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A. Document Title and Summary

1. Today's Date: 07/22/16
2. Document Title: Report on the Findings of the Southern California Edison (SCE)Plug-In Electric Vehicle (PEV) Workplace Charging Pilot
3. Document Summary (Executive Summary, Brief Description, Background, and Introduction): In Rulemaking (R.)09-08-009[1], the California Public Utilities Commission (Commission or CPUC) identified that the projected near-term growth of light-duty passenger battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV) in California was significant. The CPUC wished to evaluate the impact such growth would have on California's electric infrastructure in order to inform Commission actions to mitigate risks to the grid while simultaneously recognizing the benefits electric vehicles provide in achieving California's climate change goals. In order to gain information related to EV charging and its impact on the power supply, the Commission approved the Southern California Edison (SCE) Plug-In Electric Vehicle (PEV) Workplace Charging Pilot (Pilot) plan in January 2013. This report provides an overview of the Pilot activities and discusses findings specific to the Pilot Plan (Advice Letter 2746-E, Attachment A)[2].

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C. Documents Submitted that Reference Proceedings

If the document attached is submitted as a compliance document because of a Commission Decision, identify:

1. Proceeding Numbers: R.13-09-011 and A.14-10-014
2. D-12-04-045, CPUC Decision Adopting Demand Response Activities and Budgets For 2012 Through 2014 (April 30, 2012).
3. Ordering Paragraph Number (OP) 80 (SCE proposed the report in Advice Letter (AL) 2746-E-A, which was a supplement to SCE's AL complying with OP 80 of D.12-04-045.
4. Report Name: SCE's Final Workplace Charging Pilot Report

D. Documents Submitted that Reference other requirements

1. If the document submitted is in compliance with (i) something other than a Commission decision identified in Section C above or (ii) something in addition to the Commission decision identified above, please identify the original source of the compliance filing: (Examples may include a Resolution on an Advice Letter, Ruling Proceeding, General Order, Staff Letter, Public Utilities Code, or sender's own motion):

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[1] R.09-08-009, Order Instituting Rulemaking to Consider Alternative-Fueled Vehicle Tariffs, Infrastructure and Policies to Support California's Greenhouse Gas Emissions Reductions Goals, Ordering Paragraph 1 (August 24, 2009), http://docs.cpuc.ca.gov/word_pdf/FINAL_DECISION/106042.pdf.

[2] Advice Letter 2746-E, Proposed Plug-In Electric Vehicle Workplace Charging Pilot Plan, in Accordance with Decision 12-04-045 (June 22, 2012), https://www.sce.com/NR/sc3/tm2/pdf/2746-E.pdf.

F. Confidentiality
1. If the document submitted is marked Confidential, provide an explanation of why confidentiality is claimed and identify the expiration of the confidentiality designation (e.g. Confidential until December 31, 2020.) N/A

G. CPUC Routing
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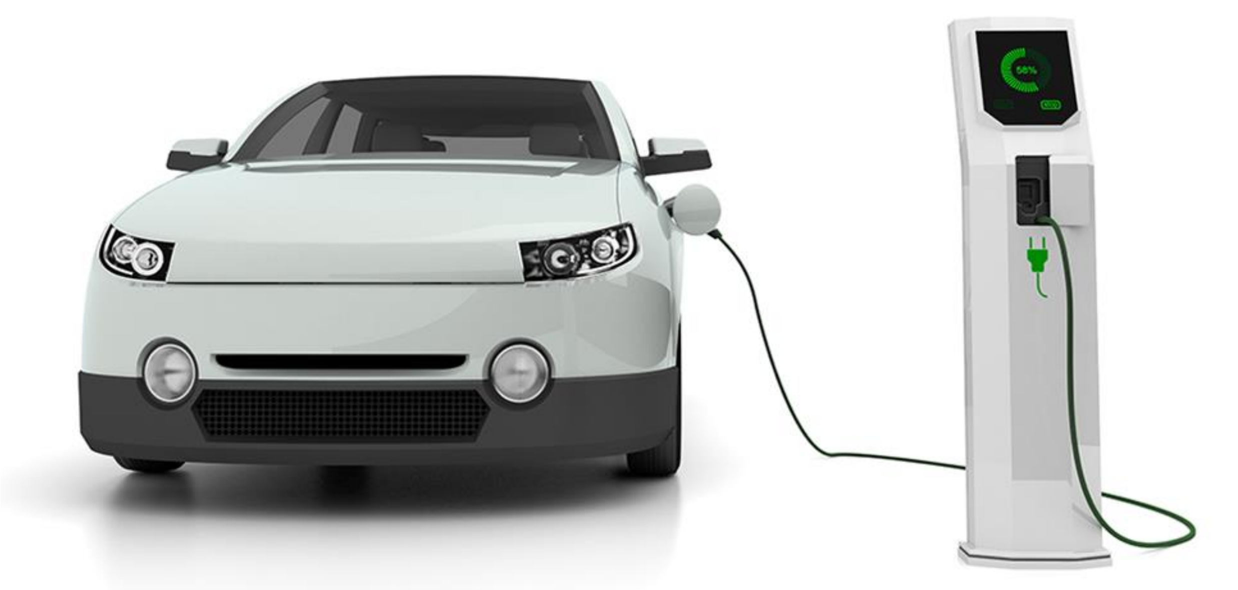
Southern California Edison
Plug-In Electric Vehicle (PEV)
Workplace Charging Pilot



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1. Executive Summary

The Plug-In Electric Vehicle (PEV) Workplace Charging Pilot (Pilot) Final Report is provided in compliance with the California Public Utilities Commission (Commission or CPUC) Demand Response Decision (D.) 12-04-045 dated April 30, 2012[1], as amended by Advice Letter (AL) 2746-E-A[2]. The Decision authorized funding for Southern California Edison Company (SCE) to conduct the pilot contingent upon the submittal and approval of the required pilot plans discussed in Ordering Paragraph 80. On December 24, 2012, SCE submitted supplemental information to AL-2746-E-A that stated SCE would report on the status of the pilot projects. This report is submitted in compliance with those requirements.

In Rulemaking (R.)09-08-009, the CPUC identified that the projected near-term growth of light-duty passenger battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV) in California was significant. The CPUC wished to evaluate the impact such growth would have on California's electric infrastructure in order to inform Commission actions to mitigate risks to the grid while simultaneously recognizing the benefits electric vehicles provide in achieving California's climate change goals[3]. In order to gain information related to PEV charging and its impact on the power supply, the Commission approved the Southern California Edison (SCE) Plug-In Electric Vehicle (PEV) Workplace Charging Pilot (Pilot) plan in January 2013[4]. This report is in compliance with (D) 12-04-045 and provides an overview of the Pilot activities and discusses findings specific to the Pilot Plan (Advice Letter 2746-E, Attachment A)[5].

[1] D.12-04-045 CPUC Decision Adopting Demand Response Activities and Budgets For 2012 Through 2014 (April 30, 2012), http://docs.cpuc.ca.gov/PublishedDocs/PUBLISHED/Graphics/165317.PDF.

[2] Advice Letter 2746-E-A, Supplemental Filing Advice 2746-E, Proposed Plug-In Electric Vehicle Workplace Charging Pilot Plan, in Accordance with Decision 12-04-045 (December 24, 2012), https://www.sce.com/NR/sc3/tm2/pdf/2746-E-A.pdf.

[3] R.09-08-009, Order Instituting Rulemaking to Consider Alternative-Fueled Vehicle Tariffs, Infrastructure and Policies to Support California's Greenhouse Gas Emissions Reductions Goals, Section 1 Summary, pg. 2, (August 24, 2009), http://docs.cpuc.ca.gov/word_pdf/FINAL_DECISION/106042.pdf

[4] https://www.sce.com/NR/sc3/tm2/pdf/2746-E.pdf.

[5] Advice Letter 2746-E, Proposed Plug-In Electric Vehicle Workplace Charging Pilot Plan, in Accordance with Decision 12-04-045 (June 22, 2012), https://www.sce.com/NR/sc3/tm2/pdf/2746-E.pdf.

The stated objectives of the SCE Pilot were to test, monitor and analyze the impacts of PEV workplace charging on power systems, evaluate consumer response to pricing and demand response (DR) strategies, better quantify the potential for PEV charging to support DR programs, and evaluate open communication standards and non-proprietary payment options.

During 2012, SCE surveyed employees to determine the level of current PEV ownership and gauge expected adoption in the near-term. The survey responses served as the basis for selection of the pilot installation sites. In addition, SCE conducted a competitive solicitation for vendor proposals to provide electric vehicle supply equipment (EVSE), open standards-based communications, and non-proprietary payment processing services required for the pilot. The solicitation resulted in selection of a primary contractor to provide equipment and manage subcontractors, including a network interface provider and payment processor. SCE also engaged a vendor to provide an OpenADR 2.0b based DR Management System (DRMS) to provide signaling and reporting functionality for the project.

Due to the innovative nature and technical complexity of the pilot, SCE and its selected vendors required approximately six months to develop project requirements, finalize the statement of work, and implement required technical capabilities. The pilot team completed contracting activities in June 2014 and acquired equipment and software by August 2014. Architectural and design activities, permitting, construction, and installation at eight (8) sites were completed by September 2014 and the pilot was launched on October 6, 2014. The project team identified one additional site after the initial launch and completed installation and launch at this last site in December 2014.

SCE filed AL 3090-E in August 2014 to modify SCE's existing Preliminary Statement Part YY, Base Revenue Requirement Balancing Account (BRRBA) to return user fees collected by SCE during the pilot to all customers by crediting the distribution sub-account of the BRRBA.

SCE tested the following factors over the course of the Pilot:

1) Time-of-Use pricing (i.e., off-peak and on-peak periods) for Level 2 (208VAC; 30 amp) charging and simulated Level 1 power level of 208VAC (7 amp) charging;
2) Demand response through dispatch and curtailment during nineteen (19) 60-minute events at various times during the work week;
3) Non-charging occupancy fee to test space management control;
4) Real-time SMS messaging to communicate charging session status to drivers;
5) Premium pricing during DR events to simulate Critical Peak Pricing scenarios.

Significant understanding regarding electric vehicle charging in the workplace was gained from SCE's Workplace Charging Pilot, including the relationship of pricing to charging, the role different vehicles and driver needs play in the charging model, the value of space management controls to optimize use of the charging infrastructure, the reliability and scalability of innovative technical solutions, demand response potential from PEV charging and issues regarding measurement of PEV charging load curtailment, and the impact that communications and issue resolution have on customer satisfaction.

On average, over 1,100 sessions per month were authorized under varying Level 1 and Level 2 pricing strategies. The majority of these participants charged their PEV between 5:00 AM and noon. This finding suggests that employees are influenced by factors such as establishing a regular charging routine, leveraging open charging spaces in the workplace, ensuring that charging is complete when needed by the driver, and opting for charging at lower, off-peak prices.

In addition, 76% of drivers participated in demand response test events scheduled during off-peak hours while 72% participated during on-peak events, which suggests that the pilot user population was generally satisfied with the DR strategies tested.

The knowledge gained from this pilot could serve as a valuable resource for other charging initiatives and the findings in this report support the research objectives as identified in the Advice Filing.

2. Introduction

In Rulemaking (R.)09-08-009, the CPUC identified that the projected near-term growth of light-duty passenger battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV) in California was significant. The CPUC in this rulemaking wished to evaluate the impact such growth would have on California's electric infrastructure in order to inform CPUC actions to mitigate risks to the grid while simultaneously recognizing the benefits electric vehicles provide in achieving California's climate change goals.[6] In order to gain information related to PEV charging and its impact on the power supply, the Commission approved the Southern California Edison (SCE) Plug-In Electric Vehicle (PEV) Workplace Charging Pilot plan in January 2013[7]. This report provides an overview of the pilot activities and discusses findings specific to the pilot Plan (Advice Letter 2746-E, Attachment A)[8].

2.1 CPUC Requirements

Pursuant to Rulemaking (R.)09-08-009 Ordering Paragraph (OP) 1, the Commission instituted a rulemaking to consider Alternative-Fuel Vehicle (AFV) tariffs, and infrastructure and policies to Support California's Greenhouse Gas (GHG) Emissions Reductions Goals.[9]

On March 1, 2011, SCE filed A.11-03-003[10], requesting approval of its DR programs, activities, pilots, and budgets for 2012-2014. In its Application, SCE proposed a

[6] See fn. 3.
[7] See fn. 4.
[8] See fn. 5.
[9] R.09-08-009, Order Instituting Rulemaking to Consider Alternative-Fueled Vehicle Tariffs, Infrastructure and Policies to Support California's Greenhouse Gas Emissions Reductions Goals, Ordering Paragraph 1, (August 24, 2009), http://docs.cpuc.ca.gov/word_pdf/FINAL_DECISION/106042.pdf.
[10] Application Of Southern California Edison (U338-E) For Approval Of Demand Response Programs, Activities And Budgets For 2012-2014 (March 1, 2011), http://www3.sce.com/sscc/law/dis/dbattach10.nsf/0/A5FA37D9FC107A5E8825784700749B9A/$FILE/A.11-03-003+DR+2012-14+-+SCE+Application+for+Demand+Response.pdf.

workplace charging pilot to analyze the impacts of PEV workplace charging on California's power system as proposed by the Commission[11].

This pilot was approved in Decision (D.)12-04-045[12], and (OP) 80 required that Southern California Edison submit a Tier 2 Advice Letter that included a pilot plan for the SCE Plug-In Electric Vehicle (PEV) Workplace Charging Pilot proposed in (A.)11-03-003. The Advice Letter was required to be filed "no later than six months before the anticipated start date of the pilot or 60 days after the issuance of this decision".

The Decision indicated that the pilot plan must include the following:

- A problem statement;
- How the pilot will address a DR goal or strategy;
- Specific objectives and goals for the pilot;
- A clear budget and timeframe;
- Relevant standards or metrics;
- Methodologies to test the cost-effectiveness of the pilot;
- An Evaluation, Measurement and Verification plan; and
- A strategy to identify and disseminate best practices and lessons learned.

The Commission authorized the SCE PEV Workplace Charging Pilot budget in D.12-04-045 contingent upon approval of the pilot plan discussed in OP 80.

To satisfy the requirement in OP 80, SCE filed Advice Letter (AL) 2746-E[13] on January 22, 2012, that included a pilot plan with the nine elements required by the Commission. AL 2746-E indicated that the Workplace Charging Pilot would:

- Test, monitor and analyze the impacts of Plug-In Electric Vehicle (PEV) workplace charging on power systems;
- Evaluate consumer preferences with respect to Demand Response (DR);

[11] See fn. 1.
[12] Ibid.
[13] See fn. 5.

- Test and evaluate different pricing, DR, and user options;
- Examine the potential for distribution system impacts and ways to mitigate them;
- Better understand consumer preferences and behaviors associated with pricing and curtailment strategies modeled in the pilot;
- Quantify installation and maintenance costs of the workplace charging infrastructure;
- Expand technology horizons by embedding standard DR message protocols, such as OpenADR 2.0 signaling, into this area to enable DR, consumer choice and feedback, which had not yet been attempted in the PEV charging marketplace.

In response to protests filed by the Department of Ratepayer Advocates (DRA) and the Green Power Institute (GPI) on July 12, 2012, SCE filed AL 2746-E-A[14] on December 24, 2012 to provide additional details on the pilot proposal.

The Commission approved AL 2746-E, as amended by supplemental AL 2746-E-A, on January 3, 2013, and requested that SCE begin the pilot immediately.

2.2 Pilot Schedule

Following CPUC approval of the SCE Workplace Charging Pilot plan in January 2013, SCE initiated project planning activities that included finalizing the research objectives, selecting the project team, issuing a second employee survey, conducting an open solicitation to select product and service providers, finalizing site selections, and developing a detailed installation plan. Procurement, construction, and installation activities were completed by September 2014 and the chargers[15] were activated in

[14] See fn. 2.

[15] For the purposes of this report, charger, charging station, and EVSE each refer to A/C Level 2 electric vehicle supply equipment.

October 2014[16]. Complimentary charging was provided from October through December 2014 in order to develop a baseline against which pilot activities could be measured. The pilot execution phase implementing fee-based charging and testing of real time driver text notifications was initiated in January 2015. The DR event testing phase was initiated in May 2015, and the space management testing phase using a penalty assessed for vehicles that remained connected more than 30 minutes after completed charging was initiated in August 2015. The complete schedule of pilot activities is shown in Table 1.

Table 1: SCE Workplace Charging Pilot Schedule

AUGUST 2009	CPUC initiated rulemaking to consider alternative-fuel vehicle tariffs, infrastructure and policies to support CA GHG emissions reductions goals (R.09-08-009).
MARCH 2011	SCE proposed the PEV Workplace Charging Pilot in its 2012-2014 DR Application (Tariffs Programs & Services).
JUNE 2012	SCE filed AL-2746-E pursuant to OP80 of D.12-04-045, which outlined 9-point pilot plan.
DECEMBER 2012	SCE filed AL-2746-E-A to supplement its 9-point pilot plan as required by CPUC.
JANUARY 2013	CPUC approved the SCE Workplace Charging pilot.
SEPTEMBER 2013	2nd PEV User Survey was conducted with SCE/EIX employees and used as the basis for installation site selection.
OCTOBER 2013	Competitive solicitation completed and bidder selected.
DECEMBER 2013	Site selection and installation plan completed; Design & engineering activities started.
JUNE 2014	New construction activities started; Technical Requirements finalized; Purchase Order issued.
SEPTEMBER 2014	Construction and Installation Activities Completed.
OCTOBER 2014	PEV Chargers Operational and Baseline Data Gathering Phase Launched: Complimentary Charging.
DECEMBER 2014	Baseline Data Gathering Phase Completed.
JANUARY 2015	Pilot Execution Phase Launched: Fee-based PEV Charging with driver text notifications started.
MAY 2015	DR Testing Phase Launched: DR Events started.

[16] Installation and activation of charging stations at the Wildomar site were completed in December 2014.

AUGUST 2015	Space Management Testing Phase Launched: Start Non-Charging Occupancy Fee.
DECEMBER 2015	Pilot Completion Date: 12/31/2015
Q1-Q2 2016	Transition 80 PEV chargers to outsourced operation and management while continuing enabled functionality. Conduct data analysis and develop pilot final report.
MAY 2016	Present SCE PEV Workplace Charging DR Pilot status update at DRMEC Meeting.
Q3 2016	Serve SCE PEV Workplace Charging DR Pilot final report with the CPUC.

2.3 Pilot Activities

Pursuant to Attachment A, Section D of Advice Letter 2746-E, SCE deployed electric vehicle charging stations at nine (9) SCE facility parking lots. Users paid a base, per-hour time-of-use (TOU) fee and a space management fee was implemented that assessed additional charges on vehicles that remained connected to the charging station more than 30 minutes after charging was complete. SCE successfully dispatched 19 DR events to evaluate DR potential from PEV charging, assess consumer response to premium pricing during DR events, and inform a methodology for accurately measuring PEV charging load curtailment. Energy consumption was measured at each charging station and used to analyze the impact of pricing, load curtailment during DR events, utilization, consumer behavior, and space management strategies. The PEV load was also compared with existing building usage and demand data to evaluate load impact on the building. SCE implemented wireless communications from individual charge stations to the vendor back office for billing and settlement, and payments were processed using a third-party billing and settlement service. Time-of-use pricing, session interval data, and DR load reductions were communicated via Open ADR 2.0 signals while non-charging occupancy fees were managed by the network provider. SCE conducted employee surveys and forums to gather feedback from drivers and non-drivers regarding PEV adoption, driving needs, work requirements, and other PEV-related topics. Based on the pilot requirements, SCE deployed and operated plug-in electric vehicle charging stations as discussed throughout this report. As such, SCE selected sites, equipment, software, communications, and other functionality that met the pilot's needs. SCE also developed and implemented pricing and demand response strategies, as well as space management controls and other processes, while monitoring the PEV driver charging experience. It should be noted that this situation was unique to the SCE pilot. The following sections provide detailed discussions regarding the pilot activities and findings.

2.4 PEV Charging Decision

Data collected during the pilot indicated that PEV drivers consider multiple, individual factors when choosing whether or not to charge their PEV as illustrated in Figure 1. This information supported development of the pilot pricing and DR strategies, and provided insight into the factors that should be considered when planning PEV charging in the workplace.

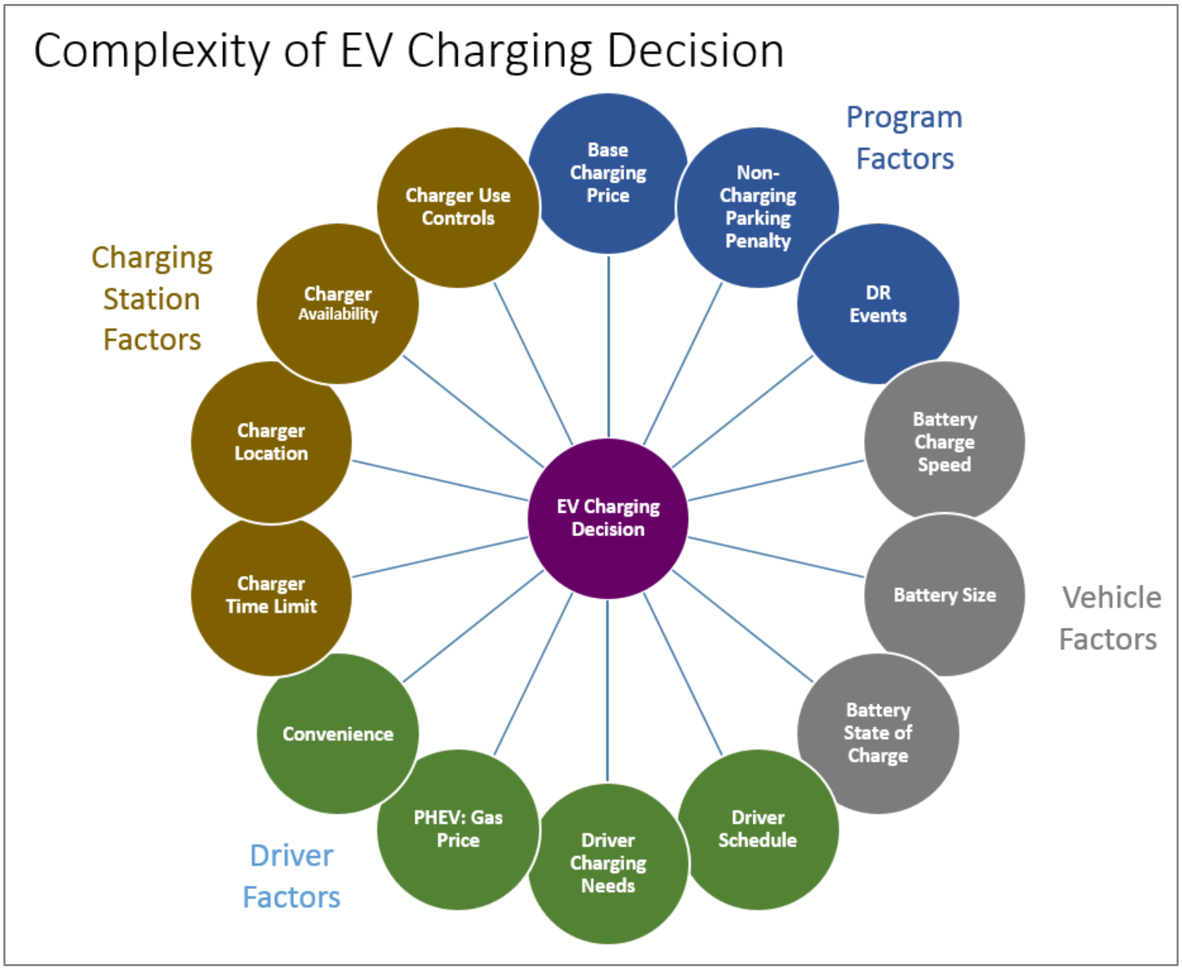


Figure 1: Factors influencing a driver's decision to charge their plug-in electric vehicle.

3. Pilot Infrastructure

Following submittal of its 2012-2014 Demand Response Application[17], the pilot team established criteria for selecting SCE facilities to participate in the pilot, including size of facility, existing and planned workforce staffing levels, existing PEV charging infrastructure, number of existing and potential PEV drivers, and geographic location. As a means of informing the June 2012 filing of Advice Letter 2746-E, SCE distributed a survey to active SCE employees in May 2012 to evaluate current and potential PEV ownership/leasing among its employees. The team also evaluated approximately 50 SCE facilities that housed at least 100 employees to better understand employee PEV charging needs at specific facilities. Using the data collected, SCE identified eight (8) facilities of varying sizes and workforce populations with existing or potential PEV charging needs to support utilization of the pilot charging stations. Subsequent to these planning activities, the team identified a suitable ninth facility at which pilot charging stations were also installed.

3.1 Construction and Installation Activities

In order to evaluate electric vehicle driver preferences relative to demand response events and dynamic pricing when charging their PEVs at the workplace, analyze impacts of PEV charging on electrical systems, test innovative technologies and open standard based protocols, and quantify installation and maintenance cost of the workplace charging infrastructure, SCE deployed 80 Level 2 (30 amp) chargers that comply with requirements of the Americans with Disabilities Act (ADA) at nine (9) SCE work facilities. Although SCE considered inclusion of DC fast chargers in the pilot, the

[17] See fn. 10.

pilot team determined that the equipment cost and variation introduced by the faster charging was inconsistent with key project processes.

Based on benefits obtained from the innovative pilot design, updated cost estimates, and approved pilot budget, the 80 intelligent charging stations SCE installed an interoperable and open standards based architecture through which fee-based charging, DR events, space management controls, and real-time driver notifications could be executed. The project was among the first large scale pilots to combine OpenADR 2.0b and Open Charge Point Protocol (OCPP) (version 1.5+) for electric vehicle charging. OCPP 1.5 was modified to perform the pilot use cases that were not addressed in OCPP 1.5, including the ability to add user charge level selection, DR selection, phone number, encrypted credit card data, and issue and remove load shed commands.

In order to minimize construction costs, SCE installed charging stations with attached payment modules at facilities that had existing PEV charging infrastructure. Facilities that required either full or partial construction and installation of new infrastructure were designed with remote payment kiosks that could serve up to eight (8) charging stations. This approach enabled SCE to gather data related to wireless communications and the impact the communication channel had on the PEV driver user experience. A listing of the SCE facilities with the number of charging stations and type of payment module installed is shown in Table 2.

Table 2: SCE Workplace Charging Pilot Installations

Facility ID	City	Number of Charging Stations Installed	Type of Payment Module	Notes
A	Rosemead, CA	22	Attached	
B	Rosemead, CA	9	Mixed	
C	Rosemead, CA	14	Remote Kiosk	
D	Rosemead, CA	12	Mixed	
E	Pomona, CA	4	Remote Kiosk	
F	Pomona, CA	4	Remote Kiosk	
G	Irwindale, CA	7	Mixed	Disabled Access
H	Santa Ana, CA	4	Attached	
I	Wildomar, CA	4	Attached	LEED Certified Facility

3.2 PEV Charging Installation Criteria and Access

Since SCE sought to optimize access to workplace PEV charging while controlling pilot costs, installation of the charging stations was contingent upon the level of existing infrastructure, proximity to the building electrical equipment, and other parking considerations. One-half of the pilot charging stations were installed in open access locations while the remainder were installed in restricted parking lots. In addition, one disabled access space was installed at the Irwindale facility pursuant to city permitting requirements.

3.3 Equipment

Although SCE evaluated use of existing PEV charging stations installed in 2010 - 2011 that were funded by American Recovery and Reinvestment Act (ARRA) grants or the SCE PEV fleet expansions, it was determined that lack of required functionality and reporting excluded them from participating in the pilot.

SCE developed a detailed installation plan to remove and replace 29 charging stations, install EVSEs at eight (8) existing stub-outs, and complete new construction to install an additional 43 stations. In total, 80 intelligent charging stations enabled with dynamic pricing, fee-based charging, space management controls, demand response curtailment functionality, user selection of charging and DR actions, and encrypted payment card authorization were installed for employee PEV charging during the pilot.

3.3.1 *Electric Vehicle Supply Equipment (EVSE)*

SCE partnered with EVSE LLC, a division of Control Module, Inc., to provide its ADA compliant Model 3703 WattPoint™ Electric Vehicle Service Equipment (EVSE) for the pilot. The 7.2 KW pole mounted EVSE is equipped with a manual cable that is capable of providing up to 30A at 208-240V AC, single phase, 50 or 60 Hz. The unit complies with the SAE J1772 specifications for supplying electrical power to a J1772 compatible plug-in electric vehicle (PEV) and users wrap the cable onto the storage hook and plug the J1772 connector into the cable holster when not in use. The model 3703 was controlled remotely to apply, reduce or disconnect power to the PEV, and it measured both voltage and current being supplied to the vehicle. The unit is equipped with five (5) LED status lights that indicate the state of the charging operation (Blue – Power; Yellow - Charger Ready or PEV Connected; Green – PEV Charging or Charge Complete; Red – Error; Orange – Charger Reserved not used during the pilot). Power was required at each charging location and was supplied by a dedicated 40A non-Ground Fault Current Interrupter (GFCI) circuit breaker at the service panel. Safety features of the Model 3703 include protection from sparks, shock, and over current, as well as plug out detection.

3.3.2 *Payment Module*

The EVSE communicates directly with an EVSE LLC Model 3725 Payment Module (i.e., gateway) that provides the communication link between the charging station and network provider. The payment module has a programmable, embedded computer, a 3x4 keypad, and a 4x20 vacuum fluorescent display (VFD).

The installation plan specified use of both single and dual surface mounted model 3703 EVSEs with a Payment Module connected either on the same pole or remotely. The payment module communicates to the EVSEs via a serial, hard-wired connection and incorporates a multiplexer for sites where the payment module is supporting more than two EVSEs. A dual surface mounted model 3703 with attached payment module is shown in Figure 2 (holsters not pictured).

Figure 2: Model 3703 WattPoint™ Electric Vehicle Service Equipment (EVSE)

The model 3725 payment module also supports an internal, 3G cellular modem, magnetic card reader, and a near-field Radio-Frequency Identification (RFID) card reader. The unit is equipped with two serial ports that communicate directly with the

EVSE controllers and receive power from the EVSE to support payment module operation. Internally, the embedded computer is connected directly to the cellular modem through its Ethernet port.

Each payment module modem has its own unique internet protocol (IP) address and forwards encrypted credit card data, user selections, phone number, and a transaction identification code (ID) to a central host for transaction authorization. The transaction ID is used to determine the transaction Start Time and End Time. Power consumed by the EVSE is transmitted to the central host in accumulated watt-hours (Wh) every 5 minutes. At times when the EVSE is not charging a vehicle, a heartbeat is transmitted by the payment module to the host every 15 minutes in order to confirm continual connectivity with the payment module. The payment module monitors EVSE operational status and, in the event of a fault, reports a chargebox ID to the host that is associated with the location, fault message, date, and time of the event. Load shed commands are forwarded to the EVSEs by the payment module.

3.3.3 *Charging Initiation Process*

After authorization and connection is complete, the vehicle generally requires up to 5 minutes to fully ramp up to its requested charging level. SAE J2894/1/2 grid impact criteria requires that, in the event of a deep voltage sag or momentary outage, the charge should “ramp up” to its required maximum at a rate of 1A/sec. In response to the latter “ramp up” requirement, the EVSE was designed to perform this “ramp up” using a ramping of the pilot signal at both charge initiation and in the event of a voltage sag or momentary outage. In the case of a voltage sag or momentary outage, the charge would start at 6A and then perform the 1A/sec “ramp up”. As an additional response to a deep voltage sag or momentary outage, the EVSE charge randomly restarted at between 2 and 5 minutes after service was restored.

3.3.4 *Device Testing*

Prior to the deployment of devices at SCE's facility, and with the support of SCE's Advanced Technology Organization (ATO), the project leads developed the design and procurement documents including use case, architecture, and requirements. Following issuance of these specifications, vendors submitted hardware to ATO's Pomona labs where Safety, Functionality and Reliability testing utilizing SAE J2894 test procedures and testing against the SAE J1772 standard were conducted. Hardware that passed technical testing were included in the final round of the procurement evaluation and, following SCE's procurement practices, the EVSE LLC and Greenlots proposal was chosen.

Following completion of technical testing, the devices were sent to ATO's Garage of the Future (GOF) lab in Westminster where SCE engineers worked with the vendors to conduct interoperability and software acceptance testing, as well as refine billing procedures, customer communications, and demand response processes to enable field deployment. The devices remained in the GOF labs throughout the life of the pilot for regression and error testing. A total of 17 PHEV's and BEV's were tested in the labs during the pilot. Following completion of all testing, the hardware was deployed at the nine (9) SCE pilot facilities.

3.4 **Load Metering**

During the pilot, energy usage was measured at the individual charging station using a non-revenue grade meter embedded in the EVSE model 3703. Usage was reported in accumulated watt-hour (Wh) values at the start of the charging session, at 5-minute intervals during the charging session, and at the end of the charging session. The load metering approach enabled SCE to measure individual PEV charging session usage, aggregate usage at each facility, and aggregate usage across the PEV infrastructure. The data collected supported analysis of consumer behavior relative to pricing strategies, charging patterns, DR event participation, impact of PEV charging on building load, and utilization rates. The usage data aggregated by facility was also evaluated relative to the building load meter data at each site to determine the impact PEV charging had on the overall building load and demand charges. Load impact analysis is provided in Section 13.

4. Employee Surveys

In order to support effective planning and execution of the pilot plan, SCE conducted an initial employee survey in May 2012 to measure both current and potential PEV ownership/leasing among SCE employees. Responses from over 6,000 SCE employees were analyzed and this data served to inform preliminary selection of SCE facilities for inclusion in the research study and provide a benchmark for the number of PEV charging stations required to serve existing and future charging needs.

Following approval of the pilot plan in January 2013, a second employee survey was conducted in September 2013 to validate the site selection list and inform development of the project installation plan. Responses from over 2,300 employees were analyzed in 2013, which enabled the installation plan to be refined and a comparison with the 2012 survey findings to be made.

A third survey was distributed to a limited population of SCE employees in March 2015 as a means of gathering initial PEV driver feedback regarding their experiences when using the pilot PEV charging stations, primary reasons for purchasing a PEV, commute distance, and primary use of the PEV. Responses from 638 employees, primarily located at the General Office complex in Rosemead CA, were analyzed to support continued development of pricing and demand response strategies.

A final employee survey was distributed to over 13,000 active SCE employees in March 2016 after completion of the SCE PEV Workplace Charging Pilot. Reponses from 6,051 employees were received, which resulted in a valid response rate of 23.5% (3,061 responses). The survey sought to measure current PEV ownership and intent to purchase, commute distance, PEV type, workplace information, work schedule, field work and travel requirements, disabled access need, and charging behavior. The 2016 survey responses and actual pilot data provided critical information for comparing actual employee behavior against pre-pilot expectations.

4.1 Comparative Survey Findings

Approximately 60 SCE employees indicated that they owned or leased a PEV in May 2012, which represented less than 1% of the total survey respondents. Over 1,000 employees who responded to the 2012 survey indicated that they were likely to purchase or lease an electric vehicle by the end of 2014, with almost 600 more respondents indicating likelihood in 2015 or later. Within 18 months, SCE employees increased their PEV ownership by over 115% to 125, which represented 5% of the total 2013 survey respondents. It is important to note that the 2013 survey distribution occurred six months after SCE completed staffing realignments and survey results may have been impacted by those actions. By March 2016, PEV ownership/leases among SCE employees had increased to 342 plug-in electric vehicles. The results indicated a 490% increase in PEV ownership as compared with 2012 responses and they represented 11% of the total 2016 respondent population.

Ownership of plug-in hybrid electric vehicles (PHEVs) increased almost 900% between 2012 and 2016, from 19 to 189 while ownership of battery electric vehicles (BEVs) increased nearly 300%, from 39 to 153. Although these findings tend to suggest that the majority of potential PEV buyers are more likely to purchase a PHEV versus a BEV, the purchase/lease decision appears to be highly influenced by length of commute, type of vehicle being considered, vehicle price range, battery range, and other personal factors as shown by the fact that 22 employees indicated that they own/lease both a BEV and PHEV. Results from the surveys conducted during 2012, 2013, and 2016 are provided in Appendix C: Survey Comparative Data.

4.2 Additional 2016 Survey Findings

4.2.1 *Workplace Arrival & Departure Time*

- Employees with >50 mile commute more frequently arrive before 7:00 a.m. and depart before 4:00 p.m.

4.2.2 *Electric Vehicle Driving and Charging Behaviors*

- Probability that an electric vehicle owner would drive their EV to work directly correlates to commute distance
- 84% of PEV owners drive their PEV to work daily (4-5 days a week)
- Probability that a PEV owner would charge more days at work directly correlates to commute distance
- PEV owners with >30 mile commute are more likely to charge at work 4-5 days per week vs drivers with shorter commute
- 33% of PEV owners charge their PEV at work daily
- 25% of PEV owners never charge at work due to lack of employee-accessible charging stations
- 77% of PEV owners would plan to charge more often if more stations were available while 60% would plan to charge every day
    - Finding does not consider fee-based vs free charging

4.2.3 *Intent to Buy an Electric Vehicle*

- The probability of an employee buying an EV in the next 2 years directly correlates to commute distance provided more employee accessible charging stations were available at their work location

- Employees with commute >40 miles are very likely to purchase an EV in the next two years
- Employees with commute <20 miles are not at all likely to purchase an EV in the next two years

4.2.4 *Craft/Field Workers*

- Comprise 17% of total respondents
- More likely to arrive before 7:00 a.m. and depart before 4:00 pm
- More likely to work 6 or more hours in the field
- More likely to have commute <5 miles (very short) or >50 miles (very long)

4.3 Employee Forums and Communications

SCE hosted employee forums at several SCE work locations in December 2014 and April 2015 to provide employees with information regarding the pilot activities, encourage charging station use, monitor employee PEV adoption, address questions and concerns, and better understand driver needs and preferences.

In order to engage users and increase access to pilot information, monthly pilot status updates were distributed to registered stakeholders and information was posted on multiple SCE employee intranet channels. In the event that an urgent charging issue was identified, such as problems impacting charging, immediate emails were distributed to advise stakeholders of the issue, status, and resolution.

These efforts served to improve customer satisfaction with the pilot activities, increase access to driver feedback, and enable the team to proactively manage opportunities and risks.

5. Pilot Design

In order to meet the critical objectives of the PEV Workplace Charging Pilot, SCE partnered with Greenlots, Control Module Inc./EVSE LLC, and AutoGrid Systems to design an interoperable and open standards based architecture through which fee-based charging, demand response events, space management controls, and real-time driver notifications could be executed. This combination of technology and strategy enabled the pilot to successfully meet its objectives by testing dynamic price signals and demand response, as well as measure the degree to which the pilot strategies may have influenced workplace charging behavior. The pilot leveraged open standards across multiple vendors to meet the testing use cases including demand management, energy shifting, situational awareness, and driver interactions.

5.1 Infrastructure and Functionality

SCE deployed 80 Level 2 (208V/30AMP) chargers and associated payment stations/gateways, which were specifically developed by EVSE LLC to support the pilot objectives, at nine (9) SCE facilities that had varying geographic, size, and staffing level characteristics. Software within the chargers enabled each station to provide Level 2 (208VAC; 30 amp) charging, a simulated Level 1 power level of 208VAC (7 amp), or any charging level between level 1 and level 2 based on the user's selection at the payment module. The team defined seven (7) use cases for testing during the pilot, including Initial User Choice, Customer Choice of Event Action, User Initiates Charging, Generic Event Scenario, Targeted Event Scenario, Charging Complete, Other Scenarios. Details regarding primary use cases is provided Section 19.

Software could also reduce charging during a DR event as discussed in Section 7.3. Payment stations enabled users to select charging level and DR event actions prior to initiating charging sessions and the sessions were billed to payment cards (e.g., credit or debit cards).

5.2 Architecture

SCE chose to develop an architecture using Open Automated Demand Response 2.0b (OpenADR) because it provides an open and standardized way for electricity providers and system operators to communicate DR signals with each other and with their customers using a common language over any existing IP-based communications network, such as the Internet.

DR event signals and session data were communicated over the Internet using Open OpenADR 2.0b from SCE's AutoGrid Systems cloud based Virtual Top Node (VTN) (i.e., OpenADR server) to and from Greenlots OpenADR Virtual End Node (VEN) (i.e., OpenADR client). Open Charge Point Protocol (OCPP) version 1.5 communications over cellular were required between the Greenlots server and the EVSE LLC gateways/payment stations. Since OCPP v1.5 did not meet all of the use cases required for the pilot, the vendors extended the protocol as needed. SCE requires that the vendor upgrade the OCPP software to version 2.0 after it is released and certifiable as a standard. A diagram of the SCE network implemented by the pilot team is shown in Figure 3.

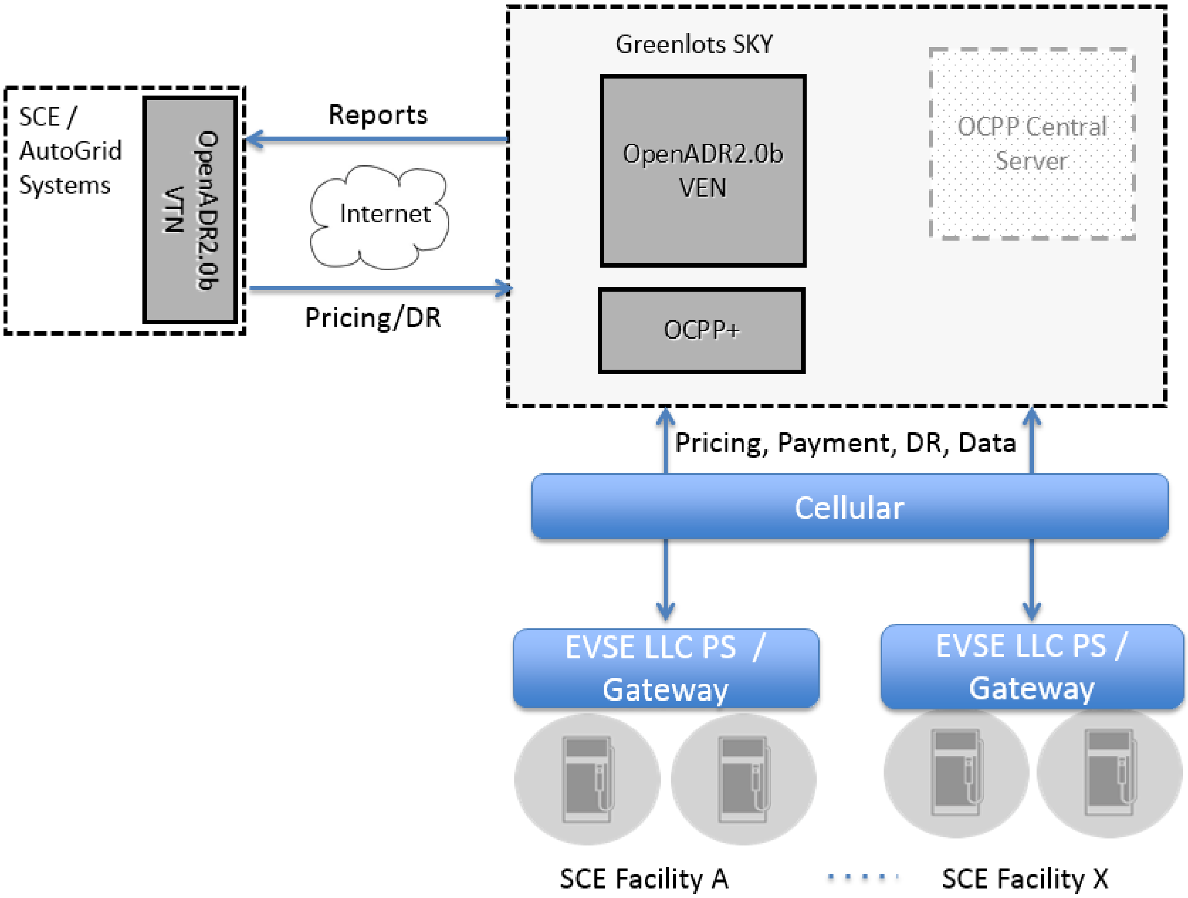


Figure 3: SCE Workplace Charging Pilot Architecture

The project was among the first large scale pilots to combine OpenADR 2.0b and OCPP (version 1.5+) for electric vehicle charging. In addition to the architecture implemented for the pilot, the solution provided options for using a central server as an OpenADR Virtual End Node (VEN); using pricing signals for billing based on session times or meter values; using load dispatch signals to obtain aggregate or individual EV charging load shed value; translating OpenADR events to OCPP 1.6 Smart Charging Profiles; and reporting from central server VEN to OpenADR VTN.

5.3 Open Charge Point Protocol (OCPP)

According to the Open Charge Alliance (OCA), "The goal for the Open Charge Point Protocol (OCPP) is to offer a uniform solution for the method of communication between charge point and central system. With this protocol it is possible to connect any central system with any charge point, regardless of the vendor."[18] Use of OCPP supported SCE's objective to design an interoperable charging platform and test non-proprietary charging options in order to identify options that minimize PEV charging infrastructure costs for the business owner.

OCPP version 1.6, which has been formally released, introduced additional support for smart charging as well as smart charging and pricing profiles.[19] OCPP version 1.6 is supported by a compliance testing toolkit to ensure more seamless interoperability and a certification program. Using the OCPP smart charging feature in this case, user selections and active event data could be translated into an OCPP smart charging profile and sent to the charging station.

5.4 AutoGrid Systems Demand Response Optimization and Management System (DROMS)

SCE selected the AutoGrid Systems (AutoGrid) Demand Response Optimization and Management System (DROMS) to exchange OpenADR events, pricing, and session data with Greenlots. The DROMS platform provided a simple, web-based operator portal for event creation, pricing adjustment, and downloadable data in multiple formats e.g., .csv, .pdf, etc.). Since time-of-use pricing is not currently available in the OpenADR standard, AutoGrid Systems developed a script that advertised Level 1 and Level 2 on-peak and off-peak pricing to Greenlots, which Greenlots subsequently sent to the

[18] http://www.openchargealliance.org/

[19] OCPP version 1.5 was used during the pilot. Version 1.6 was formally released after pilot launch.

payment stations. Screenshots of the AutoGrid DROMS interface are provided in Figure 4, Figure 5, and Figure 6.

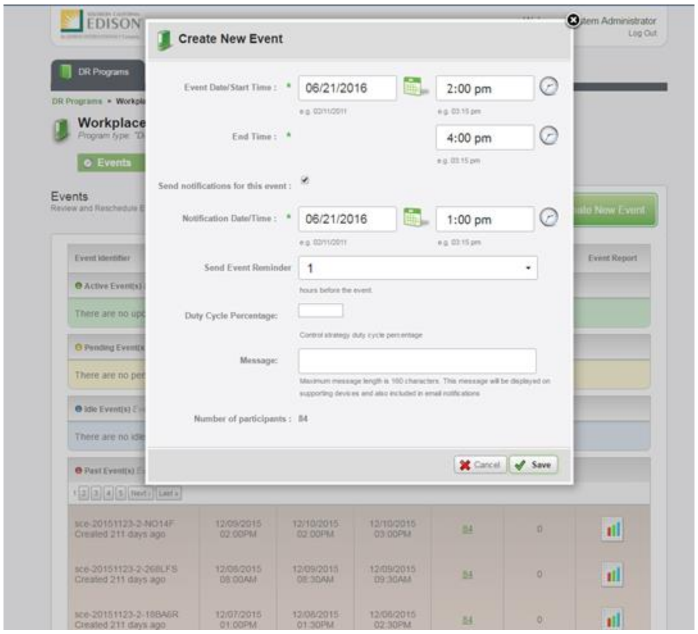


Figure 4: Screenshot of the AutoGrid DROMS DR event creation interface.

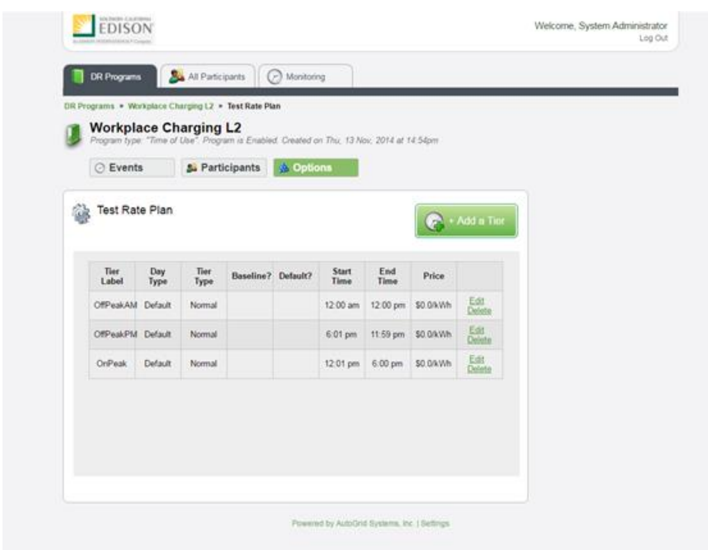


Figure 5: Screenshot of the AutoGrid DROMS TOU pricing creation interface.

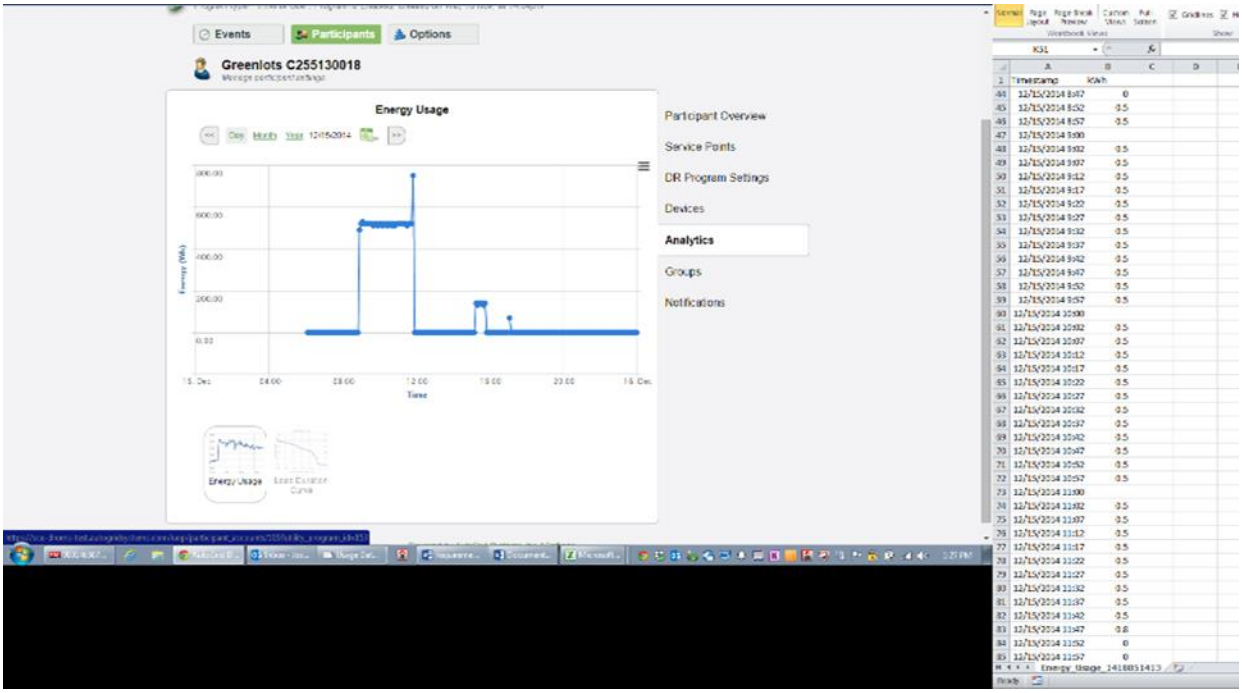


Figure 6: DROMS session data curve screenshot (Left) and related 5-minute interval file (Right). Note that each 5-minute interval is represented by a point on the curve.

5.5 Open Automated Demand Response (OpenADR)

In order for SCE to provide users with control of their charging when DR events were dispatched, SCE used an OpenADR 2.0 prescribed simple event for DR. Thus, “Moderate” signals, along with the start time and duration were sent to Greenlots for a majority of the events. SCE also could send “High” signals that meant all charging must be curtailed, or “Special” meaning all Level 2 charging must be reduced to 50% of the existing capacity (e.g., charging taking place at 30A reduced to 15A).

SCE used an OpenADR 2.0b hosted server for demand response signal transmission and communications with the Greenlots SKY network platform. This process included establishing a communication baseline and transmitting baseline data, on-peak and off-peak pricing events, and load shed events to the Greenlots network. In addition, SCE received participation and curtailment reports via the OpenADR 2.0b interface.

5.6 System Interactions

During the pilot, SCE employees could plug their PEV into an EVSE LLC charging station when they arrived at the workplace. The EVSE LLC's chargers and Payment Kiosk were integrated with Greenlots' SKY OCPP system and SCE's Demand Response platform hosted by AutoGrid Systems that uses OpenADR 2.0b. The driver accessed the system via a display on a remote payment kiosk or the individual station payment module to see the per-hour prices in effect for each charging level. The driver then selected the charging level and their level of participation in demand response events should one occur.

Each charge point registered with the Greenlots OCPP server (i.e., charge point operator) via an OCPP boot notification message. The SCE workplace network is registered with the utility as an OpenADR end point. This configuration registered every charge point in the SCE pilot on the Greenlots network as a demand-response asset in the utility’s OpenADR system.

Greenlots’ certified OpenADR 2.0 cloud based Virtual End Node (VEN) communicated with SCE’s OpenADR Virtual Top Node (VTN) to obtain time-of-use (TOU) pricing and receive notifications of demand events. The pricing information received via OpenADR along with users’ preferences was then used to bill the PEV drivers for their charging sessions.

The charging session information, including the duration and energy values, was communicated between the charging stations and Greenlots SKY network over OCPP. The energy values obtained by Greenlots over OCPP were then translated into interval data values and reported back to the OpenADR VTN using OpenADR Report Service.

The solution also allowed PEV drivers to choose the level of charging (Level 2 or simulated Level1) and opt-in/opt-out of the demand events. The power limit on the charging stations was set based on the user's selection and active demand events. The charging session process flow used during the pilot is shown in Figure 7.

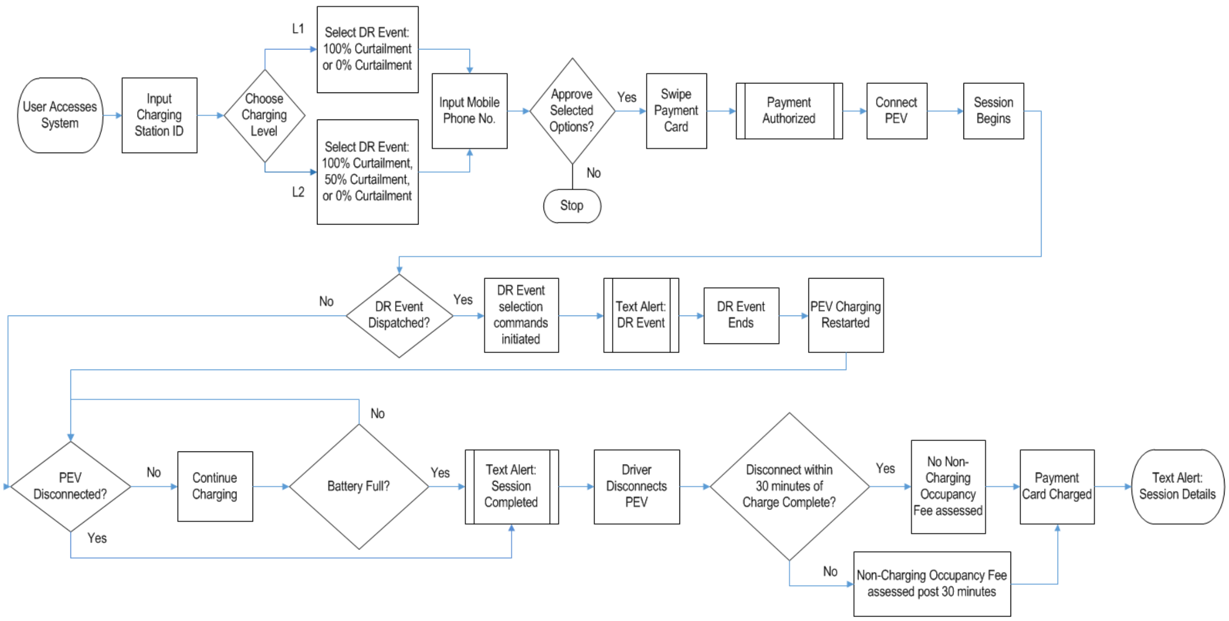


Figure 7: Pilot PEV charging session process flow.

5.7 PEV Charging Network

The Greenlots SKY charging network is a web-based network solution that provided SCE with access to real-time EVSE status, charge session data and reports, and access to detailed communication logs between the EVSE and network. SCE accessed the SKY platform via an Internet browser to view real-time status for each EVSE being managed in the portfolio, including Available, In-Use, Faulted, or Unknown (i.e., no network connection). Greenlots sent SCE an email when an EVSE experienced a critical fault or when it remained in a Faulted or Unknown status for an extended period of time. The SKY PEV Charging Network dashboard is shown in Figure 8.

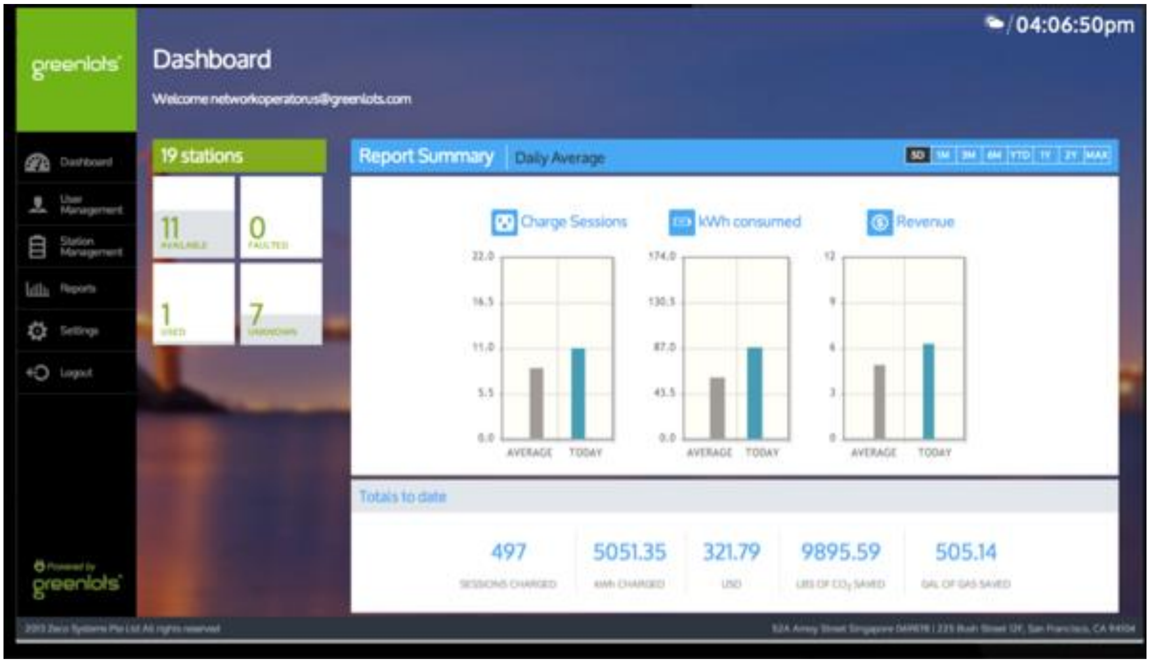


Figure 8: Greenlots SKY PEV Charging Network Dashboard

The SKY platform tracked usage and meter data for every transaction that occurred at the charging station. The data collected for the pilot included:

- total kWh per charge session
- start- and end-charge timestamps
- total fee per charge session
- unique ID for each driver via RFID, smartphone app or payment card
- individual transaction ID for each plug-in, unplug or charging session
- unique ID per charging port
- historical log of use including faults and errors

The SKY platform also tracked average number of users per day, average duration of charging and daily usage trends. While not used for the pilot, the SKY platform is capable of tracking real-time demand at the charging station. All data could be exported from the software into .csv or .pdf format. Figure 9 shows a sample chart of time-of-use energy data by hour.

Figure 9: Greenlots SKY Network Graphical Display – Sample Time-of-Use Energy Data Chart

6. User Interactions

SCE used the AutoGrid Systems OpenADR 2.0b hosted server for demand response signal transmission and communications with the Greenlots SKY network platform. This process included establishing a communication baseline and transmitting baseline data, on-peak and off-peak pricing events, and load shed events to the Greenlots network. In addition, SCE received participation and curtailment reports via the OpenADR 2.0b interface.

6.1 PEV Charging Processes

The Greenlots SKY platform translated OpenADR 2.0b messages to Open Charge Point Protocol (OCPP) v1.5 commands, subsequently sending pricing and load shed commands to the pilot EVSEs. Users made their pricing and DR selections at the EVSE when initiating the charging session. The user selections were communicated to the Greenlots SKY cloud where they were stored until needed. Pricing selections were executed immediately for the charging session. If a DR event occurred, the system referenced the DR selection and implemented the commands accordingly. During a charge session or demand response event, the user was kept informed of key events via Short Message Service (SMS) messages (i.e., text messages). The process flow used during the pilot is shown in Figure 10.

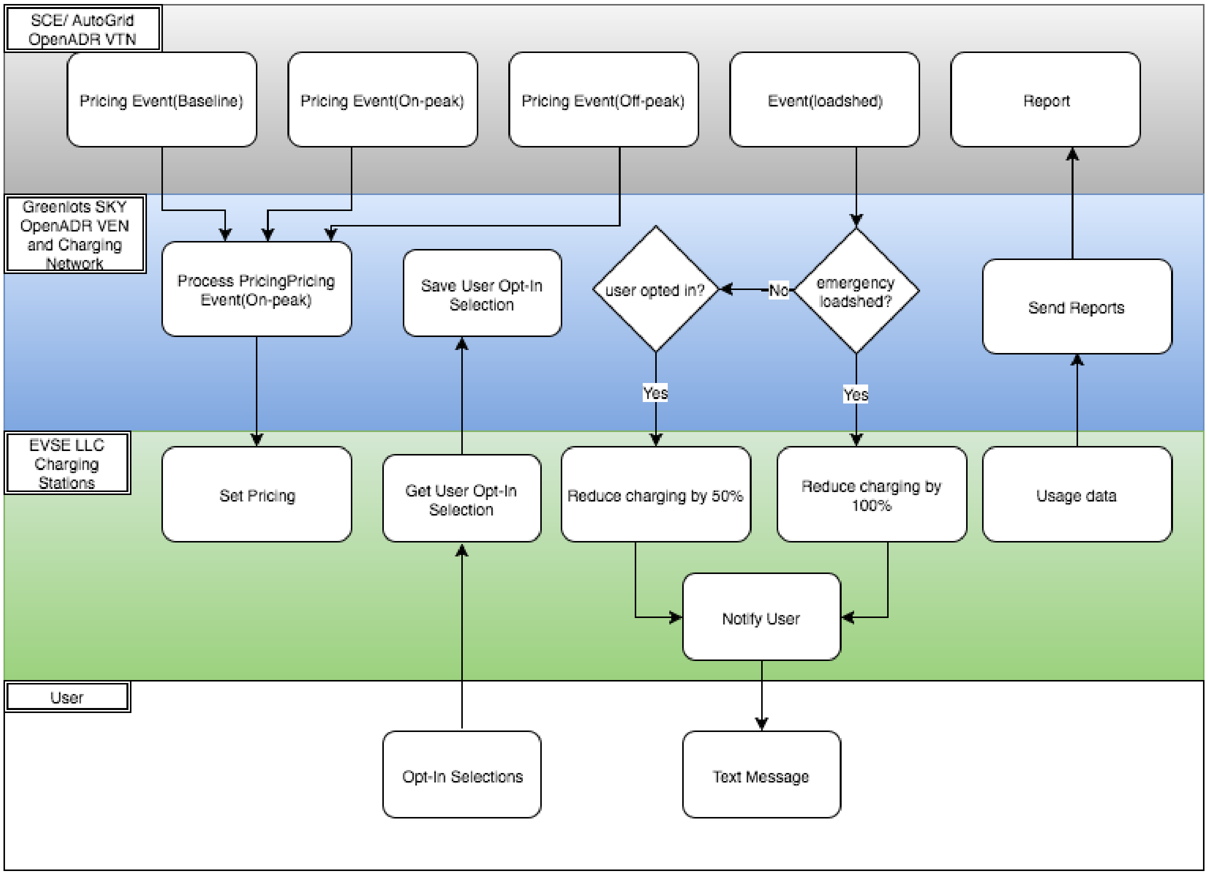


Figure 10: SCE Pilot Process Flow

6.2 Initial SMS Messaging Opt-In

In order to receive real-time text notifications regarding charging during the pilot, users were required to opt-in to the Greenlots SMS alerts. Following their first charging session activation and mobile phone number input, the user was immediately sent an Opt-In text request to which they needed to reply back with "YES". Upon receipt of the user's acceptance, the Greenlots system sent the user a text confirming that the phone number was opted-in for text notifications, an example of which is shown in Figure 11. The mobile phone number was used for sending notifications regarding charging session status, charging errors, DR events, and session details to users who opted-in to the alerts, as well as for user tracking. In the event that the user failed to opt-in correctly to the SMS message process, manual processes to add the phone number to the database were in place. Following is verbiage developed for the Text Notification Opt-In request and confirmation:

Initial Opt-In Request

SCE/Greenlots SMS alerts and offers. Msg&Data rates may apply. Reply YES to opt-in. 8887518560

Opt-In Confirmation Text

You opted-in to SCE/Greenlots SMS alerts and offers. Msg&Data rates may apply. For information 8887518560

Users were advised that various communication processes, including real-time text notifications, were being tested as part of the pilot. Due to the nature of the testing, users were directed to primarily rely on notifications/information provided by their vehicle regarding their charging session.

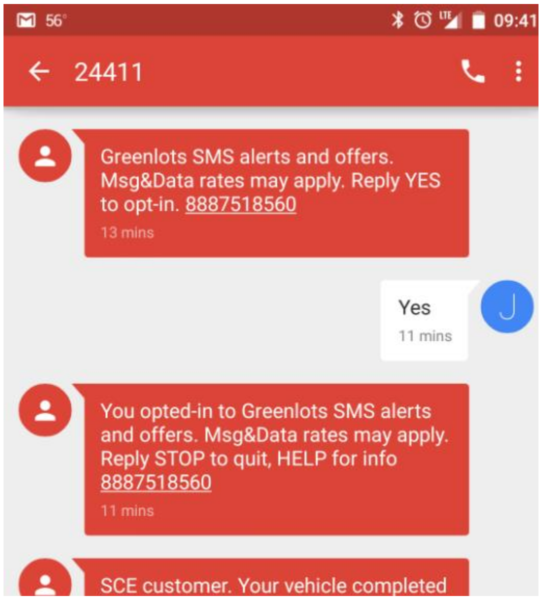


Figure 11: Sample Opt-In Request (Top) and Acceptance Confirmation (Bottom)

6.3 Real-time Text Notifications

The project team leveraged the Greenlots SKY Platform and real-time text notification functionality to provide drivers with visibility to their charging sessions and complement communications from the vehicle's system. While using the text messaging channel to notify users regarding status of a charging session was not unique to this pilot, the ability to text an anonymous payment card user to inform them of charging events was a new development for the industry that was developed by Greenlots. This innovative functionality enabled the pilot to avoid registration requirements for using the pilot stations; thereby, maximizing participation. The following sections provide an overview of the text notifications used during the pilot. Detailed information on the use cases and processes used to execute session initiation, DR event dispatch, and session conclusion can be found in Appendix D: Pilot Use Cases.

6.3.1 *Session Status Text Notifications*

At session initiation, drivers had the option to input their mobile phone number. As discussed in Section 6.2, drivers who opted-in to the notifications received a text message corresponding to their charging session at two primary session points: Charging Complete and Session End. Users also received an additional text messages if a DR event was scheduled or dispatched and if a charging error occurred.

The purpose of informing users as soon as their charging completed was to encourage them to vacate the charger so that other drivers could charge their PEV, support better space management of the parking lot, maximize charger utilization, and help drivers minimize the cost of charging their vehicle by avoiding additional fees. Prompt removal of the vehicle after completing a charge sought to ensure that each charging station was optimally used throughout the day. Following is the verbiage SCE developed for the Charging Complete notification:

> *Your vehicle completed charging at hh:mm. As a courtesy to other drivers, please disconnect and remove your vehicle. After 30 minutes, a fee of $x.xx p/h will be added to your current charging fee until disconnected. Thank you!*

The Session End text notification had two main purposes and it was sent to the driver when the PEV was disconnected from the charging station. First, it notified the driver that their vehicle had been disconnected from the charging station. In the event that they had disconnected the vehicle, no action was needed. In the event that someone other than the driver had disconnected the vehicle, the alert enabled them to check the vehicle and take appropriate action. Second, the Session End text provided the driver with a receipt for their charging session that included the start time, end time, and total fee amount charged. Following is verbiage SCE developed for the Session End notification:

> *Thank you for charging at SCE. Your session began at XX:XX am/pm and ended at XX:XX am/pm. Your payment card was charged a total of $xx.xx. If you have not disconnected your vehicle, please check its status to ensure that your vehicle is charged properly. As a courtesy to other drivers, we appreciate that you move your vehicle from the EV space! Thank You!*

6.3.2 *Demand Response Event Text Notifications*

If a demand response event was pending dispatch when the user connected to the charging station, a text message was sent to notify them that a DR event was scheduled, provide an estimate of the event duration, and remind the driver that the DR action they selected upon initiating their charging session would be enacted. SCE developed two (2) versions of the notifications dependent upon the nature of the event, examples of which follow:

Generic Demand Response Event Verbiage

SCE has scheduled a Demand Response event for mm/dd/yyyy that will start at hh:mm am/pm with an expected duration of xx minutes. The Event Action you selected upon activation will be applied during the event.

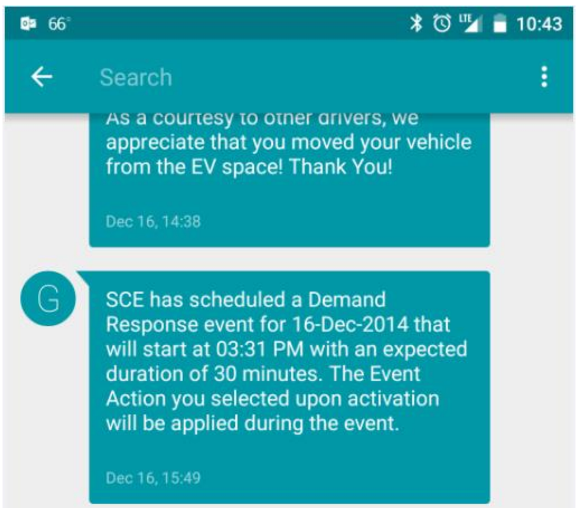


Figure 12: Sample DR Event scheduled text notification

Emergency Demand Response Event Verbiage

SCE has scheduled a Demand Response event for mm/dd/yyyy that will start at hh:mm am/pm with an expected duration of xx minutes. This is an emergency event and participation is mandatory. No fees will be applied.

Drivers who connected to the EVSE while the DR event was in process saw the following information displayed on the payment module VFD:

DR Event Active

Following session activation, these users were also sent a text notification to advise them that a DR event was in process, provide an estimate of the event duration, and remind the driver that the DR action they selected upon initiating their charging session would be enacted

Demand Response Event in Process Verbiage

SCE is currently conducting a Demand Response event for mm/dd/yyyy that started at hh:mm am/pm with an expected duration of xx minutes. The Event Action you selected upon activation will be applied during the event.

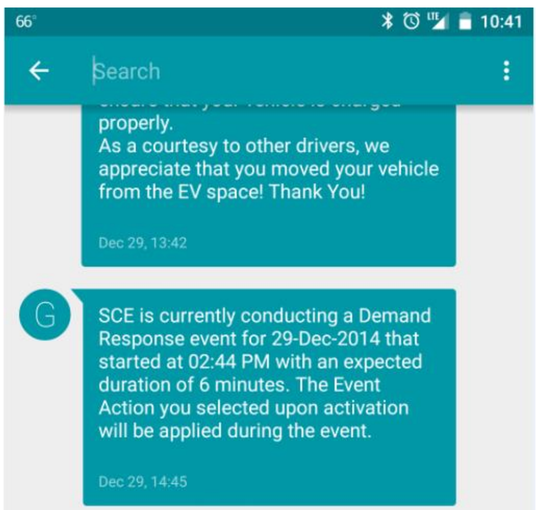


Figure 13: Sample DR Event active text notification.

A text notification was not sent to drivers when the DR event was complete and charging restored to the vehicle.

6.3.3 *Charging Error Text Notification*

If a charging error occurred during an active session, a text notification was sent to the driver advising them that an issue had occurred and that they would be advised when charging was restored. Drivers received a second text notification following resumption of charging.

Charging Error Verbiage

A charging error has occurred. You will be notified upon charging resumption and no fees will be applied during this event.

Charging Resumption Verbiage

Your charging session has restarted at hh:mm am/pm.

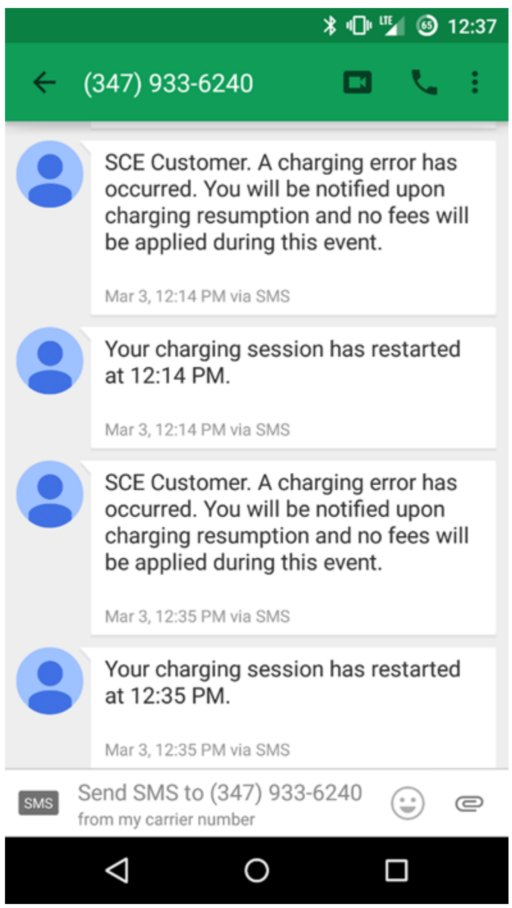


Figure 14: Sample Charging Error (Top) and Charging Resumption (Bottom) Text Notifications

7. Relation of Pilot to Goal or Strategy

As noted in Attachment A, Section B of Advice Letter 2746-E[20], the pilot was designed to support SCE's large commercial & industrial (C&I) customer workplace and public charging models and better inform SCE regarding approaches to advise and assist customers' future PEV charging strategies. In order to achieve these objectives, the SCE pilot tested various pricing strategies, tested demand response functionality, and evaluated consumer behavior related to pricing and DR. SCE worked with Greenlots to provide dynamic pricing and Demand Response Load Control (DRLC) at the point-of-sale and with AutoGrid systems to dispatch pricing and DR signals from SCE to Greenlots systems using OpenADR 2.0b. SCE developed a pricing and demand response model based on its TOU pricing and DR program parameters.

7.1 Fee-Based Charging Model

Fee-based charging was implemented in January 2015 after installation activities and testing of the pricing signal processes were completed. The off-peak price baseline for both charging levels was implemented from 12:00 a.m. – 11:59 a.m. and from 6:00 p.m. – 11:59 p.m. daily. The on-peak price baseline for both charging levels was implemented from 12:00 p.m. – 5:59 p.m. daily. Current prices were displayed on each payment module and prices remained the same for the entire calendar month, including weekdays and weekends. The decision to model pricing on a monthly basis allowed sufficient time to test pricing strategies without confusing and frustrating drivers by changing pricing too often. When a driver accessed the payment module and selected the charging level, they were presented with the price in effect for the session (e.g., on-

[20] See fn. 5.

peak, Level 2 pricing) at which point they could accept the pricing or exit from the system. The pricing model implemented during the pilot is shown in Figure 15.

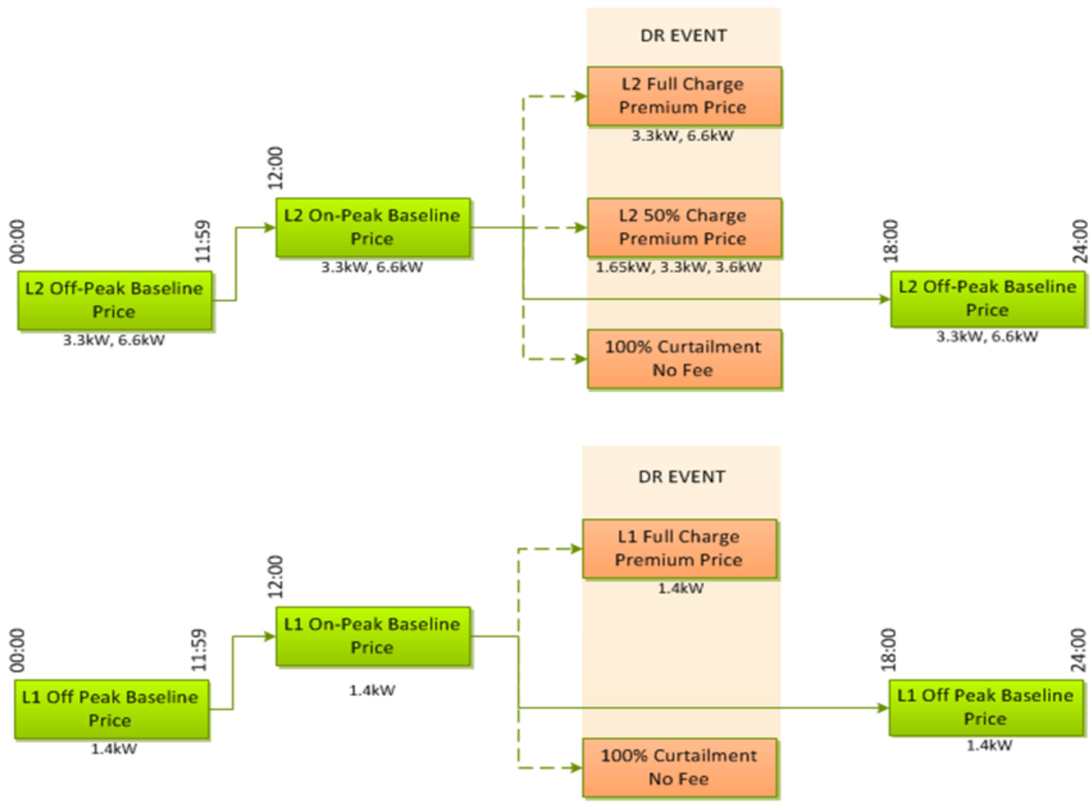


Figure 15: SCE Workplace Charging Pilot Pricing and Demand Response Model

7.2 Pricing Strategy

SCE established a monthly base price for off-peak and on-peak charging. In order to gather behavioral data related to a wide range of Level 1 and Level 2 prices, charging fees were adjusted monthly based on various factors, including previous prices tested, level of participation, comparative kWh costs, and gasoline prices. The on-peak price was calculated as 30% higher than the off-peak rates. Premium prices were also implemented for users who remained charging during a DR event. As discussed further in Section 7.3, the charging fee for Level 1 and Level 2 users who chose to continue charging at 100% power during an event was increased to 200% of base price in effect at the event dispatch. Level 2 users who chose to continue charging at 50% power during an event was increased to 150% of base price in effect. Fees were prorated to the next highest minute.

SCE tested a combination of twelve (12) Level 1 base TOU prices and sixteen (16) Level 2 TOU prices during the pilot. In order to develop a charging baseline, charging was complimentary from October – December 2014. Fee-based charging was implemented in January 2015. The off-peak base for both Level 1 and Level 2 charging were set at $0.50 in January and $0.75 in February to gauge consumer response to pricing, inform analysis regarding the importance of long-term parking versus price, and determine an appropriate price range moving forward.

During 2015, Level 1 off-peak prices ranged from $0.20 to $0.75 per hour, with an average price of $0.38 per hour, while on-peak prices ranged from $0.26 to $0.98 per hour with an average price of $0.92 per hour. Level 2 off-peak prices ranged from $0.20 to $0.75 per hour, with an average price of $0.38 per hour while on-peak prices ranges from $0.26 to $0.98 per hour with an average price of $0.92 per hour.

In addition, the pilot tested 32 Level 2 premium prices assessed for drivers who opted out of DR events, either at a 100% or 50% non-participation option, and twelve (12) Level 1 premium prices for drivers who opted-out at the 100% non-participation option. Pricing tested during 2015 is shown in Table 3.

Table 3: 2015 PEV Charging Prices Per Hour by Month

					100% Opt-Out DR Pricing				50% Opt-Out DR Pricing (Level 2)	
	Off Peak		On Peak (Inc 30%)		Off Peak Premium (Inc 100%)		On Peak Premium (Inc 100%)		Off Peak Premium (Inc 50%)	On Peak Premium (Inc 50%)
	L2 (208V)	L1 (120V)	L2 (208V)	L1 (120V)	L2 (208V)	L1 (120V)	L2 (208V)	L1 (120V)	L2 (208V)	L2 (208V)
JAN	$0.50	$0.50	$0.65	$0.65	$1.00	$1.00	$1.30	$1.30	$0.75	$0.98
FEB	$0.75	$0.75	$0.98	$0.98	$1.50	$1.50	$1.95	$1.95	$1.13	$1.46
MAR	$0.75	$0.20	$0.98	$0.26	$1.50	$0.40	$1.95	$0.52	$1.13	$1.46
APR	$0.80	$0.20	$1.04	$0.26	$1.60	$0.40	$2.08	$0.52	$1.20	$1.56
MAY	$0.95	$0.30	$1.24	$0.39	$1.90	$0.60	$2.47	$0.78	$1.43	$1.85
JUN	$0.95	$0.35	$1.24	$0.46	$1.90	$0.70	$2.47	$0.91	$1.43	$1.85
JUL	$0.90	$0.35	$1.17	$0.46	$1.80	$0.70	$2.34	$0.91	$1.35	$1.76
AUG	$0.90	$0.40	$1.17	$0.52	$1.80	$0.80	$2.34	$1.04	$1.35	$1.76
SEPT	$0.70	$0.40	$0.91	$0.52	$1.40	$0.80	$1.82	$1.04	$1.05	$1.37
OCT	$0.70	$0.40	$0.91	$0.52	$1.40	$0.80	$1.82	$1.04	$1.05	$1.37
NOV	$0.55	$0.35	$0.72	$0.46	$1.10	$0.70	$1.43	$0.91	$0.83	$1.07
DEC	$0.00	$0.35	$0.00	$0.46	$0.00	$0.70	$0.00	$0.91	$0.00	$0.00

A comparison of monthly Level 1 on-peak versus off-peak base charging prices is shown in Figure 16 and a comparison of Level 2 pricing is shown in Figure 17.

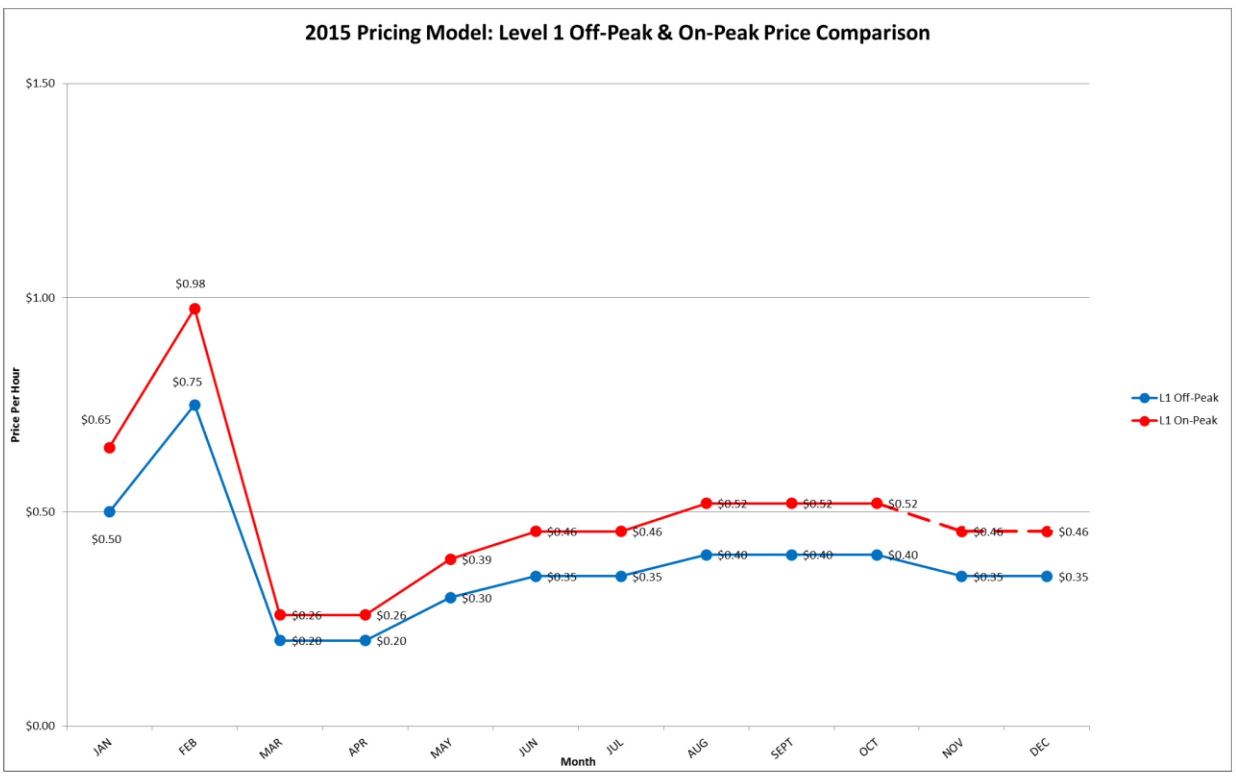


Figure 16: Level 1 Off-Peak and On-Peak Pricing Comparison

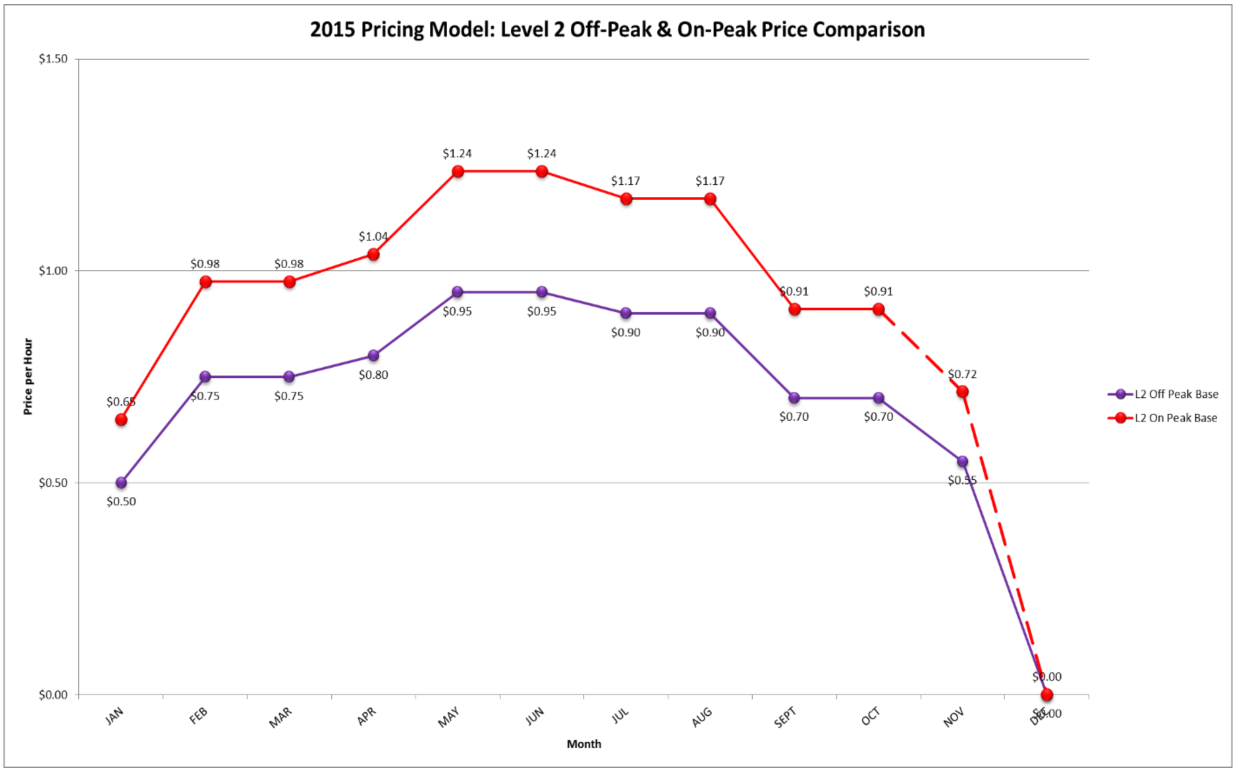


Figure 17: Level 2 Off-Peak and On-Peak Pricing Comparison

7.2.1 *Additional Charging Costs*

In addition to the base TOU fees and non-charging occupancy fee, the payment processor assessed a transaction fee of $0.30+2.9% on each authorized session. In order for the pilot team to control the number of pricing factors impacting consumer behavior during the pilot, transaction fees were deducted from revenue remitted to SCE by the vendor for return to ratepayers and were not charged to users. Pricing factors examined included base TOU fees, premium fees during for DR non-participation, and non-charging occupancy fees. User response to the pricing strategy is discussed in Section 15.6.

7.3 Demand Response

Demand response programs enable consumers to become active participants in maintaining reliability of the electric grid by reducing or shifting their electricity usage during periods of high demand in response to some type of incentive or signal.

In order to evaluate consumer response to DR events and the potential from PEV charging during workplace hours, SCE and its vendors designed a multi-tiered DR testing platform to provide drivers with greater control over their charging should a DR event be dispatched. Users controlled the action taken during a normal DR event, relative to their individual charging needs or preferences, by selecting their level of participation at each session activation. In addition, drivers were presented with the different DR pricing options prior to making their choice regarding DR participation so that they were aware of the consequence of the action they selected. If a DR event was dispatched, users were sent a text notification regarding the event and advising the driver that the action selected at activation would be enacted. Table 4 provides a comparison of pricing options available to users during a DR event.

Table 4: Comparison of Level 1 and Level 2 DR Participation Pricing

	Level 1	**Level 2**
Opt-In (Curtail Charging 100%)	No fee charged during event.	No fee charged during event.
Partial Opt-In – Level 2 ONLY (Curtail Charging 50%)	N/A	During event, fee increased to 150% of base price in effect.
Opt-Out (Remain Charging 100%)	During event, fee increased to 200% of base price in effect.	During event, fee increased to 200% of base price in effect.

7.3.1 *DR Event Testing Approach*

In order to maximize participation in the DR event testing, key criteria used to inform the DR testing strategy included data to date regarding the number of PEV charging sessions per day, amount of energy consumed per day, percentage of Level 2 charging vs. Level 1 charging, the pricing strategy in effect, holiday and vacation periods, and time of day.

Although extreme heat and cold can impact the battery range and could impact the driver's decision to charge, the lowest average temperature in the Los Angeles area during 2015 was 48ºF while the highest average temperature was 84ºF[21]. The DR strategy did consider temperature relative to the demand placed on the grid by air conditioning on hot days, and the extent to which PEV charging could be used to reduce that demand using DR events.

7.3.2 *DR Test Events*

SCE scheduled twenty (20) 60-minute demand response events during 2015 to evaluate the demand response potential from Level 1 and Level 2 electric vehicle charging and measure driver willingness to curtail their plug-in electric vehicle charging during the workday. Event dispatch was evenly distributed between morning off-peak hours (7:00 am – noon) and afternoon on-peak (noon – 3:00 pm) hours to test consumer response based on time of day and measure potential load during peak hours.

SCE sent day-ahead or day-of email notifications to stakeholders who had registered with the pilot team on 50% of the DR events. Notifications were not sent for the remainder of the events in order to test same day alert processes. Fees were

[21] http://www.usclimatedata.com/climate/los-angeles/california/united-states/usca1339

assessed for drivers who opted-out of the DR events regardless of whether an email notification was distributed.

In order to achieve maximum participation during the DR testing, events were dispatched Monday through Thursday, with the majority dispatched on Tuesdays and Thursdays. Nineteen (19) events successfully dispatched while the event scheduled for December 3 did not dispatch due to cloud server issues. Dates and times of the events dispatched are shown in Table 5.

Table 5: Demand Response Test Events

No	Date	Start Time	End Time
1	5/27/2015	8:00 AM	9:00 AM
2	6/11/2015	1:00 PM	2:00 PM
3	7/8/2015	8:30 AM	9:30 AM
4	7/14/2015	7:30 AM	8:30 AM
5	7/30/2015	9:00 AM	10:00 AM
6	8/26/2015	10:00 AM	11:00 AM
7	8/27/2015	1:00 PM	2:00 PM
8	8/31/2015	2:00 PM	3:00 PM
9	10/6/2015	8:30 AM	9:30 AM
10	10/13/2015	9:00 AM	10:00 AM
11	10/15/2015	1:00 PM	2:00 PM
12	10/29/2015	1:30 PM	2:30 PM
13	11/24/2015	1:30 PM	2:30 PM
14	11/30/2015	2:00 PM	3:00 PM
15	12/1/2015	8:00 AM	9:00 AM
16	12/7/2015	9:00 AM	10:00 AM
17	12/8/2015	1:30 PM	2:30 PM
18	12/9/2015	8:30 AM	9:30 AM
19	12/10/2015	2:00 PM	3:00 PM

7.3.3 *DR Testing Load Curtailment Algorithm*

Unlike traditional lighting and HVAC building loads that can often be reliably estimated based on past performance, PEV charging in the workplace appeared to be highly dependent upon real-time driver choice and needs, facility staffing and PEV ownership levels, company culture, work schedules, number of PEV charging stations, and level of PEV charging available. The unique characteristics of PEV charging can result in significant variances in PEV charging station utilization by site, day, week, or hour and should be considered when planning PEV charging infrastructure for charging stations interested in DR program participation. Based on the unique behavior of PEV drivers and innovative nature of the SCE pilot, the testing team found that traditional DR baselines were insufficient for accurately measuring load from PEV charging in the workplace. In order to explore more effective measurement methods, SCE developed the following methodology for quantifying load reductions.

SCE received data from its vendor in kWh consumed in 5-minute intervals.[22] SCE identified the number of 5-minute intervals that were included in each event timeframe. For each of the intervals, SCE measured actual energy consumption for PEVs that opted-out of the event and calculated curtailed load for PEVs that participated in the event based on the actual rate of charge selected by the vehicle.

For example, a PEV charging at a rate of 6.0 kW prior to the event would have received .5 kWh during each 5-minute interval during which the 60-minute DR event was active and the vehicle was connected; whereas, a PEV charging at 1.4 kW would have received approximately .12 kWh during each of the intervals.

The formula used for quantifying load curtailment is shown in Equation 1:

[22] In order to convert kWh consumption into kW demand, the 5-minute interval data was multiplied by 12.

$$DR\ Load\ Curtailment = Expected\ Load - \ Actual\ Load$$

Equation 1: DR Load Curtailment Formula

The following criteria were used to identify sessions that were impacted by the event and for which load should be measured.

A. Session initiated prior to event and active for part or all of event intervals.
B. Session initiated post-event dispatch and active for part of event intervals

During each of the tests, actual load activity was monitored by the testing team prior to and following the test event. To establish a DR baseline for Session A, data was gathered at least 50 minutes before and after the event. Similarly for Session B, data was gathered for at least 50 minutes after the event. The highest interval load value for each event was used to form the basis for quantifying the demand response value achieved during each event. This approach provided the most consistently reasonable representation of what the load would have been in the absence of a DR event occurring.

7.3.4 *DR Event Testing Results*

SCE successfully dispatched nineteen (19) one-hour DR test events using both Level 1 and Level 2 charging during 2015. Testing resulted in an average load reduction of 46.29 kW per event, which equaled an average of 2.61 kW per session. Level 1 sessions averaged 1.35 kW while Level 2 sessions averaged 3.4 kW. Figure 18 provides a comparison between the total amount of load curtailed by Level 1 charging versus Level 2 charging during the pilot DR test events.

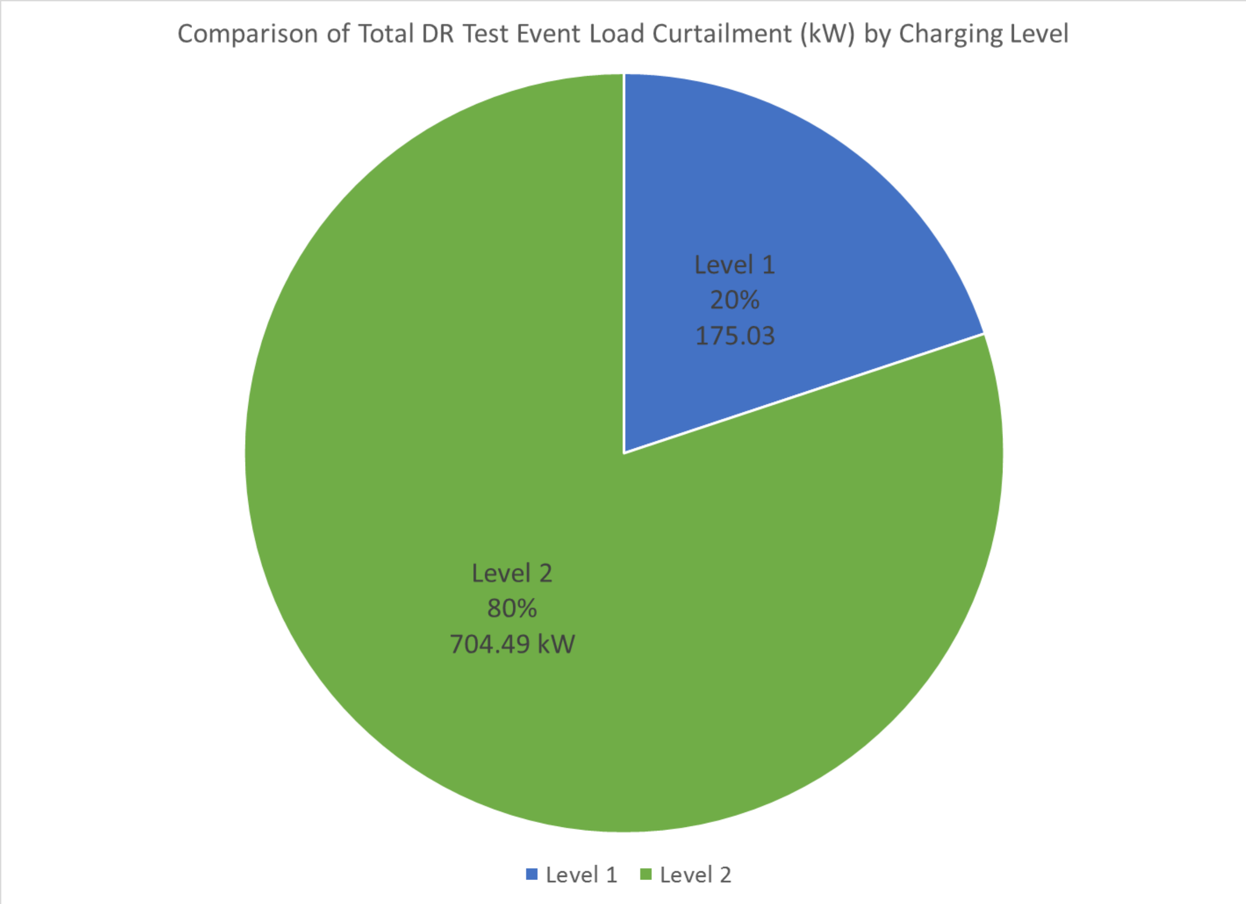


Figure 18: Comparison of total load curtailed by Level 1 vs. Level 2 charging over the nineteen DR test events.

As discussed in Section 15.4, the pilot found that the majority of employees charge their PEV between 5:00 AM and noon. This finding suggests that employees are influenced by factors such as establishing a regular charging routine, leveraging open charging spaces in the workplace, ensuring that charging is complete when needed by the driver, and opting for charging at lower, off-peak prices.

Ten (10) of the events were dispatched between 7:30 AM and 10:00 AM and nine (9) were dispatched between 1:00 PM and 2:00 PM. The fact that the majority of load curtailment was realized during events dispatched between 7:30 AM and 10:00 AM suggests that while PEV charging provides potential for DR program participation, the need for load curtailment during off-peak hours may be limited.

Program design might consider options to leverage DR during off-peak hours (e.g., emergency response), aggregate multiple facilities with lower on-peak charging demand in order to achieve sufficient load curtailment, identify PEV charging in workplaces that provide DR load during later hours (e.g., locations where normal operations occur late in the day and/or facilities with 24-hour operations) and/or leverage DR to offset periods of over generation on the electrical grid.

Although the amount of load curtailed at Level 2 charging is more than 152%[23] higher than the amount of load curtailed at Level 1 charging for the same period, both Level 1 and Level 2 PEV charging provide opportunities for DR program participation. Following are results from the DR testing:

- Total sessions participating in DR events during 2015 totaled 337 sessions.
  - 76% of total sessions (255 sessions) participated in DR events dispatched during off-peak hours as compared with 24% (82 sessions) that participated during on-peak hours.
  - Findings align with data showing that the majority of workplace charging occurs between 5:00 AM –12:00 PM.
- Level 2 (208V) charging accounted for 80% (37.12 kW) of the total load curtailment while Level 1 (120V) charging accounted for 20% (9.2 kW).
- The total average load curtailment per event during all DR testing events was 46.29 kW as measured by the pilot DR quantification methodology developed and tested.
  - Average load curtailment for the ten (10) off-peak events was 67 kW versus 23 kW for nine (9) on-peak events.
- The time of DR event dispatch did not significantly impact driver participation.

[23] Calculation based on the percentage difference between curtailing 3.4 kW versus 1.35 kW mentioned earlier in this section.

- 76% of PEVs connected during the DR events dispatched between 7:30 – 10:00 AM participated.
- 72% of PEVs connected during the DR events dispatched between 1:00 – 2:00 PM participated.

Actual load curtailment for each of the DR events, specified by charging level, is shown in Table 6 and charts specific to each DR event can be found in Appendix G: 2016 DR Test Event Plots. A comparison of DR load curtailment measured for each of the DR events dispatched with the level of participation realized is shown in Figure 19.

Table 6: Demand Response Event Load Curtailment Observations

No	Date	Start Time	End Time	L1 Sessions Impacted	L2 Sessions Impacted	Total Sessions Impacted	L1 kW Curtailment	L2 kW Curtailment	Total Amount of kW Curtailment per DR Event	Aggregated kW Curtailment	Total No. of EV's Opted Out of Event (Remained Charging)	Opt Out L1	Opt Out L2
1	5/27/2015	8:00:00 AM	9:00:00 AM	18	10	28	23.59	31.32	54.91	54.91	4	1	3
2	6/11/2015	1:00:00 PM	2:00:00 PM	8	3	11	12.50	12.01	24.51	79.42	6	1	5
3	7/8/2015	8:30:00 AM	9:30:00 AM	13	13	26	17.00	44.47	61.47	140.89	12	3	9
4	7/14/2015	7:30:00 AM	8:30:00 AM	10	7	17	12.80	23.30	36.10	176.99	4	2	2
5	7/30/2015	9:00:00 AM	10:00:00 AM	15	13	28	21.61	56.38	77.99	254.98	9	2	7
6	8/26/2015	10:00:00 AM	11:00:00 AM	10	12	22	13.53	39.58	53.11	308.09	4	0	4
7	8/27/2015	1:00:00 PM	2:00:00 PM	4	0	4	5.74	-	5.74	313.83	4	0	4
8	8/31/2015	2:00:00 PM	3:00:00 PM	3	2	5	3.59	8.43	12.02	325.85	0	0	0
9	10/6/2015	8:30:00 AM	9:30:00 AM	11	21	32	12.72	55.79	68.51	394.36	4	1	3
10	10/13/2015	9:00:00 AM	10:00:00 AM	8	16	24	11.40	68.34	79.74	474.10	6	3	3
11	10/15/2015	1:00:00 PM	2:00:00 PM	5	6	11	8.13	31.46	39.59	513.69	5	0	5
12	10/29/2015	1:30:00 PM	2:30:00 PM	4	6	10	4.94	17.99	22.93	536.62	3	0	3
13	11/24/2015	1:30:00 PM	2:30:00 PM	3	6	9	2.31	19.50	21.81	558.43	1	0	1
14	11/30/2015	2:00:00 PM	3:00:00 PM	6	4	10	8.47	17.28	25.75	584.18	2	0	2
15	12/1/2015	8:00:00 AM	9:00:00 AM	4	25	29	4.05	84.26	88.31	672.49	4	0	4
16	12/3/2015	1:00:00 PM	2:00:00 PM	0	0	0	-	-	-	672.49	0	0	0
17	12/7/2015	9:00:00 AM	10:00:00 AM	3	20	23	4.50	55.46	59.96	732.45	17	0	17
18	12/8/2015	1:30:00 PM	2:30:00 PM	2	9	11	3.24	29.06	32.30	764.75	7	1	6
19	12/9/2015	8:30:00 AM	9:30:00 AM	1	26	27	1.68	90.82	92.50	857.25	14	1	13
20	12/10/2015	2:00:00 PM	3:00:00 PM	2	8	10	3.23	19.04	22.27	879.52	5	0	5
			Aggregated	130	207	337	175.03	704.49	879.52		111	15	96
			Percentages	39%	61%		20%	80%				14%	86%

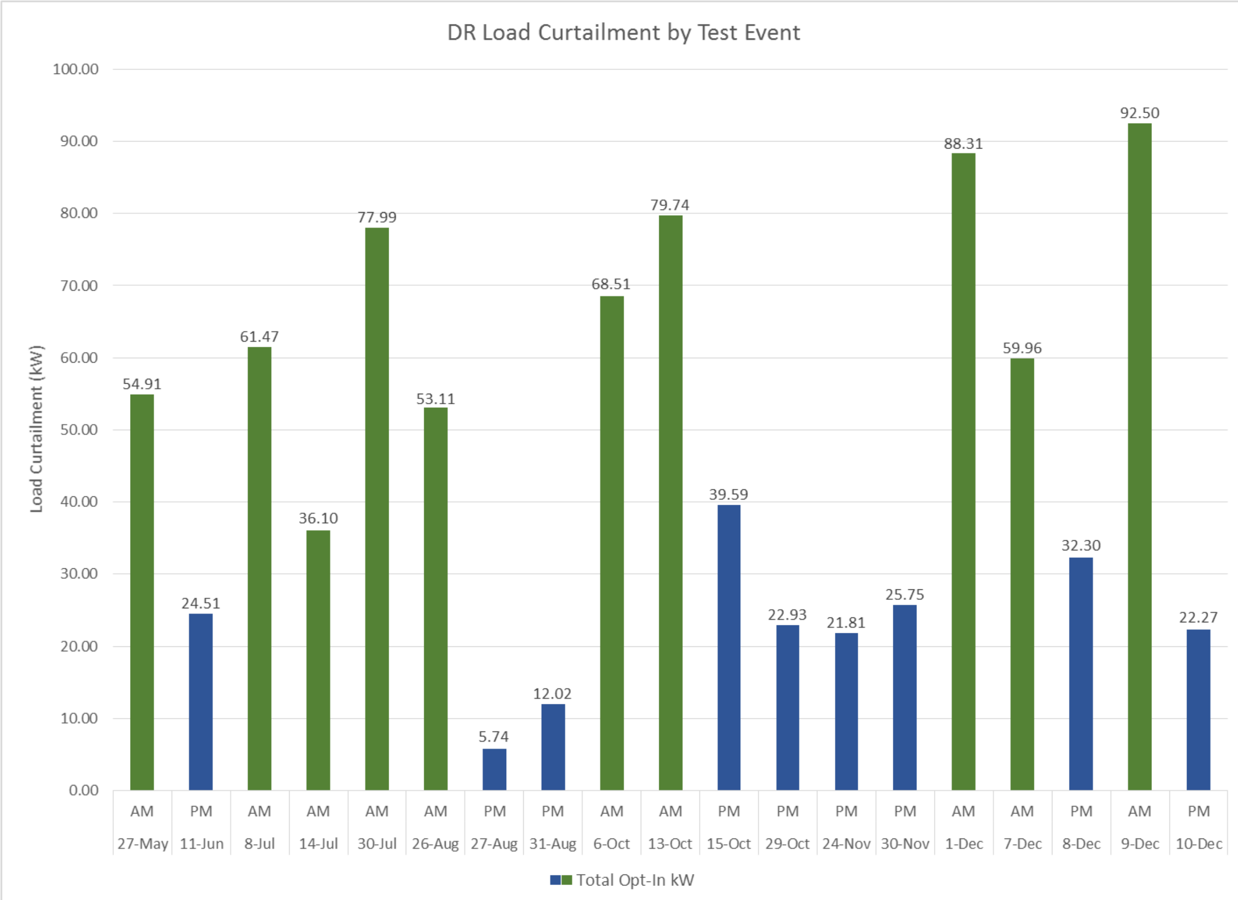


Figure 19: Comparison of load curtailed during each DR event by participation level. Solid green data series represents off-peak DR event participation. Solid blue data series represents on-peak DR event participation.

8. Space Management

In order to control infrastructure costs, optimize charger utilization, and support drivers in getting the electric charge their vehicle needed, SCE implemented a $2.00 per hour non-charging occupancy fee in August 2015 to encourage space turnover and maximize the number of charging sessions at each of the pilot charging stations. Drivers could control their PEV charging costs when using the pilot charging stations by disconnecting and moving their PEV as soon as possible after the PEV had completed charging, and preferably no later than 30 minutes after completed charging. Drivers who chose to remain connected after charging was complete experienced higher than necessary costs for their PEV charging. Drivers were advised to primarily rely on their PEV notification system and personal charging experience for status on their PEV charging progress. In addition, the pilot text notification system was designed to supplement PEV notifications regarding PEV charging status for those drivers who had opted in to the alerts.

8.1 Responsiveness to Space Management Controls

Prior to implementation of fee-based charging, drivers had no incentive to unplug and move their PEV. Since the base per-hour fee was charged from the time a session was initiated until the vehicle was disconnected, drivers had a minor financial incentive to unplug and move their PEV after fee-based charging was introduced in January 2015. Following implementation of the additional $2.00 per hour non-charging occupancy fee in August 2015, a user's financial incentive to move the vehicle increased significantly. In order to understand consumer behavior related to space usage, the pilot team compared behavioral data from three (3) distinct time periods:

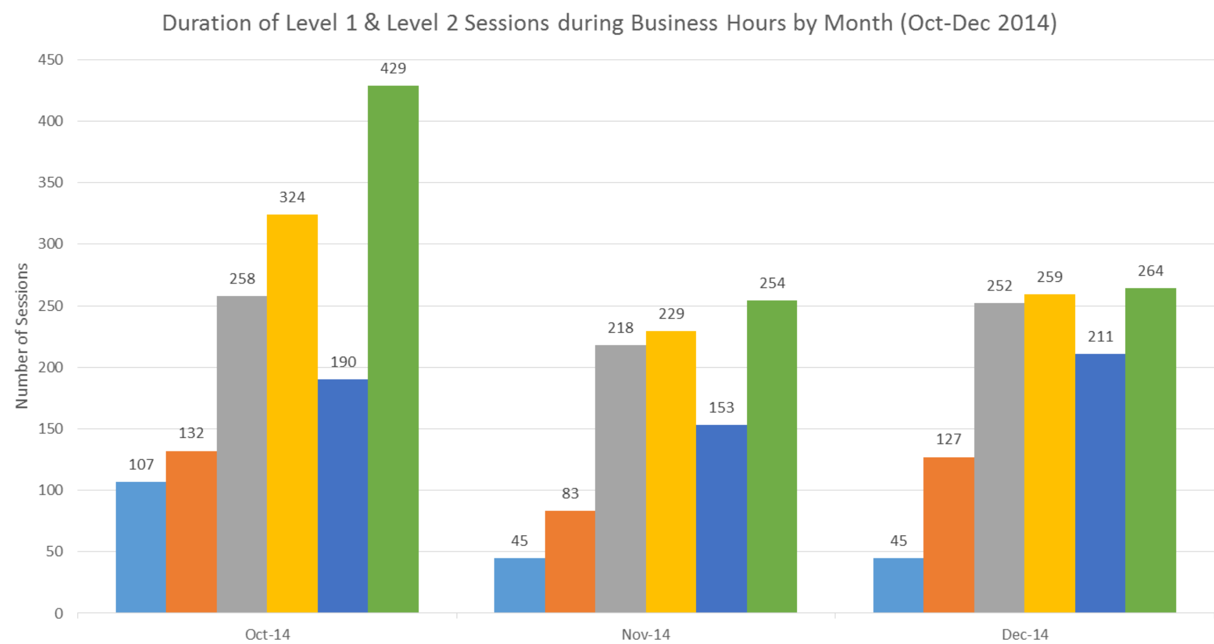
- Complimentary Level 2 charging: October – December 2014

- Fee-based charging without non-charging occupancy fee: January – July 2015
- Fee-based charging with non-charging occupancy fee: August – December 2015[24]

8.1.1 *Session Duration Analysis*

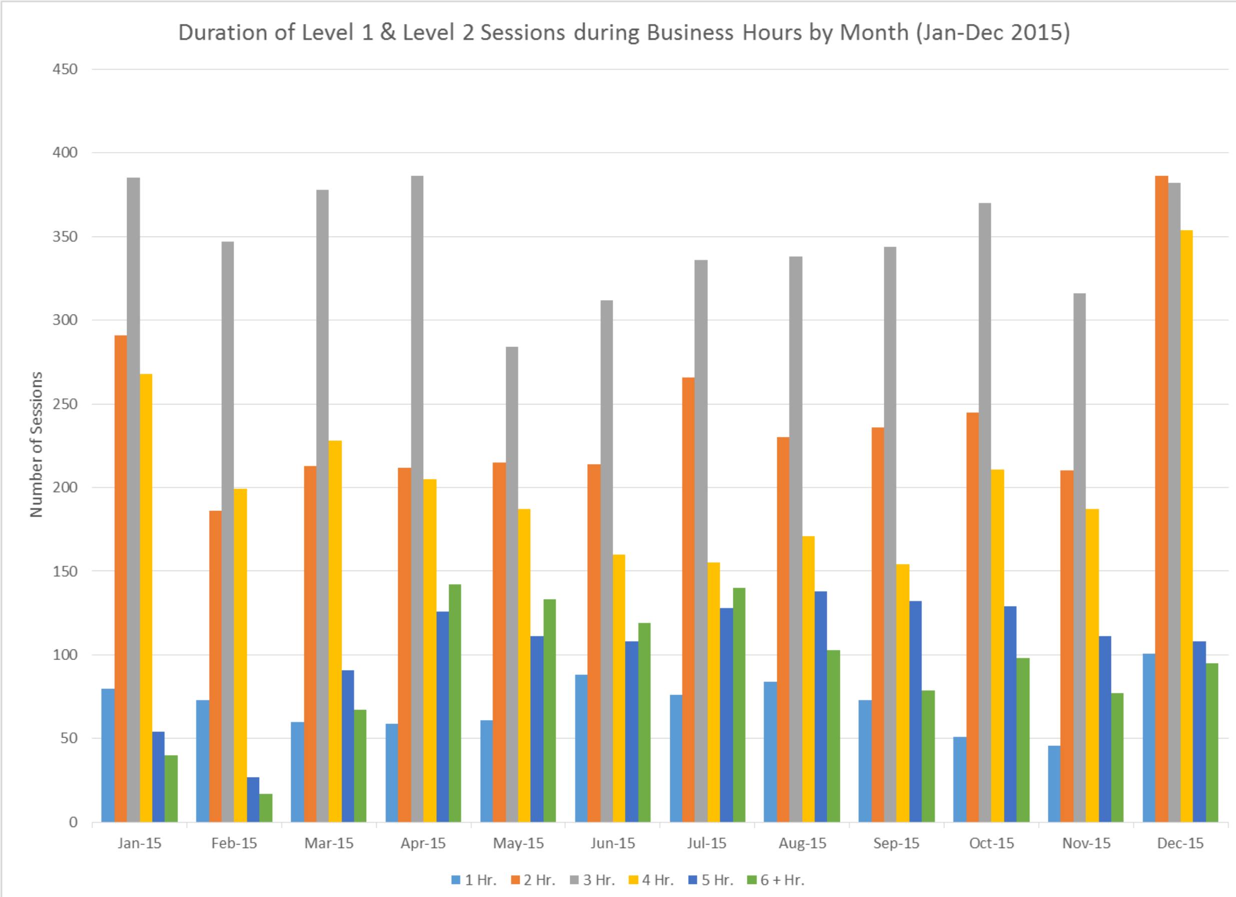
Analysis revealed that the percentage of charging sessions during October – December 2014 lasting six (6) or more hours, prior to implementation of base charging fees and non-charging occupancy fees, was 178% to 338% higher than comparable sessions authorized from October – December 2015. This data suggests that drivers during Q4 2014 did not remove their PEV after the battery was charged and supports the premise that fee-based charging and other space management controls encouraged space turnover and optimized charging station use. Following implementation of fee-based charging and space management control, 76% of drivers disconnected their PEV within 30 minutes of their battery charge completion with 86% disconnecting within one hour of charging being complete.

[24] December 2015 Level 2 off-peak and on-peak base fee was $0.00 with non-charging occupancy fee.



	Oct-14	Nov-14	Dec-14
1 Hr.	107	45	45
2 Hr.	132	83	127
3 Hr.	258	218	252
4 Hr.	324	229	259
5 Hr.	190	153	211
6 + Hr.	429	254	264

Figure 20: Duration of combined Level 1 and Level 2 charging sessions from October – December 2014 by hours connected by month. Limited functionality was available during this period, including unavailability of pricing, identification of charging level, text notifications, and mobile phone number tracking.



	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15
1 Hr.	80	73	60	59	61	88	76	84	73	51	46	101
2 Hr.	291	186	213	212	215	214	266	230	236	245	210	386
3 Hr.	385	347	378	386	284	312	336	338	344	370	316	382
4 Hr.	268	199	228	205	187	160	155	171	154	211	187	354
5 Hr.	54	27	91	126	111	108	128	138	132	129	111	108
6 + Hr.	40	17	67	142	133	119	140	103	79	98	77	95

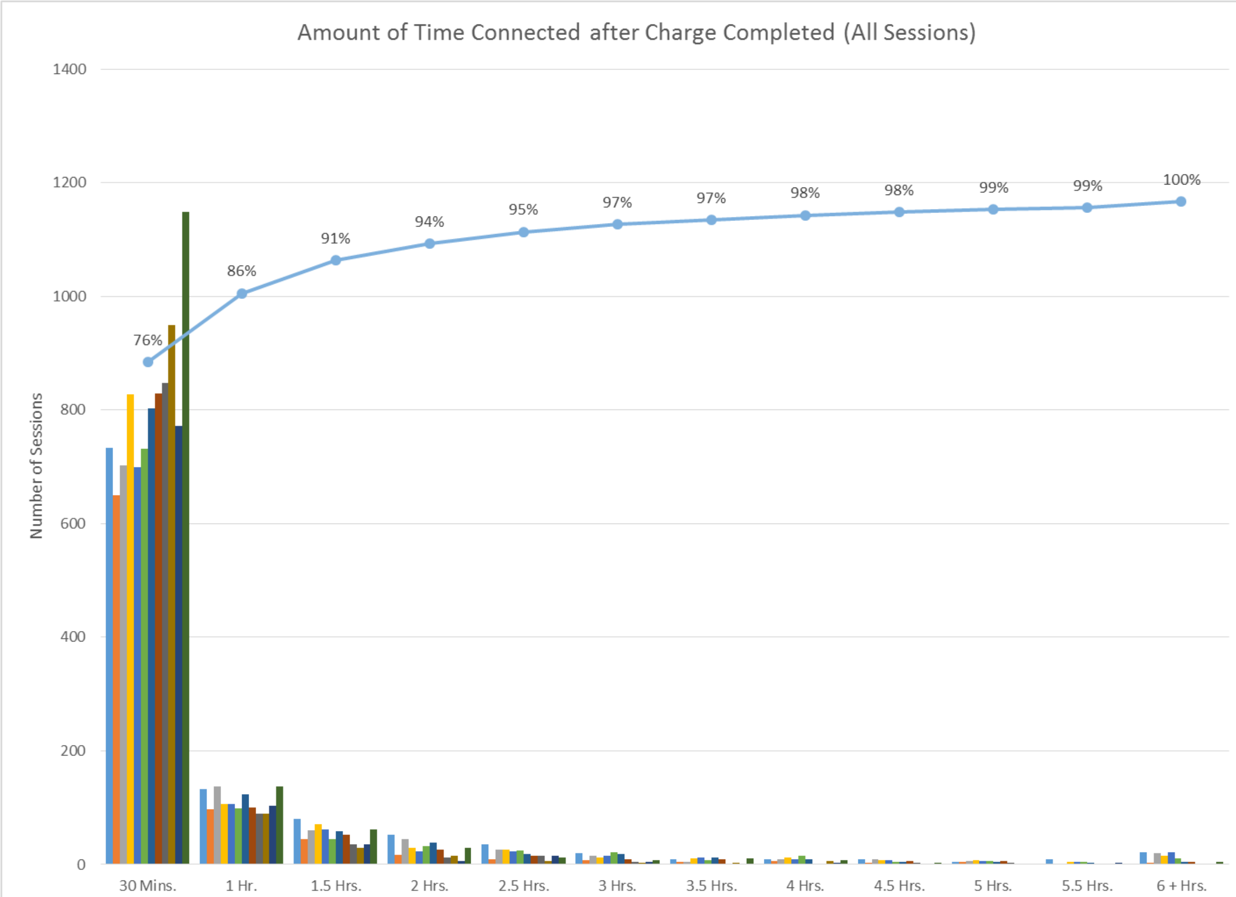
Figure 21: Duration of combined Level 1 and Level 2 charging sessions during business hours by hours connected by month.

8.1.2 *Time Connected after Charging Complete Analysis*

The team actively engaged drivers through user forums, personal interviews, and published information to inform them about the pilot activities and emphasize the need for drivers to disconnect promptly following completion of charging so that other drivers could use the stations. In addition, a non-charging occupancy fee was implemented in August 2015 that assessed a $2.00 per hour fee on vehicles that remained connected more than 30 minutes after charging was complete.

In order to further evaluate the impact fee-based charging and the non-charging occupancy fee had on consumer behaviors during work hours, the team analyzed the amount of time users remained connected after charging was complete. Users could obtain information regarding their battery status from at various sources, including communications from the vehicle’s system, real-time text notifications from the Greenlots system, and/or personal knowledge of the battery status and normal charging pattern.

During 2015, data shows that the 76% of drivers disconnected their PEV within 30 minutes of their battery charge completion with 86% disconnecting within one hour of charging being complete. In addition, this trend generally increased from February through December as shown in Figure 22. The decrease in November appears to reflect a 12% decrease in charging sessions as compared with the preceding four (4) months, which may have been caused by holiday schedules.



	30 Mins.	1 Hr.	1.5 Hrs.	2 Hrs.	2.5 Hrs.	3 Hrs.	3.5 Hrs.	4 Hrs.	4.5 Hrs.	5 Hrs.	5.5 Hrs.	6 + Hrs.
JAN	733	133	80	52	35	20	10	10	9	5	10	21
FEB	650	97	45	17	9	8	4	6	3	5	2	3
MAR	702	138	60	44	26	15	5	9	10	6	2	20
APR	827	106	71	30	26	12	11	12	7	7	5	16
MAY	699	107	61	23	23	16	12	10	8	6	4	22
JUN	732	99	44	32	24	21	7	16	5	6	4	11
JUL	803	124	59	38	19	19	12	9	4	4	3	5
AUG	829	101	53	27	16	10	9	1	6	6	1	5
SEP	847	89	36	13	15	5	2	2	3	3	1	2
OCT	950	89	29	15	6	3	3	6	1	1	0	1
NOV	772	103	36	6	15	4	1	3	1	1	3	2
DEC	1149	137	62	30	12	7	11	8	3	1	1	5

Figure 22: Amount of time connected after charge complete (30-minute increments).

Findings suggest that use of an hourly pricing model for the use of the space versus price per kWh, assessment of an additional non-charging occupancy fee for PEVs that remained connected more than 30 minutes after charging was complete, and implementation of real-time text notifications to drivers regarding status of the charging session effectively supported space and PEV charging station turnover.

9. Budget

SCE developed a preliminary cost estimate to support its $1,243,125 pilot funding request in A.11-03-003 and subsequently provided this estimate to the Commission as a supplement to the filing. As noted previously, D.12-04-045 authorized $1,243,125 for SCE's Workplace Charging Pilot and the pilot plan was approved in January 2013. Since the estimate was contingent upon final project requirements and actual costs, which were completed in late-2013, it did not include costs specific to creating an interoperable and open standards based architecture, nor did it consider the cost for installing intelligent PEV charging stations capable of providing the level of communication and data transfer required by the pilot design. The following sections discuss the pilot costs and reasons for variances from the preliminary plan.

9.1 Use of Existing Charging Stations

SCE's pilot plan proposed deployment of up to 233 charging stations, which included 50 stations installed prior to 2012 that were funded by American Recovery and Reinvestment Act (ARRA) grants or the SCE PEV fleet expansions. Although SCE evaluated use of the existing stations, it was determined that lack of required functionality and reporting excluded them from participating in the pilot. SCE was able to collect minimal aggregate usage data from fourteen (14) existing charging stations connected to a proprietary network at three facilities during the period October – December 2013. This data was compared with data from the pilot charging stations installed from October – December 2014 and informed development of the charging baseline. SCE removed 29 existing proprietary or obsolete charging stations and replaced them with intelligent devices that participated in the pilot.

9.2 Pilot Costs

SCE spent a total of $903,868 on the project, including PEV charging equipment, construction and installation, network interface, communications, contract services, and other required components. The pilot underspent the authorized budget by $339,257, which was approximately 27% below budget. A comparison of the total authorized budget amount, actual spend, and net pilot revenues is shown in Figure 23.

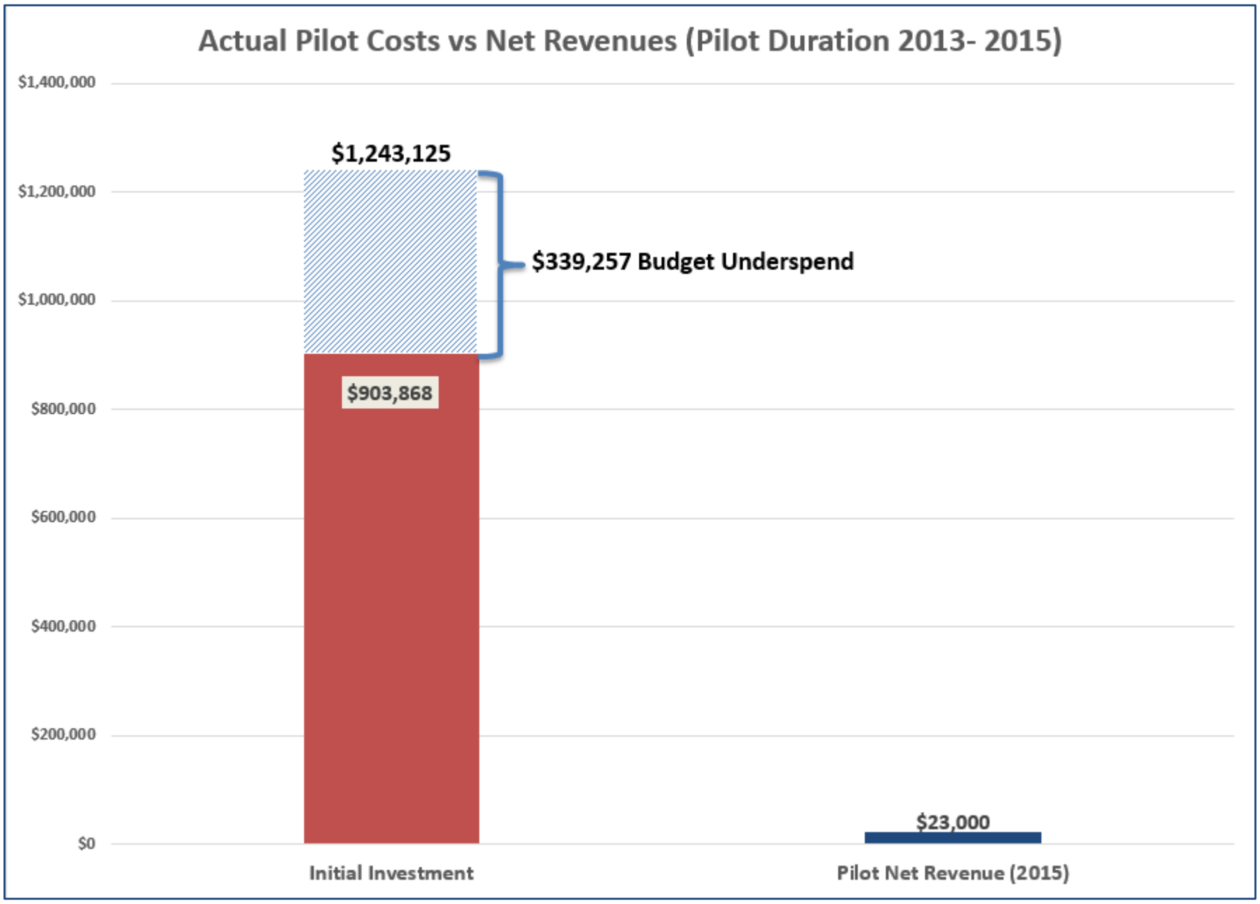


Figure 23: Authorized budget vs. actual costs and net revenue

As expected, almost 85% of the project costs were allocated to construction and installation, equipment, and network interface processes. New construction costs, including architectural/engineering design, permitting, construction, and installation were approximately $10,000 per space.[25] Wiring and installation costs using existing infrastructure were approximately $2,000 per space. Electrical, architectural and design, permitting, and installation costs accounted for the largest percentage of project costs at 31%. Costs of equipment, training, and related components accounted for 28% of pilot costs while the network interface required 25% of the budget. Labor costs for SCE resources were not charged to the pilot. An overview of the percentage of the budget required for each of the cost elements is shown in Table 7.

Table 7: Percentage of Budget Required by Each Cost Element

Cost Element	Percentage of Costs
Electrical/Construction	31%
Equipment & Training	28%
Network Interface	25%
DROMS	11%
Contractor Services	3%
Signage	1%
Cellular Service	1%

9.3 Estimated versus Actual Costs

Despite significant variances between the estimated and actual pilot costs, SCE achieved pilot objectives and adhered to the project scope while underspending the approved budget by $339,257.

[25] Deployment did not require any distribution facility upgrades.

The critical variance resulted from underestimating the cost of charging equipment procured for the pilot. The preliminary estimate assumed purchases of both Level 1 and Level 2 chargers at an approximate cost of $1,100 per device but did not consider emerging technology costs or costs for hardware and software components required to build the interoperable and non-proprietary pilot charging infrastructure. The actual cost of the pilot devices was approximately 300% greater than the equipment estimate developed prior the pilot launch in 2013. Due to the higher cost, SCE opted to remain within budget and achieve pilot goals by installing 80 intelligent EVSEs that enabled the team to meet pilot requirements, gather significant data for informing other PEV charging initiatives, and allow for future PEV charging infrastructure expansion.

The pilot team reduced construction and installation costs by over 20% by installing dual EVSEs with attached payment modules at sites with existing infrastructure and dual EVSEs with a remote payment kiosk that provides service to up to 8 charging stations at new construction sites. The team also collaborated with other SCE projects to share the cost of the DROMS for DR and price signals, which reduced costs to the pilot by approximately 50%.

10. Relevant Standards or Metrics

As discussed previously, the pilot DR event signals and session data were communicated over the Internet using Open OpenADR 2.0b from SCE's cloud based Virtual Top Node (VTN) (i.e., OpenADR server) to and from Greenlots OpenADR Virtual End Node (VEN) (i.e., OpenADR client). Open Charge Point Protocol (OCPP) version 1.5 communications over cellular were required between the Greenlots server and the EVSE LLC Gateways/Payment Stations. Since OCPP v1.5 did not meet all of the use cases required for the pilot, the vendors extended the protocol as needed. SCE requires that the OCPP software be upgraded to version 2.0 after it is released and certifiable as a standard.

11. Pilot Cost Analysis

Pursuant to Advice Letter 2746-E (Attachment A), SCE evaluated pilot costs and revenue generated relative to user behavior under various pricing scenarios. As discussed in related sections of the report, SCE tested various pricing strategies, gathered data regarding the number of charging sessions at each charging level and price, and used that data to evaluate price elasticity for the pilot population and inform revenue analysis. While costs and revenue observed during the pilot do not appear to sufficiently support a reasonable ROI for business based EV charging infrastructure, socialization of utility-based business models could potentially improve the financial appeal of EV charging deployment in the workplace. In addition to revenue generated, other benefits of EV charging in the workplace may include participation in DR programs, air quality improvement, GHG reductions, higher employee satisfaction, low-carbon fuel credits, and better corporate citizenship.

11.1 Expected Participation

Survey responses indicated that electric vehicle adoption among employees increased almost 500% from 2012 to 2016 (i.e., 58 to 342). In addition, the total number of unique phone numbers input for PEV charging at the pilot stations between February and December 2015 versus the January baseline, increased nearly 177% from 211 to 584. Continued PEV adoption could support and expansion of the market potential for DR participation. Pilot data also demonstrates that installation of PEV charging infrastructure in the workplace supports California’s clean air quality and GHG reduction initiatives by providing PEV owners with charging resources needed to support their commute.

11.2 Customer Satisfaction Relative to DR Testing

In order to encourage participation and avoid user fatigue (i.e., opt-out), SCE limited the pilot DR test events to 60-minutes. Users could also control their level of participation by opting-in or opting-out of the event at 100%, and Level 2 users had a third option that allowed for 50% participation. Day-ahead and day-of email alerts, real-time text messaging, and notifications on the charger displays served to provide customers with information they needed to prepare for, and participate in, the DR event. In addition, approximately 50% of the events were dispatched during morning off-peak hours (7:00 am – noon) and the remainder during afternoon on-peak (noon – 3:00 pm) hours.

The 76% DR participation rate during morning events and 72% during afternoon events suggests that the pilot user population was generally satisfied with the DR strategies tested.

11.3 Incentives

Survey feedback from stakeholders suggested that users considered access to PEV charging in the workplace and other personal benefits to be sufficient incentive to purchase or lease a PEV and/or participate in the workplace charging pilot. Since approximately 25% of drivers opted-out of DR events, it appears that the premium fee model SCE implemented during pilot test events was adequate to encourage drivers to participate in the event provided that lack of charging did not adversely impact their charging needs. This data suggests that premium opt-out fees could be structured to provide charging station operators who choose to participate in DR programs with revenue to offset costs for vehicles that do not curtail load during the event.

12. Revenue Analysis

SCE opted to file Advice Letter 3090-E to request modification to the BRRBA to return net revenues generated from January – December 2015 to customers. As discussed in Section 9.2, net revenue received from users during the pilot period totaled $22,973.26, or approximately $2,089 per month. Net revenue included base fees charged to the user for PEV charging plus non-charging occupancy fees less the transactional fee of 3.9% + $0.30 assessed by the payment processor.

12.1 Benefits to Cost Analysis

Benefit to cost analysis indicates that costs of operations, maintenance, construction and installation, networking, and other related functions of the PEV charging infrastructure implemented during the pilot outweighed net revenues generated at the pricing levels tested. In order to design an effective PEV infrastructure for a facility, stakeholders may wish to consider costs, revenues, and other benefits, such as utility subsidies, cost of energy, demand charges or demand response, and asset amortization and other tax benefits related to implementing PEV charging so that all factors impacting a business owner's decision to provide PEV drivers with charging in the workplace are considered.

13. Evaluation, Measurement and Verification

In order to meet pilot objectives and goals, SCE sought to examine the effects of workplace charging on supply systems and determine ways to minimize the impact of workplace PEV charging on the electrical grid without adversely affecting PEV owners, suppliers, and the utility during working hours. It also sought to provide guidance to larger C&I customers interested in coordinating their existing DR programs with PEV charging infrastructure. To that end, the SCE Load Research team analyzed data to evaluate the impact of installing PEV charging stations on the existing building load and determine the variance in electricity costs due to the added load. The team concluded that the addition of PEV charging to the building load resulted in a very minimal financial impact. Details regarding the analysis are presented in the following sections.

13.1 Building Load Impact Analysis

The research team compared historical building loads to the load after PEV charging had been initiated to determine the impact of PEV charging in terms of both load and cost. Facilities A, B, C, and D had the largest PEV charging stations installations as shown in Table 8.

Table 8: Pilot PEV Charging Stations

Facility ID	City	Number of Charging Stations Installed
A	Rosemead, CA	22
B	Rosemead, CA	9
C	Rosemead, CA	14
D	Rosemead, CA	12
E	Pomona, CA	4
F	Pomona, CA	4
G	Irwindale, CA	7
H	Santa Ana, CA	4
I	Wildomar, CA	4

As shown in Table 9, facilities A and D had the highest staffing levels as of December 2015, while facilities A, B, and D had the highest seating potential. The team concluded that variances noted in the building staffing levels and charging behaviors over time[26] reflected movement of employees between facilities, as well as resource realignments during 2015.

[26] Refer to Appendix E: Charging Sessions by Facility

Table 9: Pilot Facility Capacity and Staffing

Facility	Building Capacity	Building Population as of Dec. 2015 (Approx.)	Potential EV Charging Station Users as of Dec. 2015 (Est.)
A	1784	1193	1351
B	985	264	265
C	600	375	543
D	882	641	641
E	456	345	385
F	538	365	377
G	509	349	356
H	105	83	180
I	202	127	127

Consistent with the staffing information, facilities A, B, and D had the highest calculated electricity costs[27], as well as the highest number of PEV charging stations available for employee use. It should be noted that the calculated electricity cost at facility A ranged from 3 to 13 times higher than the estimated cost at the other pilot facilities.

Analysis of the PEV charging load as a percentage of the annualized average building load indicated that the charging load over the testing period averaged less than 4.5% of total building load at each of the pilot sites. Due to the high normal building load and estimated electricity cost per month, annualized PEV charging load at facility A accounted for 1.2% of total load based on an average of 284 sessions (2,987 kWh) per month. In comparison, the charging load at facility B accounted for 1.9% while averaging 140 sessions (1,636 kWh) per month.

[27] Simplified facility electricity costs were calculated using building usage data.

The average PEV load relative to total building load averaged approximately 3.0% at sites C, D, E, and F. Site C averaged 119 sessions (1,396 kWh) per month, facility D averaged 209 (1,723 kWh), facility E averaged 102 (1,281 kWh), and facility F averaged 112 (981 kWh). Although only 49 sessions (507 kWh) were authorized at facility H on average per month, PEV load accounted for 4.4% of the total building load.

PEV charging load was 0.7% at facility G, which was involved in major resource realignment efforts and averaged 32 sessions (255 kWh) per month. Facility I primarily provided charging access to visitors and served as a charging hub for employees at a distant location. PEV load accounted for 0.7% at this facility, with an average of 17 sessions (150 kWh) per month.

Table 10: PEV Charging Load as Percentage of Building Load (Annualized Average)

Average of % EV LOAD TO BUILDING LOAD													
Facility	**Jan-15**	**Feb-15**	**Mar-15**	**Apr-15**	**May-15**	**Jun-15**	**Jul-15**	**Aug-15**	**Sep-15**	**Oct-15**	**Nov-15**	**Dec-15**	**Grand Total**
A	1.3%	1.1%	0.2%	1.2%	1.4%	1.4%	0.9%	1.3%	1.5%	1.5%	1.3%	1.4%	1.2%
B	2.4%	2.0%	0.4%	3.1%	2.2%	2.2%	1.7%	2.4%	2.3%	1.8%	1.2%	0.8%	1.9%
C	2.7%	2.4%	0.3%	3.8%	3.4%	3.0%	2.5%	3.3%	3.4%	3.8%	3.4%	4.8%	3.1%
D	3.4%	3.3%	0.5%	4.0%	4.6%	2.8%	1.9%	2.6%	2.5%	2.7%	2.7%	4.8%	3.0%
E	5.0%	3.7%	0.5%	2.7%	2.9%	1.7%	1.0%	1.9%	2.9%	3.7%	4.7%	5.4%	3.0%
F	1.7%	2.2%	0.3%	2.9%	3.4%	2.6%	1.8%	2.1%	2.2%	3.4%	3.5%	4.4%	2.5%
G	3.7%	0.1%		0.4%	0.5%	0.8%	0.4%	0.4%	0.4%	0.3%	0.2%	0.2%	0.7%
H	1.1%	1.5%	0.1%	1.2%	2.9%	3.3%	2.9%	5.7%	7.1%	9.1%	8.4%	9.2%	4.4%
I	1.1%	1.1%	0.1%	1.0%	1.2%	0.9%	0.4%	0.6%	0.6%	0.3%	0.4%	0.3%	0.7%
Monthly Avg %	**2.5%**	**1.9%**	**0.3%**	**2.3%**	**2.5%**	**2.1%**	**1.5%**	**2.2%**	**2.5%**	**3.0%**	**2.9%**	**3.5%**	**2.3%**

The load research team also evaluated 15-minute interval PEV charging usage per month at each pilot installation site and compared the usage with historical and current building electricity loads. This comparison indicated that the electricity cost difference prior to implementing PEV charging at these facilities and after charging was initiated was very minimal as shown in Table 11.

Table 11: Comparison of Building Electricity Costs

Facility	BILL DIFFERENCE
A	0.3%
B	0.4%
C	0.8%
D	0.8%
G	0.3%
E	1.0%
F	0.7%
H	0.7%
I	0.2%

The research team concluded that there was no statistically significant correlation between building usage and PEV charging usage. Operation of the pilot PEV charging infrastructure at the selected SCE facilities did not significantly impact building load or electricity costs for the pilot facilities. This finding suggests that buildings of varying sizes and staffing levels could support a PEV infrastructure, and that system and financial impacts could be controlled to minimize negative effects resulting from the additional energy load.

14. Utilization

In order to measure charging station utilization, the team compared the total number of hours available for charging per day during business hours against the total number of hours PEV charging occurred during each day. This approach considered several variables, including battery size, consumer needs and preference, varying length of charging sessions, and the fact that some drivers disconnected prior to a full battery.

14.1 Evaluation Approach

The total number of hours available for charging was calculated using the total number of business hours per month multiplied by the total number of charging stations. The utilization rate compared the total available hours against the amount of time the charging stations were in use during business hours during the month. As shown in Figure 28, the utilization rate across the pilot PEV charging infrastructure (i.e., 80 charging stations at nine (9) facilities) ranged from 12% to 18%.

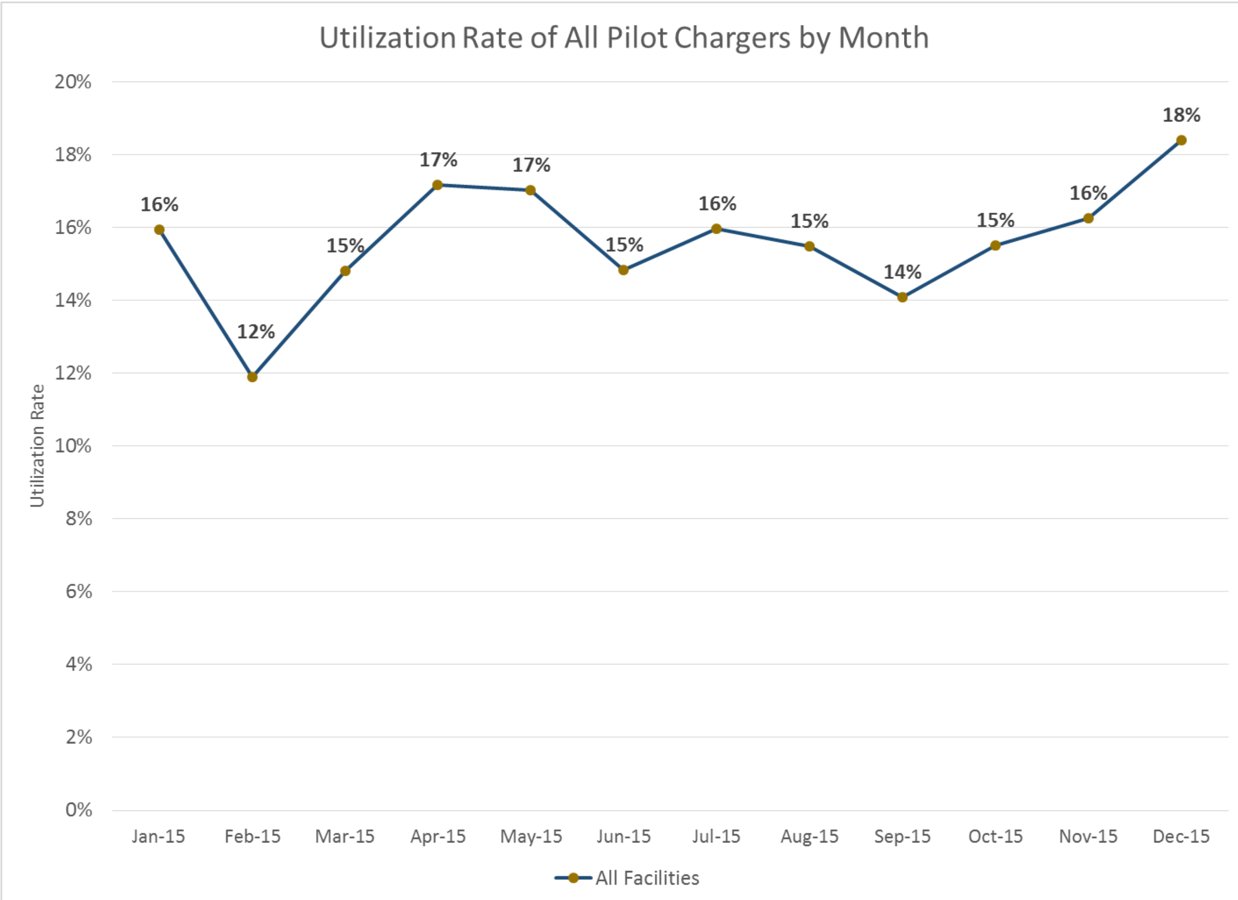


Figure 24: Utilization rate of all chargers at all facilities by month.

Detailed analysis of utilization rates at the facility level was also performed to identify impacts from building size, staffing levels, and number of charging stations available, analysis was also performed. As shown in following charts, utilization was higher at facilities with PEV charging high demand and limited charging stations. Findings indicate that PEV charging demand, number of charging stations available, and system reliability impact utilization rates. In general, space management controls that optimize charger use and encourage space turnover appear to be beneficial regardless of the infrastructure model implemented.

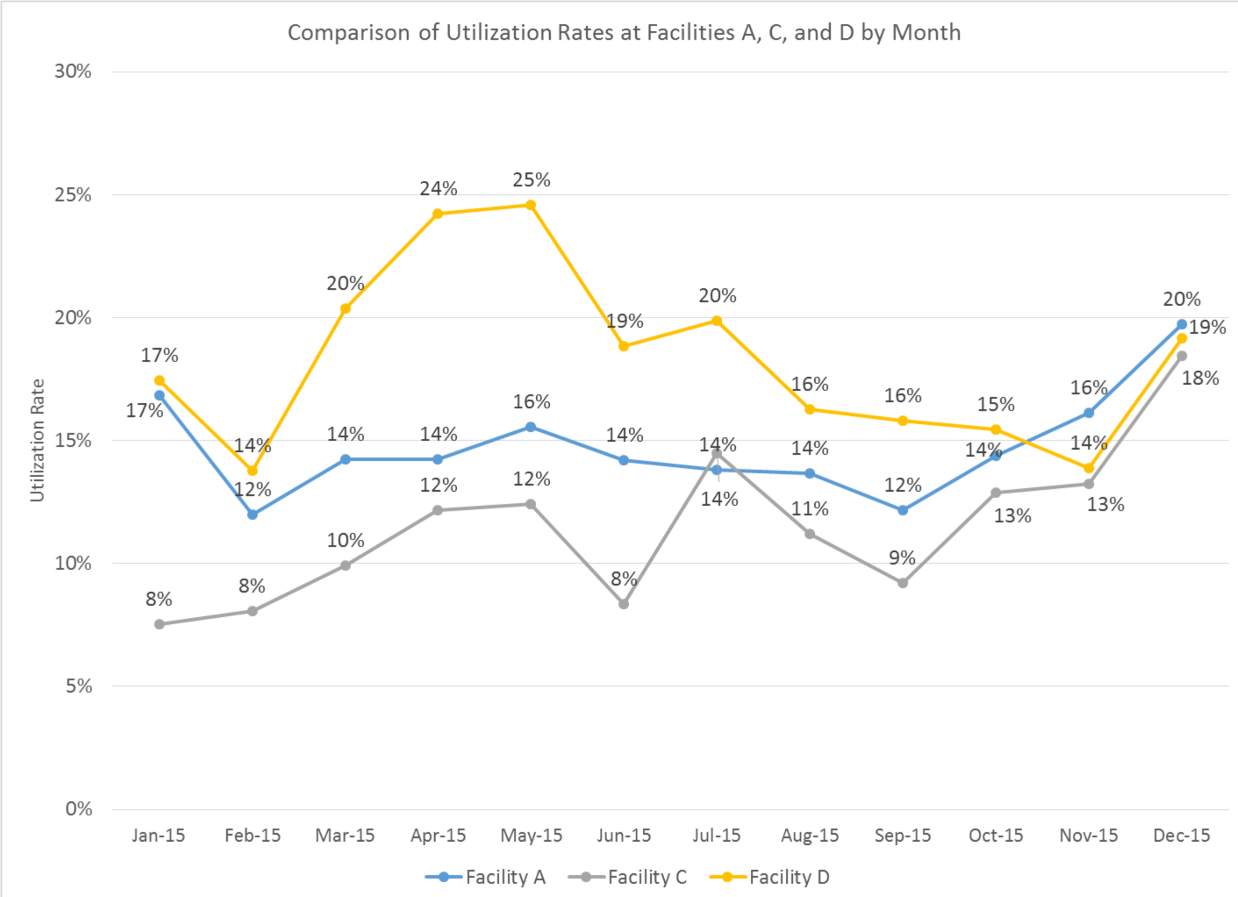


Figure 25: Comparison of charger utilization at facilities with larger building load and relatively stable staffing levels during 2015.

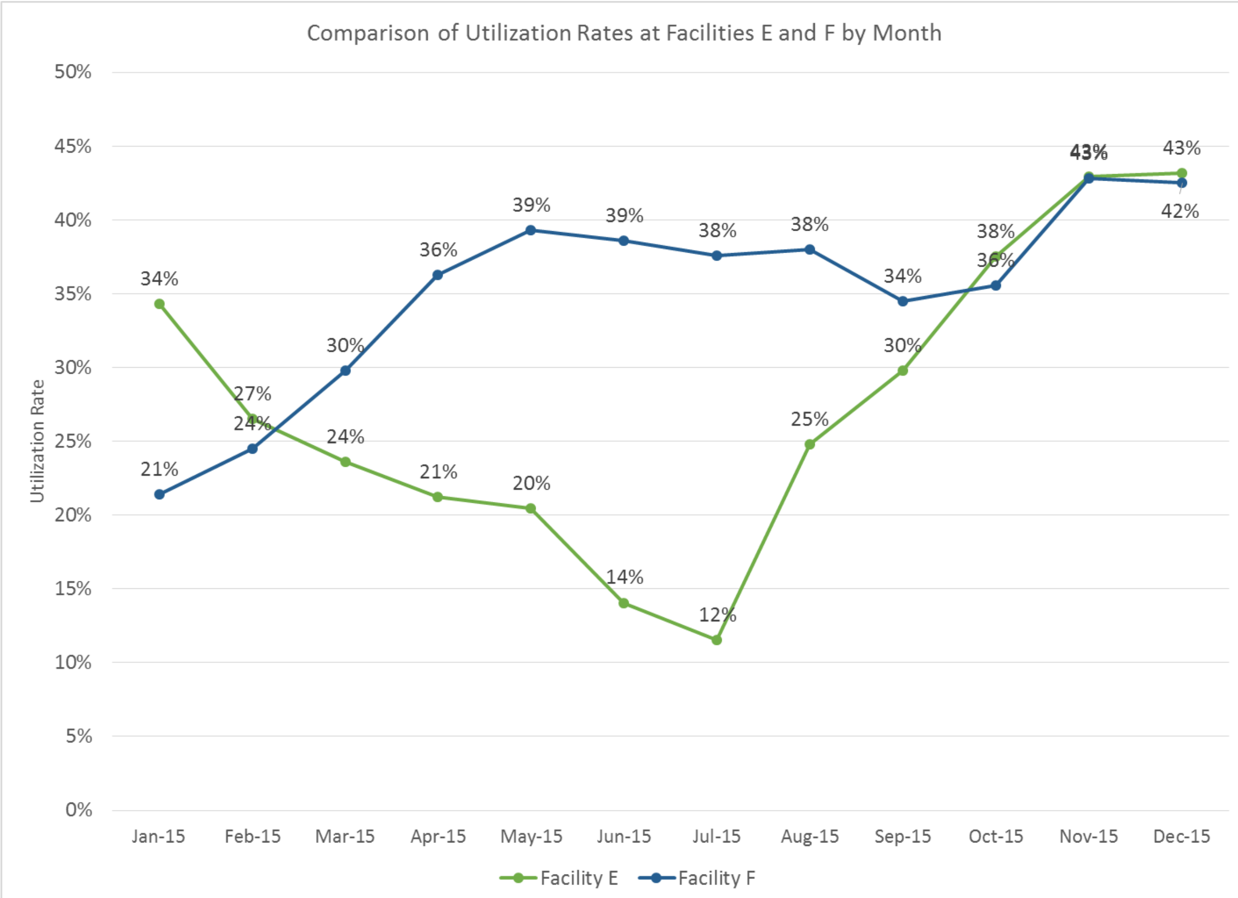


Figure 26: Comparison of charger utilization at facilities with high daily PEV charging demand and limited charging stations.

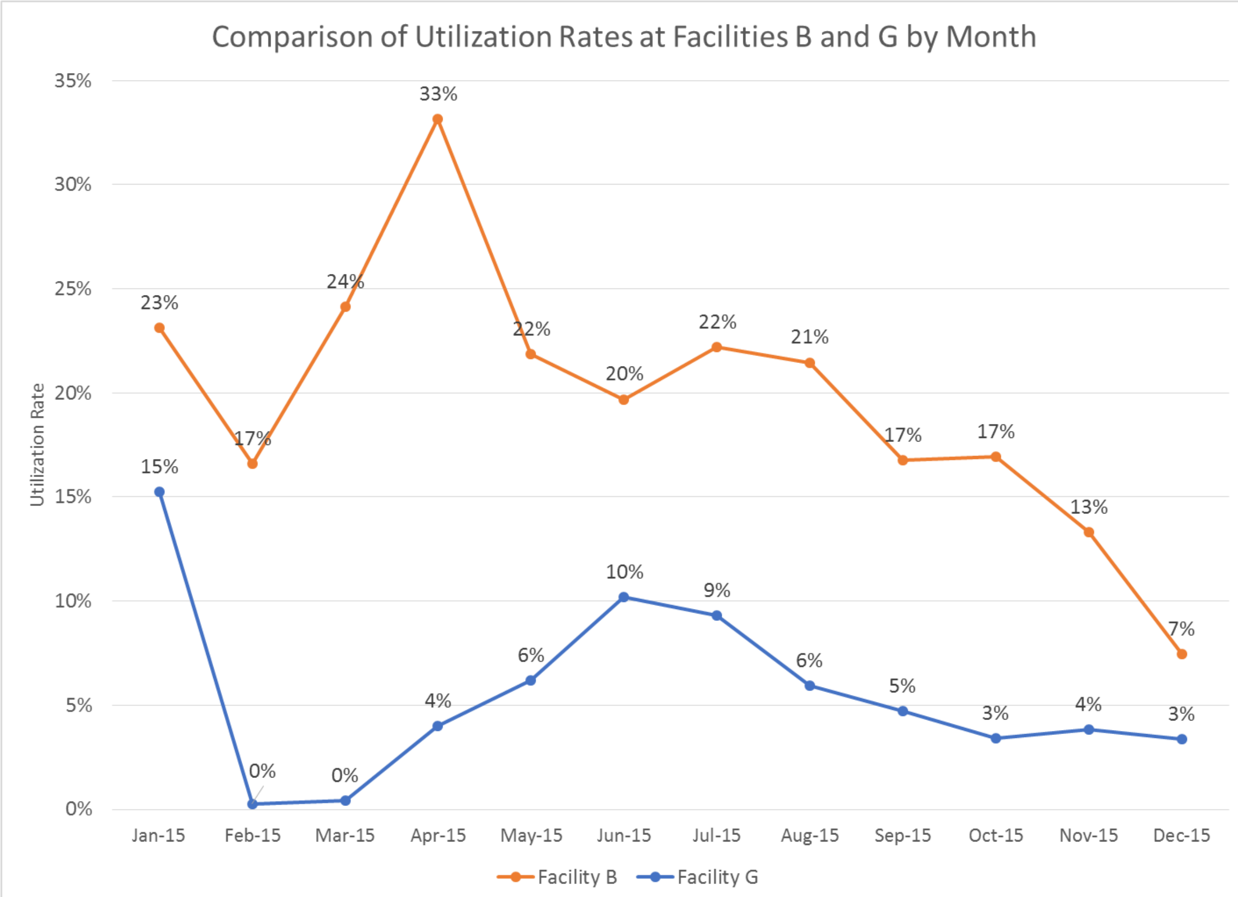


Figure 27: Comparison of charger utilization at facilities subject to significant staffing realignments in 2015.

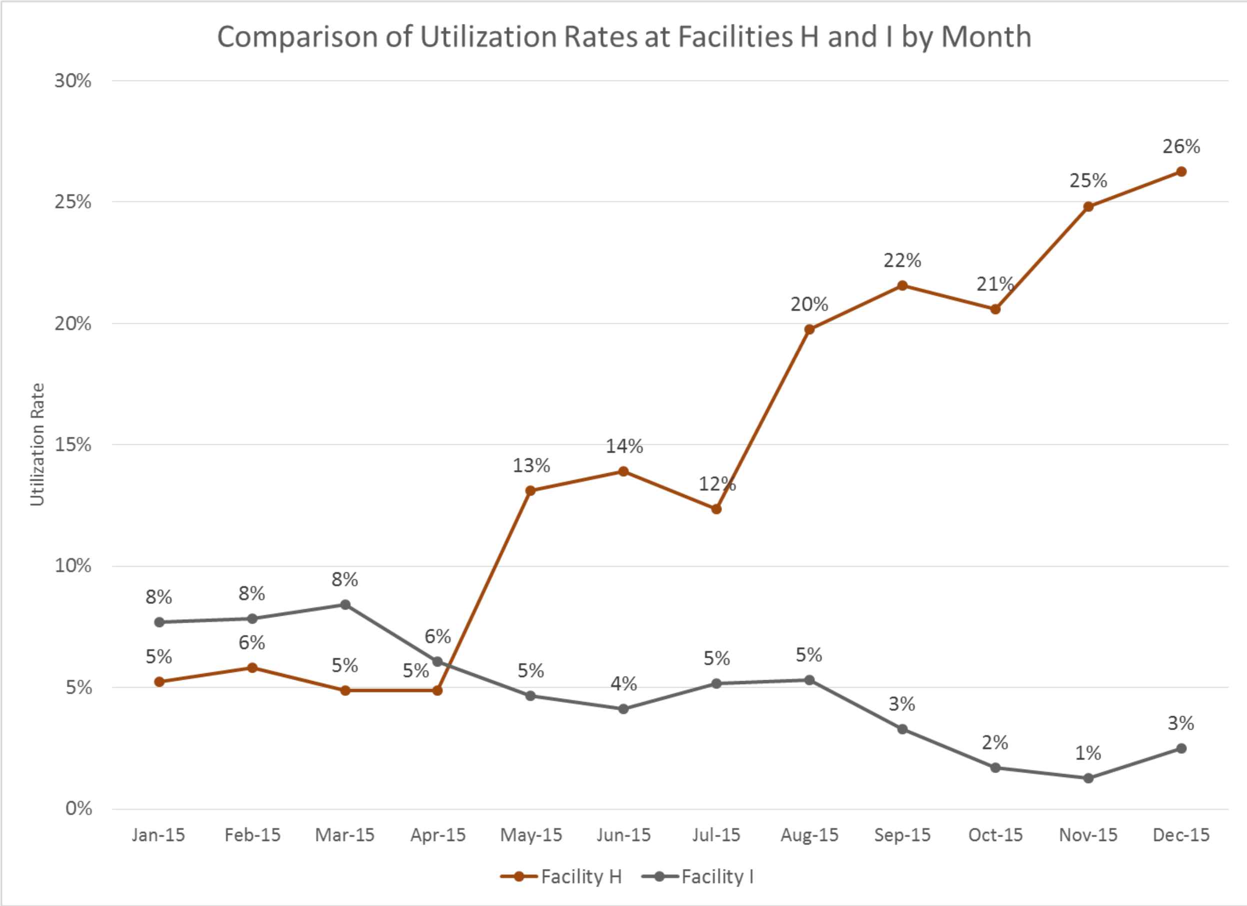


Figure 28: Comparison of charger utilization at facilities with low daily PEV charging demand and limited number of charging stations.

14.2 Charging Station Utilization Simulations

In order to understand the potential that a fully utilized PEV charging infrastructure could have on revenues and load, forecasts were created to model different charging level utilization scenarios in the workplace. Actual utilization rates impacting gross revenues and energy consumption were plotted against simulations using the following variables: charging station utilization rate of 100% at each pilot facility, 1.4 kW Level 1 rate, 6.2 kW Level 2 charge rate, and monthly pricing tested during the pilot.

The results of the simulations are shown in Figure 29 and Figure 30.

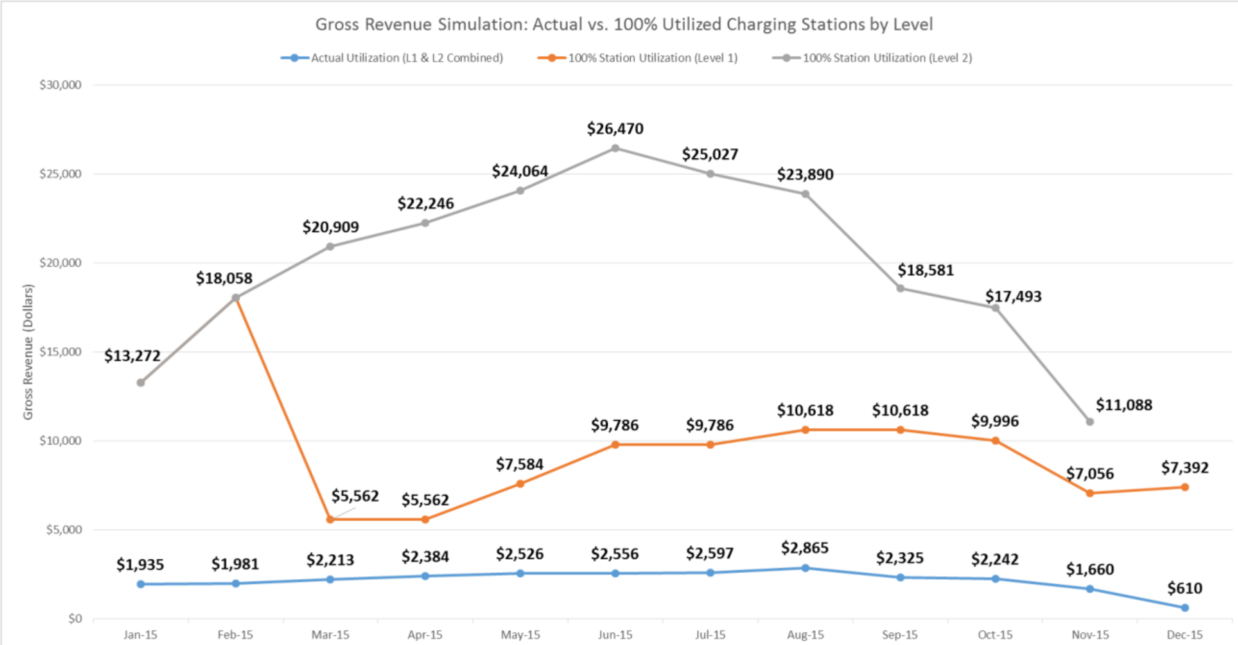


Figure 29: Simulation of gross revenue generation showing actual gross revenues vs. 100% utilization of the charging infrastructure by Level 1 (1.4 kW) and Level 2 (6.2 kW) options

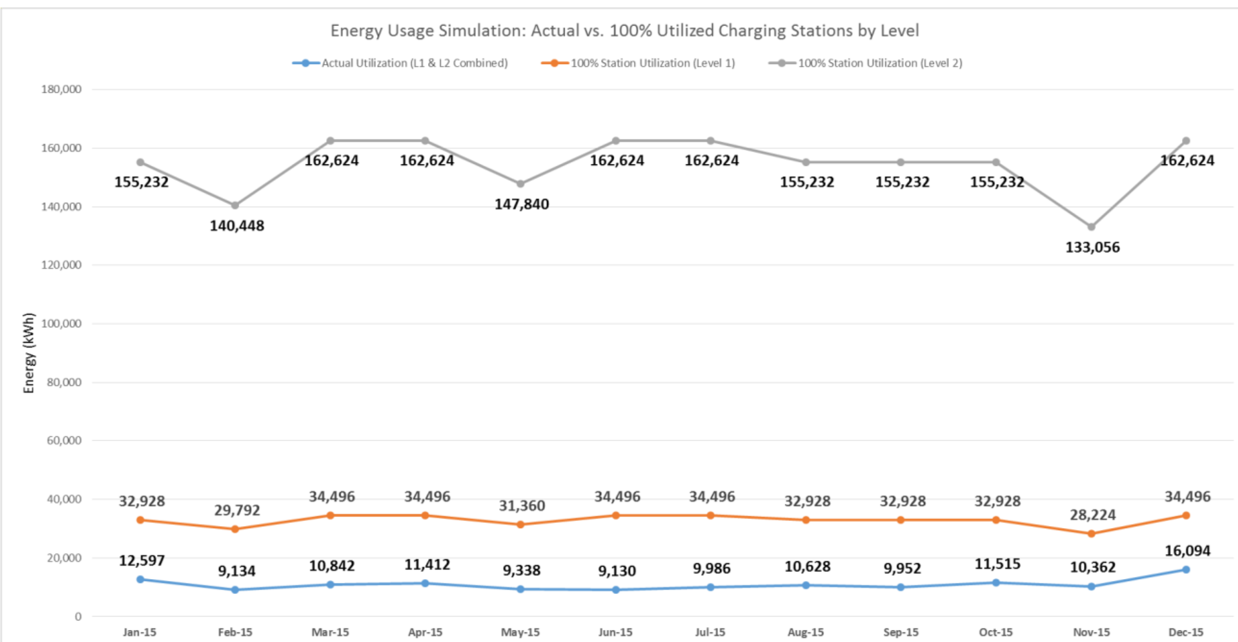


Figure 30: Simulation of energy consumed showing actual consumption vs. 100% utilization of the charging infrastructure by Level 1 (1.4 kW) and Level 2 (6.2 kW) options.

15. Pilot Findings, Complexities and Considerations

The SCE Plug-In Electric Vehicle Workplace Charging Pilot successfully tested innovative technologies and interoperable communications to identify efficient and cost-effective PEV charging options that could reduce the cost of workplace PEV charging installations and promote consumer PEV adoption while enabling dynamic TOU pricing, space management controls, and demand response participation. The following sections address the primary issues explored during the pilot.

15.1 Consumer Behavior

The pilot team evaluated data collected from the employee surveys, driver interviews, and charging session data to develop the following conclusions regarding consumer behaviors related to PEV charging in the workplace. Data suggests that critical factors influencing the charging decision include commute distance, convenience, range anxiety and, for some hybrid drivers, the price of gasoline. Data also suggests that, as the consumer's level of need increases, their tolerance of fees increases.

Findings related to consumer behaviors are listed below and discussed further in other sections of this report.

- Commute distance and convenience impact the charging decision for most drivers.
- 33% of 2015 survey respondents noted HOV access as the primary reason for buying/leasing a PEV, with an equal number noting high gas prices.
- EV ownership among SCE employees increased almost 500% from 2012 to 2016 (i.e., 58 to 342) based on employee survey responses.
- BEV drivers are more tolerant of fee-based charging than hybrid PEV drivers.

- Gasoline prices, which fluctuated significantly during 2015[28], impact the charging decision for hybrid PEV drivers.
- Availability of PEV charging in the workplace influences employee PEV buy/lease decisions.
- The large majority of drivers (75%) chose Level 2 (208V) charging in the workplace.
- Approximately 80% of drivers opted to charge during off-peak morning (5:00 am – noon) hours.
- The time of DR event dispatch did not significantly impact driver participation.

15.2 Driver Participation

The number of unique drivers using the PEV charging infrastructure was measured by analyzing the number of mobile phone numbers input for each session authorized. Since phone numbers were not input until fee-based pricing was implemented in January 2015, the 211 phone numbers input in January formed the baseline against which driver charging behavior during the remainder of 2015 was evaluated. As shown in Table 12, the total number of unique phone numbers input between February and December, as compared against the January baseline, increased by 177% from 211 to 584.

[28] Refer to Appendix H: 2015 California Weekly Average Gasoline Prices

Table 12: Comparison of Mobile Phone Number Input by Month

Month	No. of Sessions (6AM-8PM)	No. of Phone Numbers Input	No. of New Phone Numbers Input	% of New Phone Numbers Input	Cumulative No. of Phone Numbers	Percentage Increase in New Phone Numbers
JAN	1,118	211	211	100%	211	
FEB	849	154	44	29%	255	21%
MAR	1,037	165	41	25%	296	16%
APR	1,130	179	49	27%	345	17%
MAY	991	163	29	18%	374	8%
JUN	1,001	174	41	24%	415	11%
JUL	1,099	160	28	18%	443	7%
AUG	1,064	186	41	22%	484	9%
SEP	1,018	155	16	10%	500	3%
OCT	1,104	152	19	13%	519	4%
NOV	947	158	34	22%	553	7%
DEC	1,426	197	31	16%	584	6%

Data regarding the number of drivers participating in the pilot, combined with PEV adoption data collected from the employee surveys, suggests that driver needs and preferences in making the charging decision outweighed the price and space management controls implemented. An increasing number of drivers who purchased or leased PEVs after the pilot was initiated were aware of the fees and controls, they may have considered these factors in the purchase/lease decision, and they still chose to charge at the pilot stations.

15.3 Charging Level

On average, over 1,100 sessions per month were authorized under varying Level 1 and Level 2 pricing strategies. Data shows that an average of 75% of users selected Level 2 charging versus Level 1 charging during 2015. The pilot realized almost 10,500 Level 2 sessions vs. 3,400 Level 1 sessions over the 12-month testing period.

Variances noted in January, February, and December 2015 appear to have been caused by the pricing strategy implemented, which influenced user behaviors. As mentioned in Section 7.2, the off-peak base for both Level 1 and Level 2 charging was set at $0.50 in January and $0.75 in February to gauge consumer response to pricing, inform analysis regarding the importance of long-term parking versus price, and determine an appropriate range moving forward. Analysis shows that the number of Level 1 charging sessions ranged from 22% - 41% of total sessions authorized, with an average Level 1 selection rate of 25%. Data suggests that $0.50 and $0.75 per hour prices influenced drivers to select the faster Level 2 charging since no price differential existed. Approximately 20% of users shifted their charging level from Level 2 to Level 1 in March data when the Level 1 price was reduced to $0.20 per hour and a $0.55 per hour price differential existed.

Complimentary Level 2 off-peak and on-peak charging in December 2015 resulted in 95% of users selecting Level 2 charging while the remaining users chose to charge at the slower Level 1 charging rate.

Since some PEV on-board chargers have a maximum power rating that limits the rate of charge the vehicle can receive from Level 2 charging, users needed to consider the cost of both Level 1 and Level 2 fees, as well as their personal charging needs and preferences, prior to making their charging selection. Data regarding charging sessions authorized at each of the pilot facilities is provided in Appendix E: Charging Sessions by Facility.

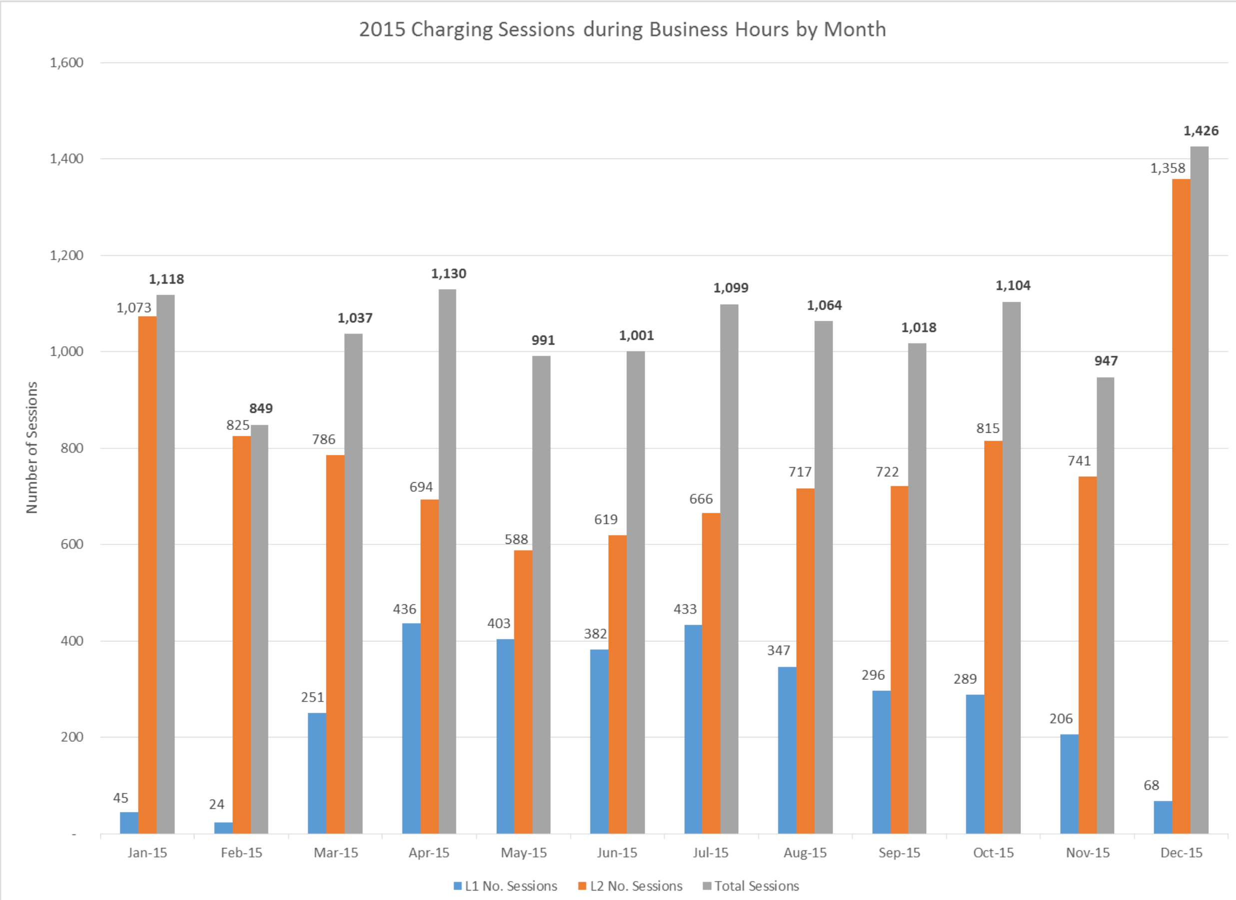


Figure 31: Charging sessions by month during business hours (6AM-8PM)

15.4 Time-of-Use

Approximately 80% of drivers opted to charge during off-peak morning hours (5:00 am – noon) hours regardless of the base fee charged. In addition, despite removing the price differential between off-peak and on-peak pricing in December, 76% of users opted to charge during morning off-peak hours versus 24% of sessions after 12:00 PM.

This finding suggests that users are influenced by factors such as establishing a regular charging routine upon arrival at the workplace, leveraging open charging spaces in the workplace, and ensuring that charging is complete when needed by the driver in addition to pricing levels. Sessions authorized during off-peak and on-peak periods is shown in Figure 32.

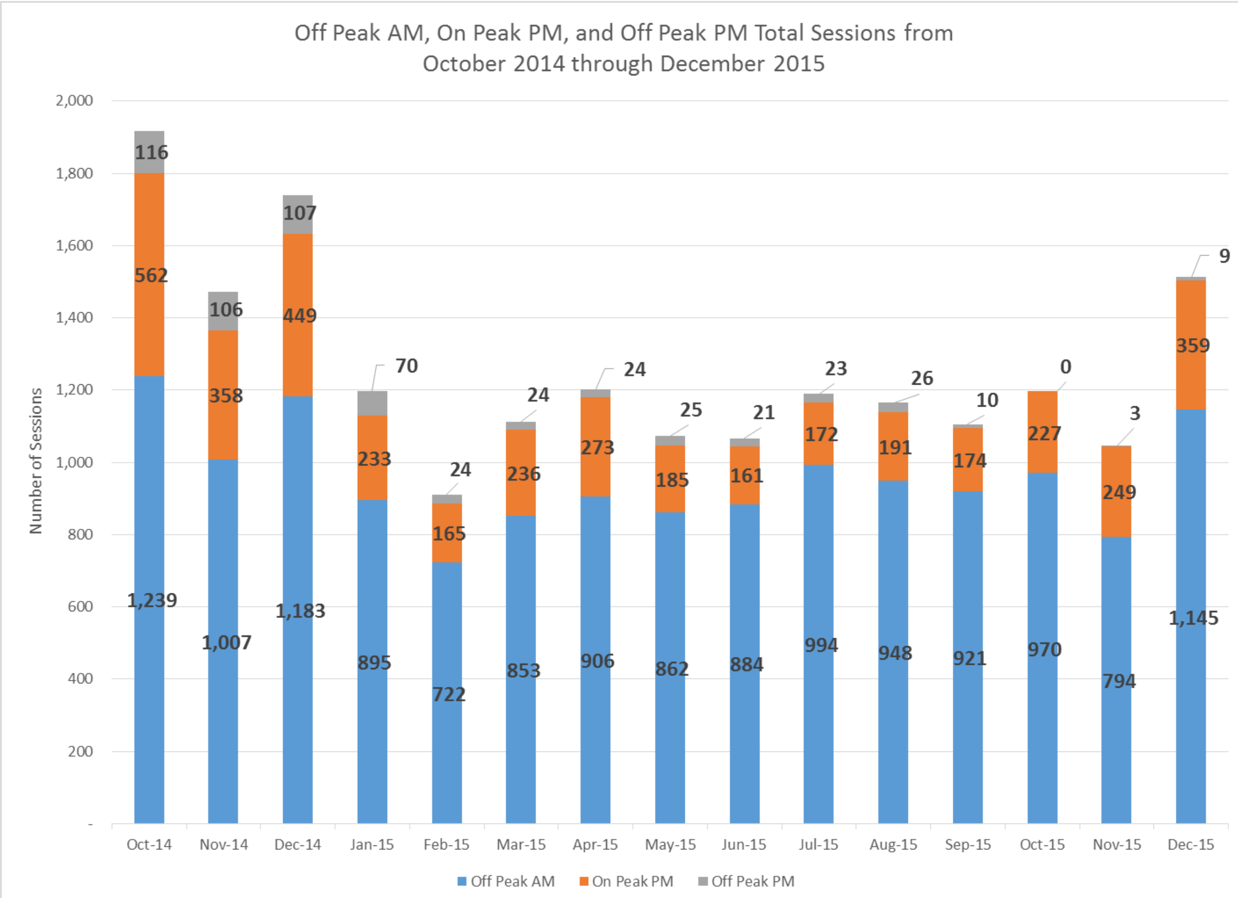
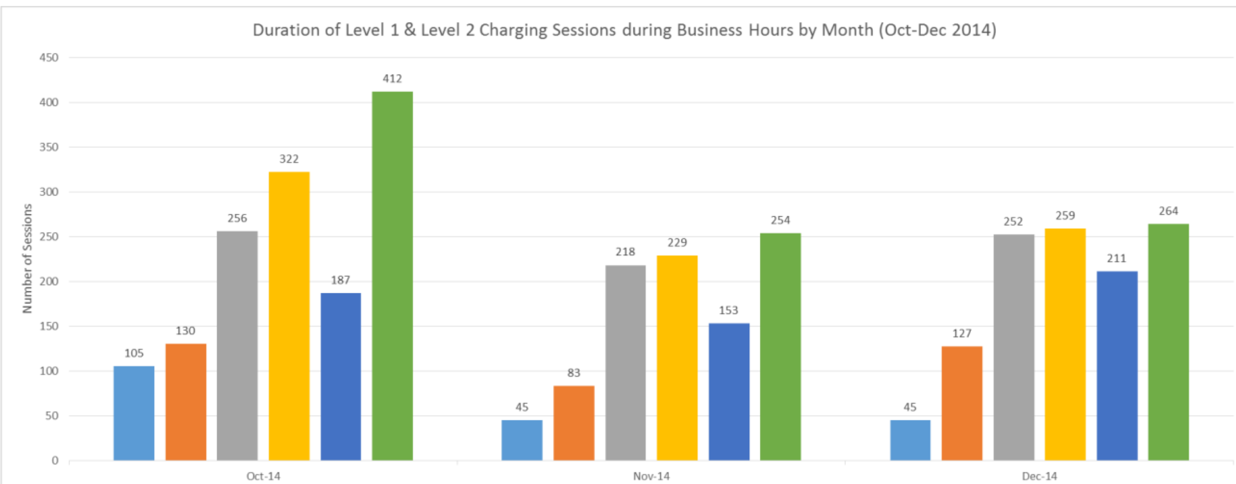


Figure 32: Charging sessions by time of day by month.

Analysis also revealed that, on average, 219 users per-month chose to charge their PEV during on-peak hours, possibly due to limited charging station availability at their normal work facility and/or afternoon meetings scheduled at a facility that was not the user’s normal workplace.

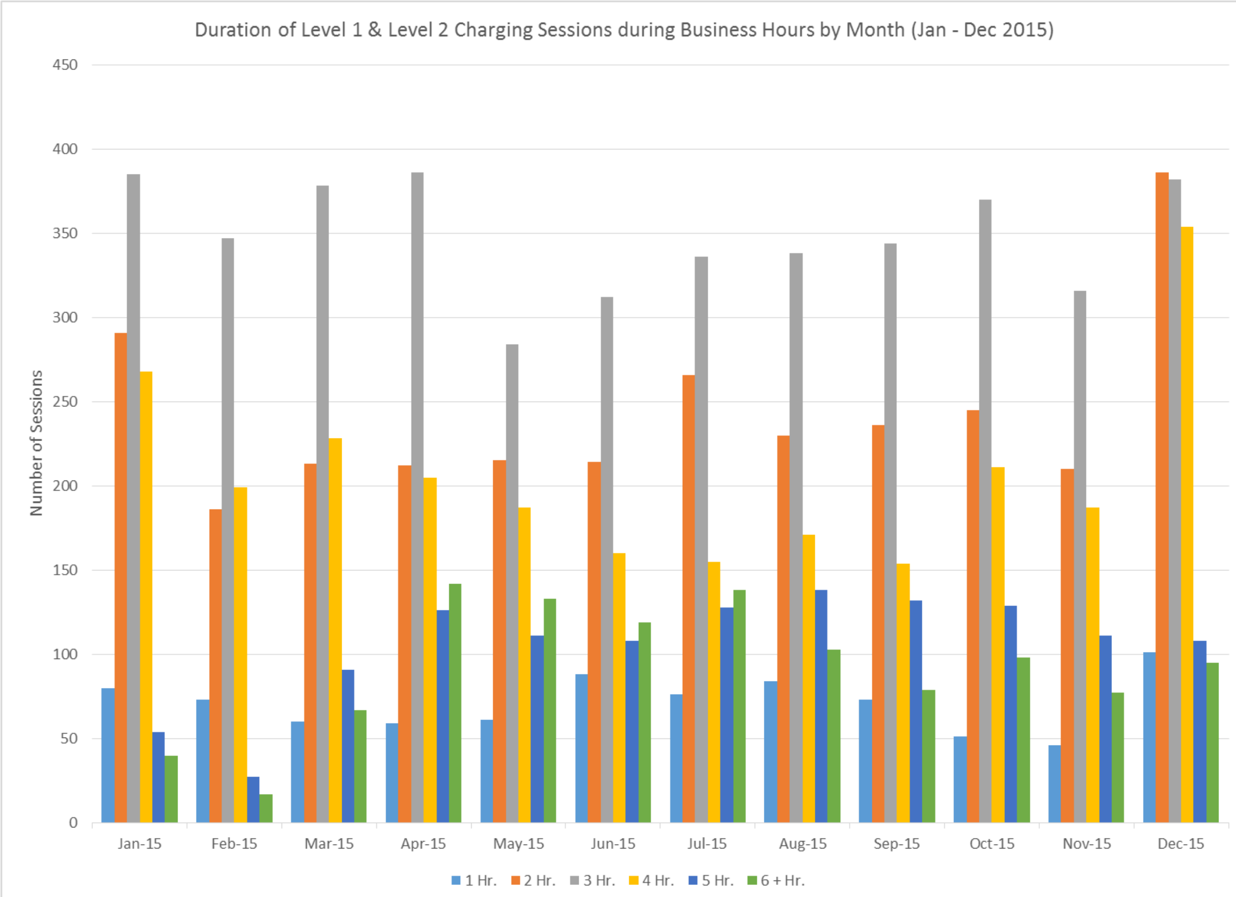
15.5 Charging Duration Analysis

Despite data indicating that over 62% of participating PEVs complete charging within three (3) hours, analysis revealed that the number of vehicles that remained connected more than six (6) hours during October – December 2014, prior to implementation of base charging fees and non-charging occupancy fees, ranged from 254 - 412 sessions per month. The total number of vehicles that remained connected more than six (6) hours following implementation of the base charging fees and non-charging occupancy fees decreased approximately 71% to an average of 90 sessions per month based on comparable sessions authorized from October – December 2015. This data suggests that drivers during Q4 2014 did not remove their PEV after the battery was charged and supports the premise that fee-based charging and other space management controls encouraged space turnover, thereby optimizing charging station use.



	Oct-14	Nov-14	Dec-14
1 Hr.	105	45	45
2 Hr.	130	83	127
3 Hr.	256	218	252
4 Hr.	322	229	259
5 Hr.	187	153	211
6 Hr. +	412	254	264

Figure 33: Duration of 2014 charging sessions per month (October – December 2014).



	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15
1 Hr.	80	73	60	59	61	88	76	84	73	51	46	101
2 Hr.	291	186	213	212	215	214	266	230	236	245	210	386
3 Hr.	385	347	378	386	284	312	336	338	344	370	316	382
4 Hr.	268	199	228	205	187	160	155	171	154	211	187	354
5 Hr.	54	27	91	126	111	108	128	138	132	129	111	108
6 + Hr.	40	17	67	142	133	119	138	103	79	98	77	95

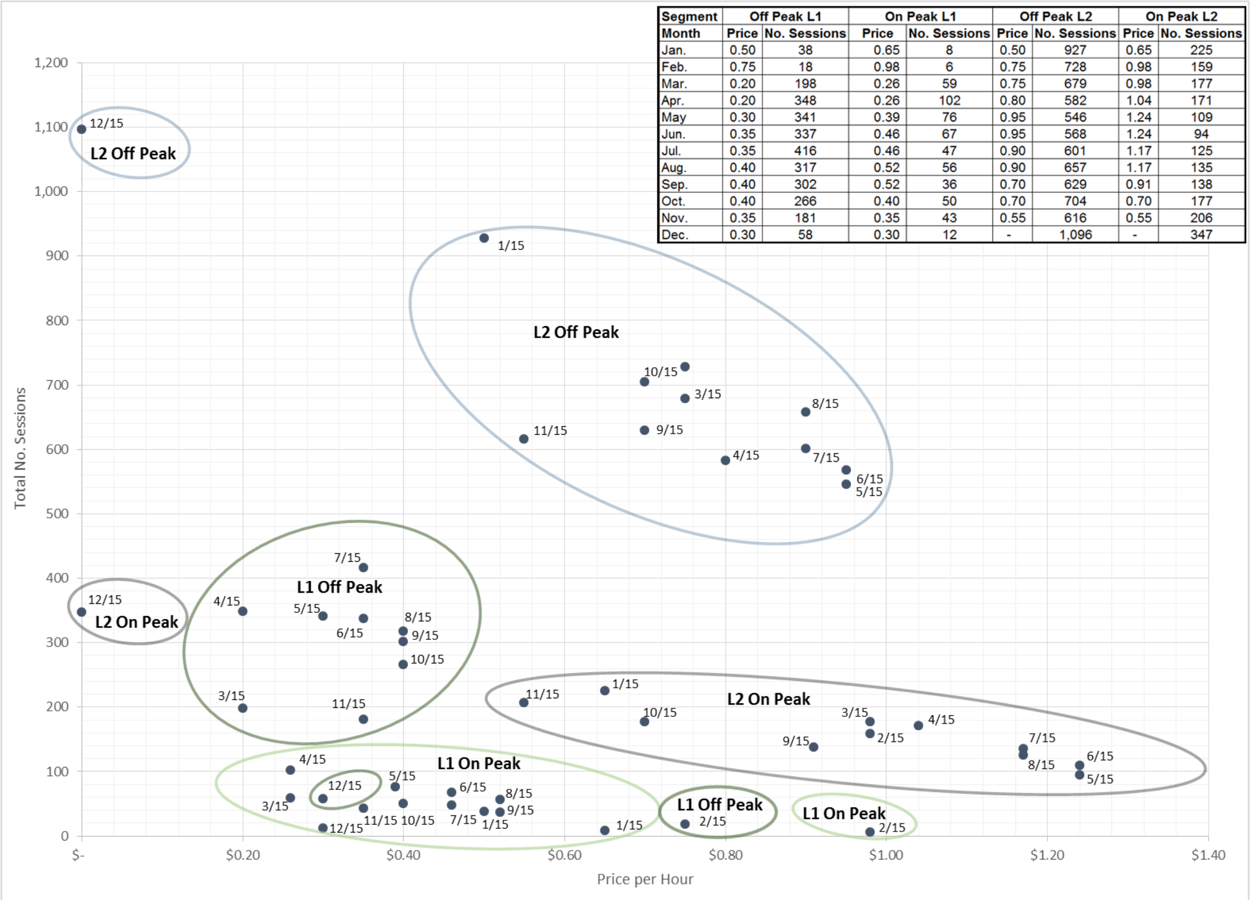
Figure 34: Duration of 2015 charging sessions during business hours by month.

15.6 Price Sensitivity

In order to inform PEV charging models, SCE examined the relationship between the demand for PEV charging and the price established for varying charging levels and time-of-use. Data relating to this analysis included the pricing strategy implemented, number of sessions authorized at each pricing level, and the distribution of the charging sessions by charging level and time-of-use.

Analysis of total charging sessions from January – December 2015 and prices charged during each of those months provides valuable clues regarding the importance that pricing and other factors have on the charging decision. Although price and quantity usually reflect an inverse relationship (i.e., quantity increase with price decrease), charging sessions did not always reflect this relationship, which suggests that price was not the only factor motivating driver charging behavior. As shown in Figure 35, some key findings include:

- March: Price decrease in March from $0.75 to $0.20 had a significant impact on the number of charging sessions.
- April: 76% increase in charging sessions appears to have been due to entrants to the charging population. In addition, the 12% reduction in Level 2 charging sessions appears to have been offset by an increase in Level 1 sessions.
- December: 95% of users selected Level 2 complimentary charging with the non-charging parking fee but 5% of users chose to charge at the slower Level 1 charging rate at $0.30 per hour.
- Approximately 60 Level 1 users and 150 Level 2 users charged during on-peak business hours during March – November.



Segment	Off Peak L1		On Peak L1		Off Peak L2		On Peak L2	
Month	Price	No. Sessions	Price	No. Sessions	Price	No. Sessions	Price	No. Sessions
Jan.	0.50	38	0.65	8	0.50	927	0.65	225
Feb.	0.75	18	0.98	6	0.75	728	0.98	159
Mar.	0.20	198	0.26	59	0.75	679	0.98	177
Apr.	0.20	348	0.26	102	0.80	582	1.04	171
May	0.30	341	0.39	76	0.95	546	1.24	109
Jun.	0.35	337	0.46	67	0.95	568	1.24	94
Jul.	0.35	416	0.46	47	0.90	601	1.17	125
Aug.	0.40	317	0.52	56	0.90	657	1.17	135
Sep.	0.40	302	0.52	36	0.70	629	0.91	138
Oct.	0.40	266	0.40	50	0.70	704	0.70	177
Nov.	0.35	181	0.35	43	0.55	616	0.55	206
Dec.	0.30	58	0.30	12	-	1,096	-	347

Figure 35: Price sensitivity by month for all sessions authorized (Business and Non-Business Hours)

15.6.1 *Complimentary Charging*

As expected, the team compared data from the complimentary charging periods (i.e., October – December 2014 and December 2015) and found that the highest number of Level 2 charging sessions occurred when charging was free. However, data also showed that approximately 20% of Level 1 drivers who normally charged during off-peak and on-peak hours continued to pay for charging at $0.30 per hour despite complimentary Level 2 charging during December. This finding suggests that some drivers may have preferred to pay a fee in return for a longer parking time.

15.6.2 *Level 1 Charging and Price Analysis*

Data showed that an average of 360 Level 1 total off-peak and on-peak sessions were authorized during business hours each month[29], with an average of 300 charging sessions authorized during off-peak business hours and an average of 60 authorized during on-peak hours.

As mentioned previously, the off-peak base for both Level 1 and Level 2 charging was set at $0.50 in January and $0.75 in February to gauge consumer response to pricing and level set an appropriate range moving forward. Analysis indicates that Level 1 drivers were not responsive to off-peak prices greater than $0.50 per hour and associated on-peak prices greater than $0.65 per hour that were tested during January and February 2015 as charging sessions during on-peak and off-peak periods totaled 45 and 24 sessions respectively for those months. At these price levels, it appeared that drivers opted to charge at the faster Level 2 rather than Level 1 due to the lack of a price differential.

Analysis of Level 1 sessions during business hours between March and November, which excludes sessions impacted by variation introduced by the January, February, and December pricing strategies, shows that total Level 1 business hour sessions per month ranged from 206 to 436 during this period. It is interesting that July Level 1 off-peak pricing of $0.35 per hour resulted in 416 off-peak sessions, which was the highest number of monthly Level 1 sessions during 2015. However, the July per hour price was $0.15 higher than pricing in March or April, and was at the same price level as June.

In addition, although the March off-peak price was $0.20 per hour and the per-hour prices in May through October were $0.10 to $0.20 higher than March, the number of off-peak sessions authorized per month between April and October were 27%-87%

[29] Average was adjusted to reduce skewness caused by January, February and December 2015 pricing strategies.

higher than the March sessions. As shown in Figure 36 and Figure 37, there does not appear to be a correlation between Level 1 pricing and the number of sessions authorized at either off-peak or on-peak periods.

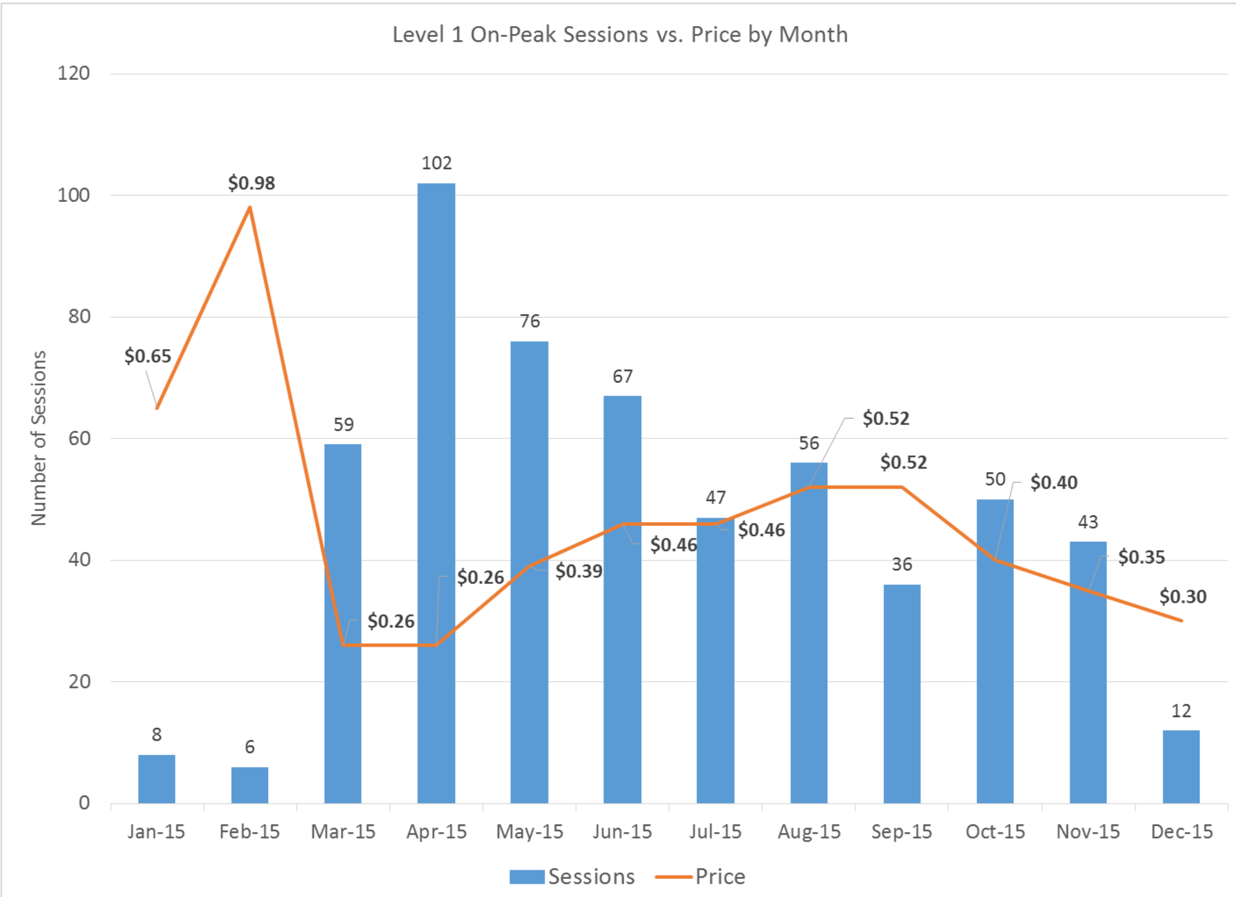


Figure 36: Comparison of Level 1 on-peak charging sessions by per-hour price by month.

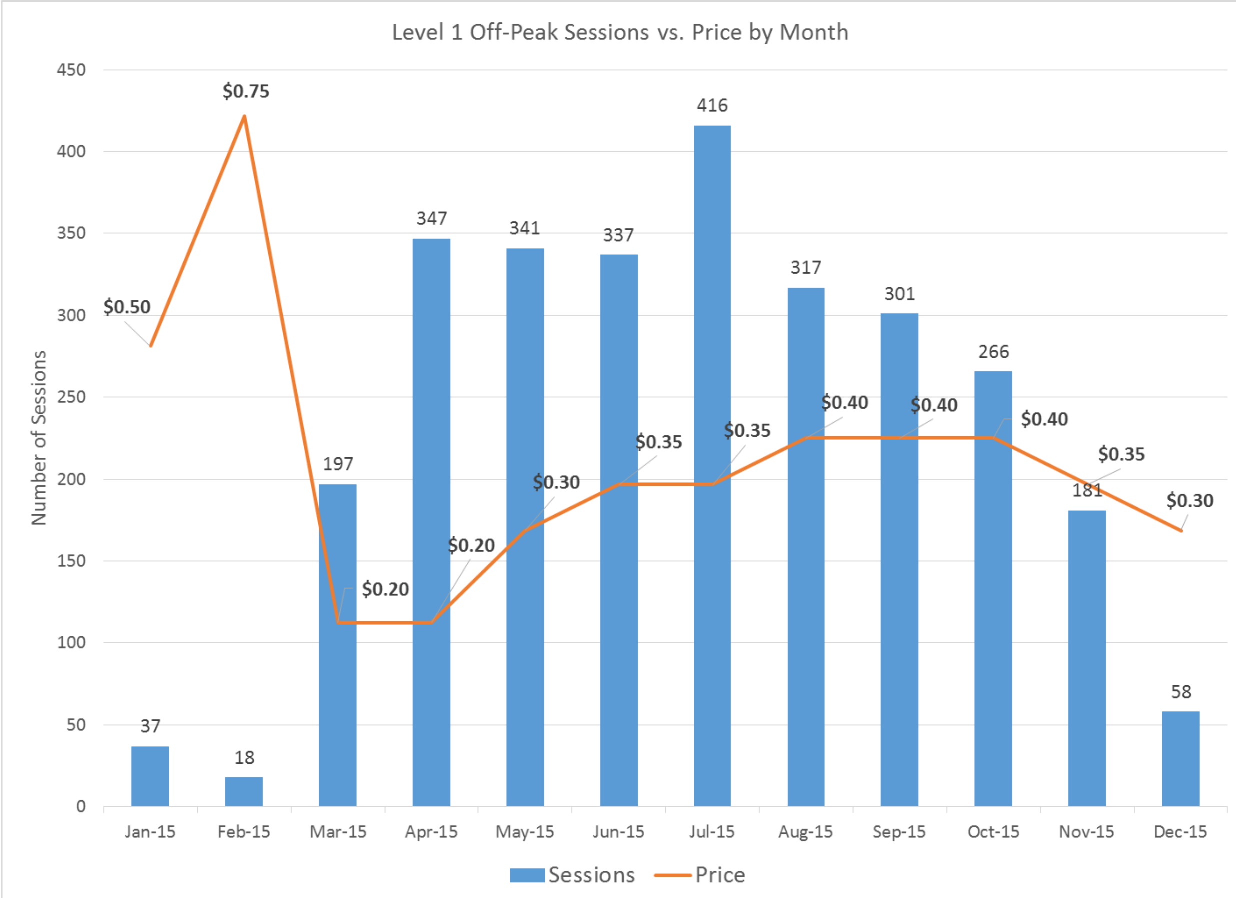


Figure 37: Comparison of Level 1 off-peak charging sessions by per-hour price by month

These findings suggest that users who select Level 1 charging are influenced by price and other factors, including type of vehicle driven, personal needs and preferences, battery size and charge rate, and/or gasoline prices.

15.6.3 *Level 2 Charging and Price Analysis*

Data showed that an average of 800 Level 2 sessions were authorized during business hours each month, with an average of 635 charging sessions authorized during morning business hours and 165 authorized during afternoon hours.

As mentioned previously, complimentary off-peak and on-peak charging was implemented in December 2015. As expected, free charging with a non-charging occupancy fee increased charging authorizations by nearly 90% over the sessions authorized during February through November, and the increase was approximately 27% higher than January's sessions.

Complimentary Level 2 on-peak charging resulted in 347 sessions, which was the highest number of monthly on-peak sessions authorized during 2015. January on-peak pricing of $0.65 per hour resulted in 225 sessions. As shown in Figure 38, the fewest number of Level 2 on-peak sessions were authorized at the highest per-hour price, and the inverse was generally true at lower pricing levels.

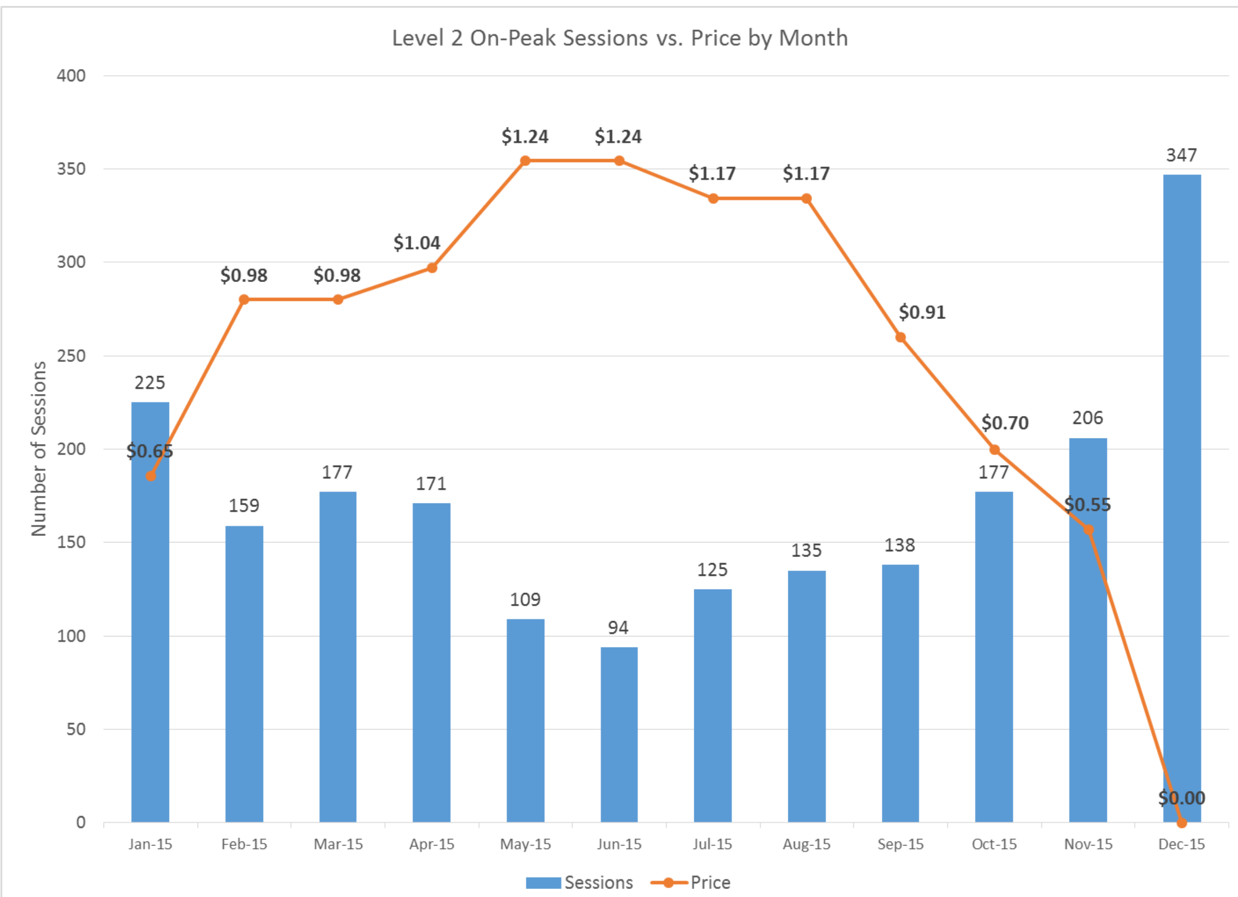


Figure 38: Comparison of Level 2 on-peak charging sessions by per-hour price by month.

While analysis of Level 2 off-peak prices and charging behavior generally indicates a correlation between price of sessions authorized, some variances were noted as shown in Figure 39.

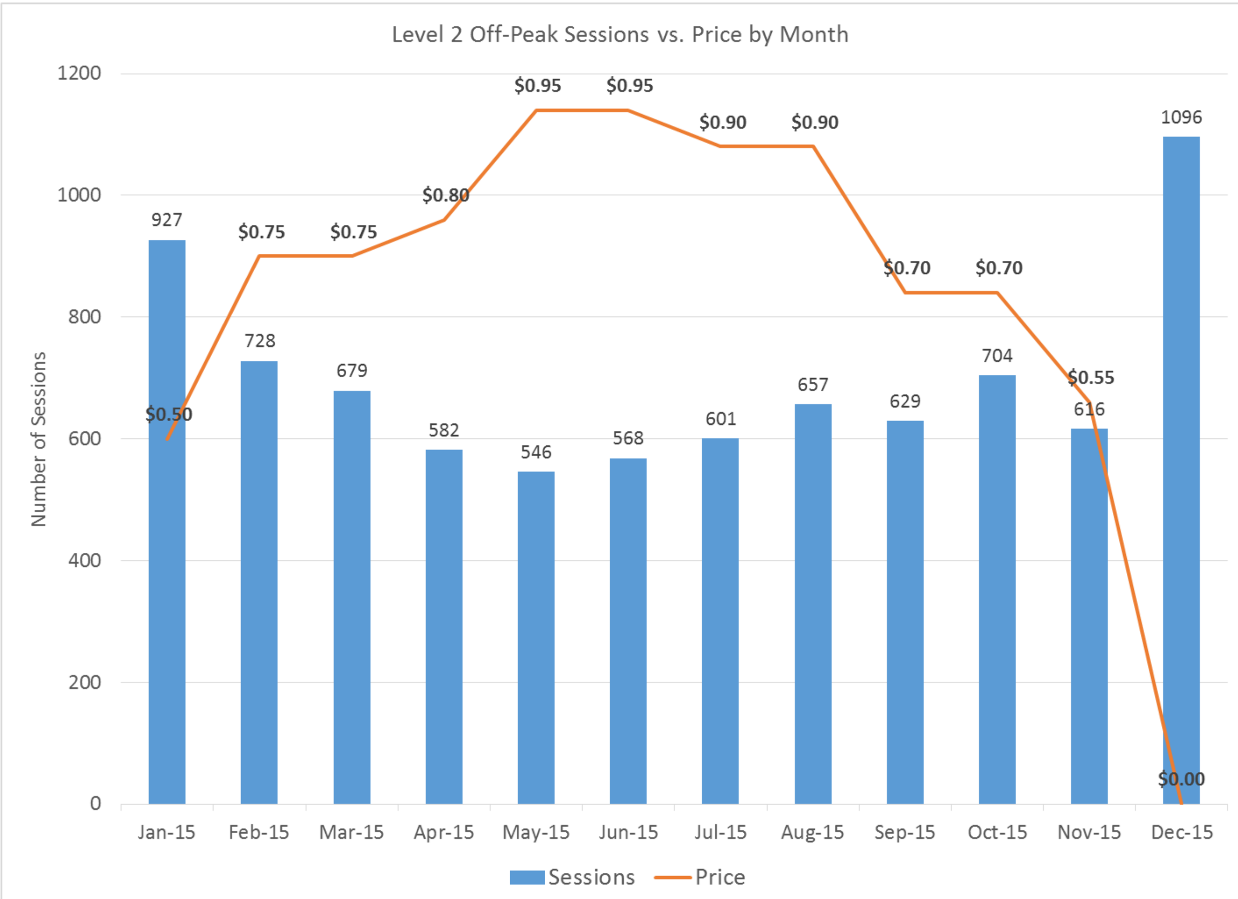


Figure 39: Comparison of Level 2 off-peak charging sessions by per-hour price by month

Charging sessions decreased during November despite a price decrease of $0.15 per hour versus October, however, this variance may have been influenced by the holiday schedule that resulted in at least three (3) less days during the month. Findings suggest that the breakeven point between number of sessions and optimal pricing exist, as shown in Figure 40.

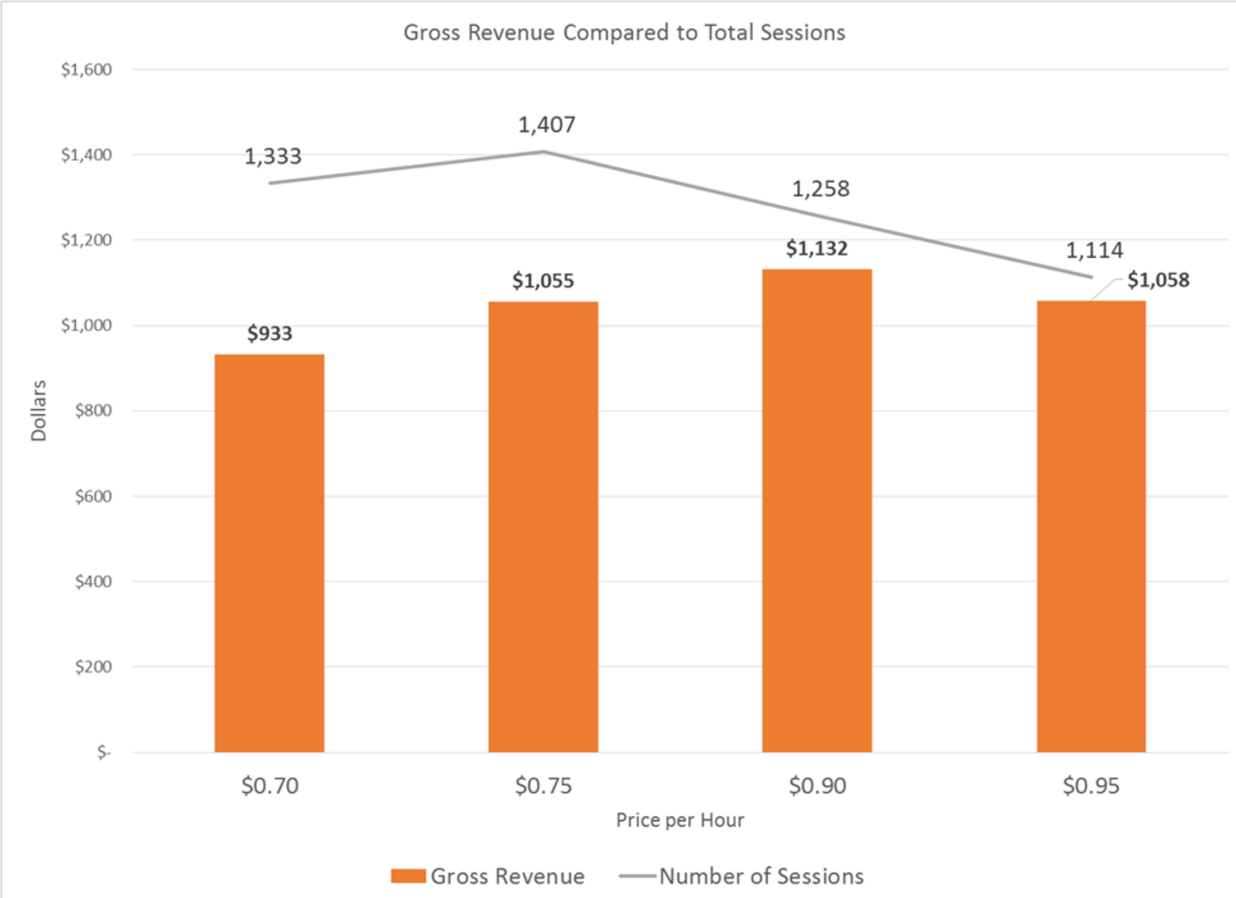


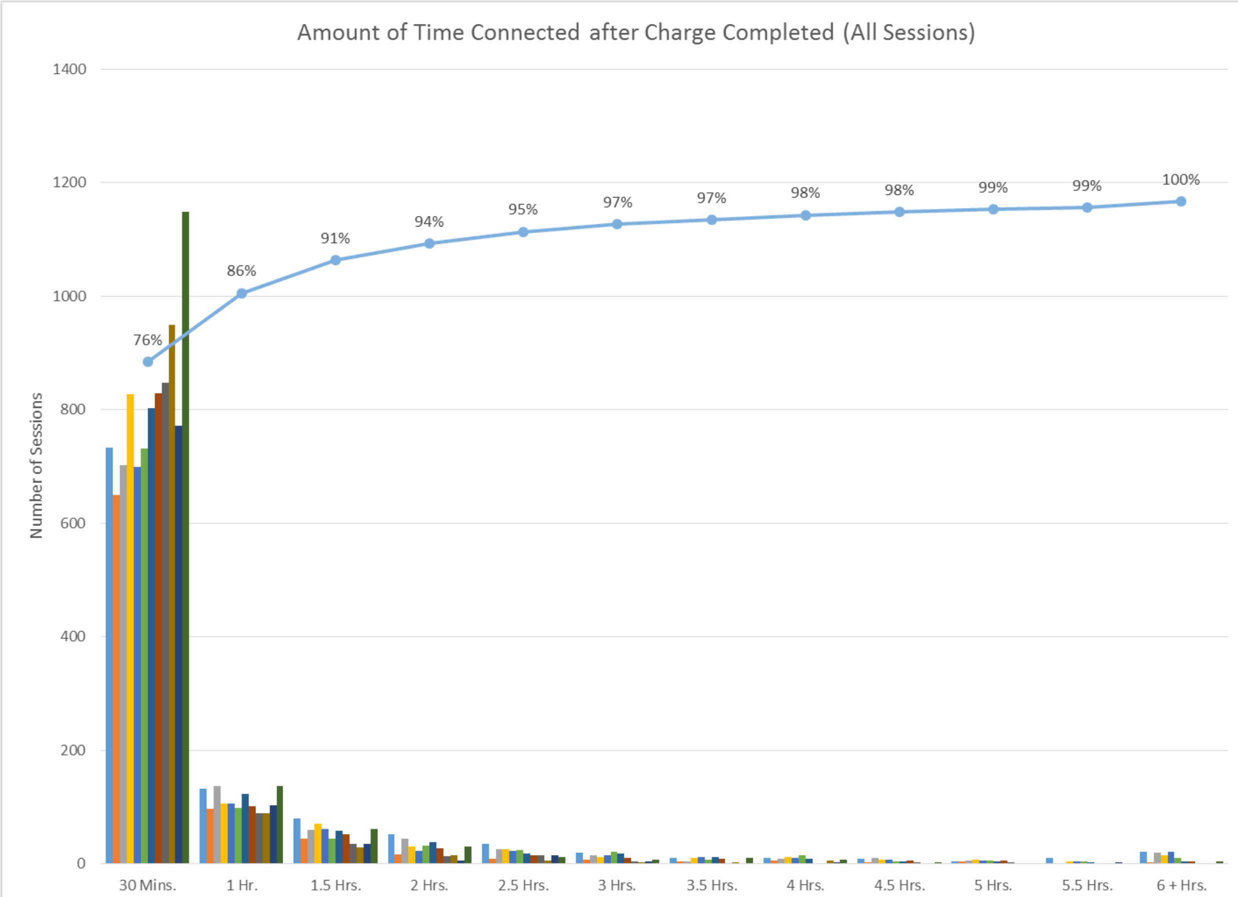
Figure 40: Comparison of gross revenue at different pricing levels.

15.7 Real Estate Optimization

Based on various pilot findings, the team concluded that business owners planning to install PEV charging stations may need to optimize potentially limited real estate while meeting the needs of PEV drivers and/or enterprise goals. In order to inform business owners regarding the length of time PEV drivers require when charging their PEV in the workplace, the pilot analyzed the duration of all charging sessions that occurred from October 2014 through December 2015. No fees were assessed for PEV charging from October through December 2014. Sessions executed from January through December 2015 were subject to varying fees and an additional $2.00 per hour non-charging occupancy fee as discussed in Section 7 and Section 8.

As discussed in Section 15.5, over 62% of participating PEVs completed charging within 3 hours, dependent upon battery state-of-charge (SOC), battery size, charging rate, and other factors. The pilot team also found that customer outreach and education, fee-based pricing, a non-charging occupancy fee for vehicles that remain connected after a certain amount of time, and real-time text notifications were effective means of encouraging space turnover and maximizing charging utilization.

As shown in Figure 41, 76% of drivers disconnected their PEV within 30 minutes after charging was complete, and 86% disconnected within one hour. This behavior enabled a maximum number of PEV drivers access to the charging stations, access that was critical at locations with a high level of demand and limited supply, such as Facility E and Facility F. In addition, data regarding disconnection time at each of the pilot facilities is provided in Appendix F: Disconnection Efficiency by Facility.



	30 Mins.	1 Hr.	1.5 Hrs.	2 Hrs.	2.5 Hrs.	3 Hrs.	3.5 Hrs.	4 Hrs.	4.5 Hrs.	5 Hrs.	5.5 Hrs.	6 + Hrs.
JAN	733	133	80	52	35	20	10	10	9	5	10	21
FEB	650	97	45	17	9	8	4	6	3	5	2	3
MAR	702	138	60	44	26	15	5	9	10	6	2	20
APR	827	106	71	30	26	12	11	12	7	7	5	16
MAY	699	107	61	23	23	16	12	10	8	6	4	22
JUN	732	99	44	32	24	21	7	16	5	6	4	11
JUL	803	124	59	38	19	19	12	9	4	4	3	5
AUG	829	101	53	27	16	10	9	1	6	6	1	5
SEP	847	89	36	13	15	5	2	2	3	3	1	2
OCT	950	89	29	15	6	3	3	6	1	1	0	1
NOV	772	103	36	6	15	4	1	3	1	1	3	2
DEC	1149	137	62	30	12	7	11	8	3	1	1	5
Cum %	76%	86%	91%	94%	95%	97%	97%	98%	98%	99%	99%	100%

Figure 41: Amount of time connected after charge complete for all sessions per month.

In order to optimize PEV charging in the workplace, the infrastructure design should consider real estate available, current charging needs, estimated PEV adoption growth, costs, site-specific factors, appropriate pricing, space management options, and average PEV requirements.

15.8 Greenhouse Gas (GHG) Emissions Reductions

Carbon dioxide equivalents reduced by SCE employees and visitors during 2015 totaled 107.26 million metric tons[30]. Approximately 11,000 kWh of energy was consumed each month to achieve the reduction and 83% of GHG reductions resulted from Level 2 (208V) charging as shown in Figure 42.

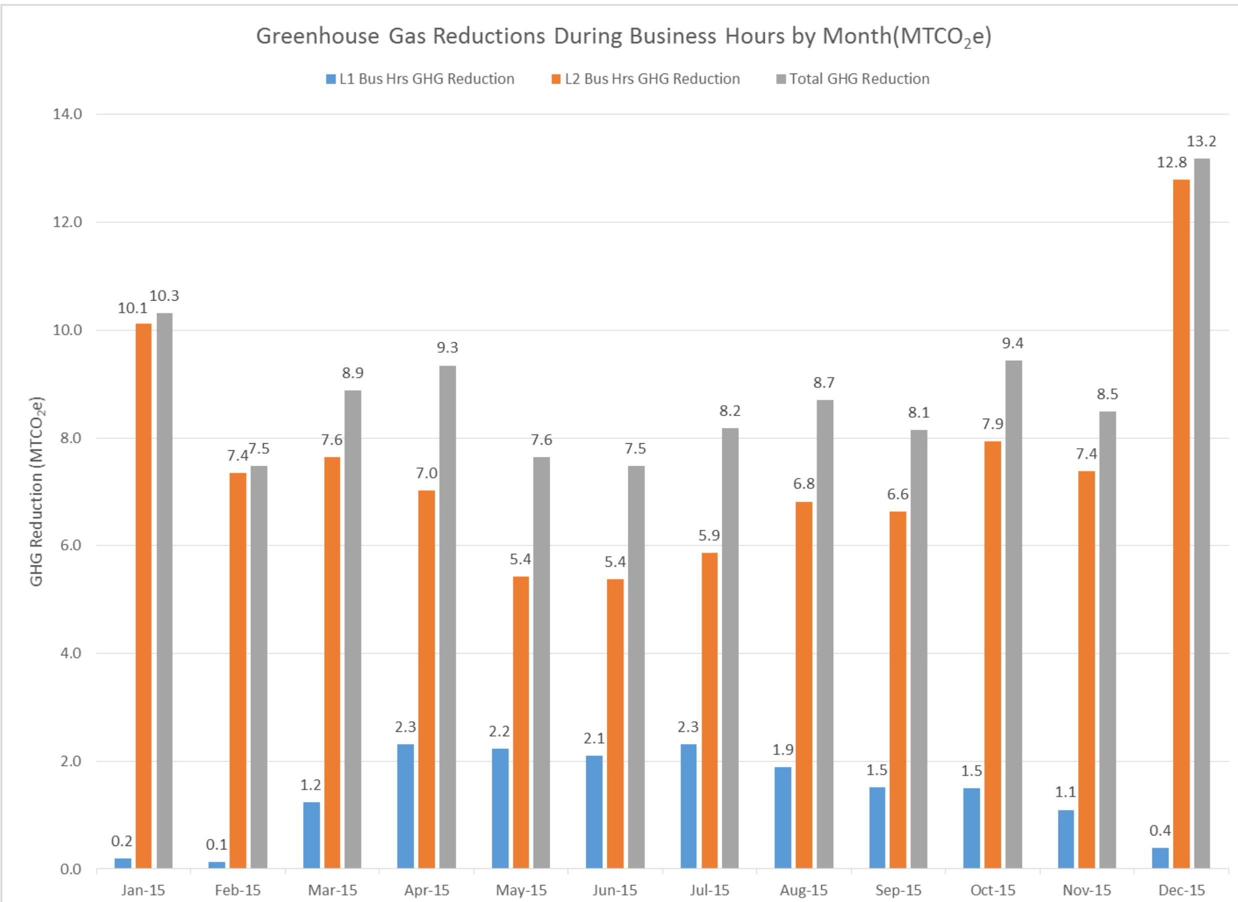


Figure 42: Greenhouse gas reductions ($MTCO_2e$) from sessions during business hours by charging level.

[30] Greenhouse gas reductions based on the California Air Resources Board Low Carbon Fuel calculation, pages 43-44, (http://www.arb.ca.gov/regact/2015/lcfs2015/lcfsfinalregorder.pdf).

15.9 Charging Complexities

During the course of the pilot, the team collaborated with drivers to identify and resolve issues encountered when using the charging stations. Despite the complexity of this innovative pilot, issues fell into three (3) main categories: Communication, Equipment, and Driver Error. Following are specific issues addressed, including cause and remedial actions taken.

1. Charging Initiation Issues
    a. PEV make/model 1 ("subject vehicle") charging software: After successfully authorizing a session, the subject vehicle experienced "goal posting" (i.e., flashing dashboard indicator light) but failed to initiate charging. Issue appeared to be related to the subject vehicle operating system that required immediate charging, which was not consistent with the charge initiation code implemented[31].
        i. Resolution: Since the subject vehicle OS recorded the charging ramp up period as an error, the OS prevented charging and caused the charging session to time out. SCE, CMI, and Greenlots discussed the issue with the manufacturer, which was unaware of the issue and could not provide immediate solution[32]. CMI made revisions to the device firmware and uploaded new firmware to all of the devices to allow immediate charging and resolve the timing out problem.
        ii. The PEV referenced above was the only vehicle make/model identified during the pilot that did not tolerate the J1772 pilot signal

[31] Refer to discussion regarding ramp up process in Section 3.3.3.

[32] Manufacturer issued a software update in May 2014 for 2014 models built on/before March 12, 2014 to correct its blinking charge indicator (goal post). 2013 model drivers who did not receive this software update did not report issues when charging.

ramp up. As a result, problems were encountered during the charge initiation process for the subject vehicle. This charge initiation "ramp up" characteristic was removed from the EVSE but retained for the deep voltage sag or momentary outage condition. Consequently, the problem was resolved for the subject vehicle on charge initiation but was unavoidable in the case of a deep voltage sag or momentary outage condition. In those cases, the subject vehicle needed to restart the charging session or take other actions to recover from this error condition.

b. Other Vehicle Settings: After successfully authorizing a session, the vehicle failed to initiate charge. Issue appeared to be related to vehicle settings.
    i. Resolution: Drivers were advised that the PEV should be set to "charge immediately" mode.
c. Credit Card Authorization Issue: Some drivers advised that they experienced issues with payment card authorizations. Issue appeared to be related to the normal procedure enacted by the payment processor through which it placed a financial hold on the driver's payment card at the time of the card swipe. This hold was replaced with the final settlement amount within 24 - 48 hours after the charging session completion. If the session cost was greater than the hold amount, the provider would not authorize future sessions on that payment station.
    i. Resolution: SCE worked with the payment processor to increase the hold amount per session and monitor session that exceeded the hold amount.

2. Line Voltage Errors (LVE)

a. Due to the nature of electricity transmission, LVEs frequently occurred across the SCE charging infrastructure and generally self-restored.

3. Electrical: Breaker Trip
    a. Cause of this issue was undetermined.
        i. Resolution: Required manual resetting of breaker in the electrical panel.
        ii. Resolution: If issue was related to faulty breaker, replacement of the breaker was required.
4. Charge Pilot Error
    a. Generally occurred when water intruded into the SAE J1772 standard charging connector due to failure of users to properly re-holster the J1772 connector after use and other factors.
        i. Resolution: Issue was generally resolved after the connector dried. Use of pressurized dry air to blow out the moisture from the connector was recommended. In the event that water caused corrosion inside the connector, removal and cleaning of the connector to remove the corrosion was required.
5. Model 3703 Cable Detachment
    a. Generally occurred due to normal equipment use or inadequate tightening of the cable mounting nuts during service.
        i. Resolution: Required accessing charger head and tightening the cable mounting nuts.
6. Device Unknown:
    a. Generally occurred when an electrical or communication issue did not self-correct. Causes included:
        1. Intermittent cellular signal that self corrected over time.

2. Raven (i.e., modem) problem resulting from a Line Voltage Error that dropped the modem voltage below a threshold limit but greater than zero, and prevented the Raven modem from resetting.
3. Faulty GFCI or breaker trip that prevented the EVSE from communicating more than 30 minutes.

ii. Resolution: Required manual evaluation of the unit to determine cause of unknown status. Restoration efforts included:

1. Power cycle the unit (i.e., manually power off the payment module and reset communications.
2. Replace payment module.

7. Network Unavailable
   a. Generally occurred when the payment module cannot connect to the cellular network due to poor cellular signal strength.
   b. Connectivity was generally restored when signal strength improved.
   c. Efforts to improve reliability of the connection included:
      i. CMI increased frequency with which the system pinged the device.
      ii. CMI repositioned the modem antennae to reduce interference.
8. Ground Fault Current Interrupter (GFCI) Failure
   a. Generally occurred when some type of damage impacts the internal GFCI. GFCI conducts an initial safety check upon start up and makes three attempts.
      i. If failure caused by line voltage error, breaker reset may clear the issue.
      ii. If failure caused by component problem or other issue, replacement of the GFCI was required.

    iii. Revisions to the GFCI firmware were also uploaded to improve functionality.

9. Model 3703 Power Failure
    a. Causes included wiring, breaker, or equipment component failures.
        i. Required root cause analysis by electrical contractor. In the event that no wiring issue was identified, replacement of the GFCI or model 3703 may have been required.
10. Pricing or DR Signal Failure
    a. Three (3) pricing and one (1) DR signal failures were recorded. Issue was generally caused by server upgrades that had not been fully disseminated to the field devices.
        i. Resolution: Improvements to the quality control process for system upgrades were made to prevent future occurrences.
11. Payment Station Failure
    a. Generally caused by cellular modem or other component failures.
        i. Resolution: Required replacement of payment module.

16. Appendix A: GLOSSARY

Term or Acronym	Definition
AC	Alternating Current
ADA	Americans with Disabilities Act
AFV	Alternative Fuel Vehicle
AL	Advice Letter
amp	Ampere; measure of electric current
ARRA	American Recovery and Reinvestment Act
ATO	Advanced Technology Organization
BBRBA	Base Revenue Requirement Balancing Account
BEV	Battery Electric Vehicle
C & I	Commercial and Industrial
CPUC	California Public Utilities Commission
.CSV	Comma Separated Values Date File Format
DC	Direct Current
DLC	Direct Load Control
DR	Demand Response
DRA	Department of Ratepayer Advocates
DRLC	Demand Response Load Control
DRMEC	Demand Response Measurement and Evaluation Committee
DRMS	Demand Response Management System
DROMS	Distributed Resources Optimization and Management System
EIA	U.S. Department of Energy's Energy Information Administration
EIX	Edison International
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
GFCI	Ground Fault Current Interrupter
GHG	Greenhouse Gas
GOF	SCE Garage of the Future
GPI	Green Power Institute
HOV	High-Occupancy Vehicle
HVAC	Heating, Ventilation and Air Conditioning
Hz	Hertz; unit of frequency

Term or Acronym	Definition
IOU	Investor Owned Utility
IP	Internet Protocol
KW	Kilowatt
KWH	Kilowatt Hour
L1	Level 1 (120V) Charging level
L2	Level 2 (240V/208V) Charging level
LED	Light-emitting Diode; light source
LEED	Leadership in Energy and Environmental Design
LVE	Line Voltage Error
$MTCO_2e$	Million Metric Tons of Carbon Dioxide Equivalent
OCA	Open Charge Alliance
OCPP	Open Charge Point Protocol
OP	Ordering Paragraph
OpenADR	Open Automated Demand Response
OS	Operating System
.PDF	Portable Document Data File Format
PEV	Plug-in Electric Vehicle
PHEV	Plug-in Hybrid Electric Vehicle
PS/Gateway	Payment Station
RFID	Radio Frequency Identification
SAE J1772	Society of Automotive Engineers standard for EV/PEV conductive charge coupler.
SCE	Southern California Edison
SMS	Short Message Service (aka Text Message)
TOU	Time-of-Use
V	Volt
VAC	Volts of Alternating Current
VEN	Virtual End Node
VTN	Virtual Top Node
VFD	Vacuum Fluorescent Display

17. Appendix B: Project Lexicon

Attached Payment Module	Payment module attached to the charging station pole, providing payment functionality to one or two charging stations.
Available Status	EVSE is available for use.
Base Fee Calculation	Once a session is authorized, the Base Fee continues until the PEV is disconnected. The fee does not end when the charging is complete because the fee is applied for use of the space not for electricity.
Chargebox ID	Identification code that is associated with the location, fault message, date and time and that is transmitted from the payment module to the host when a device fault occurs.
Charging Complete	Time at which the PEV stops receiving energy.
Elastic	Charging sessions are responsive to price changes.
PEV Load Curtailment	Expected amount of energy the vehicle would have received from the charging station in the absence of a DR event.
Faulted Status	An error has occurred on the EVSE.
Fee Calculation Timeframe	Following session authorization, applicable fees continue until the PEV is disconnected.
In-use Status	The EVSE is being used to charge a vehicle.
Inelastic	Charging sessions are not responsive to price changes.
Mixed Payment Module Design	Both attached payment modules and remote payment kiosks installed at one facility.
Multiplexer	Device that selects one of several analog or digital input signals and forwards the selected input into a single line.
Non-Charging Occupancy Fee Calculation	A $2.00 per hour penalty amount will be added to the fee in effect at the time of charging for vehicles that are not disconnected within 30 minutes of completed charging.
Raven	Brand name of the Sierra Wireless modem used in the payment module.
Remote Payment Kiosk	Payment module mounted on a pole separate from the EVSEs that to which it provides payment functionality. Remote kiosks provide service to up to eight (8) charging stations.
Session End Time	Time at which the PEV is disconnected.
Session Start Time	Time at which a user authorizes a charging session.
Short Message Service (SMS)	Text messaging service component of phone, Web, or mobile communication systems that uses standardized communications protocols to allow fixed line or mobile phone devices to exchange short text messages.
Stub Out	Conduit installed for electrical wiring.
Unknown Status	The EVSE is not communicating with the network.
Watt-hour	Unit of energy equivalent to one watt (W) of power expended for one hour of time.

18. Appendix C: Survey Comparative Data

Table 13: SCE Workplace Charging Survey Response Comparisons

Survey	2012	2013	Δ	2016	*Δ vs 2012*
Total Responses Analyzed	**6,007**	**2,317**		**3,061**	
Total Current Ownership/Lease	**58 (1%)**	**125 (5%)**	*116%*	**342 (11%)**	*490%*
Currently own/lease PHEV	19 (33%)	69 (55%)	*263%*	189 (55%)	*895%*
Currently own/lease BEV	39 (67%)	56 (45%)	*44%*	153 (5%)	*292%*
High probability of buying EV within 2 years	**887 (15%)**	**593 (27%)**		**880 (29%)**	
Type of Vehicle Likely to be Purchased/Leased					
BEV	232 (22%)	124 (15%)	*47%*	—	
PHEV	613 (57%)	282 (33%)	*54%*	—	
Unsure	227 (21%)	445 (52%)	*96%*	—	
Current drivers: Drive to work daily	45 (77%)	99 (79%)		267 (78%)	
Future drivers: Drive to work daily	693 (82%)	1046 (82%)		576 (65%)	
Fee-based Charging (Existing & Future Drivers)					
Charging Level Preferred					
Level 1 (120V) Preferred				360 (32%)	
Level 2 (208V) Preferred				768 (68%)	
Commute Distance >30 Miles	>229	784		976	

19. Appendix D: Pilot Use Cases

19.1 Initiate Charging Session

- User accessed system via a VFD on the payment kiosk.
  - User entered charging station ID number.
  - Price per-hour in effect for each charging level and time displayed.
  - Off-peak price baseline for both charging levels was implemented from 12:00 a.m. – 11:59 a.m. and from 6:00 p.m. – 11:59 p.m. daily.
  - On-peak price baseline for both charging levels was implemented from 12:00 p.m. – 5:59 p.m. daily.
- User selected charging level: Level 2 208VAC (30 amp) or simulated Level 1 208VAC (7 amp).

Figure 43: VFD showing entry screen for selection of charging level.

Figure 44: VFD showing Level 2 TOU pricing and hours.

- User selected level of participation should a demand response event be dispatched.
    - Level 1 Options:
    - Remain Charging (i.e., Opt out)
    - During event, fee increased to 200% of base price in effect at time of the event.
    - Curtail charging (i.e., opt-in)
    - No fee charged during the event.
    - Level 2 Options:
    - Remain Charging (i.e., Opt out)
    - During event, fee increased to 200% of base price in effect at time of the event.
    - Reduced power to 50% of current charging rate
    - During event, fee increased to 150% of base price in effect at time of the event.
    - Curtail charging (i.e., opt-in)
    - No fee charged during the event.

Figure 45: VFD showing Level 2 DR pricing for users who remain charging (i.e., opt-out) of DR event.

- User entered mobile phone number.
  - Required field.
  - Enabled text notification functionality, provided users with visibility to the charging session, complemented PEV communication system, and provided limited user tracking functionality.

Figure 46: VFD requesting mobile phone input.

- User confirmed selections.
- User swiped a payment card.

- User connected the PEV and charging started.

Figure 47: VFD requesting acceptance of user charging level, price, and DR selections.

19.2 Dispatch Demand Response Event

- SCE scheduled date, time and length of DR event via the AutoGrid Systems DROMS.
- SCE sent day-ahead or day-of email notifications to stakeholders who had registered with the pilot team for 50% of the DR events. Notifications were not sent for the remainder of the events in order to test same day alert processes. Fees were assessed for drivers who opted-out of the DR events regardless of the email notification.
- At DR event dispatch, the Greenlots system referenced user DR selections and implemented commands accordingly.
- Greenlots system transmitted text messages regarding the DR event to users who had registered their mobile phone number.
    - Notified users that event had been dispatched and advised of event duration.

- Reminded users that the DR action they selected upon initiating the charging session would be enacted during the event.
- Users who connected prior to a scheduled DR event were sent a notification advising that an event was pending dispatch.
- Users who connected during a DR event were sent a notification advising that an event was in process.
- SCE developed two (2) versions of the notifications dependent upon the nature of the event, examples of which follow:

Generic Demand Response Event Verbiage

SCE has scheduled a Demand Response event for mm/dd/yyyy that will start at hh:mm am/pm with an expected duration of xx minutes. The Event Action you selected upon activation will be applied during the event.

Emergency Demand Response Event Verbiage

SCE has scheduled a Demand Response event for mm/dd/yyyy that will start at hh:mm am/pm with an expected duration of xx minutes. This is an emergency event and participation is mandatory. No fees will be applied.

19.3 Session Conclusion

- Vehicle battery management system signaled that it no longer required energy (i.e., battery full), and system registered the status as Charging Complete.
    - Registered users were sent a Charging Complete text message.
- Vehicle disconnected from the EVSE and system registered the status as Session End.

  - Registered users were sent Session End (i.e., PEV disconnected) text message.
- Session End signal triggered transmission of session information, including the duration and energy values, between the charging stations and Greenlots SKY network over OCPP.
- Energy values obtained over OCPP translated into interval data values and reported back to the OpenADR VTN using the OpenADR Report Service.

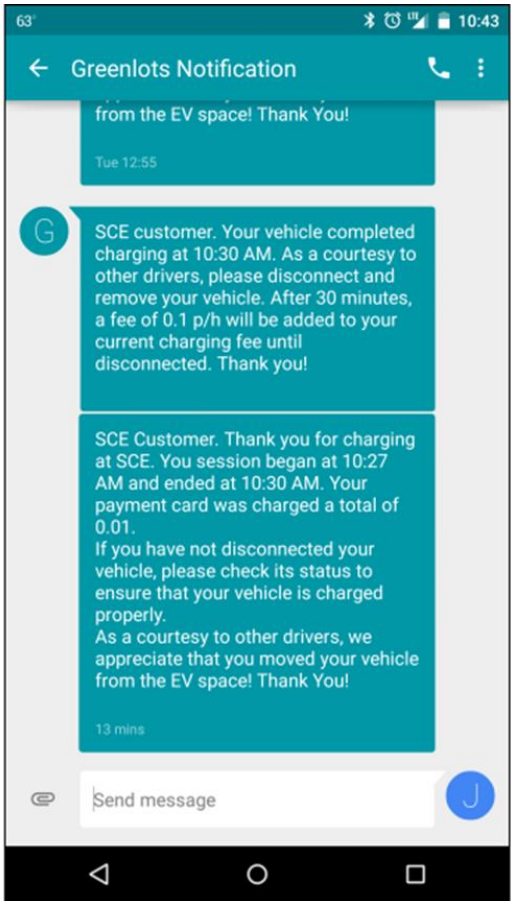


Figure 10- Sample Charging Complete (Top) and Session End text notifications (Bottom)

20. Appendix E: Charging Sessions by Facility

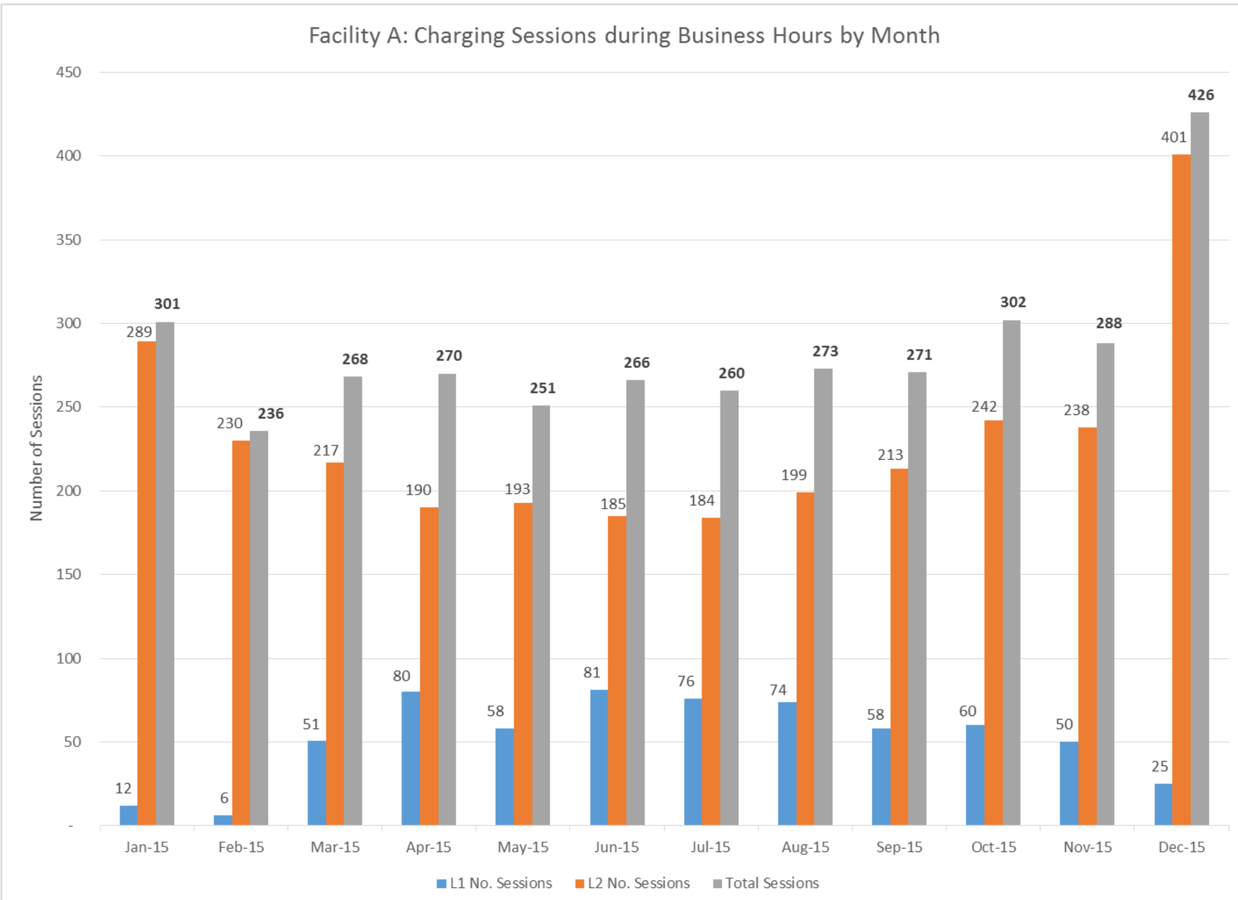


Figure 48: Facility A charging sessions by month.

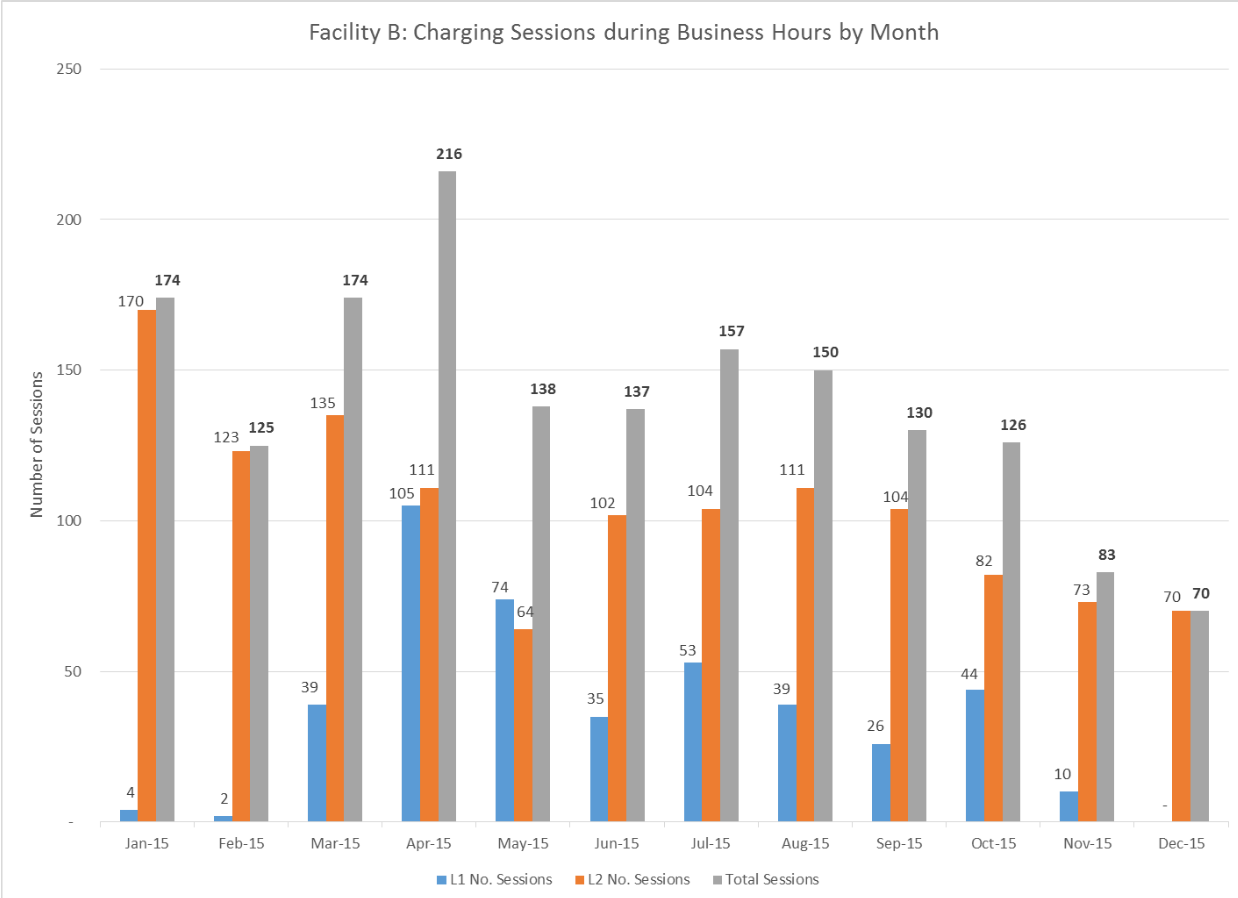


Figure 49: Facility B charging sessions by month

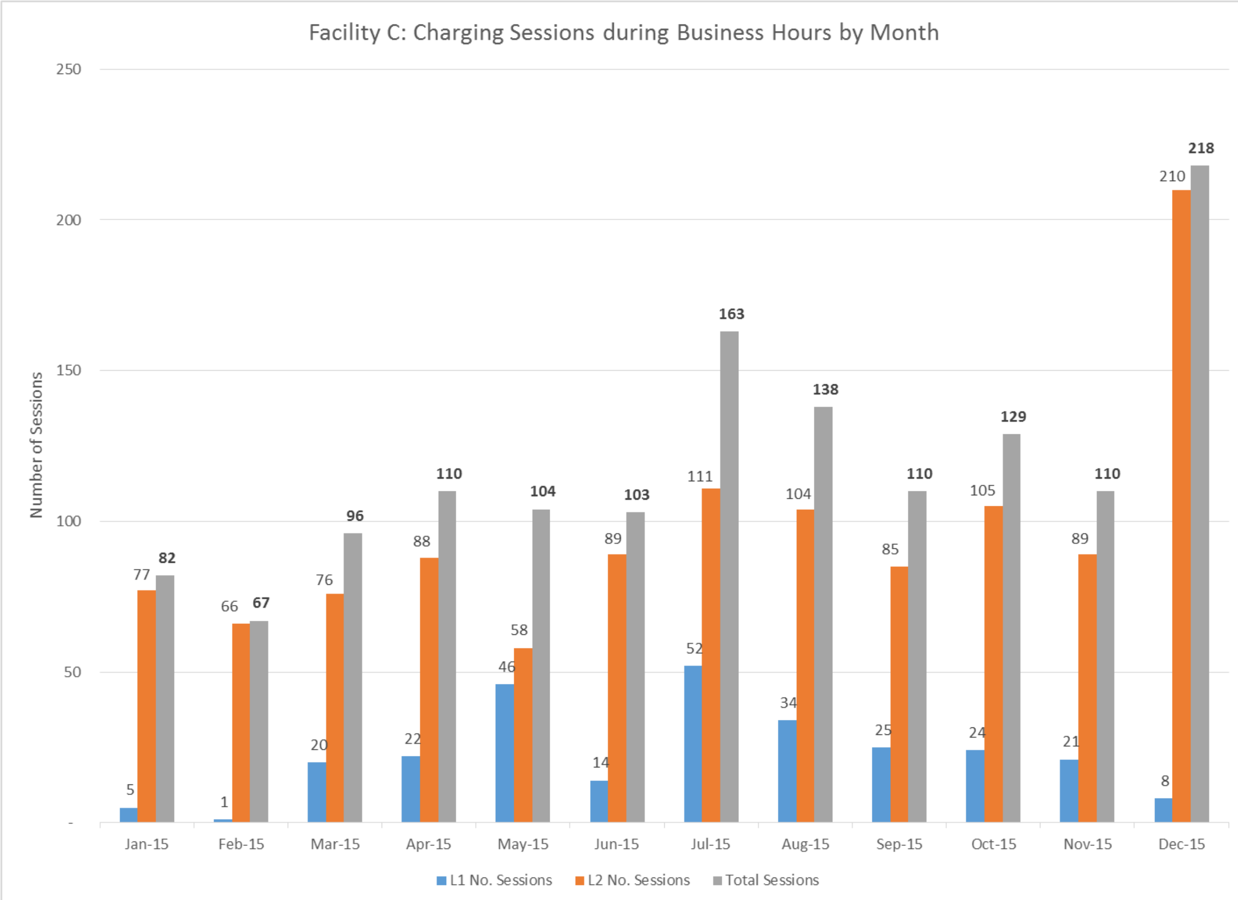


Figure 50: Facility C charging sessions by month

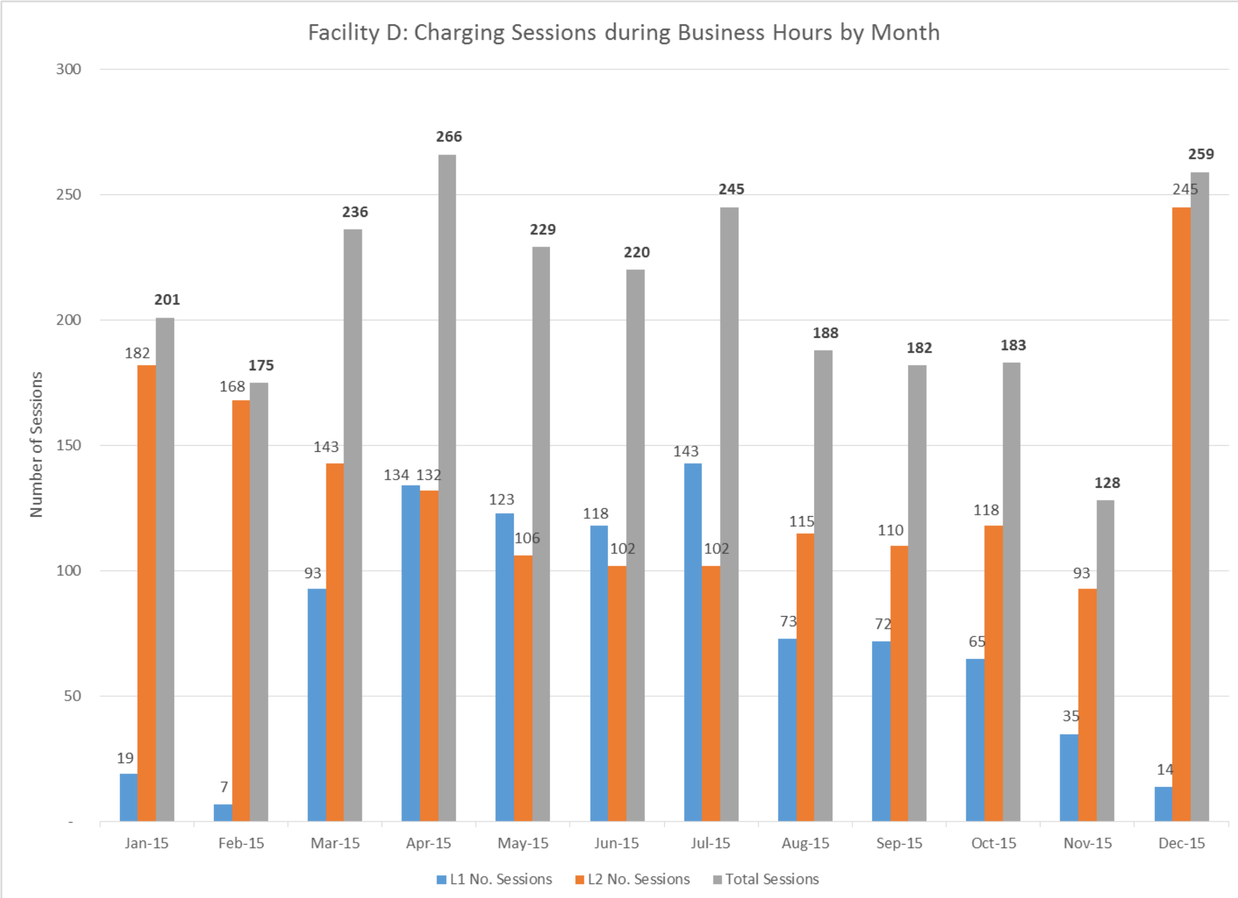


Figure 51: Facility D charging sessions by month

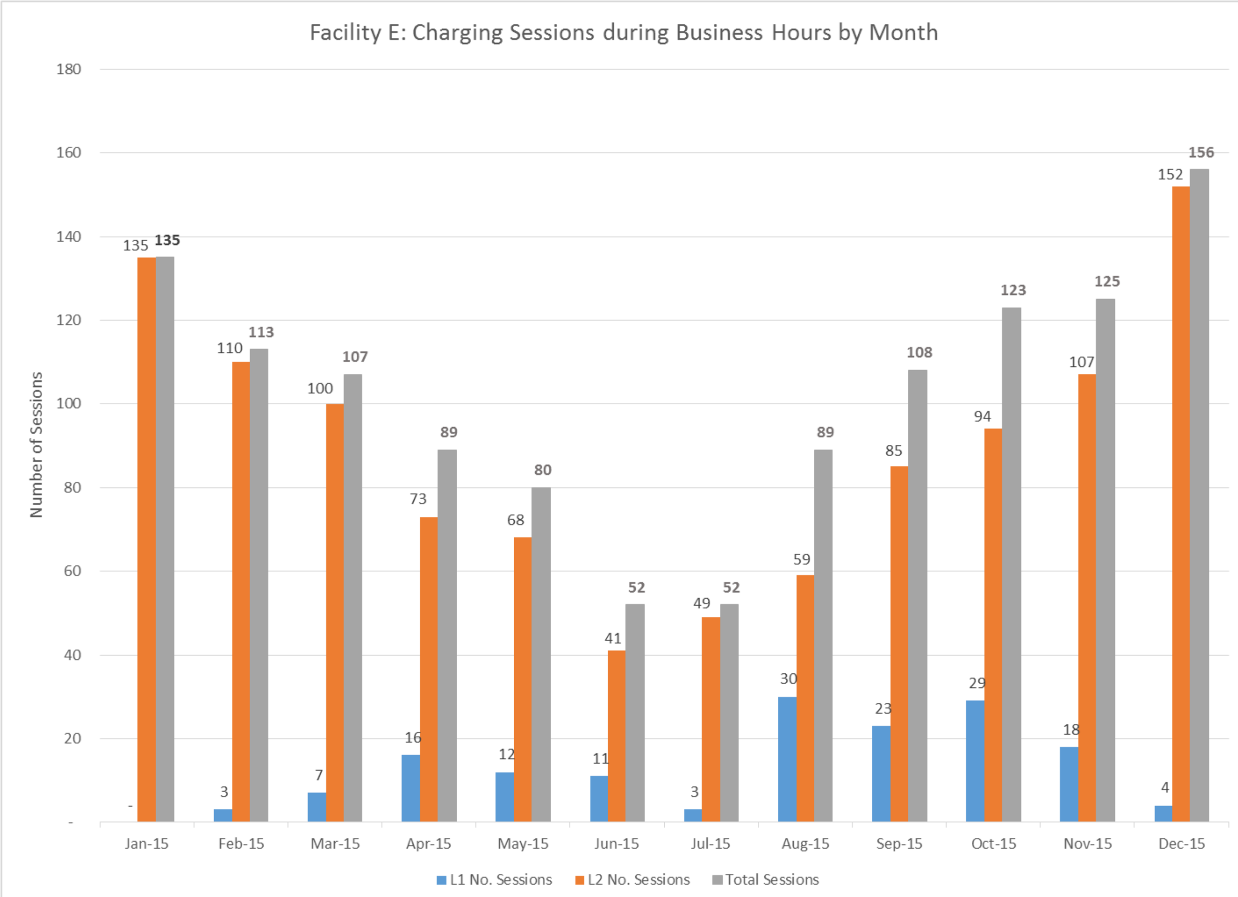


Figure 52: Facility E charging sessions by month

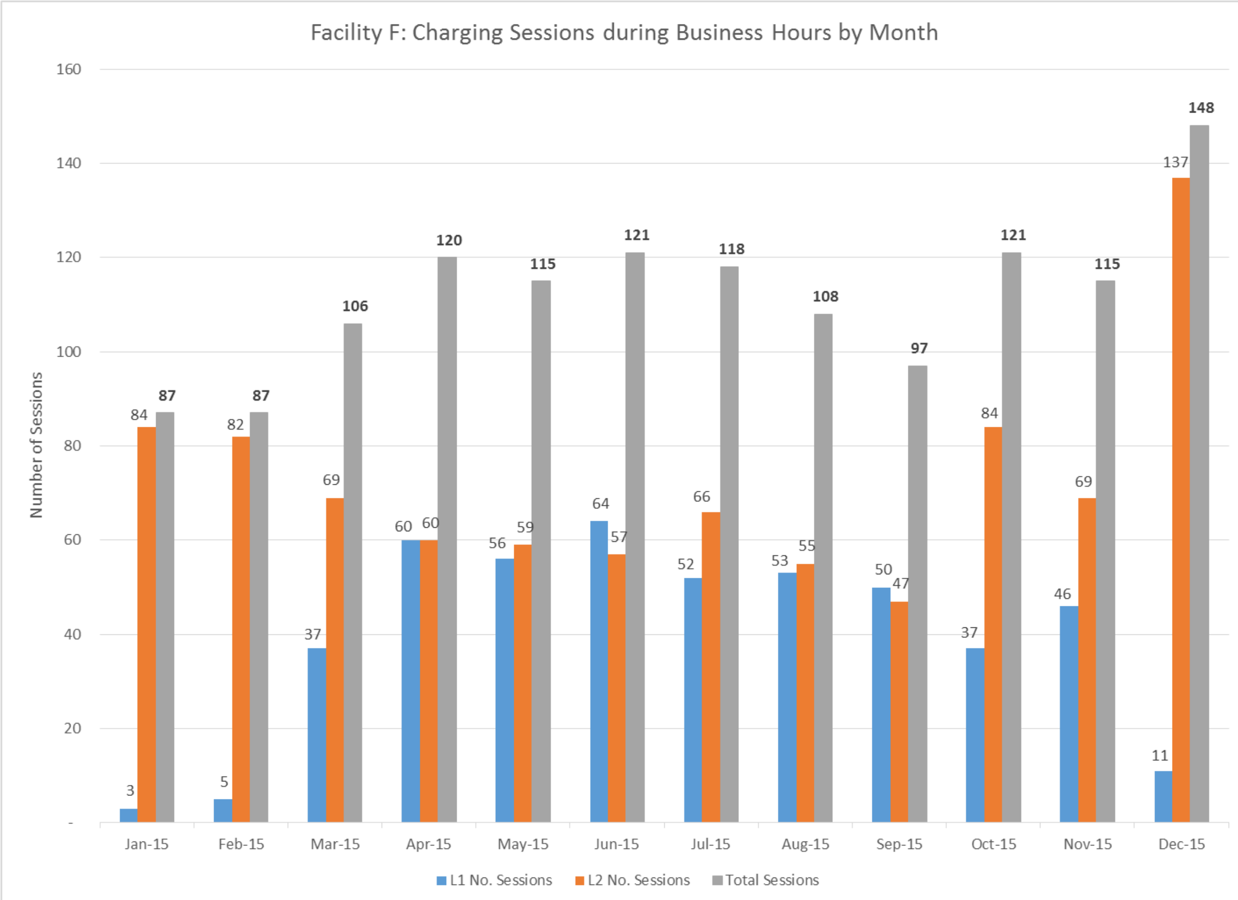


Figure 53: Facility F charging sessions by month

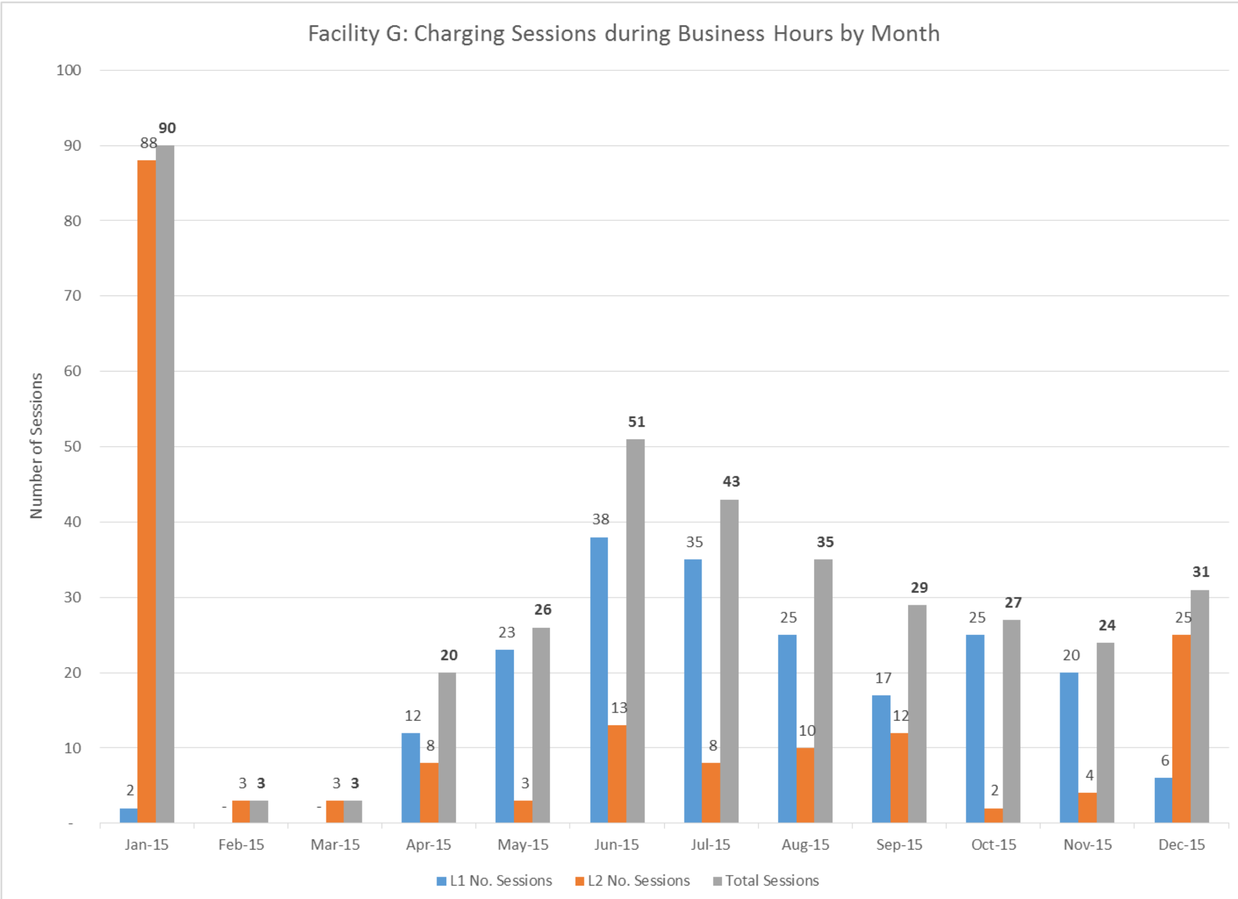


Figure 54: Facility G charging sessions by month

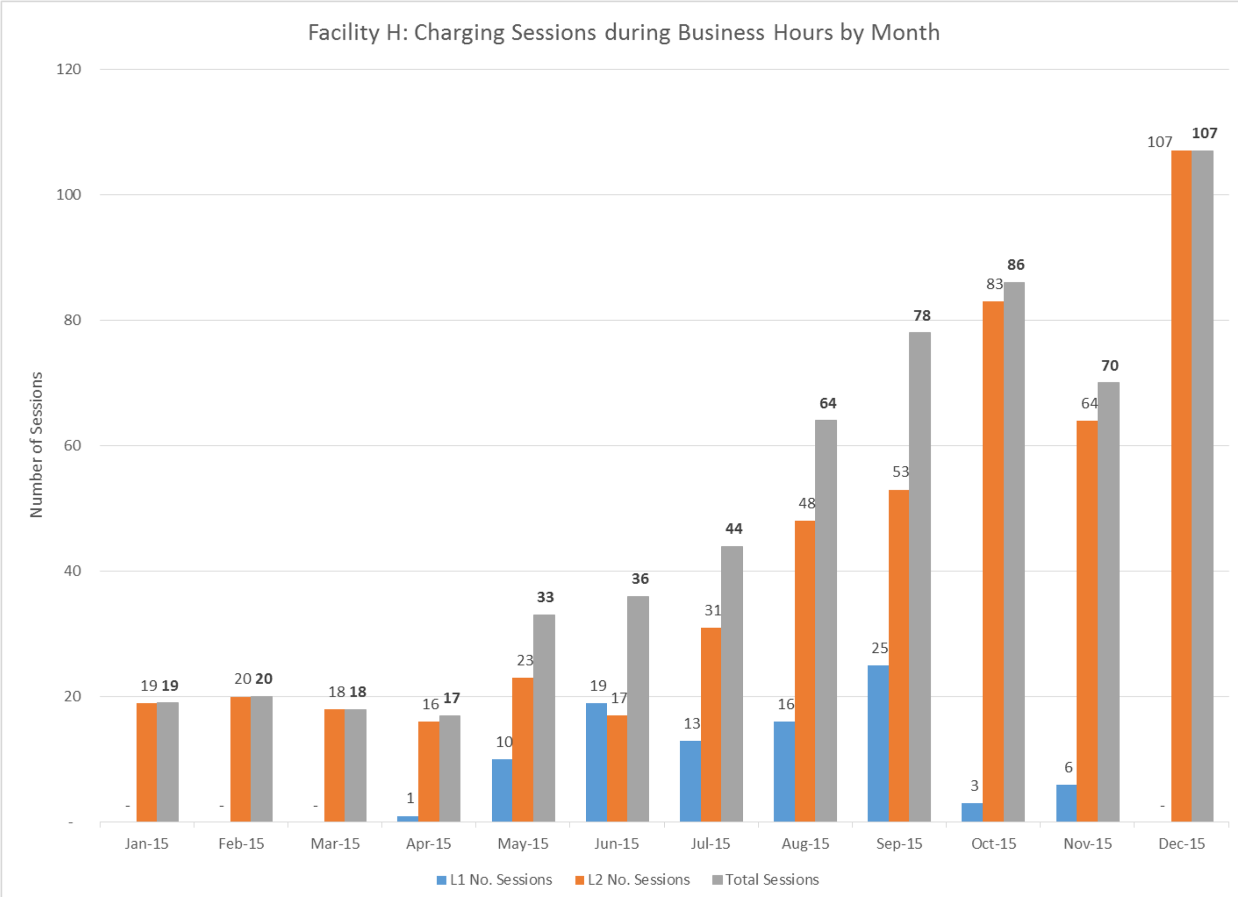


Figure 55: Facility H charging sessions by month

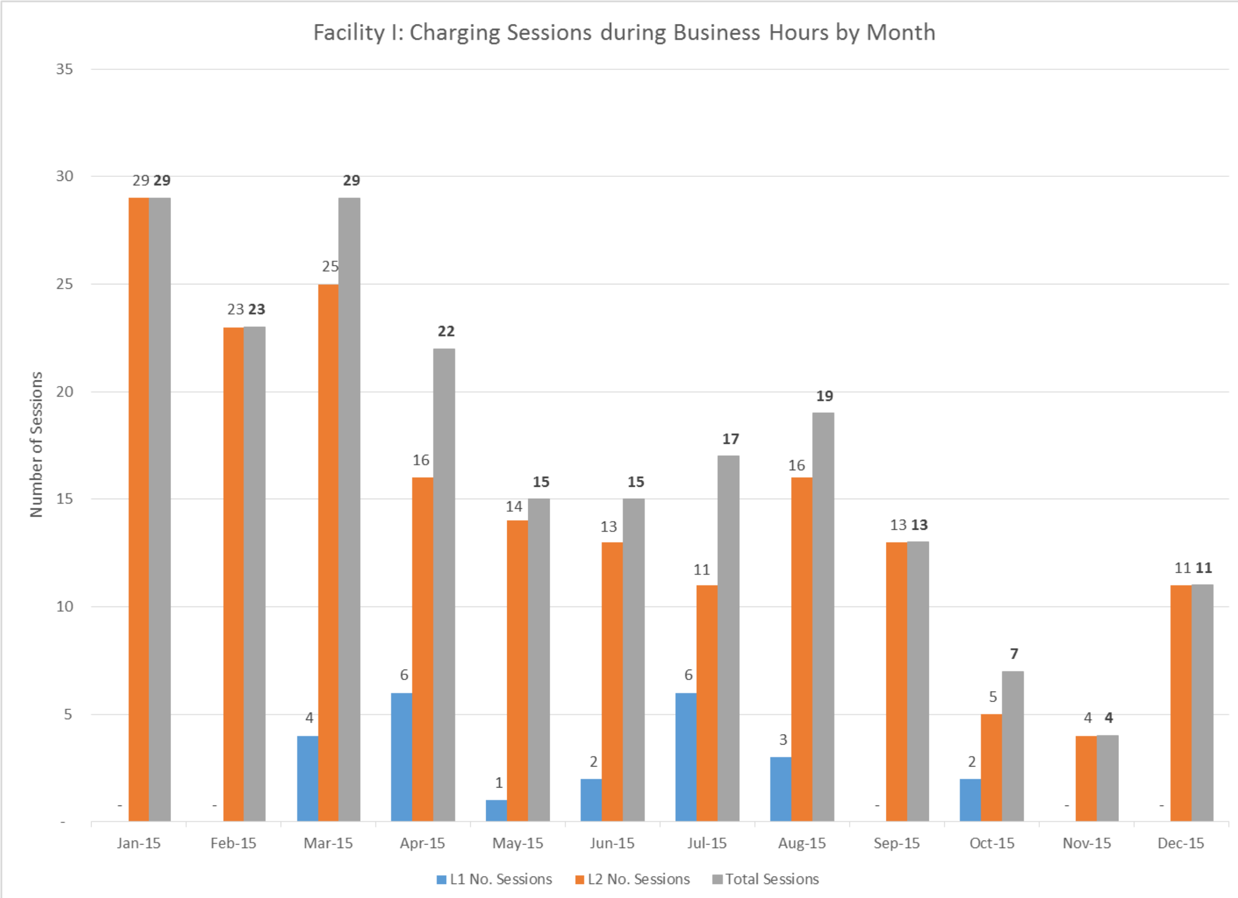


Figure 56: Facility I charging sessions by month

21. Appendix F: Disconnection Efficiency by Facility

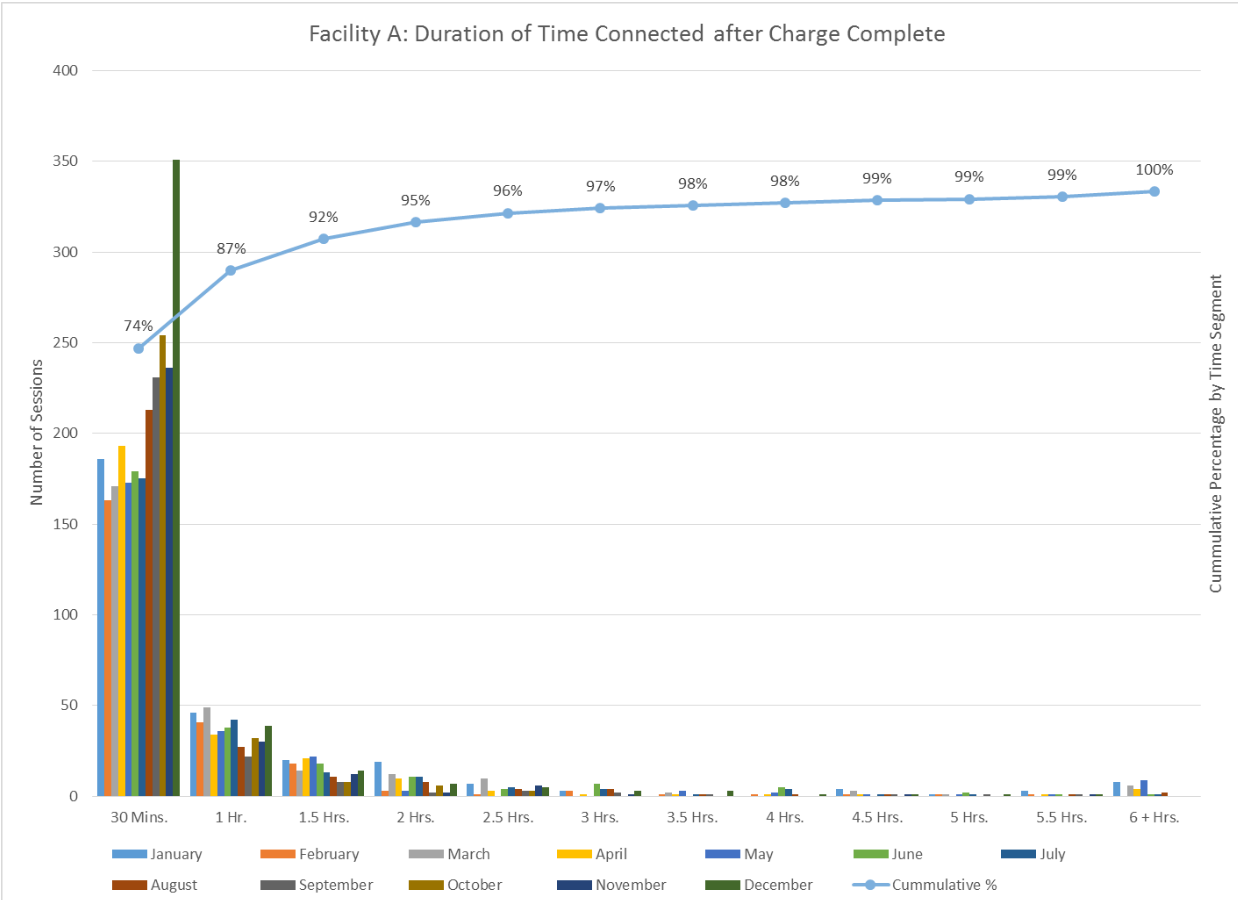


Figure 57: Facility A duration of time after charge complete shows that 74% of vehicles disconnected within 30 minutes.

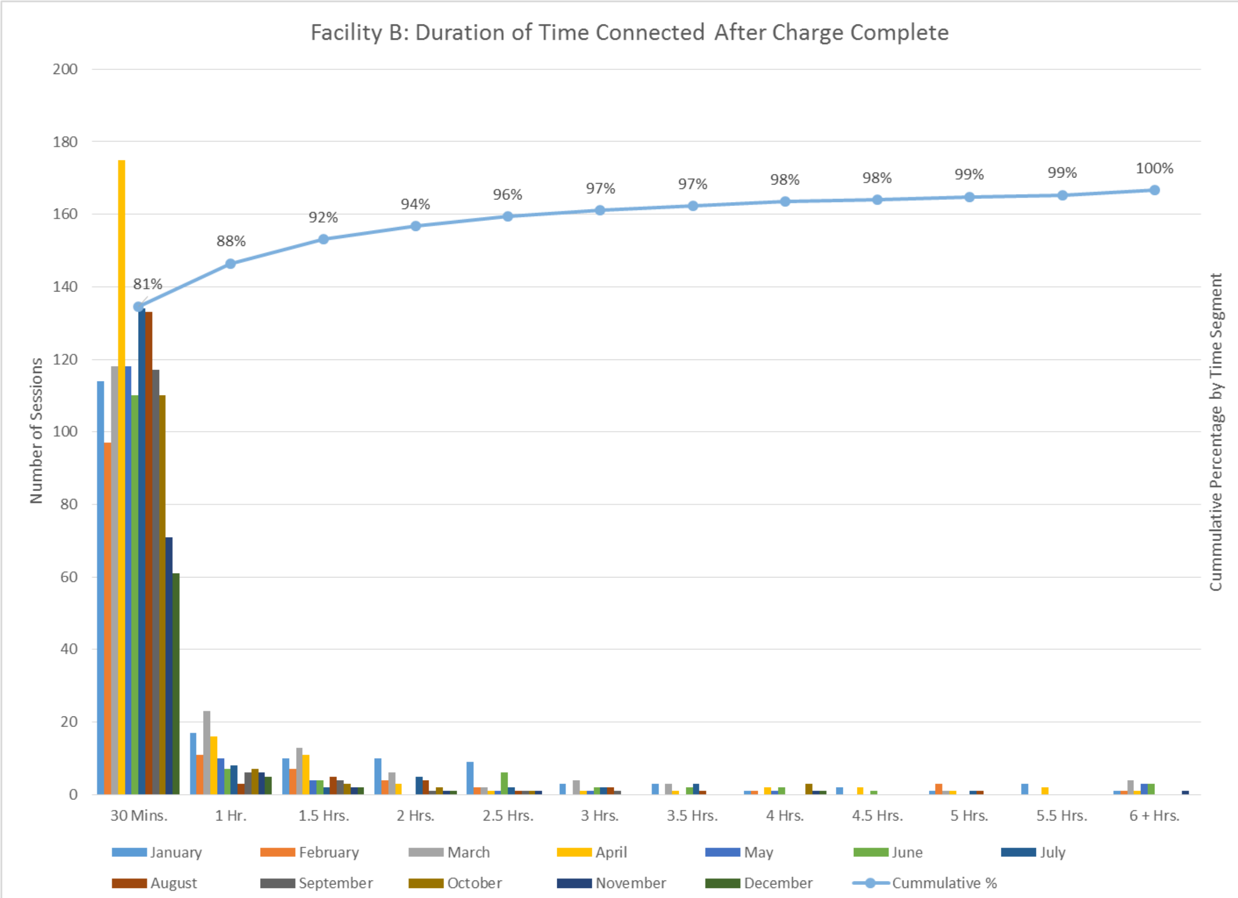


Figure 58: Facility B duration of time after charge complete shows that 81% of vehicles disconnected within 30 minutes.

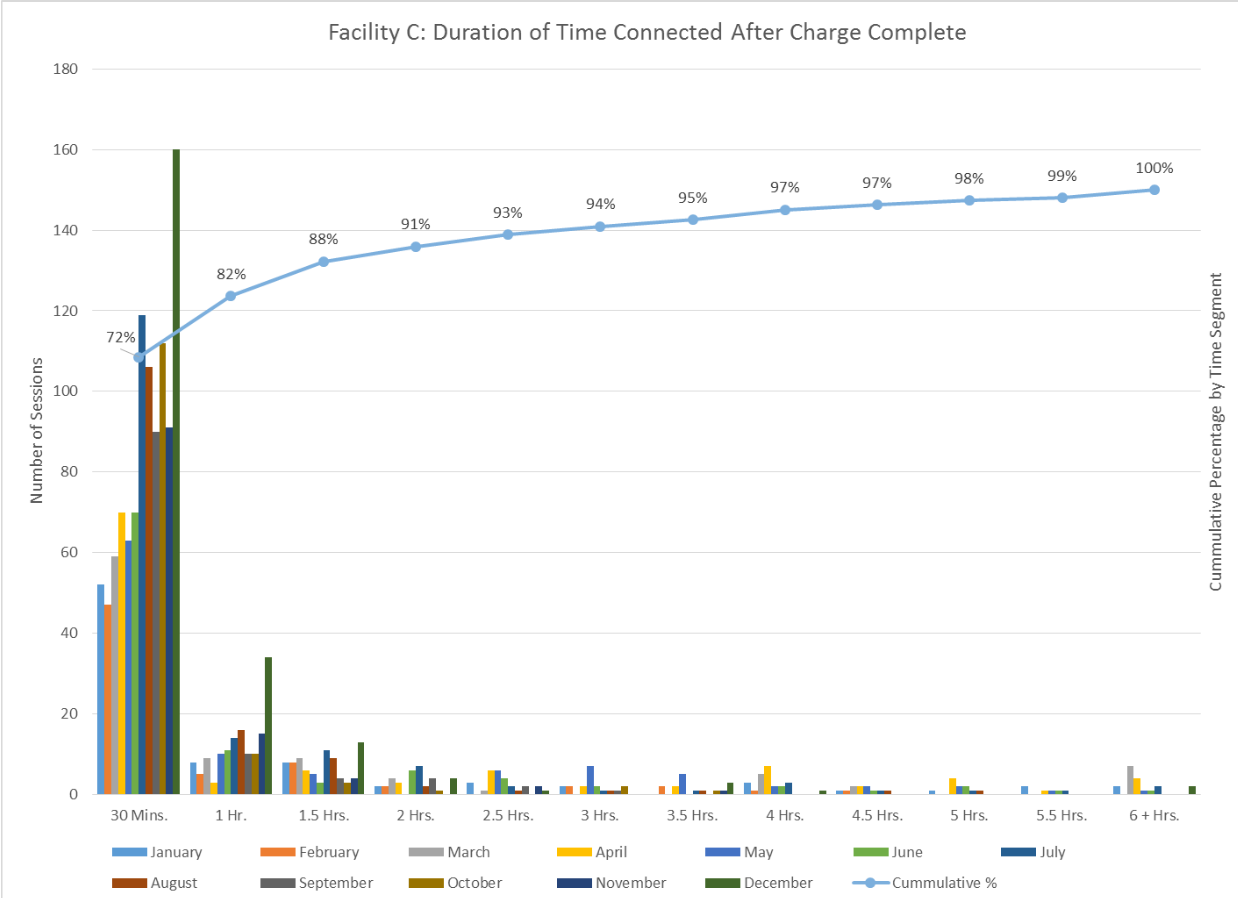


Figure 59: Facility C duration of time after charge complete shows that 72% of vehicles disconnected within 30 minutes.

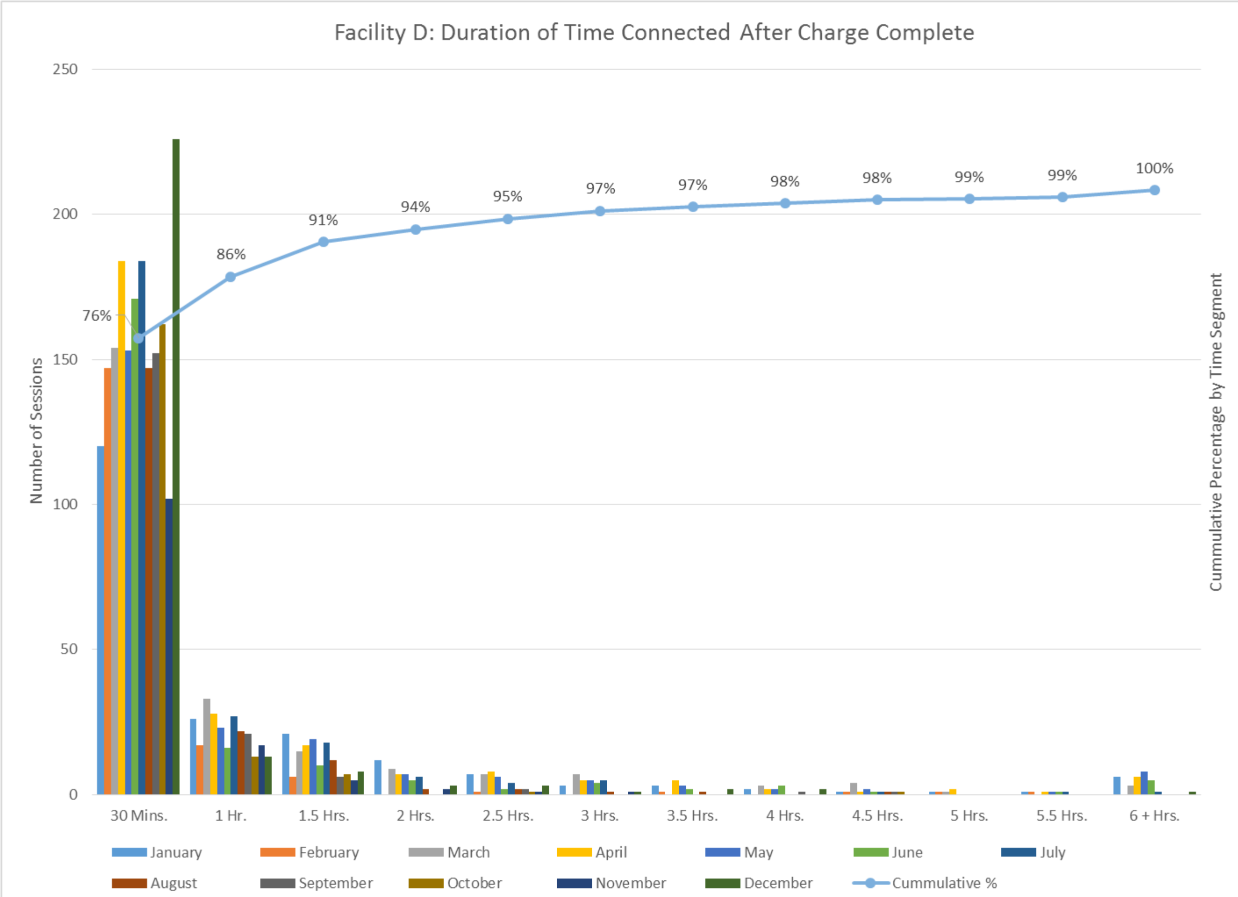


Figure 60: Facility D duration of time after charge complete shows that 76% of vehicles disconnected within 30 minutes

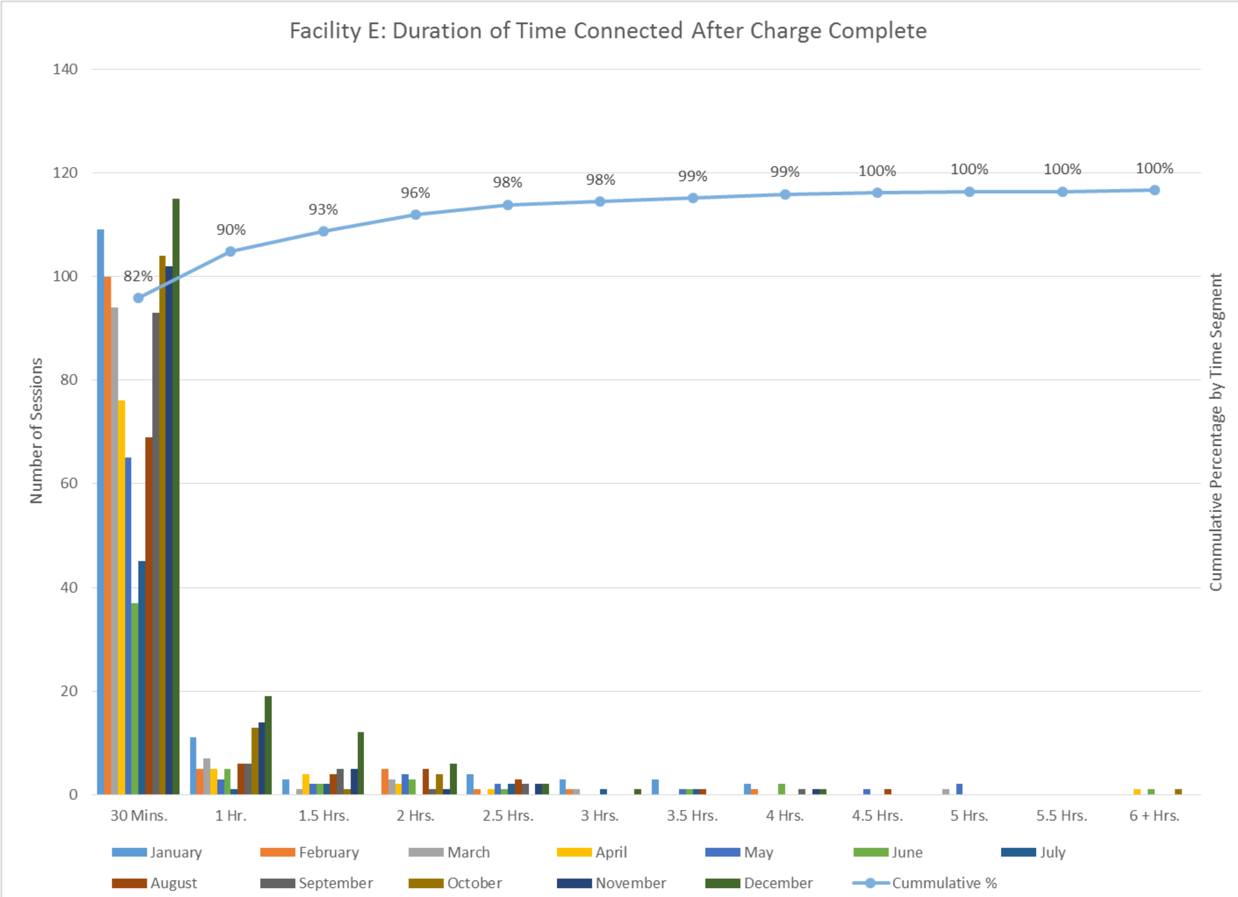


Figure 61: Facility E duration of time after charge complete shows that 82% of vehicles disconnected within 30 minutes.

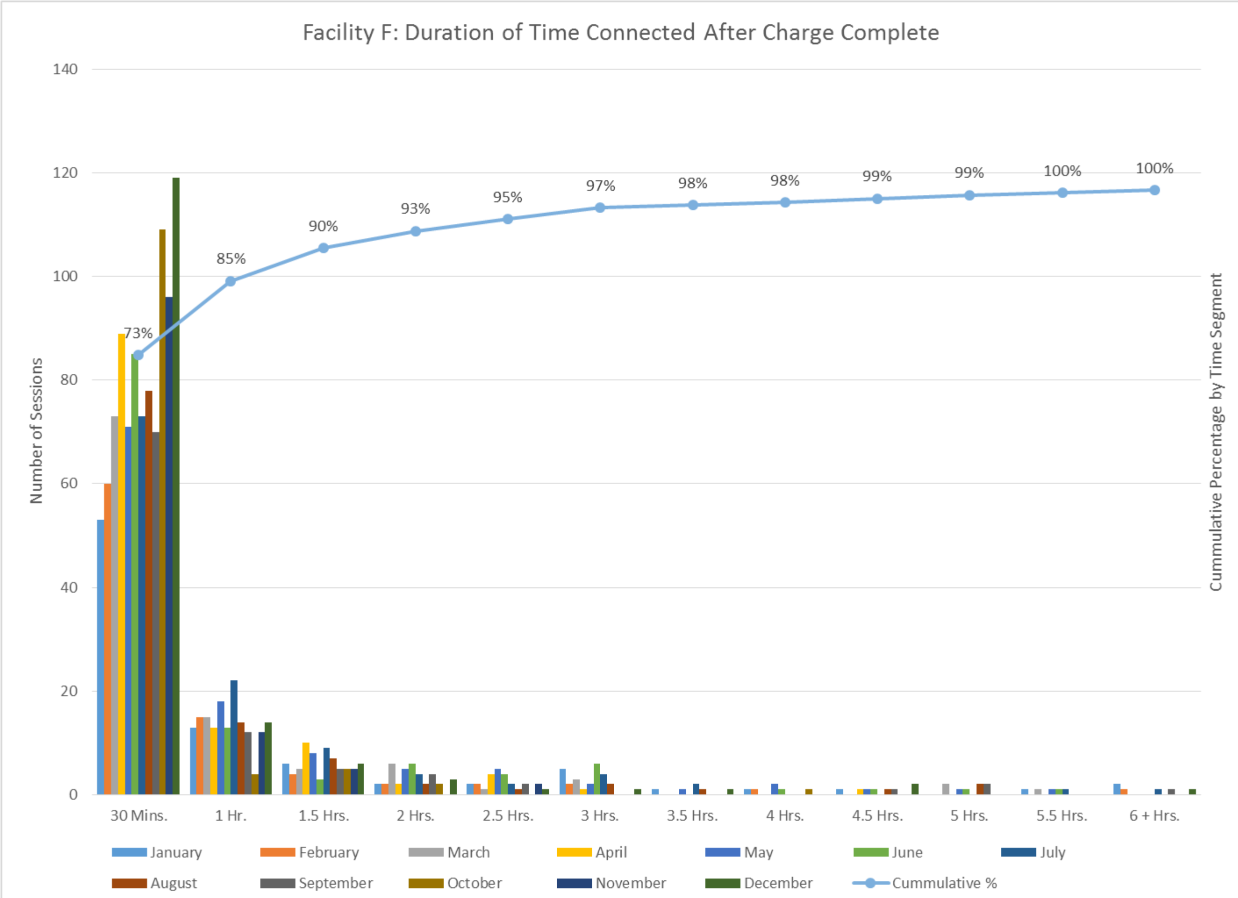


Figure 62: Facility F duration of time after charge complete shows that 73% of vehicles disconnected within 30 minutes.

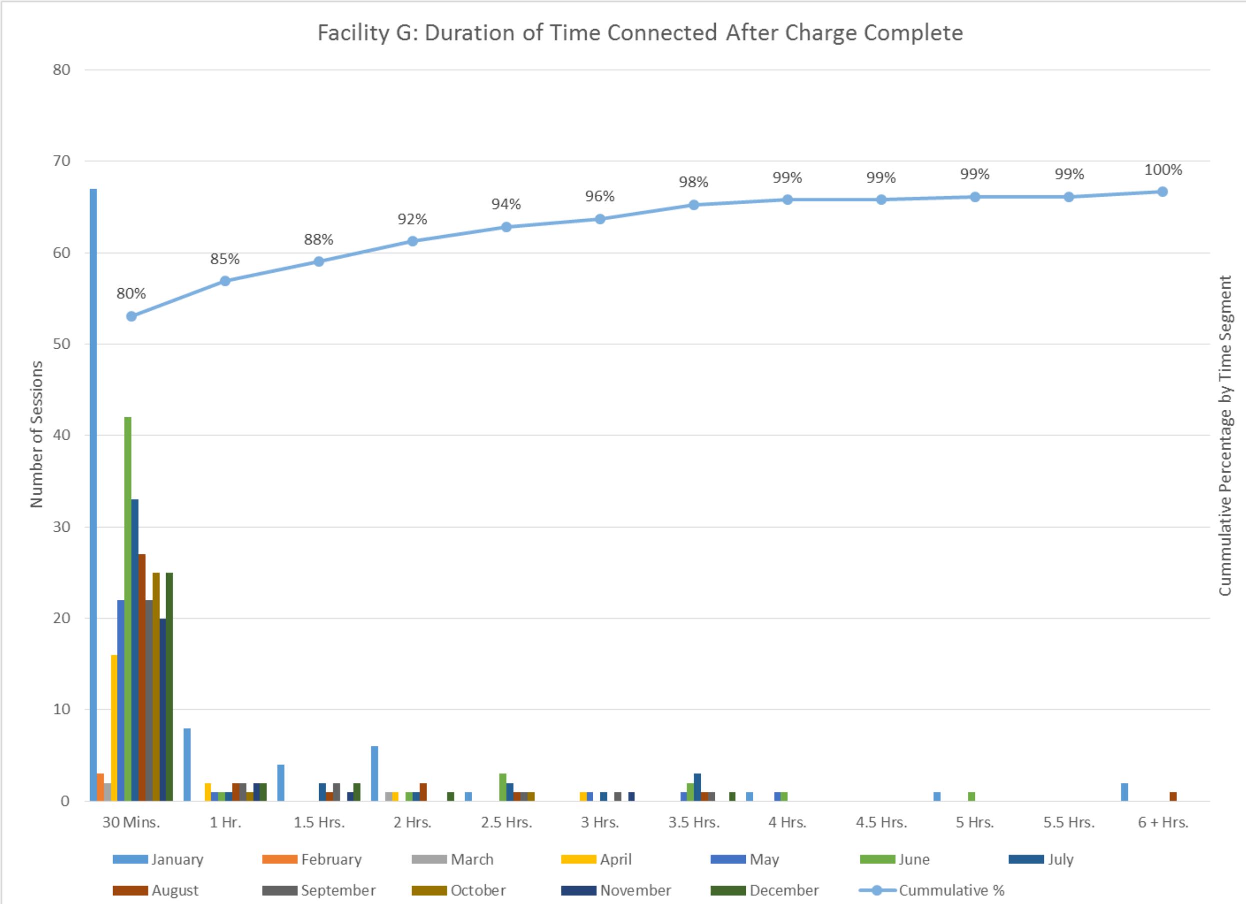


Figure 63: Facility G duration of time after charge complete shows that 80% of vehicles disconnected within 30 minutes.

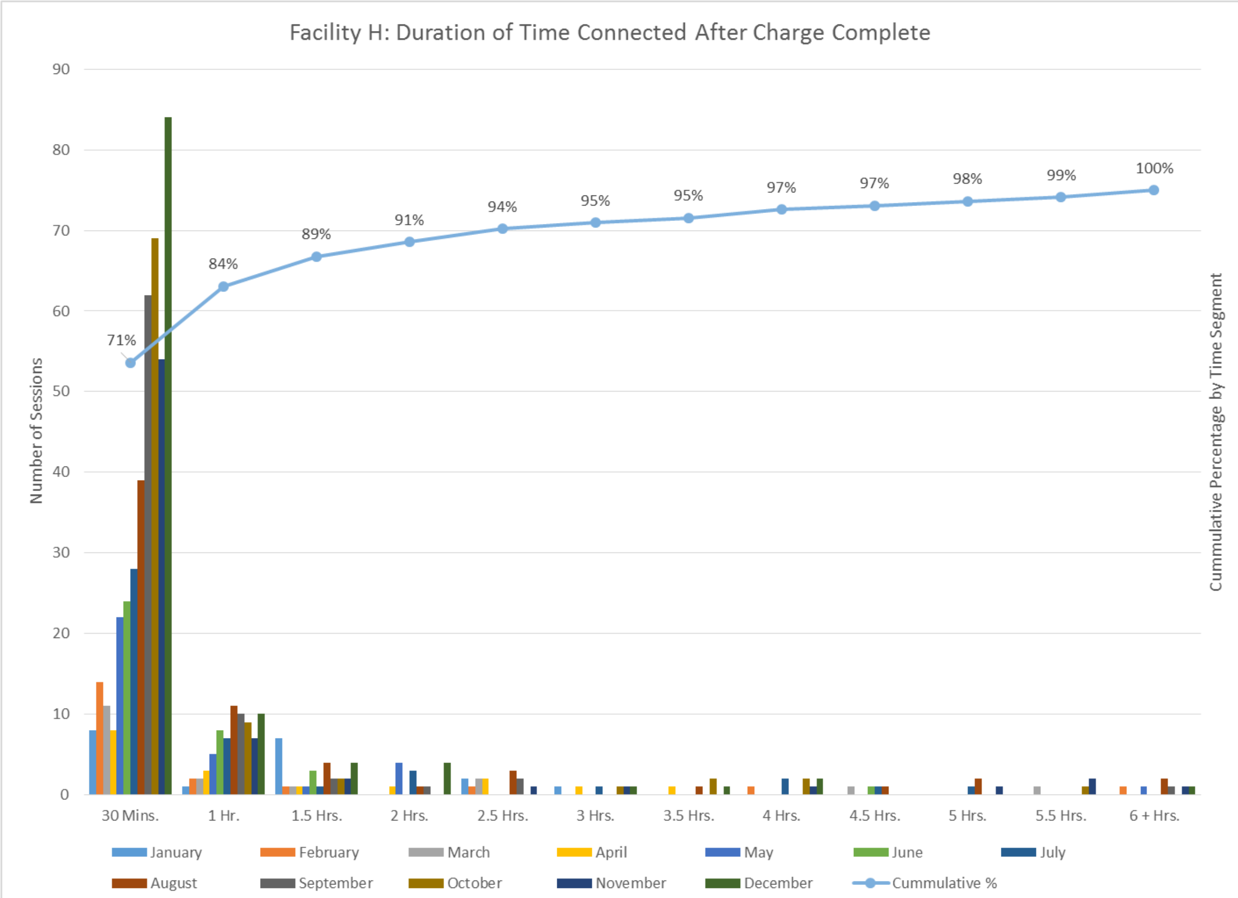


Figure 64: Facility H duration of time after charge complete shows that 71% of vehicles disconnected within 30 minutes.

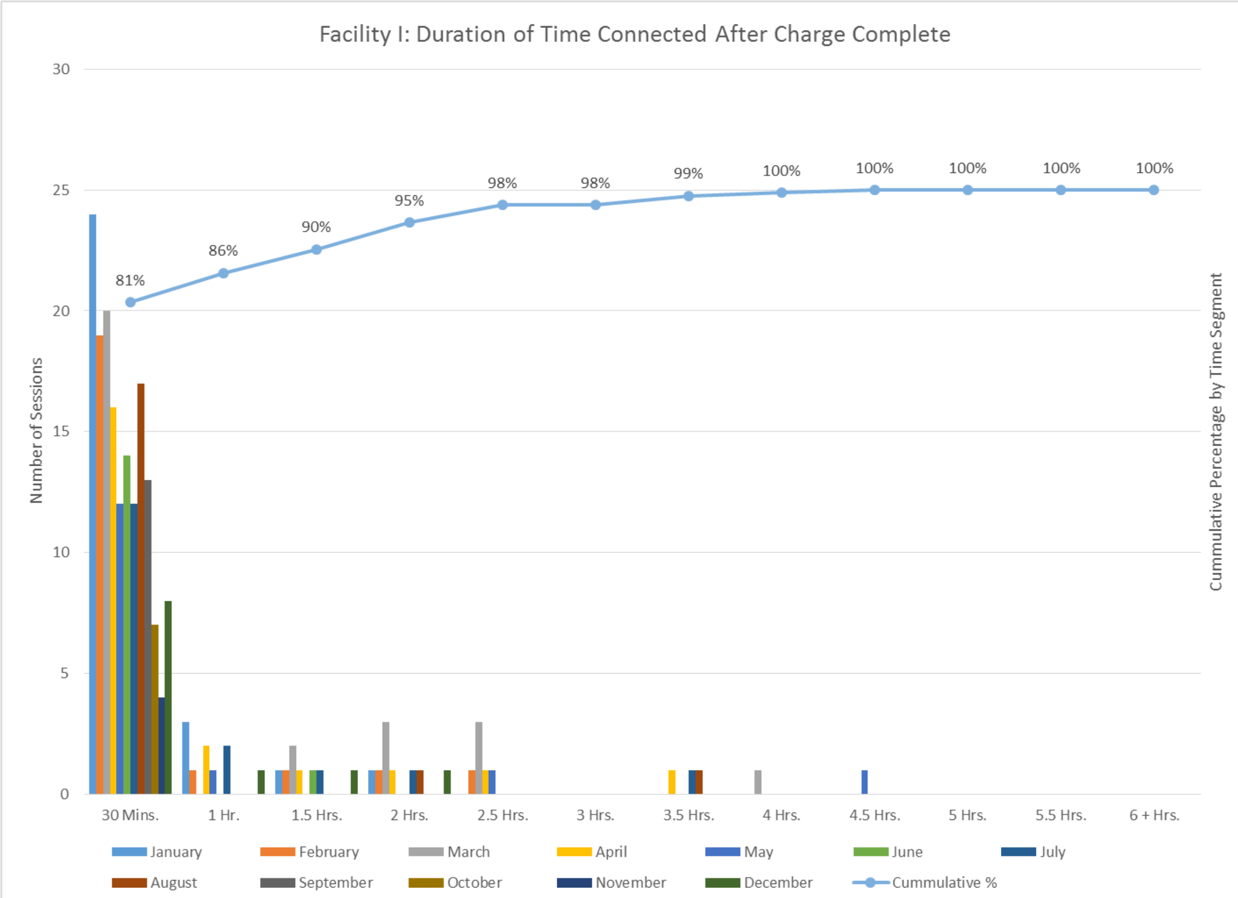


Figure 65: Facility I duration of time after charge complete shows that 81% of vehicles disconnected within 30 minutes.

22. Appendix G: 2016 DR Test Event Plots

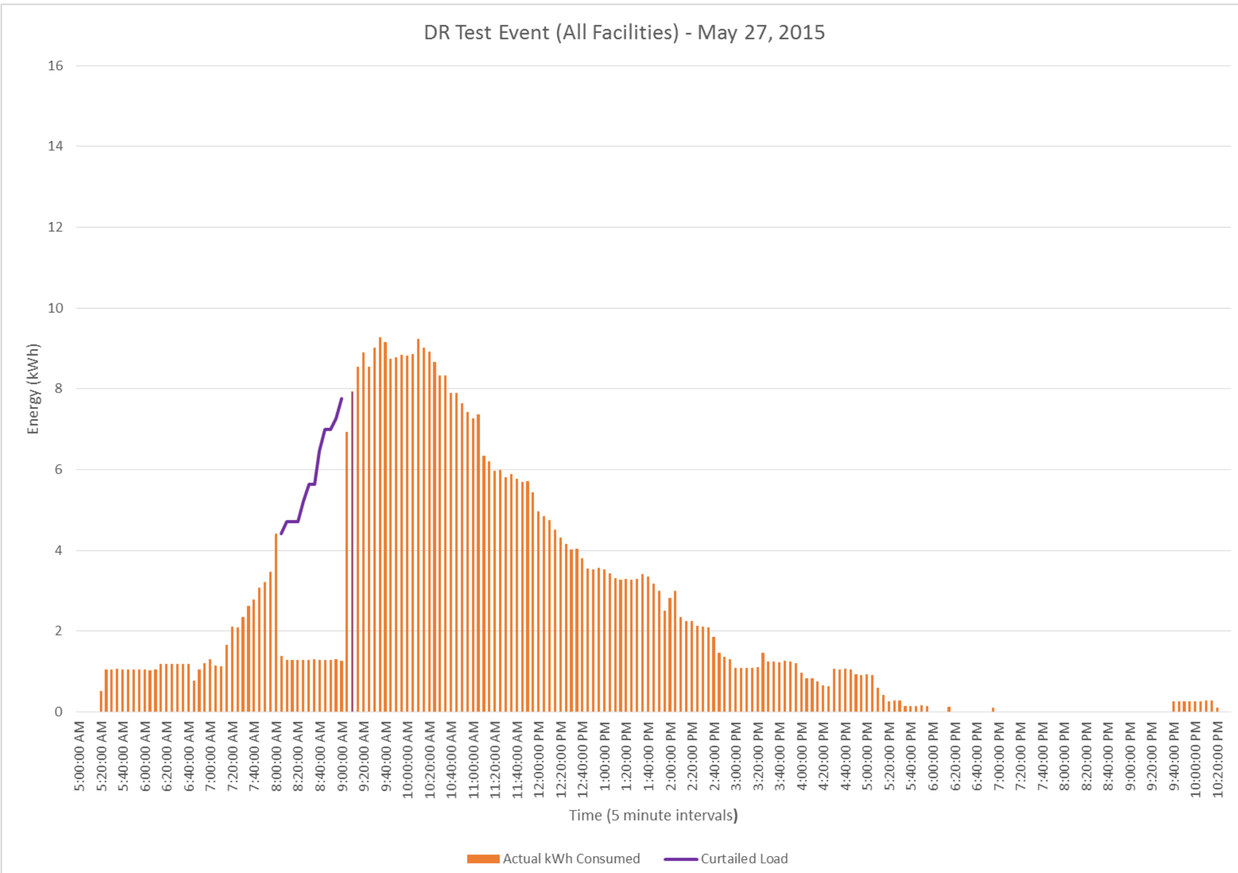


Figure 66: DR Event on May 27, 2015 realized load curtailment of 54.91 kW from 28 sessions (18 Level 1 sessions for a total of 23.59 kW and 10 Level 2 sessions for a total of 31.32 kW).

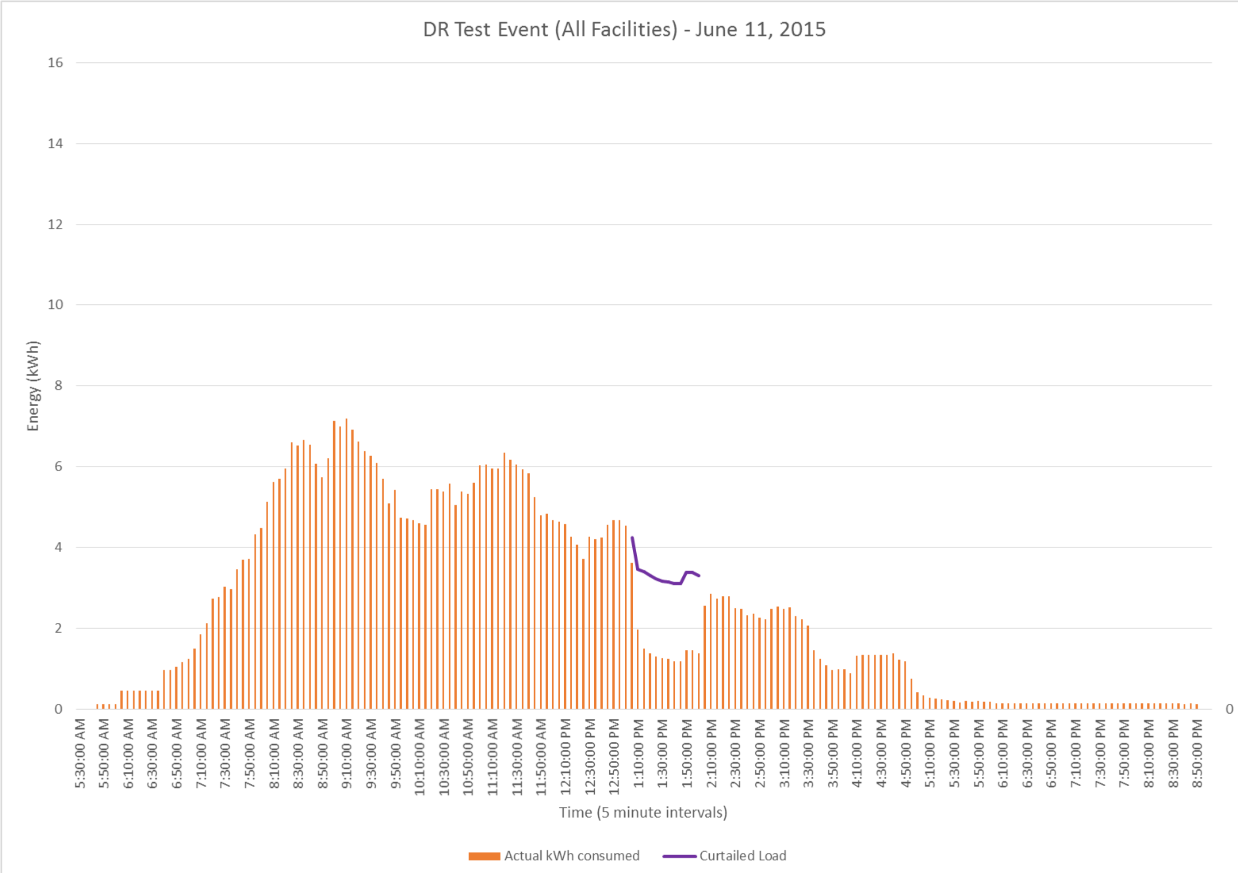


Figure 67: DR Event on June 11, 2015 realized load curtailment of 24.51 kW from 11 sessions (8 Level 1 sessions for a total of 12.5 kW and 3 Level 2 sessions for a total of 12.1 kW).

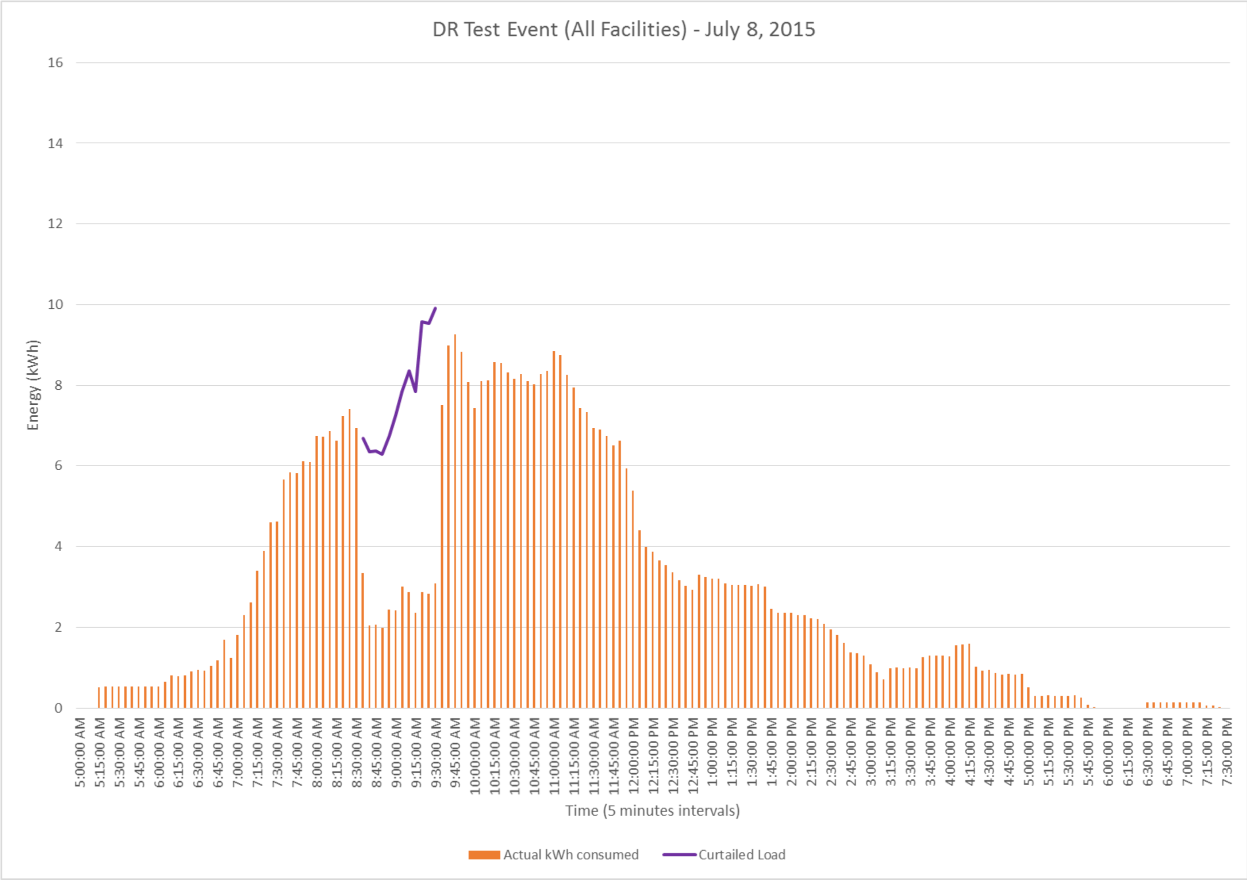


Figure 68: DR Event on July 8, 2015 realized load curtailment of 61.47 kW from 26 sessions (13 Level 1 sessions for a total of 17 kW and 13 Level 2 sessions for a total of 44.47 kW).

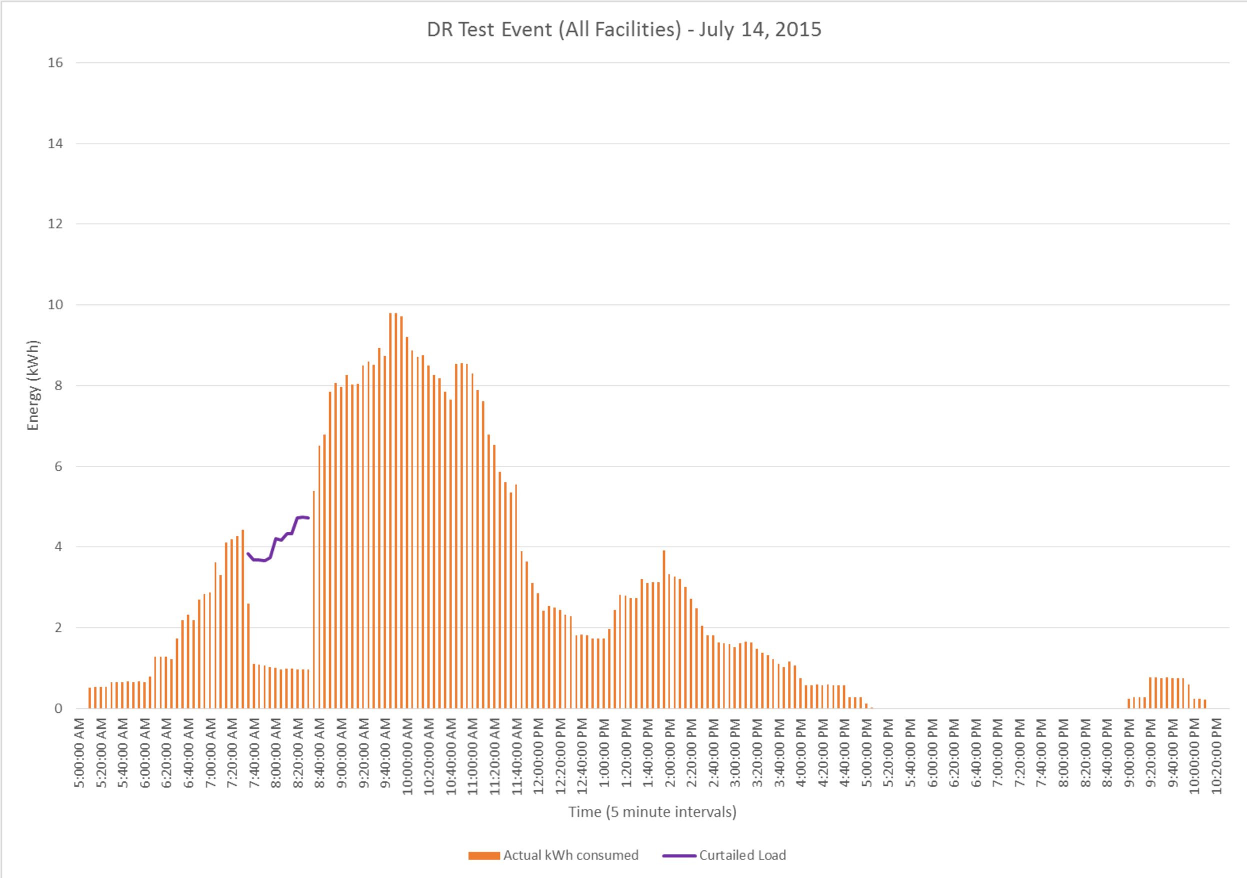


Figure 69: DR Event on July 14, 2015 realized load curtailment of 36.1 kW from 17 sessions (10 Level 1 sessions for a total of 12.8 kW and 7 Level 2 sessions for a total of 23.3 kW).

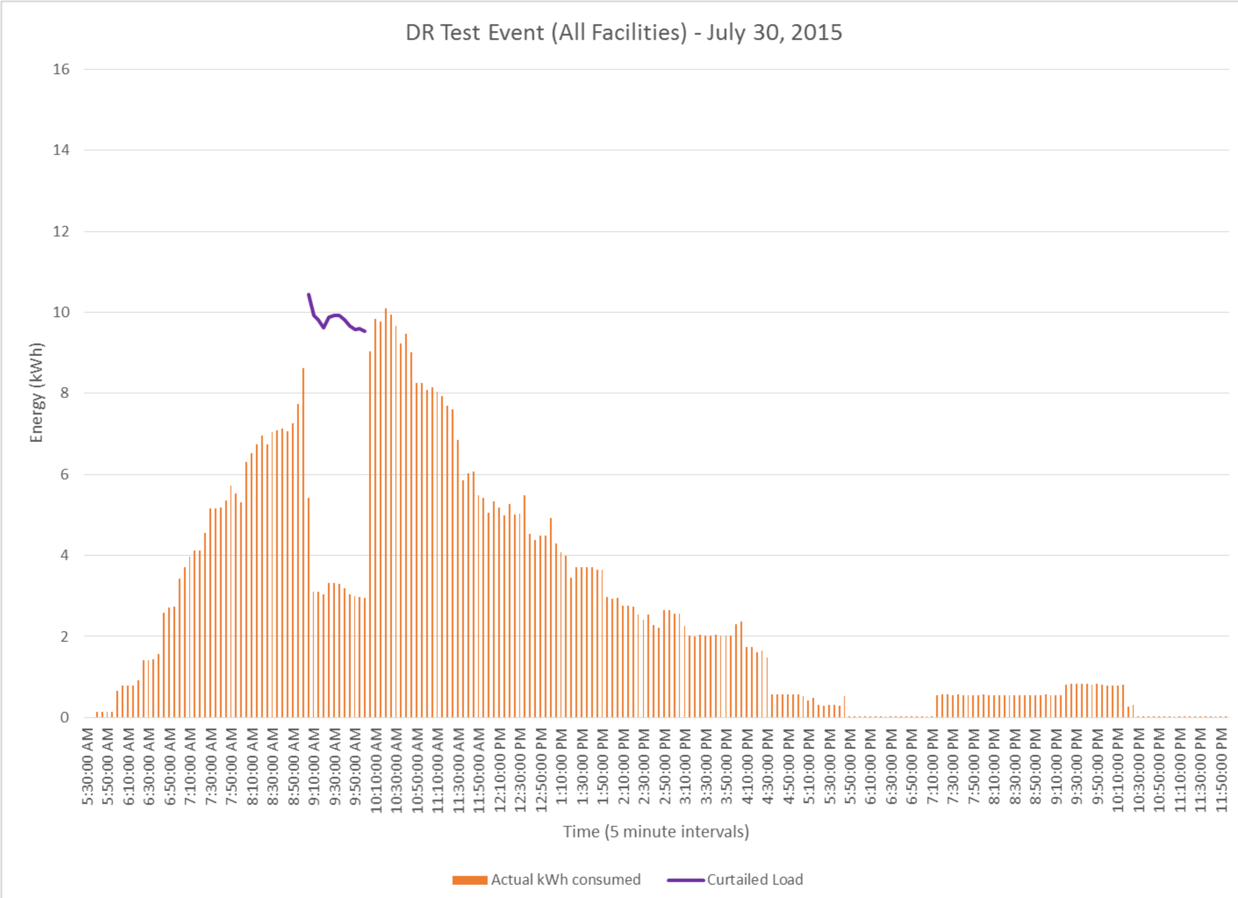


Figure 70: DR Event on July 30, 2015 realized load curtailment of 77.99 kW from 28 sessions (15 Level 1 sessions for a total of 21.61 kW and 13 Level 2 sessions for a total of 56.38 kW).

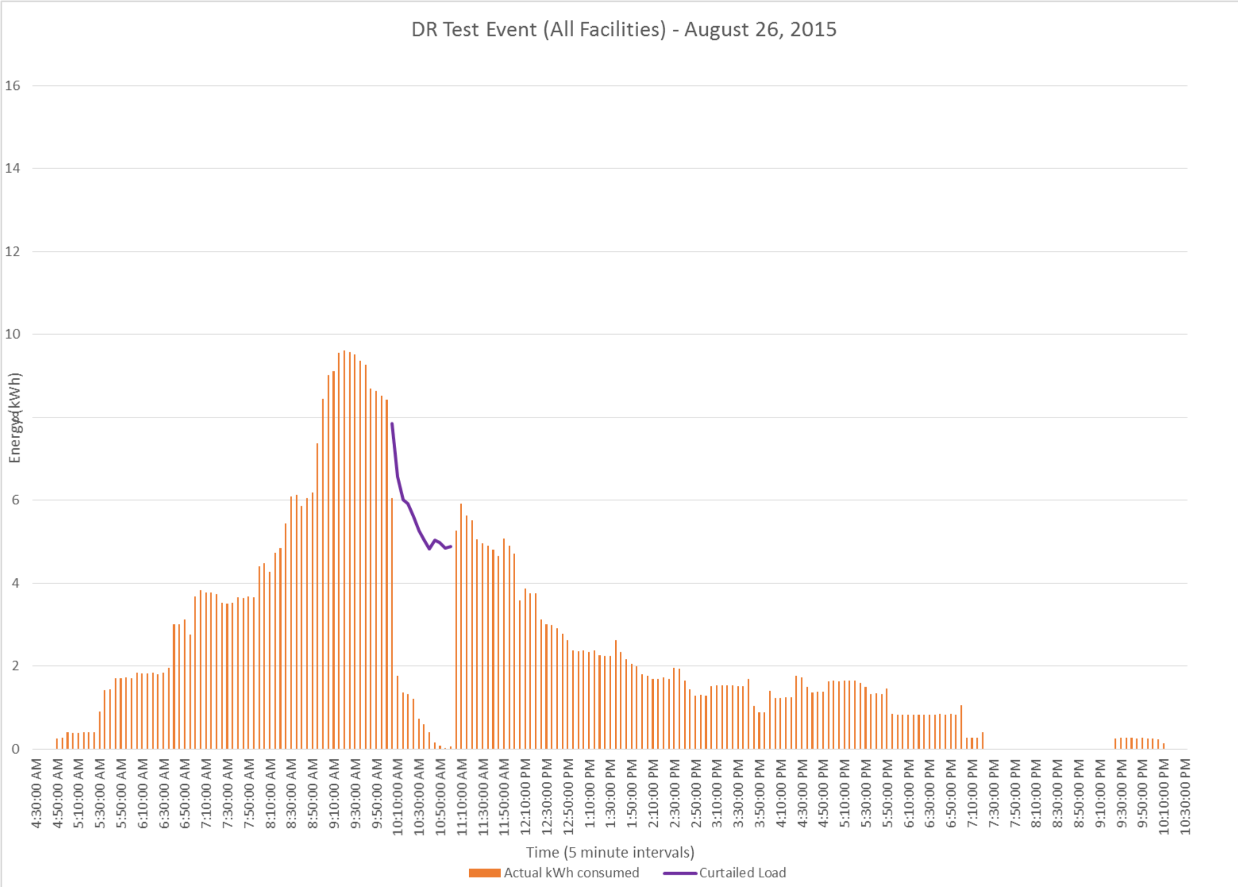


Figure 71: DR Event on August 26, 2015 realized load curtailment of 53.11 kW from 22 sessions (10 Level 1 sessions for a total of 13.53 kW and 12 Level 2 sessions for a total of 39.58 kW).

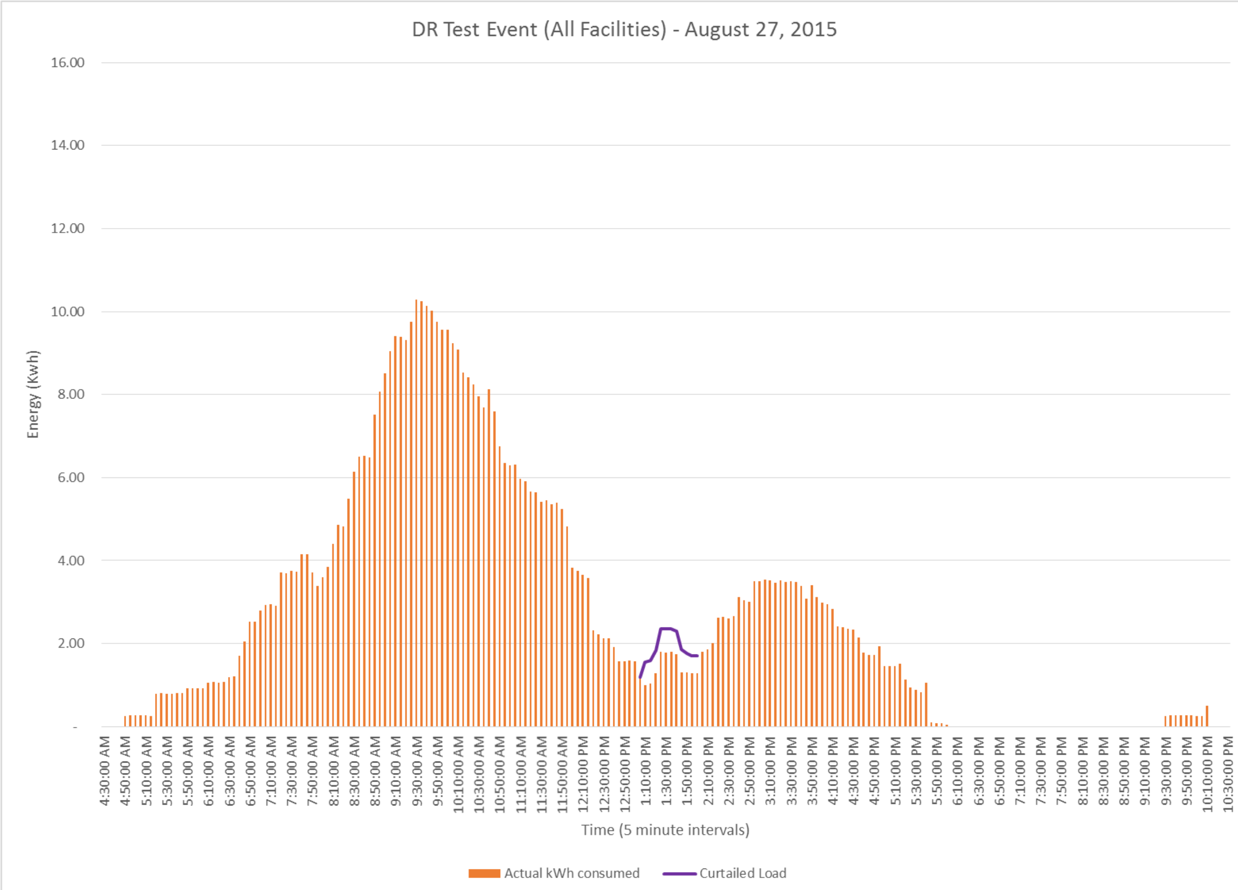


Figure 72: DR Event on August 27, 2015 realized load curtailment of 5.74 kW from 4 sessions (4 Level 1 sessions for a total of 5.74 kW).

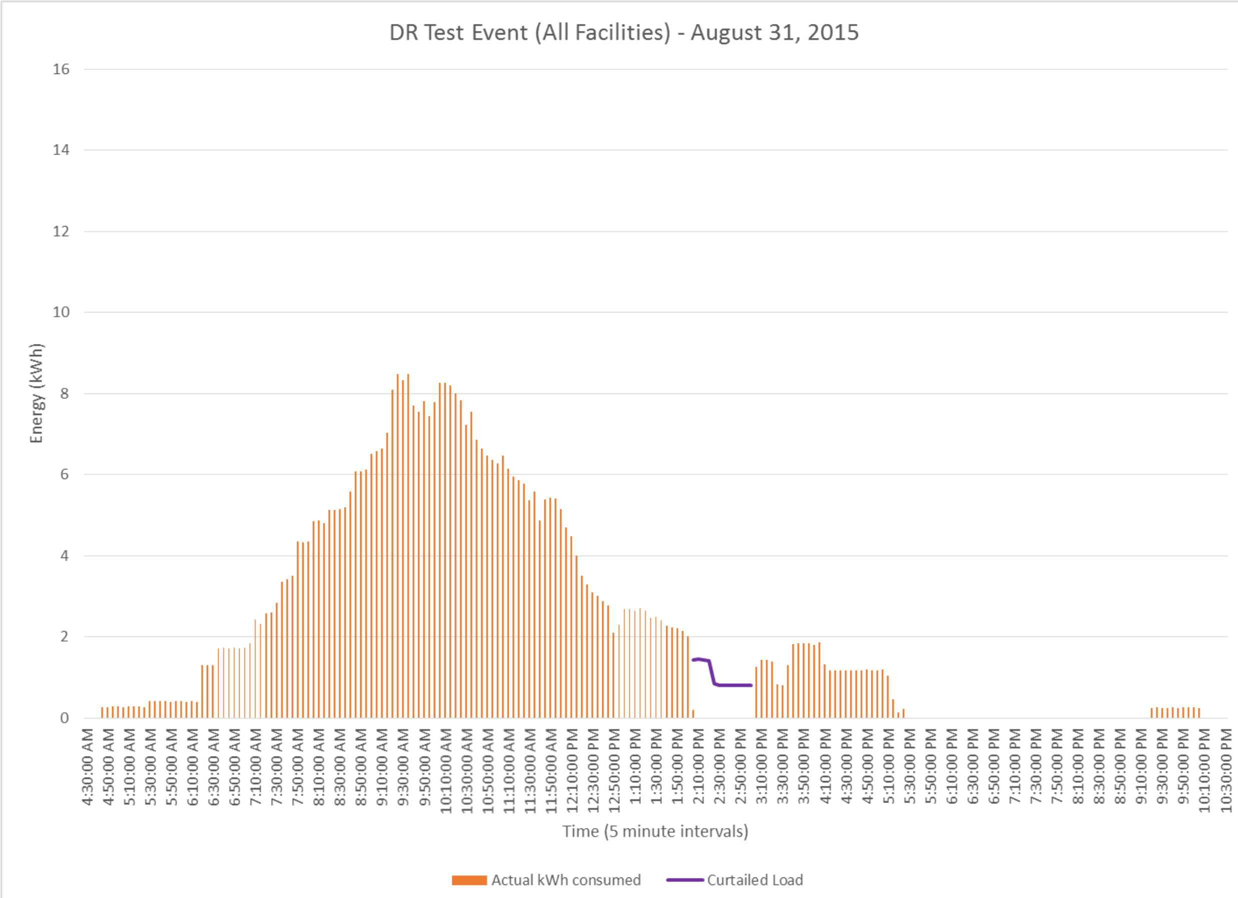


Figure 73: DR Event on August 31, 2015 realized load curtailment of 12.02 kW from 5 sessions (3 Level 1 sessions for a total of 3.59 kW and 2 Level 2 sessions for a total of 8.43 kW).

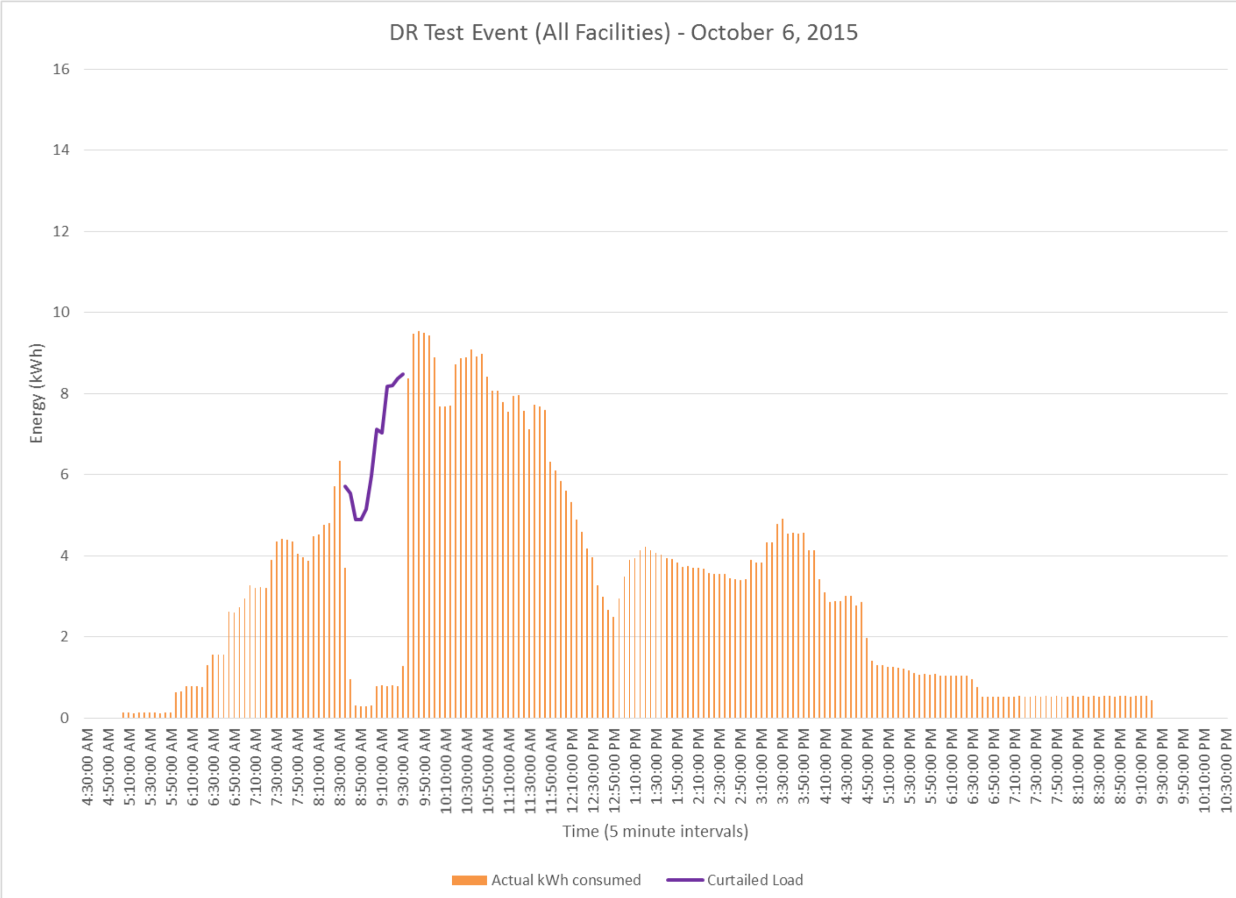


Figure 74: DR Event on October 6, 2015 realized load curtailment of 68.51 kW from 32 sessions (11 Level 1 sessions for a total of 12.72 kW and 21 Level 2 sessions for a total of 55.79 kW).

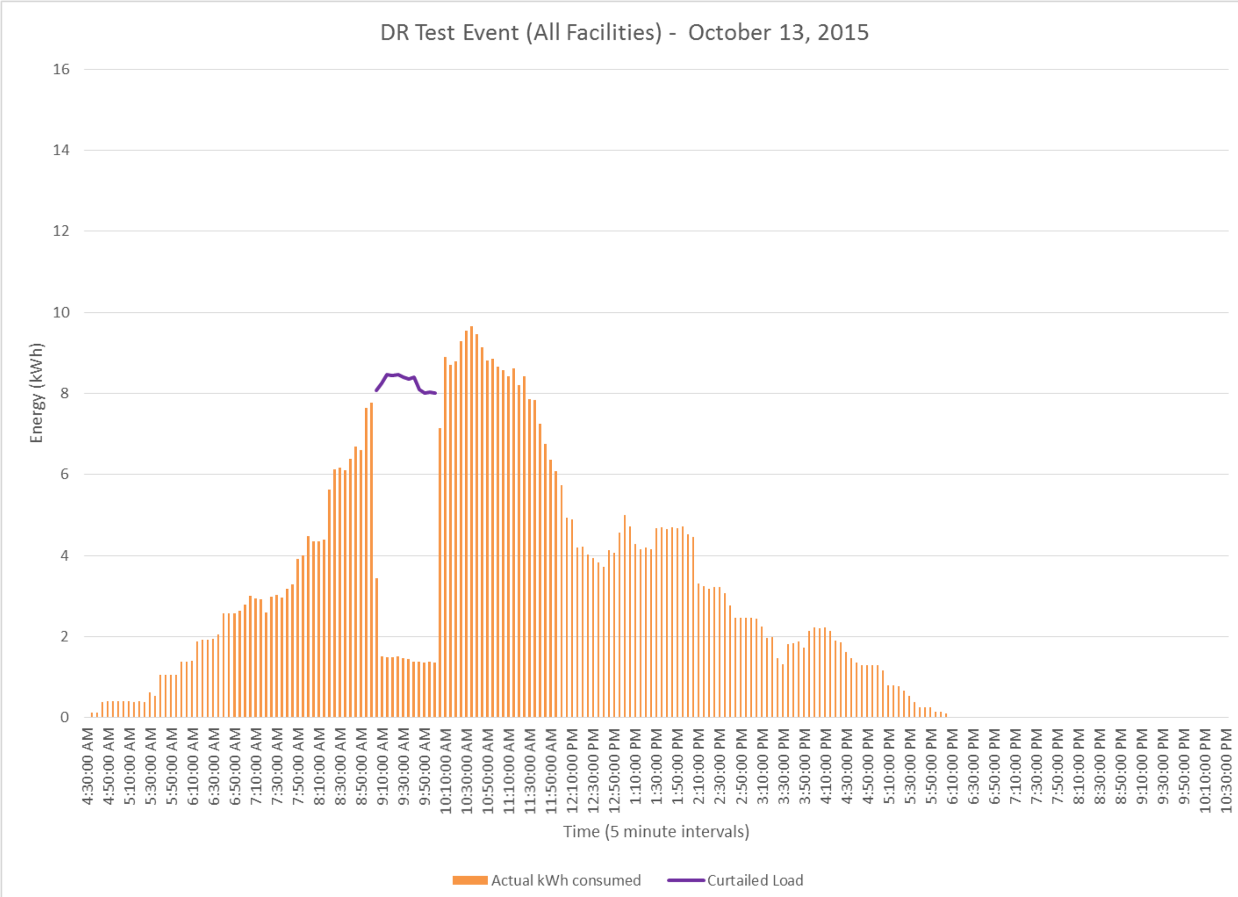


Figure 75: DR Event on October 13, 2015 realized load curtailment of 79.74 kW from 24 sessions (8 Level 1 sessions for a total of 11.4 kW and 16 Level 2 sessions for a total of 68.34 kW).

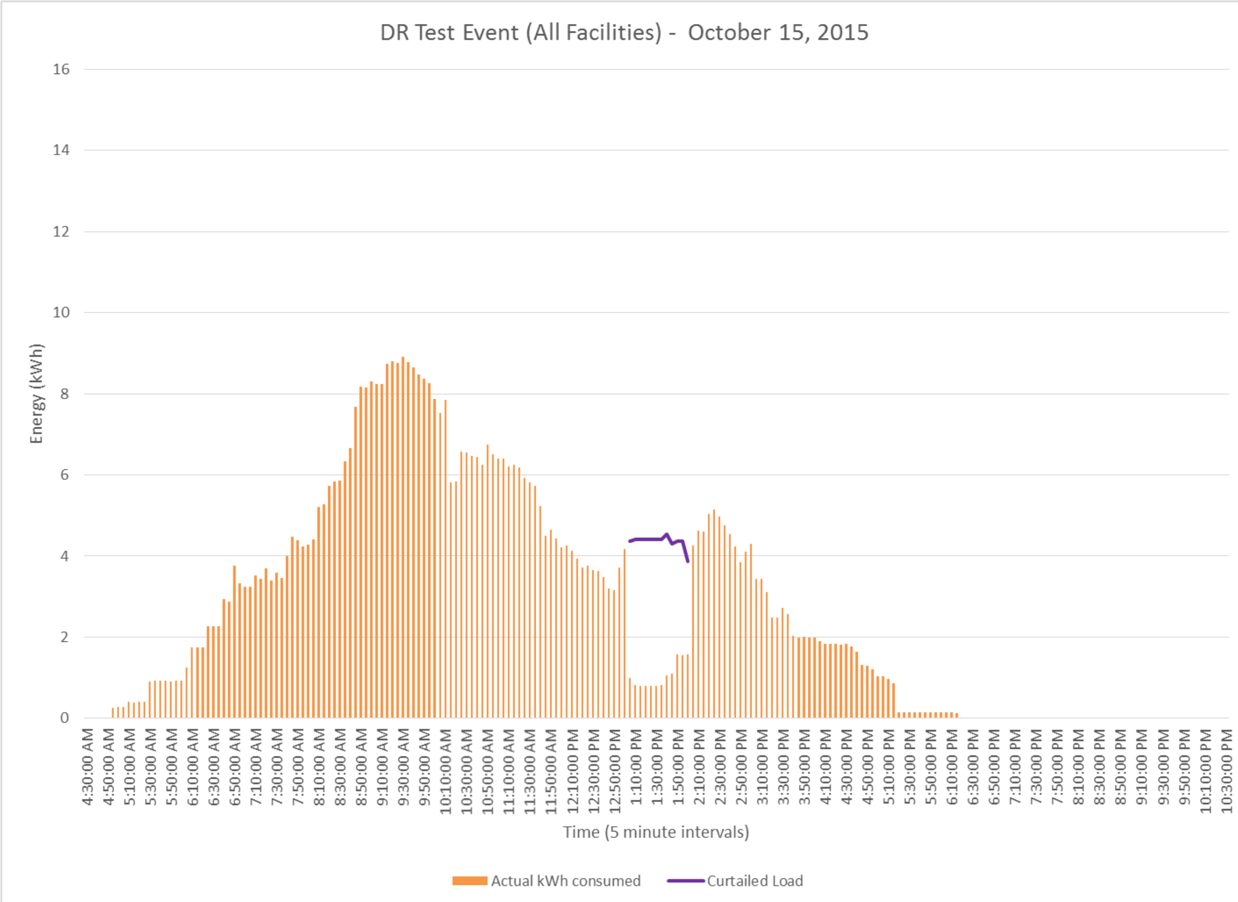


Figure 76: DR Event on October 15, 2015 realized load curtailment of 39.58 kW from 11 sessions (5 Level 1 sessions for a total of 8.13 kW and 6 Level 2 sessions for a total of 31.46 kW).

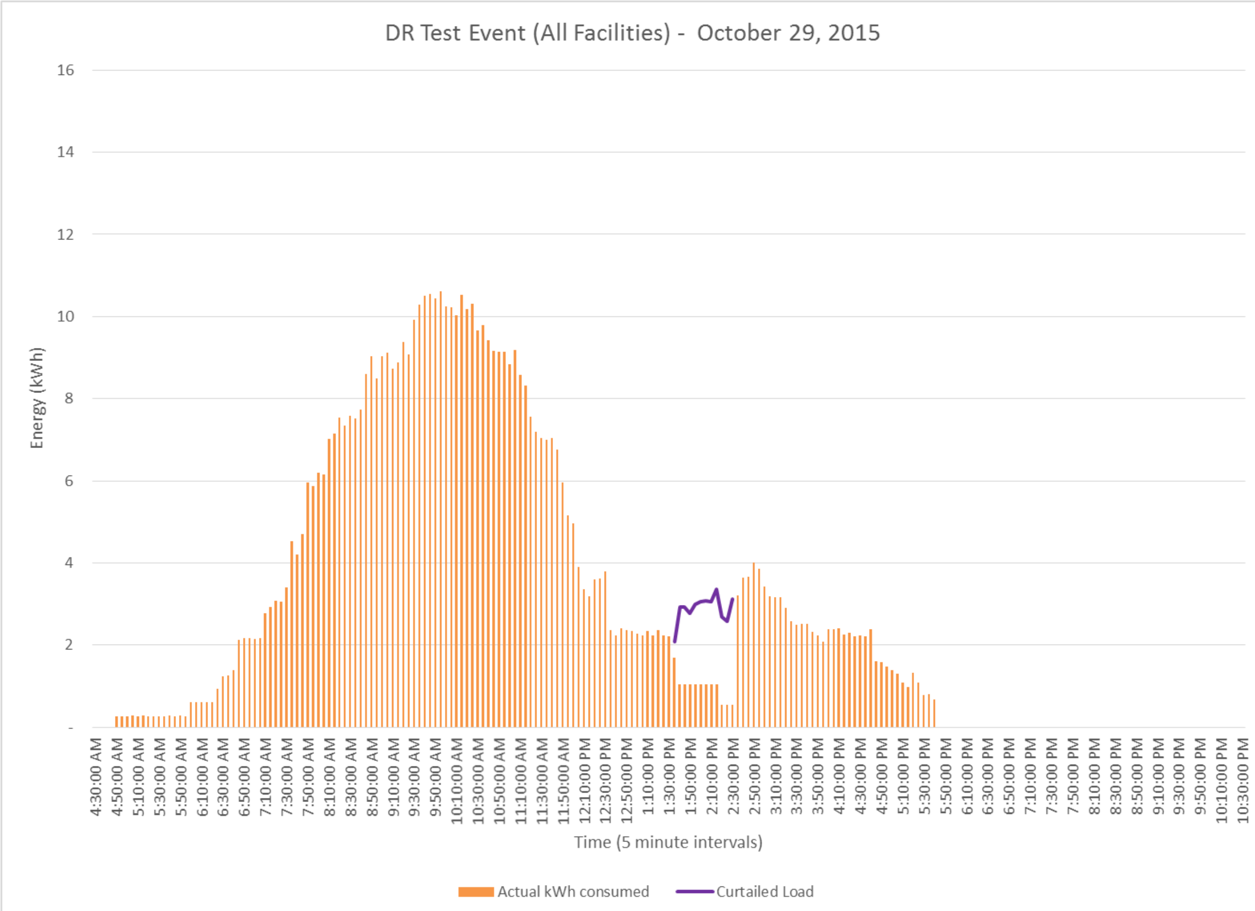


Figure 77: DR Event on October 29, 2015 realized load curtailment of 22.93 kW from 10 sessions (4 Level 1 sessions for a total of 4.94 kW and 6 Level 2 sessions for a total of 17.99 kW).

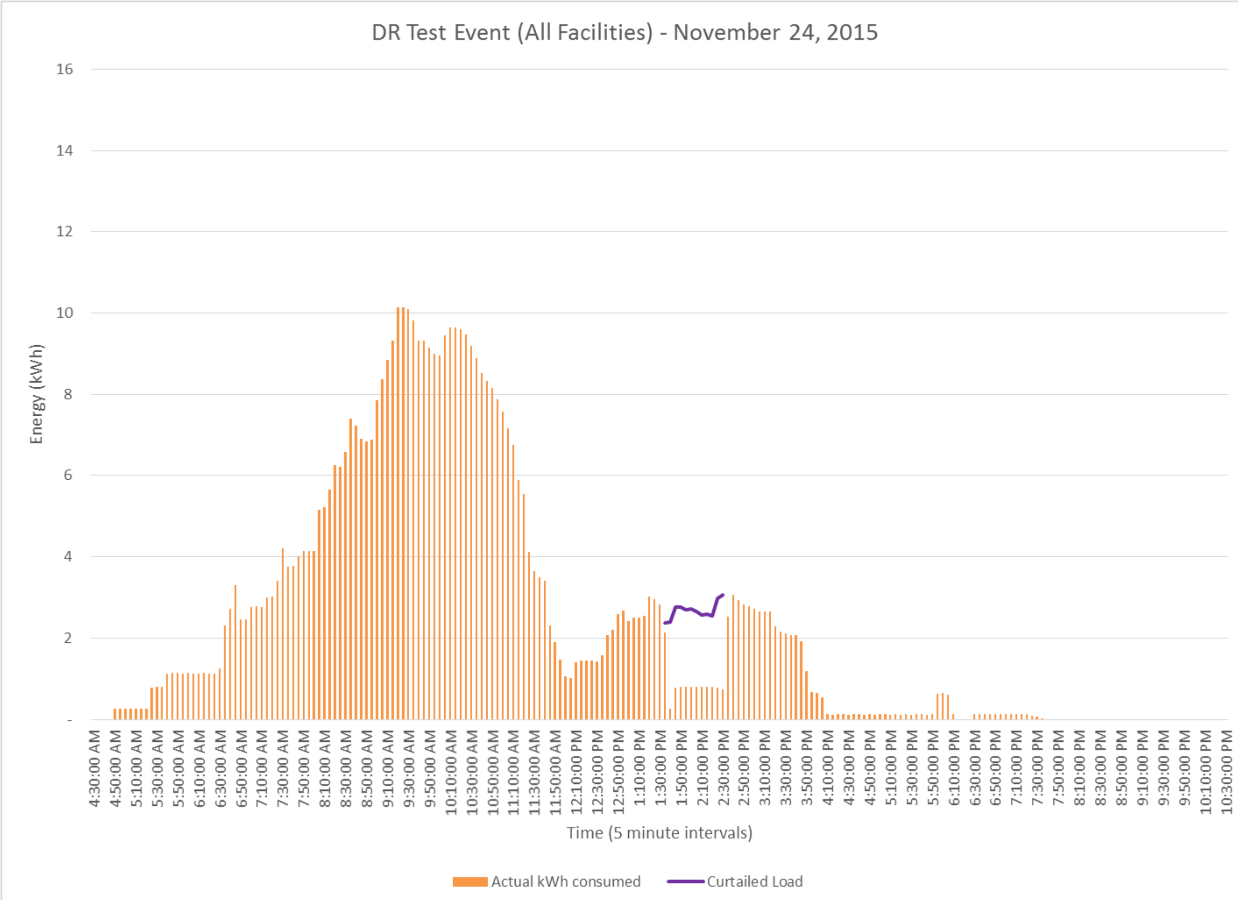


Figure 78: DR Event on November 24, 2015 realized load curtailment of 21.81 kW from 9 sessions (3 Level 1 sessions for a total of 2.31 kW and 6 Level 2 sessions for a total of 19.50 kW).

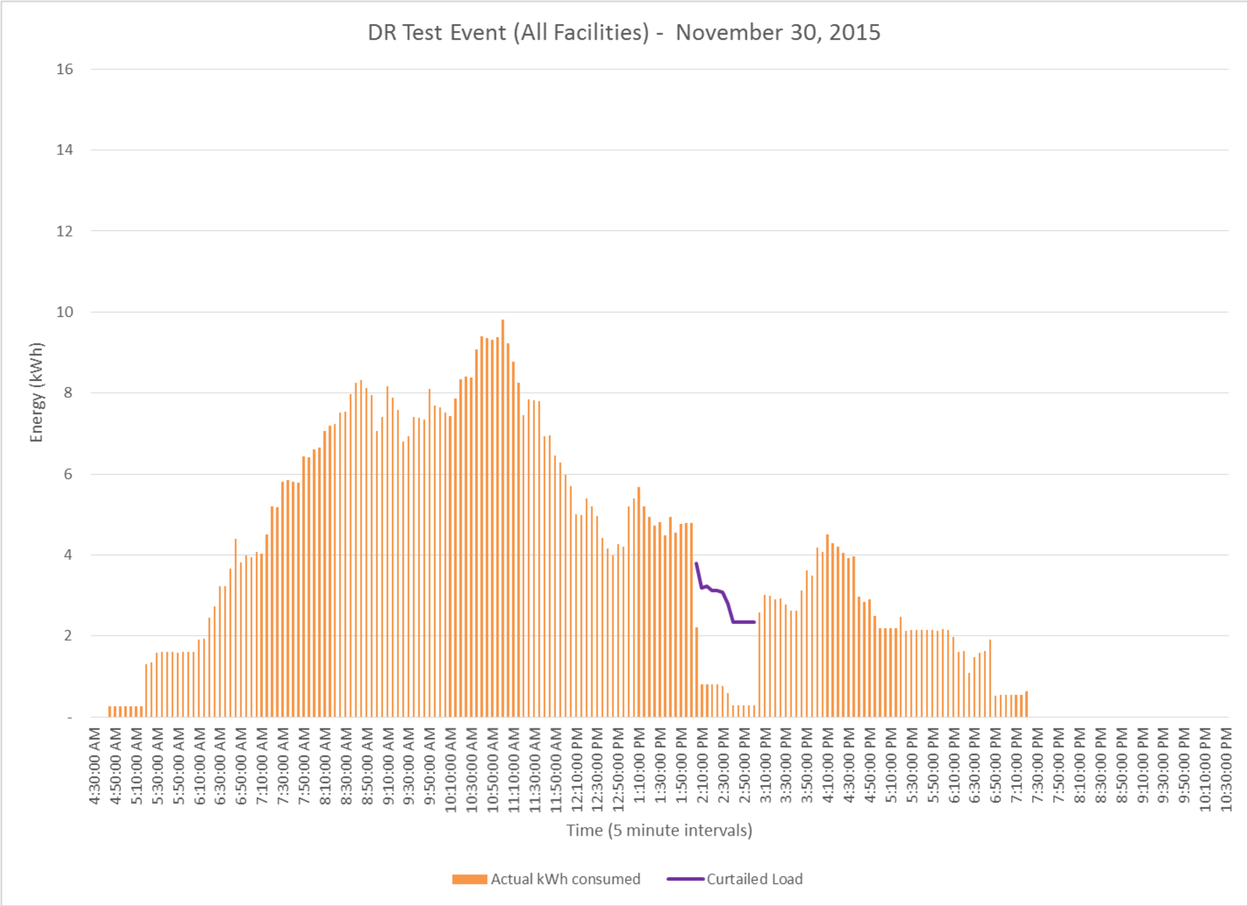


Figure 79: DR Event on November 30, 2015 realized load curtailment of 25.75 kW from 10 sessions (6 Level 1 sessions for a total of 8.47 kW and 4 Level 2 sessions for a total of 17.28 kW).

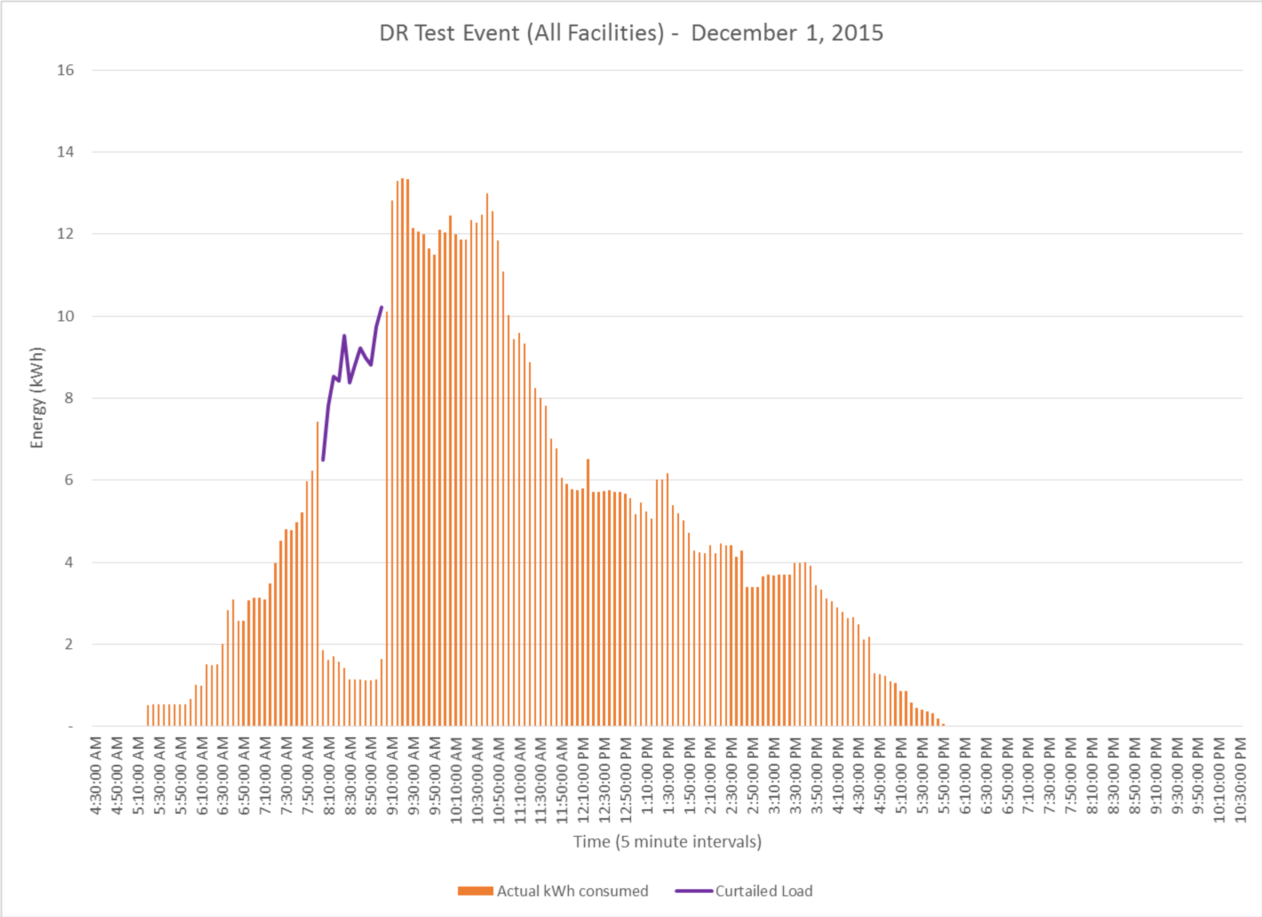


Figure 80: DR Event on December 1, 2015 realized load curtailment of 88.31 kW from 29 sessions (4 Level 1 sessions for a total of 4.05 kW and 25 Level 2 sessions for a total of 84.26 kW).

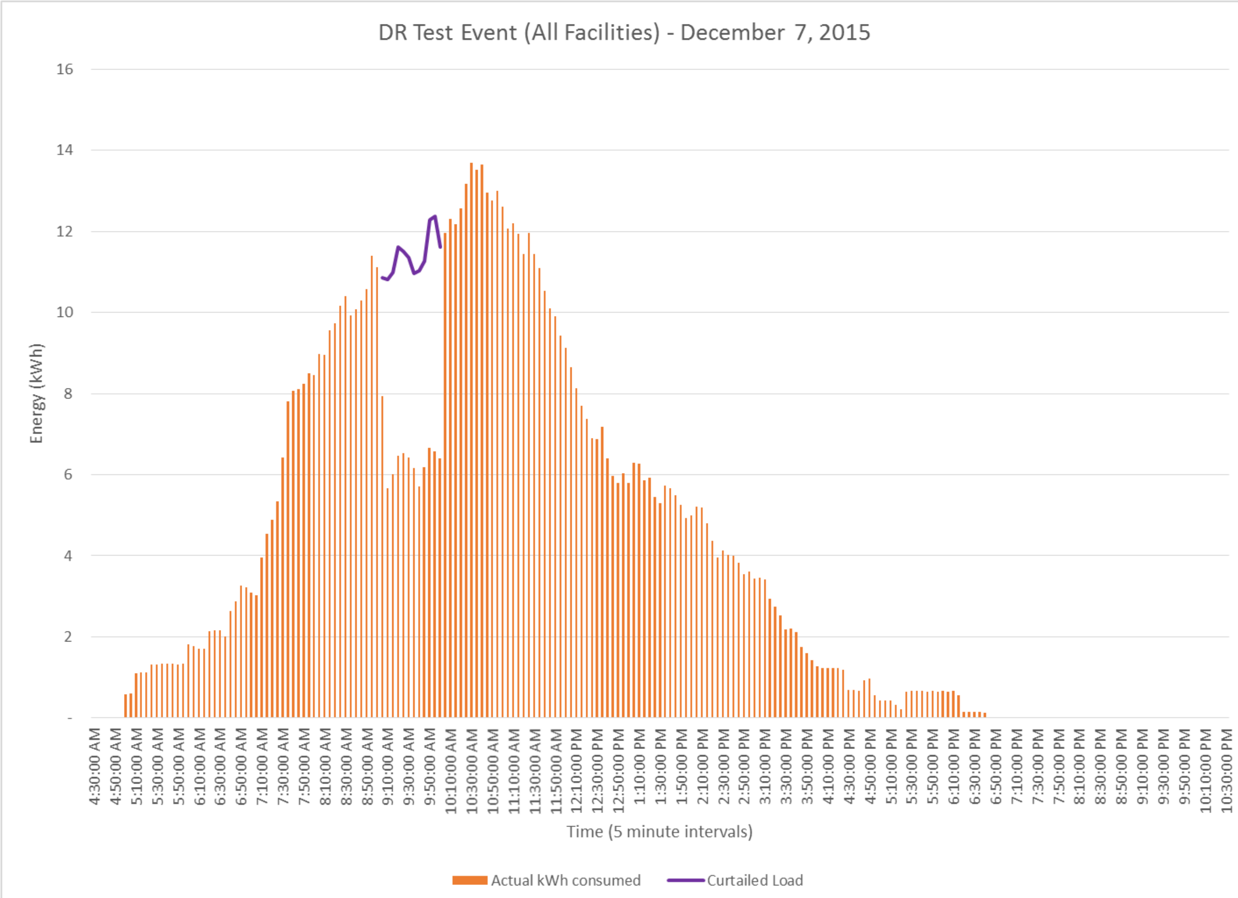


Figure 81: DR Event on December 7, 2015 realized load curtailment of 59.96 kW from 23 sessions (3 Level 1 sessions for a total of 4.5 kW and 20 Level 2 sessions for a total of 55.46 kW).

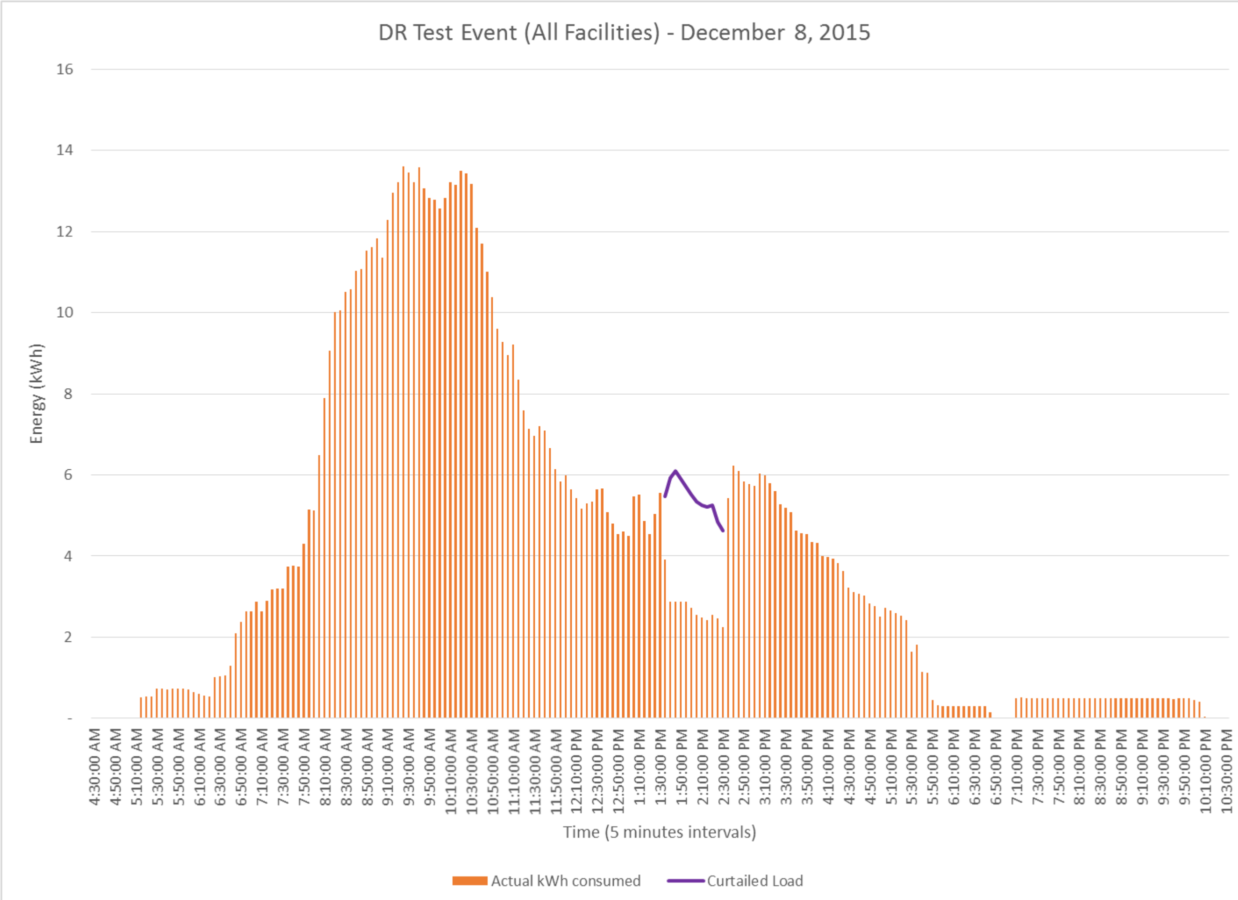


Figure 82: DR Event on December 8, 2015 realized load curtailment of 32.20 kW from 11 sessions (2 Level 1 sessions for a total of 3.24 kW and 9 Level 2 sessions for a total of 29.06 kW).

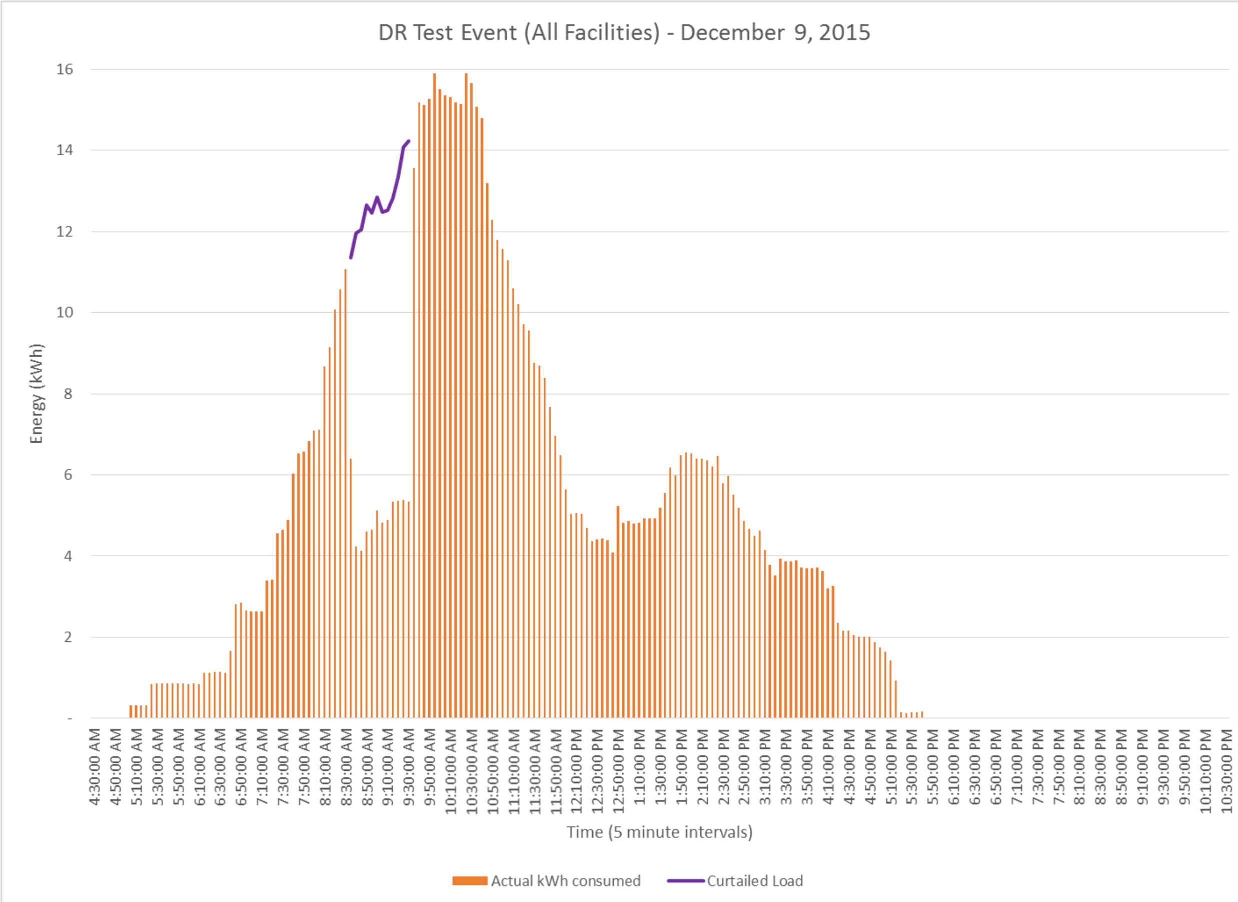


Figure 83: DR Event on December 9, 2015 realized load curtailment of 92.50 kW from 27 sessions (1 Level 1 sessions for a total of 1.68 kW and 26 Level 2 sessions for a total of 90.82 kW).

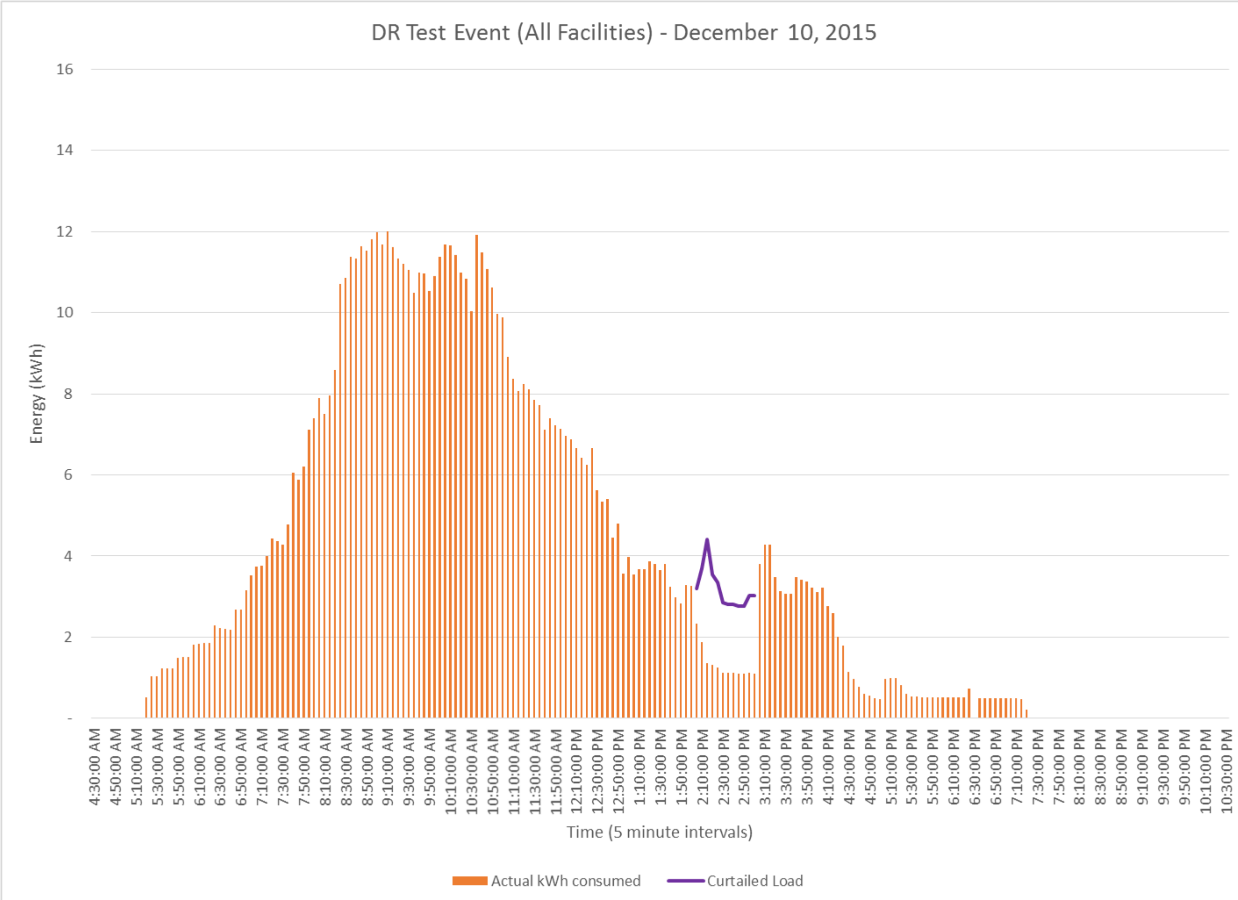


Figure 84: DR Event on December 10, 2015 realized load curtailment of 22.27 kW from 10 sessions (2 Level 1 sessions for a total of 3.23 kW and 8 Level 2 sessions for a total of 19.04 kW).

23. Appendix H: 2015 California Weekly Average Gasoline Prices[33]

Weekly California statewide average prices in dollars per gallon are compiled by the U.S. Department of Energy's Energy Information Administration (EIA) from a telephone survey that includes a sample of 38 California gasoline stations. These stations were sampled with a likelihood equal to the company's proportional size to the total annual volume of gasoline, by grade, sold in California.

Table 14: 2015 California Average Weekly Gas Prices

Date	Regular	% △	Midgrade	% △	Premium	% △
Week 1	$2.68		$2.79		$2.90	
Week 2	$2.67	-0.3%	$2.79	-0.1%	$2.89	-0.1%
Week 3	$2.59	-3.0%	$2.71	-2.9%	$2.81	-2.8%
Week 4	$2.48	-4.4%	$2.59	-4.4%	$2.70	-4.2%
Week 5	$2.44	-1.8%	$2.55	-1.6%	$2.66	-1.5%
Week 6	$2.44	0.0%	$2.56	0.1%	$2.66	0.2%
Week 7	$2.63	7.1%	$2.74	6.6%	$2.85	6.4%
Week 8	$2.80	6.1%	$2.91	5.9%	$3.02	5.7%
Week 9	$2.96	5.4%	$3.07	5.4%	$3.18	5.2%
Week 10	$3.42	13.4%	$3.53	13.0%	$3.64	12.6%
Week 11	$3.44	0.6%	$3.55	0.6%	$3.66	0.5%
Week 12	$3.36	-2.5%	$3.47	-2.5%	$3.61	-1.5%
Week 13	$3.27	-2.7%	$3.38	-2.6%	$3.48	-3.5%
Week 14	$3.21	-1.8%	$3.32	-1.7%	$3.43	-1.7%
Week 15	$3.15	-2.0%	$3.26	-1.8%	$3.39	-1.2%
Week 16	$3.10	-1.5%	$3.22	-1.3%	$3.33	-1.8%
Week 17	$3.16	1.8%	$3.27	1.5%	$3.38	1.5%
Week 18	$3.43	8.0%	$3.55	7.8%	$3.66	7.6%
Week 19	$3.71	7.5%	$3.84	7.5%	$3.95	7.4%
Week 20	$3.73	0.6%	$3.85	0.2%	$3.95	0.1%
Week 21	$3.81	2.0%	$3.93	2.0%	$4.04	2.2%
Week 22	$3.76	-1.3%	$3.88	-1.3%	$4.00	-0.9%

[33] Source: http://energyalmanac.ca.gov/gasoline/retail_gasoline_prices.html#2014v

Date	Regular	% △	Midgrade	% △	Premium	% △
Week 23	$3.69	-1.7%	$3.80	-1.9%	$3.92	-2.1%
Week 24	$3.59	-2.8%	$3.71	-2.5%	$3.83	-2.4%
Week 25	$3.51	-2.3%	$3.63	-2.3%	$3.71	-3.2%
Week 26	$3.48	-0.9%	$3.60	-0.9%	$3.71	0.0%
Week 27	$3.45	-0.9%	$3.57	-0.8%	$3.68	-0.8%
Week 28	$3.43	-0.5%	$3.55	-0.5%	$3.67	-0.4%
Week 29	$3.88	11.5%	$4.02	11.6%	$4.14	11.4%
Week 30	$3.90	0.4%	$4.02	0.0%	$4.14	0.0%
Week 31	$3.81	-2.2%	$3.94	-1.8%	$4.06	-1.8%
Week 32	$3.72	-2.4%	$3.86	-2.2%	$3.98	-2.2%
Week 33	$3.57	-4.5%	$3.69	-4.6%	$3.81	-4.5%
Week 34	$3.58	0.5%	$3.71	0.5%	$3.83	0.6%
Week 35	$3.48	-2.9%	$3.60	-2.9%	$3.73	-2.8%
Week 36	$3.34	-4.2%	$3.47	-3.8%	$3.59	-3.8%
Week 37	$3.27	-2.3%	$3.39	-2.4%	$3.51	-2.3%
Week 38	$3.16	-3.5%	$3.28	-3.4%	$3.39	-3.4%
Week 39	$3.07	-2.7%	$3.19	-2.6%	$3.31	-2.7%
Week 40	$2.99	-2.6%	$3.11	-2.6%	$3.23	-2.4%
Week 41	$2.95	-1.5%	$3.07	-1.6%	$3.18	-1.4%
Week 42	$2.91	-1.2%	$3.03	-1.1%	$3.15	-1.1%
Week 43	$2.86	-1.9%	$2.98	-1.8%	$3.09	-1.8%
Week 44	$2.85	-0.5%	$2.97	-0.4%	$3.08	-0.4%
Week 45	$2.82	-1.1%	$2.95	-0.6%	$3.06	-0.5%
Week 46	$2.82	0.2%	$2.95	-0.1%	$3.06	-0.1%
Week 47	$2.78	-1.6%	$2.90	-1.4%	$3.02	-1.5%
Week 48	$2.72	-2.4%	$2.83	-2.5%	$2.94	-2.4%
Week 49	$2.69	-0.9%	$2.81	-0.7%	$2.92	-0.8%
Week 50	$2.68	-0.4%	$2.79	-0.8%	$2.91	-0.6%
Week 51	$2.74	2.1%	$2.86	2.4%	$2.97	2.3%
Week 52	$2.65	-3.1%	$2.77	-3.2%	$2.88	-3.1%