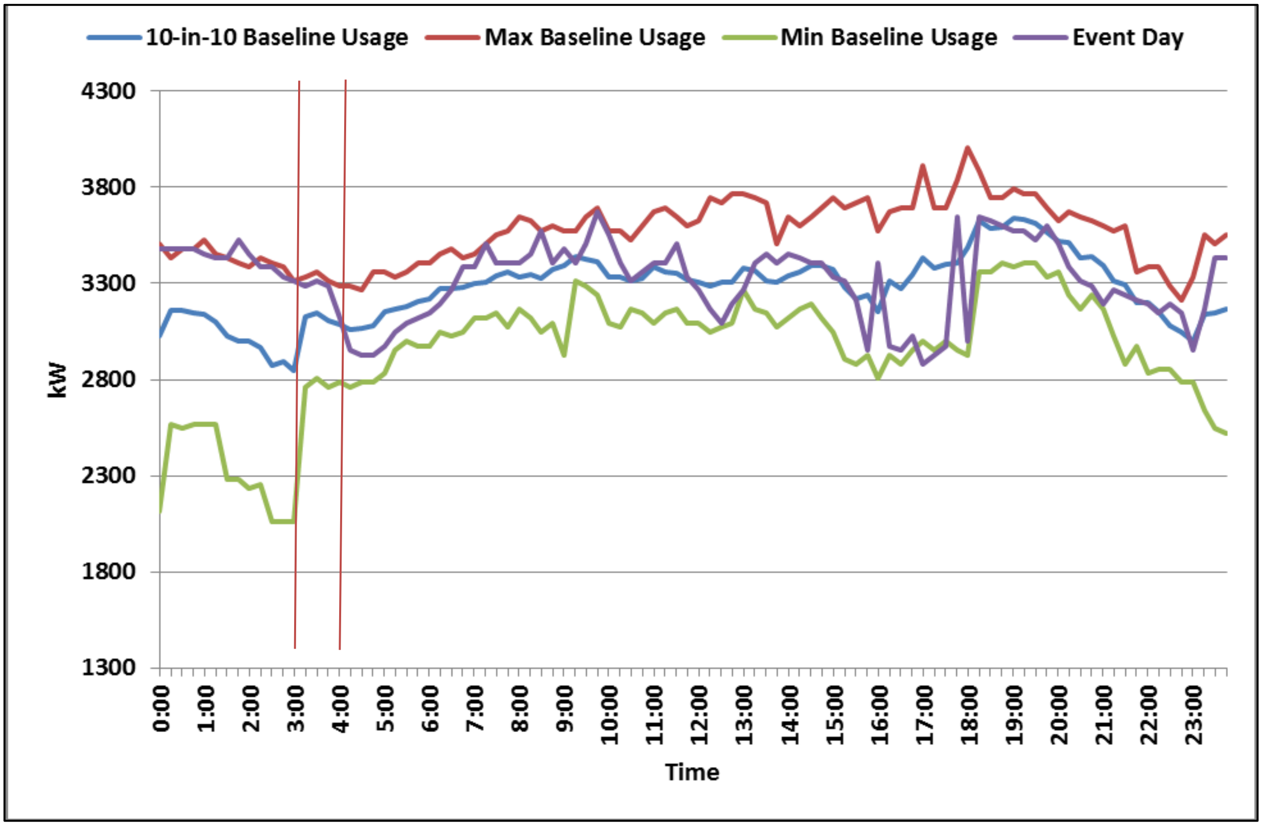


Figure 137. June 8 03:00-04:00 Customer 2 Start Charging – SCE Meter Data

Figure 138 shows that the event day "Start Charging" change of usage does not indicate a significant response to the dispatch signal. A large downward slope of the event day usage outpaces the slight downward slope is observed in the average baseline across the 3:30-4:00 timeframe.

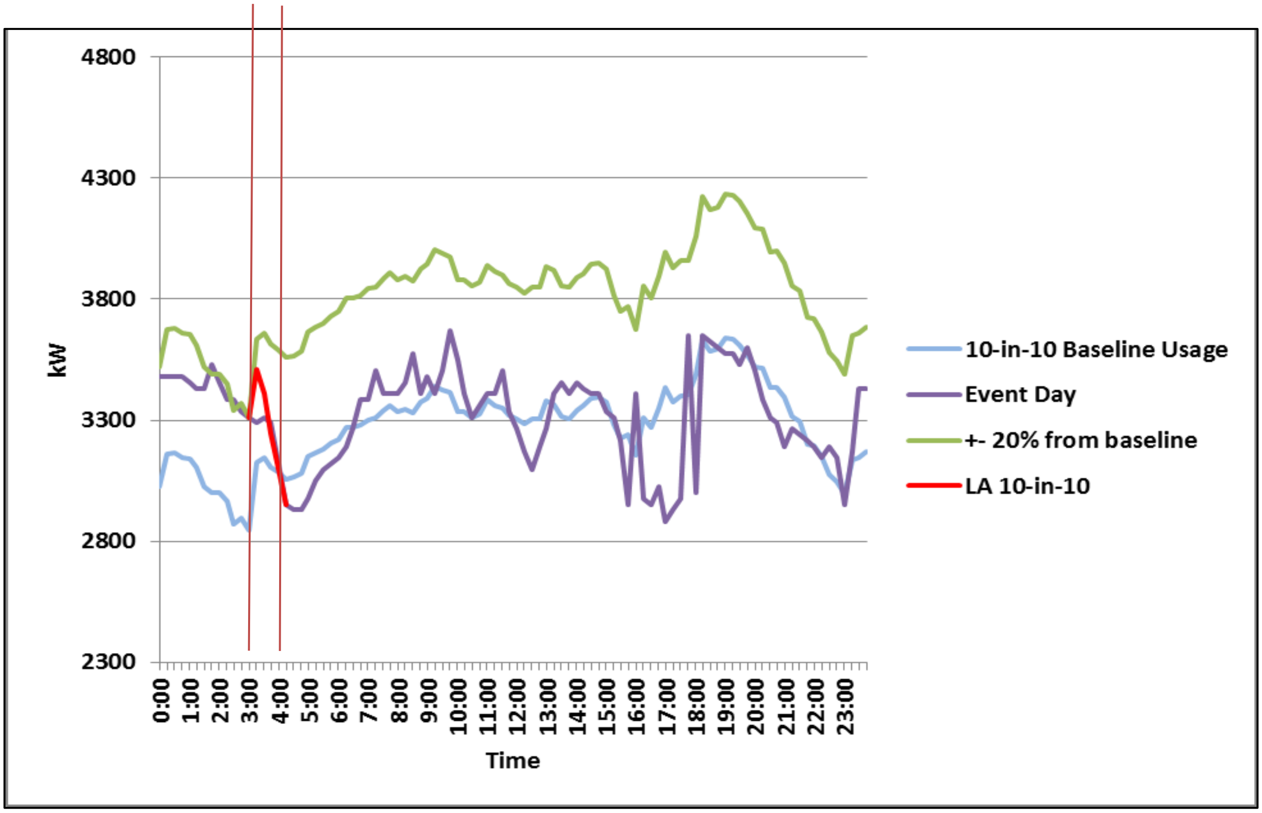


FIGURE 138. JUNE 8 03:00-04:00 CUSTOMER 2 START CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 29. JUNE 8 3:00-4:00 CUSTOMER 2 START CHARGING – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
2:45-3:00	3,312.00	-	-	-
3:00-3:15	3,288.00	163.20	(347.94)	(224.13)
3:15-3:30	3,312.00	168.00	(346.28)	(97.13)
3:30-3:45	3,288.00	182.40	(325.60)	43.56
3:45-4:00	3,120.00	36.00	(468.47)	20.32
4:00-4:15	2,952.00	-	-	-
Average kW	**3,252.00**	**137.40**	**(372.07)**	**(64.35)**
Average kWh	**3,252.00**	**137.40**	**(372.07)**	**(64.35)**
CBP Bid (kW)		200		
CBP Event Performance		**69%**		

b) Battery ALCS Baseline Analysis

Figure 139 shows that the battery system was likely offline for the event day as the *Event Day Battery Net* line stayed at zero throughout the day.

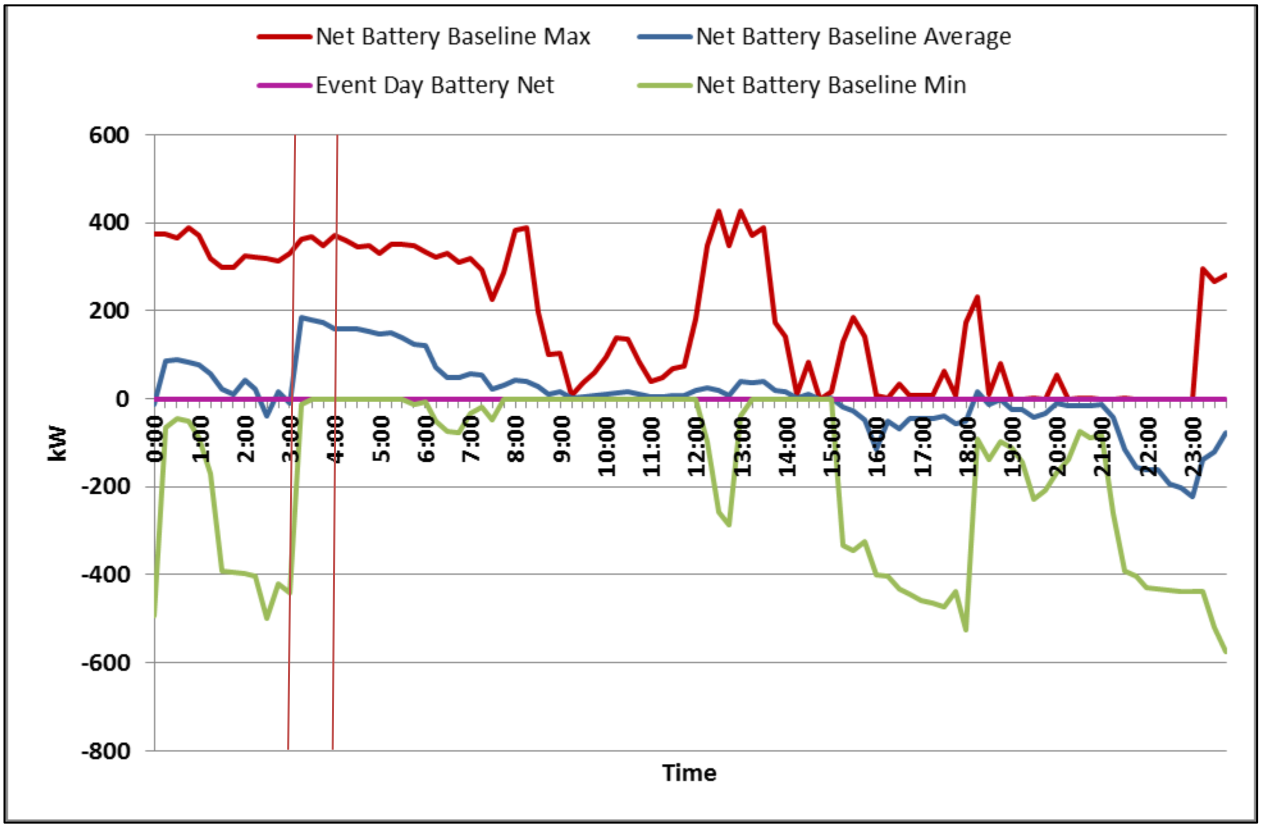


Figure 139. June 8 3:00-4:00 Customer 2 Start Charging – Battery ALCS Net Meter Data

Figure 140 supports the conclusions reached in Figure 139.

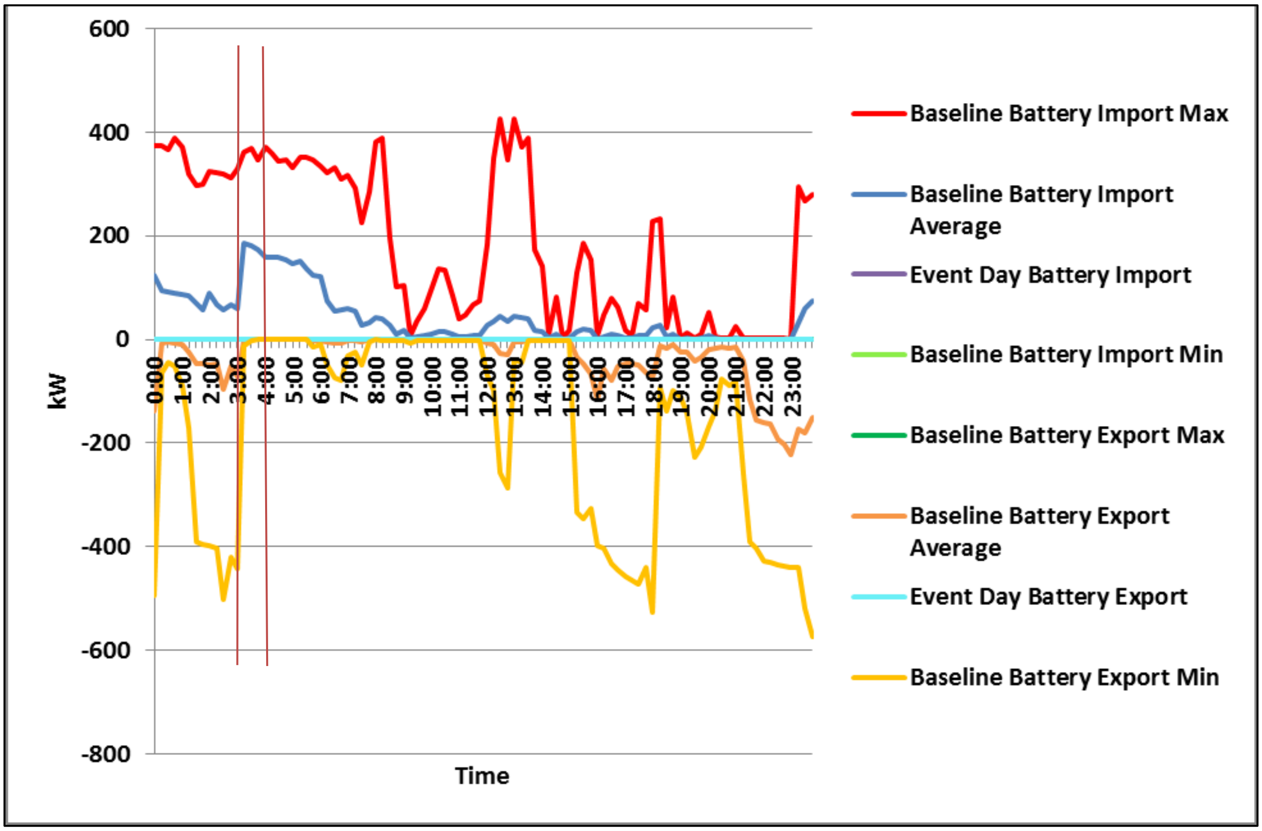


FIGURE 140. JUNE 8 3:00-4:00 CUSTOMER 2 START CHARGING – BATTERY ALCS NET METER DATA

c) PQ MEASUREMENTS

Figure 141 contrasts with the Battery ALCS graphs shown in Figure 139 and Figure 140. The Battery ALCS meter indicates that the battery was offline for the event day with a flat event day battery net line in Figure 139 and a flat event day battery import and export lines in Figure 140. The PO meter data shown in Figure 141 indicates that the battery was following the normal charging pattern from 23:00 on June 7 – 04:00 on June 8. This indicates that the battery was already charging and therefore there was no net change in battery import or export upon receipt of the "Start Charging" dispatch signal.

The SCE data shown in Figure 137 and Figure 138 indicates higher net facility load from midnight through 03:45 on June 8 which aligns with the charging profile shown from 23:00 on June 7 – 04:00 on June 8 in Figure 141.

As with prior events, the lower chart in Figure 141 shows that the VThd was within the normal range (< 5%) prior to, during, and after the test event period.

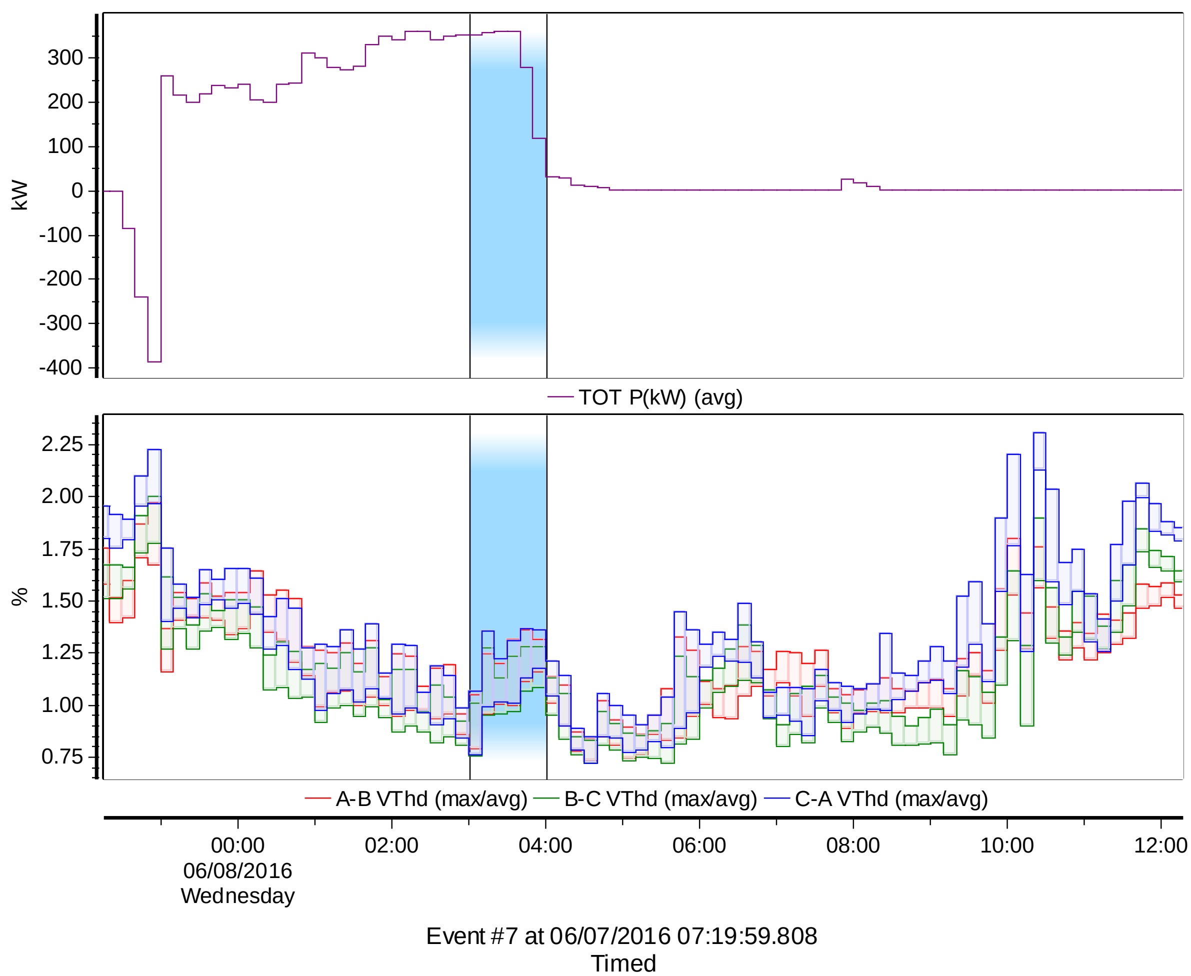


FIGURE 141. JUNE 8 3:00-4:00 CUSTOMER 2 START CHARGING–PQ METER DATA

CUSTOMER 2 POWER QUALITY EVALUATION

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.

a) Customer 2 Power Quality Evaluation Trend Data

Over three months of data was collected at the Customer 2 battery storage system. The monitor was connected directly at the 480V main input to the battery energy storage system. Three distinct cycles of charging (positive power) and discharging (negative power) were observed over the days of June 7-10, 2016.

The basic quantities of voltage, current, power, and reactive power are trended in Figure 142. Positive power (kW) indicates that the battery system is charging and negative power indicates that the system is discharging. In general, the system will charge in the early morning hours (midnight to 4am) and it will discharge in the late afternoon (3-6 pm).

Figure 143 is a trend of the voltage, power, and perceptible voltage flicker. The Pst is a 10-minute measure of the steadiness of the system voltage, where the IEEE Standard 1453 recommends that the system maintain variations less than Pst < 1.0 as is the case at the connection of the Customer 2 battery system.

Figure 144 compares the power and the harmonic voltage distortion. The trends show that the voltage distortion is within a good range, easily meeting the IEEE Standard 519 recommended limit of 5%.

Figure 145 shows characteristic lower order harmonic voltages (3^{rd}, 5^{th}, and 7^{th}). The trends do not reflect the cycling of the battery energy storage system, rather they are influenced by the background (other sources) of harmonic levels on the grid.

Figure 146 shows higher order harmonic voltages (23^{rd}, 25^{th}, and 35^{th}) that is typical of energy storage inverters. It is seen in the trend that these harmonics are slight and are not affected by the operation of the battery energy storage system.

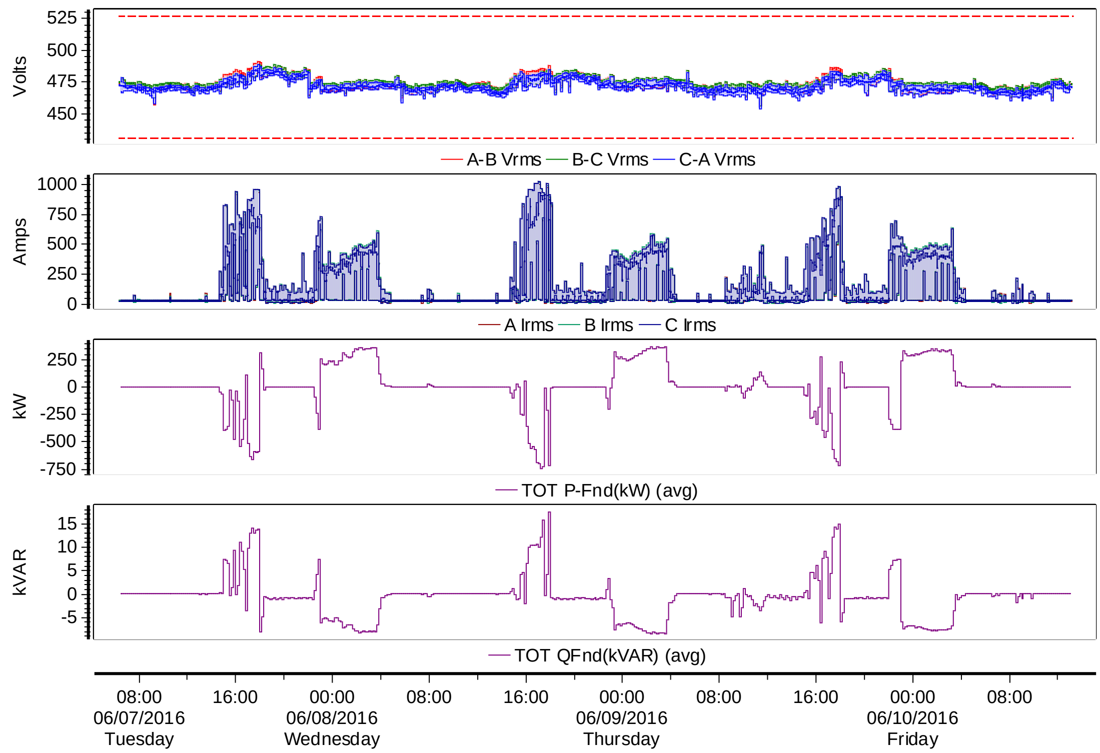


FIGURE 142. VOLTAGE (VRMS), CURRENT (IRMS), POWER (KW), AND REACTIVE POWER (KVAR)

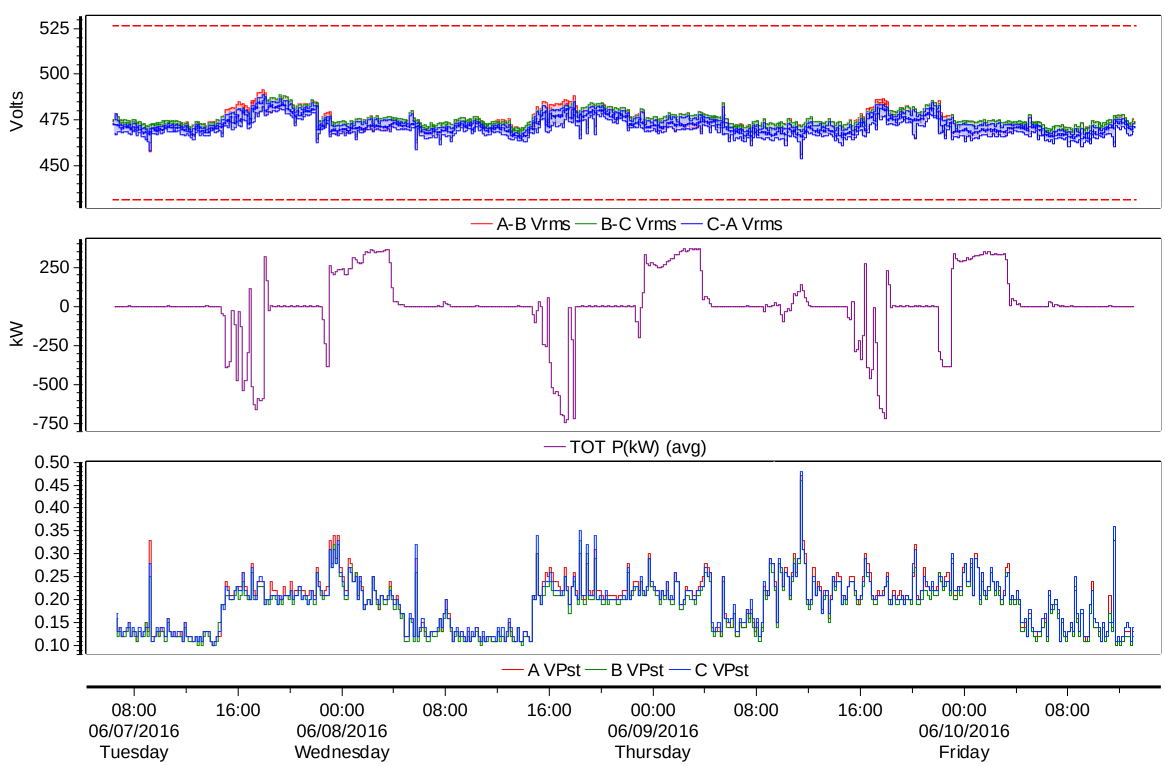


FIGURE 143. VOLTAGE (VRMS), POWER (KW), AND PERCEPTIBLE VOLTAGE FLICKER (PST)

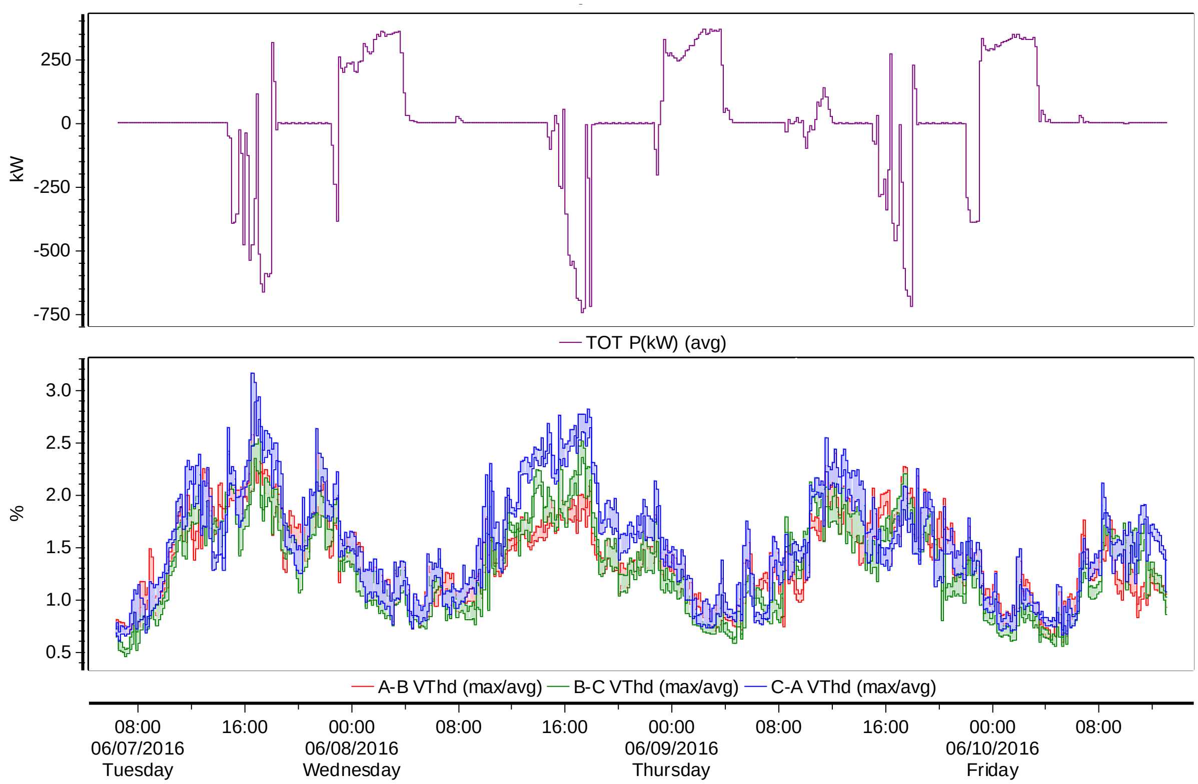


FIGURE 144. POWER (KW) AND HARMONIC DISTORTION (VTHD)

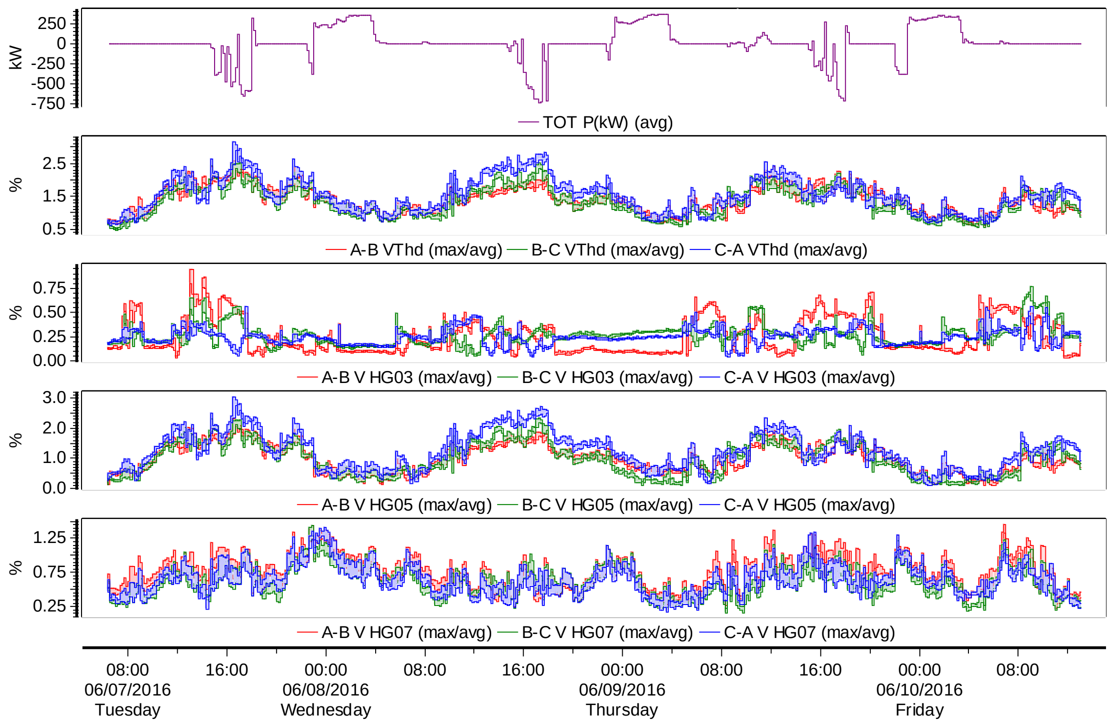


FIGURE 145. POWER (KW), HARMONIC DISTORTION (VTHD), 3RD HARMONIC VOLTS (HG03), 5TH HARMONIC VOLTS (HG05), AND 7TH HARMONIC VOLTS (HG07)

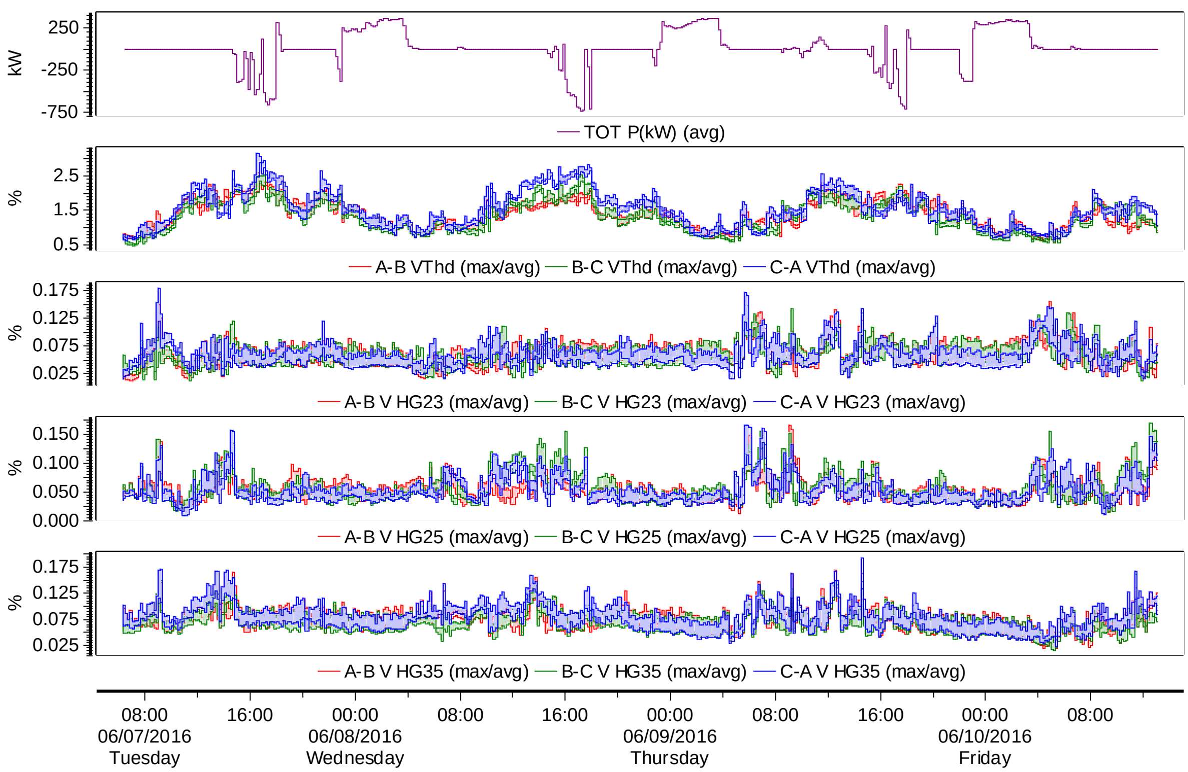


FIGURE 146. POWER (KW), HARMONIC DISTORTION (VTHD), 23RD HARMONIC VOLTS (HG23), 25TH HARMONIC VOLTS (HG25), AND 35TH HARMONIC VOLTS (HG35)

b) Customer 2 Power Quality Analysis of the Waveform Data

The voltage waveform shown in Figure 147 with the battery system off is clear of inverter switching noise. The current waveform mainly shows instrumentation noise, with some small trickle of single-phase current (Phase A-B) to the control circuitry of the battery system. The harmonic spectrum (Figure 148) of the voltage has its highest component of 5^{th} harmonic voltage, which is a common power grid characteristic.

The voltage waveform in Figure 149 is with the battery charging, and there is a slight influence of higher frequency (2 kHz) noise. The phasor diagram shows the current in phase with the voltage, representing the power being absorbed by the system. The harmonic spectrums in Figure 150 show slight amounts of harmonics, and the 7^{th} harmonic voltage component is the highest but is still well within the IEEE Standard 519 recommended limit of 5%.

Figure 151 is the voltage and current waveform with the battery discharging, where there is a noticeable, but acceptable amount of higher frequency (2 kHz) noise. The phasor diagram shows that the current is 180^{o} out of phase with the voltage, indicating negative power, as the battery is discharging back to the grid. The harmonic spectrums in Figure 152 also show acceptable levels of harmonic components.

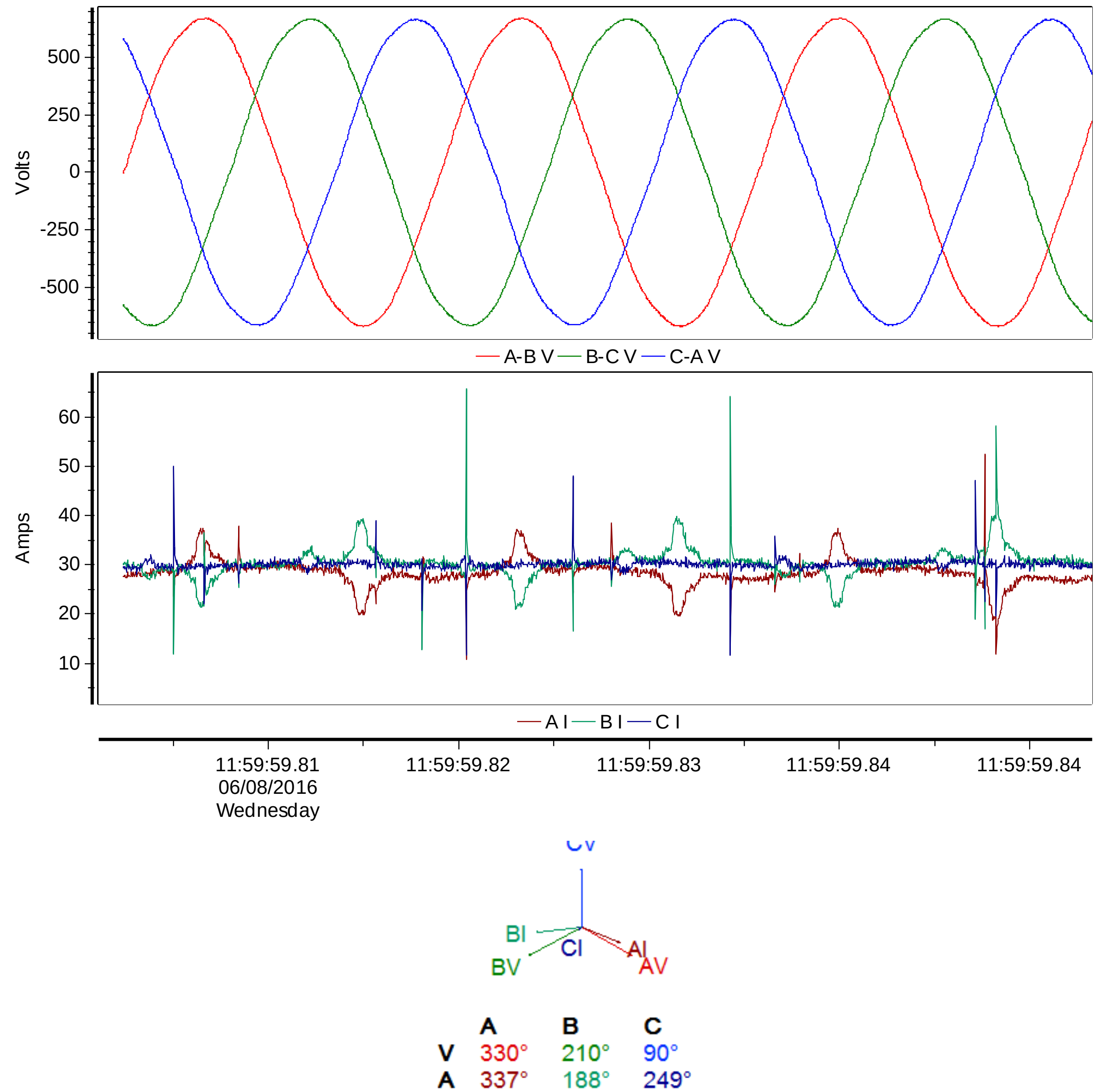
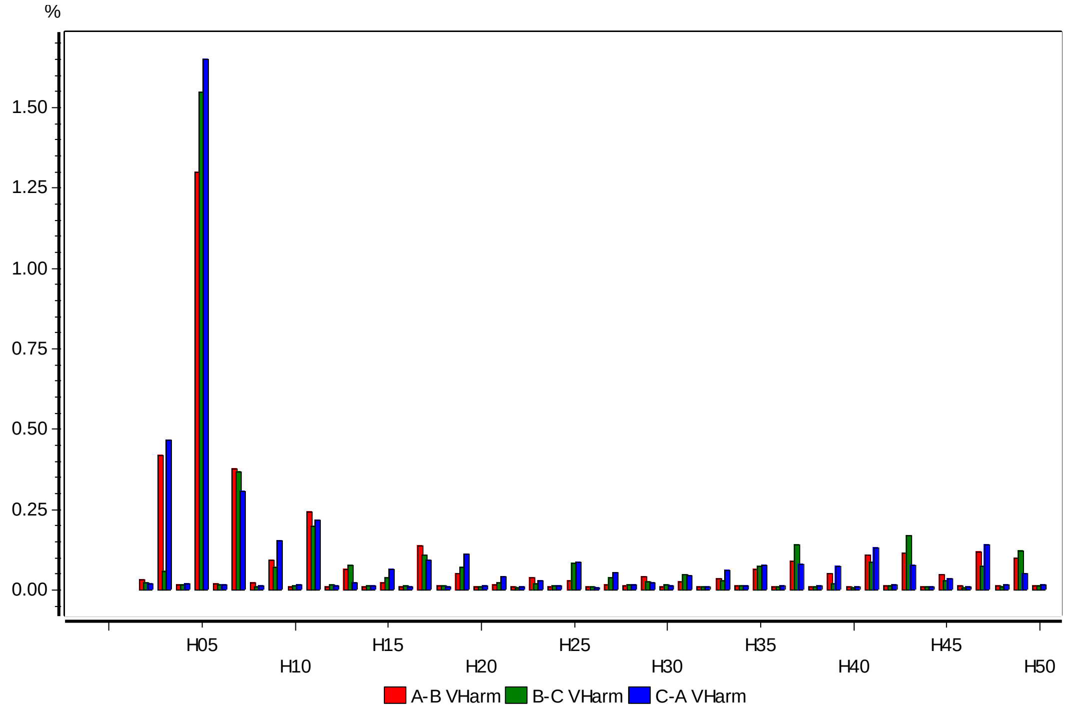


FIGURE 147. VOLTAGE AND CURRENT WAVEFORMS WITH PHASOR DIAGRAM (BATTERY OFF)



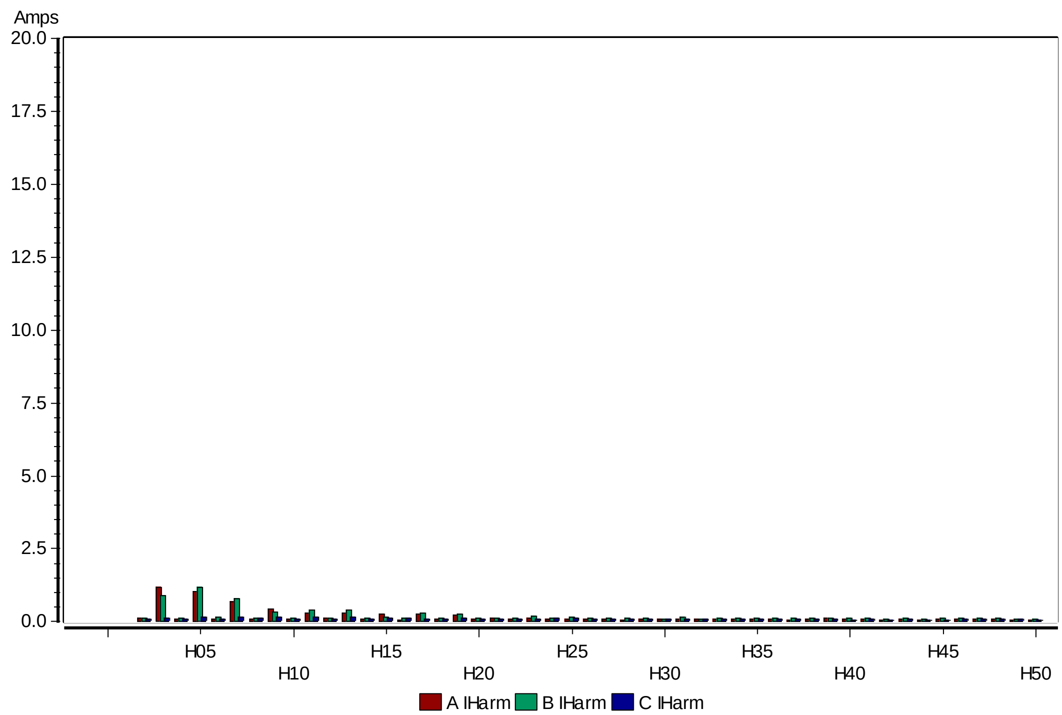


FIGURE 148. HARMONIC SPECTRAL ANALYSIS (BATTERY OFF)

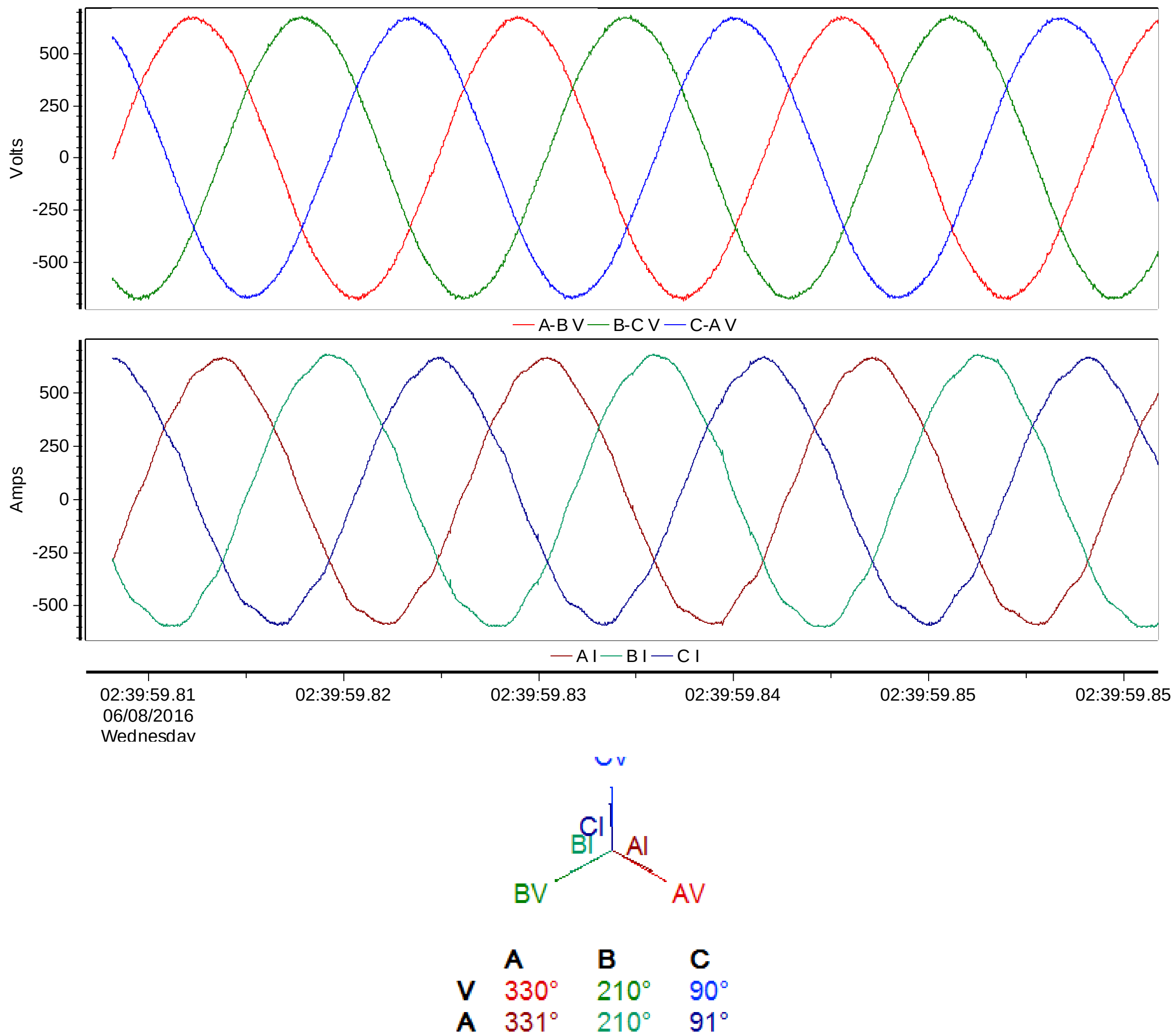


FIGURE 149. VOLTAGE AND CURRENT WAVEFORMS WITH PHASOR DIAGRAM (BATTERY CHARGING)

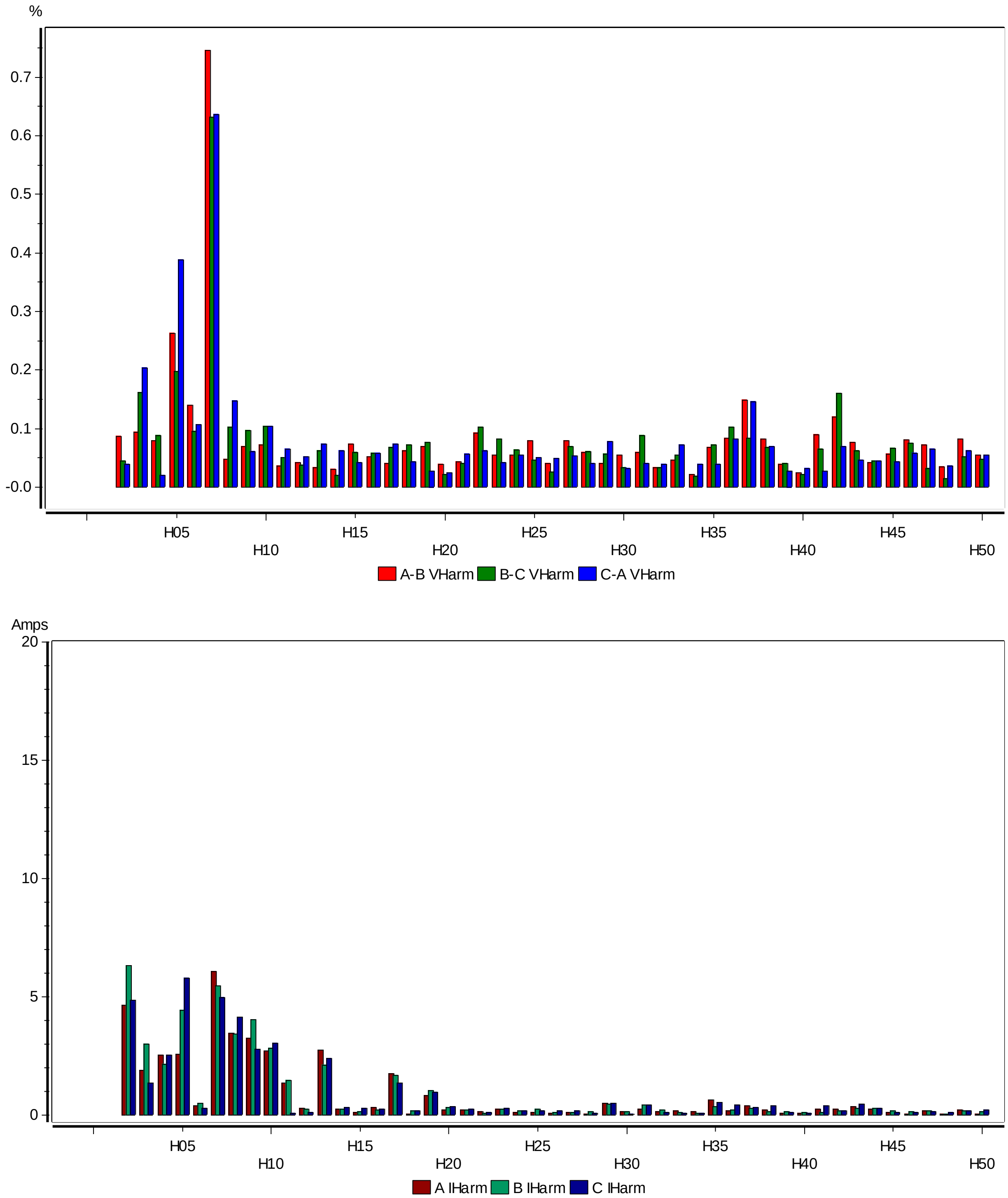


FIGURE 150. HARMONIC SPECTRAL ANALYSIS (BATTERY CHARGING)

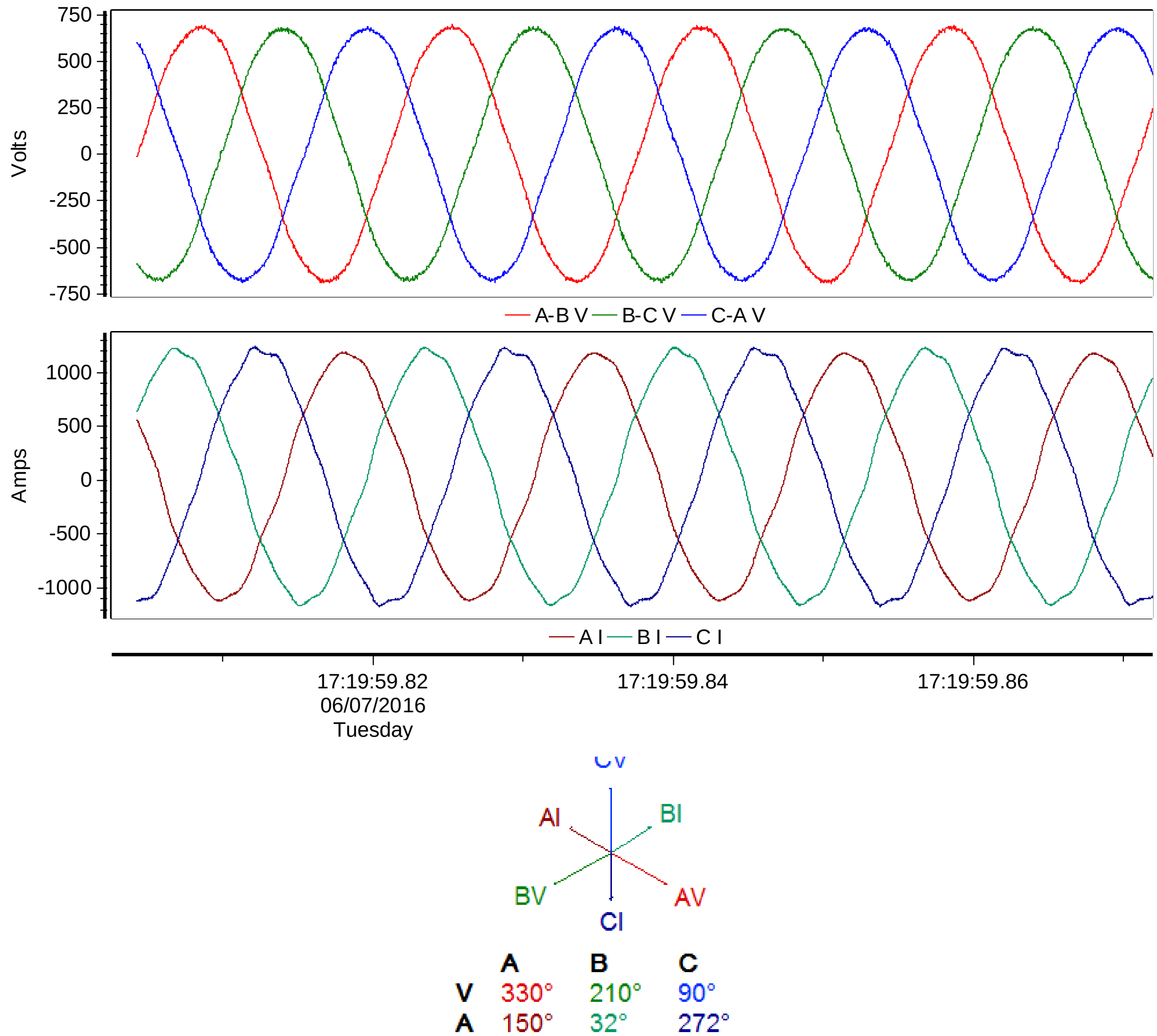


FIGURE 151. VOLTAGE AND CURRENT WAVFORMS WITH PHASOR DIAGRAM (FULL DISCHARGE)

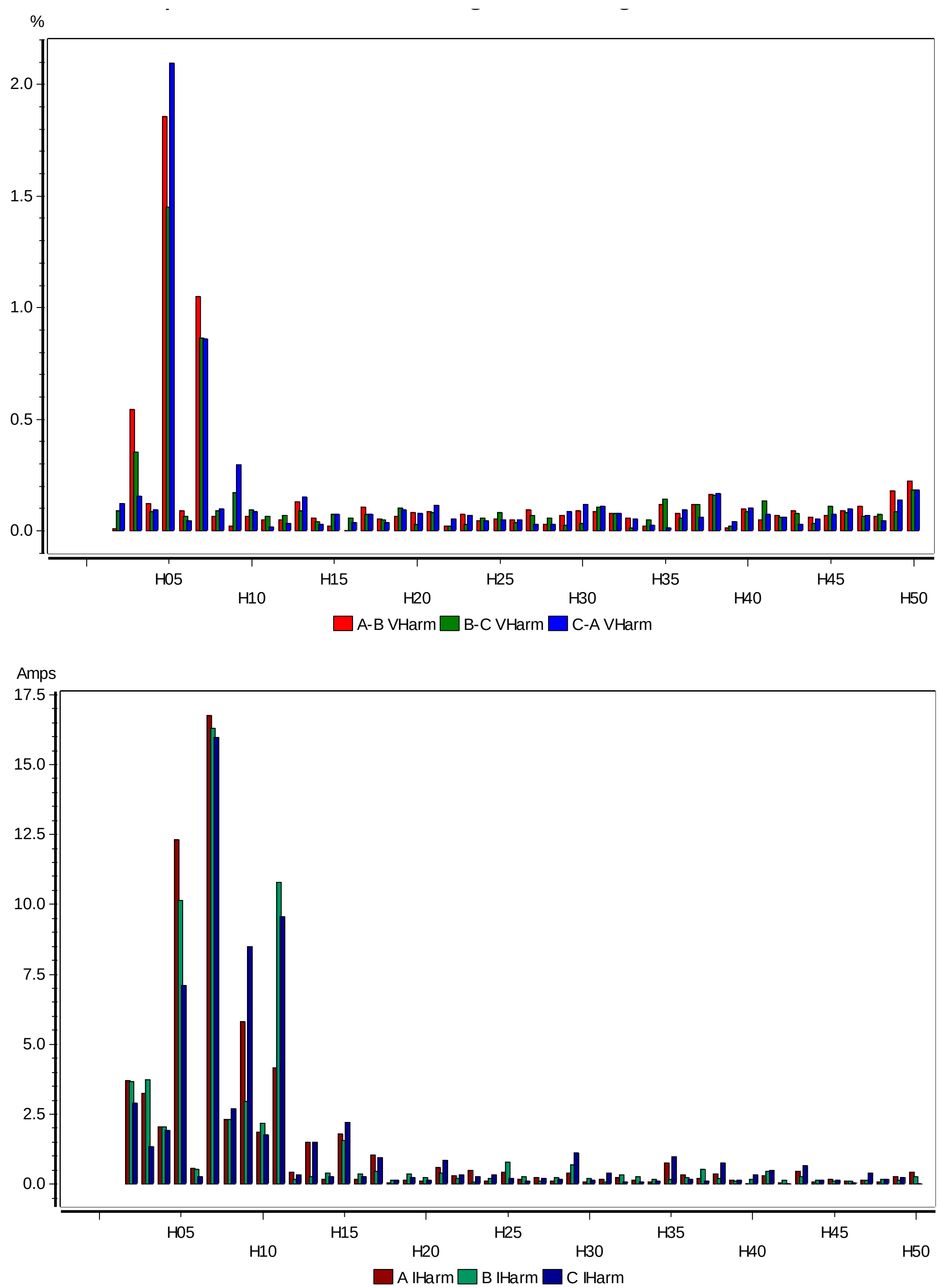


FIGURE 152. HARMONIC SPECTRAL ANALYSIS (FULL DISCHARGE)

Customer 3 Demand Response Observations and Power Quality 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.

Test Event 1: Tuesday April 5, 22:00-23:00 PDT – Turn Off Charging

The test site was offline for maintenance on April 5, therefore, there are no results for this test event.

Test Event 2: Tuesday April 12, 14:00-15:00 PDT – Discharge

a) SCE Meter Baseline Analysis

In Figure 153, the event day energy usage prior to the event roughly follows the average baseline curve until approximately 90 minutes prior to the test event when usage jumps to the maximum baseline usage. For the one hour "Discharge" event, usage is expected to decrease. Usage significantly decreases over the first 15-minute interval and then reaches 0 for the next few intervals, before returning to usage levels higher than the maximum baseline following the test event. This shows the batteries discharging in response to the event and actually assumed the load for the entire meter.

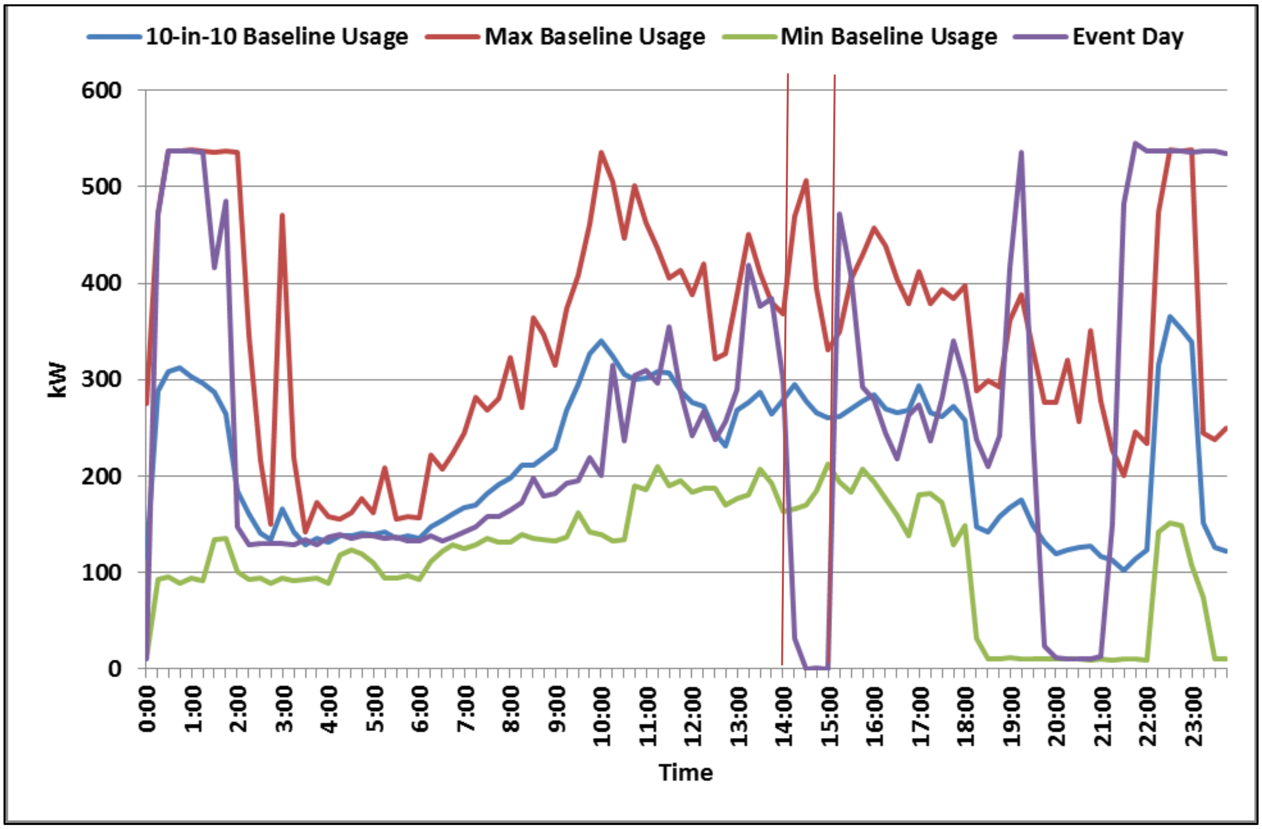


Figure 153. April 12 14:00-15:00 Customer 3 Discharge – SCE Meter Data

Usage immediately prior to the event was higher than the 10-in-10 average baseline usage and was approaching the maximum baseline usage shown in Figure 180. Both the *10-in-10 Baseline Usage* and the ±*20% from baseline* curves in Figure 154 show the expected electricity usage at the facility during the test event period given the starting point to be significantly higher than what was observed, which indicates a response. The LA 10-in-10 curve appears to be heavily influenced by the spike in usage immediately following the event. At other sites, such as May 13 at Customer 2 (Figure 119), the spike following the event has been the result of the battery recharging following the event.

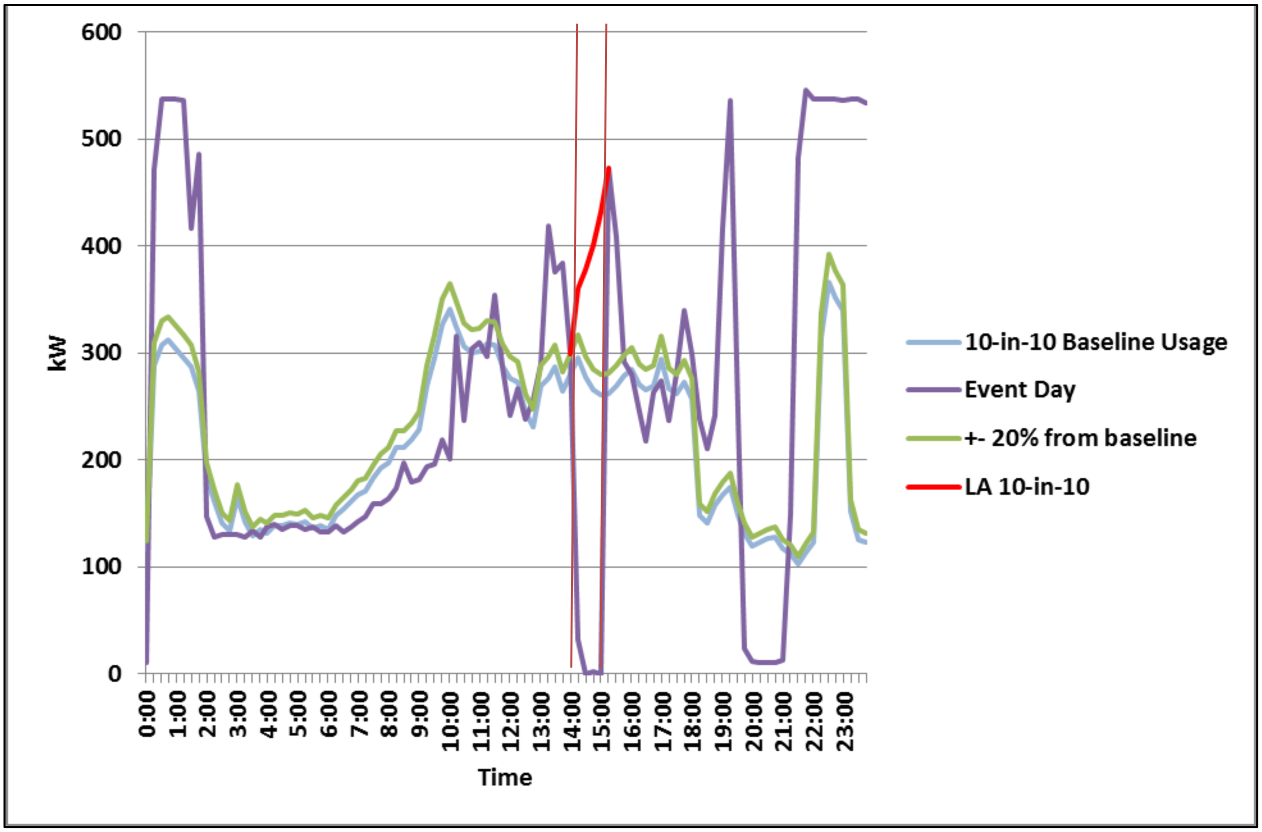


FIGURE 154. APRIL 12 14:00-15:00 CUSTOMER 3 DISCHARGE – DR BASELINE ESTIMATES

Error! Reference source not found. shows the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 30. APRIL 12 14:00-15:00 CUSTOMER 3 DISCHARGE – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
13:45-14:00	299.52	-	-	-
14:00-14:15	31.68	(263.81)	(284.97)	(328.26)
14:15-14:30	-	(277.20)	(297.05)	(378.28)
14:30-14:45	1.44	(263.81)	(282.80)	(399.39)
14:45-15:00	-	(260.64)	(279.31)	(432.05)
15:00-15:15	472.32	-	-	-
Average kW	**8.28**	**(266.36)**	**(286.03)**	**(384.50)**
Average kWh	**8.28**	**(266.36)**	**(286.03)**	**(384.50)**
CBP Bid (kW)		(100)		
CBP Event Performance		**266%**		

b) BATTERY ALCS BASELINE ANALYSIS

Figure 155 shows event day discharge during the 14:00-15:00 hour is significantly greater than what was observed in the baseline period. This indicates a response to the "Discharge" signal. Just as with the May 13 Customer 2 event, the battery entered charge mode in the 15 minute period following the conclusion of the event.

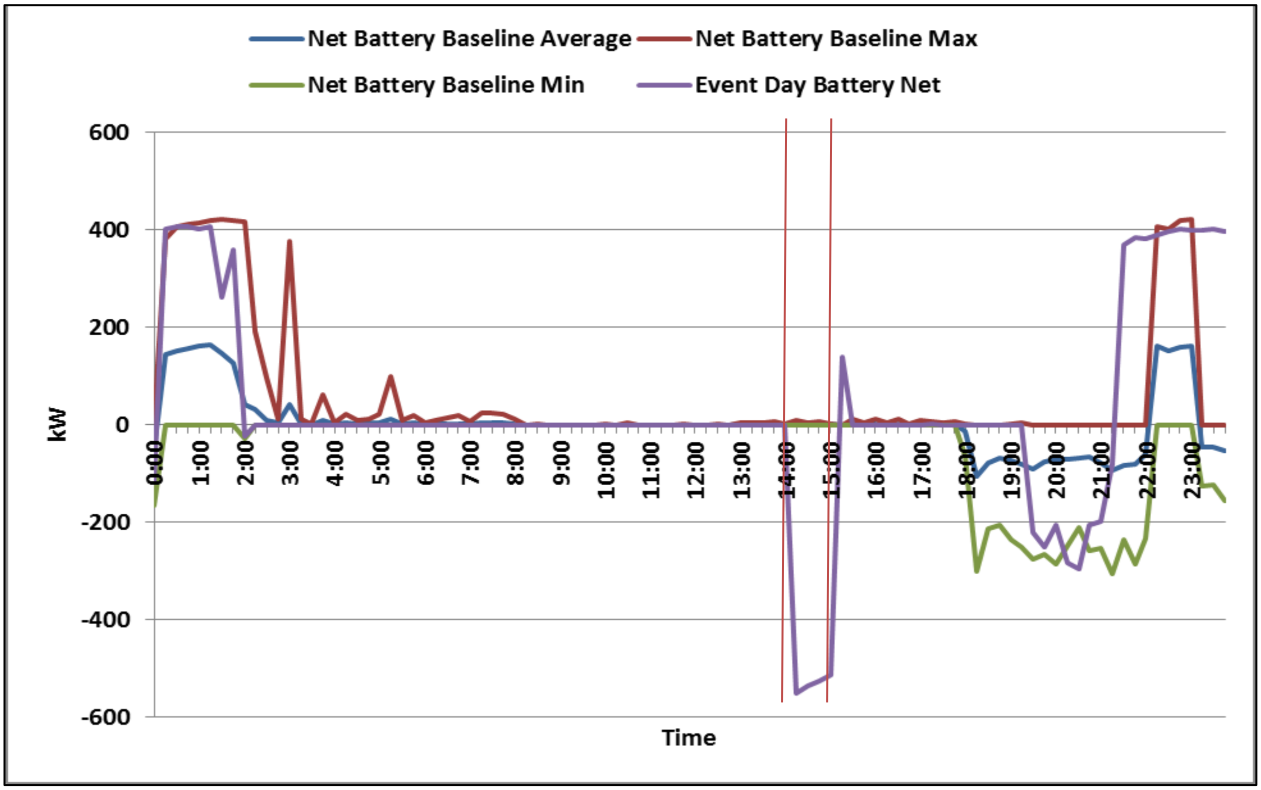


FIGURE 155. APRIL 12 14:00-15:00 CUSTOMER 3 DISCHARGE – BATTERY ALCS NET METER DATA

Figure 156 supports the conclusion of net meter data graph.

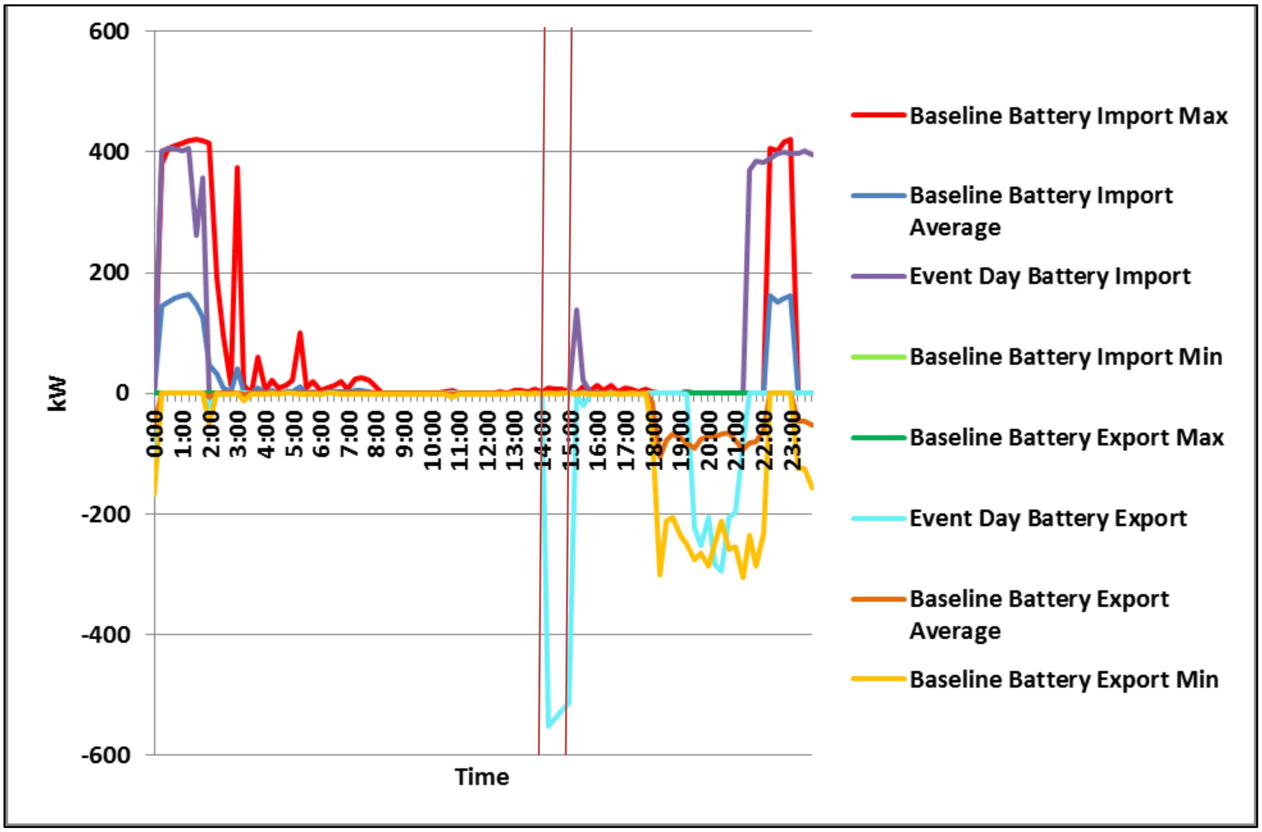


FIGURE 156. APRIL 12 14:00-15:00 CUSTOMER 3 DISCHARGE – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ Measurements

The upper chart in Figure 157 aligns with both the Battery ALCS data shown in Figure 155 and Figure 156 as well as the SCE meter data shown in Figure 153 and Figure 154. The lower chart in Figure 157 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during and after the test event period.

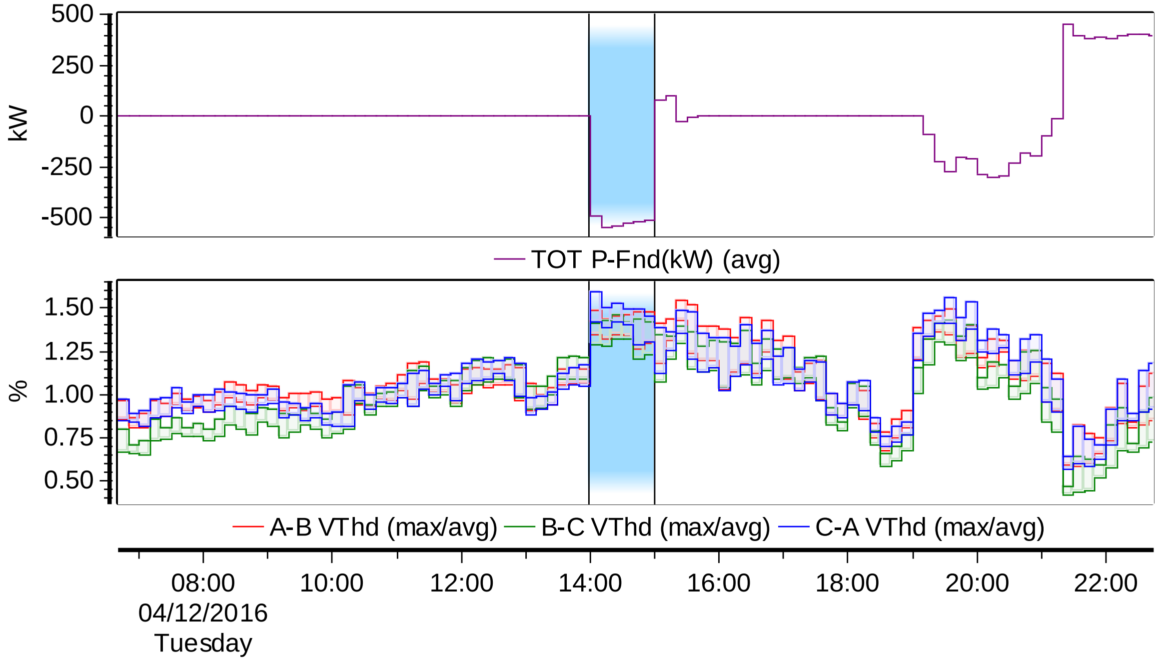


Figure 157. April 12 14:00-15:00 Customer 3 Discharge – PQ Meter Data

Test Event 3: Tuesday April 19, 22:00-23:00 PDT – Turn Off Charging

a) SCE Meter Baseline Analysis

The usage on the test event day varies between the 10-in-10 baseline and the maximum baseline usage as shown in Figure 158. There is a usage drop during the first 30 minutes of the test event followed by a usage increase for the final 30 minutes of the test event. That decrease across the first 30 minutes compared with the typical usage profile is a solid indication that charging was turned off on event day.

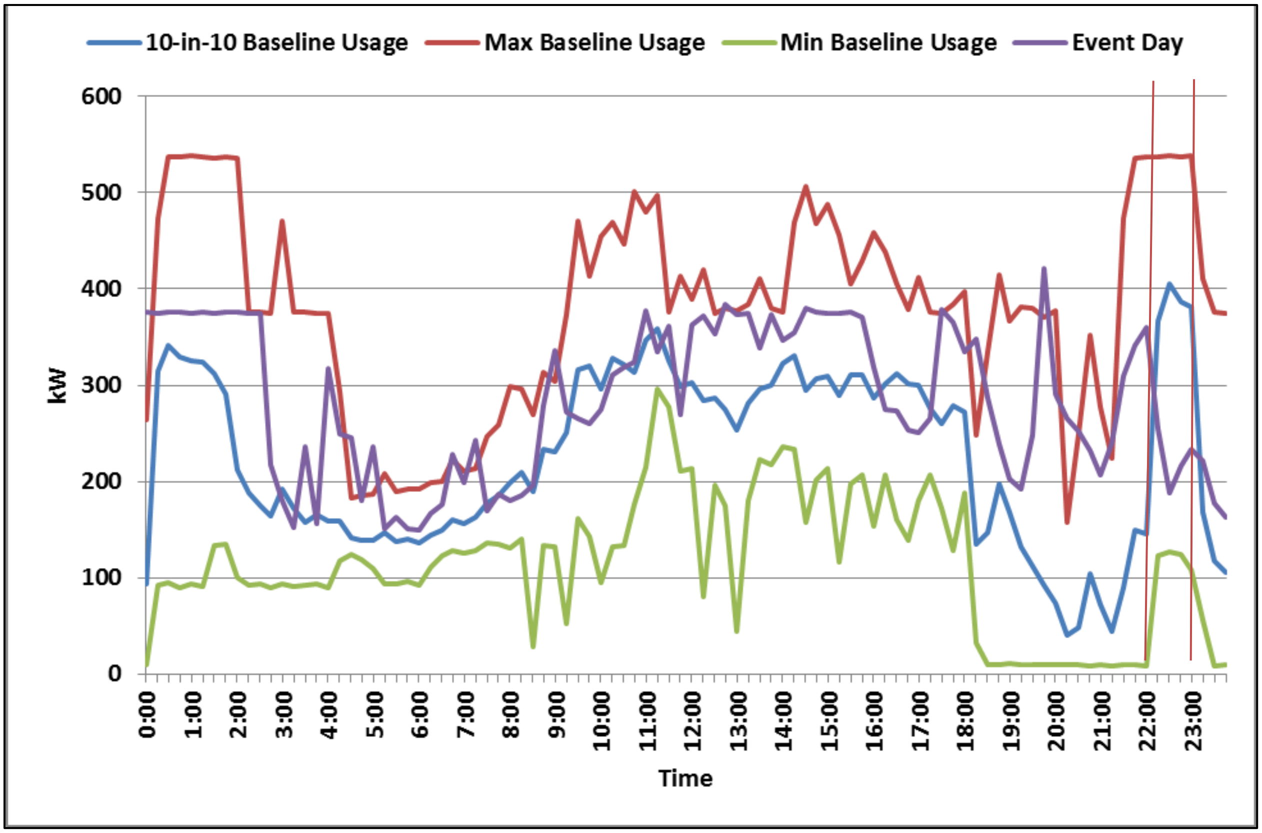


FIGURE 158. APRIL 19 22:00-23:00 CUSTOMER 3 TURN OFF CHARGING – SCE METER DATA

Each of the baselines in Figure 159 agrees that usage should have ramped up from the high start point at 22:00. The LA 10-in-10 curve appears to overestimate that usage increases because of the high usage immediately prior to the event at 22:00.

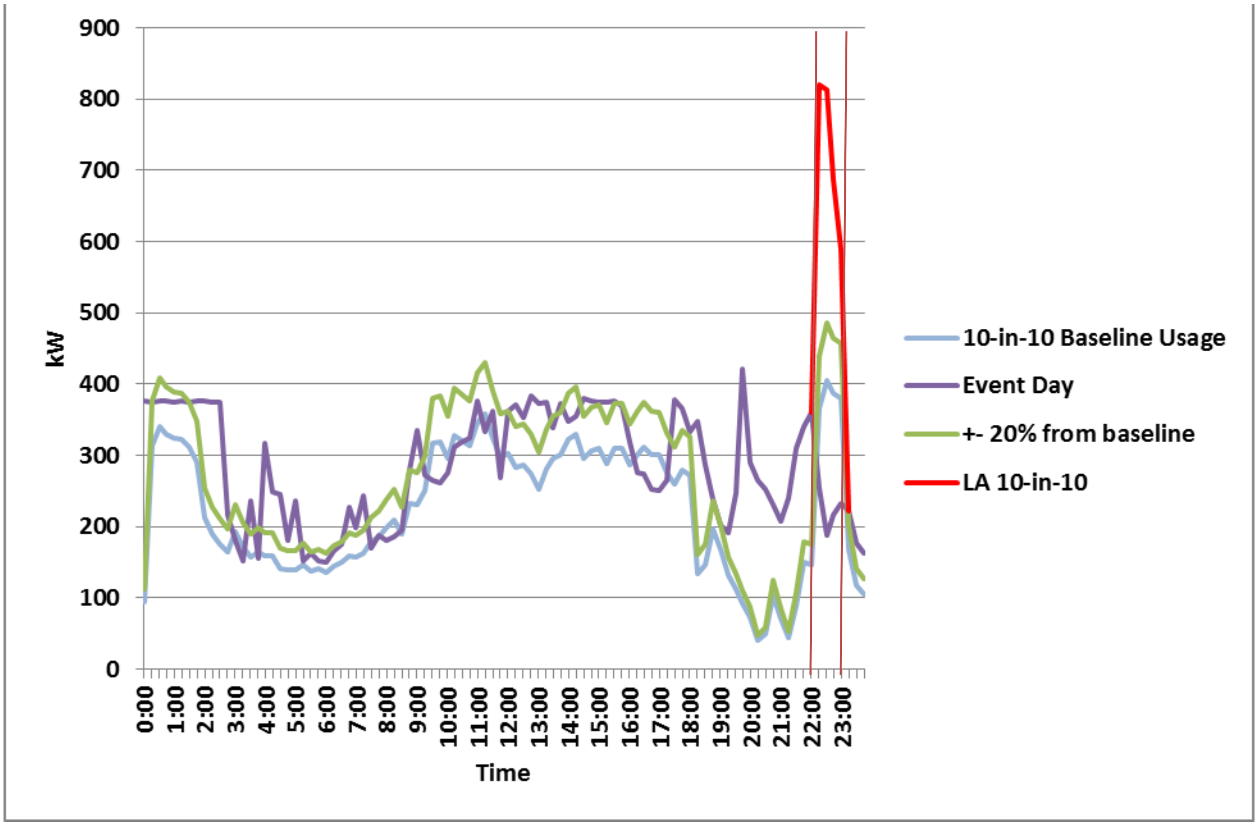


FIGURE 159. APRIL 19 22:00-23:00 CUSTOMER 3 TURN OFF CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 31. APRIL 19 22:00-23:00 CUSTOMER 3 TURN OFF CHARGING – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
21:45-22:00	360.00	-	-	-
22:00-22:15	254.88	(111.74)	(185.07)	(566.02)
22:15-22:30	188.64	(216.58)	(297.62)	(624.96)
22:30-22:45	221.76	52.99	19.24	-
22:45-23:00	233.28	(147.60)	(223.78)	(355.28)
23:00-23:15	221.76	-	-	-
Time Period	**224.64**	**(105.73)**	**(171.81)**	**(386.56)**
21:45-22:00	**224.64**	**(105.73)**	**(171.81)**	**(386.56)**
CBP Bid (kW)		(100)		
CBP Event Performance		**106%**		

b) Battery ALCS Baseline Analysis

While the SCE meter data indicates a small decrease in demand in Figure 158, the battery ALCS data displayed in Figure 160 indicates that the system may be offline with no change in net or import/export after 16:00. While the SCE meter data appears to indicate that the battery responded to the "Turn Off Charging" signal, that may not have been the case because the battery also did not display normal behavior in the hours leading up to the event. However, the decrease in demand during the event period may still be attributable to the lack of charging during the period.

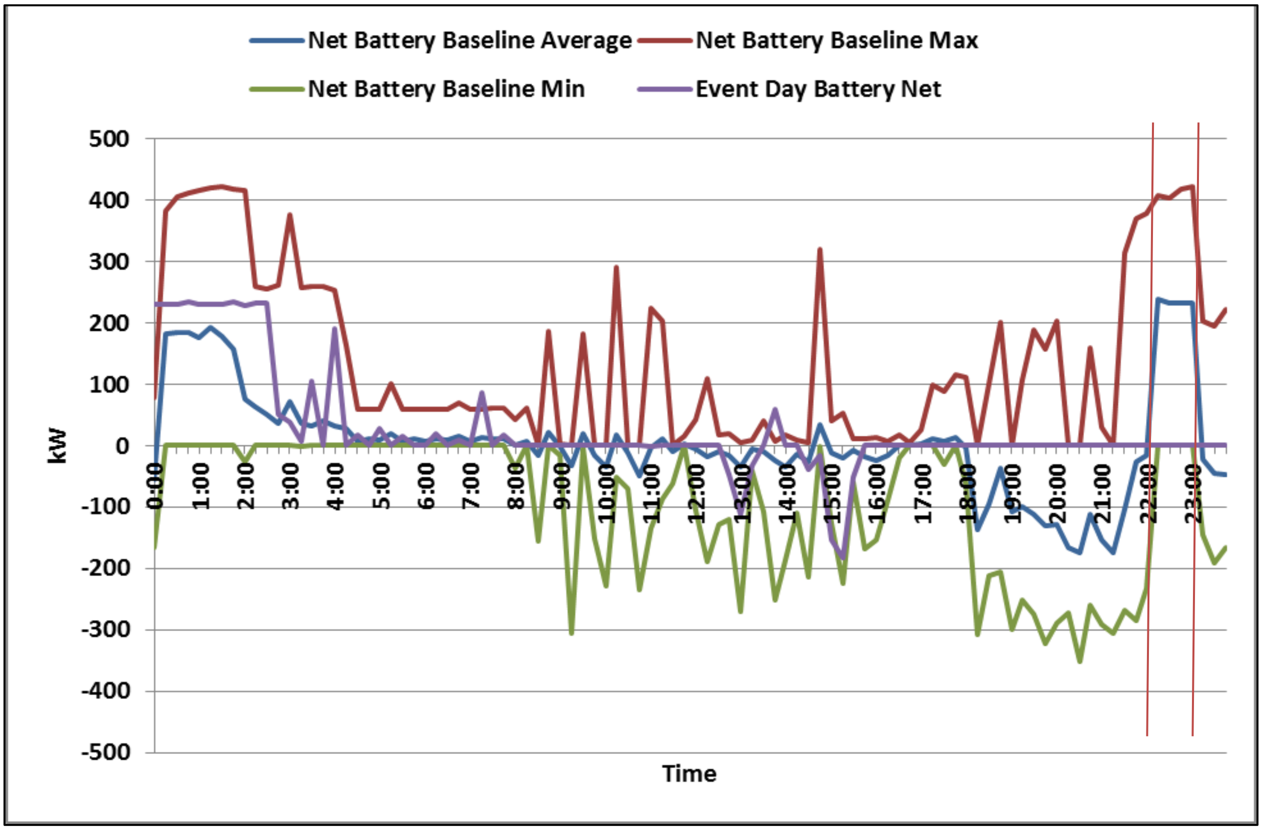


FIGURE 160. APRIL 19 22:00-23:00 CUSTOMER 3 TURN OFF CHARGING – BATTERY ALCS NET METER DATA

The Import Export chart in Figure 161 supports the event day observations outlined in Figure 160.

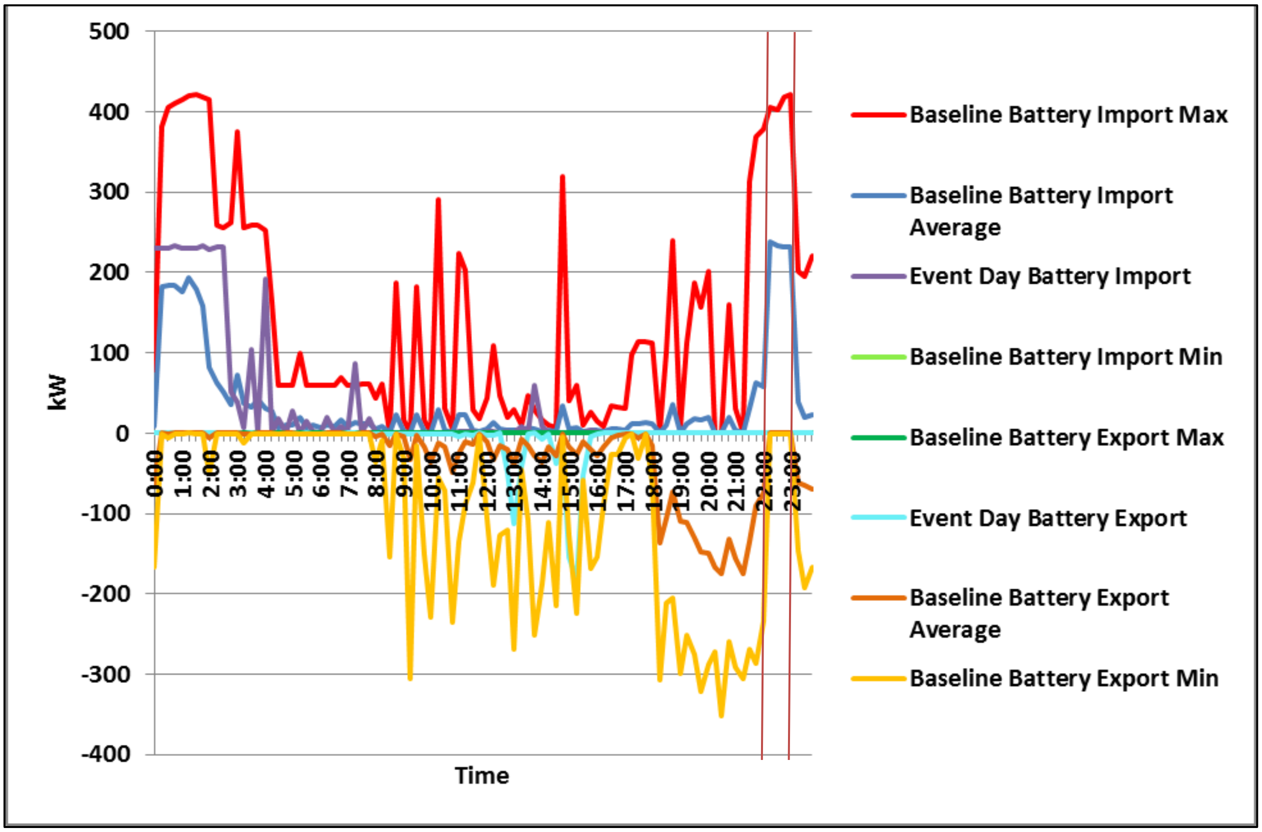


FIGURE 161. APRIL 19 22:00-23:00 CUSTOMER 3 TURN OFF CHARGING – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ Measurements

No data was collected at Customer 3 from April 16-April 21. The instrument was reset and data collection continued.

Test Event 4: Friday April 22 14:00-15:00 PDT - Discharge

a) SCE METER BASELINE ANALYSIS

Figure 162 shows that usage significantly decreases over the first 15-minute interval and then reaches 0 for the next few intervals, before returning to usage levels higher than the maximum baseline following the event. This appears to show that the batteries discharged in response to the event and again assumed the full facility load. This response is very similar to what was observed during the April 12 "discharge" event.

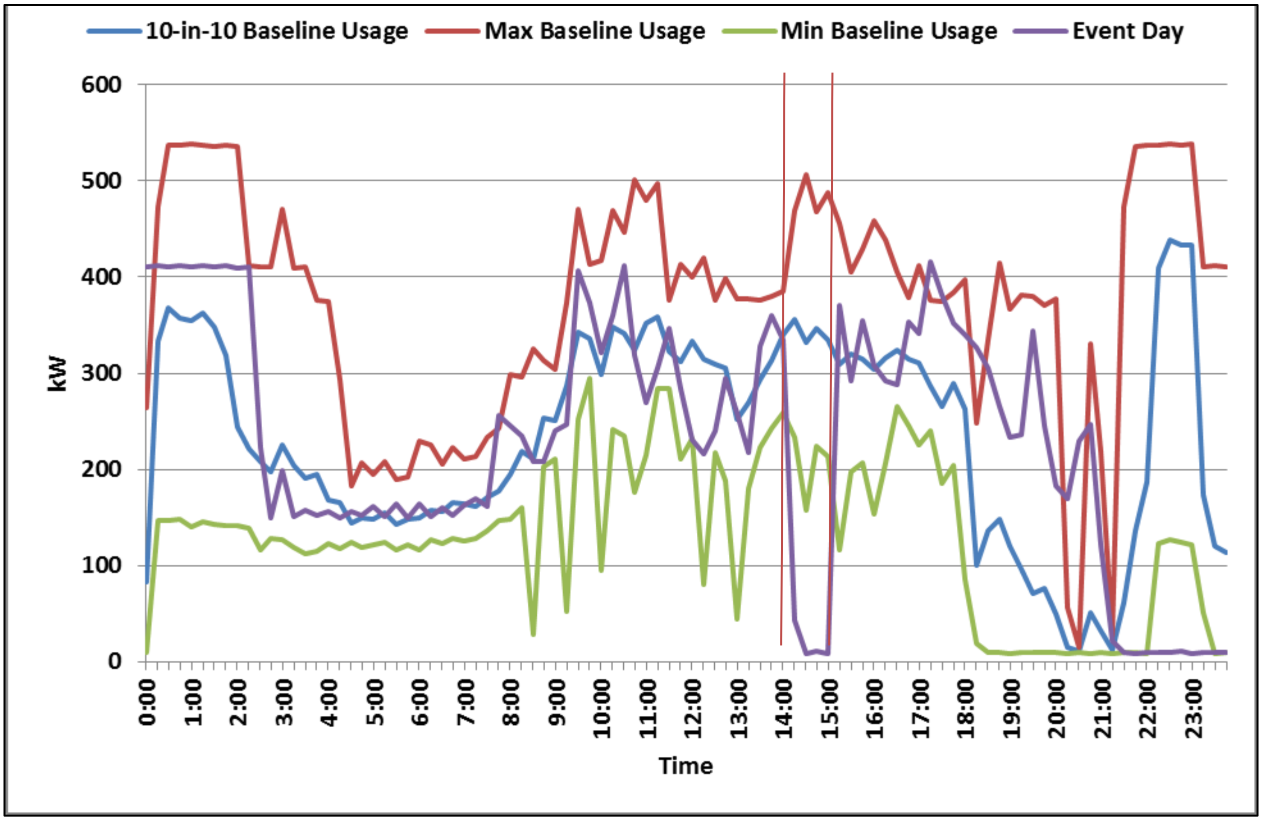


FIGURE 162. APRIL 22 14:00-15:00 CUSTOMER 3 DISCHARGE – SCE METER DATA

The three baselines in Figure 163 show that usage might have remained relatively stable in the absence of a "discharge" event. Similar to other events, it appears that the LA 10-in-10 may be influenced by the battery charging in the 15 minutes immediately following the event, thus forcing this baseline estimation higher. A similar effect occurs with other forms of DR where the load "rebounds" after a DR dispatch – especially when a system like HVAC is turning on to catch up after being shut down for a period of time.

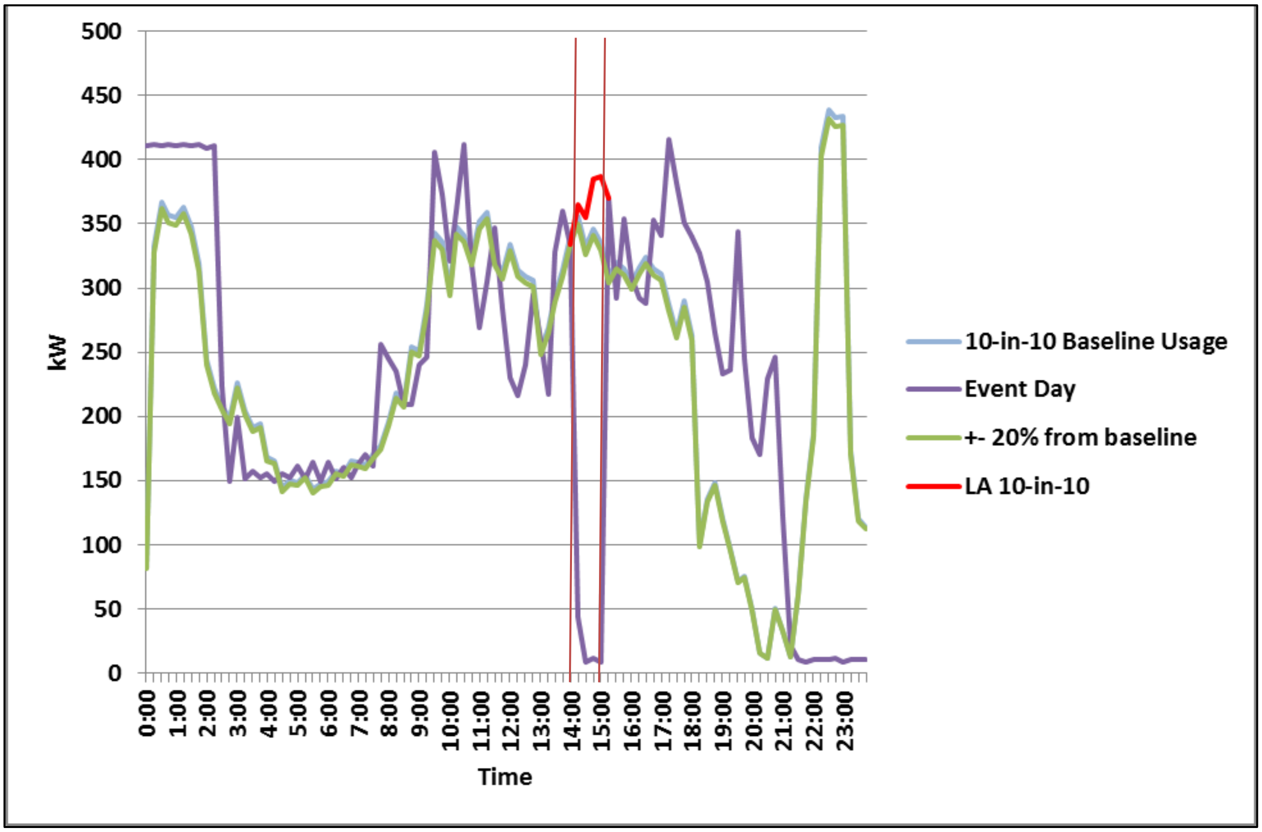


FIGURE 163. APRIL 22 14:00-15:00 CUSTOMER 3 DISCHARGE – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 32. APRIL 22 14:00-15:00 CUSTOMER 3 DISCHARGE– PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
13:45-14:00	334.08	-	-	-
14:00-14:15	43.20	(312.62)	(306.89)	(322.14)
14:15-14:30	8.64	(322.99)	(317.65)	(346.07)
14:30-14:45	11.52	(334.51)	(328.94)	(373.42)
14:45-15:00	8.64	(325.87)	(320.48)	(377.82)
15:00-15:15	370.08	-	-	-
Average kW	**18.00**	**(324.00)**	**(318.49)**	**(354.86)**
Average kWh	**18.00**	**(324.00)**	**(318.49)**	**(354.86)**
CBP Bid (kW)		(100)		
CBP Event Performance		**324%**		

b) Battery ALCS Baseline Analysis

According to the net battery data in Figure 164 below, the battery discharged as it was signaled to do from 14:00-15:00. A slight charge at 15:15 is evident, but that charge is within the bounds of what was observed during the baseline period.

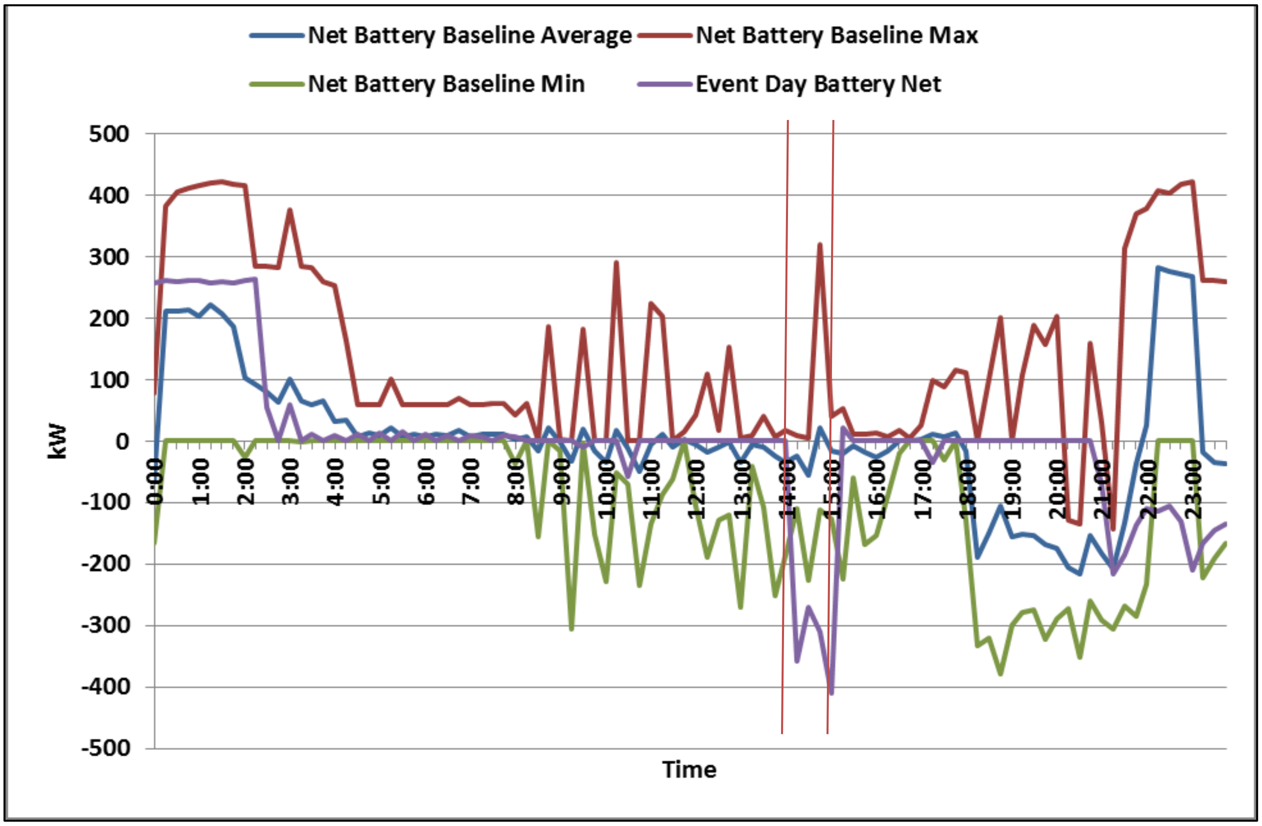


Figure 164. April 22 14:00-15:00 Customer 3 Discharge – Battery ALCS Net Meter Data

The Import Export chart in Figure 165supports the event day observations outlined in Figure 164.

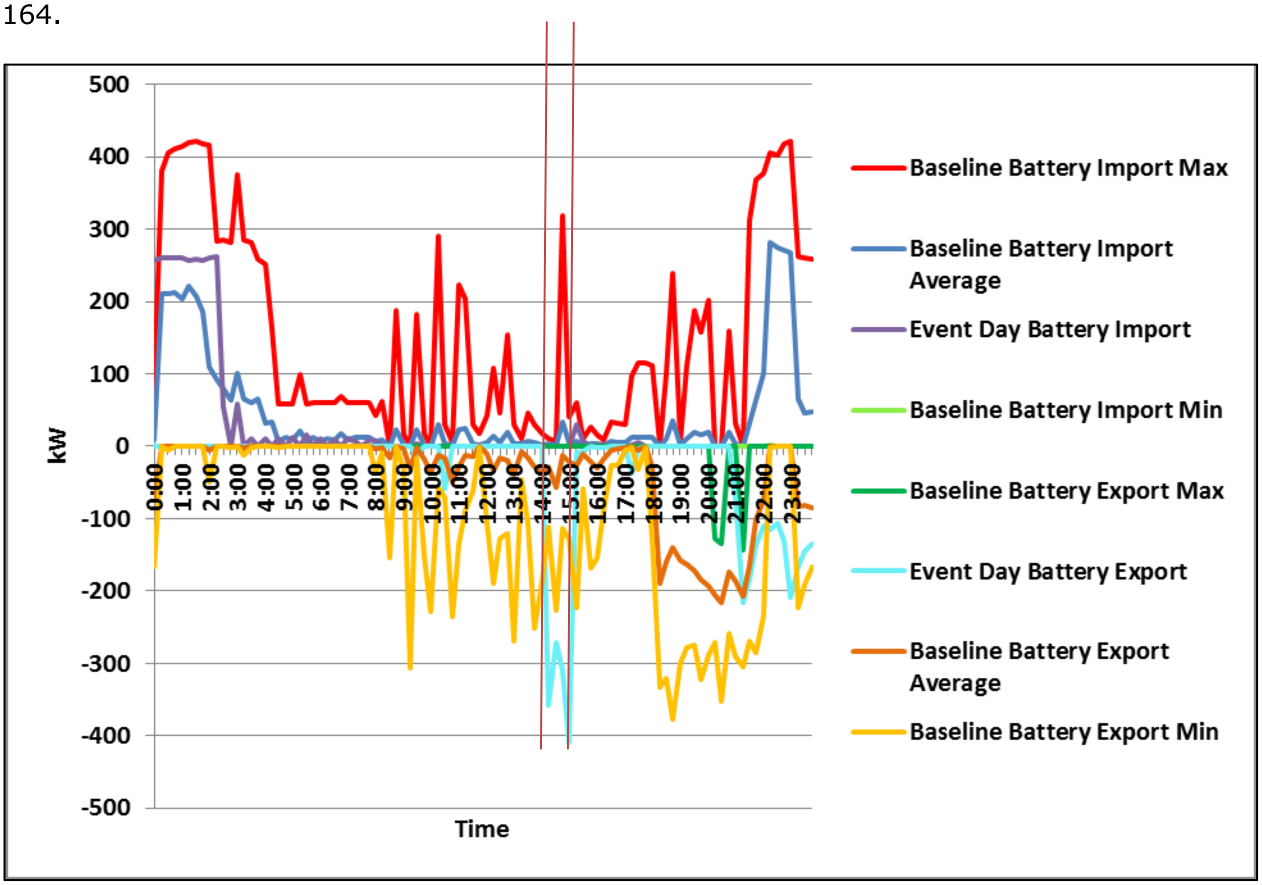


FIGURE 165. APRIL 22 14:00-15:00 CUSTOMER 3 DISCHARGE – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ MEASUREMENTS

The upper chart in Figure 166 aligns with both the Battery ALCS data shown in Figure 164 and Figure 165 as well as the SCE meter data shown in Figure 162 and Figure 163. The lower chart in Figure 166 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during and after the test event period.

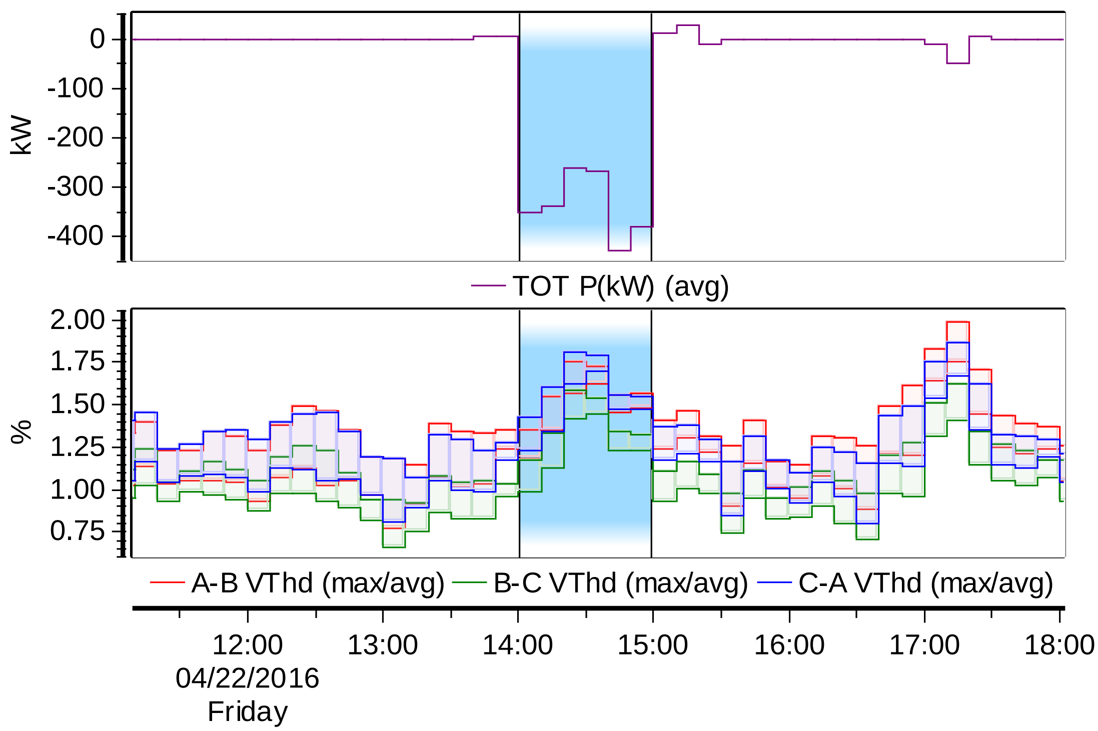


FIGURE 166. APRIL 22 14:00-15:00 CUSTOMER 3 DISCHARGE–PQ METER DATA

TEST EVENT 5: FRIDAY APRIL 29, 22:00-23:00 PDT – TURN OFF CHARGING

a) SCE Meter Baseline Analysis

Figure 167 shows that event day usage varies across the minimum and maximum baselines. All of the baseline usage patterns show plateaued usage patterns across roughly the 22:00-23:00 hour before a sharp decline at 23:15. The event day is much more of a peak, with a rise in usage across a single 15-minute time period. This pattern might display a response to the "Turn Off Charging" signal, but the usage rise at 22:45 likely represents a blip where the battery did charge.

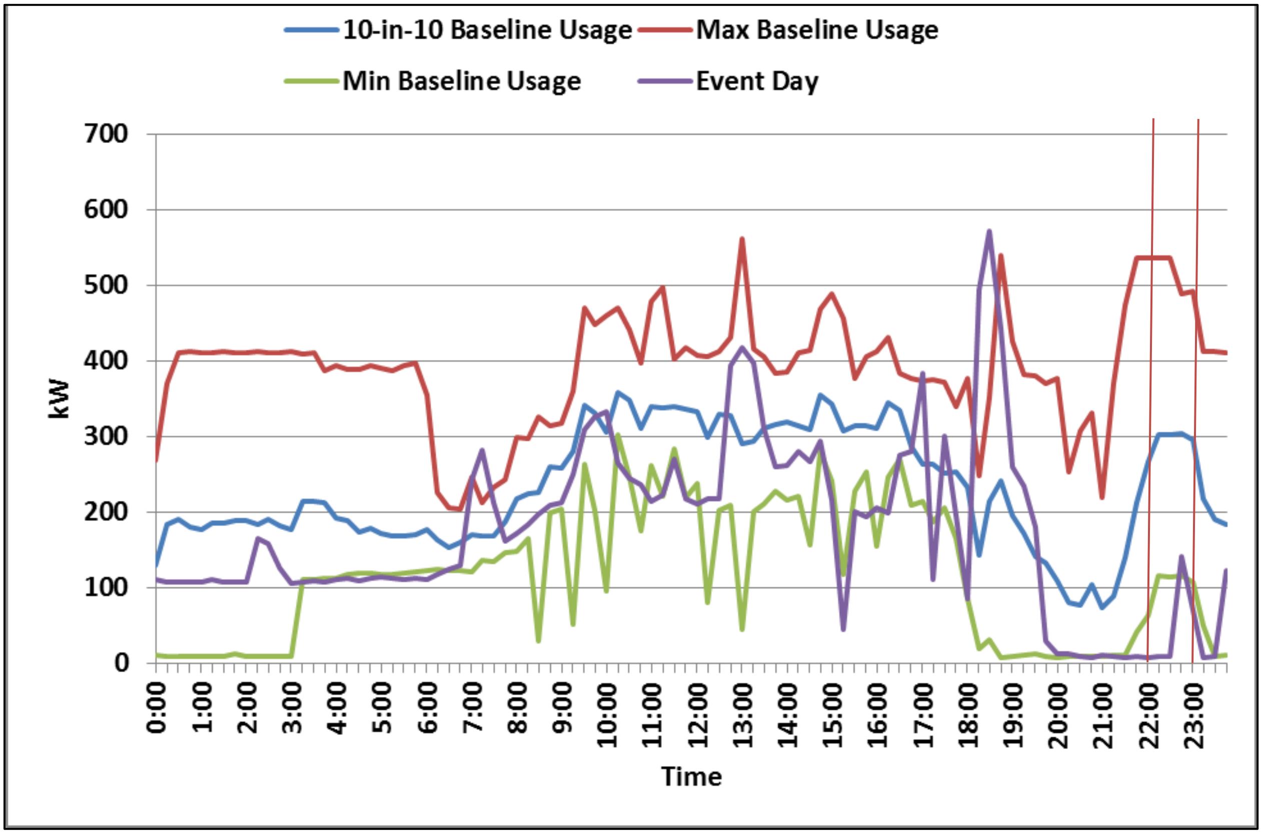


Figure 167. April 29 22:00-23:00 Customer 3 Turn Off Charging– SCE Meter Data

The LA 10-in-10 baseline curve in Figure 168 demonstrates that, on average, usage is fairly flat across the 22:00-23:00 hour. Since usage is zero on event day leading up to 22:00, the impact of the event is not dramatic. The 10-in-10 and ± 20% from baseline curves are both representative of the baseline period usage with the ± 20% reflecting the fact that event day usage was significantly lower than the average 10-in-10 baseline. There is still no insight into what appears to be battery charging at the 22:45 time interval. If this increase in usage is due to battery charging, that is be the opposite of the "Turn Off Charging" signal.

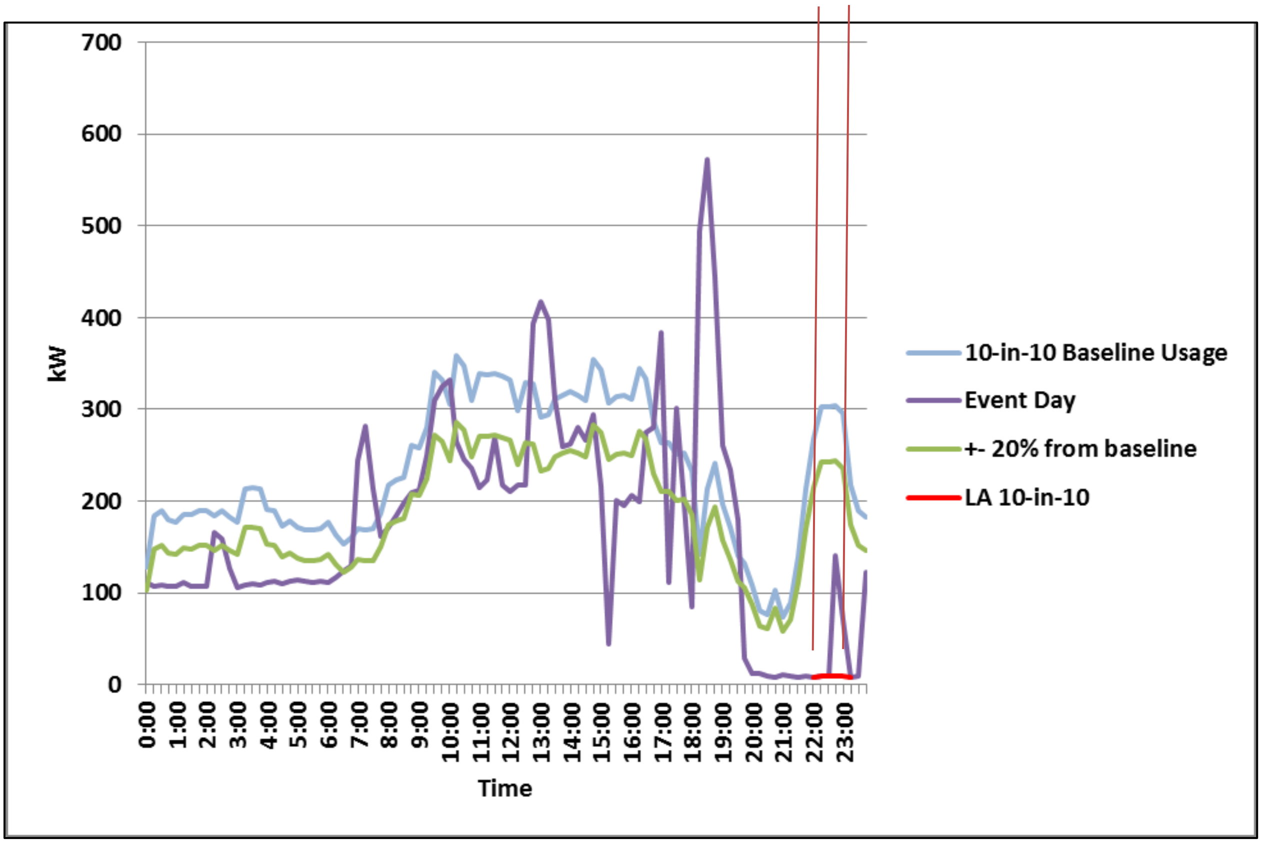


FIGURE 168. APRIL 29 22:00-23:00 CUSTOMER 3 TURN OFF CHARGING- DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 33. APRIL 29 22:00-23:00 CUSTOMER 3 TURN OFF CHARGING – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
21:45-22:00	7.20	-	-	-
22:00-22:15	8.64	(293.76)	(233.28)	0.13
22:15-22:30	8.64	(293.76)	(233.28)	(0.25)
22:30-22:45	141.12	(163.58)	(102.64)	131.79
22:45-23:00	70.56	(224.50)	(165.48)	61.16
23:00-23:15	7.20	-	-	-
Average kW	**57.24**	**(243.90)**	**(183.67)**	**48.21**
Average kWh	**57.24**	**(243.90)**	**(183.67)**	**48.21**
CBP Bid (kW)		(100)		
CBP Event Performance		**244%**		

b) BATTERY ALCS BASELINE ANALYSIS

Figure 169 shows the system is discharging at the start of the test event and has one period of charging during the test event. The figure also shows that the flat nature of the event period is not the result of consistent battery performance. The most important takeaway from this is that the battery did charge for a brief period during the event.

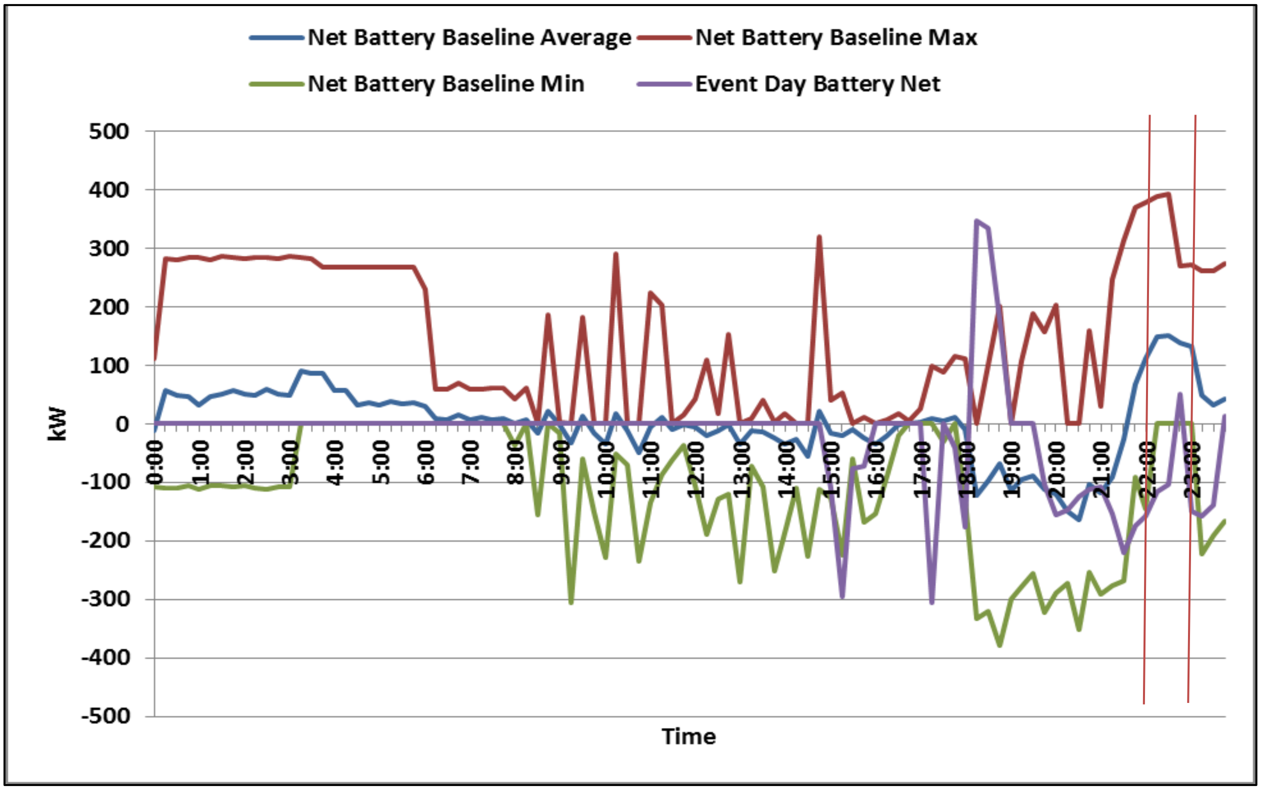


FIGURE 169. APRIL 29 22:00-23:00 CUSTOMER 3 TURN OFF CHARGING– BATTERY ALCS NET METER DATA

The Import Export chart in Figure 170 supports the event day observations outlined in Figure 169.

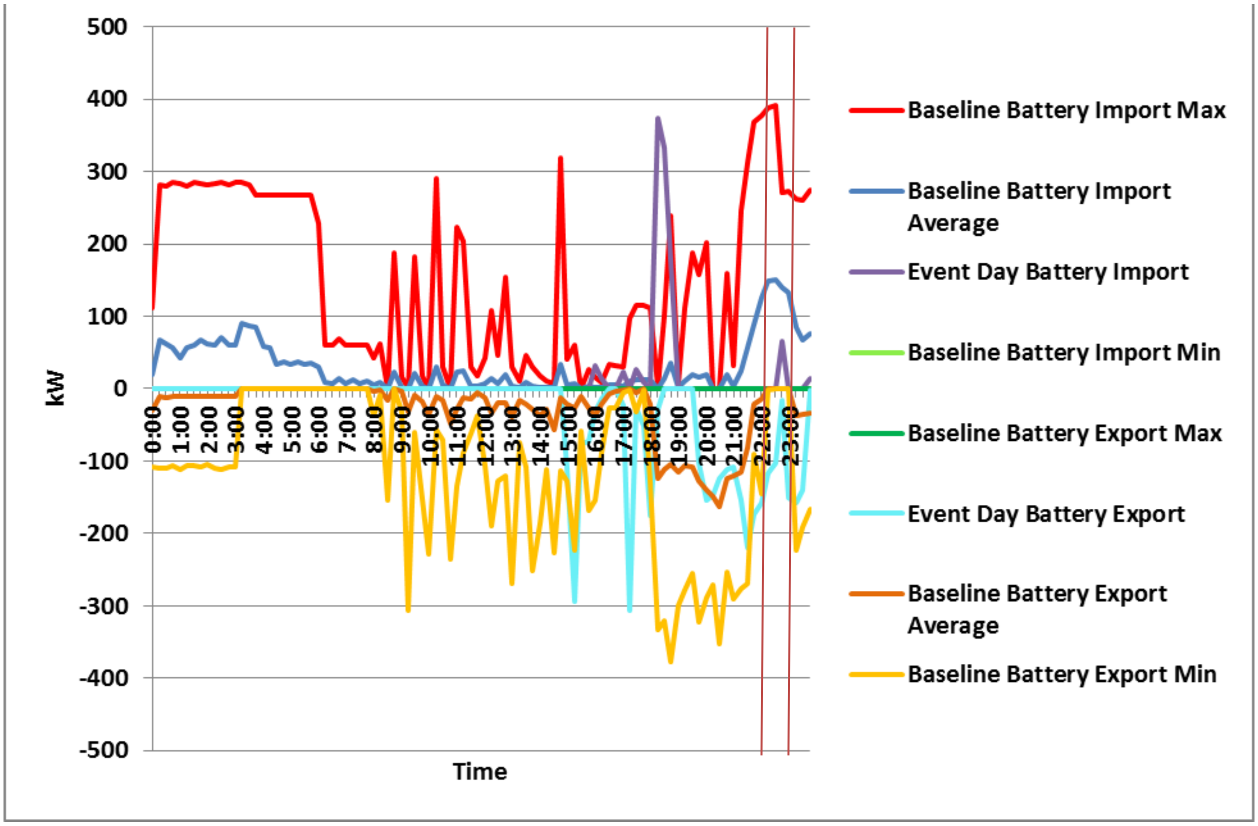


FIGURE 170. APRIL 29 22:00-23:00 CUSTOMER 3 TURN OFF CHARGING– BATTERY ALCS EXPORT METER DATA

C) PQ MEASUREMENTS

The upper chart in Figure 171 aligns with both the Battery ALCS data shown in Figure 169 and Figure 170 as well as the SCE meter data shown in Figure 167 and Figure 168. The lower chart in Figure 171 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during and after the test event period.

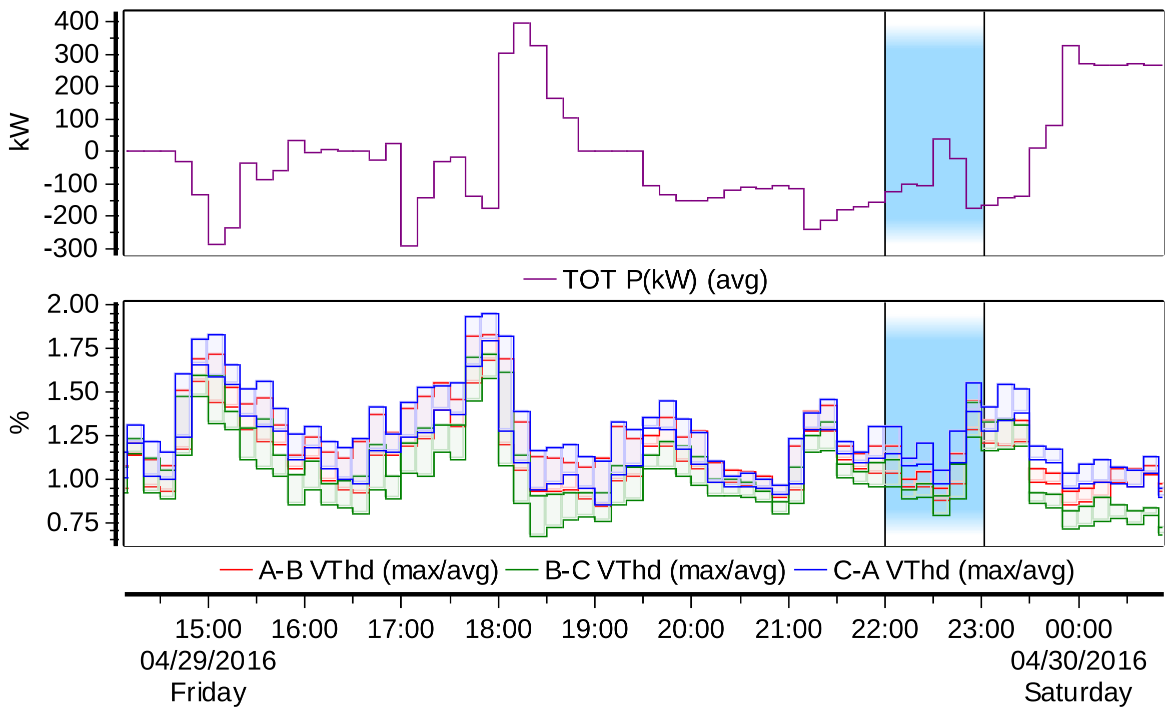


FIGURE 171. APRIL 29 22:00-23:00 CUSTOMER 3 URN OFF CHARGING–PQ METER DATA

TEST EVENT 6: MONDAY MAY 2, 14:00-15:00 PDT – DISCHARGE

a) SCE Meter Baseline Analysis

The graph in Figure 172 is an example of the classic demand response pattern. Usage drops significantly across the first 15-minute period, remains low throughout the event, and returns to near-average usage after the conclusion of the event.

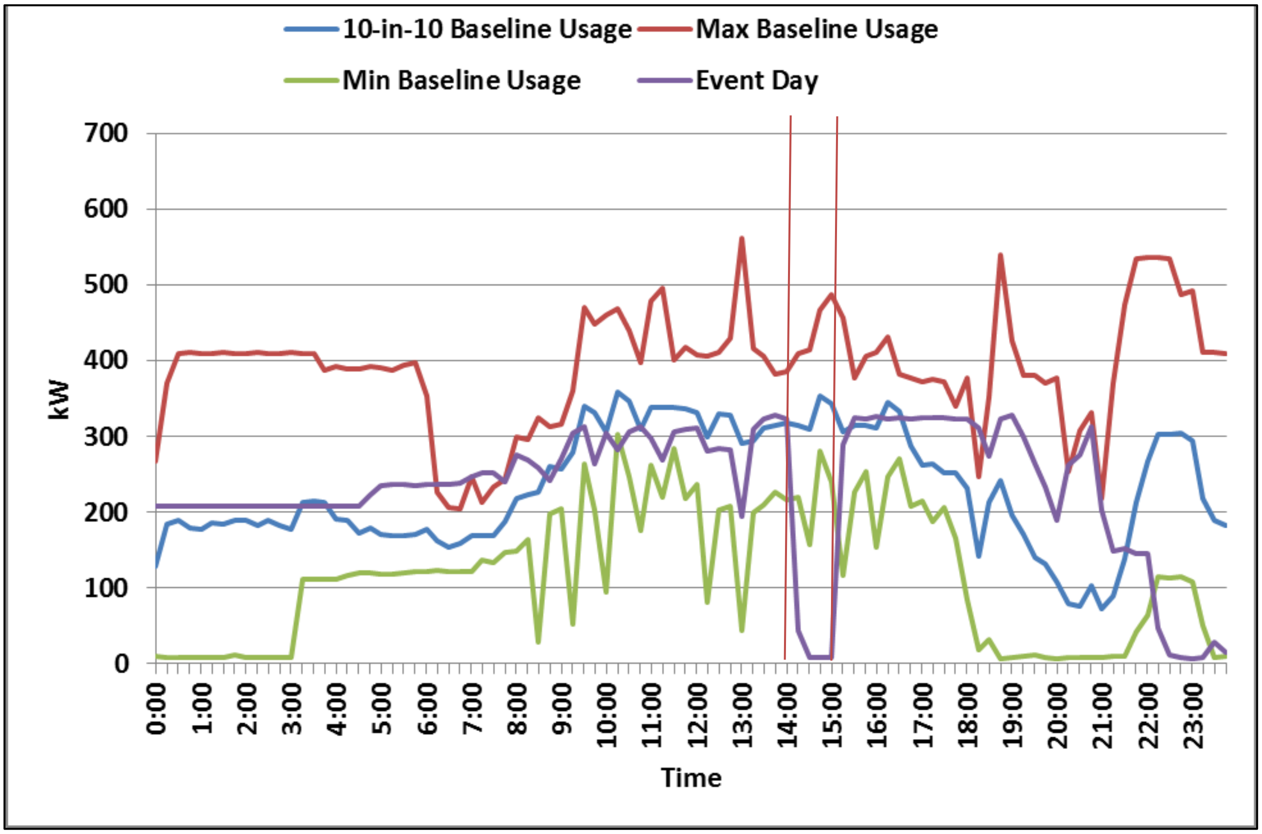


Figure 172. May 2 14:00-15:00 Customer 3 Discharge – SCE Meter Data

Usage immediately prior to the event was slightly higher than the 10-in-10 average baseline usage. Still, both the *10-in-10 Baseline Usage* and the *±20% from baseline and LA 10-in-10* curves in Figure 173 show the expected performance of the facility during the event period to be significantly higher than what was observed, which indicates a response. This event appears to be the most effective DR event as it does not exhibit a usage spike following the event that is the result of the battery recharging following the event.

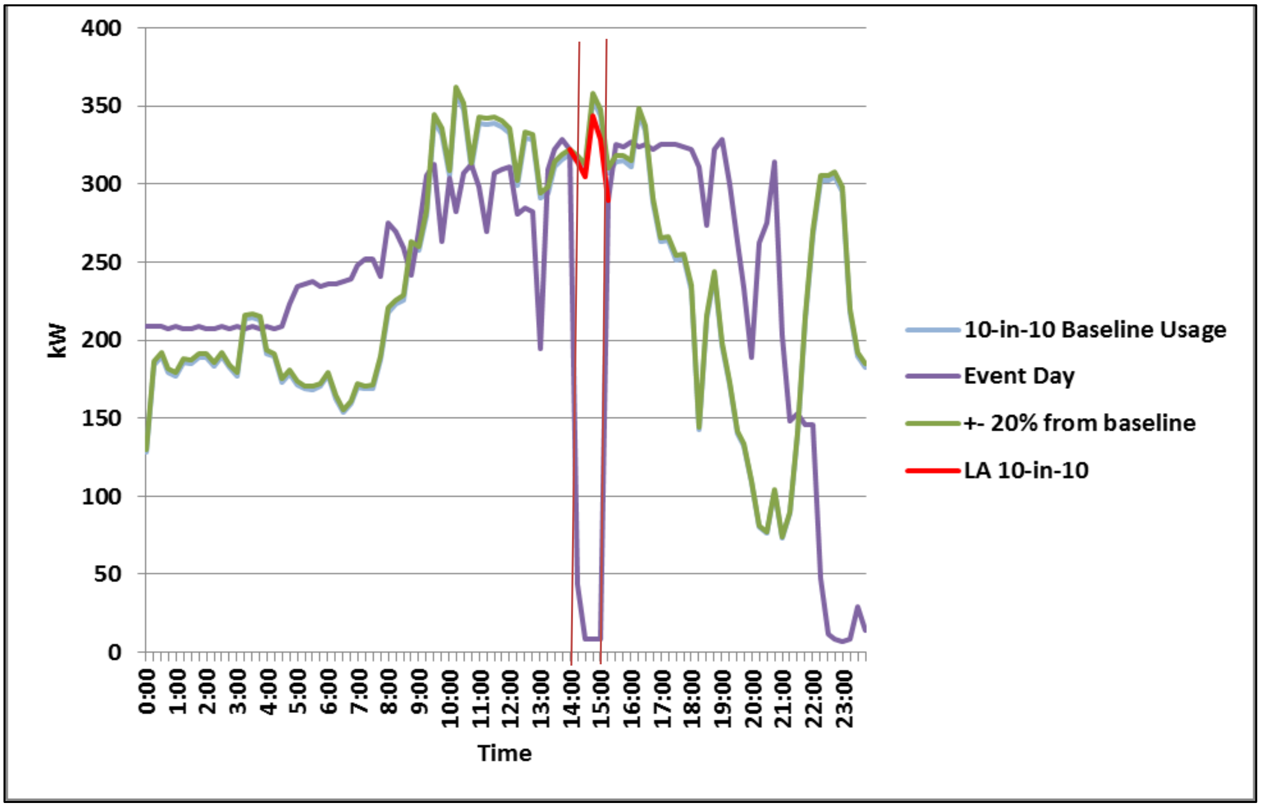


FIGURE 173. MAY 2 14:00-15:00 CUSTOMER 3 DISCHARGE – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 34. MAY 2 14:00-15:00 CUSTOMER 3 DISCHARGE– PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
13:45-14:00	322.56	-	-	-
14:00-14:15	43.20	(271.44)	(274.99)	(270.74)
14:15-14:30	8.64	(300.67)	(304.16)	(295.80)
14:30-14:45	8.64	(345.74)	(349.74)	(335.36)
14:45-15:00	8.64	(335.09)	(338.97)	(320.37)
15:00-15:15	289.44	-	-	-
Average kW	**17.28**	**(313.24)**	**(316.97)**	**(305.57)**
Average kWh	**17.28**	**(313.24)**	**(316.97)**	**(305.57)**
CBP Bid (kW)		(100)		
CBP Event Performance		**313%**		

b) BATTERY ALCS BASELINE ANALYSIS

The Customer 3 Net Battery Profile in Figure 174 shows a response that is in line with what is observed at the meter. A spike in charging at 15:15 that was not evident at the meter in the same way that other dramatic spikes were is also observed. The usage spike following the event is pertinent to establishing baseline protocols for properly evaluating the impact of the event.

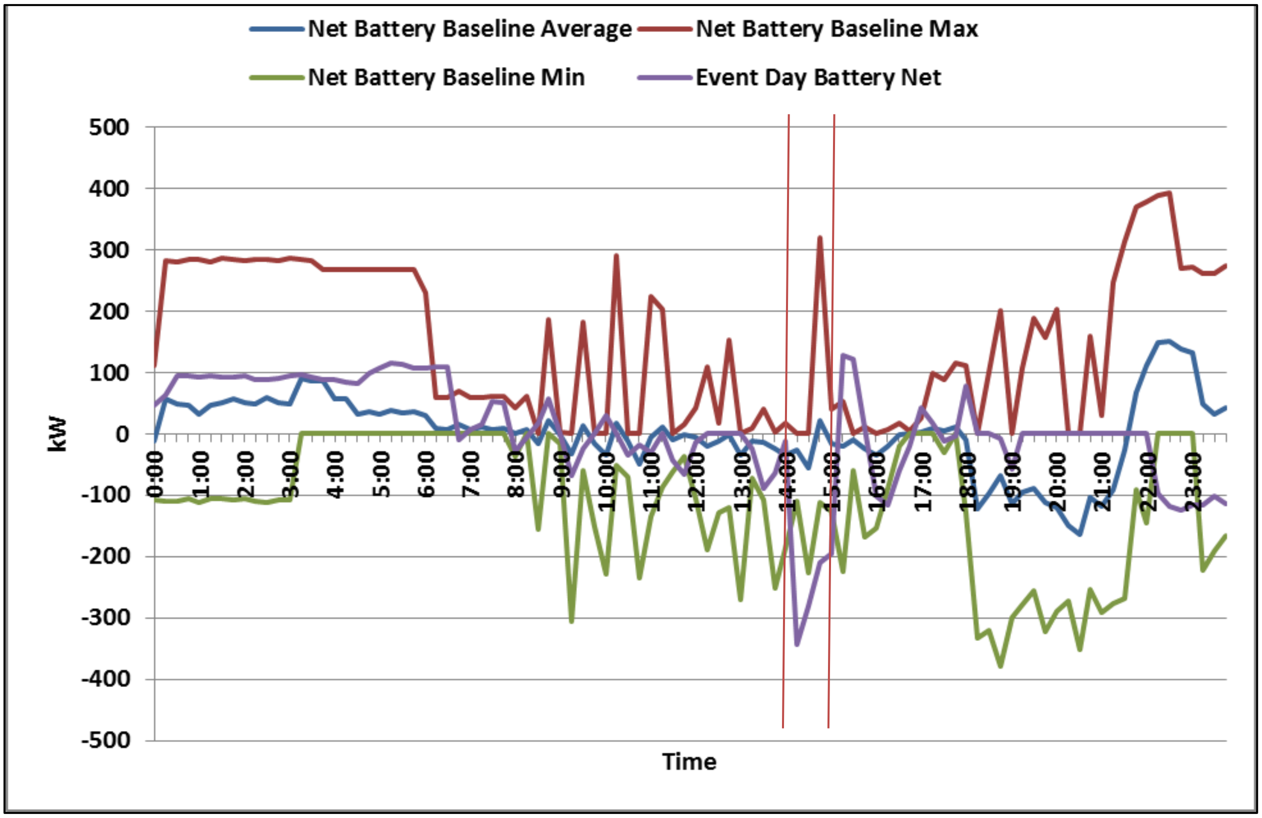


FIGURE 174. MAY 2 14:00-15:00 CUSTOMER 3 DISCHARGE – BATTERY ALCS NET METER DATA

Figure 175 supports the conclusions reached in Figure 174.

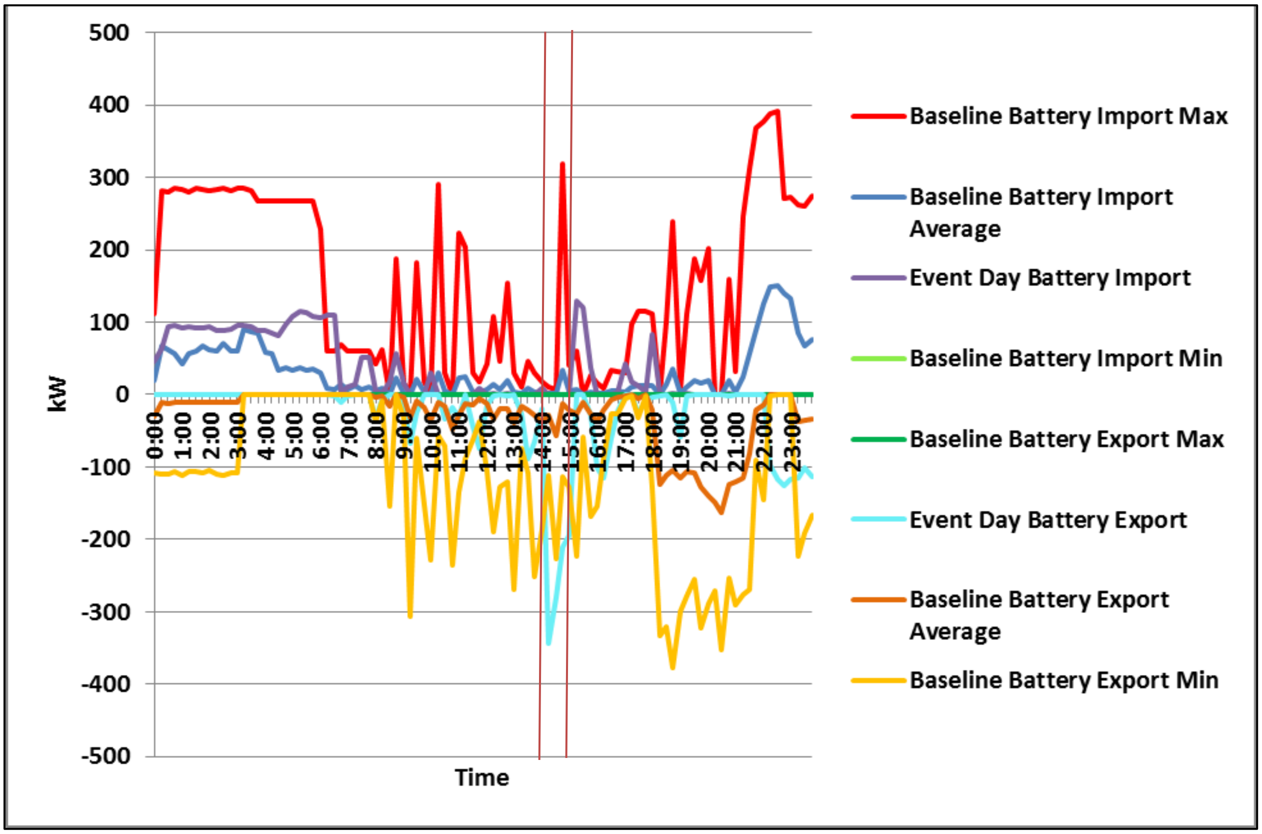


FIGURE 175. MAY 2 14:00-15:00 CUSTOMER 3 DISCHARGE – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ MEASUREMENTS

The upper chart in Figure 176 aligns with both the Battery ALCS data shown in Figure 174 and Figure 175 as well as the SCE meter data shown in Figure 172 and Figure 173. The lower chart in Figure 176 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during and after the test event period.

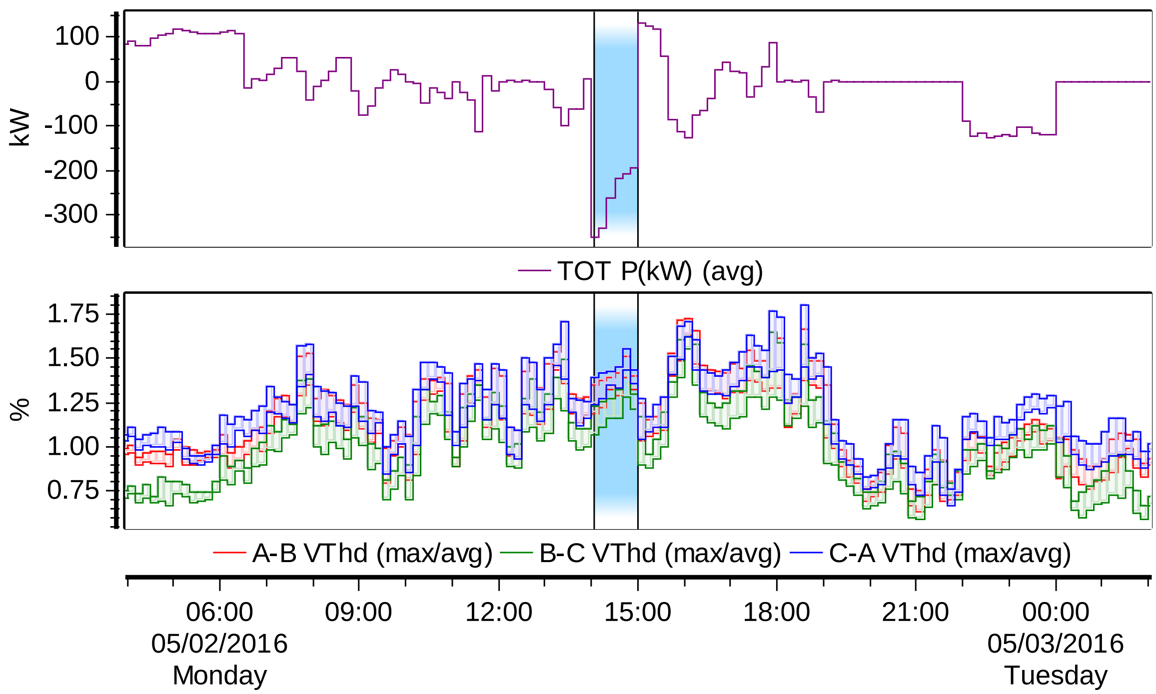


FIGURE 176. MAY 2 14:00-15:00 CUSTOMER 3 DISCHARGE–PQ METER DATA

TEST EVENT 7: FRIDAY MAY 6, 3:00-4:00 PDT – START CHARGING

a) SCE Meter Baseline Analysis

Figure 177 shows the event day usage begins below the average baseline usage. In response to the "Start Charging" signal, usage increases between the 3:00-3:15 period and then remains relatively steady throughout the rest of the event hour. The minimum and average baseline usage curves follow similar usage patterns as the event day, with a large usage increase across the 3:00-3:15 period.

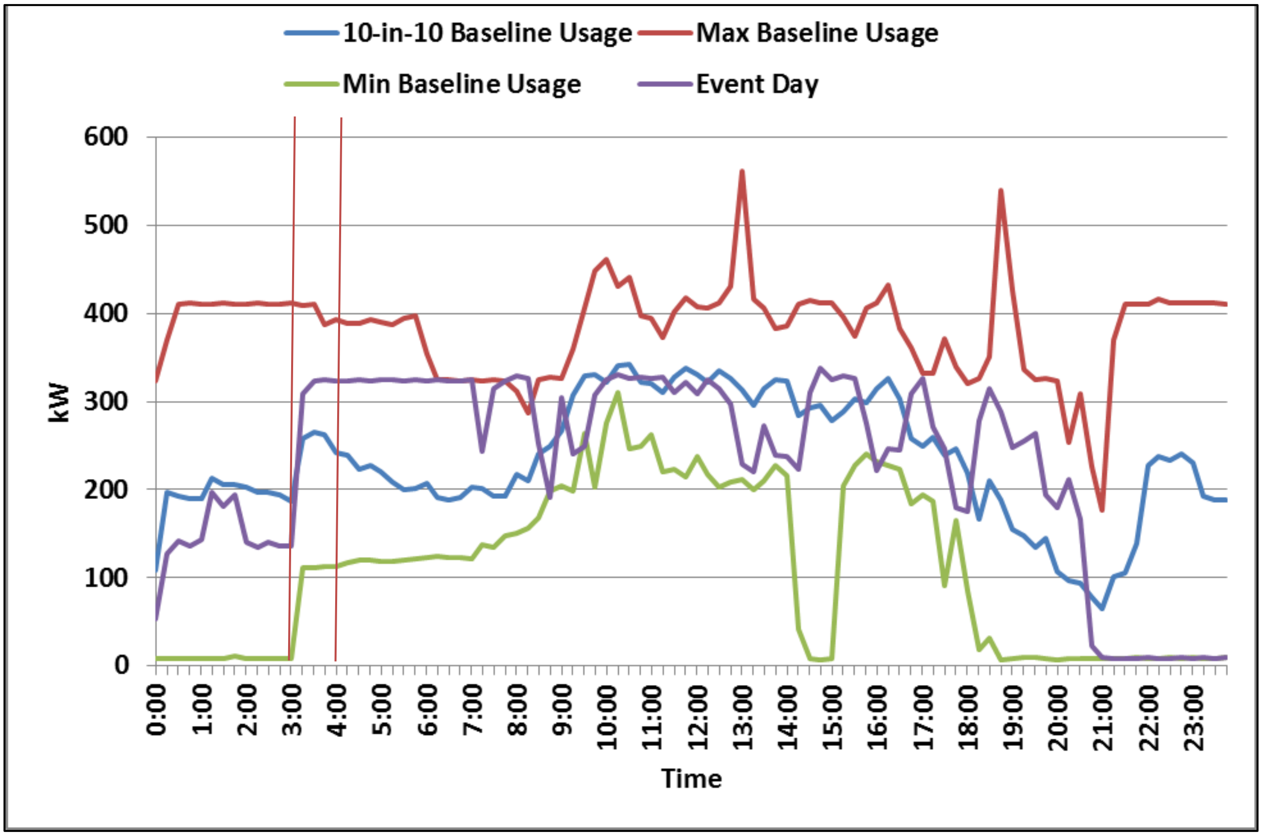


Figure 177. May 6 03:00-04:00 Customer 3 Start Charging – SCE Meter Data

Similar to the May 20 Customer 1 event, Figure 178 shows that the event day indicates a response to the start charging dispatch based on the baseline estimations for usage in the absence if a test event. For much of the morning prior to the event, usage was lower than the baseline average. Then, immediately after the start of the event, usage rises significantly. The *10-in-10* and ± *20% from baseline* provide good estimates for what usage might have been in the absence of a test event. The LA 10-in-10 is skewed by the continuing higher usage after the end of the test event.

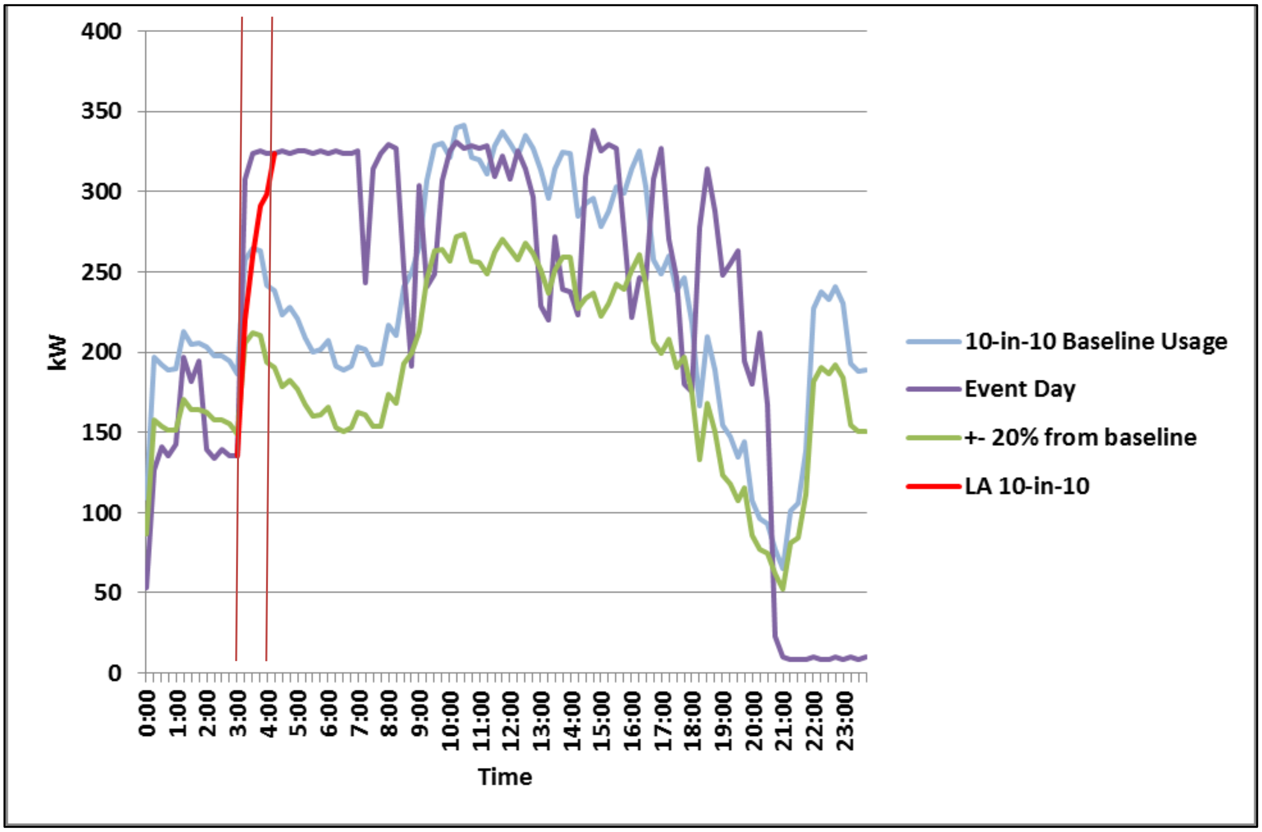


FIGURE 178. MAY 6 03:00-04:00 CUSTOMER 3 START CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 35. MAY 6 3:00-4:00 CUSTOMER 3 START CHARGING – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
2:45-3:00	135.36	-	-	-
3:00-3:15	308.16	50.69	102.18	88.45
3:15-3:30	324.00	58.90	111.92	64.28
3:30-3:45	325.44	62.50	115.08	34.62
3:45-4:00	324.00	82.22	130.58	26.05
4:00-4:15	324.00	-	-	-
Average kW	**320.40**	**63.58**	**114.94**	**53.35**
Average kWh	**320.40**	**63.58**	**114.94**	**53.35**
CBP Bid (kW)		100		
CBP Event Performance		**64%**		

b) Battery ALCS Baseline Analysis

Figure 179 illustrates that the battery typically increases charging from at 3:15. The event day charge increase is more dramatic than average, and therefore is a representation that the batteries did respond to the "Start Charging" dispatch signal.

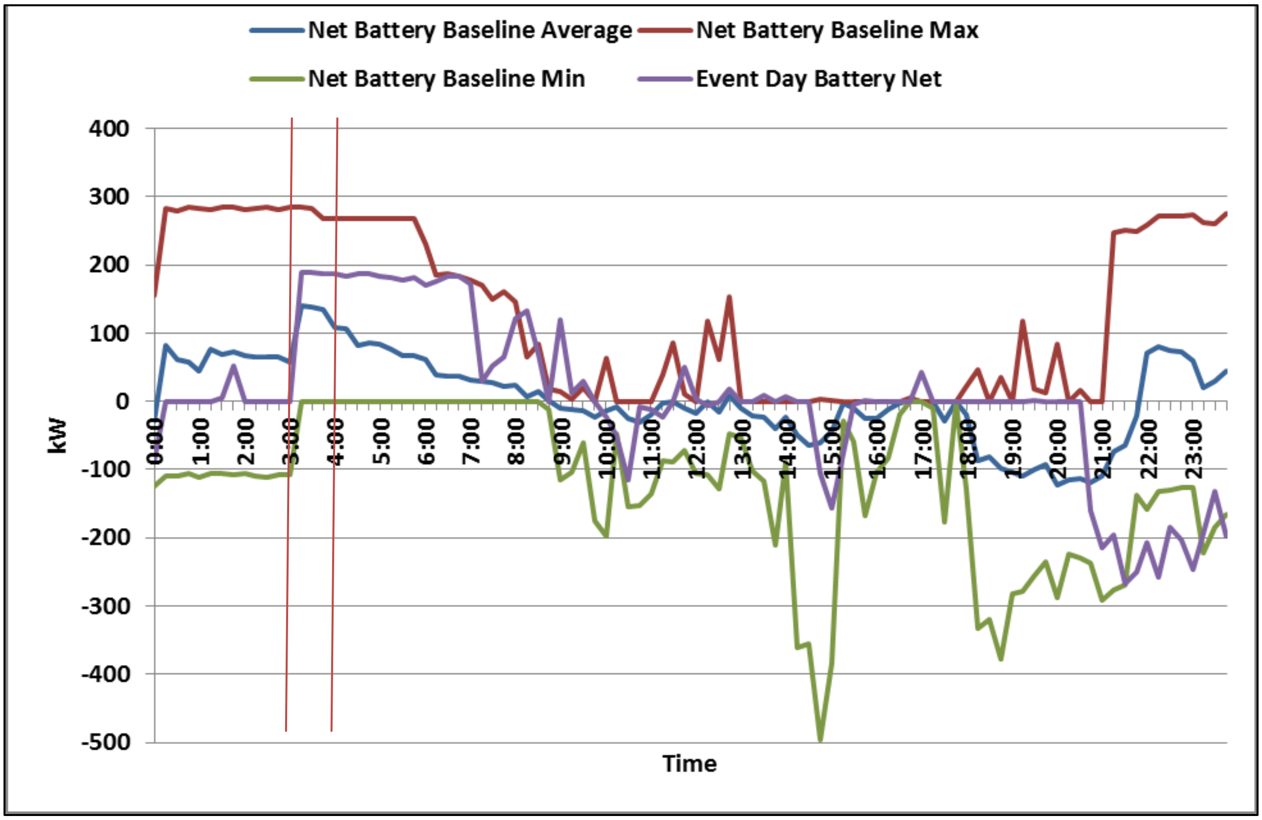


Figure 179. May 6 03:00-04:00 Customer 3 Start Charging – Battery ALCS Net Meter Data

Figure 180 supports the conclusions reached in Figure 179.

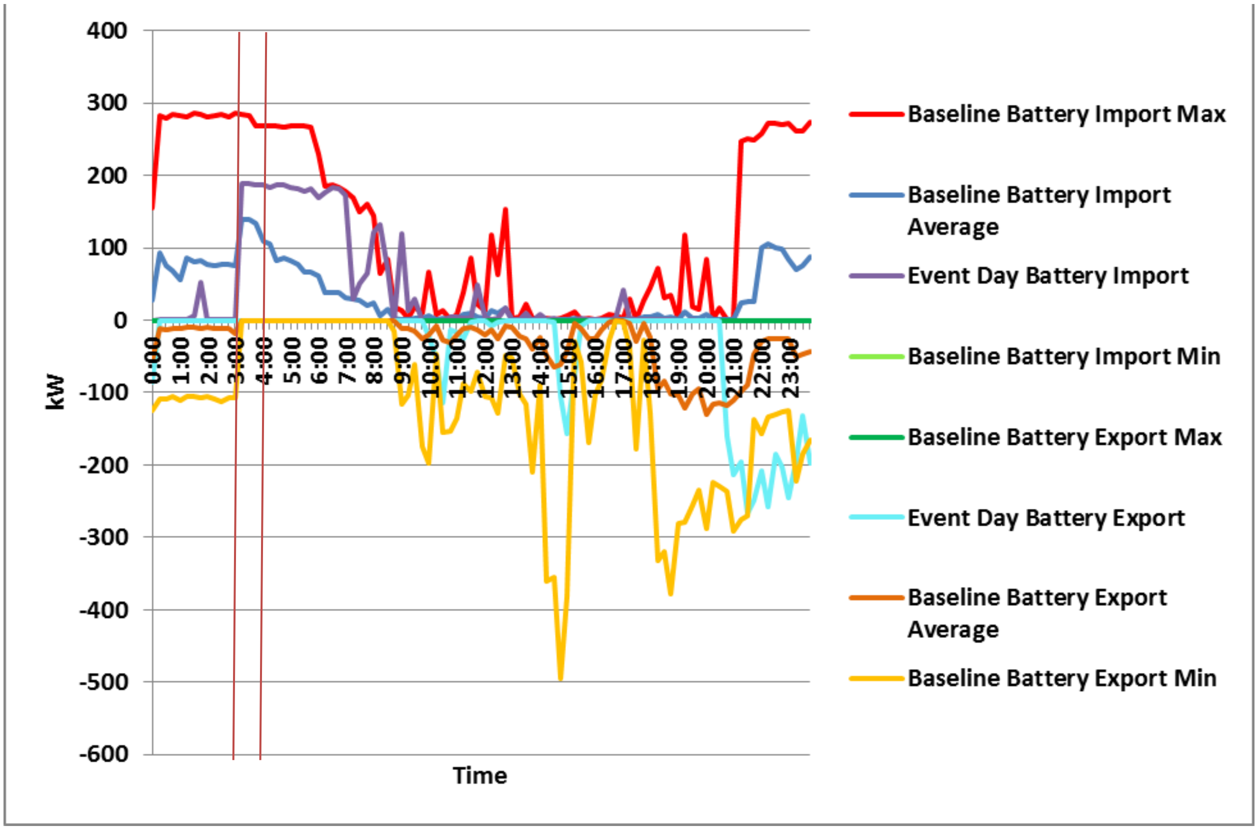


FIGURE 180. MAY 6 03:00-04:00 CUSTOMER 3 START CHARGING – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ MEASUREMENTS

The upper chart in Figure 181 aligns with both the Battery ALCS data shown in Figure 179 and Figure 180 as well as the SCE meter data shown in Figure 177 and Figure 178. The lower chart in Figure 181 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during and after the test event period.

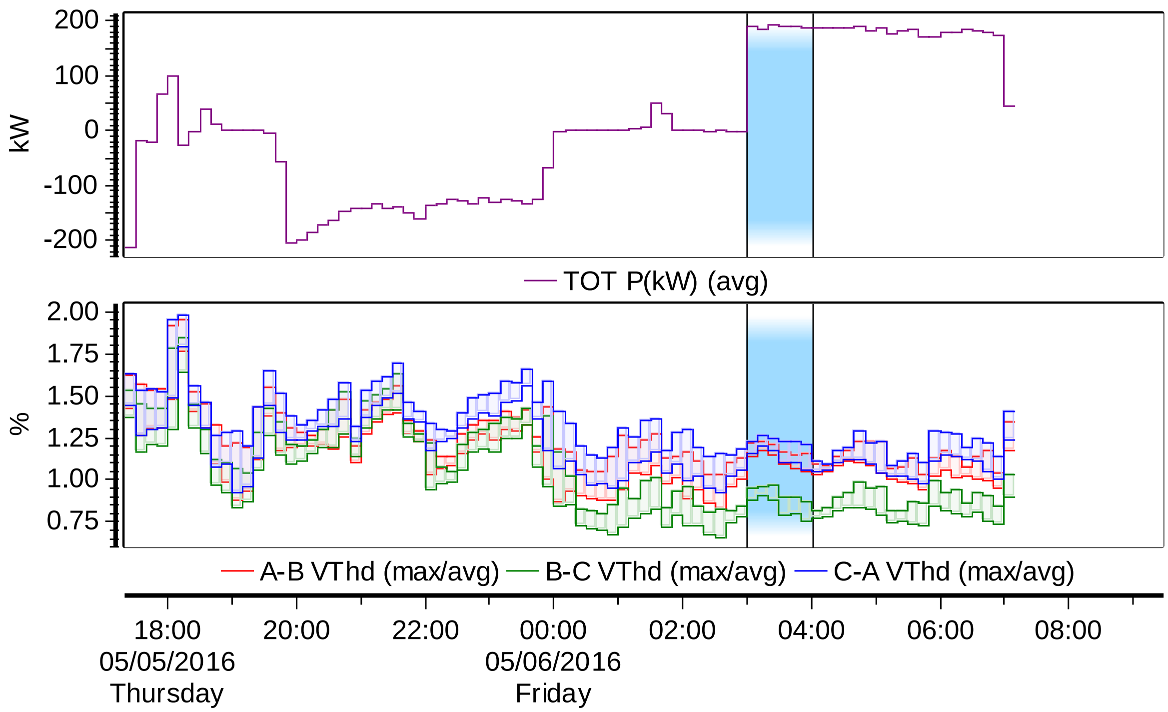


FIGURE 181. MAY 6 3:00-4:00 CUSTOMER 3 START CHARGING–PQ METER DATA

Test Event 8: Tuesday May 10, 22:00-23:00 PDT – Turn Off Charging

a) SCE Meter Baseline Analysis

The low rate of usage across the 22:00-23:00 hour in Figure 181 suggests that the battery was not charging in the late night hours leading up to, during, or after the event.

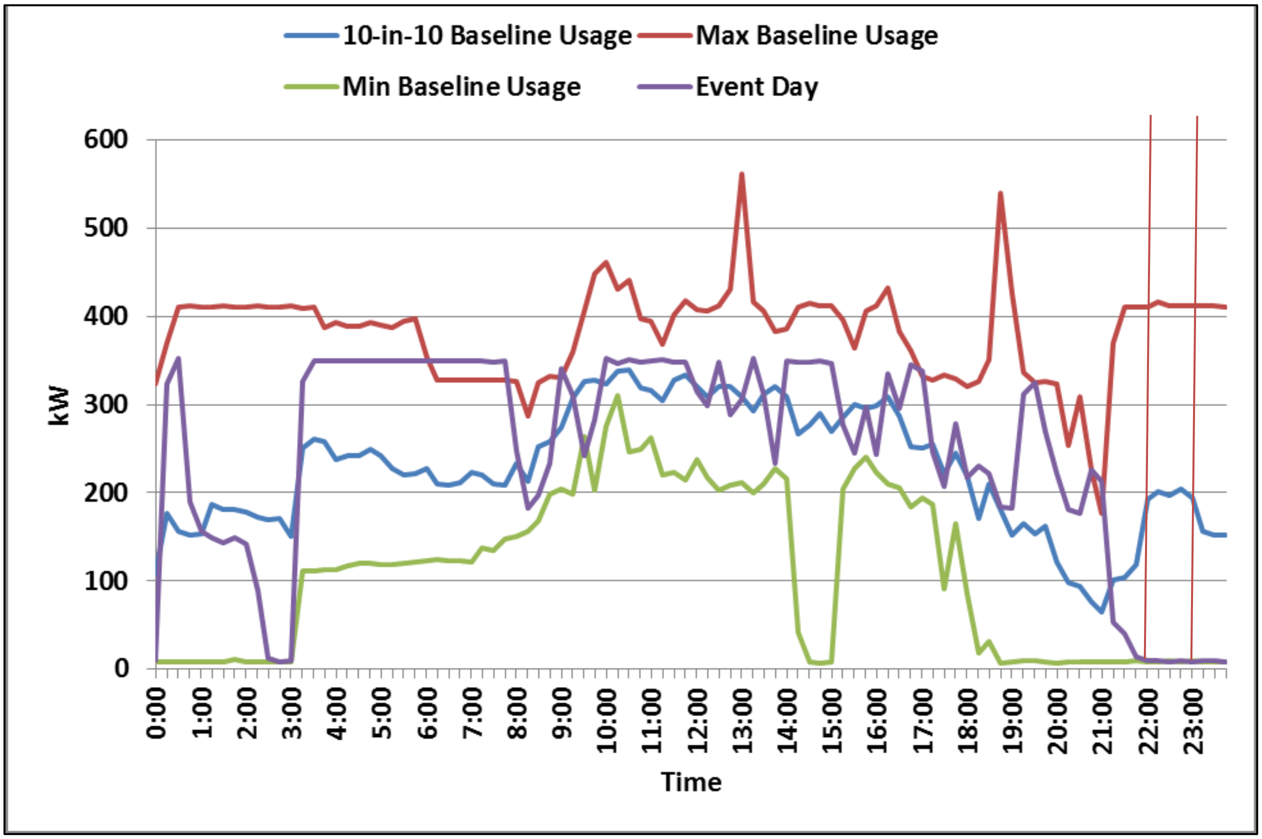


Figure 182. May 10 22:00-23:00 Customer 3 Turn Off Charging – SCE Meter Data

The *10-in-10 baseline* and the ± *20% from baseline* curves in Figure 183 are representative of what usage might have been in the absence of a test event. The -20% adjustment is appropriate since the usage prior to the test event is significantly lower than the average 10-in-10 baseline. The LA 10-in-10 curve demonstrates that usage prior to and subsequent to the test event (from 21:30 until past midnight) is fairly constant. Therefore, the test event dispatch itself resulted in no net change in usage at 22:00 or subsequent to test event termination at 23:00.

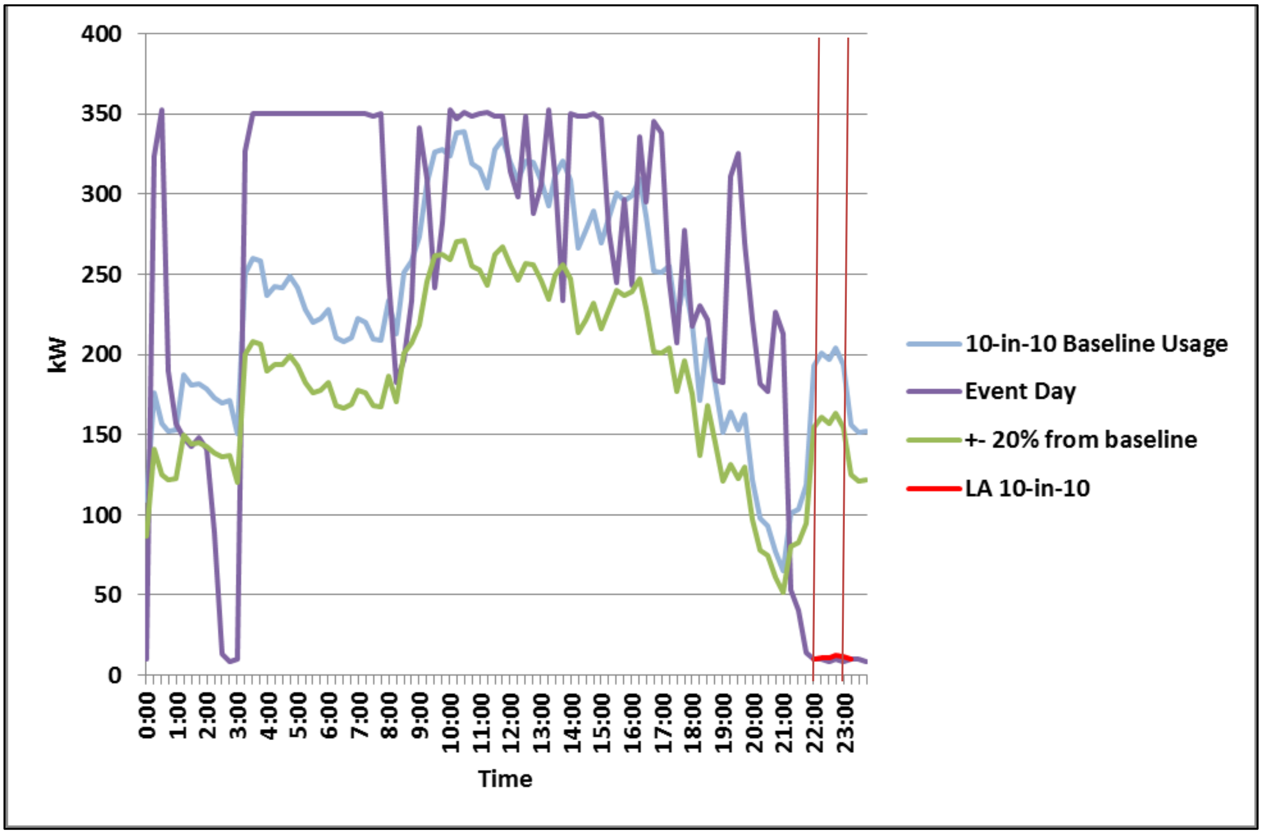


FIGURE 183. MAY 10 22:00-23:00 CUSTOMER 3 TURN OFF CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 36. MAY 10 22:00-23:00 CUSTOMER 3 TURN OFF CHARGING– PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
21:45-22:00	10.08	-	-	-
22:00-22:15	10.08	(190.80)	(150.62)	(0.89)
22:15-22:30	8.64	(187.92)	(148.61)	(2.58)
22:30-22:45	10.08	(193.82)	(153.04)	(2.07)
22:45-23:00	8.64	(184.90)	(146.19)	(3.37)
23:00-23:15	10.08	-	-	-
Average kW	**9.36**	**(189.36)**	**(149.62)**	**(2.23)**
Average kWh	**9.36**	**(189.36)**	**(149.62)**	**(2.23)**
CBP Bid (kW)		(100)		
CBP Event Performance		**189%**		

b) BATTERY ALCS BASELINE ANALYSIS

Figure 184 displays the battery was discharging prior to and during the "Turn Off Charging" event. Discharging was allowed for a "Turn Off Charging" test event. However, from this graph no charging is evident, but it is apparent that the discharge was greater than any charge. The battery was discharging prior to, during, and after the test event. Therefore the net effect of the "Turn Off Charging" event is lost in the SCE meter data.

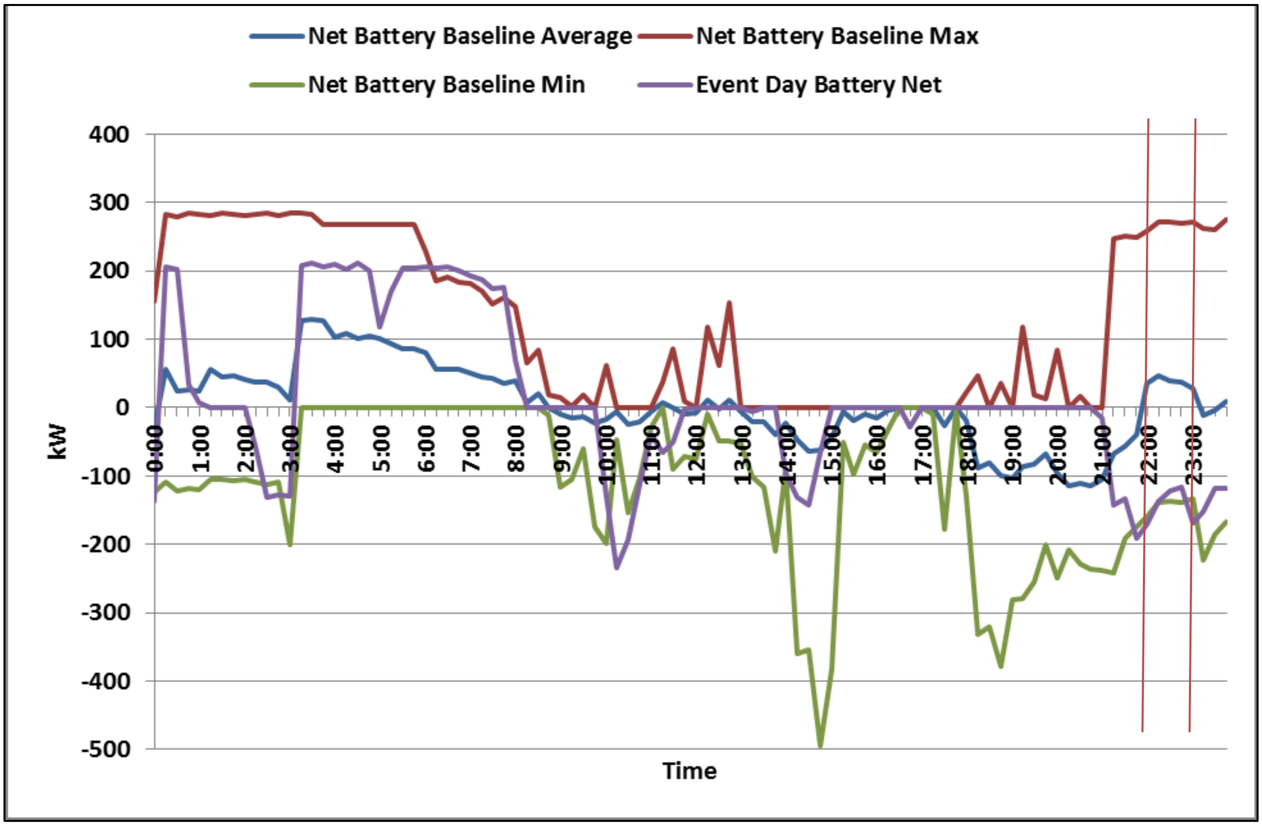


FIGURE 184. MAY 10 22:00-23:00 CUSTOMER 3 TURN OFF CHARGING – BATTERY ALCS NET METER DATA

The Import Export graph in Figure 185 confirms that there was no importing (charging) across the event period.

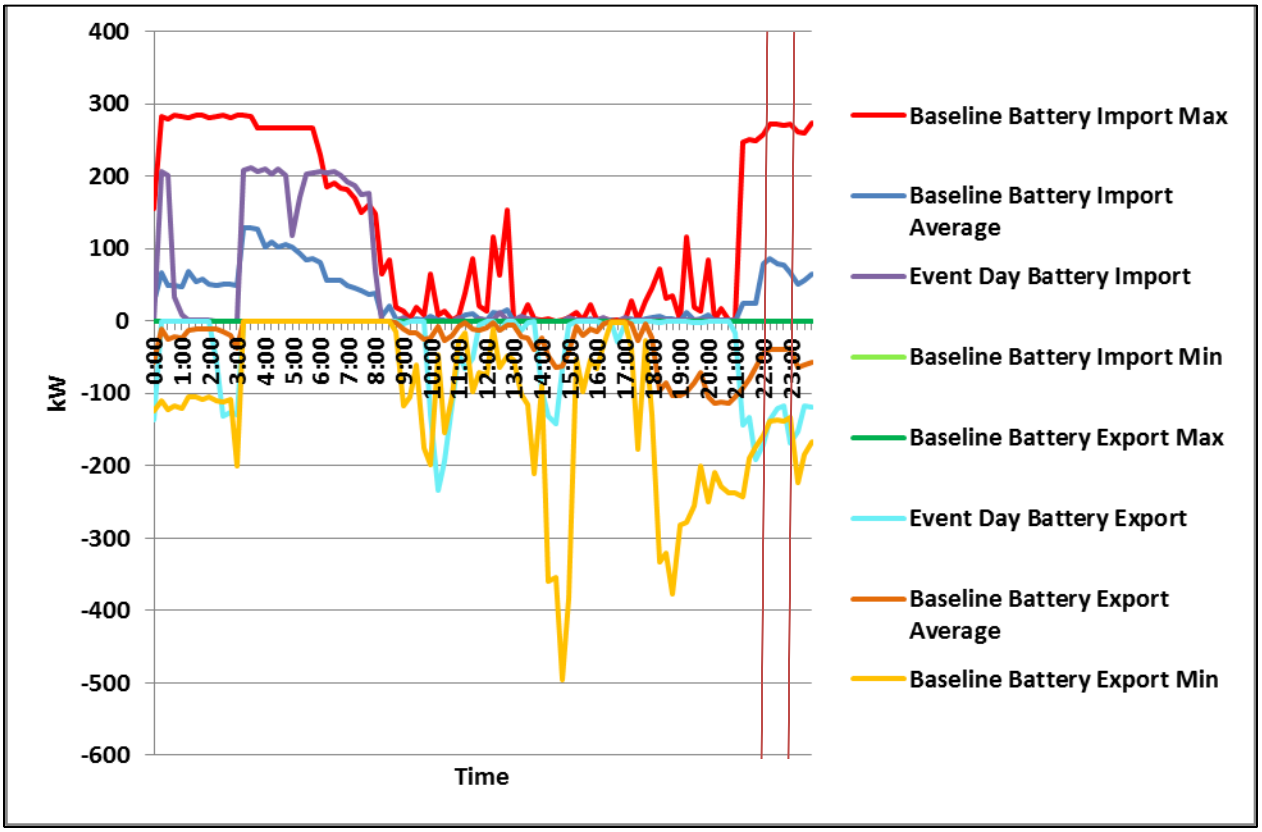


FIGURE 185. MAY 10 22:00-23:00 CUSTOMER 3 TURN OFF CHARGING – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ Measurements

The upper chart in Figure 186 aligns with both the Battery ALCS data shown in Figure 184 and Figure 185 indicating that the battery was discharging prior to, during, and after the test event. Therefore, the net effect of the "Turn Off Charging" event is lost in the SCE meter data shown in Figure 182 and Figure 183. The lower chart in Figure 186 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during, and after the test event period.

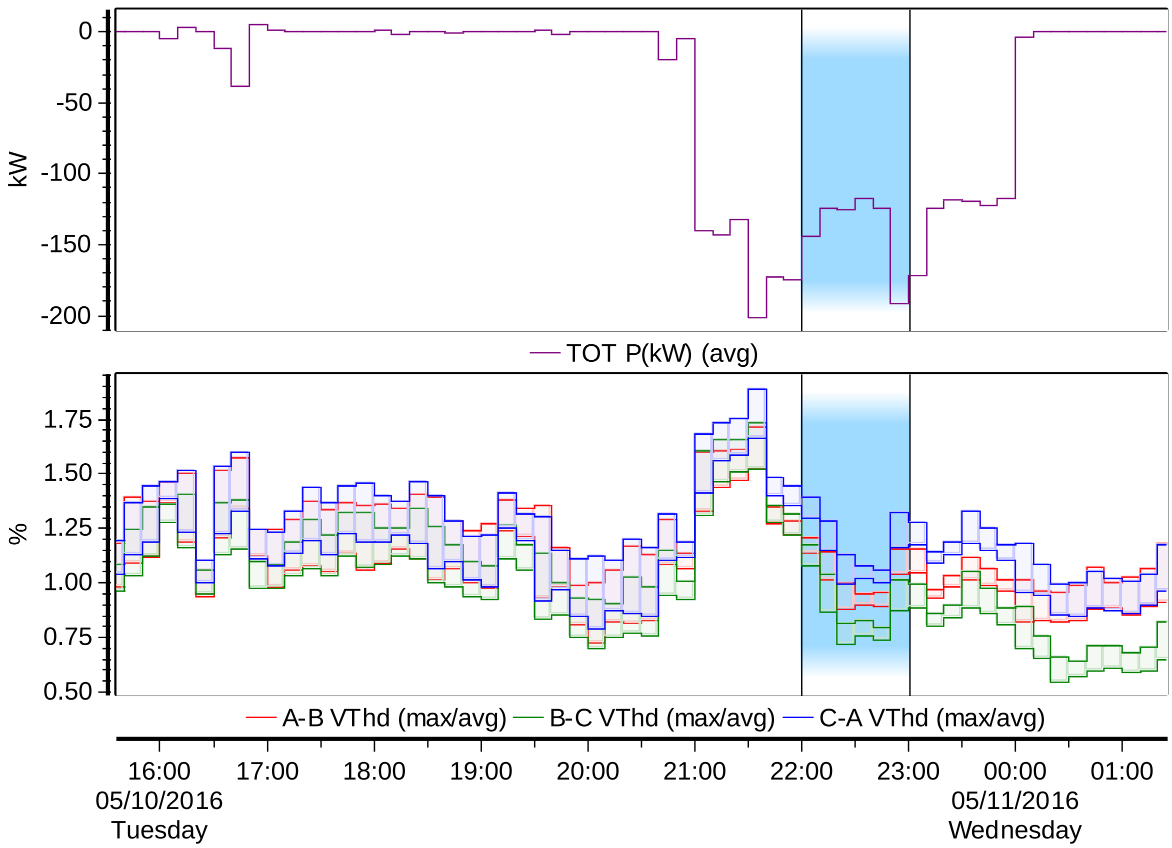


Figure 186. May 10 22:00-23:00 Customer 3 Turn Off Charging–PQ Meter Data

Test Event 9: Friday May 13, 14:00-15:00 PDT – Discharge

a) SCE Meter Baseline Analysis

Figure 187 shows the event day usage varied between the maximum and minimum usage in the early morning hours, before settling roughly between maximum and average baseline usage. The event period appears to show classic demand response patterns, where usage drops quickly across the event period before returning to pre-event levels in the 15-minute period immediately following the event. The event seems to mirror the minimum baseline usage pattern across the 14:00-15:00 hour. That minimum baseline usage, a seemingly DR pattern, occurred on May 3, when no event was scheduled for this project.

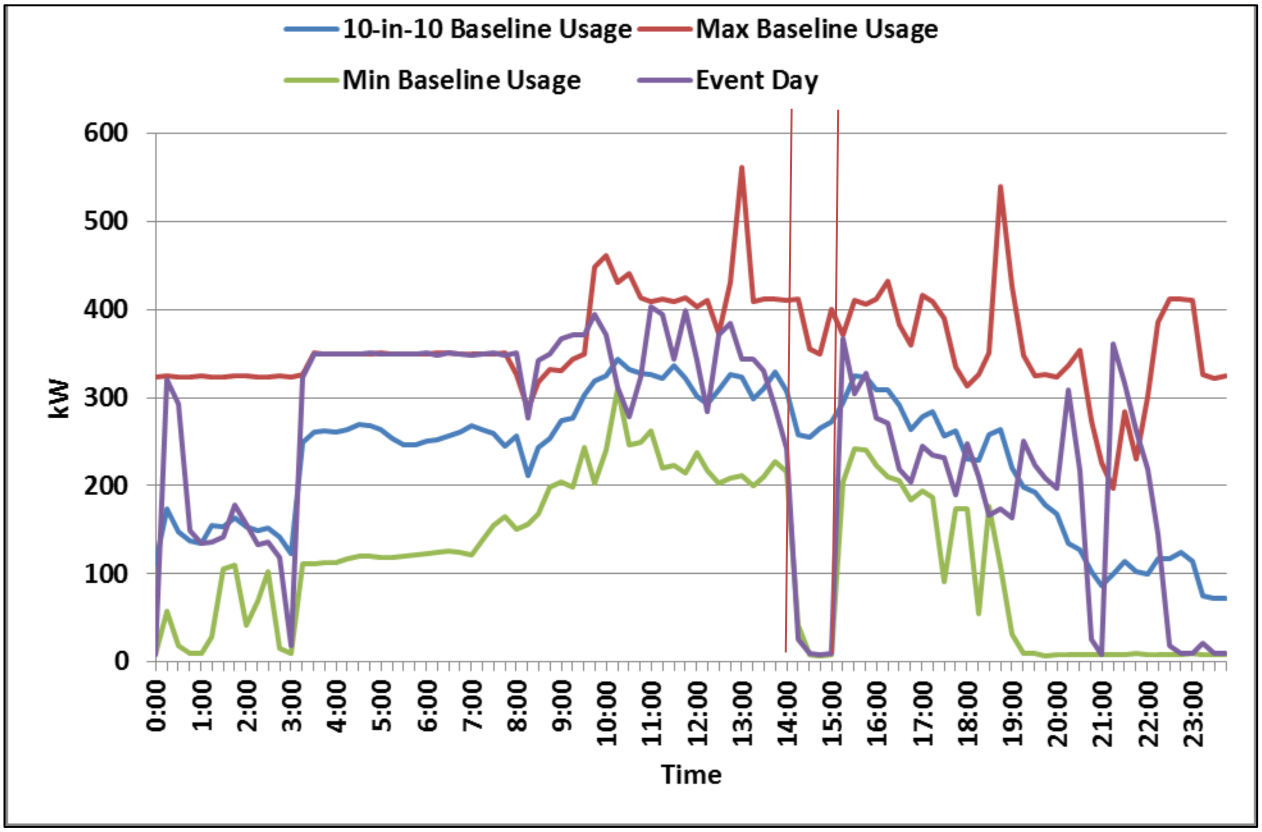


Figure 187. May 13 14:00-15:00 Customer 3 Discharge – SCE Meter Data

For much of the day, usage was higher than the baseline average. Immediately prior to the event, usage dropped to lower than the 10-in-10 average baseline usage. Still, both the *10-in-10 Baseline Usage* and the *±20% from baseline* curves in Figure 188 show the expected performance of the facility during the event period to be significantly higher than what was observed, which indicates a response. The LA 10-in-10 curve appears to be influenced by the spike in usage immediately following the event. At other sites, such as May 13 at Customer 2, that spike following the event has been the result of the battery recharging following the event.

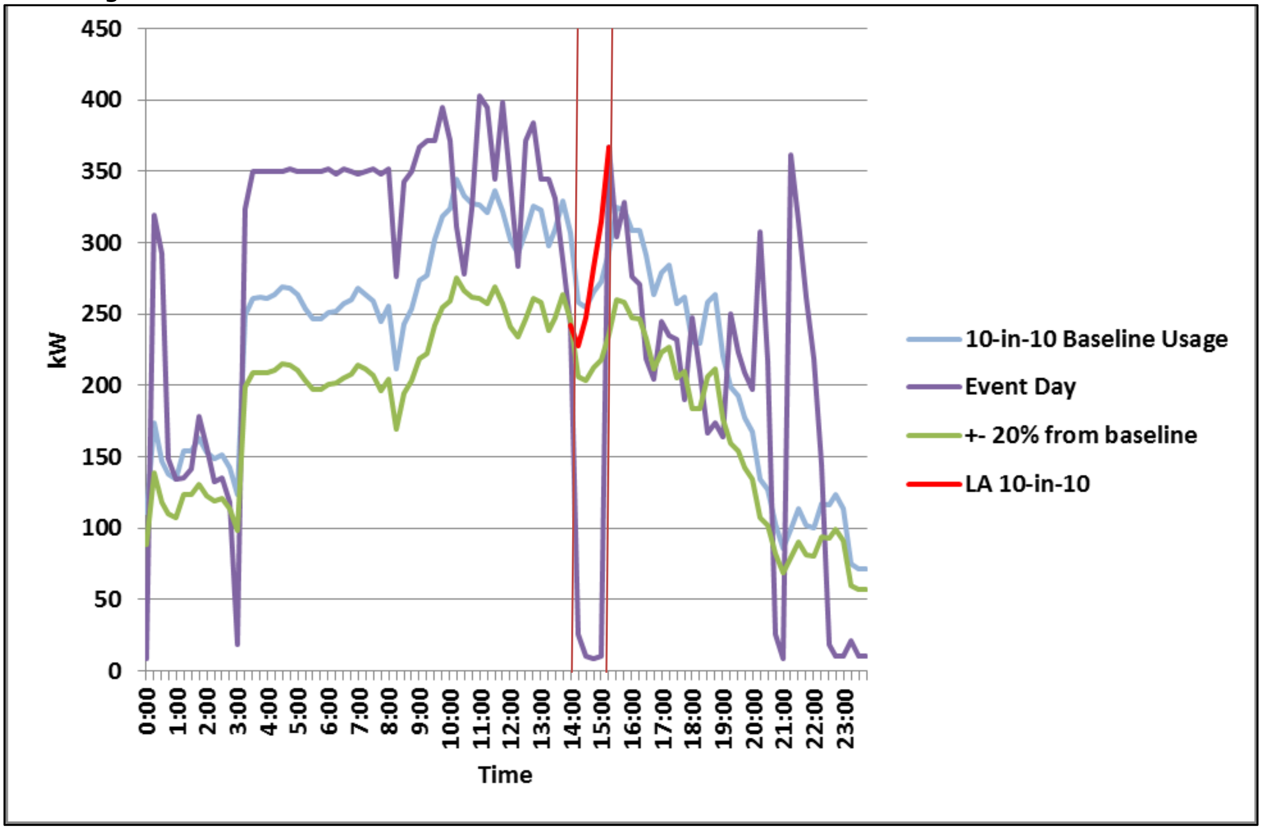


FIGURE 188. MAY 13 14:00-15:00 CUSTOMER 3 DISCHARGE – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 37. MAY 13 14:00-15:00 CUSTOMER 3 DISCHARGE– PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
13:45-14:00	241.92	-	-	-
14:00-14:15	25.92	(232.42)	(180.75)	(201.47)
14:15-14:30	10.08	(244.66)	(193.71)	(237.53)
14:30-14:45	8.64	(256.75)	(203.67)	(273.70)
14:45-15:00	10.08	(262.66)	(208.11)	(305.13)
15:00-15:15	367.20	-	-	-
Average kW	**13.68**	**(249.12)**	**(196.56)**	**(254.46)**
Average kWh	**13.68**	**(249.12)**	**(196.56)**	**(254.46)**
CBP Bid (kW)		(100)		
CBP Event Performance		**249%**		

b) Battery ALCS Baseline Analysis

Figure 189 shows that event day discharge during the 14:00-15:00 hour is significantly greater than the average that was observed in the baseline period. This indicates a response to the "Discharge" signal. Just as with the May 13 Customer 2 event and the April 12 Customer 3 event, the battery subsequently charges in the immediate 15 minutes following the conclusion of the test event.

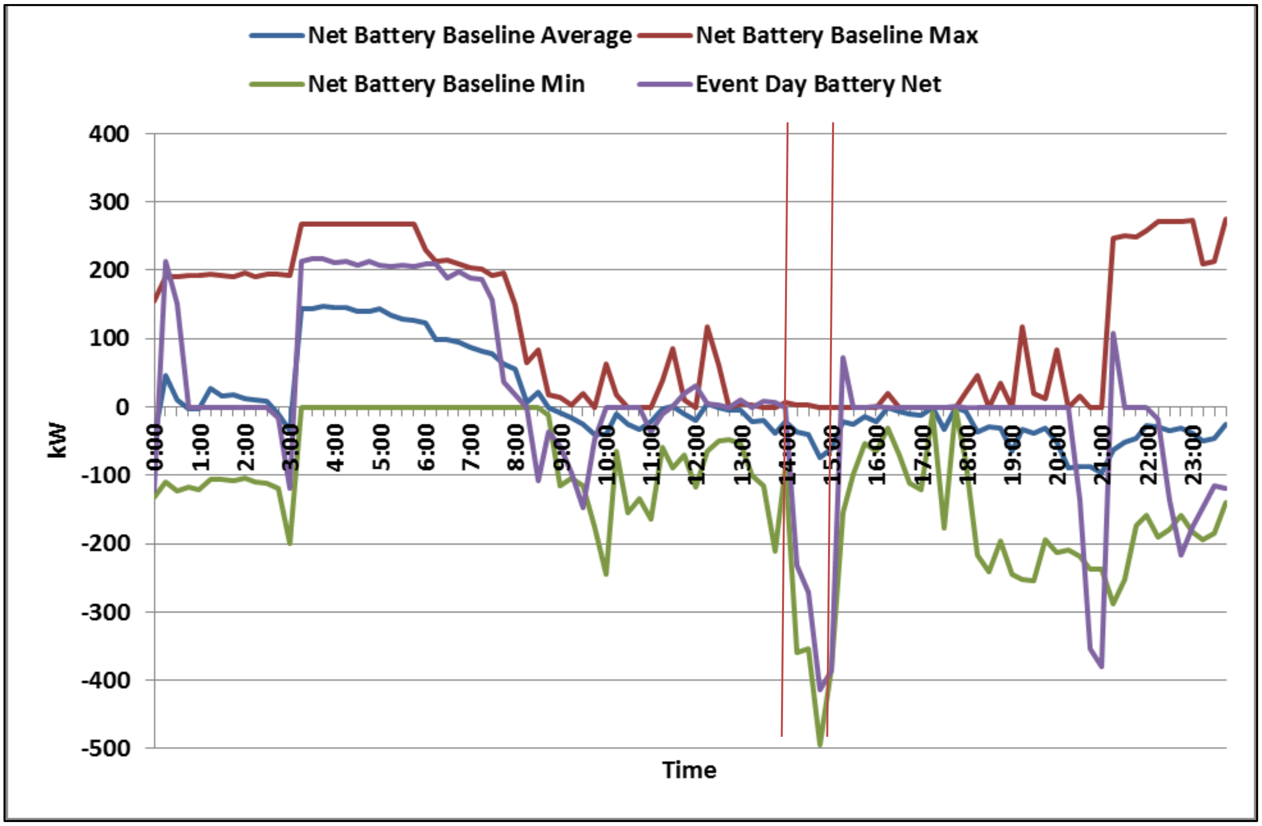


Figure 189. May 13 14:00-15:00 Customer 3 Discharge – Battery ALCS Net Meter Data

Figure 190 supports the conclusions reached in Figure 189.

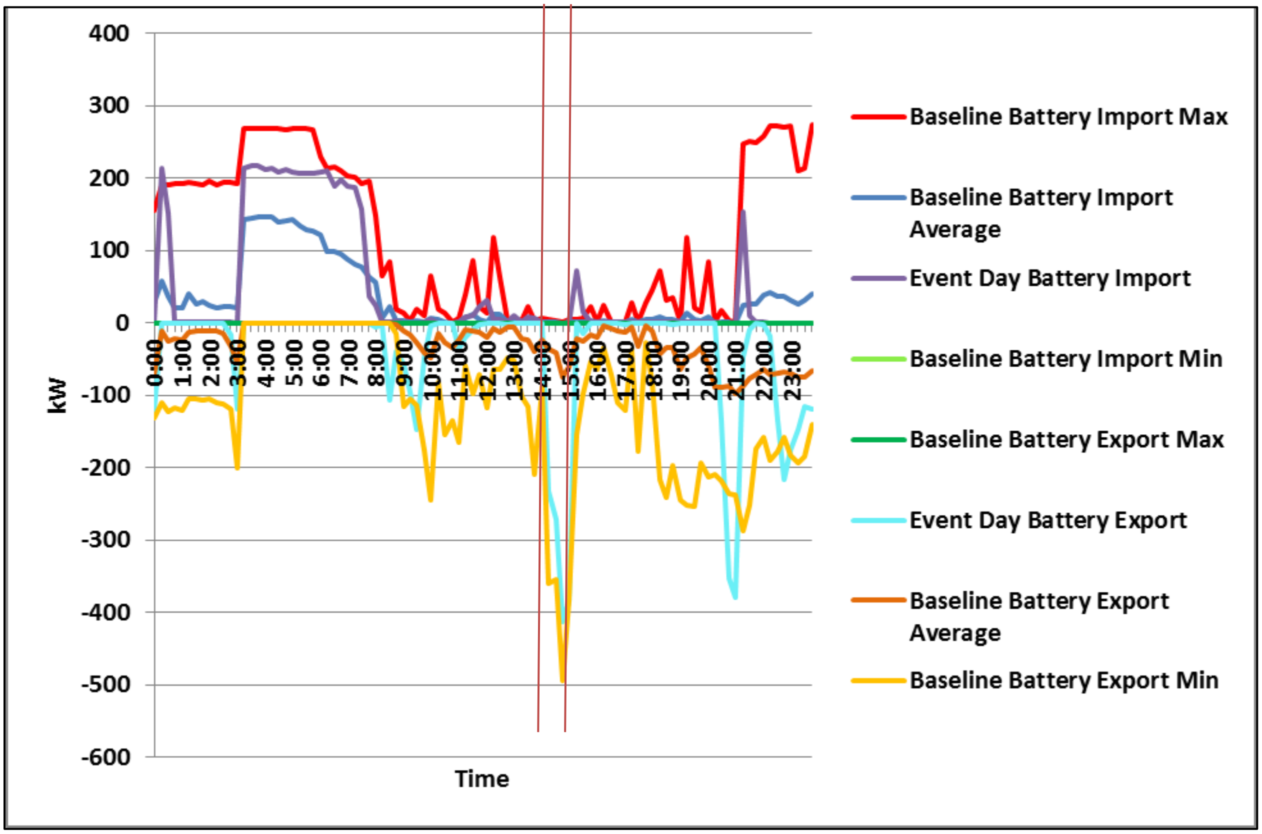


FIGURE 190. MAY 13 14:00-15:00 CUSTOMER 3 DISCHARGE– BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ Measurements

The upper chart in Figure 191 aligns with both the Battery ALCS data shown in Figure 189 and Figure 190 as well as the SCE meter data shown in Figure 187 and Figure 188. The lower chart in Figure 191 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during, and after the test event period.

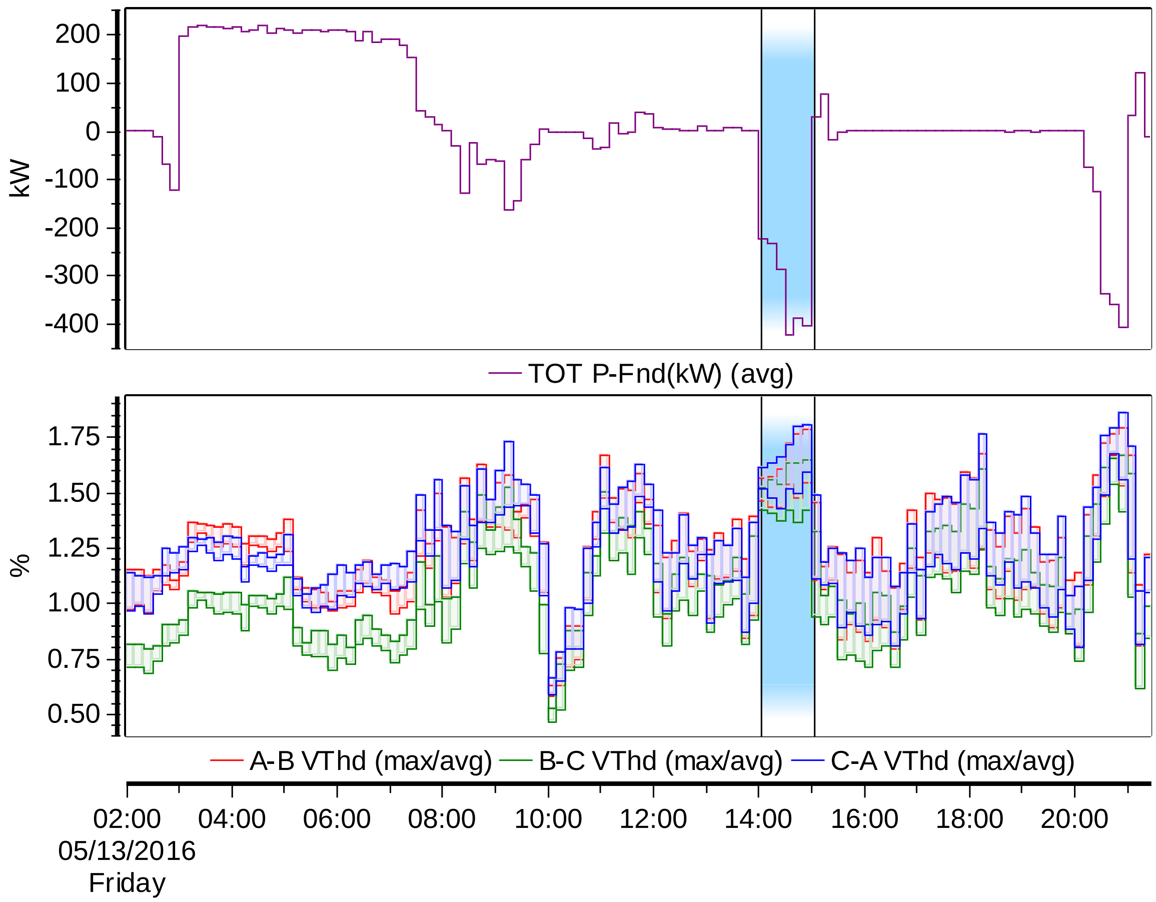


Figure 191. May 13 14:00-15:00 Customer 3 Discharge–PQ Meter Data

TEST EVENT 10: TUESDAY MAY 17, 3:00-4:00 PDT – START CHARGING

a) SCE Meter Baseline Analysis

According to Figure 192, the battery system was charging when the “Start Charging” command was received. However, the net facility load begins to drop as the test event progresses. This is likely attributable to the battery system being charged to near capacity prior to the event signal at 3:00.

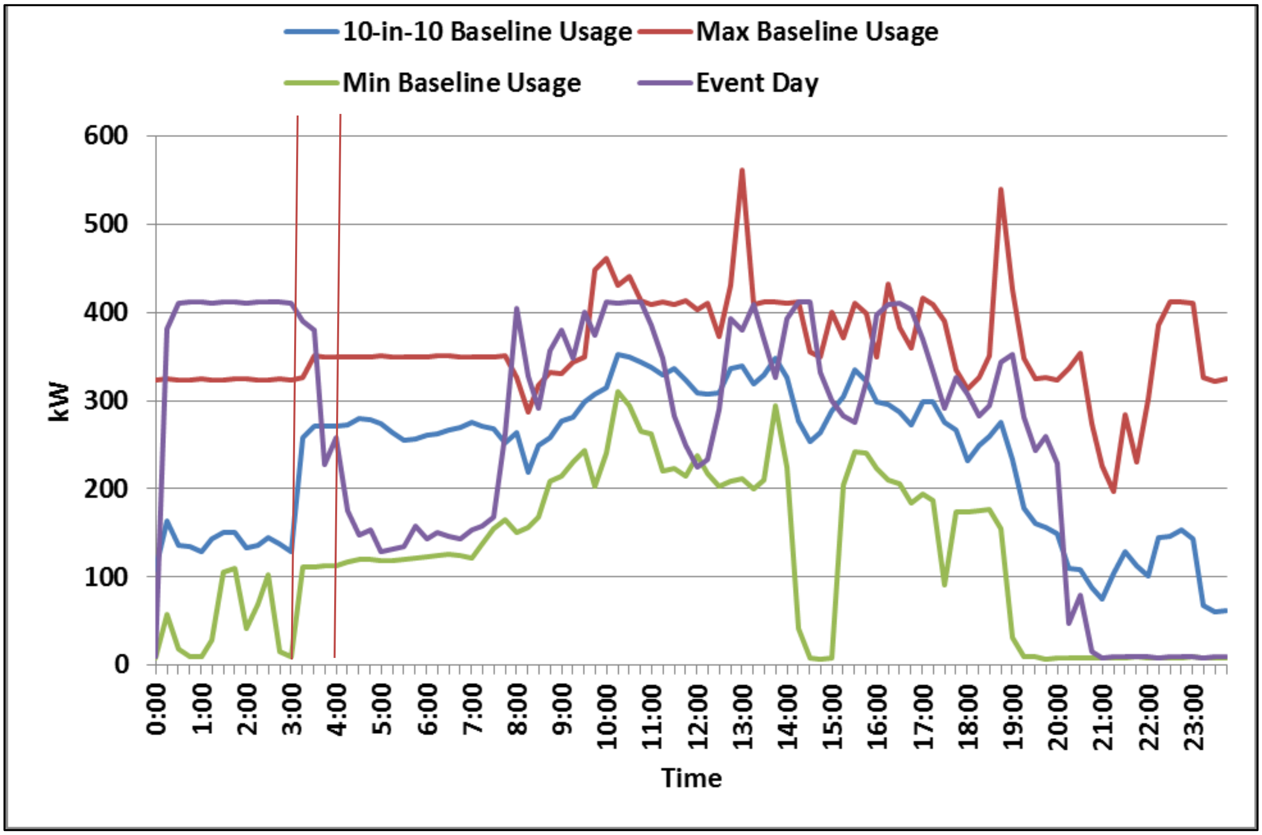


Figure 192. May 17 03:00-04:00 Customer 3 Start Charging – SCE Meter Data

The LA 10-in-10 estimate displayed in Figure 193 factors in the typical rise in charging-related usage that usually occurs at 3:15. The LA 10-in-10 is obviously not appropriate for this test event as a result. While event day usage indicates some demand response performance for the first 30 minutes, the general downward slope on event day does not indicate a strong response for charging across the event period.

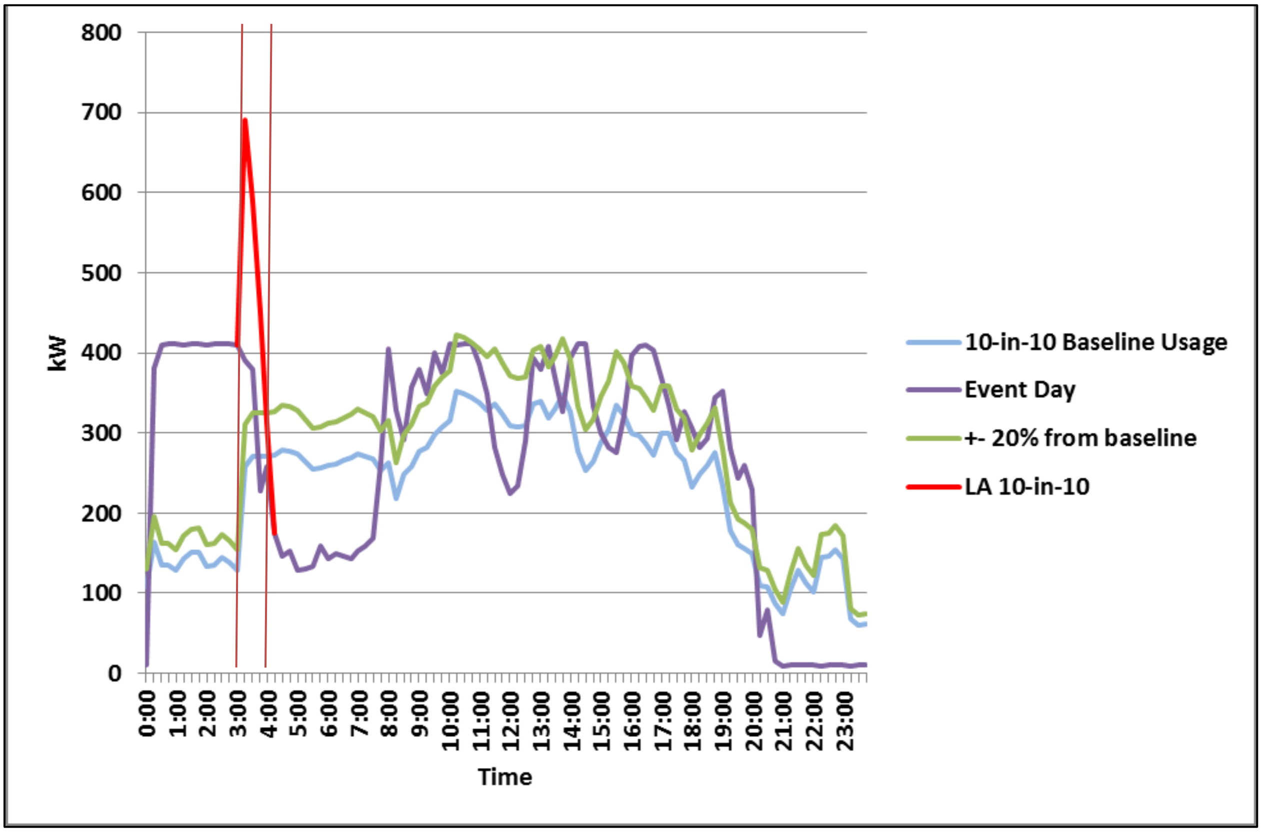


FIGURE 193. MAY 17 03:00-04:00 CUSTOMER 3 START CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 38. MAY 17 3:00-4:00 CUSTOMER 3 START CHARGING – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
2:45-3:00	410.40	-	-	-
3:00-3:15	390.24	131.76	80.06	(300.80)
3:15-3:30	380.16	108.72	54.43	(207.82)
3:30-3:45	227.52	(43.49)	(97.69)	(222.03)
3:45-4:00	257.76	(13.54)	(67.80)	(54.63)
4:00-4:15	175.68	-	-	-
Average kW	**313.92**	**45.86**	**(7.75)**	**(196.32)**
Average kWh	**313.92**	**45.86**	**(7.75)**	**(196.32)**
CBP Bid (kW)		100		
CBP Event Performance		**45%**		

b) Battery ALCS Baseline Analysis

The theory that the high usage preceding the event is due to battery charging behavior is verified in Figure 194. The battery begins at higher than what was observed in the baseline timeframe at 3:00 before trend towards neutral. Essentially, the battery system was already in an atypically high charging mode for the 2.5 hours prior to the "Start Charging" test event and as a result had reached full charge 30 minutes into the test event.

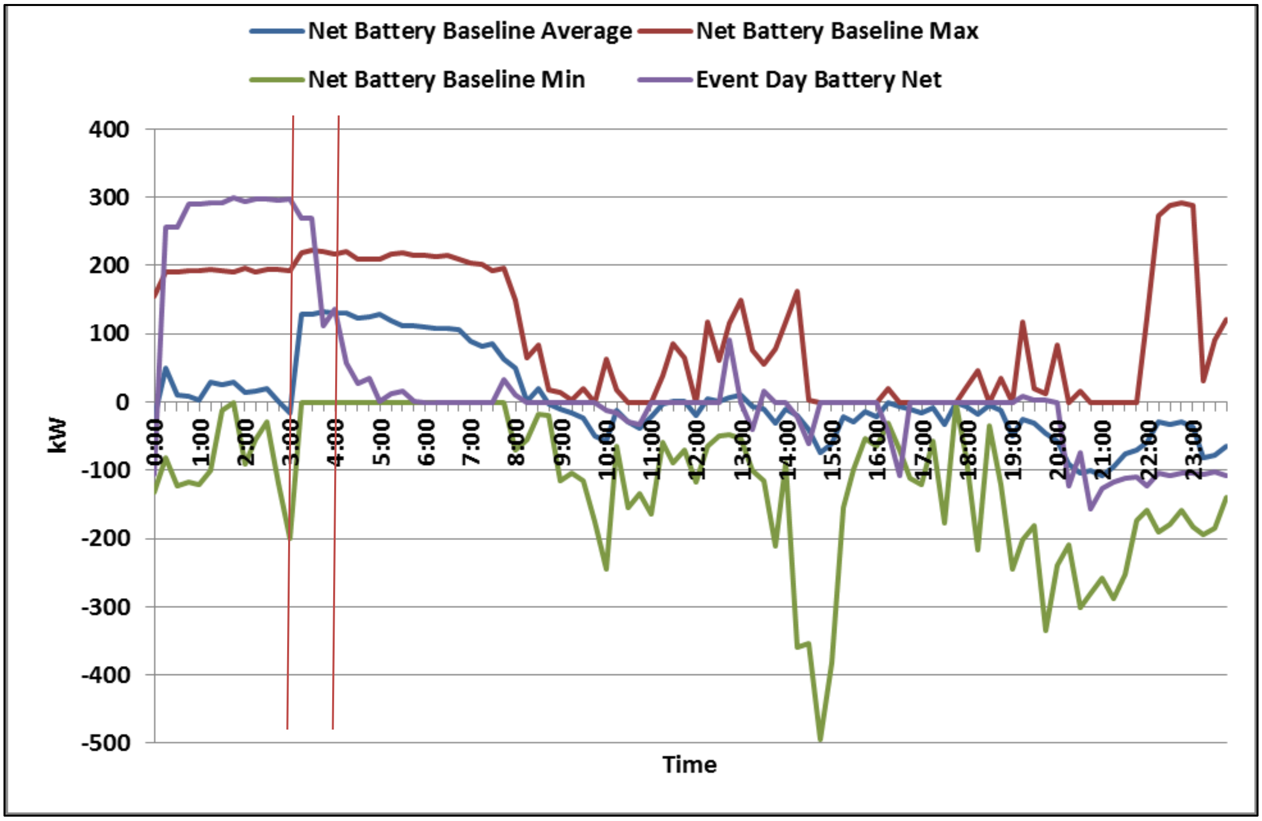


FIGURE 194. MAY 17 03:00-4:00 CUSTOMER 3 START CHARGING – BATTERY ALCS NET METER DATA

Figure 195 supports the conclusions reached shown in Figure 194.

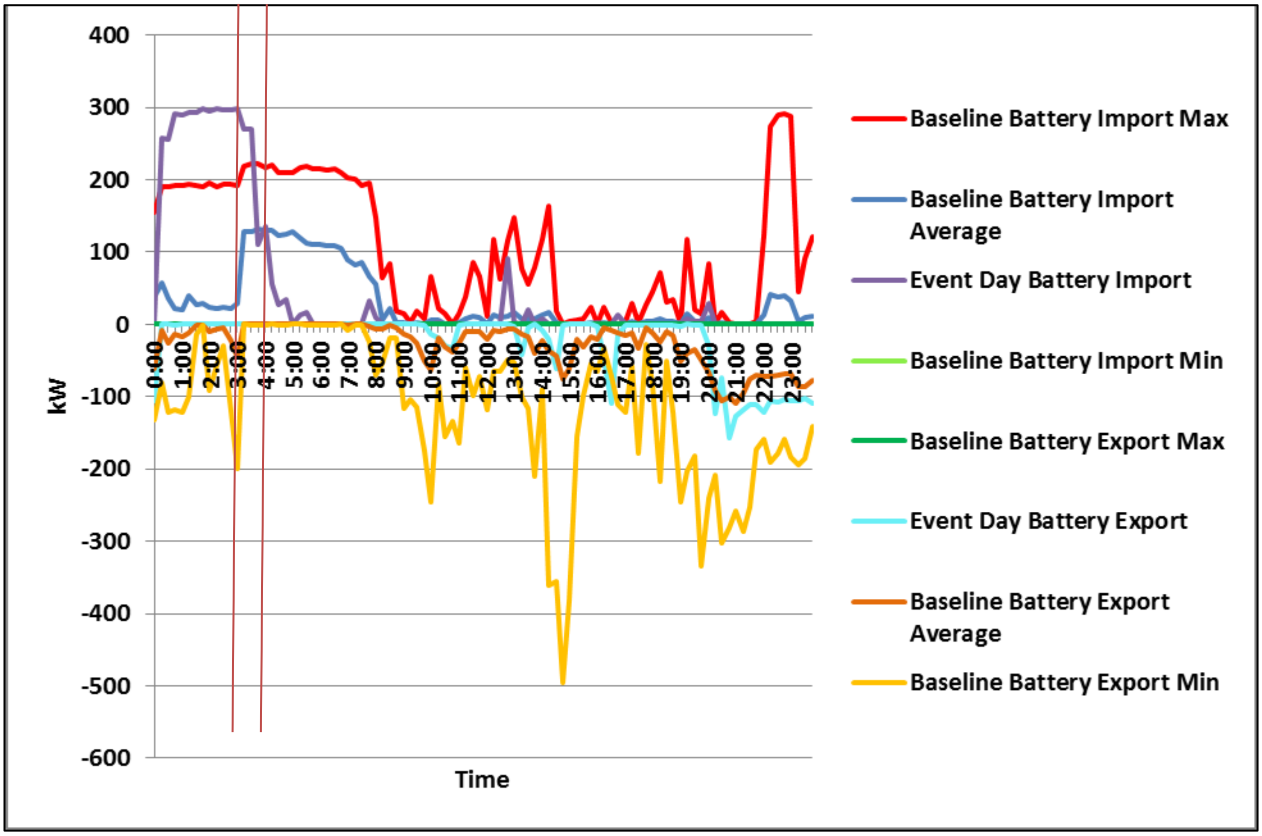


FIGURE 195. MAY 17 3:00-4:00 CUSTOMER 3 START CHARGING – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ MEASUREMENTS

The upper chart in Figure 196 aligns with both the Battery ALCS data shown in Figure 194 and Figure 195 as well as the SCE meter data shown in Figure 192 and Figure 193. The lower chart in Figure 196 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during, and after the test event period.

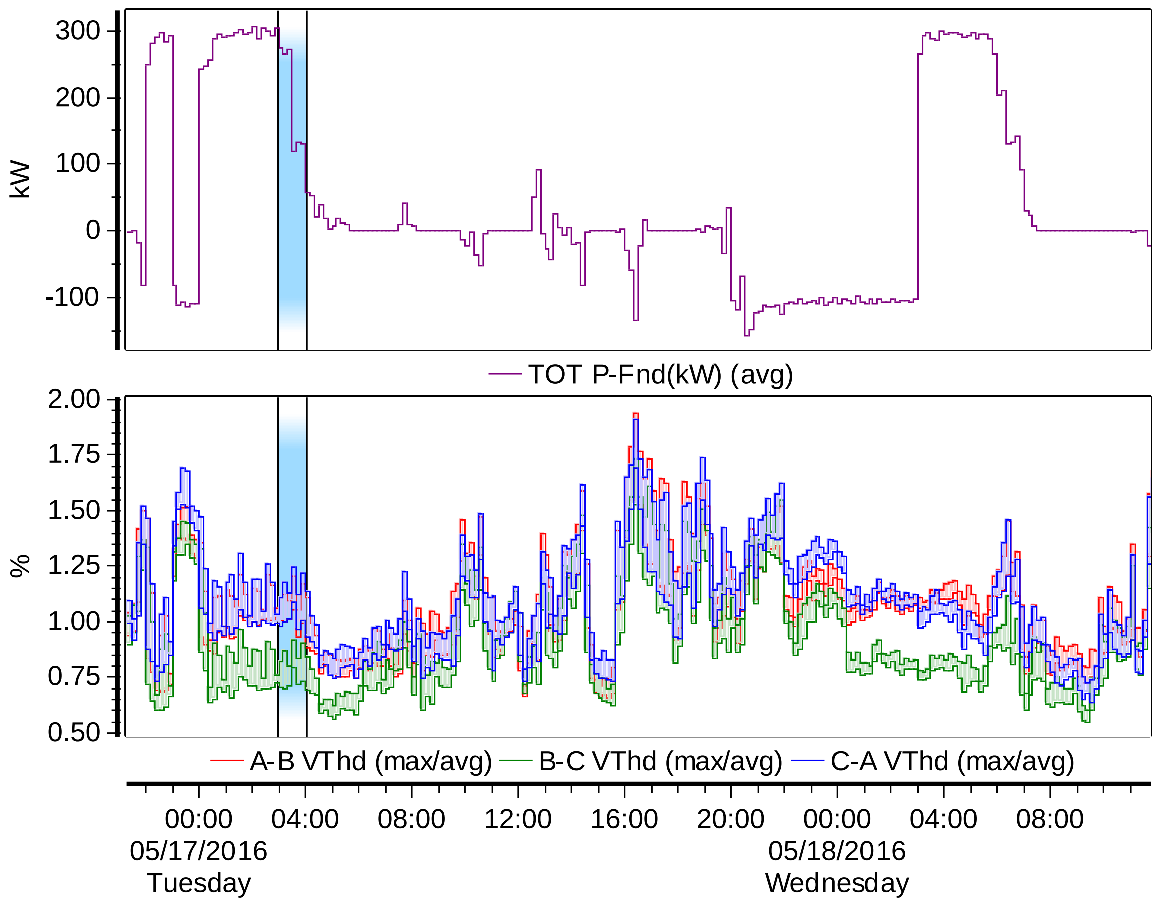


FIGURE 196. MAY 17 3:00-4:00 CUSTOMER 3 START CHARGING–PQ METER DATA

TEST EVENT 11: FRIDAY MAY 20, 3:00-4:00 PDT – START CHARGING

a) SCE Meter Baseline Analysis

The average, maximum, and minimum baseline usage in Figure 197 consistently increases from 3:00-3:15. This pattern of usage increase beginning at 3:00 complicates the Start Charging test at this same period. Event day usage increases from the minimum baseline usage to the maximum baseline usage from 3:00-3:15 seemingly in response to the Start Charging signal. Usage then remains at roughly the maximum baseline levels throughout the event period and for almost two hours thereafter.

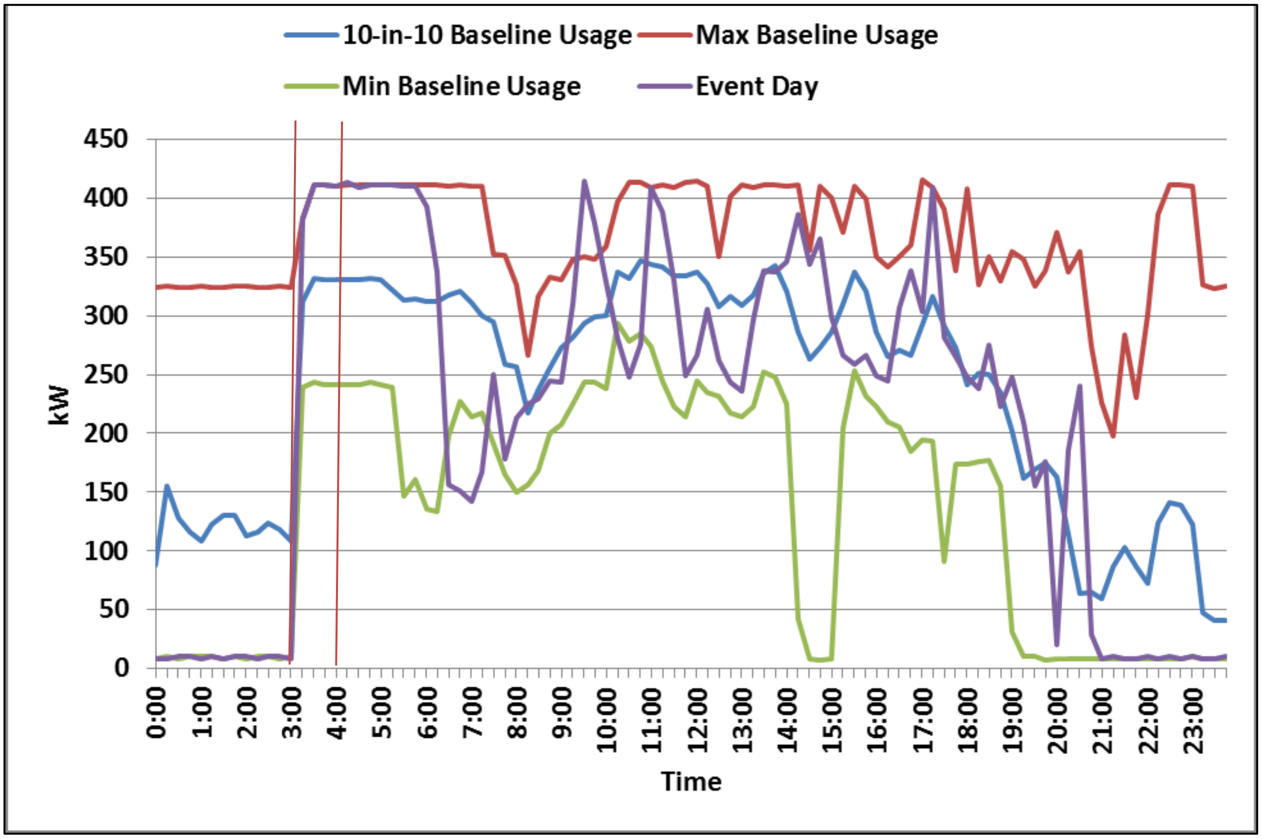


Figure 197. May 20 03:00-04:00 Customer 3 Start Charging – SCE Meter Data

Similar to the May 20 Customer 1 event, Figure 198 shows that the event day did response to a "Start Charging" test event in comparison with what would be expected with no event. For much of the morning prior to the event, usage was lower than the baseline average and near zero. Then, immediately after the start of event, usage rises significantly. It is interesting that usage remains high in the two hours following the conclusion of the event. In this instance, the *10-in-10 baseline* is the most conservative estimate of performance, the ± 20% from baseline adjusts for the usage being so low at the start of the event and the *LA 10-in-10* may best quantify the event performance since usage did not decrease subsequent to the test event.

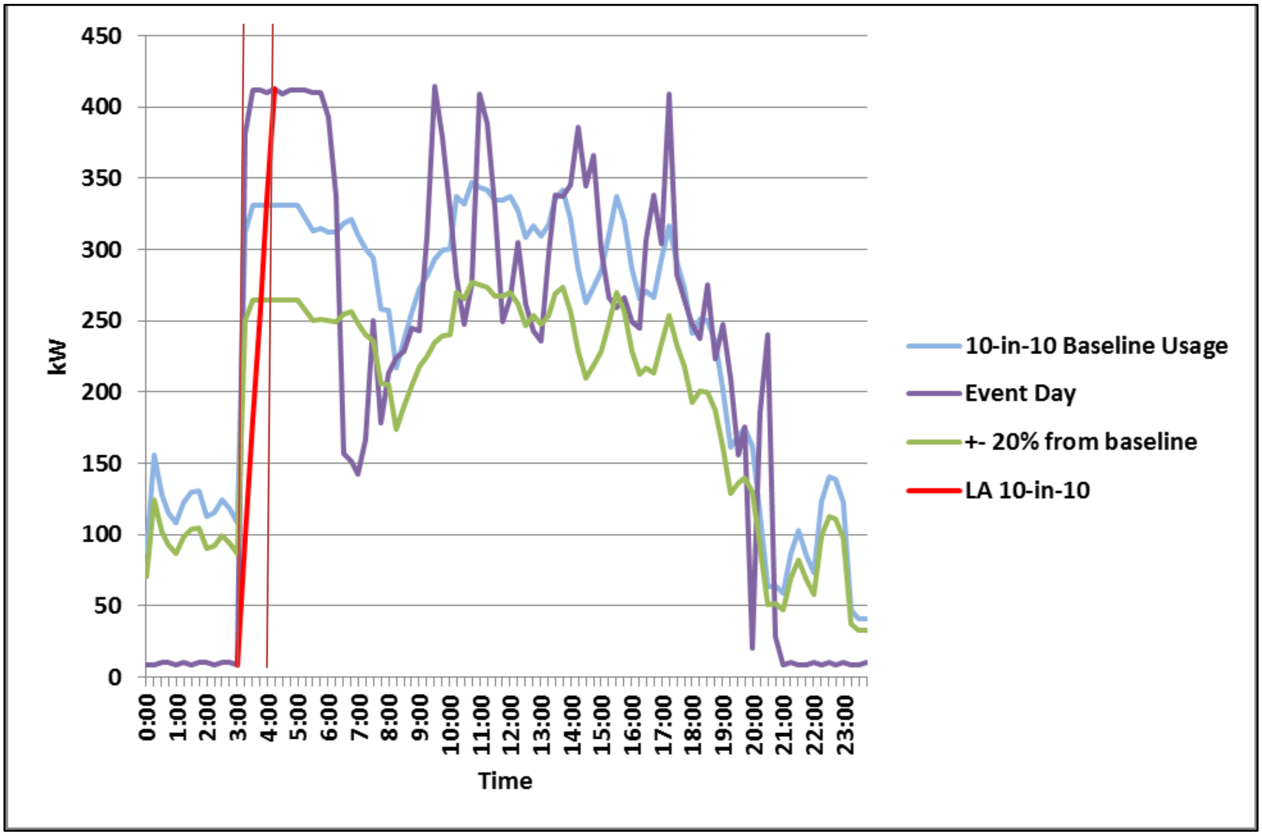


FIGURE 198.. MAY 20 03:00-04:00 CUSTOMER 3 START CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 39. MAY 20 3:00-4:00 CUSTOMER 3 START CHARGING – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
2:45-3:00	8.64	-	-	-
3:00-3:15	381.60	69.12	131.62	283.70
3:15-3:30	411.84	80.50	146.76	230.61
3:30-3:45	411.84	80.93	147.11	153.54
3:45-4:00	410.40	79.63	145.79	74.94
4:00-4:15	413.28	-	-	-
Average kW	**403.92**	**77.54**	**142.82**	**185.70**
Average kWh	**403.92**	**77.54**	**142.82**	**185.70**
CBP Bid (kW)		100		
CBP Event Performance		**78%**		

b) BATTERY ALCS BASELINE ANALYSIS

Figure 199 shows that for much of the morning prior to the event, battery performance was discharging at a rate of greater magnitude than the baseline average and near the minimum net battery baseline. Then, immediately after the start of event, battery performance rises significantly to the maximum. The event day blip in charging across 4:30-5:00 seen here is not observed at the meter.

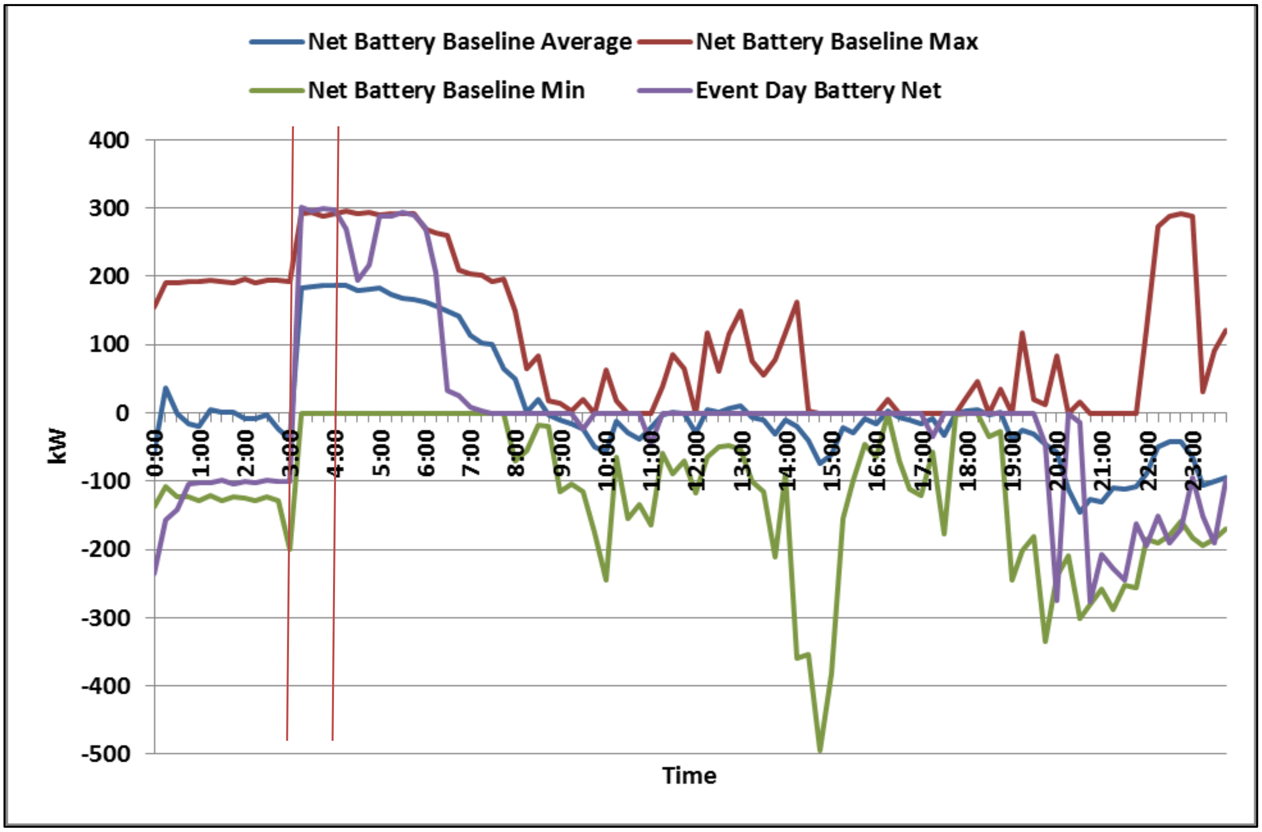


FIGURE 199. MAY 20 03:00-4:00 CUSTOMER 3 START CHARGING – BATTERY ALCS NET METER DATA

Figure 200 supports the conclusions reached in Figure 199.

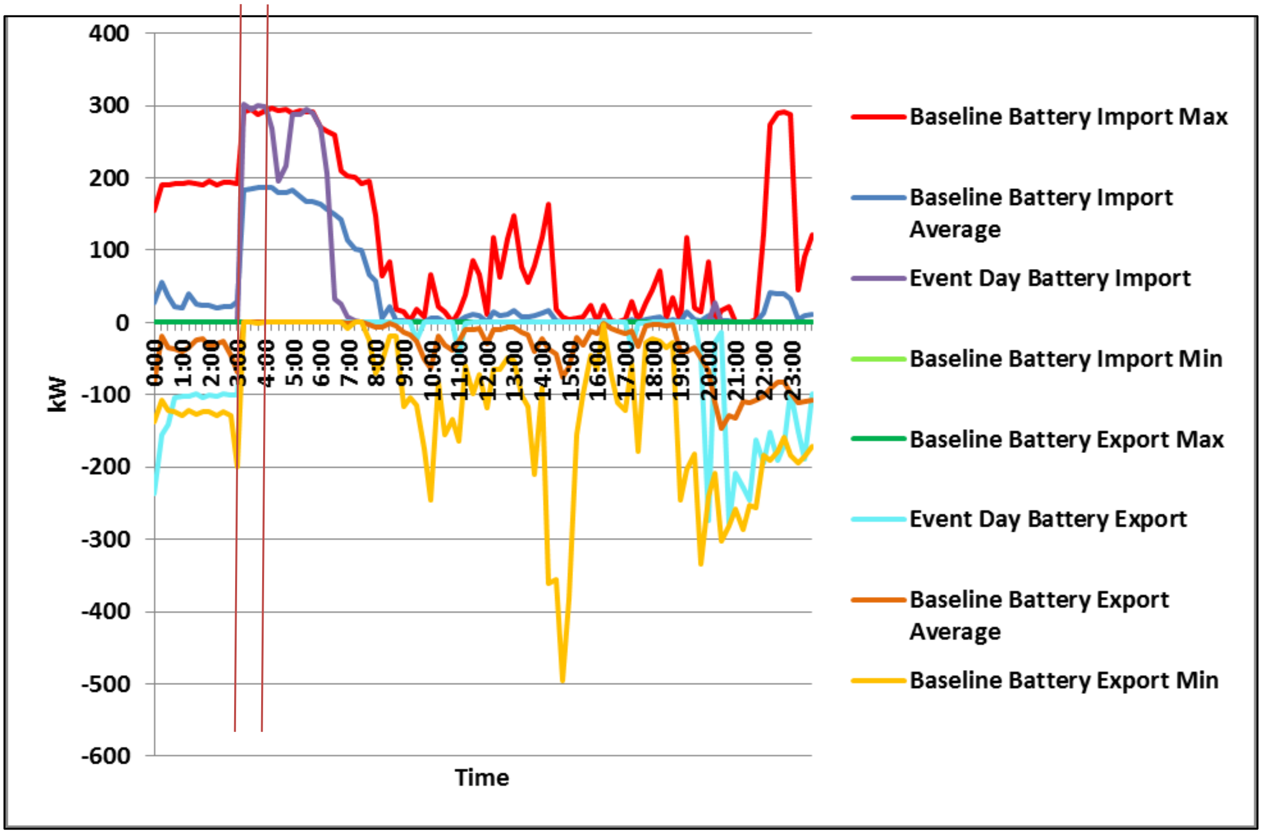


FIGURE 200. MAY 20 3:00-4:00 CUSTOMER 3 START CHARGING – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ Measurements

The upper chart in Figure 201 aligns with both the Battery ALCS data shown in Figure 199 and Figure 200 as well as the SCE meter data shown in Figure 197 and Figure 198. The lower chart in Figure 201 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during, and after the test event period.

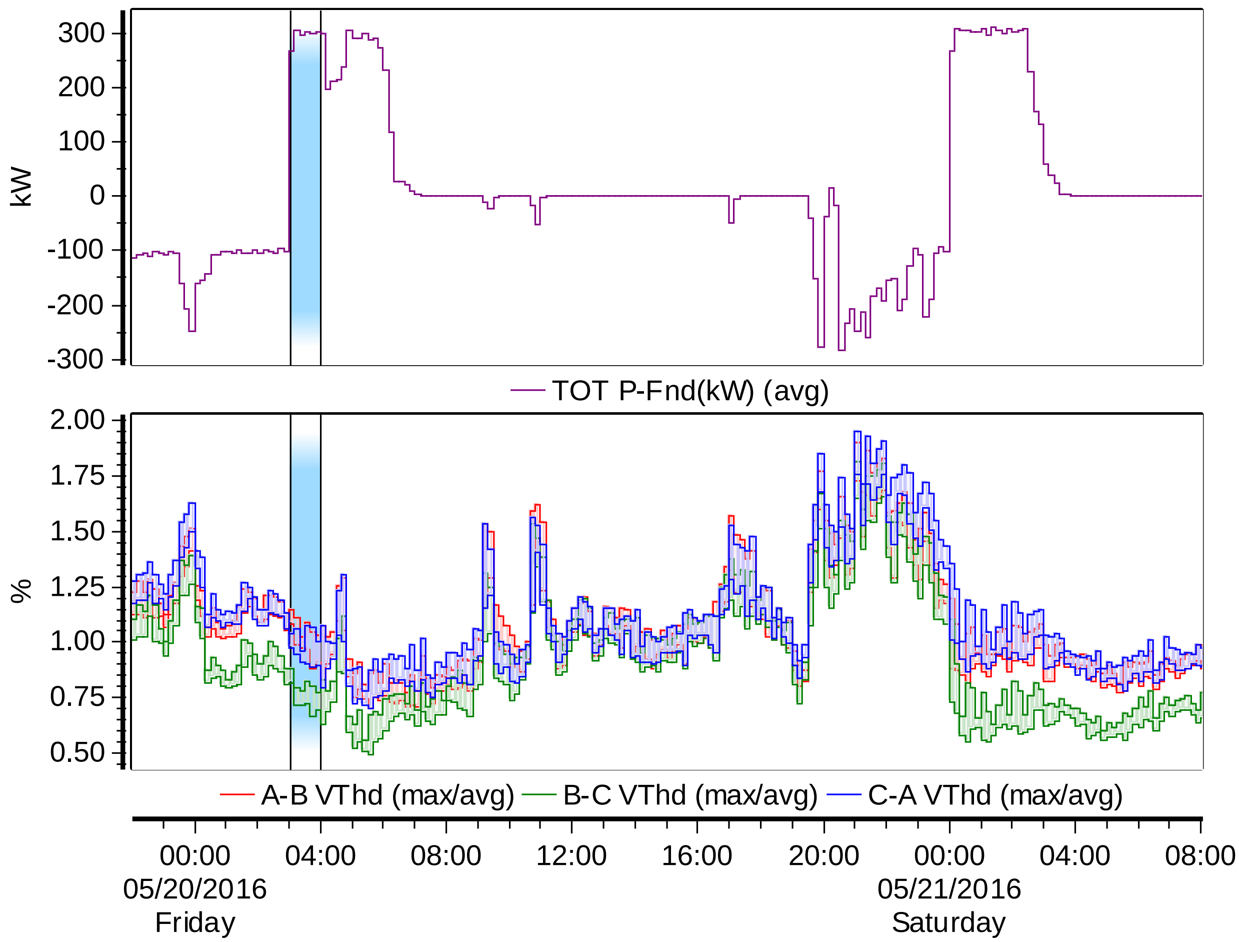


FIGURE 201. MAY 20 3:00-4:00 CUSTOMER 3 START CHARGING–PQ METER DATA

TEST EVENT 12: TUESDAY MAY 24, 3:00-4:00 PDT – START CHARGING

a) SCE Meter Baseline Analysis

Figure 202 shows the average, maximum, and minimum baseline usage increases from 3:00-3:15. This pattern of usage increase beginning at 3:00 complicates the Start Charging test at this same period. Event day usage increases from the minimum baseline usage to the maximum baseline usage from 3:00-3:15 seemingly in response to the Start Charging signal. Usage then remains at roughly the maximum baseline levels throughout the event period and for two hours thereafter in parallel with the max baseline usage (which actually continues at maximum for another hour in comparison to the event day).

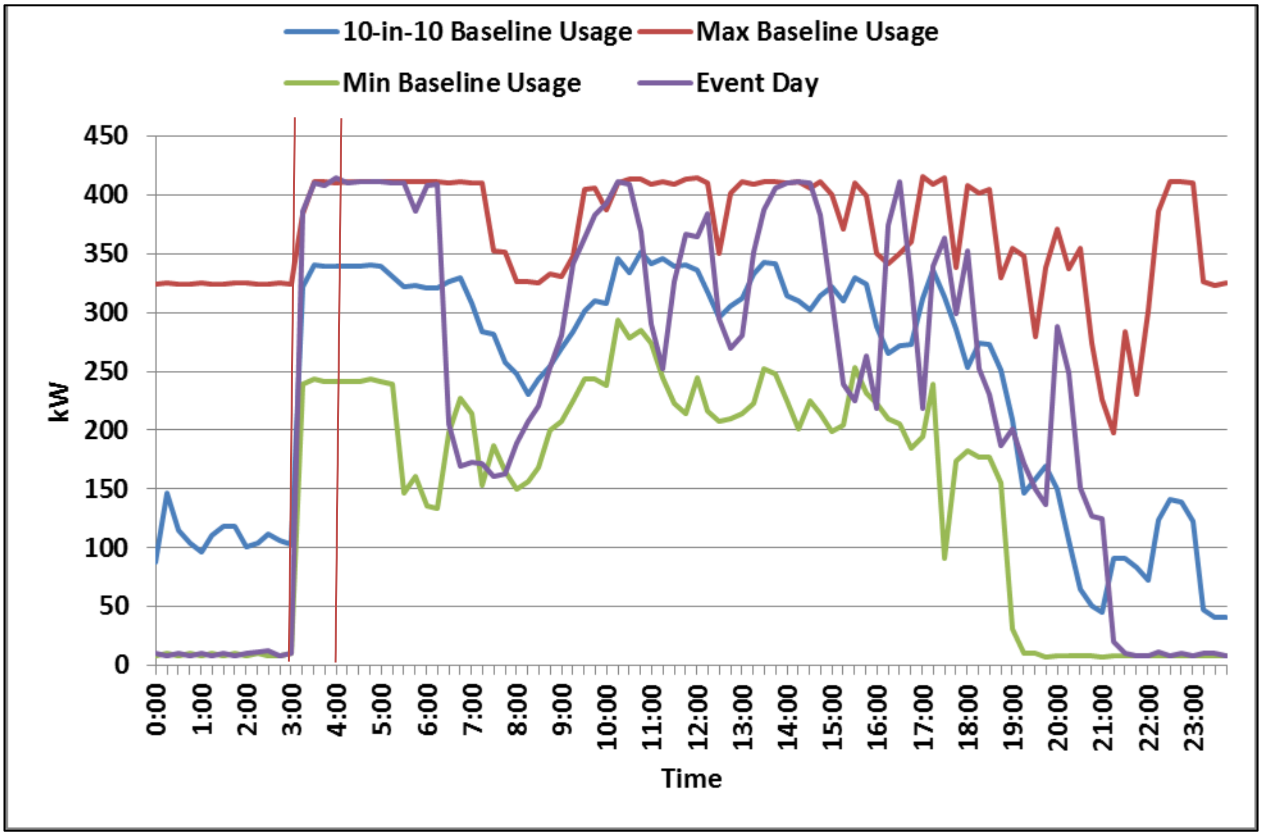


FIGURE 202. MAY 24 03:00-04:00 CUSTOMER 3 START CHARGING – SCE METER DATA

This test event is very similar to the May 20 test event. Figure 203 displays that the event day usage provided demand response compared to what is expected with no event. For much of the morning prior to the event, usage was lower than the baseline average and near zero. Then, immediately after the start of event, usage rises significantly. It is interesting that usage remains high in the two hours following the conclusion of the event. The baseline conclusions are the same as the May 20 test event with the *10-in-10 baseline* being a conservative measurement of performance, the ± *20 from baseline* adjusting for the very low usage prior to the test event and the *LA 10-in-10* adjusting to both the low usage prior to the test event and the continued high usage subsequent to the test event.

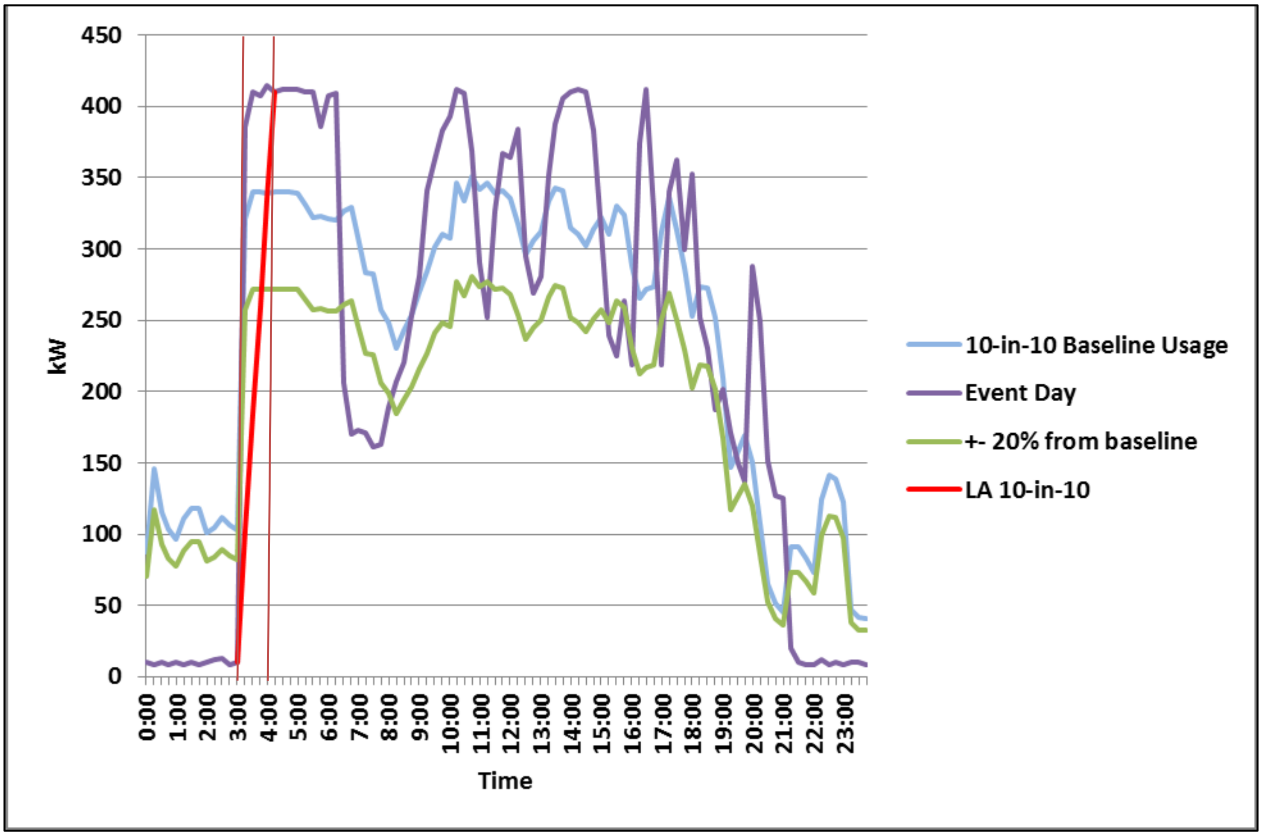


FIGURE 203. MAY 24 03:00-04:00 CUSTOMER 3 START CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. illustrates the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis.

TABLE 40. MAY 24 3:00-4:00 CUSTOMER 3 START CHARGING – PERFORMANCE OF EVENT

Time Period	Event Day Load	10-in-10 Performance (CPB EB)	10-in-10 20% cap Performance	LA 10-in-10 Performance
2:45-3:00	10.08	-	-	-
3:00-3:15	385.92	64.37	128.68	283.04
3:15-3:30	410.40	70.27	138.30	226.09
3:30-3:45	407.52	67.82	135.76	148.06
3:45-4:00	414.72	75.60	143.42	80.45
4:00-4:15	410.40	-	-	-
Average kW	**404.64**	**69.52**	**136.54**	**184.41**
Average kWh	**404.64**	**69.52**	**136.54**	**184.41**
CBP Bid (kW)		100		
CBP Event Performance		**70%**		

b) BATTERY ALCS BASELINE ANALYSIS

Figure 204 shows that, similar to the May 20 event, battery performance was discharging at a rate of greater magnitude than the baseline average and near the minimum net battery baseline. Then, immediately after the start of event, battery charging rises significantly to align with the net battery baseline maximum.

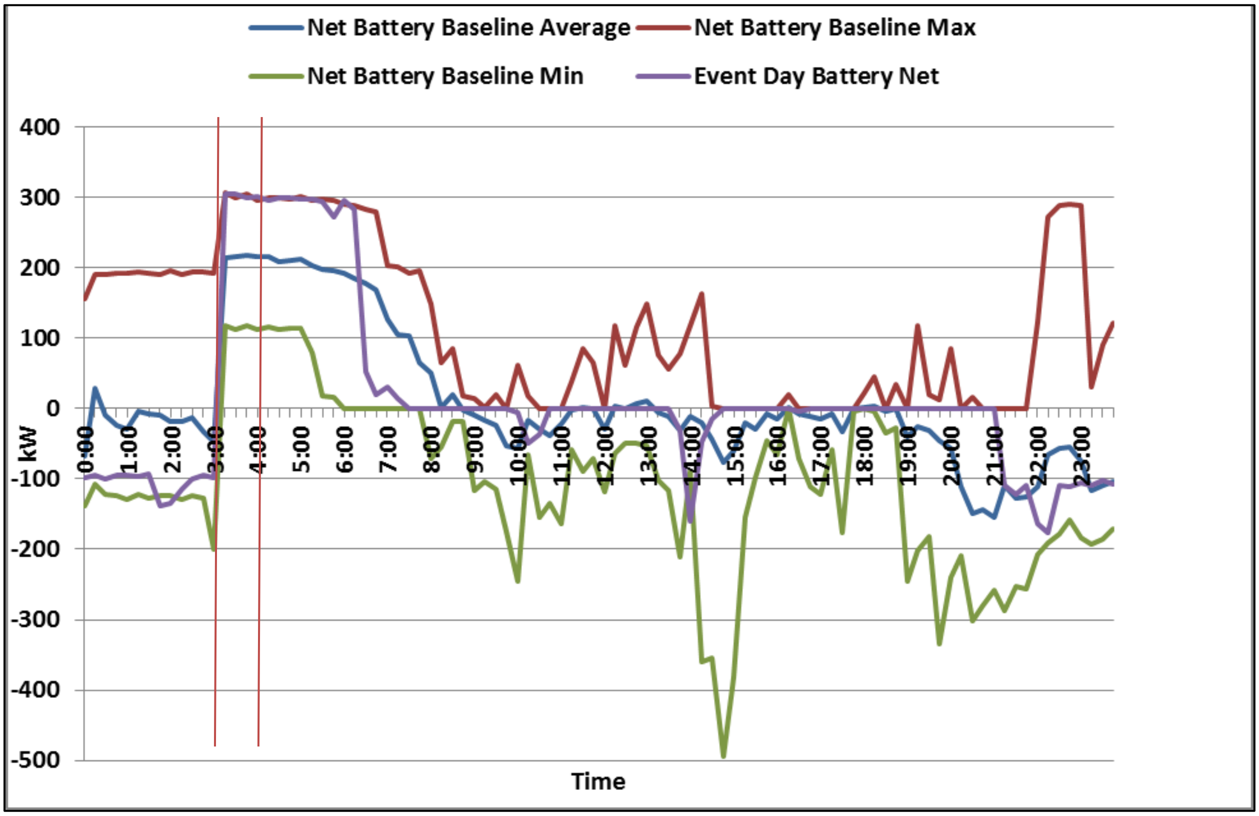


FIGURE 204. MAY 24 03:00-4:00 CUSTOMER 3 START CHARGING – BATTERY ALCS NET METER DATA

Figure 205 supports the conclusions reached above.

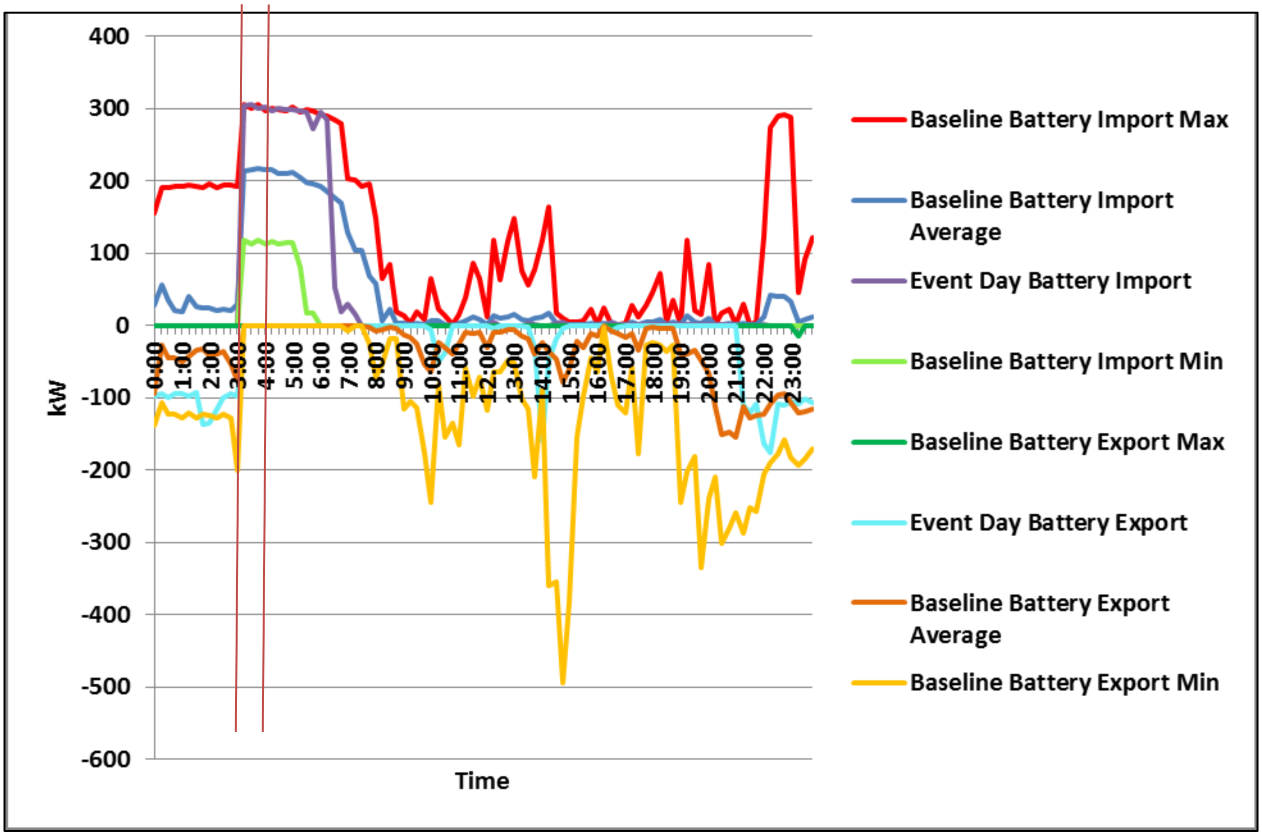


FIGURE 205. MAY 24 3:00-4:00 CUSTOMER 3 START CHARGING – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ Measurements

The upper chart in Figure 206 aligns with both the Battery ALCS data shown in Figure 204 and Figure 205 as well as the SCE meter data shown in Figure 202 and Figure 203. The lower chart in Figure 206 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during and after the test event period.

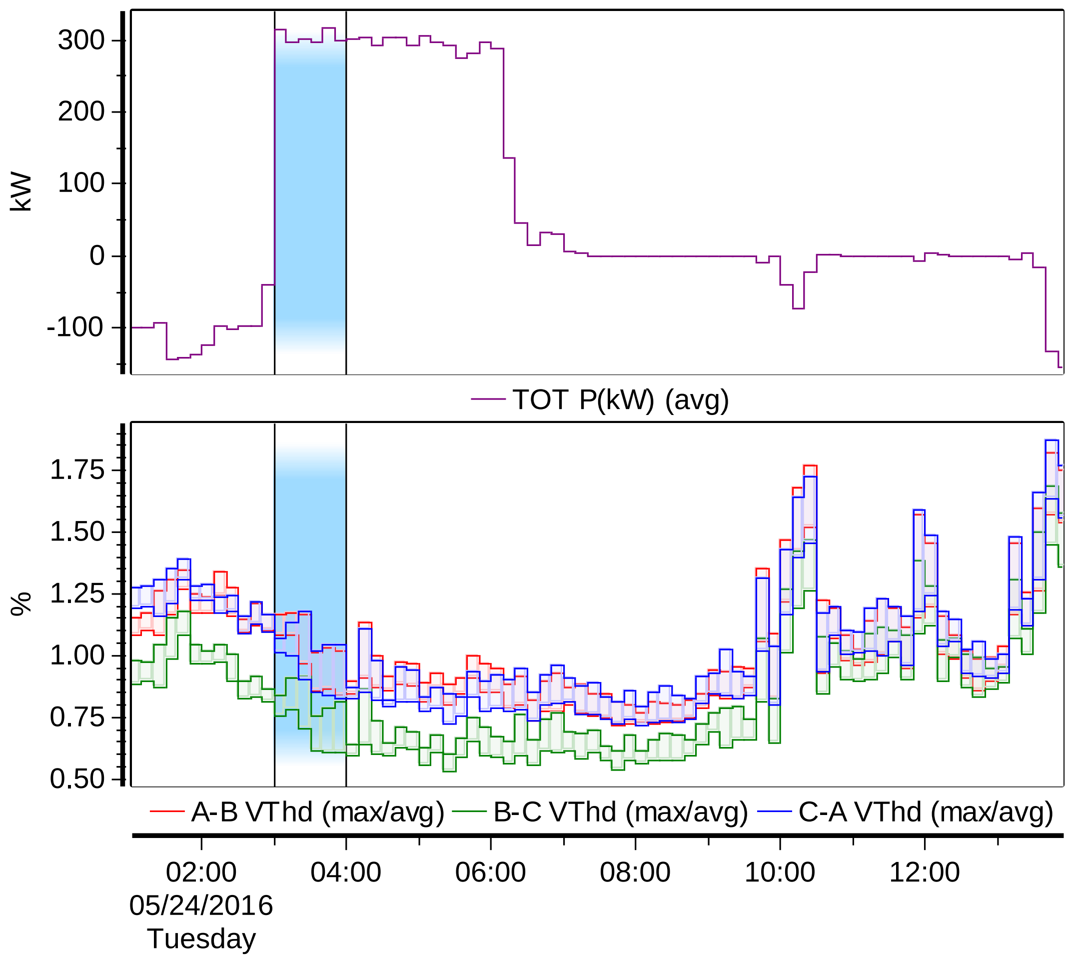


Figure 206. May 24 3:00-4:00 Customer 3 Start Charging–PQ Meter Data

Test Event 13: Wednesday June 8, 3:00 -4:00 PDT – Start Charging

a) SCE Meter Baseline Analysis

Similar to the June 8 Customer 2 event, Figure 207 shows the event day usage trended near the Maximum baseline usage preceding the event before dropping below the average baseline usage by the end of the event. The big difference is that the event day usage only maintained its high usage for the first 15 minutes of the event (instead of 30 at Customer 2), which results in an even worse performance for the "Start Charging" signal.

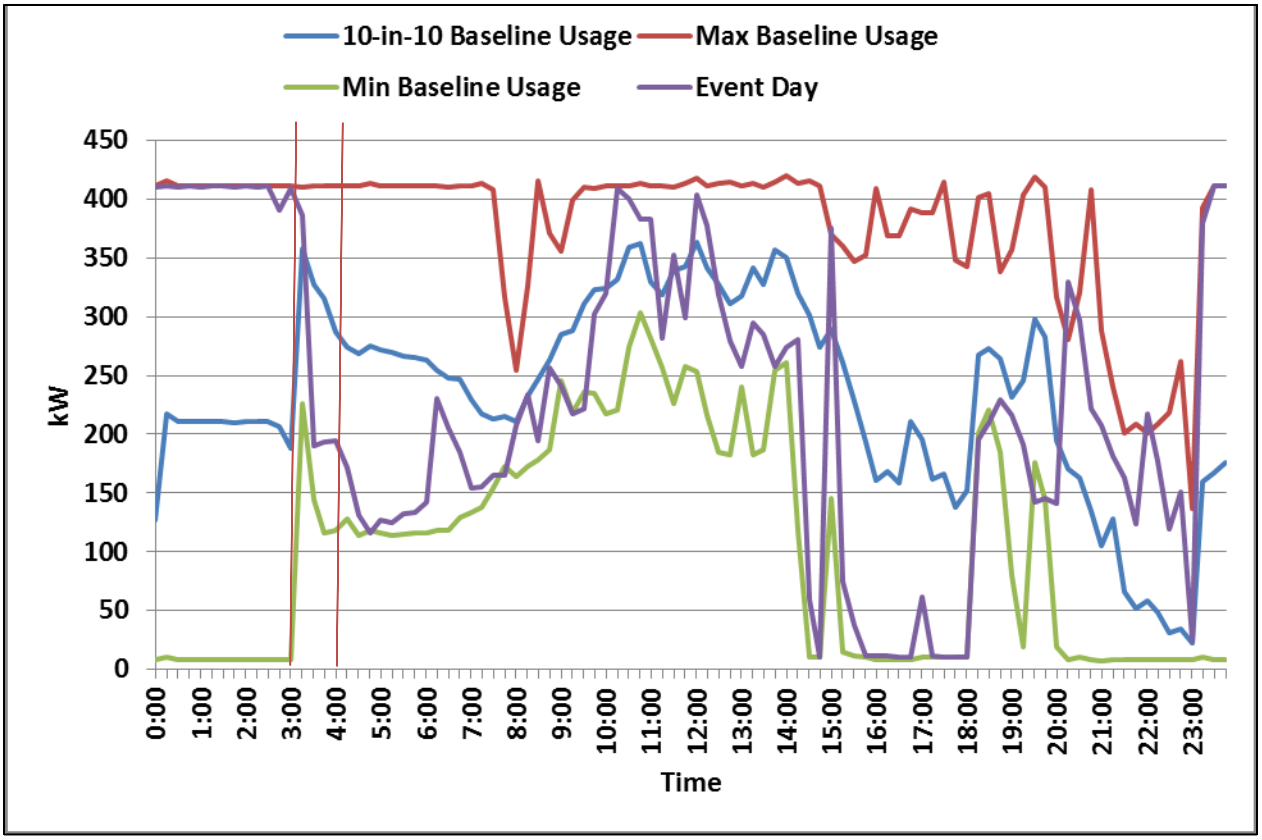


Figure 207. June 8 03:00-04:00 Customer 3 Start Charging – SCE Meter Data

Figure 208 supports the observation from above that the battery did not respond to the event day "Start Charging" signal. There is a sharp decrease in usage during the event period, while an ideal response to the "Start Charging" signal will be a sharp increase. The LA 10-in-10 baseline does not look appropriate as the event day usage varies from maximum baseline prior to the test event and minimum baseline subsequent to the event making the linear adjustment of the 10-in-10 baseline unsuitable for measuring event performance. The ± 20% baseline in this instance exacerbates the underperformance of the "Start Charging" test event by moving the baseline curve up relative to the 10-in-10 baseline curve.

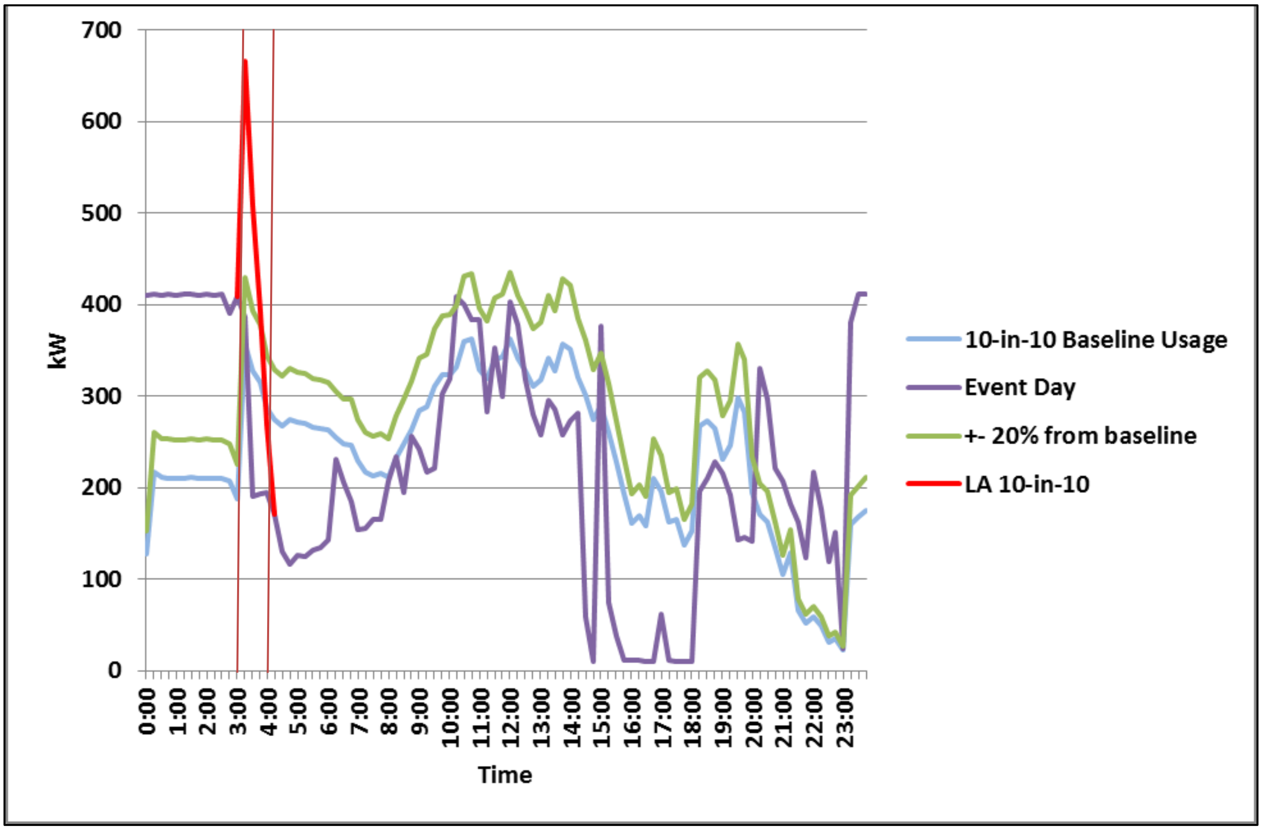


FIGURE 208. JUNE 8 03:00-04:00 CUSTOMER 3 START CHARGING – DR BASELINE ESTIMATES

Error! Reference source not found. shows the calculated energy and demand response for the different baseline methodologies utilized for the DR M&V analysis. The negative CBP event performance indicates that the battery responded opposite of what was expected. In this instance, instead of an increase in usage relative to the baseline for the Start Charging event, there was an average 81 kW decrease in usage relative to the baseline.

TABLE 41. JUNE 8 3:00-4:00 CUSTOMER 3 START CHARGING – PERFORMANCE OF EVENT

TIME PERIOD	EVENT DAY LOAD	10-IN-10 PERFORMANCE (CPB EB)	10-IN-10 20% CAP PERFORMANCE	LA 10-IN-10 PERFORMANCE
2:45-3:00	408.96	-	-	-
3:00-3:15	385.92	28.37	(43.14)	(279.82)
3:15-3:30	190.08	(137.52)	(203.04)	(318.56)
3:30-3:45	192.96	(121.97)	(184.95)	(198.59)
3:45-4:00	194.40	(92.88)	(150.34)	(73.92)
4:00-4:15	171.36	-	-	-
Average kW	**240.84**	**(81.00)**	**(145.37)**	**(217.72)**
Average kWh	**240.84**	**(81.00)**	**(145.37)**	**(217.72)**
CBP Bid (kW)		100		
CBP Event Performance		**-81%**		

b) Battery ALCS Baseline Analysis

Figure 204 shows that the battery was charging at a level greater than the baseline average in advance of the event. Then, as the event started, the battery began charging less. The event day battery profile did not perform up to the baseline for the 4 hours following the event.

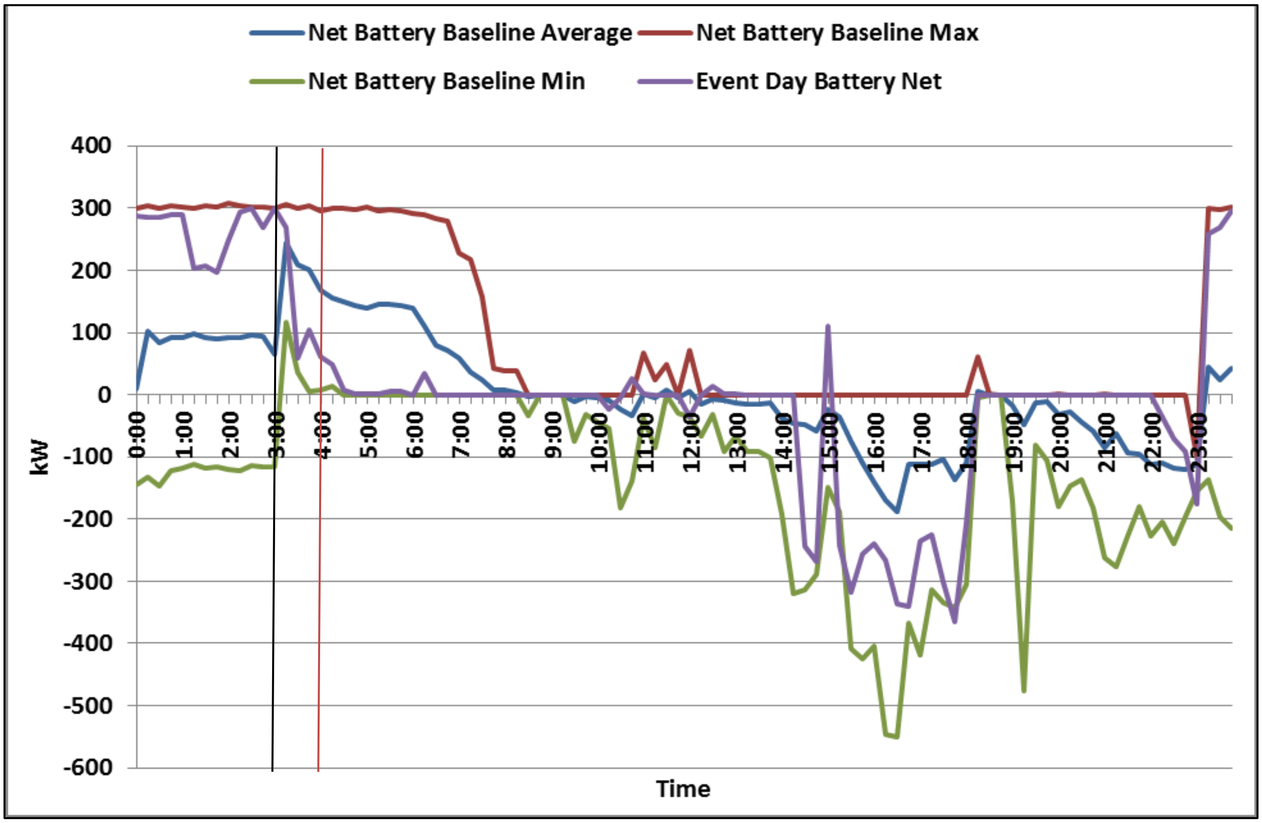


Figure 209. June 8 03:00-4:00 Customer 3 Start Charging – Battery ALCS Net Meter Data

Figure 205 supports the conclusions outlined in Figure 204.

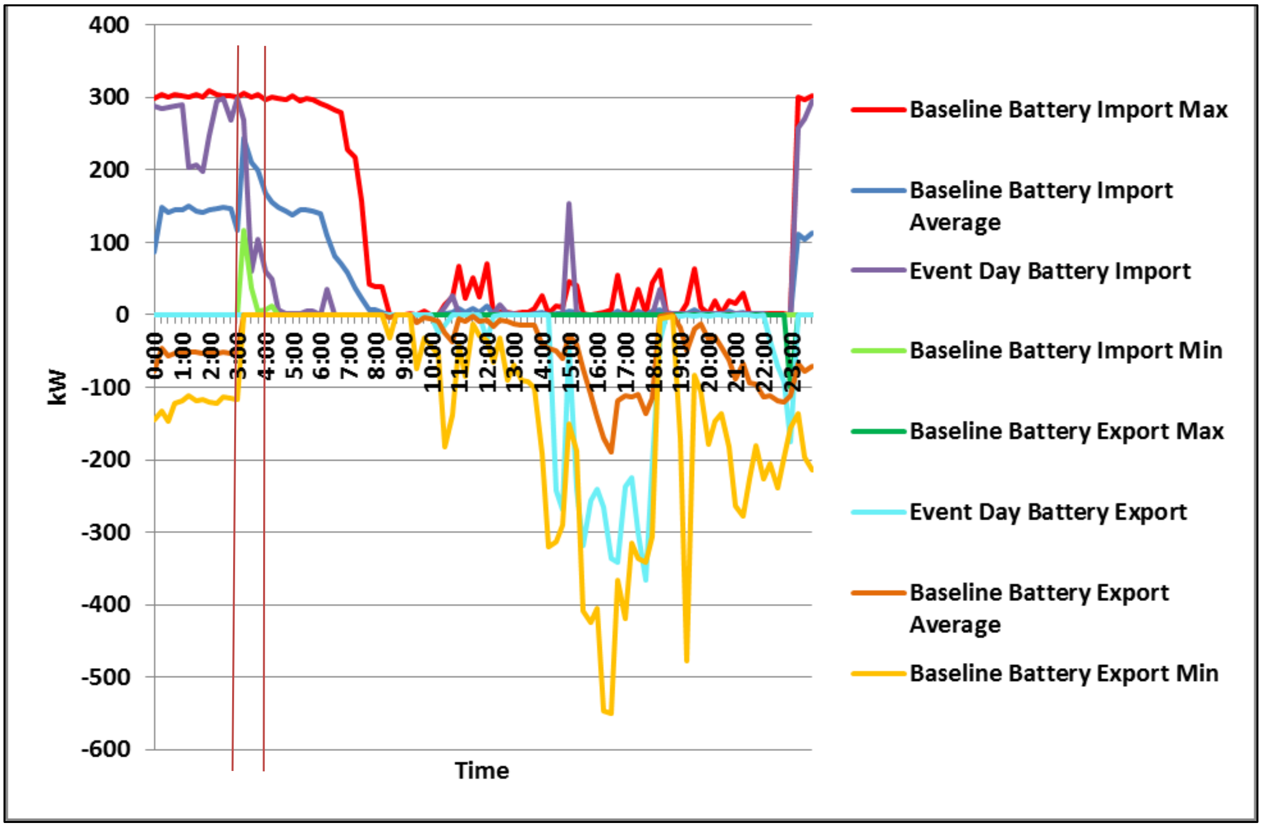


FIGURE 210. JUNE 8 3:00-4:00 CUSTOMER 3 START CHARGING – BATTERY ALCS IMPORT/EXPORT METER DATA

c) PQ Measurements

The upper chart in Figure 211 aligns with both the Battery ALCS data shown in Figure 209 and Figure 210 as well as the SCE meter data shown in Figure 207 and Figure 208. The lower chart in Figure 211 shows that the VThd as a measurement of power quality was within the normal range (< 5%) prior to, during, and after the test event period.

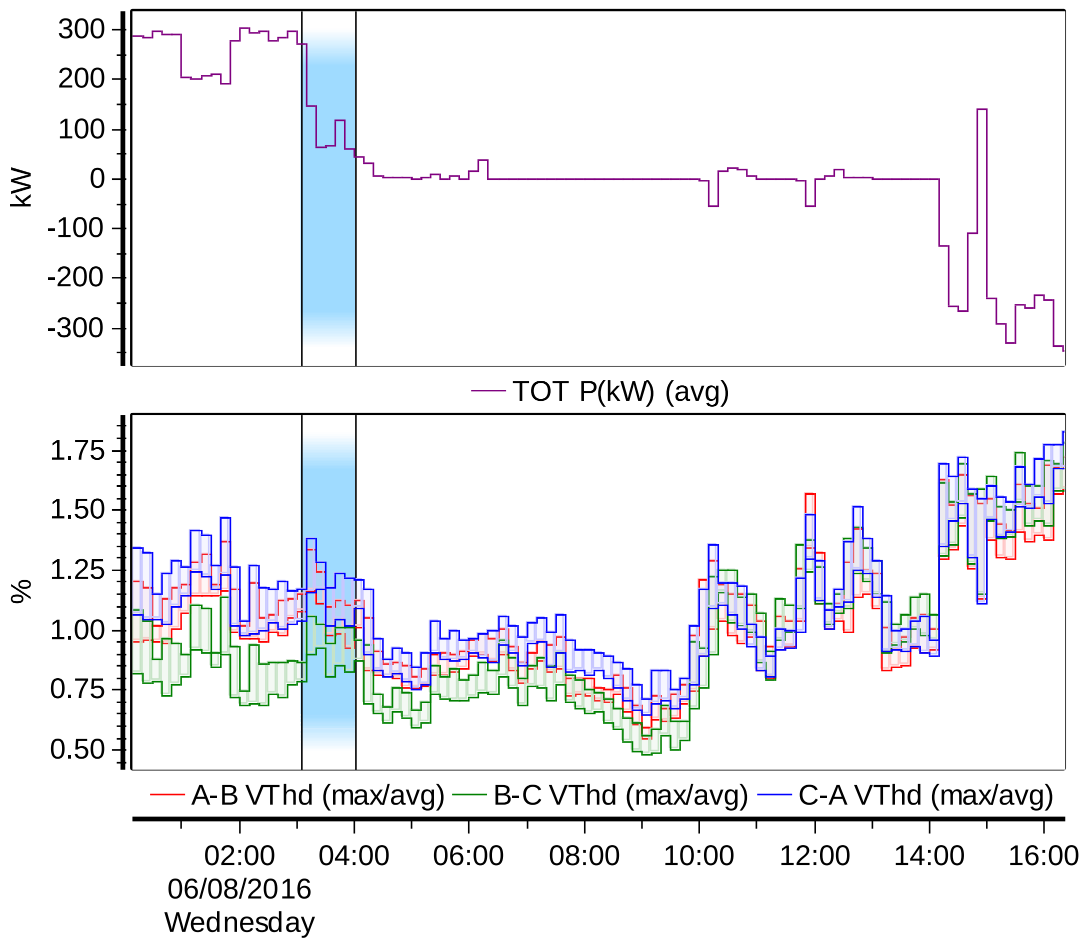


Figure 211. June 8 3:00-4:00 Customer 3 Start Charging–PQ Meter Data

CUSTOMER 3 POWER QUALITY EVALUATION

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.

a) CUSTOMER 3 POWER QUALITY EVALUATION TREND DATA

For three months of PQ data was collected from the Customer 3 battery storage system. The monitor was connected directly at the 480V combiner panel input to the battery system. Approximately 10 cycles of charging (positive power) and discharging (negative power) were observed over the days of June 10-20, 2016.

The basic quantities of voltage, current, power, and reactive power are trended in Figure 212. Positive power (kW) indicates that the battery system is charging and negative power indicates that the system is discharging energy back to the grid. In general, the system will charge in the early morning hours (midnight to 4am) and it will discharge in the late afternoon (3-6 pm).

Figure 213 is a trend of the voltage, power, and perceptible voltage flicker. The flicker Pst is a 10-minute measure of the steadiness of the system voltage, where the IEEE Standard 1453 recommends that the system maintain variations less than Pst < 1.0 as is the case at the connection of the Customer 2 battery system.

Figure 214 compares the power and the harmonic voltage distortion. The trends show that the voltage distortion is within a good range, easily meeting the IEEE Standard 519 recommended limit of 5%.

Figure 215 shows characteristic lower order harmonic voltages (3^{rd}, 5^{th}, and 7^{th}). The trends do not reflect the cycling of the battery system, rather they are influenced by the background (other sources) of harmonic levels on the grid.

Figure 216 shows higher order harmonic voltages (23^{rd}, 25^{th}, and 35^{th}) that will be typical of energy storage inverters.

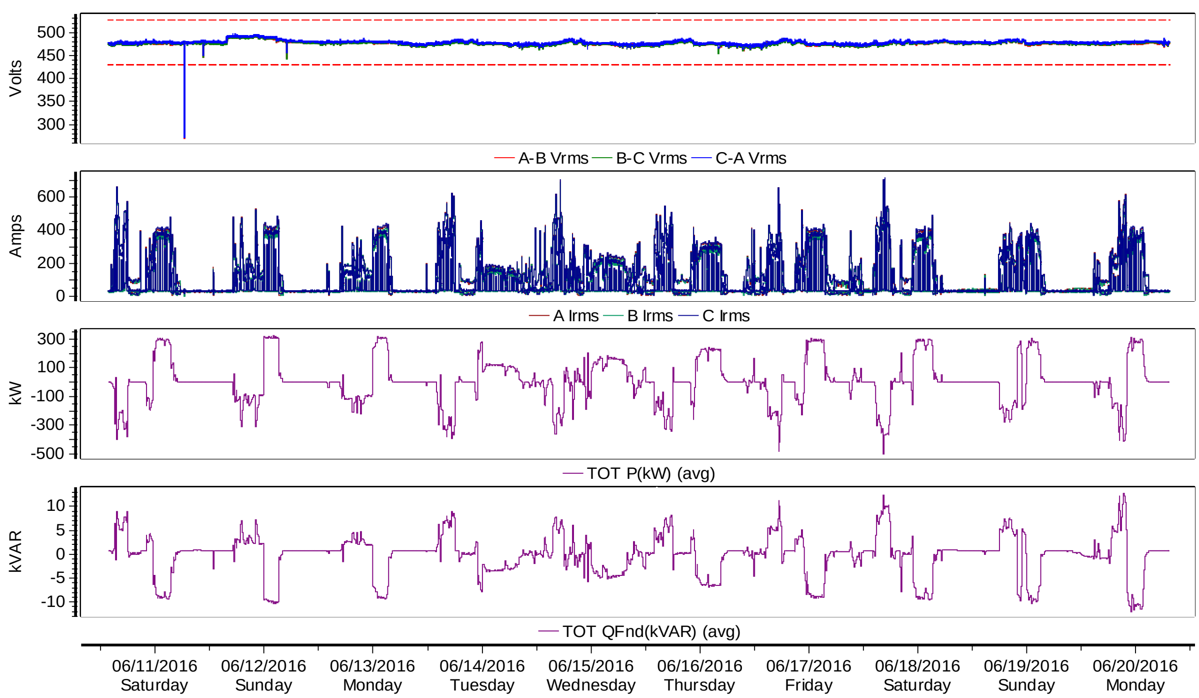


FIGURE 212. VOLTAGE (VRMS), CURRENT (IRMS), POWER (KW), AND REACTIVE POWER (KVAR)

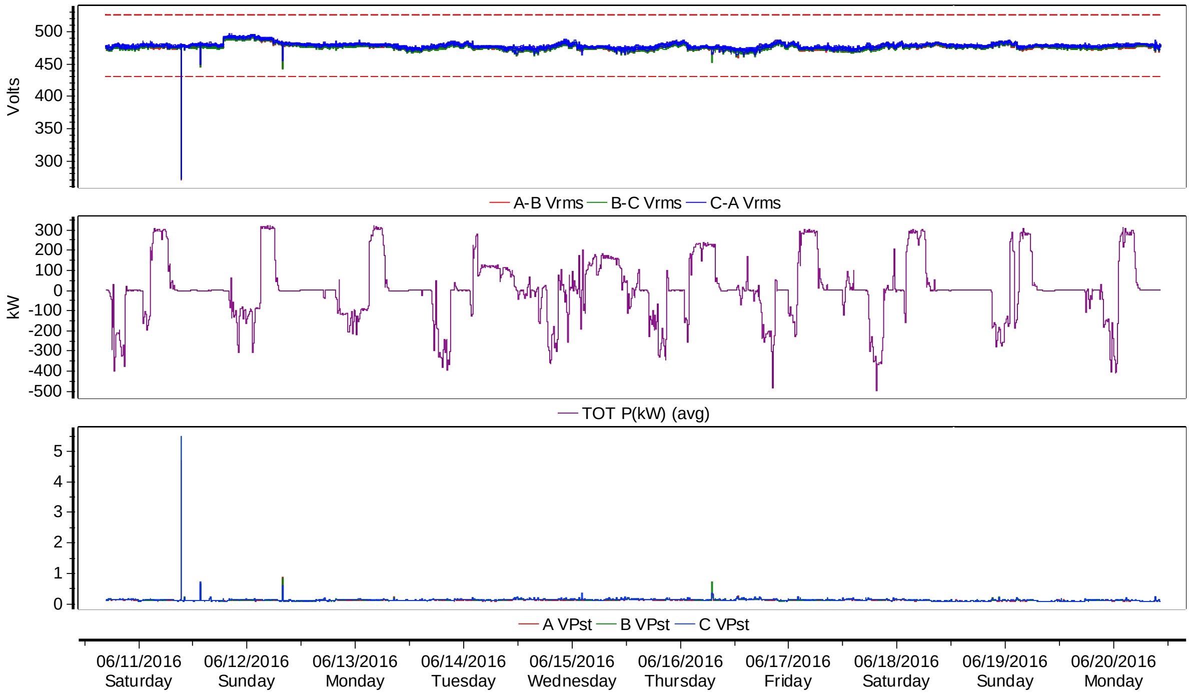


FIGURE 213. VOLTAGE (VRMS), POWER (KW), AND PERCEPTIBLE VOLTAGE FLICKER (PST)

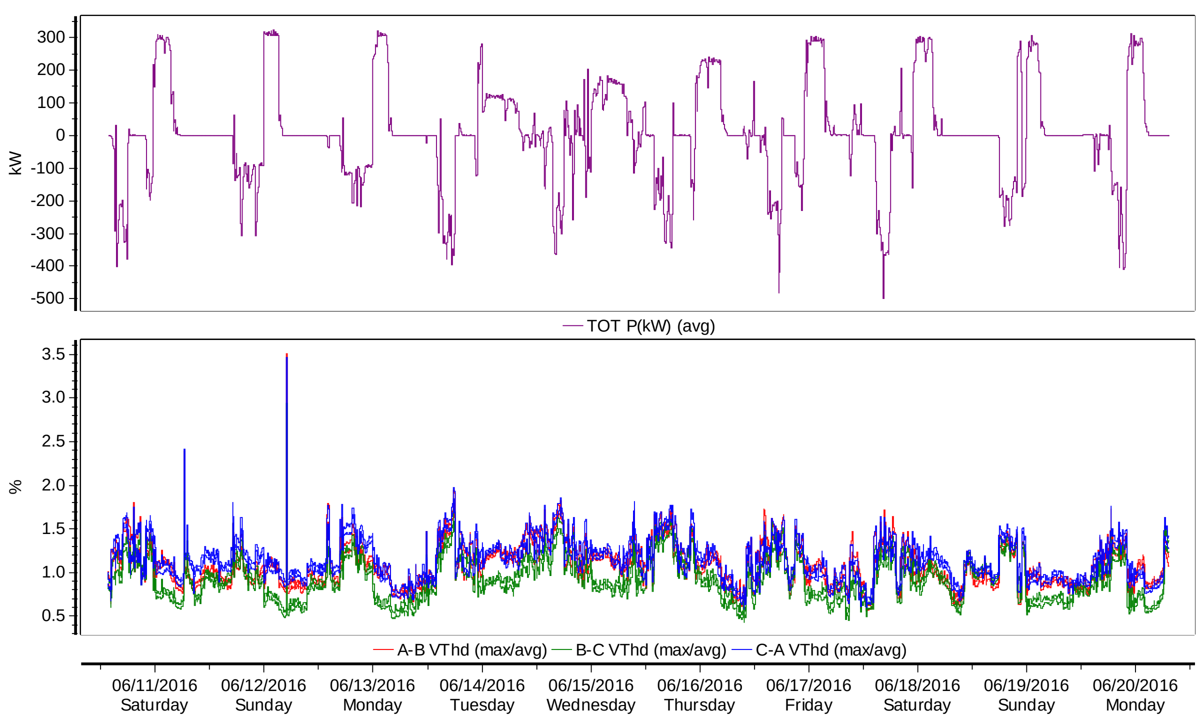


FIGURE 214. POWER (KW) AND HARMONIC DISTORTION (VTHD)

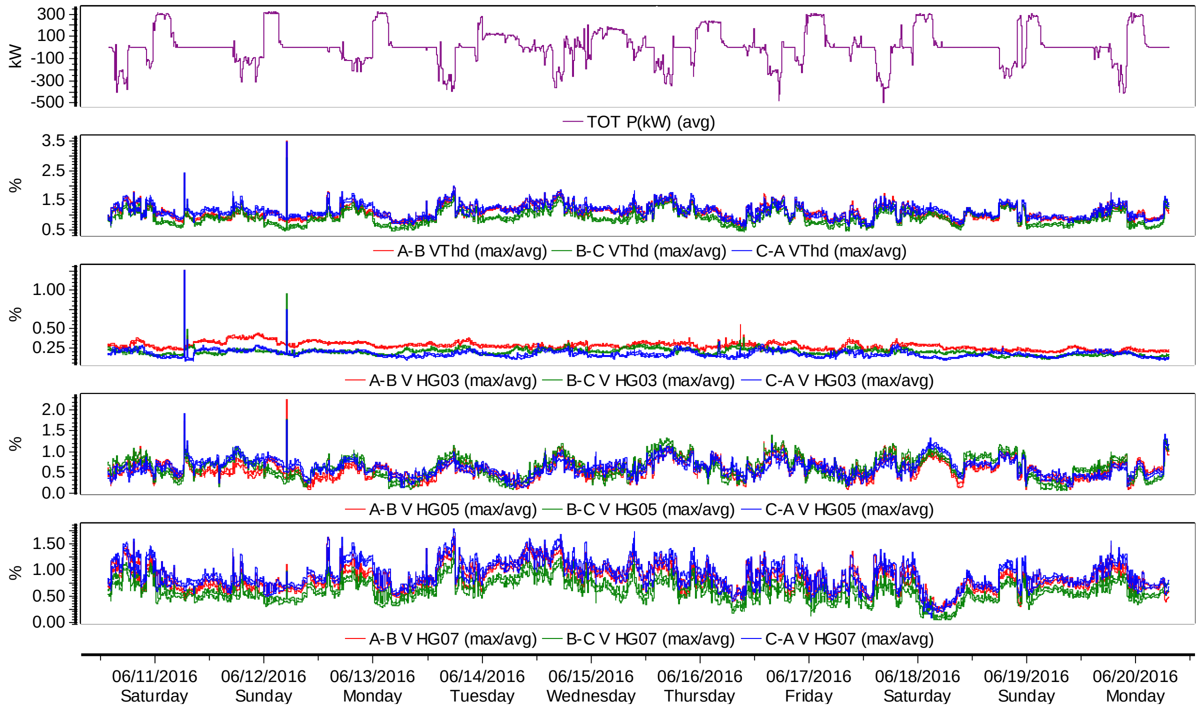


FIGURE 215. POWER (KW), HARMONIC DISTORTION (VTHD), 3RD HARMONIC VOLTS (HG03), 5TH HARMONIC VOLTS (HG05), AND 7TH HARMONIC VOLTS (HG07)

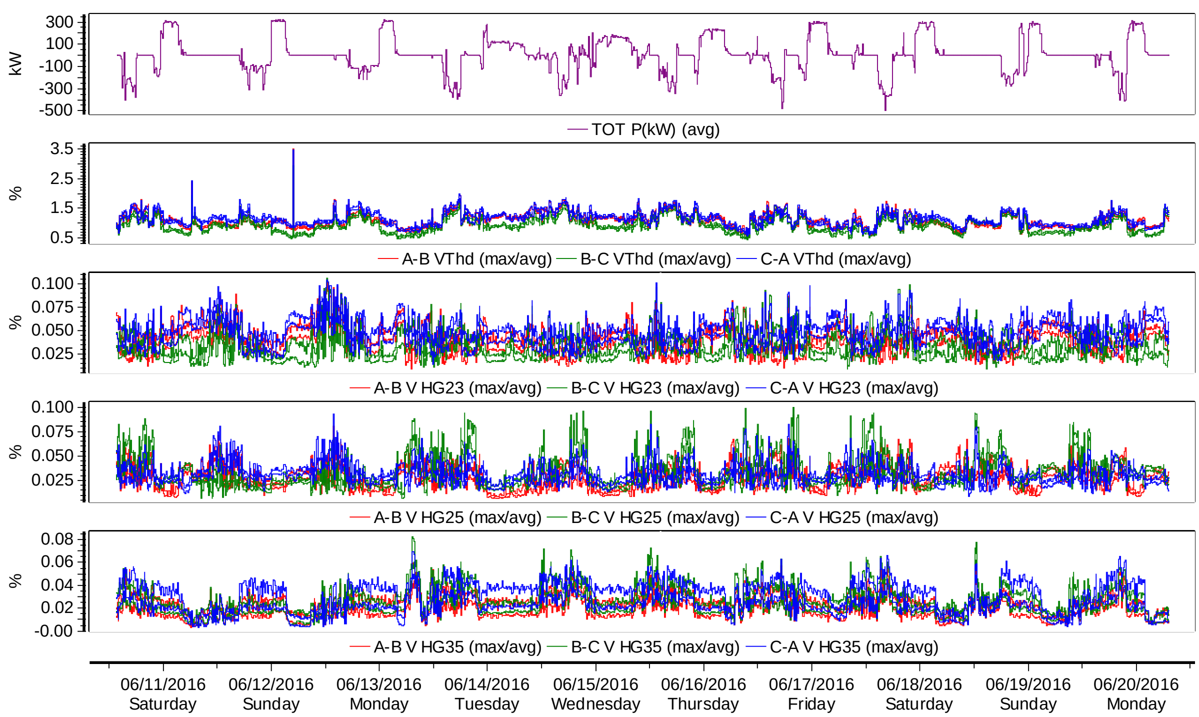


FIGURE 216. POWER (KW), HARMONIC DISTORTION (VTHD), 23RD HARMONIC VOLTS (HG23), 25TH HARMONIC VOLTS (HG25), AND 35TH HARMONIC VOLTS (HG35)

b) Customer 3 Power Quality Analysis of the Waveform Data

The voltage waveform (Figure 217) with the battery system off is clear of inverter switching noise. The current waveform mainly shows instrumentation noise, with some small trickle of single-phase current (Phase A-B) to the control circuitry of the battery energy storage system. The harmonic spectrum (Figure 218) of the voltage has its highest component of 5th harmonic voltage, which is a common power grid characteristic.

The voltage waveform in Figure 219 shows the battery charging, and there is very little influence of higher frequency (2 kHz) noise. The phasor diagram shows the current in phase with the voltage, representing the power being absorbed by the system. The harmonic spectrums in Figure 220 show slight amounts of harmonics, and the 7th harmonic voltage component is the highest.

Figure 221 is the voltage and current waveform with the battery discharging, where there is also very little higher frequency (2 kHz) noise. The phasor diagram shows that the current is 180° out of phase with the voltage, indicating negative power, as the battery is discharging back to the grid. The harmonic spectrums in Figure 222 also show acceptable levels of harmonic components.

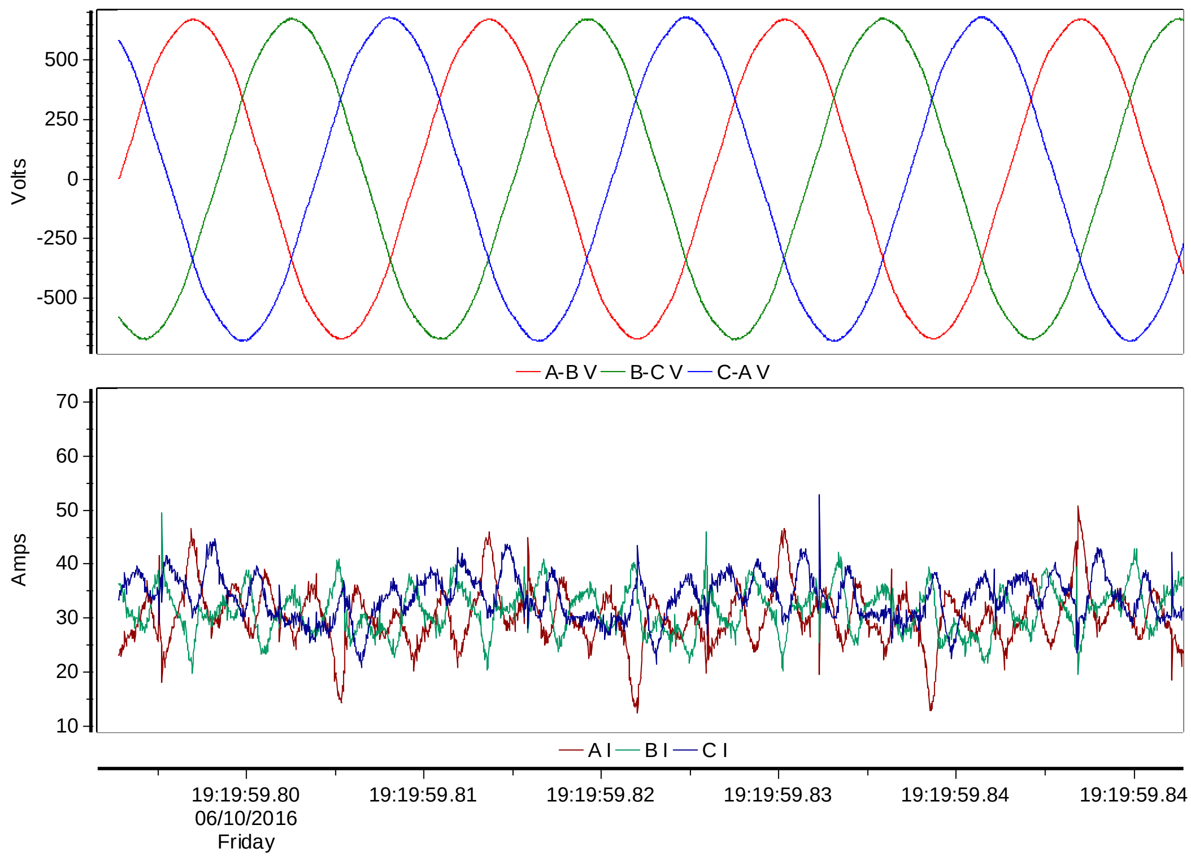


Figure 217. Voltage and Current Waveforms (Battery Off)

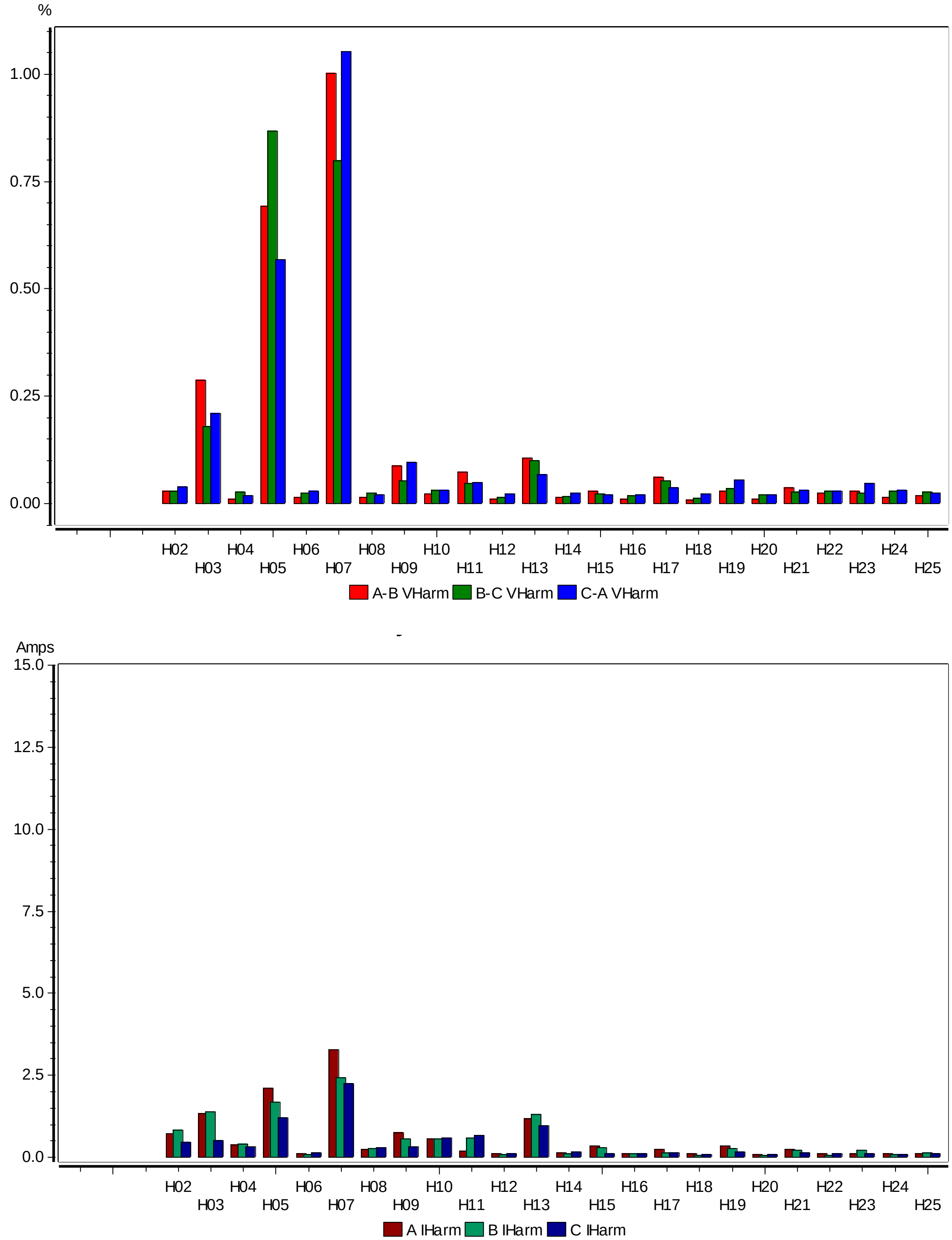


FIGURE 218. HARMONIC SPECTRAL ANALYSIS (BATTERY OFF)

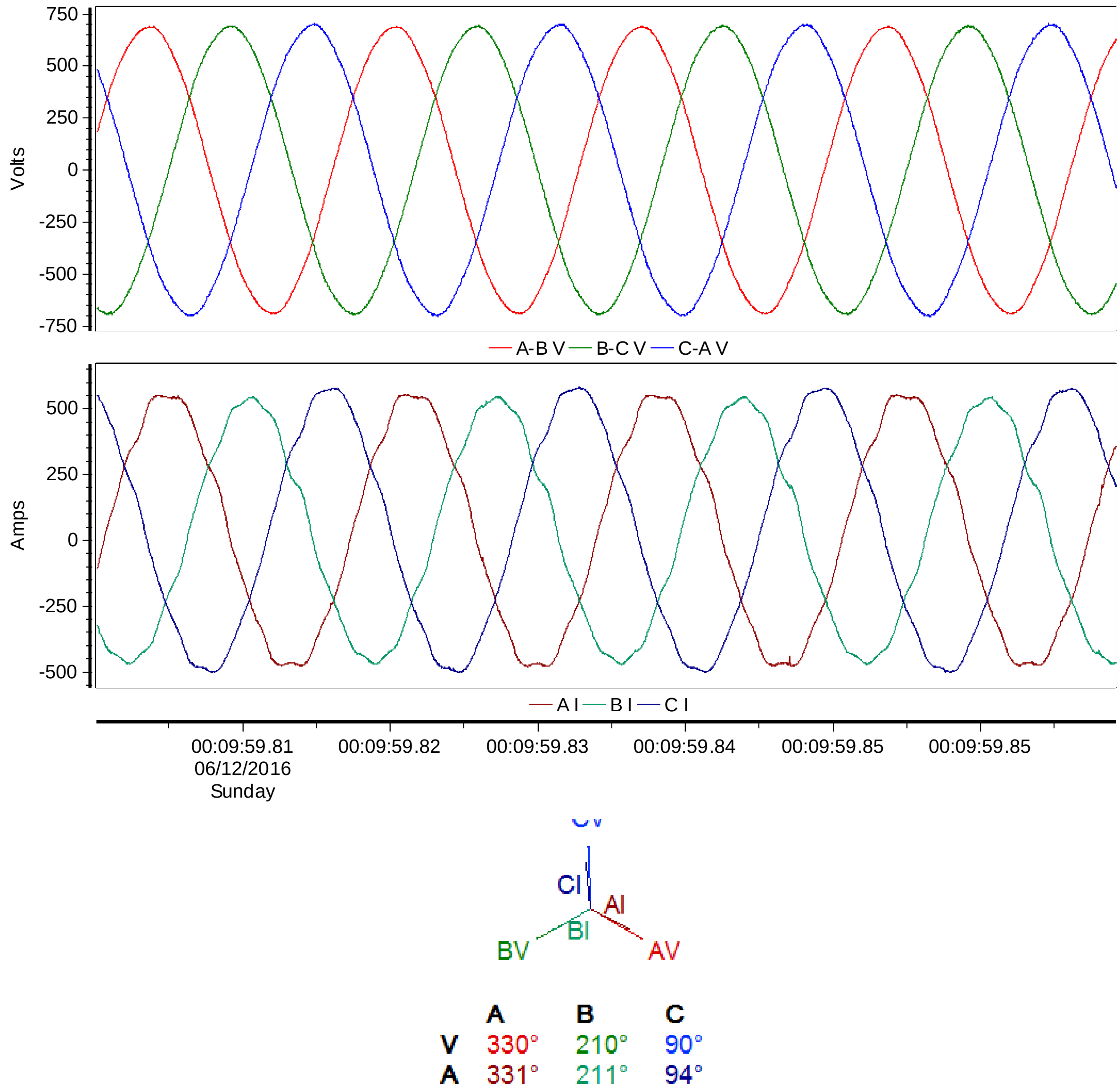


FIGURE 219. VOLTAGE AND CURRENT WAVEFORMS WITH PHASOR DIAGRAM (BATTERY CHARGING)

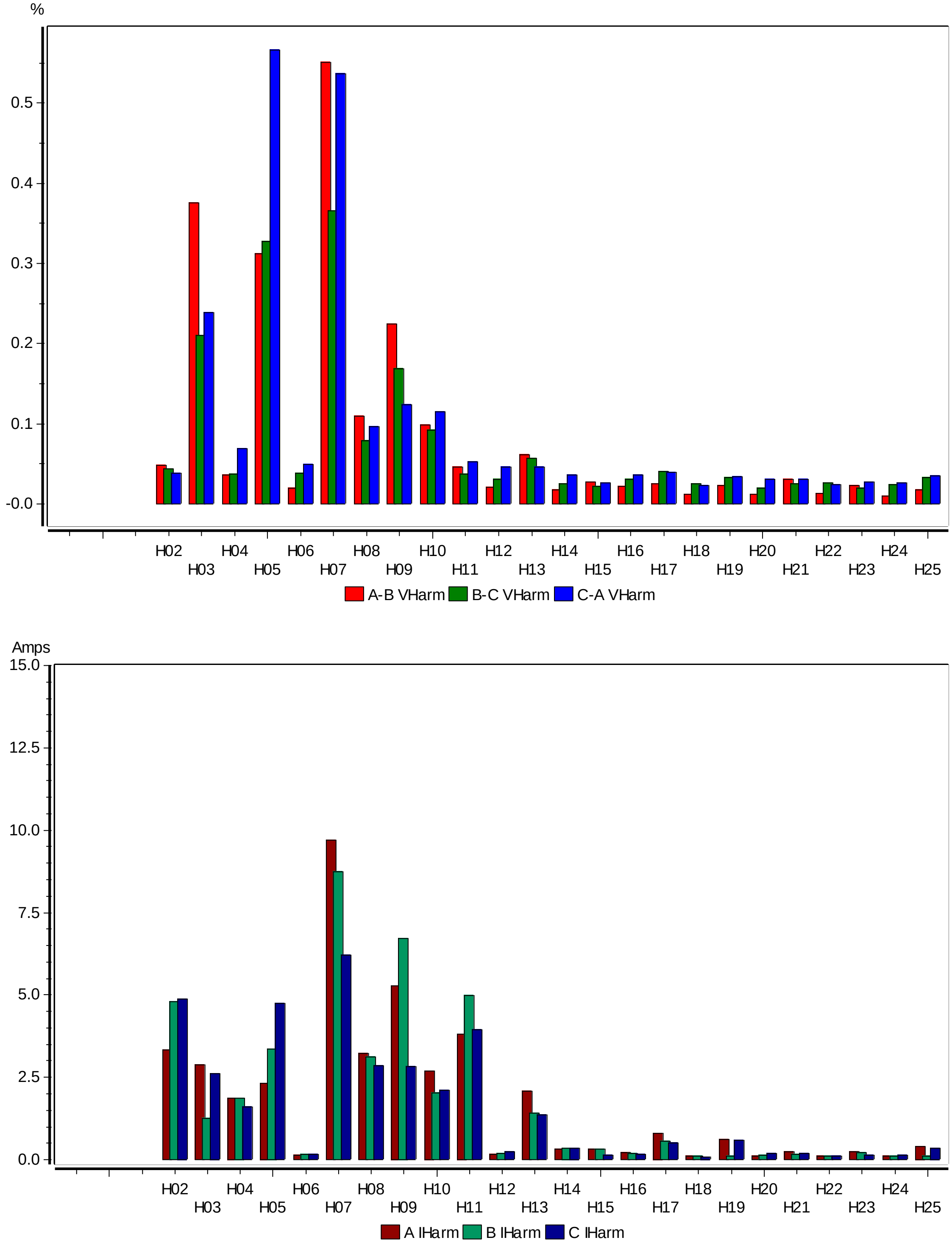


FIGURE 220. HARMONIC SPECTRAL ANALYSIS (BATTERY CHARGING)

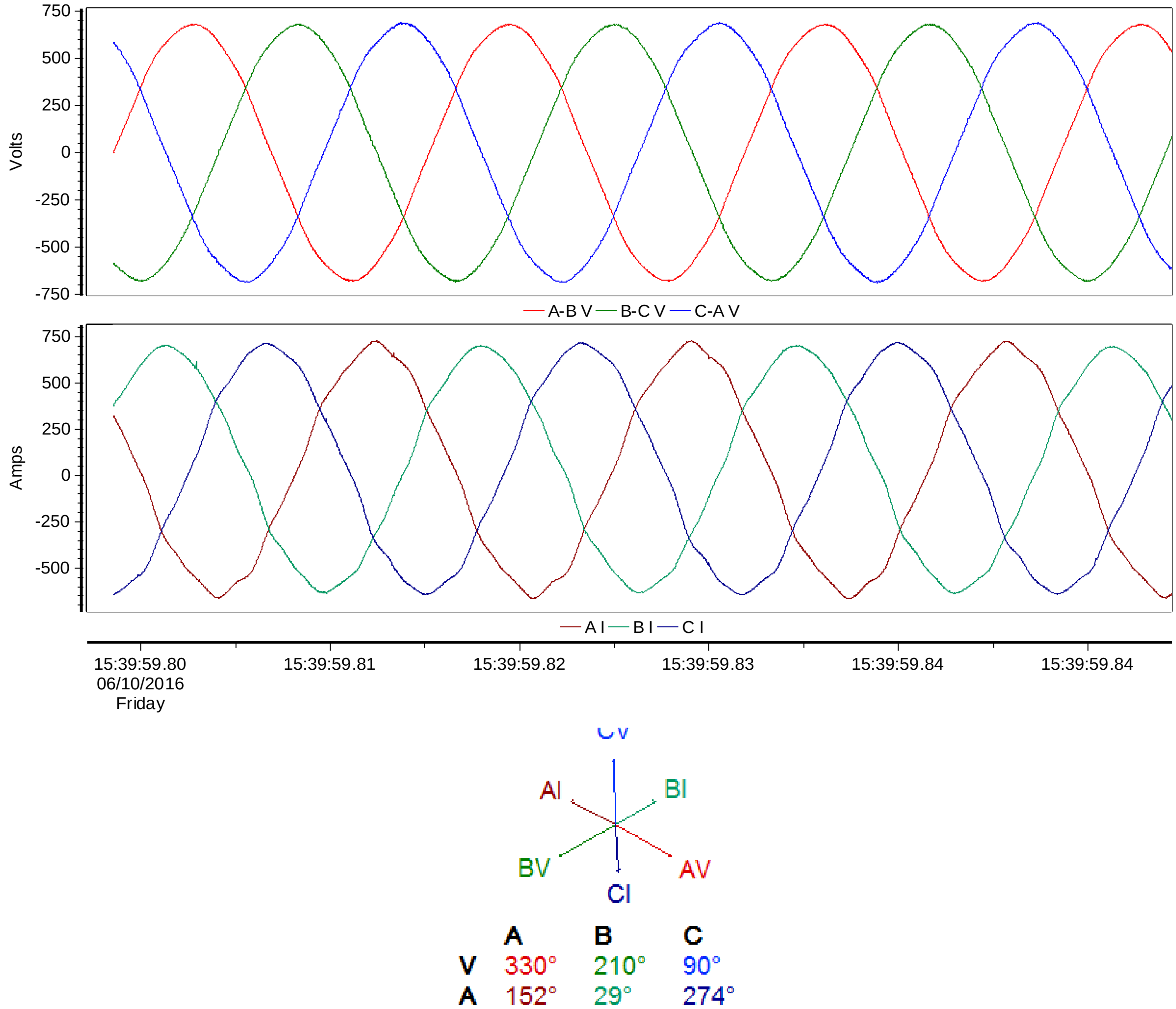


FIGURE 221. VOLTAGE AND CURRENT WAVEFORMS WITH PHASOR DIAGRAM (FULL DISCHARGE)

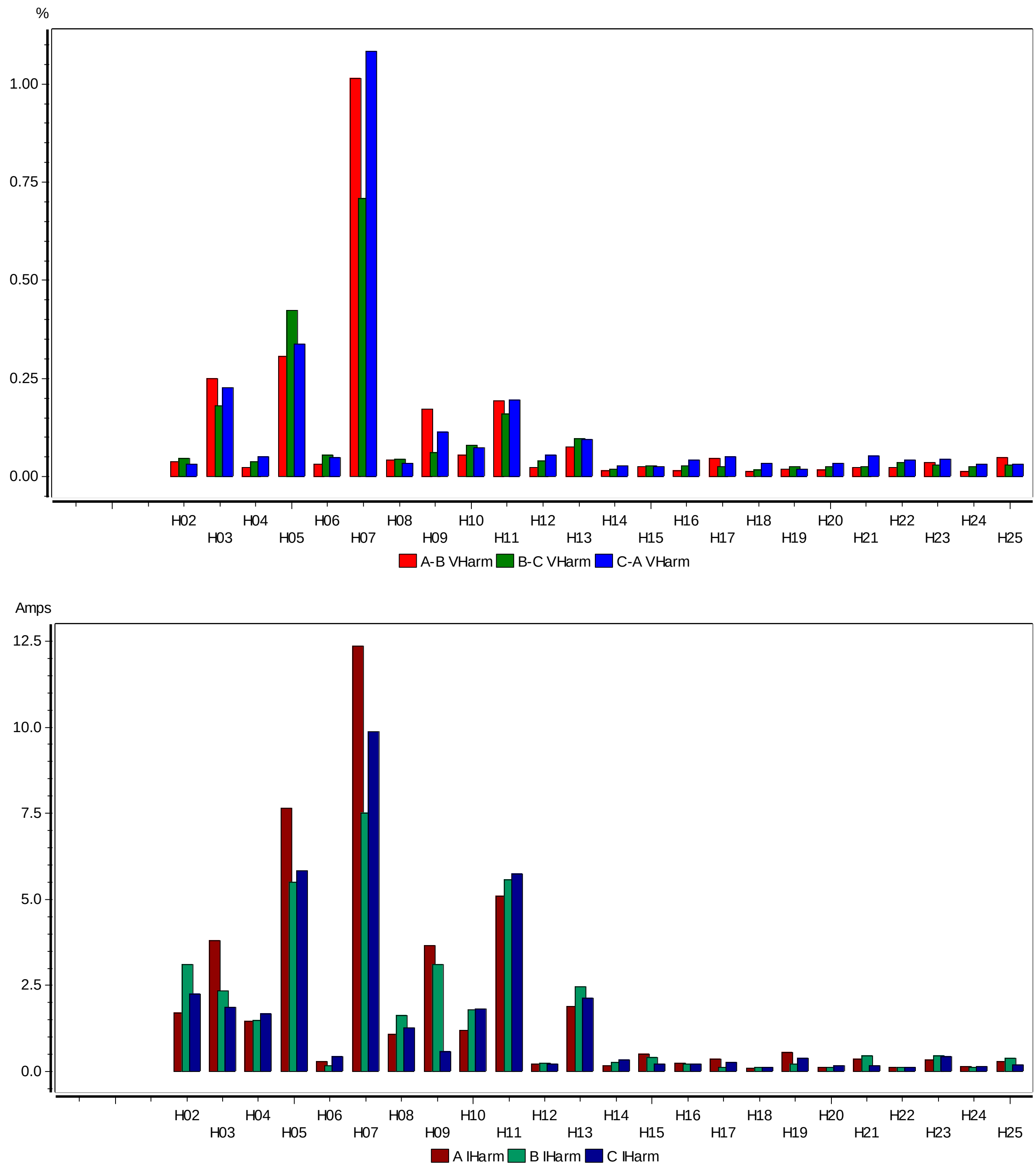


FIGURE 222. HARMONIC SPECTRAL ANALYSIS (FULL DISCHARGE)

DISCUSSION

The demand response battery technology did not perform predictably or consistently across the multiple test events that are analyzed in this project. While the battery systems performed (and often even exceed) the anticipated response given the signal, the batteries did not respond to many test events or have results that were inconsistent with expectations. The lack of response is likely attributable to a multitude of factors. Two factors that greatly affected the performance of the project were:

- Issues with the battery system being offline or unavailable on event day; and
- An imprecise dispatch signal structure that requested an action by the battery system (Turn Off Charging, Start Charging, and Discharge) rather than a specific amount of power (kW) or energy (kWh).

Demand response is evaluated by perceiving a change to the net energy usage or demand at the initiation of a DR event and again at the conclusion of the event. The performance is then measured against a baseline estimate of what the usage or demand would have been in the absence of a DR event. The Turn Off Charging, Start Charging, and Discharge dispatch signals result in observed net energy consumption and demand that are inconsistent:

- A Turn Off Charging dispatch signal is only effective if the battery is charging when the dispatch signal is received. Additionally, allowing the battery to discharge or continue discharging during a "Turn Off Charging" test dispatch results in performance that is either exaggerated by the discharge or results in little to no perceivable change in net energy usage at the initiation or conclusion of a test event if the battery was already in Discharge mode.
- A Start Charging Dispatch signal is only effective if the battery is not already charging at the time of dispatch. Otherwise there is little to no perceivable change in net energy usage at the initiation or conclusion of a test event. Additionally, a one hour "Start Charging" dispatch should also be terminated with a "Stop Charging" dispatch to get the true effect of a charging DR event. Finally, the battery can only charge if it isn't already charged to capacity.
- A Discharge Dispatch signal is only effective if the battery is not already discharging at the time of dispatch. Otherwise there is little to no perceivable change in net energy usage at the initiation or conclusion of a test event. Additionally, the battery is unable to discharge if it has already been discharged to capacity.

The intent is for the CBP dispatch instructions of High, Medium, and Low to align with Turn off Battery charging, Battery Discharge, and Start Battery charging quantities of 200MW for customers 1 and 2 and 100MW for Customer 3. However, the results vary significantly from this goal.

Another complicating factor is that the test event day usage often varies from the baseline usage range (maximum to minimum) and pattern or shape. This may be due to the standard battery schedule to minimize energy (kWh) usage and demand (kW) being manually overridden on test event days. Because baselines are utilized to measure DR event performance, significant variation from the baseline results in an inaccurate quantification of performance.

Therefore, the two biggest barriers to quantifying battery energy storage performance as a dispatchable distributed energy resource are:

- The perceived inconsistent performance based on current DR measurement and valuation baseline techniques; or
- Developing an alternative to the baseline approach to perceive a change in usage or demand at the initiation and termination of a DR test event.

TABLE 42. DEMAND RESPONSE OBSERVATION SUMMARY LEGEND

ICON	EVENT TYPE
	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.	

TABLE 43 BATTERY DEMAND RESPONSE OBSERVATION SUMMARY

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

[19] For purposes of this project the 10-in-10 baseline is equivalent to the CBP Energy Baseline used for performance calculation and settlement with the customers participating in this project.

[20] Because of the configuration of how the Customer 1 PQ device was monitoring the battery and facility load, the device was monitoring the net result of a portion of the facility load and the battery output. As such, we have omitted categorization of the performance from this table. Results are presented in the results section of this report

5/24/16 3:00	Start Charging	●	97%	●	-	●	48%	●	●	●	70%	●	●
6/8/16 3:00	Start Charging	●	69%	●	-	●	69%	●	●	●	-81%	●	●

CONFOUNDING FACTORS TO ANALYSIS

QUANTIFYING PERFORMANCE

a) Starting the Baseline

EnerNex utilized three different methodologies to quantify the performance of each event. Those methodologies are outlined in the Analysis Section of this document. Each of the methodologies has strong benefits, and a few drawbacks observed through detailed analysis.

Because of the high volatility of the usage profiles for the selected sites, it is difficult to select a point from which to make baseline adjustments for the ± 20% 10-in-10 baseline or the LA 10-in-10 baseline. Usage varied so much from one 15-minute period to the next that no single period seemed particularly more representative of a given day's overall profile than any other period. Ultimately, the points 15 minutes before and after the event to frame the ±20% from Baseline and LA 10-in-10 estimates were utilized.

Upon examining each of the events, it was observed that a few of the LA 10-in-10 estimates appear to be heavily influenced by changes in load immediately before/after the event attributable to different battery behavior than was observed during the preceding 10 like non-event days.

The 2011 Report on Transition of SCE DR Programs into MRTU outlined this possible downside to the LA 10-in-10 approach: "If there is a post-event rebound in the load, or unexplained spike prior to or after the event at points A or B, the LA 10-in-10 will inadvertently increase the DR quantification. The limited applicability of this approach is due to "gaming" concerns where a participant can increase the pre-event load in order to increase the amount of perceived DR." While the 2011 Report focused solely on what would be "Discharge" signals in this study, similar effects can be observed with Start Charging dispatch signals.

With the large volatility in usage, it was observed that event day usage in the period immediately preceding the event for 17 of the 25 (68%) events at Customer 3 and Customer 1 were more than 20% different from the average 10-in-10 profile. Just 1 of the 13 events at Customer 2 varied by more than 20%, but that is likely in part due to the additional load that is not tied into the battery system. This brings the overall percentage down to 47%. Still, roughly half of the events ran into the 20% maximum adjustment to the baseline and are therefore not coincidental with the event day at the start of the event.

The 10-in-10 Baseline average line does a good job of soothing the imperfections associated with selecting the jumping off point, but does not adjust for inherent event day usage variance.

b) Selecting the Appropriate Markets and Event Times to Maximize Results

Overall, many of the event day profiles performed differently on event day prior to and following the event start than was observed in the baseline period. The different performance leading up to the event hints that the batteries were aware of and prepared for an upcoming event. In our study, the schedule for events was set days in advance and shared with the customers. The preparation that was observed may or may not be necessary for the battery to perform in a real-life DR scenario. The amount of lead-up time necessary should be considered when weighing the technical and economic viability of these resources for DR.

Considering the lead-up time necessary to prepare these batteries for participation in any DR event is vital in selecting the appropriate wholesale markets for participation. There are multiple markets for which DR has been deployed with success, and also varying value. The day-ahead market and hour-ahead market are both central to DR deployment value propositions, but so is the overall reliability of the system.

Part of the reason for the lack of response to the Start Charging signals throughout our study is that the batteries typically began charging at that time anyway. Success would have to be measured over and above the typical pattern in the usage profile.

The difficulty in quantifying response given normal battery profiles and the overall success rate of responses in the study should be considered when evaluating deployment of these resources.

CAISO Wholesale Energy Market Integration

To support reliability demand response, where the system operator is looking for any assistance to either increase usage/demand when there is excess generation or decrease demand when there is a shortage or imbalance between supply and demand, the imprecision of the battery performance may be appropriate. However, in order to participate in the CAISO market products being developed for energy storage more precision is required.

The current Generation Resource (NGR)[21] is similar to Participating Load[22] where both charging and discharging of the battery system will be scheduled with CAISO. This approach helps understand the charging and discharging status for the battery resource because the schedule will be filed with CAISO. However, this greatly reduces the flexibility of the battery to minimize energy and demand charges for the customer. For NGR, CAISO will request deviation from the scheduled charging and discharging and those deviations will be the demand response of either increasing or decreasing demand relative to the schedule. The key aspect of NGR is that the charging and discharging schedule as well as the dispatch signals will take the form

[21] California ISO Non-Generation Resource https://www.caiso.com/participate/Pages/Storage/Default.aspx

[22] California ISO Participating Load https://www.caiso.com/participate/Pages/Load/Default.aspx

of specific MW quantities over the hour (MWh) for the day-ahead market or 5 minute for the real-time market.

The emerging and Energy Storage and Distributed Energy Resources (ESDER)[23] is similar to the Proxy Demand Resource (PDR)[24] market product developed for more conventional (and potentially aggregated) demand response end uses. For PDR and ESDER, a load schedule is not filed with the CAISO except for the one filed by the Load Serving Entity (LSE) for their overall customer usage. The PDR and ESDER resources will bid into the day-ahead or real-time energy markets with a given quantity (MW), cost ($/MWh) and availability. The CAISO will then dispatch the resource if their availability and quantity matched the market need as the next least cost resource. Precision is important, especially with real-time ancillary services CAISO dispatches which attempt to balance supply and demand. ESDER deviation from the specific MW dispatch will likely result in additional ancillary service resources to be dispatched to either make up the difference for ESDER under performance or compensate for over performance.

Transactive energy is an emerging concept where Distributed Energy Resources (DER) will interact with a Distribution System Operator (DSO) and devices such as smart inverters on solar photovoltaic systems and energy storage will adjust output to help balance supply and demand in a local area thereby reducing the amount of energy that will need to flow from the transmission system. Dispatch precision requirements are likely to be even more important in this potential future utilizing local DER interacting as transactive energy.

Inconsistency Across Metering

The contract that establishes the relationship between the battery resources and SCE stipulates that the customer cannot be a net exporter of energy[25]. Therefore, export from the battery resources cannot exceed the demand at the site, and feed power back into the grid, for any 15-minute period. This stipulation has important ramifications, including:

- The battery resource preforms at a maximum of the site demand, even if its capacity to perform is greater.
- The logic built into the battery controller is only as good as the information that is being fed into the formulas. In the case of the Customer 2 site, the battery controller was only monitoring a portion of the whole-site power usage. All sites displayed some discrepancy between the SCE meter reads and battery ALCS as displayed in the graphs below.
- It is difficult to discern a response to a “Discharge” signal from merely low usage at a site.

[23] California ISO Energy Storage and Distributed Energy Resources (ESDER) https://www.caiso.com/informed/Pages/StakeholderProcesses/EnergyStorage_AggregatedDistributedEnergyResources.aspx

[24] California ISO Proxy Demand Resource (PDR) https://www.caiso.com/23bc/23bc873456980.html

[25] SCE Net Energy Metering Interconnection Handbook: https://www.sce.com/wps/wcm/connect/69531af9-15f6-43e1-8368-a195c65fa249/NEM+Interconnection+Handbook.pdf?MOD=AJPERES

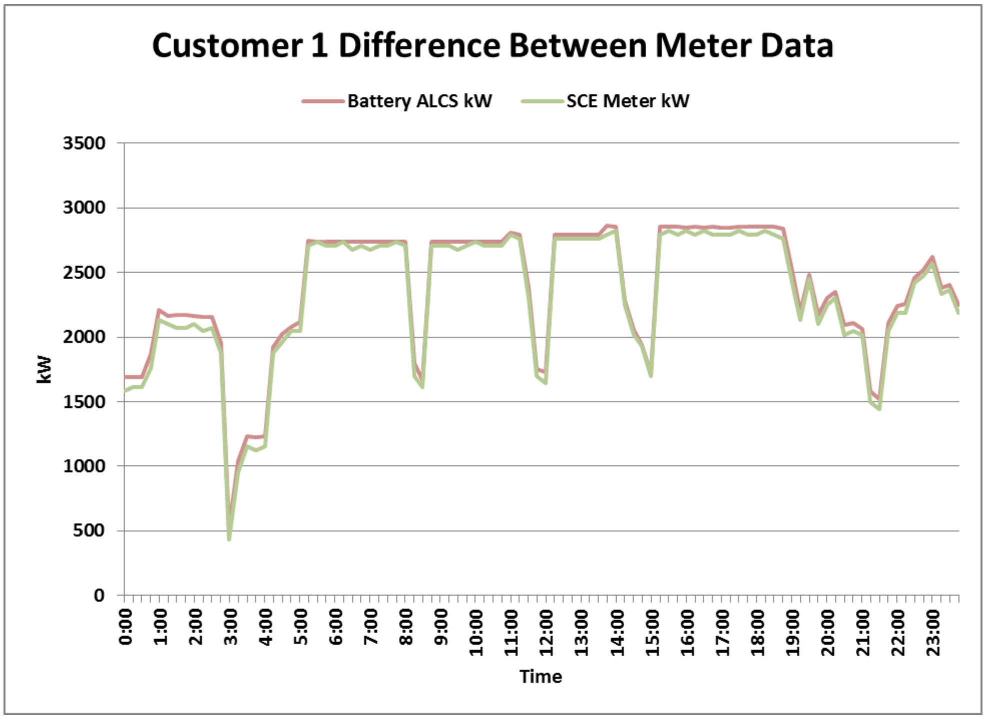


FIGURE 223. CUSTOMER 1 DIFFERENCE BETWEEN SCE METER AND BATTERY SUBMETERING ON MAY 2

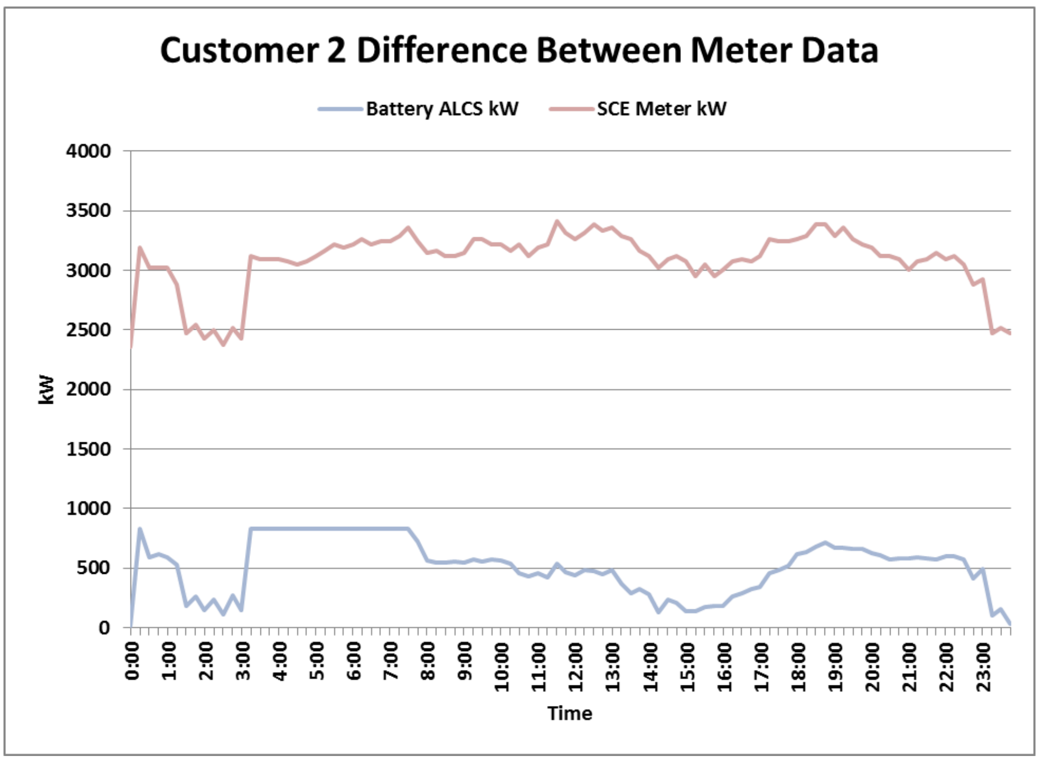


FIGURE 224. CUSTOMER 2 DIFFERENCE BETWEEN SCE METER AND BATTERY SUBMETERING ON MAY 2

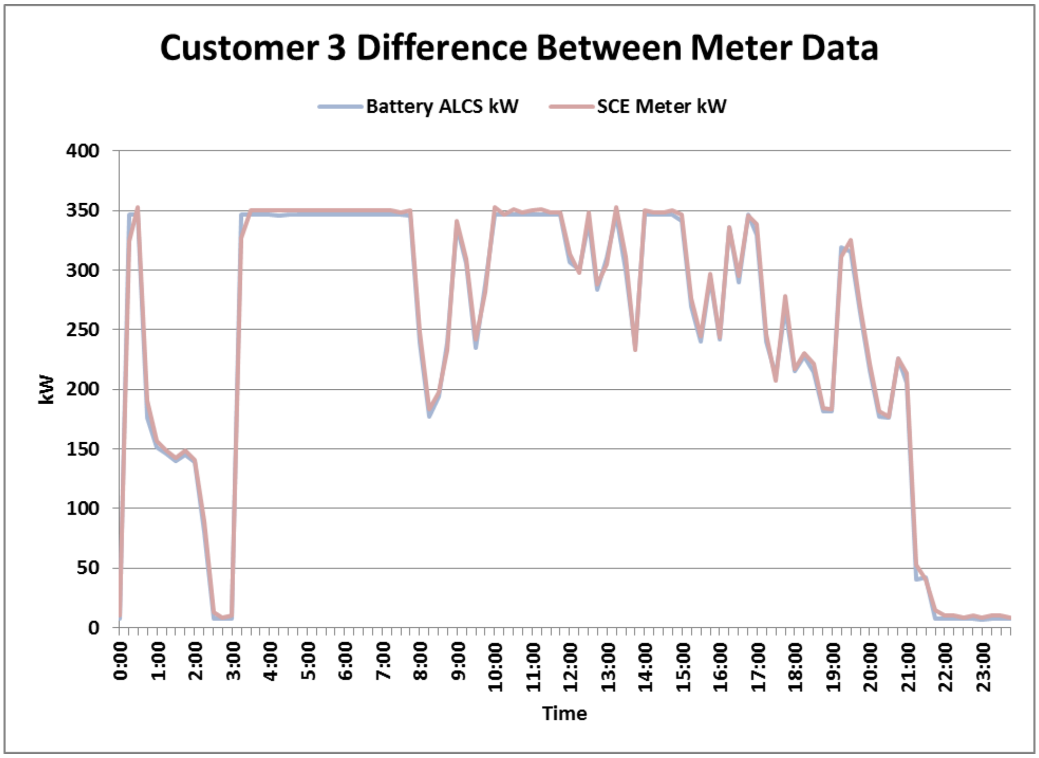


FIGURE 225. CUSTOMER 3 DIFFERENCE BETWEEN SCE METER AND BATTERY SUBMETERING

Another way of displaying the meter differences is shown in Figure 226. The difference between the SCE meter and battery ALCS metering varies greatly throughout the year. Customer 1 exhibits a skew right with a mode around 34, meaning that the Battery ALCS most often differs from the SCE meter by 34 kW. As described in Customer 2 Results Section, the battery controller at Customer 2 only monitors and responds to a portion of the total facility load. Therefore, the Customer 2 is skew left with a mode around -2240 is explained by the non-metered portion of the load at the facility. Customer 3 appears to be a relatively normal distribution with a mode at negative two (-2). Further, there appears to be no corrective measure that can be applied across the three sites to compensate for the discrepancy in meter data. Corrective action will be easy if the meters varied by a consistent amount throughout the year. These differences are highlighted as a possible reason for inconsistent event response. Without consistent metering across all stakeholders, event responses can vary in success.

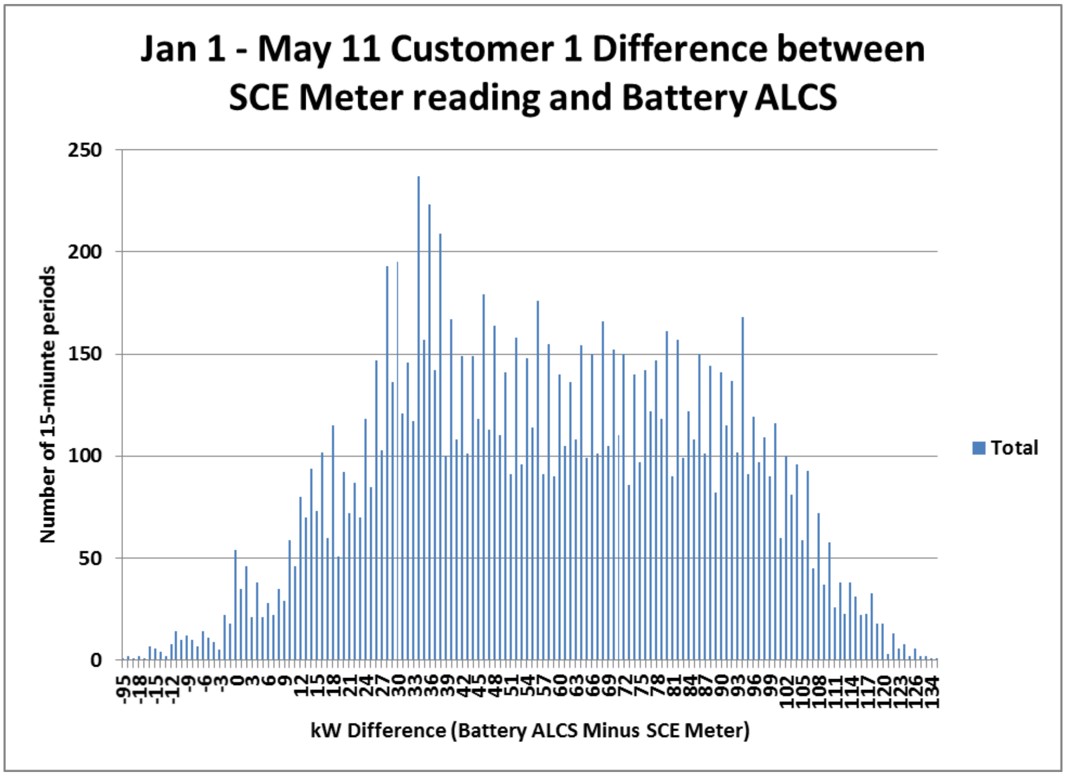


FIGURE 226. CUMULATIVE CUSTOMER 1 DIFFERENCE BETWEEN SCE METER AND BATTERY SUBMETERING

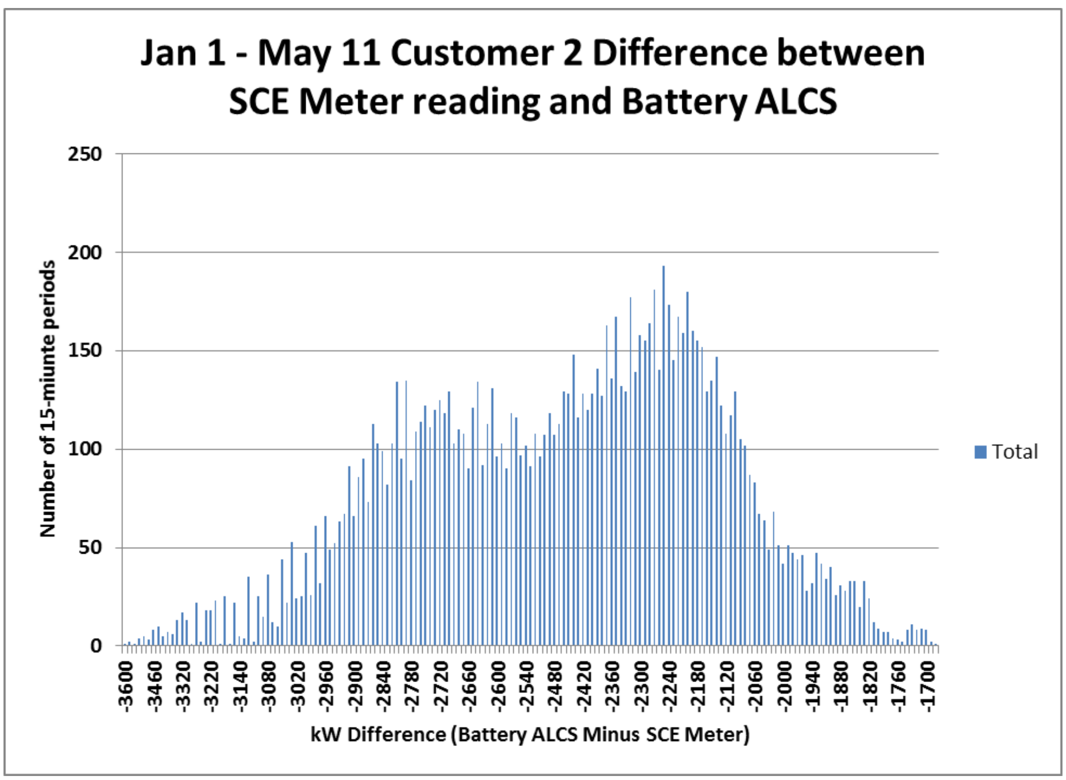


FIGURE 227. CUMULATIVE CUSTOMER 2 DIFFERENCE BETWEEN SCE METER AND BATTERY SUBMETERING

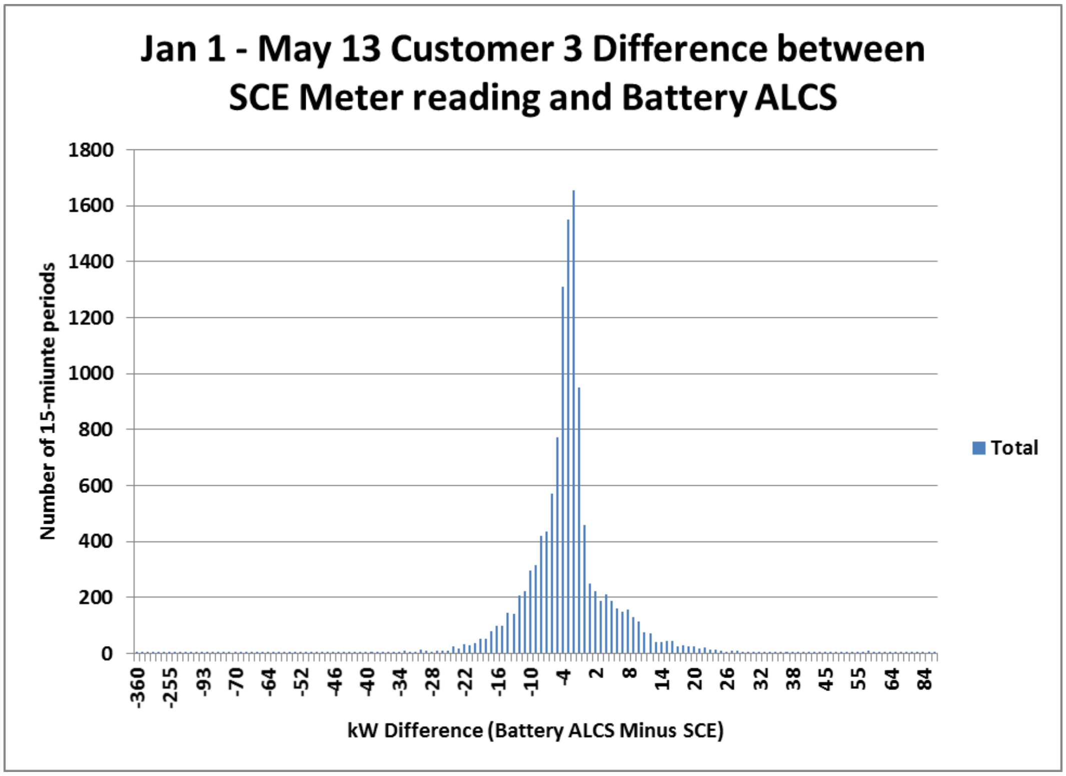


FIGURE 228. CUMULATIVE CUSTOMER 3 DIFFERENCE BETWEEN SCE METER AND BATTERY SUBMETERING

CONCLUSIONS

DISPATCH SIGNALS

Due to the OpenADR Demand Response Automation System (DRAS) configuration for CBP, the dispatch instructions are limited to high, medium, and low. Therefore, three dispatch signals were utilized for this demonstration project:

- High: Turn off Battery charging.
- Medium: Battery Discharge.
- Low: Start Battery charging.

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

DEVIATION FROM TYPICAL USAGE

One of the observations from the baseline curves is that the event day usage often deviated from the range of baseline period usage. It is likely that the typical programmed battery schedule, which is optimized to minimize energy and demand charges, was manually overridden on test event days. Unfortunately, this deviation from the standard schedule in the timeframe prior to and subsequent to the test events had a significant impact on the ability for standard baseline methodologies (10-in-10, ± 20% from baseline and LA 10-in-10) to properly quantify the battery systems demand response 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.

POWER QUALITY

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%. Voltage and current waveform captures were also examined during various states of the battery energy storage system. No anomalies were found during the various operating modes of idle, charging, or discharging.

RECOMMENDATIONS

The state of California is pursuing incorporation of energy storage into the portfolio of electricity resources utilized in the state and as a component in a progression to generation sources with less greenhouse gas emissions. The characteristics and capabilities of battery energy storage can work to mitigate the potential impact of other DER resources such as intermittent solar PV and also participate in the CAISO market as a NGR or ESDER. However, 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. Hopefully this project and other subsequent projects will provide the feedback and data needed to further refine how battery energy storage systems can be integrated as a DR and more broadly a DER.

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 transactive 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 OpenADR[26] 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.

[26] OpenADR Alliance: http://www.openadr.org/

APPENDIX

A. LINEARLY ADJUSTED 10-IN-10 COMPUTATIONS

The LA 10-in-10 computational specifics are illustrated in Equation 1 and Equation 2:

EQUATION 1. LOAD POINT ADJUSTMENT

$$LPA_A = \frac{\text{actual event day load in the interval immediately before dispatch}}{\text{unadjusted 10 - in - 10 load in the interval immediately before dispatch}}$$

$$LPA_B = \frac{\text{actual event day load in an interval after restoration and snapback load spike}}{\text{unadjusted 10 - in -10 load the same post - event interval}}$$

Let the number of interval steps between points A and B be n and LPA_i be the LPA for the i^{th} interval between A and B. For each LPAi for i in {1,…,n}, multiply the 10-in-10 at each interval between the start and end of the event by its corresponding LPA calculated in steps 2 and 3.

EQUATION 2. LINEAR ADJUSTMENT

$$LPA_i = LPA_A + i * \frac{(LPA_B - LPA_A)}{n}$$

B. TEMPERATURE AS A PERFORMANCE VARIABLE

Because outside air temperature has been shown to impact electricity usage in the Southern California region, EnerNex ran basic analysis to ensure that the temperatures experienced on "Test Days" were similar to the range of temperatures during each baseline period. Each facility demonstrated very little correlation between temperature and demand in 2016, which is consistent with expectations given the nature of each facility.

TABLE 44. FACILITY TEMPERATURE CORRELATION

FACILITY	JANUARY 1-JUNE 8 2016 TEMPERATURE/DEMAND CORRELATION
Customer 1	0.02
Customer 2	0.23
Customer 3	0.29

Given the low correlation and similar Test Day and baseline period temperatures, outdoor air temperature will not be considered in analyzing the effectiveness of each test.

a) April 5 Event Day

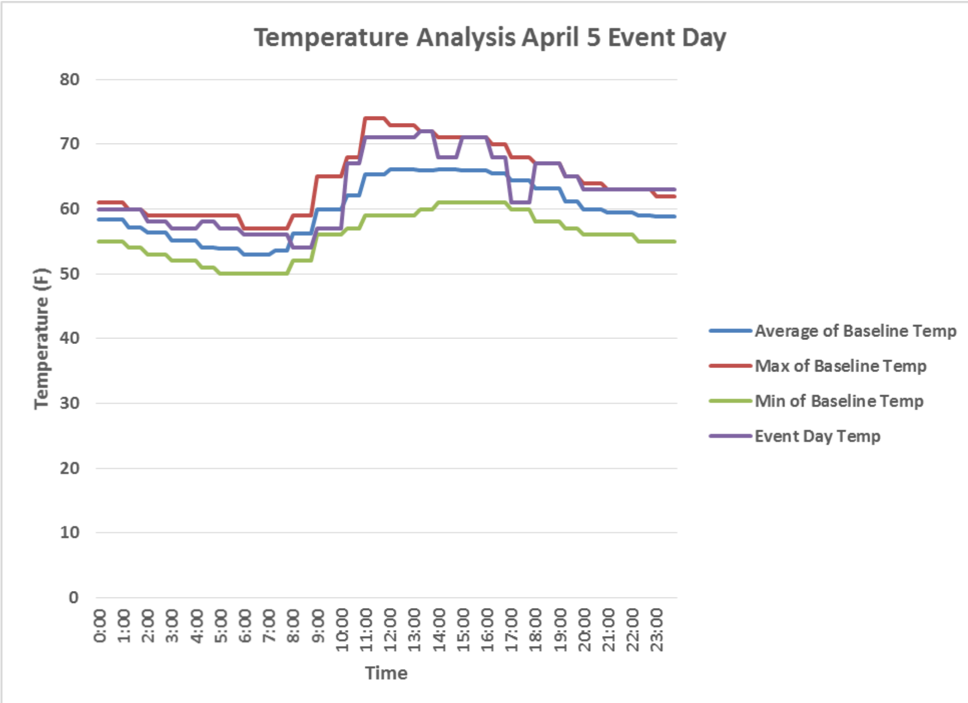


Figure 229. Temperature Analysis for April 5 Event Day

b) APRIL 12 EVENT DAY

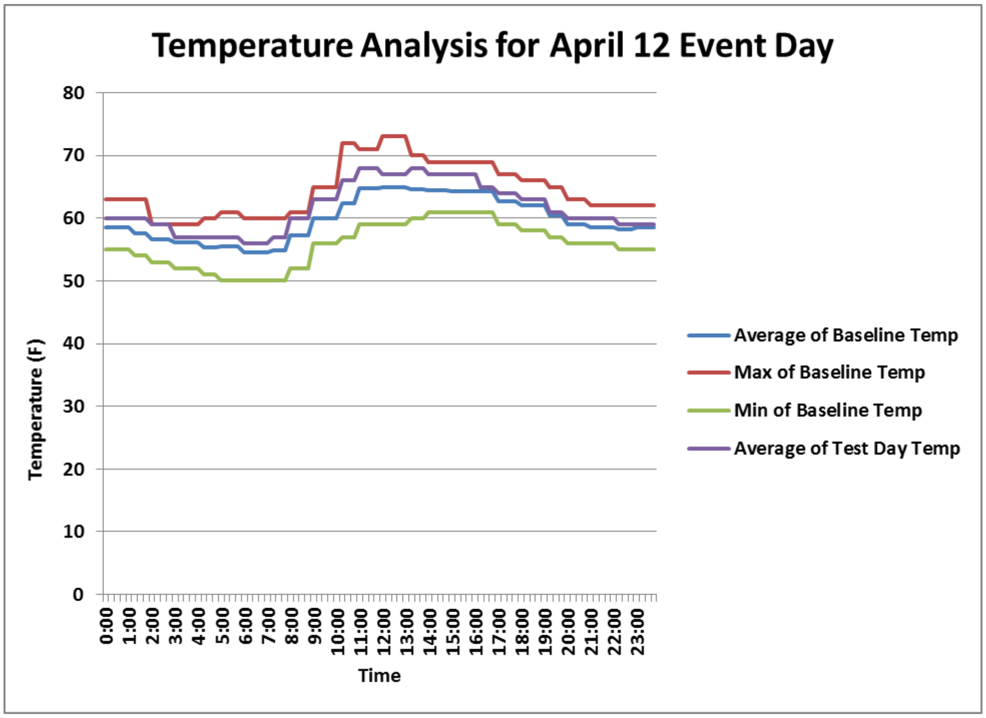


FIGURE 230. TEMPERATURE ANALYSIS FOR APRIL 12 EVENT DAY

c) April 19 Event Day

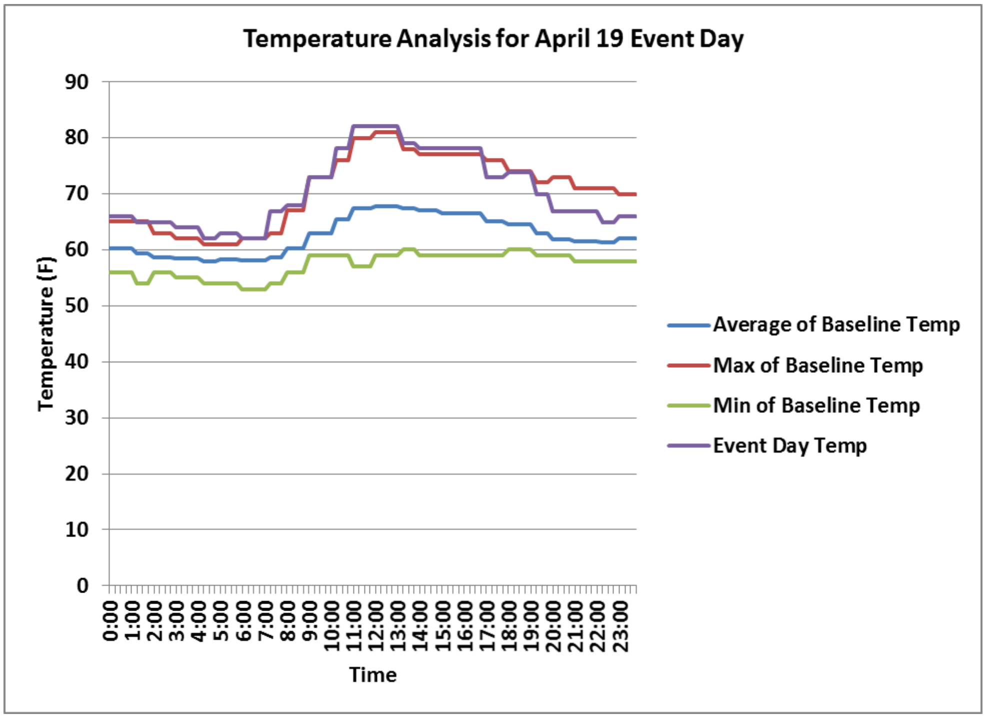


Figure 231. Temperature Analysis For April 19 Event Day

d) April 22 Event Day

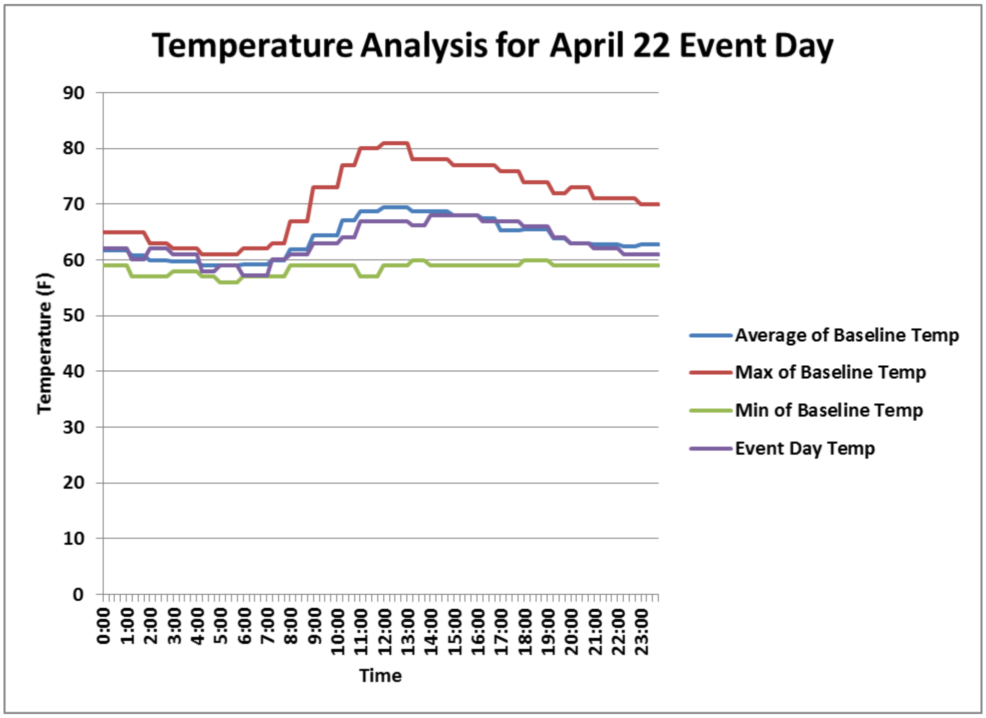


Figure 232. Temperature Analysis for April 22 Event Day

e) APRIL 29 EVENT DAY

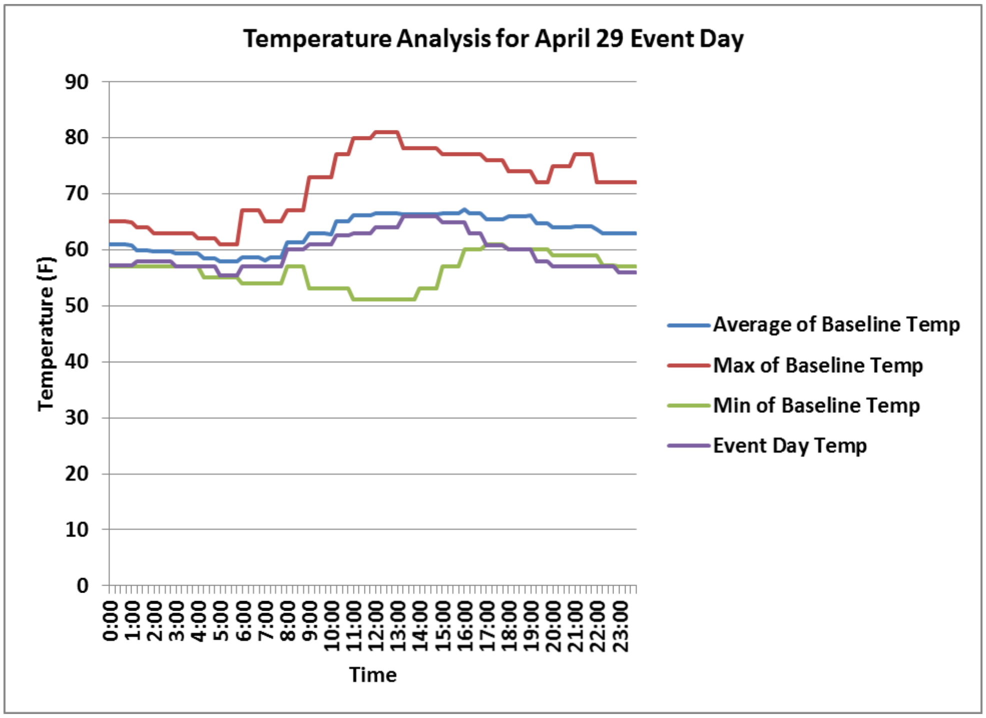


FIGURE 233. TEMPERATURE ANALYSIS FOR APRIL 29 EVENT DAY

f) MAY 2 EVENT DAY

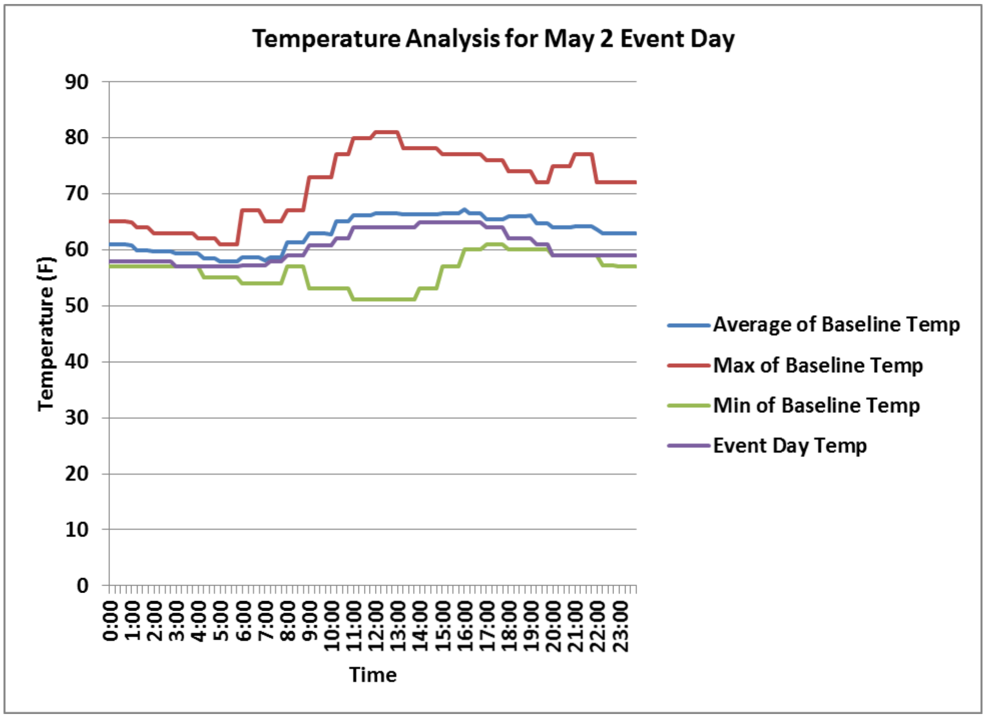


FIGURE 234. TEMPERATURE ANALYSIS FOR MAY 2 EVENT DAY

g) MAY 6 EVENT DAY

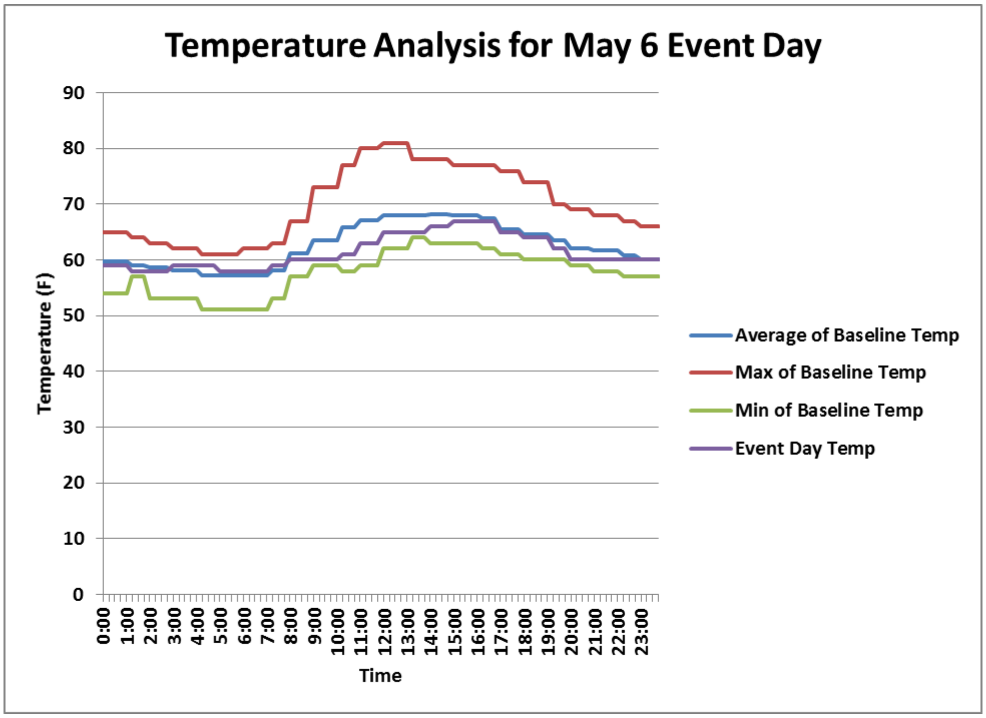


FIGURE 235. TEMPERATURE ANALYSIS FOR MAY 6 EVENT DAY

h) MAY 10 EVENT DAY

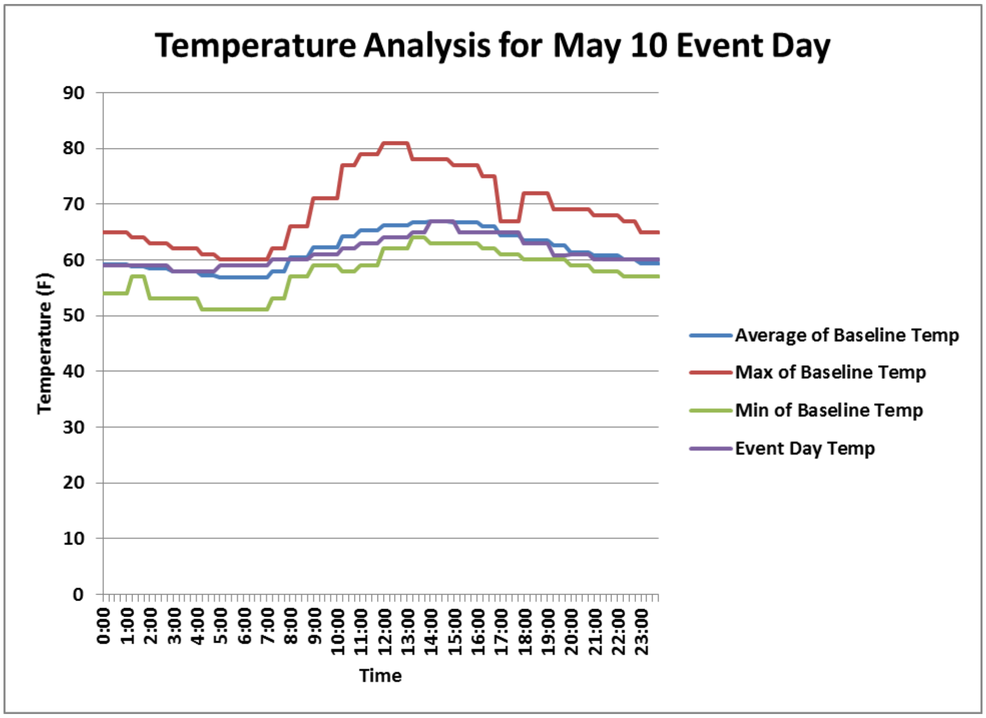


FIGURE 236. TEMPERATURE ANALYSIS FOR MAY 10 EVENT DAY

i) MAY 13 EVENT DAY

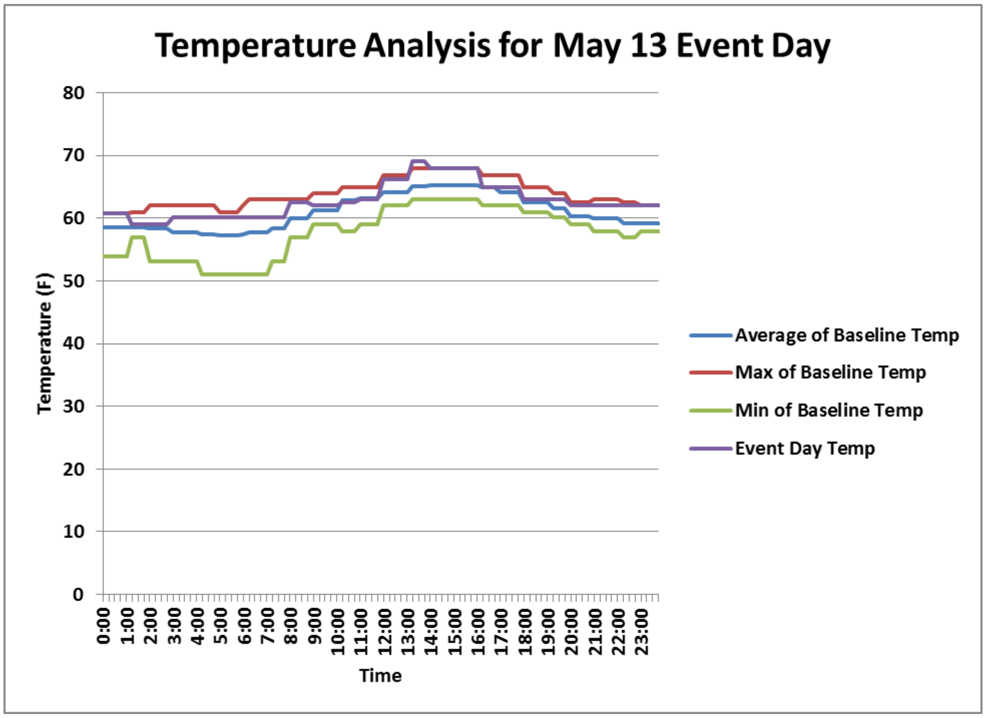


FIGURE 237. TEMPERATURE ANALYSIS FOR MAY 13 EVENT DAY

j) MAY 17 EVENT DAY

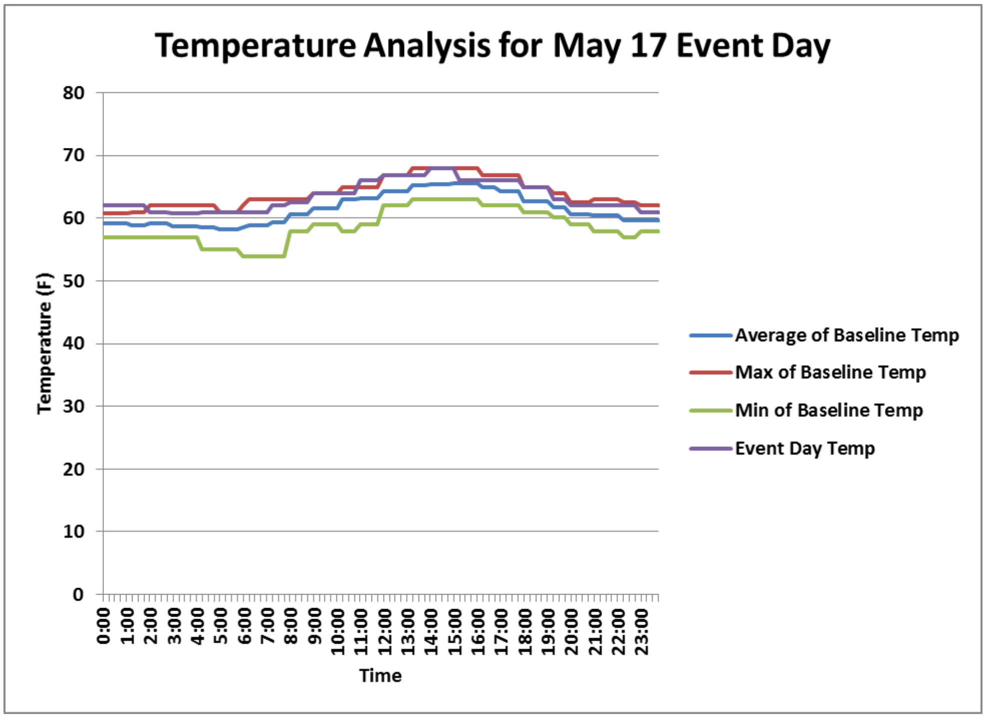


FIGURE 238. TEMPERATURE ANALYSIS FOR MAY 17 EVENT DAY

k) MAY 20 EVENT DAY

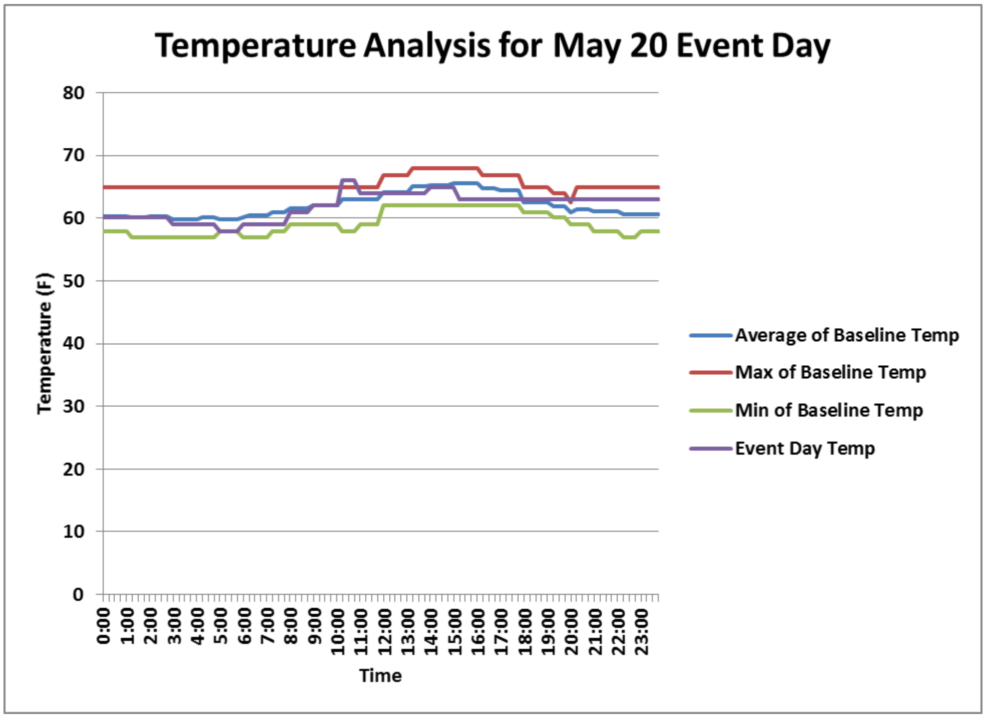


FIGURE 239. TEMPERATURE ANALYSIS FOR MAY 20 EVENT DAY

I) May 24 Event Day

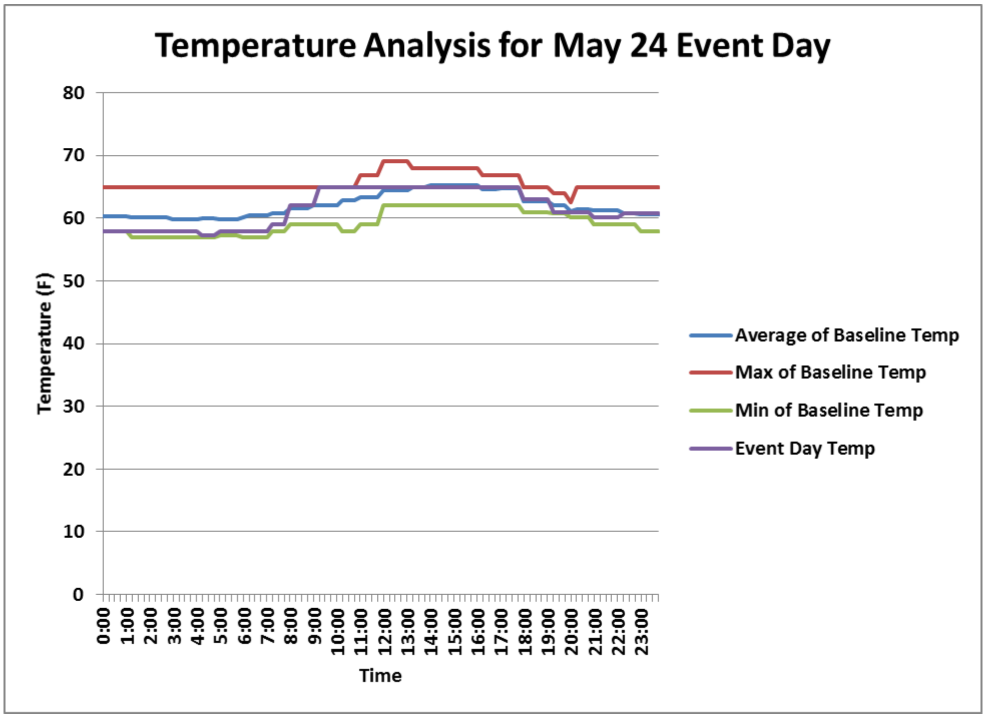


Figure 240. Temperature Analysis for May 24 Event Day

m) June 8 Event Day

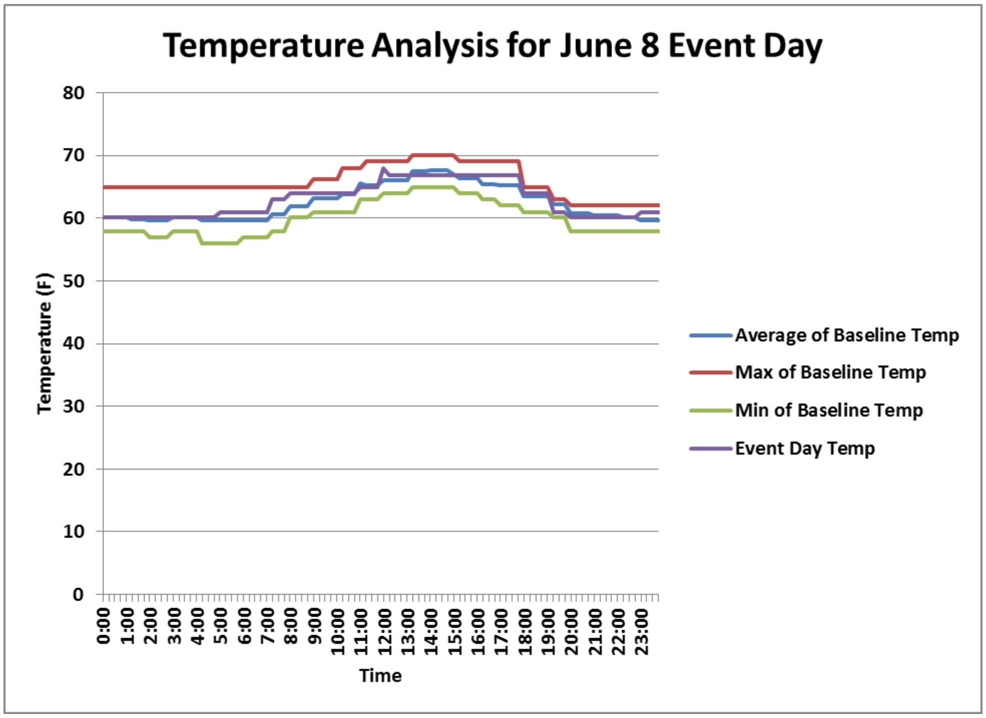


FIGURE 241. TEMPERATURE ANALYSIS FOR JUNE 8 EVENT DAY

C. PQ Meter Configuration

The PQ metering units were calibrated at the factory, and the units have calibration certificates showing that they were up-to-date. At all of the sites, trend data was captured every 10 minutes which provided minimum, average, and maximum values over the previous 10 minutes. Power quality characteristics that were trended included voltage, current, power, reactive power, harmonics, and flicker.

Customer 1 PQ Configuration

Firmware	V 1.2.4 Ver.: V 1.2, Build: 4
Serial Number	HDPXAJA064
Site/Filename	ton Forge
Measured from	330d - 15:50:54
Measured to	11/01/1996 23:08:39
Synchronization	Standard A
Configuration	3 WIRE / 3 PROBE (DELTA)
Monitoring type	STANDARD PQ IEEE
Nominal voltage	4160.0 V
Nominal current	168.1 A

Nominal frequency	60.0 Hz
Anti-aliasing	OFF
Use inverse sequence	No
Using currents	Yes
Characterizer mode	IEEE 1159

Current probes

Chan A	TR2510, 0A-10A RMS (Scale=6.67)
Chan B	TR2510, 0A-10A RMS (Scale=6.67)
Chan C	TR2510, 0A-10A RMS (Scale=6.67)
Chan D	Other (Scale=1.00)

Voltage scale factors

Chan A	40.000
Chan B	40.000
Chan C	40.000
Chan D	1.000

Current scale factors

Chan A	160.000
Chan B	160.000
Chan C	160.000
Chan D	1.000

Cross Trigger

Group ID	0
Address	0.0.0.0

Trigger Response Setups

Summary Pre-trigger cycles	6 cycles
Summary Post-trigger cycles IN-TO-OUT	60 cycles
Summary Post-trigger cycles OUT-TO-IN	60 cycles
Waveform Pre-trigger cycles	2 cycles
Waveform Post-trigger cycles	6 cycles

Trigger-	Saved waveforms										
channel	Va	Vb	Vc	Vd	Ia	Ib	Ic	Id	AB	BC	CA
Volts A	Va	-	-	-	-	-	-	-	-	-	-
Volts B	Va	-	-	-	-	-	-	-	-	-	-
Volts C	Va	-	-	-	-	-	-	-	-	-	-
Volts D	Va	-	-	Vd	-	-	-	-	-	-	-
Amps A	Va	-	-	-	Ia	Ib	Ic	-	VAB	VBC	VCA
Amps B	Va	-	-	-	Ia	Ib	Ic	-	VAB	VBC	VCA
Amps C	Va	-	-	-	Ia	Ib	Ic	-	VAB	VBC	VCA
Amps D	Va	-	-	-	-	-	-	-	-	-	-
Volts A-B	Va	Vb	Vc	-	Ia	Ib	Ic	-	VAB	VBC	VCA
Volts B-C	Va	Vb	Vc	-	Ia	Ib	Ic	-	VAB	VBC	VCA
Volts C-A	Va	Vb	Vc	-	Ia	Ib	Ic	-	VAB	VBC	VCA

Timed Waveform savings every: 600 seconds
After recording: STOP

Limit Setups

Voltages	A	B	C	D	A-B	B-C	C-A
RMS High:	0.0	0.0	0.0	0.0	4576.0	4576.0	4576.0
RMS Low:	0.0	0.0	0.0	0.0	3744.0	3744.0	3744.0
RMS Very Low:	0.0	0.0	0.0	0.0	416.0	416.0	416.0
Crest:	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wave:	832.0	832.0	832.0	0.0	832.0	832.0	832.0
DC:	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DEG:	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WAVE Window Mag:	832.0	832.0	832.0	0.0	832.0	832.0	832.0
WAVE Window Dur:	15.0	15.0	15.0	0.0	15.0	15.0	15.0
HF:	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Currents	A	B	C	D
RMS High:	0.0	0.0	0.0	0.0
RMS Low:	0.0	0.0	0.0	0.0
RMS Very Low:	0.0	0.0	0.0	0.0
Crest:	0.0	0.0	0.0	0.0
Wave:	0.0	0.0	0.0	0.0
DC:	0.0	0.0	0.0	0.0
DEG:	0.0	0.0	0.0	0.0
WAVE Window Mag:	0.0	0.0	0.0	0.0
WAVE Window Dur:	0.0	0.0	0.0	0.0
HF:	0.0	0.0	0.0	0.0

Periodic Journal Intervals

Voltage	10.0 minutes	
Current	10.0 minutes	
Power	10.0 minutes	
Harmonics	10.0 minutes	
Demand	15.0 minutes, Subintervals/Intervals:	3
Energy	15.0 minutes	
Inst. flicker	10.0 minutes	
Short term flicker	10.0 minutes	
Long term flicker	120.0 minutes	
EN50160 compliance	0 seconds	

Customer 2 PQ Configuration

Firmware	V 1.2.4 Ver.: V 1.2, Build: 4
Serial Number	HDPXAJA063
Site/Filename	eX
Measured from	146d - 12:21:34
Measured to	88d - 18:41:11
Synchronization	Standard A
Configuration	3 WIRE / 3 PROBE (DELTA)
Monitoring type	STANDARD PQ IEEE
Nominal voltage	478.9 V
Nominal current	29.6 A
Nominal frequency	60.0 Hz
Anti-aliasing	OFF
Use inverse sequence	No
Using currents	Yes
Characterizer mode	IEEE 1159

Current probes

Chan A	DRANFLEX 3000XL (Range3), 3000A (Scale=2000.00)
Chan B	DRANFLEX 3000XL (Range3), 3000A (Scale=2000.00)
Chan C	DRANFLEX 3000XL (Range3), 3000A (Scale=2000.00)
Chan D	DRANFLEX 3000XL (Range3), 3000A (Scale=2000.00)

Voltage scale factors

Chan A	1.000
Chan B	1.000
Chan C	1.000
Chan D	1.000

Current scale factors

Chan A	1.000
Chan B	1.000
Chan C	1.000
Chan D	1.000

Cross Trigger

Group ID	0
Address	0.0.0.0

Trigger Response Setups

Summary Pre-trigger cycles	6 cycles
Summary Post-trigger cycles IN-TO-OUT	60 cycles
Summary Post-trigger cycles OUT-TO-IN	6 cycles
Waveform Pre-trigger cycles	2 cycles
Waveform Post-trigger cycles	6 cycles

Trigger-channel	Saved waveforms Va	Vb	Vc	Vd	Ia	Ib	Ic	Id	AB	BC	CA
Volts A	Va	-	-	-	-	-	-	-	-	-	-

Volts B	Va	-	-	-	-	-	-	-	-	-	-
Volts C	Va	-	-	-	-	-	-	-	-	-	-
Volts D	Va	-	-	Vd	-	-	-	-	-	-	-
Amps A	Va	-	-	-	Ia	Ib	Ic	-	VAB	VBC	VCA
Amps B	Va	-	-	-	Ia	Ib	Ic	-	VAB	VBC	VCA
Amps C	Va	-	-	-	Ia	Ib	Ic	-	VAB	VBC	VCA
Amps D	Va	-	-	-	-	-	-	-	-	-	-
Volts A-B	Va	Vb	Vc	-	Ia	Ib	Ic	-	VAB	VBC	VCA
Volts B-C	Va	Vb	Vc	-	Ia	Ib	Ic	-	VAB	VBC	VCA
Volts C-A	Va	Vb	Vc	-	Ia	Ib	Ic	-	VAB	VBC	VCA

Timed Waveform savings every: 600 seconds
After recording: STOP

Limit Setups

Voltages	A	B	C	D	A-B	B-C	C-A
RMS High:	0.0	0.0	0.0	0.0	526.8	526.8	526.8
RMS Low:	0.0	0.0	0.0	0.0	431.0	431.0	431.0
RMS Very Low:	0.0	0.0	0.0	0.0	47.9	47.9	47.9
Crest:	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wave:	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DC:	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DEG:	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WAVE Window Mag:	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WAVE Window Dur:	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HF:	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Currents	A	B	C	D
RMS High:	0.0	0.0	0.0	0.0
RMS Low:	0.0	0.0	0.0	0.0
RMS Very Low:	0.0	0.0	0.0	0.0
Crest:	0.0	0.0	0.0	0.0
Wave:	0.0	0.0	0.0	0.0
DC:	0.0	0.0	0.0	0.0
DEG:	0.0	0.0	0.0	0.0
WAVE Window Mag:	0.0	0.0	0.0	0.0
WAVE Window Dur:	0.0	0.0	0.0	0.0
HF:	0.0	0.0	0.0	0.0

Periodic Journal Intervals

Voltage	10.0 minutes	
Current	10.0 minutes	
Power	10.0 minutes	
Harmonics	10.0 minutes	
Demand	15.0 minutes, Subintervals/Intervals:	3
Energy	15.0 minutes	
Inst. flicker	10.0 minutes	
Short term flicker	10.0 minutes	
Long term flicker	120.0 minutes	
EN50160 compliance	0 seconds	

CUSTOMER 3 PQ CONFIGURATION

Firmware	V 1.2.4 Ver.: V 1.2, Build: 4
Serial Number	HDPXAJA066
Site/Filename	a
Measured from	08/23/2030 04:47:56
Measured to	10/14/2002 21:35:30
Synchronization	Standard A
Configuration	3 WIRE / 3 PROBE (DELTA)
Monitoring type	STANDARD PQ IEEE
Nominal voltage	478.2 V
Nominal current	32.7 A
Nominal frequency	60.0 Hz
Anti-aliasing	OFF
Use inverse sequence	No
Using currents	Yes
Characterizer mode	IEEE 1159

Current probes

Chan A	DRANFLEX 3000XL (Range3), 3000A (Scale=2000.00)
Chan B	DRANFLEX 3000XL (Range3), 3000A (Scale=2000.00)
Chan C	DRANFLEX 3000XL (Range3), 3000A (Scale=2000.00)
Chan D	DRANFLEX 3000XL (Range3), 3000A (Scale=2000.00)

Voltage scale factors

Chan A	1.000
Chan B	1.000
Chan C	1.000
Chan D	1.000

Current scale factors

Chan A	1.000
Chan B	1.000
Chan C	1.000
Chan D	1.000

Cross Trigger

Group ID	0
Address	0.0.0.0

Trigger Response Setups

Summary Pre-trigger cycles	6 cycles
Summary Post-trigger cycles IN-TO-OUT	60 cycles
Summary Post-trigger cycles OUT-TO-IN	60 cycles
Waveform Pre-trigger cycles	2 cycles
Waveform Post-trigger cycles	60 cycles

Trigger-	Saved waveforms									
channel	Va	Vb	Vc	Vd	Ia	Ib	Ic	Id	AB	BC	CA
Volts A	Va	-	-	-	-	-	-	-	-	-	-

Volts B	Va	-	-	-	-	-	-	-	-	-	-
Volts C	Va	-	-	-	-	-	-	-	-	-	-
Volts D	Va	-	-	Vd	-	-	-	-	-	-	-
Amps A	Va	-	-	-	Ia	-	-	-	-	-	-
Amps B	Va	-	-	-	-	Ib	-	-	-	-	-
Amps C	Va	-	-	-	-	-	Ic	-	-	-	-
Amps D	Va	-	-	-	-	-	-	Id	-	-	-
Volts A-B	Va	Vb	Vc	-	Ia	Ib	Ic	-	VAB		VBC	VCA
Volts B-C	Va	Vb	Vc	-	Ia	Ib	Ic	-	VAB		VBC	VCA
Volts C-A	Va	Vb	Vc	-	Ia	Ib	Ic	-	VAB		VBC	VCA

Timed Waveform savings every: 600 seconds
After recording: STOP

Limit Setups

Voltages	A	B	C	D	A-B	B-C	C-A
RMS High:	0.0	0.0	0.0	0.0	526.1	526.1	526.1
RMS Low:	0.0	0.0	0.0	0.0	430.4	430.4	430.4
RMS Very Low:	0.0	0.0	0.0	0.0	47.8	47.8	47.8
Crest:	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wave:	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DC:	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DEG:	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WAVE Window Mag:	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WAVE Window Dur:	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HF:	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Currents	A	B	C	D
RMS High:	0.0	0.0	0.0	0.0
RMS Low:	0.0	0.0	0.0	0.0
RMS Very Low:	0.0	0.0	0.0	0.0
Crest:	0.0	0.0	0.0	0.0
Wave:	0.0	0.0	0.0	0.0
DC:	0.0	0.0	0.0	0.0
DEG:	0.0	0.0	0.0	0.0
WAVE Window Mag:	0.0	0.0	0.0	0.0
WAVE Window Dur:	0.0	0.0	0.0	0.0
HF:	0.0	0.0	0.0	0.0

Periodic Journal Intervals

Voltage	10.0 minutes	
Current	10.0 minutes	
Power	10.0 minutes	
Harmonics	10.0 minutes	
Demand	15.0 minutes, Subintervals/Intervals:	3
Energy	15.0 minutes	
Inst. flicker	10.0 minutes	
Short term flicker	10.0 minutes	
Long term flicker	120.0 minutes	
EN50160 compliance	0 seconds	