SMUD's EV Innovators Pilot - Load Impact Evaluation

Encouraging responsible electric vehicle charging through time-based rates and managed charging options

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Herter Energy
RESEARCH SOLUTIONS

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EXECUTIVE SUMMARY – EV INNOVATORS

Electric vehicle (EV) charging has the potential to be costly to SMUD and to SMUD's customers – particularly if charging occurs during system peak hours, when high air-conditioning use combined with a high density of EV charging could overload transformers. The EV Innovators Pilot examined two potential solutions to this problem: (1) use time-varying rates to incentivize EV drivers to charge off peak every day and especially on "Conservation Days" – 12 days each summer when electric demand relief is most needed, and (2) remotely manage EV charging for customers on Conservation Days.

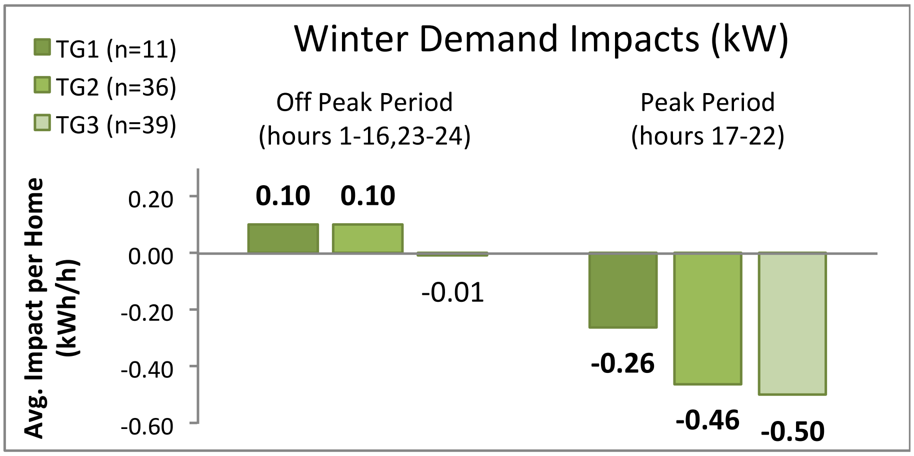
Between January and July of 2013, a group of customers, known by SMUD to be EV drivers, were solicited for two experimental time-varying rates: RPEV1, a time-of-use (TOU) pricing plan that applied to the entire electric load of the home, and RPEV2, which applied only to the EV charging load. RPEV2 loads were exposed to summer weekday TOU pricing plus 12 critical peak pricing (CPP) events on 12 unscheduled summer Conservation Days. Of the nearly 200 customers who agreed to participate, about 20% signed up for RPEV1, and about 80% signed up for RPEV2. Sixty of the RPEV2 participants were given communicating charging stations, or "EV supply equipment" (EVSE), designed with direct load control (DLC) capabilities, allowing SMUD to reduce the charging rate to 1.4 kW during Conservation Day peak periods, creating a total of three study groups or "treatment groups" as follows:

- Treatment Group 1 (TG1) on the whole-house TOU pricing plan (RPEV1).
- Treatment Group 2 (TG2) on the EV-only TOU-CPP pricing plan (RPEV2).
- Treatment Group 3 (TG3) on the EV-only TOU-CPP pricing plan (RPEV2) with DLC.

Due to the limited number of EV drivers in the SMUD service territory at the time of recruitment, some of the load impact evaluation subgroups are small and cannot be considered externally valid. As a result, the following findings should be used with caution.

1. **The TOU rates elicited statistically significant peak period demand reductions.** Average savings during the winter peak period (4-10pm) ranged from 0.26 kW to 0.50 kW (Figure 1). Overall, 94% of RPEV2 charging occurred during the off-peak period (Table 44).

FIGURE 1. WINTER DEMAND IMPACTS



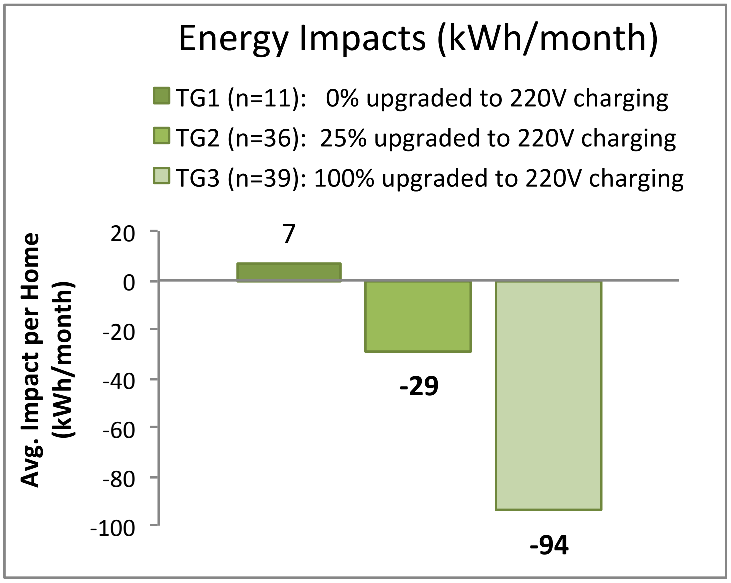
Statistically significant results in bold (α=0.05)

2. **The CPP event impacts were statistically equivalent to the TOU peak impacts.** The lack of incremental savings is likely due to programming of the EVs to charge off peak every day, obviating the effect of the CPP events.

3. **Event impacts for the group with smart EVSEs were statistically equivalent to those without smart EVSEs.** Again, this lack of differentiation may be due to programming of the EVs to avoid the TOU peak price every day, obviating the effect of DLC on event days.

4. **Level 2 charging appears to have saved energy relative to Level 1.** For all three groups, winter energy savings are roughly proportional to the fraction of participants that upgraded to the faster and more efficient level 2 charging at the beginning of the study (Figure 2).

FIGURE 2. MONTHLY ENERGY IMPACTS, WINTER RESULTS



Statistically significant results in bold (α=0.05)

Based on these findings, the authors recommend the following:

- Offer TOU or TOU-CPP rates to EV owners.
- Do not offer a free EVSE to control loads of customers on a TOU-CPP rate without further study.
- Conduct vigorous testing of communicating technologies before implementation.
- **Determine existing EV charging patterns in the SMUD service territory.**

Suggested questions for further research include:

- Does the CPP demand charge encourage daily TOU off-peak charging?
- Can smart EVSEs provide effective DLC load management under different incentive structures?
- How can we effectively encourage customers to program their EVs to charge off peak?

1. EV INNOVATORS - INTRODUCTION

SMUD's Smart Sacramento Project Execution Plan described plans for the implementation of a residential pilot to investigate advanced or "smart" electric vehicle supply equipment (EVSE). The Plan indicates that the pilot will pursue three objectives: (1) test time-based rate options; (2) measure electricity use and maximum load; and (3) test the smart EVSE with the DRMS to confirm functional interoperability.

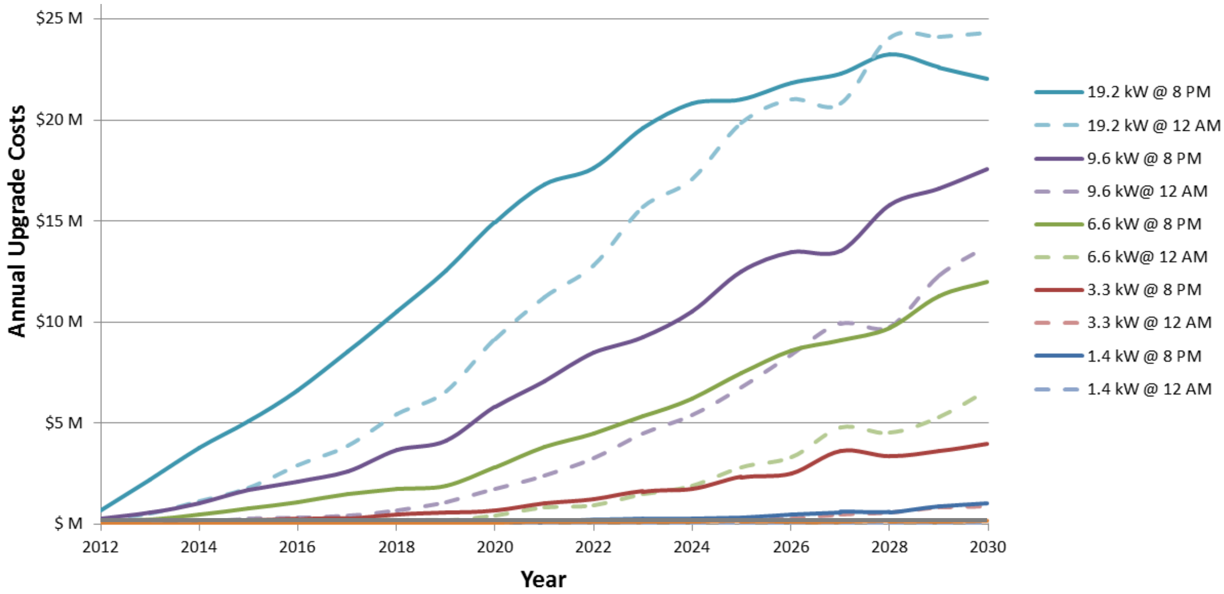
The primary purpose of the EV Innovators pilot was not load research. Rather the pilot was designed to meet the implementation requirements of the grant provided to SMUD through the American Recovery and Reinvestment Act. In this context, EV load research was a secondary goal that was directed and limited by the implementation requirements. This and other factors led to a relatively small number of pilot participants with the 2012 pre-treatment EV charging load data that was needed to construct a baseline. Thus, despite a sufficient number of enrollees in the pilot, the load impact evaluation subgroups were in some cases too small to consider externally valid. As a result, these findings should be used with caution.

PROBLEM STATEMENT

Electric vehicle charging has the potential to be costly to SMUD and their customers – particularly if charging occurs during system peak hours, when wholesale power costs more. EV charging during peak times can also bring about infrastructure costs, through the early retirement of transformers overloaded by simultaneous air conditioning and EV charging loads, most likely to occur between 4 pm and midnight.

Figure 3 shows the annual costs to SMUD of transformer replacements and other system costs under several charging demand scenarios that assume 140,000 EVs in the SMUD service territory by 2030. In the worst-case scenario, shown by the solid blue line at the top, the annual costs associated with 19.2 kW EV charging is expected to exceed $15 million within 5 years. A more likely scenario of 6.6 kW average EV charge demand (consistent with a standard BEV charging load) shows a more gradual increase in annual costs to $12 million by 2030. SMUD further predicts that they can cut these annual costs in half, to just $6 million in 2030, simply by shifting the start time of the charge cycle from 8 pm to midnight.

FIGURE 3. SYSTEM COSTS FOR UNMODERATED RESIDENTIAL EV CHARGING



Source: SMUD

To reduce the likelihood of these scenarios, SMUD is hoping to implement pricing or programs that entice EVs to charge after midnight in the summertime, when AC loads are high and transformers are most vulnerable to overheating and failure, thereby substantially reducing system costs of transformer replacements.

As of March 2013, there were about 400 EV drivers in the SMUD service territory. By May 2014, this number had quadrupled to 1,600. SMUD's expectation is that EV saturation in the SMUD service territory will continue to climb quickly. Based on current projections, SMUD has 5 to 8 years to develop good solutions to avoid significant peak and transformer issues.

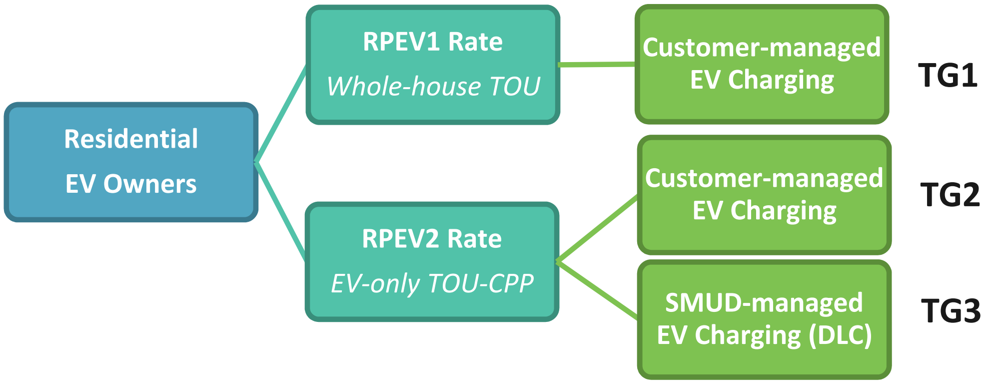
STUDY OVERVIEW

The EV Innovators pilot examined two solutions to the EV charging problem described above: (1) use time-varying rates to incentivize EV drivers to charge off peak every day and especially on Conservation Days, and (2) manage the EV charging for customers on Conservation Days. In addition to these main objectives, SMUD conducted market research to assess PEV driver preferences regarding charging hardware and rate options. A summary of this and other findings outside the load impact evaluation can be found in the *EV Innovators Pilot Program Summary*, available from SMUD.

STUDY DESIGN

Due to the limited number of EV drivers in the SMUD service territory at the time of the EV Innovators Pilot, only a few program options could be tested. The goal of the pilot was to solicit up to 180 residential EV drivers for two experimental time-varying rates – RPEV1 and RPEV2 – with roughly half of the RPEV2 participants being given communicating charging stations designed with direct load control (DLC) capabilities, allowing SMUD to reduce the charging rate to 1.4 kW during 12 unscheduled summer peak events. Between January and July of 2013, nearly 200 customers agreed to participate in one of three study groups, referred to in this report as treatment groups 1, 2 and 3 – or TG1, TG2, and TG3, respectively (Figure 4).

FIGURE 4. BASIC SAMPLE DESIGN



Participants were asked to choose their preferred treatment group. Upon application, participants were advised on which treatment group would potentially give them the most bill savings based on their lifestyle, miles driven, vehicle type and energy use. A fourth group of 14 EV owners charging at Level 1 (not shown in Figure 4) was recruited without an experimental rate for the sole purpose of collecting their EV load data. Including this fourth group, SMUD enrolled a total of 215 participants, of which 210 had sufficient load data for the load impact analysis (Table 1).

TABLE 1. EXPERIMENTAL DESIGN

Group	Rate	Rate type	Rate target	EVSE type	EVSE management	Other Incentive	Sample size
TG1	RPEV1	TOU	Home	Level 1	Customer	None	39
TG2	RPEV2	TOU-CPP	EV only	Level 1 or 2	Customer	Submeter	97
TG3	RPEV2	TOU-CPP	EV only	Level 2	SMUD	Dedicated Circuit + Submeter + EVSE	60
Data	RTEV	TOU	EV only	Level 1	Customer	Dedicated Circuit + Submeter	14
Total							210

Treatment Group 1 (TG1) was comprised of participants charging at 110V (Level 1) on the whole house TOU rate (RPEV1), which did not require the installation of equipment. EV customers that charged at 220V (Level 2) were prohibited from participation in TG1. When recruitment launched, TG1 participants did not receive any incentive to participate beyond the rate.

Treatment Group 2 (TG2) participants were on the RPEV2 rate with the self-managed charging during Conservation Day events. TG2 was comprised of 93 customers with 220V Level 2 EVSEs, and just 4 participants who charged at a maximum of 110V. As a participation incentive, SMUD installed a submeter socket box and an EV submeter (where not already present) on an existing dedicated circuit at no cost to the customer.

Treatment Group 3 (TG3) was comprised entirely of participants with 220V (Level 2) smart EVSEs with SMUD-managed load control during Conservation Day events. The smart EVSE incorporated a Zigbee radio that receives a load control signal from the smart meter on Conservation Days to reduce charging to 1.4kW during the peak period. Customers were able to override this load reduction at any time. As a participation incentive, SMUD installed a dedicated circuit, submeter socket box, an EV submeter (where not already present) and a smart EVSE at no cost to the customer. This offer was limited to the first 60 participating customers.

Note that customers with the Tesla roadster or model S could not enroll in TG3 due to technical challenges with the CPP demand limiting, thus all Tesla owners in this study participated in TG2.

SCHEDULE

Table 2 outlines the major phases of project activity and corresponding research tasks.

TABLE 2. EV PILOT SCHEDULE

Task	Dates	Activities
Field Study Preparation	Jun 2012 – Jan 2013	• Design rates • Collect lists of EV drivers • Prepare recruitment and educational materials • Prepare IT and billing
Recruitment	Jan 2013 – Jul 2013	• Recruitment • Mail information to interested customers • Create and maintain participant database
Field Study	Jun 2013 – Jan 2014	• Notify participants of events (Table 9)

IMPLEMENTATION

RECRUITMENT AND INSTALLATION

To recruit EV owners for the EV Innovators pilot, SMUD invited existing RTEV customers by email and promoted the pilot on the EV web site at www.smud.org/pev. Marketing efforts started in January 2013 and continued through July 16, 2013. Eligible customers were enrolled on a first-come basis for the treatment group in which they expressed interest.

All pilot participants received an incentive for their participation. The first wave of incentives included the provision and installation of submeters and smart EVSEs, as shown in Table 3. In March 2013, enrollments began to slow for TG1 and TG2, so additional incentives were provided. TG3 filled quickly without additional incentives. A second wave of incentives was offered in April 2013. TG1 participants were then offered a convenience cord-set for Level 1 charging, and TG2 participants with an existing submeter were offered a $599 rebate for pilot enrollment. Incentives were provided to all participants, including those who had already enrolled.

TABLE 3. EV INNOVATORS PARTICIPATION INCENTIVES

Group	Incentive	Installations	Max paid by SMUD (per participant)	Average cost (per participant)
Data	Dedicated 120V circuit, EV meter socket box	19	$1,600	$1,395
TG2	EV meter socket box	71	$600	$725
TG3	Dedicated 240V circuit, EV meter socket box, Smart EVSE	60	$1,600	$1,479

SURVEYS

SMUD collected responses to five surveys during the study period:

- Pre-pilot survey
- Post-installation survey
- Summer survey
- Winter survey
- Conjoint survey

The Pre-pilot, Summer, Winter, and Conjoint surveys were sent to all participants, while the Post-installation-survey was sent to treatment group 3 (TG3) participants only. The Conjoint survey was also sent to a group of selected EV owners in the SMUD service territory plus a selection of non-EV drivers who qualified as prospective EV drivers in the near future.

ELECTRICITY RATES

When recruitment efforts began in January 2013, electric vehicle drivers had the option to remain on the standard 2-tier residential rate (Table 4) or to sign up for the RTEV rate, a now retired TOU rate that applied only to the electricity used for EV charging (Table 5).

TABLE 4. 2013 STANDARD 2-TIER RESIDENTIAL RATE

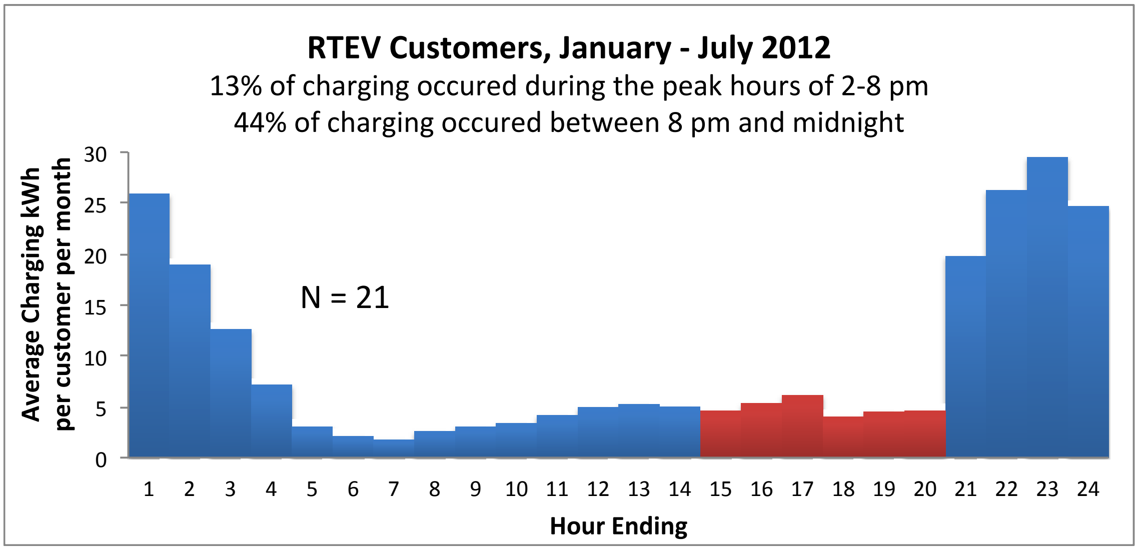
Season	Rate Period	Criteria	Standard (per kWh)
Winter	Base Usage	≤ 620 kWh	9.11 ¢
	Base Plus	> 620 kWh	17.38 ¢
Summer	Base Usage	≤ 700 kWh	9.89 ¢
	Base Plus	> 700 kWh	18.03 ¢

TABLE 5. 2013 RTEV RATE (NO LONGER OFFERED)

Season	Rate Period	Time Period	RTEV (per kWh)
Winter	On-Peak	Non-Holiday Weekdays 7-10 am and 5-8 pm	11.20 ¢
	Off-Peak	All other hours	7.94 ¢
Summer	On-Peak	Non-Holiday Weekdays 2-8 pm	24.41 ¢
	Off-Peak	All other hours	8.80 ¢

Figure 5 shows that the average monthly EV charging kWh for customers on the RTEV rate increased abruptly at 8 pm when the price of electricity on the RTEV rate dropped. As discussed previously, an 8 pm charging start time was predicted to incur high transformer replacement costs relative to a midnight charging start time (Figure 3). As a result, the RTEV rate was retired on January 1, 2014.

FIGURE 5. HOURLY EV CHARGING LOADS FOR CUSTOMERS ON THE RTEV RATE, JANUARY – JULY 2012



To prepare for the transition away from the RTEV rate, SMUD developed two experimental rates to test the effectiveness of time-based rates for encouraging off-peak charging: RPEV1 and RPEV2 (Table 6). Both rates incorporate a 4 pm to 10 pm winter peak; however, the two rates differ in the timing of their summer peak period, with RPEV1 ending at 10 pm and RPEV2 ending at midnight, as shown in Table 6 and Table 7. All RTEV customers participating in this study were encouraged to switch to the RPEV2 rate.

TABLE 6. RPEV1 SMART CHARGING RATES

Season	Rate Period	Days*	Applies to	RPEV1	
				Time	*$/kWh*
SUMMER	**Super Peak**	Weekdays	All home & EV kWh	4pm - 7pm	$ 0.2730
	On Peak	Weekdays		2pm - 4pm 7pm - 10pm	$ 0.1470
		Weekends & Holidays		2pm - 10pm	
	Off Peak	All other hours		All other hours	$ 0.0830
WINTER	**On Peak**	Daily	All home & EV kWh	4pm - 10pm	$ 0.1300
	Off Peak	All other hours		All other hours	$ 0.0740

* Note that "weekdays" do not include holidays.

TABLE 7. RPEV2 SMART CHARGING RATES

Season	Rate Period	Days	Applies to	RPEV2	
				Time	*$/kWh*
SUMMER	**Super Peak**	Non-event days	All EV kWh	4pm - 7pm	$ 0.4260
	On Peak	All days		2pm - 4pm 7pm - 12am	$ 0.3000
	Off Peak			All other hours	$ 0.0600
	Critical Peak	Event Days	EV kWh >2 kWh/h	2pm - 12am	$ 3.5000
WINTER	**On Peak**	All days	All EV kWh	4pm - 10pm	$ 0.1300
	Off Peak			All other hours	$ 0.0600

The RPEV1 rate was designed for Level 1 charging and applies to the whole house. Customers on the RPEV1 rate do not need an EV sub-meter or an EVSE, so entry costs are very low. To save money, RPEV1 customers can charge their EV and use other electric appliances in their home at an off-peak rate of 8.3¢/ kWh in the summer and 7.4¢/ kWh in the winter.

The RPEV2 rate was designed for Level 2 charging and applies only to the EV loads, meaning an EV sub-meter must be installed at the premises. To save money, RPEV2 customers can charge their EV at an off-peak rate of 6.0¢/kWh in both the summer and winter seasons. The RPEV2 rate also incorporates a dynamic demand charge, which SMUD dispatched 12 times during the summer of 2013. During critical peak events, which began at 2 pm and ended at midnight, those on the RPEV2 rate were charged $3.50/kWh for any EV charging demand averaging more than 2 kWh in any given hour.

The pricing plans were originally created with the intent to be in effect for 36 months from the beginning of the pilot (January 1, 2013) or until fully adopted by the SMUD Board of Directors. For more on the RPEV rates see SMUD's *Rate Policy and Procedures Manual, Rate Pilot 12-02*.

At the end of the study, participants remained on the RPEV rates.

EV CHARGING

All EVs come with the ability to schedule charging. EV owners have a choice of two voltage levels for charging electric vehicles, where higher voltage levels support faster vehicle charging.

- All plug-in electric vehicles come with a 120-volt convenience charger – an 18-foot cord with the SAE J1772 connector at one end and a 120V plug at the other. These Level 1 convenience chargers can be purchased through the car dealers for around $500.
- EV drivers wanting a faster charge can install a dedicated 240-volt circuit (up to 80 amps) and Level 2 charging station in their garage, costing anywhere from $1,200 to $3,000 including installation.

A customer using a Level 1 charger on a 15-amp circuit would require about 10 hours to charge a fully depleted 15 kWh battery, while use of a Level 2 charger on a 30-amp circuit would charge the same battery in less than 3 hours.

LOAD CONTROL TECHNOLOGY

Participation in the RPEV2 rate for TG2 and TG3 required the installation of an EV submeter. SMUD installed submeters, as needed, along with up to $600 to cover the cost of installation. Participants who signed up for the SMUD-managed charging option (TG3) were additionally required to accept a free Zigbee-enabled Level 2 EVSE and installation from SMUD. SMUD paid up to $1,600 for the installation of this hardware plus a submeter.

On normal days, the smart EVSE units carried a maximum charge of 30 amps at 240 volts, for a total demand of 7.2 kW. On event days, the smart EVSEs received an event signal through SMUD's AMI network initiating a load reduction to a Level 1 equivalent of 1.4 kW during the On Peak and Super Peak periods, from 2 pm to midnight.

If a TG3 participant dropped out before the end of study period, SMUD repossessed the smart EVSE and range extender, if one was installed. TG2 and TG3 participants kept the submeter socket box since it was a semi-permanent component in the electrical system.

Although the TG3 smart EVSEs were designed to be compatible with SMUD's planned demand response management system (DRMS), the EVSE-signaling module of the DRMS was not yet functional at the time of this pilot. Additional problems arose in connecting the EVSE with the submeter using Zigbee to enable DLC during events, resulting in less than half of the TG3 EVSEs being notified on event days. This was a significant interoperability issue that SMUD, the EVSE manufacturer and the Zigbee radio supplier attempted to solve for several months.

2. EV INNOVATORS - DATA

EVALUATION PERIOD

The summer pretreatment period for the EV Innovators pilot spans from July 1, 2012 to September 30, 2012, while the winter pretreatment period spans from October 1, 2012 to January 31, 2013. The summer treatment period starts on July 1, 2013 and ends on September 30, 2014, while the winter treatment period starts on October 1, 2013 and ends on January 31, 2014.

Table 8 provides the dates for which hourly load and temperature data were collected.

TABLE 8. EVALUATION PERIOD START AND END DATES

Evaluation period	Start date	End date
Pretreatment	7/1/12	1/31/13
Treatment	7/1/13	1/31/14

EVENTS

The RPEV1 tariff did not involve any events. The RPEV2 tariff involved 12 events as shown in Table 9. These events coincided with the 12 Conservation Days called for the 2013 Smart Pricing Options tariff. On the day before chosen event days, SMUD notified TG2 and TG3 participants of the impending event via email, SMS text messaging, and telephone, as chosen by each participant in the Participation Agreement.

TABLE 9. EVENT DATES AND TEMPERATURES

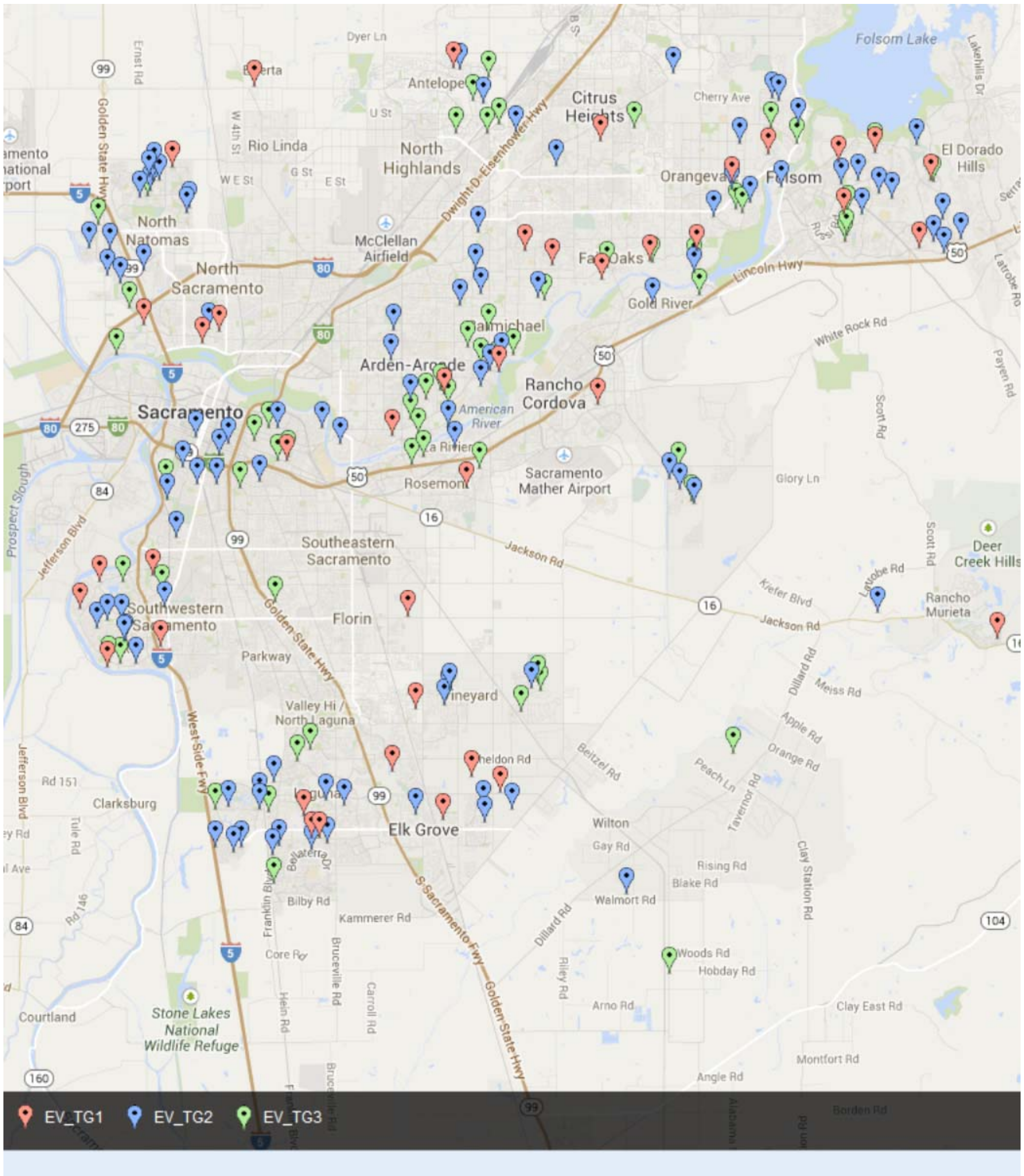
Date	Day of the Week	Minimum Temperature	Maximum Temperature
6/28/14	Friday	67°F	104°F
7/2/13	Tuesday	74°F	103°F
7/3/13	Wednesday	69°F	105°F
7/19/13	Friday	59°F	100°F
8/15/13	Thursday	62°F	95°F
8/19/13	Monday	71°F	102°F
9/6/13	Friday	55°F	92°F
9/9/13	Monday	61°F	100°F
9/10/13	Tuesday	63°F	88°F
9/13/13	Friday	60°F	92°F
9/19/13	Thursday	53°F	90°F
9/30/13	Monday	60°F	78°F

Event days were determined one day in advance based on the predicted maximum temperature for the following day. In general, events were triggered by a predicted maximum temperature that exceeded 95°F. As the summer progressed, it became apparent that this threshold would not deliver the 12 events required by the tariff, so several events were called in September on days with predicted highs well below the threshold 95°F.

PARTICIPANT LOCATIONS

The location of treatment group homes are mapped in Figure 6, with TG1 in red, TG2 in blue, and TG3 in green. The reasonably even distribution provides evidence that a strong geographic bias is not present.

FIGURE 6. MAP OF PARTICIPANTS BY TREATMENT



PARTICIPANTS AND THEIR EVS

Table 10 provides the number of EVs in each model year. Note that nearly half of participants purchased their EVs in 2013. This factor plays a significant role in the final sample sizes for the summer and winter load impact analyses, since the baseline was constructed using load data of just 23 participants who had purchased their EVs prior to the summer of 2012.

TABLE 10. PARTICIPATING EV MODEL YEARS

Model Year	Number of EVs
2003	1
2008	1
2011	33
2012	74
2013	101
Total	**210**

Table 11 provides the number of EVs by model. All participating vehicles are either plug-in hybrids (PHEVs) or battery electric vehicles (BEVs). Nearly half of the EVs in the study are Nissan Leafs, and about one-quarter are Chevy Volts. Combined models denote multiple-EV households. For detailed information on each EV model, see Appendix G.

TABLE 11. PARTICIPATING EV MODELS

Make	Model	EV Type	Data	TG1	TG2	TG3	Total
NISSAN+CHEVY	**Leaf+Volt**	--	0	0	0	1	1
BMW	**Active E**	BEV	0	0	1	0	1
FORD	**C Max Energi**	PHEV	1	2	1	0	4
CODA	**Sedan**	BEV	0	0	1	0	1
HONDA	**Fit EV**	BEV	0	1	1	0	2
FORD	**Focus EV**	BEV	2	1	5	4	12
FORD	**Fusion Energi**	PHEV	1	2	2	0	5
NISSAN	**Leaf**	BEV	2	16	46	39	103
TESLA	**Model S**	BEV	0	0	17	0	17
TOYOTA	**Prius Plug-In**	PHEV	2	4	2	0	8
TOYOTA	**Prius Plug-In x2**	--	0	1	0	0	1
TOYOTA	**RAV4 EV**	BEV	0	0	1	1	2
TOYOTA+TESLA	**RAV4 EV+Model S**	--	0	0	1	0	1
TESLA	**Roadster**	BEV	0	0	1	0	1
CHEVY	**Volt**	PHEV	6	12	18	15	51
Total			14	**39**	**97**	**60**	**210**

* PHEV = Plug-in Hybrid EV; BEV = Battery EV; EREV = Extended Range EV

LOAD DATA

WHOLE-HOUSE LOAD DATA

For all participants in the EV Innovators pilot, SMUD provided hourly electric load data for the whole house. These load values represented the combined house and EV (HOUSE+EV) loads. Figure 7 and Figure 8 plot the average House+EV loads for summer 2013 and winter 2013-14, respectively. Note that all hours for all days are included in these averages, including those hours for which electric demand was zero.

FIGURE 7. ACTUAL SUMMER 2013 HOUSE+EV LOADS

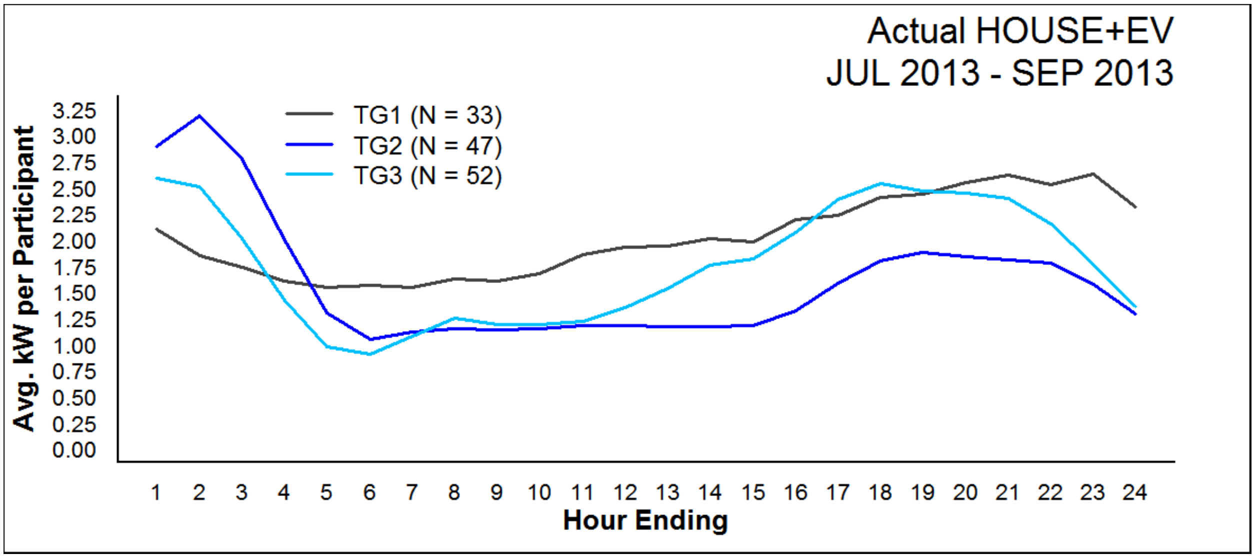
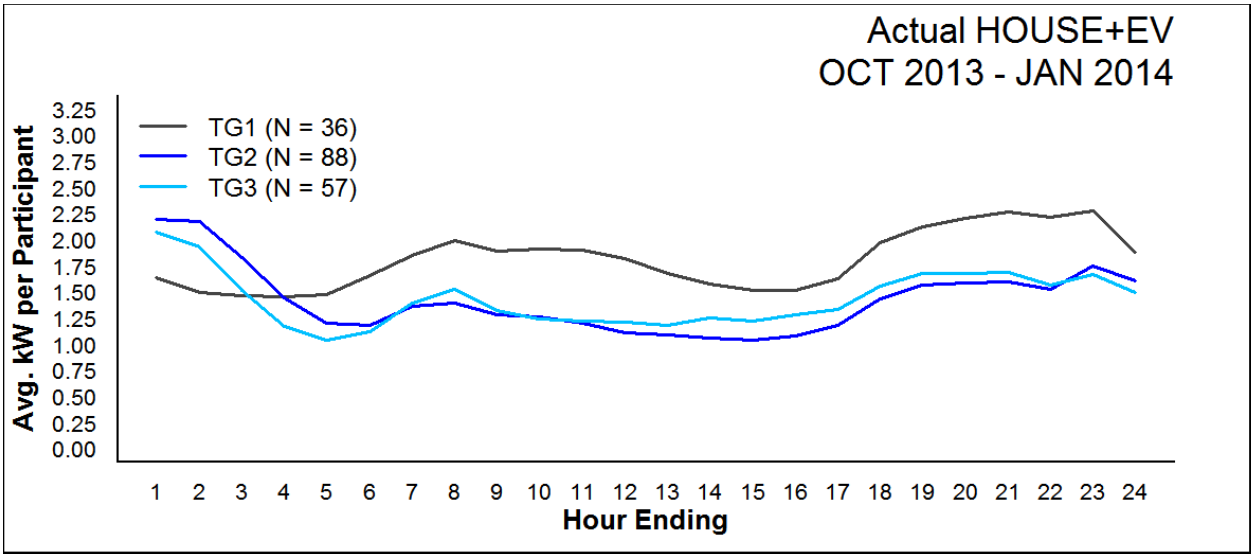


FIGURE 8. ACTUAL WINTER 2013 HOUSE+EV LOADS



EV SUBMETER LOAD DATA

Figure 9 and Figure 10 plot the average EV-only loads for summer 2013 and winter 2013-14, respectively. Note that EV submetered loads are unavailable for TG1 participants, who were not provided with EV submeters. Note that all hours for all days are included in these averages, including those hours for which electric demand was zero.

FIGURE 9. ACTUAL SUMMER 2013 EV LOADS

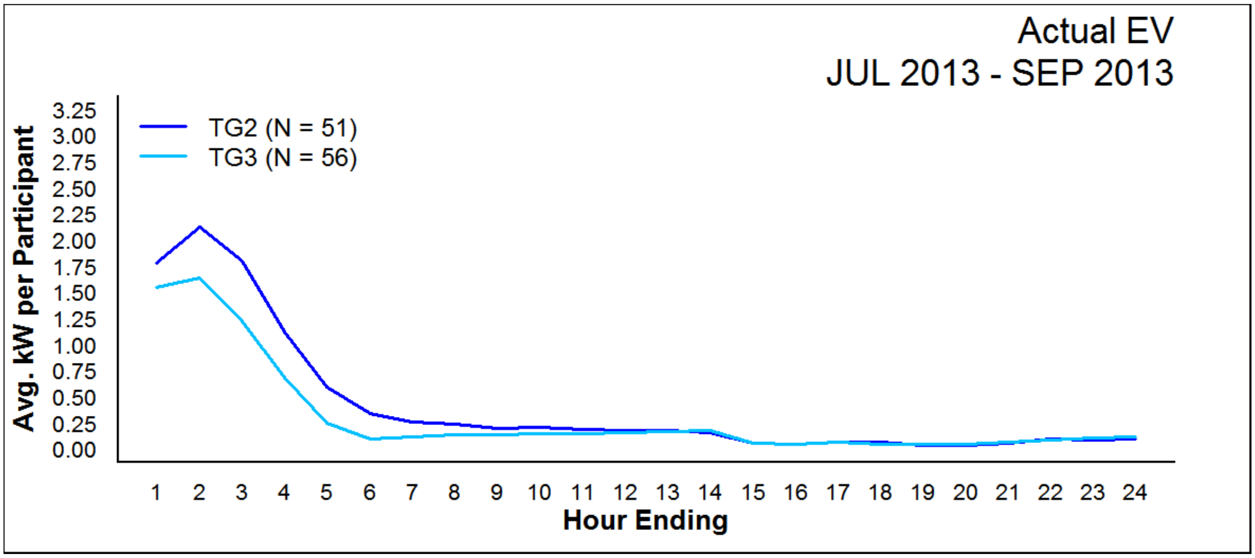
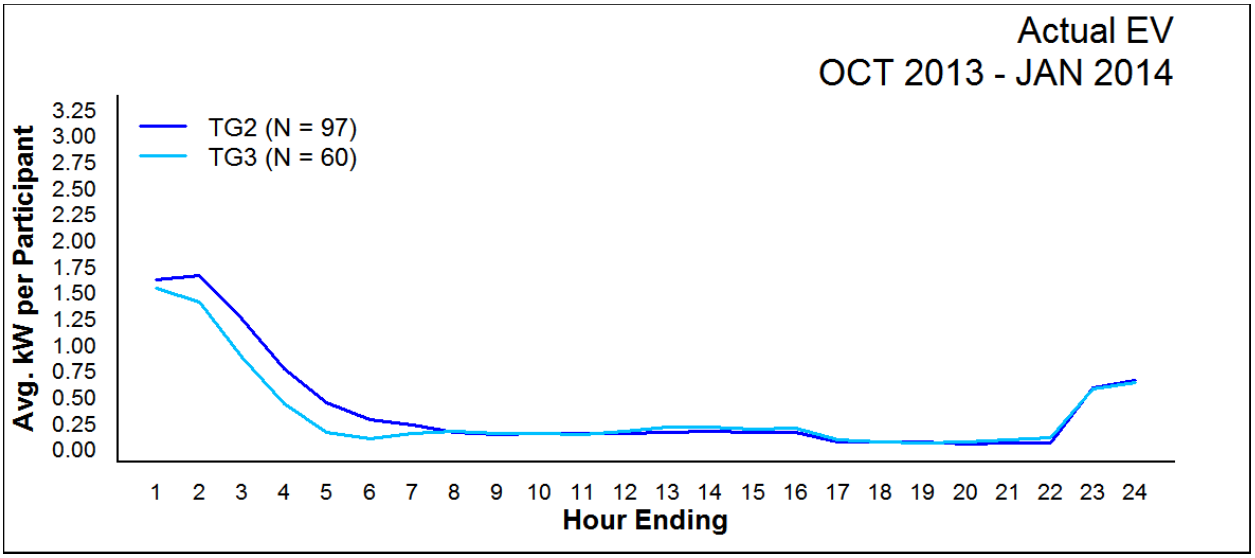


FIGURE 10. ACTUAL WINTER 2013 EV LOADS



TEMPERATURE DATA

Hourly temperature data were downloaded for ten weather stations in the SMUD service territory (Figure 11). To ensure as-accurate-as-possible outdoor temperatures, participants were each assigned to the data recorded at the station closest to their home.

FIGURE 11. WEATHER STATIONS USED FOR LOAD IMPACT EVALUATION

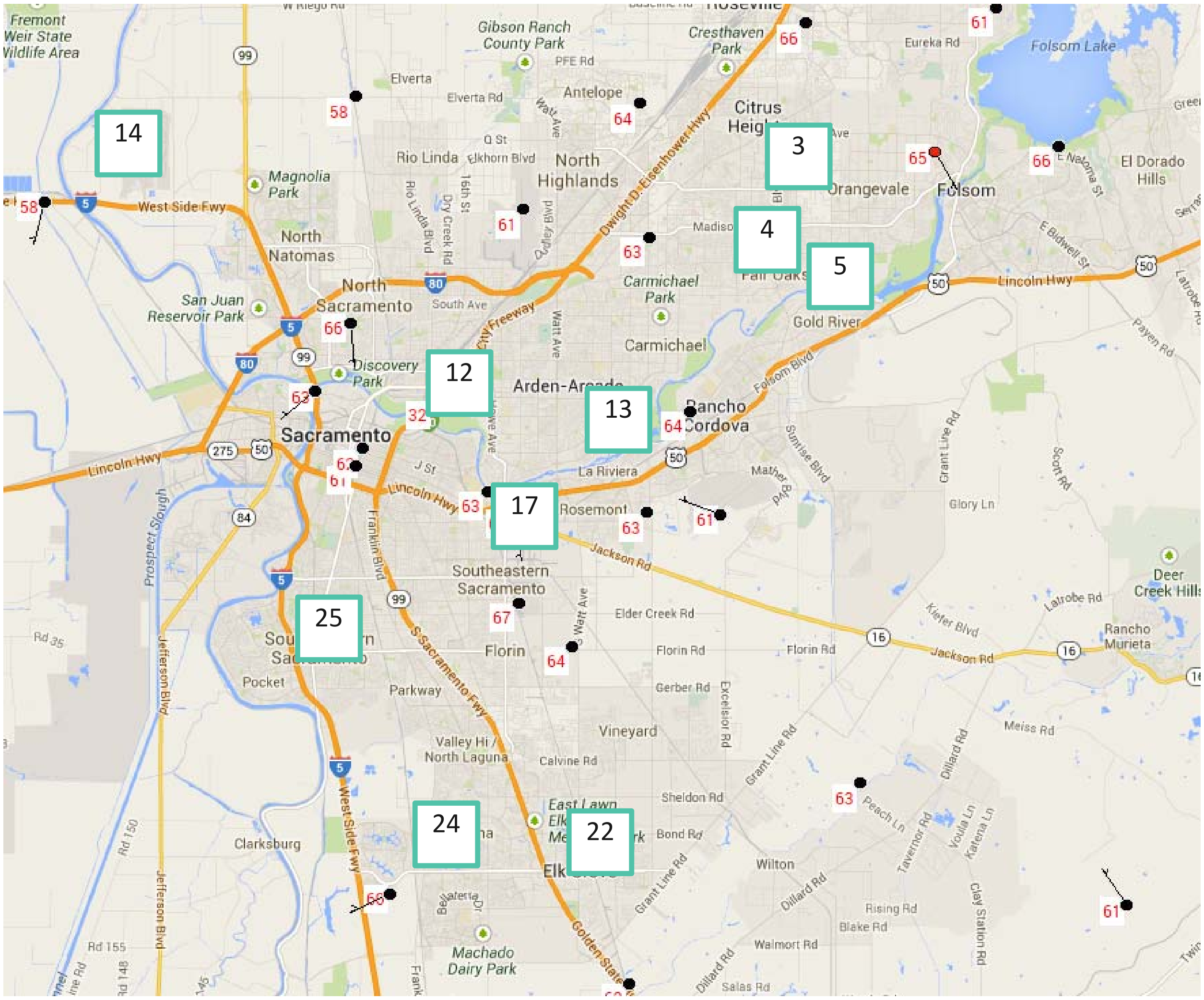


Figure 12 plots the average hourly summer temperatures at each of the 10 weather stations used in this analysis. Note that there are visible differences in temperatures across stations due to local microclimates, thus justifying the multiple-station approach.

FIGURE 12. AVERAGE HOURLY TEMPERATURE READINGS, BY STATION, SUMMER 2013

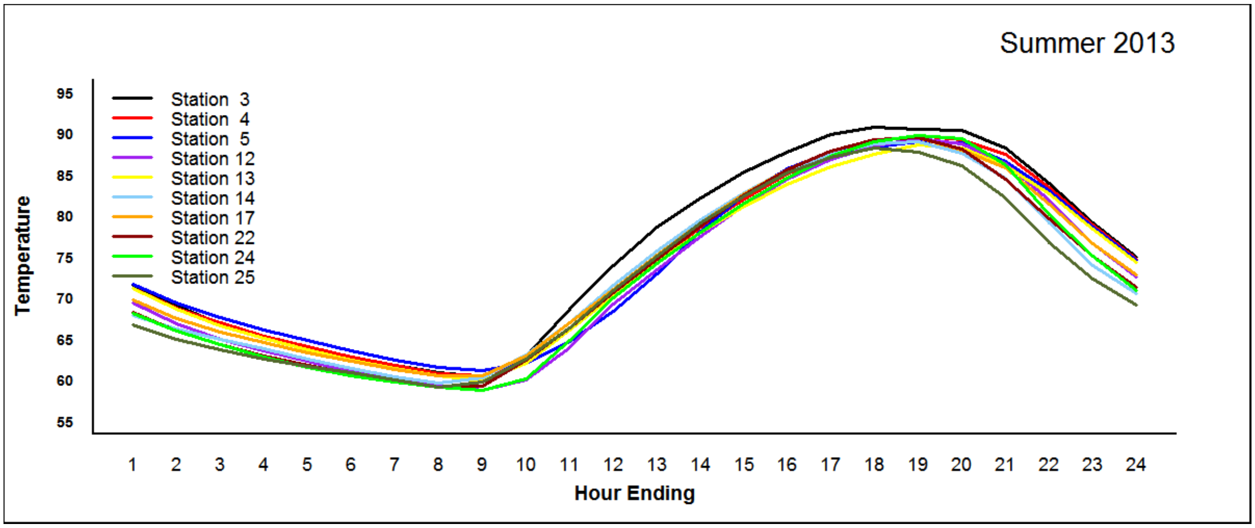
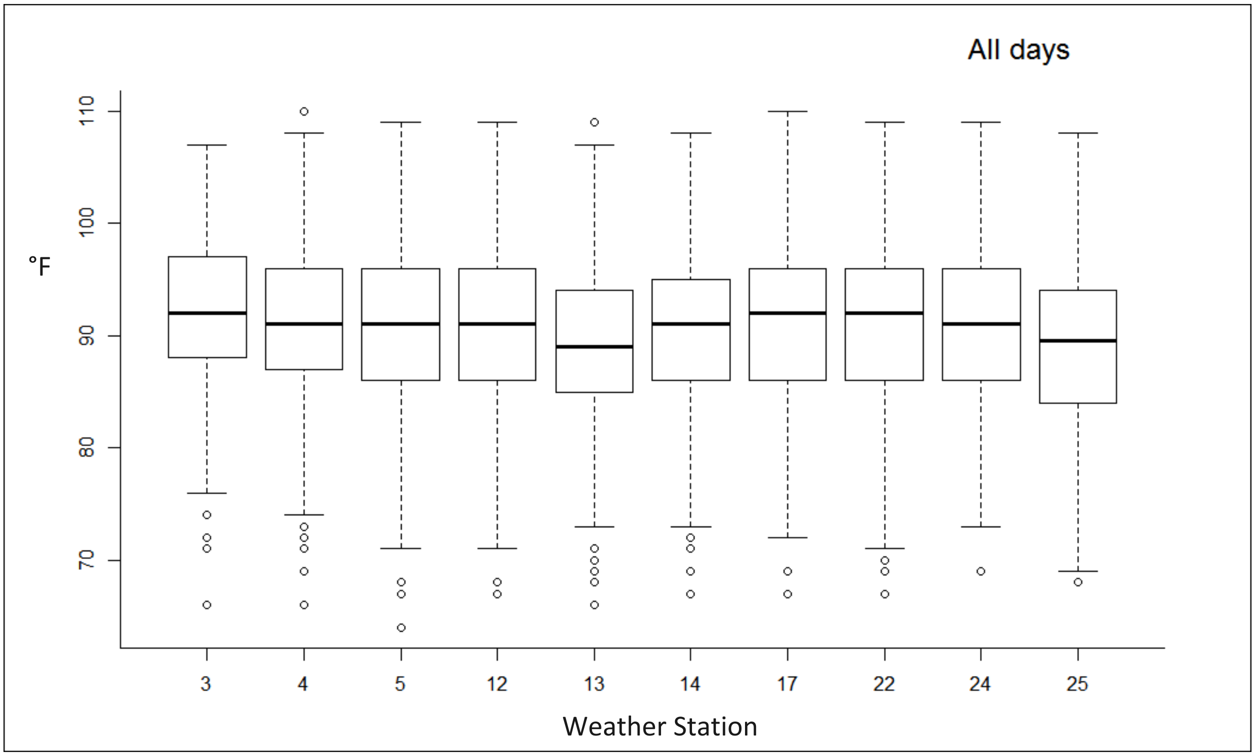


Figure 13 provides the distribution of hourly peak temperature measurements at each weather station for the summer of 2013, with the centerline of each box indicating the median, and the bottom and top edges of the boxes the first and third quartiles, respectively. Whiskers extend to the most extreme data point that is no more than 1.5 times the interquartile range. All points beyond the whiskers are outliers.

FIGURE 13. BOXPLOTS OF HOURLY TEMPERATURE READINGS, BY STATION, SUMMER 2013



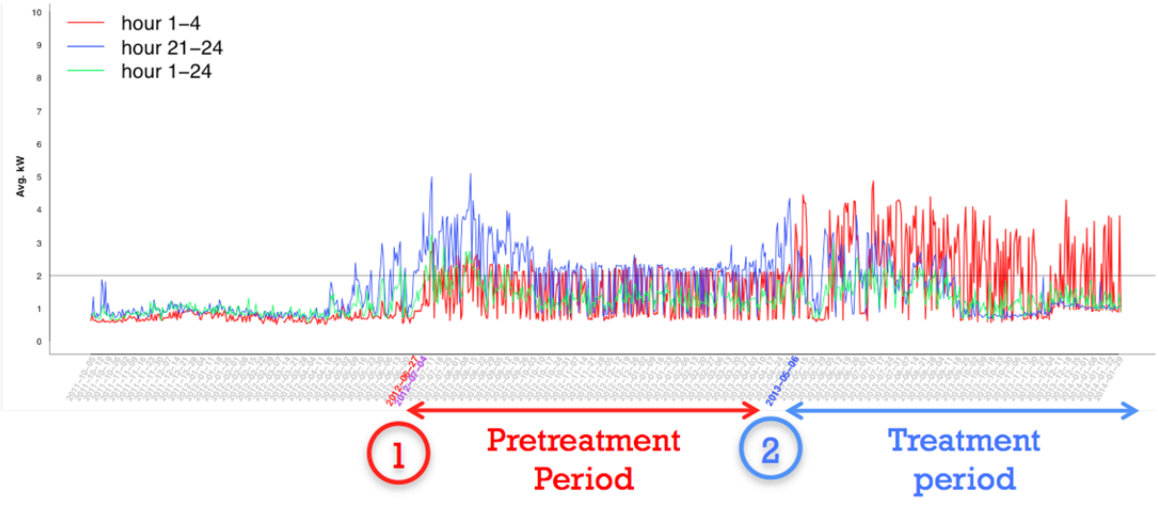
3. ANALYSIS AND RESULTS

APPROACH

Data collected from the field study were analyzed to determine whether the RPEV1 and RPEV2 rates shifted a significant portion of charging loads out of the peak period on Conservation Days (event days) and nonevent days as follows.

1. **Non-event days.** First, hourly whole-house loads (Figure 14) were visually examined to estimate the purchase date of each EV and thus the pretreatment start date for each participant. This value was checked against the EV purchase dates provided by survey respondents and corrected where applicable. In all cases, the RPEV rate start date was selected as the end of the pretreatment period and the beginning of the treatment period.

FIGURE 14. DETERMINATION OF PRETREATMENT AND TREATMENT PERIODS USING WHOLE-HOUSE LOADS



After determination of the pretreatment and treatment periods, nonevent load impacts were calculated separately for summer and winter, using the following approach:

   a. <u>Winter impacts</u> were calculated as the difference between average October 2013 - January 2014 treatment period loads and a weekday baseline constructed from October 2012 - January 2013 pretreatment load data. A total of 86 participants had the baseline and treatment data needed for the winter analysis.
   b. <u>Summer weekday impacts</u> were calculated as the difference between average July-September 2013 weekday loads and a weekday baseline constructed from July-September 2012 loads corrected for hourly outdoor temperatures. Note that June was omitted to keep sample sizes as high as possible, given that so few customers had purchased their EV before July 2012. A total of 23 participants had the baseline and treatment data needed for the summer analysis.

2. **Conservation Days.** Event impacts were calculated as the difference between the average EV submeter loads from July through September 2013 and a baseline constructed from July through September 2013 non-event weekday EV loads corrected for hourly outdoor temperatures. This analysis applied to TG2 and TG3 only, because TG1 participants were not exposed to events. Note that the event day called in June 2013 was excluded for consistency with the summer nonevent weekday analysis, which also excluded June data as discussed above.

The following sections provide the modeled loads and load impacts derived using this approach. For consistency and ease of comparison, all loads and impacts are presented in units of average kilowatt-hours per hour (kWh/h), abbreviated in most cases to kW, where positive impact values indicate an increase in energy use relative to the baseline, and negative impact values indicate savings. Note that these hourly kW values are easily converted to kWh through multiplication by the number of hours across the desired time period.

Table 12 summarizes the data and approach for the load impact evaluations.

TABLE 12. LOAD IMPACT EVALUATION DATA AND APPROACH

Analysis	Treatment Groups	Treatment Period	Baseline	Load Data
Winter	TG1, TG2, TG3	All days 10/1/13-1/31/14 Peak= 4–10 pm	EV purchase to treatment start	HOUSE+EV (modeled)
Summer	TG1, TG2, TG3	Weekdays 7/1/13-9/30/13 Super-peak = 4-7pm RPEV1 Peak = 2–4 pm, 7–10 pm RPEV2 Peak = 2–4 pm, 7 pm – 12 am	EV purchase to treatment start	HOUSE+EV (modeled)
Conservation Day CPP Events	TG2, TG3	Conservation Days	Non-event weekdays	- EV Submeter (actual) - HOUSE+EV (modeled)

SUMMER WEEKDAYS NULL HYPOTHESES

The following equations are the basis for the evaluation of summer weekday load impacts.

1. TREATMENT LOADS ARE NOT DIFFERENT FROM BASELINE LOADS (ADJUSTED FOR WEATHER AND EXOGENOUS EFFECTS)

$$H_0: \left(\mu_{(treat.event.House+EV)_i} - \mu_{(treat.nonevent.House+EV)_i}\right) - \left(\mu_{(treat.event.House)_i} - \mu_{(treat.nonevent.House)_i}\right) = 0$$

$$H_a: \left(\mu_{(treat.event.House+EV)_i} - \mu_{(treat.nonevent.House+EV)_i}\right) - \left(\mu_{(treat.event.House)_i} - \mu_{(treat.nonevent.House)_i}\right) \neq 0$$

$\mu_{treat.event.House+EV_i}$ = average participant HOUSE+EV loads during the event period for $treatment_i$

$\mu_{treat.nonevent.House+EV_i}$ = average participant HOUSE+EV loads during the nonevent period for $treatment_i$

$\mu_{treat.event.House_i}$ = average participant HOUSE loads during the event period for $treatment_i$

$\mu_{treat.nonevent.House_i}$ = average participant HOUSE loads during the nonevent period for $treatment_i$

2. TREATMENT TYPE HAS NO EFFECT ON IMPACTS (ADJUSTED FOR WEATHER AND EXOGENOUS EFFECTS)

$$H_0: \left[\left(\mu_{(treat.event.House+EV)_i} - \mu_{(treat.nonevent.House+EV)_i}\right) - \left(\mu_{(treat.event.House)_i} - \mu_{(treat.nonevent.House)_i}\right)\right] - \left[\left(\mu_{(treat.event.House+EV)_{i'}} - \mu_{(treat.nonevent.House+EV)_{i'}}\right) - \left(\mu_{(treat.event.House)_{i'}} - \mu_{(treat.nonevent.House)_{i'}}\right)\right] = 0$$

$$H_a: \left[\left(\mu_{(treat.event.House+EV)_i} - \mu_{(treat.nonevent.House+EV)_i}\right) - \left(\mu_{(treat.event.House)_i} - \mu_{(treat.nonevent.House)_i}\right)\right] - \left[\left(\mu_{(treat.event.House+EV)_{i'}} - \mu_{(treat.nonevent.House+EV)_{i'}}\right) - \left(\mu_{(treat.event.House)_{i'}} - \mu_{(treat.nonevent.House)_{i'}}\right)\right] \neq 0$$

$\mu_{treat.event.House+EV_i}$ = average participant HOUSE+EV loads during the event period for $treatment_i$

$\mu_{treat.event.House+EV_{i'}}$ = average participant HOUSE+EV loads during the event period for $treatment_{i'}$

$\mu_{treat.nonevent.House+EV_i}$ = average participant HOUSE+EV loads during the nonevent period for $treatment_i$

$\mu_{treat.nonevent.House+EV_{i'}}$ = average participant HOUSE+EV loads during the nonevent period for $treatment_{i'}$

$\mu_{treat.event.House_i}$ = average participant HOUSE loads during the event period for $treatment_i$

$\mu_{treat.event.House_{i'}}$ = average participant HOUSE loads during the event period for $treatment_{i'}$

$\mu_{treat.nonevent.House_i}$ = average participant HOUSE loads during the nonevent period for $treatment_i$

$\mu_{treat.nonevent.House_{i'}}$ = average participant HOUSE loads during the nonevent period for $treatment_{i'}$

SUMMER AND WINTER DAYS NULL HYPOTHESES

The following equations are the basis for the evaluation of summer and winter load impacts.

1. TREATMENT LOADS ARE NOT DIFFERENT FROM BASELINE LOADS (ADJUSTED FOR WEATHER AND EXOGENOUS EFFECTS)

$$H_0: \left(\mu_{(treat.House+EV)_i} - \mu_{(treat.baseline.House+EV)_i}\right) = 0$$
$$H_a: \left(\mu_{(treat.House+EV)_i} - \mu_{(treat.baseline.House+EV)_i}\right) \neq 0$$

$\mu_{treat.House+EV_i}$ = average participant HOUSE+EV loads during the treatment period for $treatment_i$

$\mu_{treat.baseline.House+EV_i}$ = average participant HOUSE+EV loads during the baseline period for $treatment_i$

2. TREATMENT TYPE HAS NO EFFECT ON IMPACTS (ADJUSTED FOR WEATHER AND EXOGENOUS EFFECTS)

$$\begin{aligned} H_0: & \left[\left(\mu_{(treat.House+EV)_i} - \mu_{(treat.baseline.House+EV)_i}\right)\right] - \\ & \left[\left(\mu_{(treat.House+EV)_{i'}} - \mu_{(treat.baseline.House+EV)_{i'}}\right)\right] = 0 \\ H_a: & \left[\left(\mu_{(treat.House+EV)_i} - \mu_{(treat.baseline.House+EV)_i}\right)\right] - \\ & \left[\left(\mu_{(treat.House+EV)_{i'}} - \mu_{(treat.baseline.House+EV)_{i'}}\right)\right] \neq 0 \end{aligned}$$

$\mu_{treat.House+EV_i}$ = average participant HOUSE+EV loads during the treatment period for $treatment_i$

$\mu_{treat.House+EV_{i'}}$ = average participant HOUSE+EV loads during the treatment period for $treatment_{i'}$

$\mu_{treat.baseline.House+EV_i}$ = average participant HOUSE+EV loads during the baseline period for $treatment_i$

$\mu_{treat.baseline.House+EV_{i'}}$ = average participant HOUSE+EV loads during the baseline period for $treatment_{i'}$

WINTER IMPACTS

This section considers the effect of the three treatments on daily winter loads. Like the summer load impact analysis, this analysis employs a three-level mixed-effects regression equation, with hours nested within days and days nested within participants, as shown in Equation 1.

EQUATION 1. WINTER MODEL EQUATION

$$kw_{ijk} =$$
$$\beta1_k hour_{ijk} + \beta2CDH_{ijk} + \beta3CDD_{ij} + \beta4HDH_{ijk} + \beta5HDD_{ij} + \beta6_{m-1}Treatment\_Period_m +$$
$$+\beta7_{(k-1):(m-1)}\left(hour_{ijk} * Treament\_Period_m\right) + r_i + r_{ij} + \varepsilon_{ijk}$$

kw_{ijk}: kilowatt load for customer i on day j at hour k
$hour_{ijk}$: indicator variable for hour of the day (1-24)
CDH_{ijk}: cooling degree hour for customer i on day j at hour k
CDD_{ij}: cooling degree day for customer i on day j
HDH_{ijk}: heating degree hour for customer i on day j at hour k. If Temperature < 65 for customer i on day j at hour k, then HDH for customer i on day j at hour k is 65 - Temperature; otherwise, HDH for customer i on day j at hour k is 0
HDD_{ij}: heating degree day for customer i on day j. (Sum of 24 HDH values)
$Treatment\_Period_m$: indicator variables for treatment and treatment period (TG1.baseline, TG1.treatment, TG2.baseline, TG2.treatment, TG3.baseline, TG3.treatment)
r_i: random effects for customer $\sim N(0, \varphi_1)$, assumed to be independent for different i
r_{ij}: random effects for day $\sim N(0, \varphi_2)$, assumed to be independent for different i or j and to be independent of r_i
ε_{ijk}: error terms $\sim N(0, \delta^2 I)$, assumed to be independent for different i or j and to be independent of random effects

Impacts were then calculated as the difference between the baseline and treatment loads as shown in Equation 2.

EQUATION 2. AVERAGE HOURLY IMPACT CALCULATION, BY TREATMENT

$EV\_impact\_kW_{tk}$ = $House+EV\_Treatment_{tk}$ – $House+EV\_Baseline_{tk}$

Where, for treatment t at hour *k*:

EV_impact_kW$_{tk}$ = average hourly EV impact
House+EV_Treatment$_k$ = modeled average hourly House+EV treatment demand
House+EV_Baseline$_{tk}$ = modeled average hourly House+EV baseline demand

Survey responses combined with an examination of individual customer loads between 2011 and 2013 detected 86 participants who had purchased their EVs prior to the winter of 2012-2013. These 86 homes were used to construct the baseline EV load shape and estimate the winter weekday impacts. Figure 15 plots the modeled treatment and baseline load shapes on winter days. Figure 16 plots the difference between the baseline and load shapes for each of the three treatment groups. Once again, large load increases are apparent in the early morning hours starting at midnight, and large reductions are seen in the first hour of the Super-peak period.

FIGURE 15. MODELED WINTER HOUSE+EV LOADS, BY TREATMENT

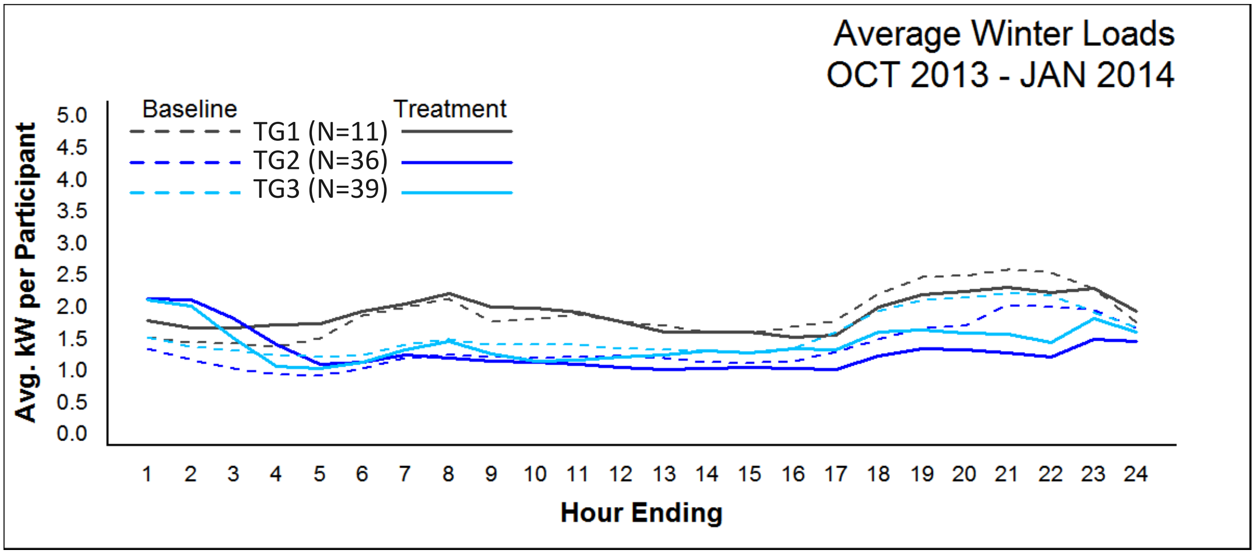


FIGURE 16. MODELED WINTER HOUSE+EV IMPACTS, BY TREATMENT

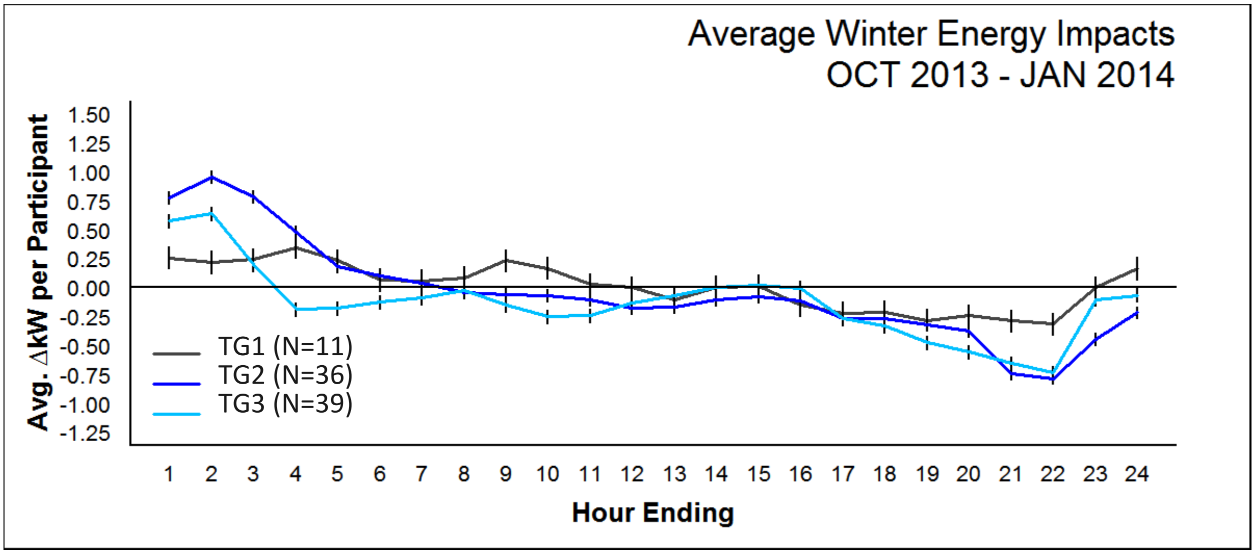


Table 13 shows the differences between the treatment and baseline load shapes. Values marked with an asterisk (*) indicate that the impact differs significantly from zero, and that the null hypothesis of the treatment being equal to the baseline load is rejected (α=0.05). Note that percent (%) impacts represent the percent change from whole-house loads, including but not limited to EV loads.

In winter, all three treatments show significant load reductions during the Peak period from 4 to 10 pm. As was the case for the summer analysis, in winter too participants in TG3 show a statistically significant energy savings – in this case 8.8% savings. This similar pattern strengthens the previous hypothesis that greater savings may have accrued to TG3 because all participants switched from Level 1 to the more efficient Level 2 charging. The smaller savings in TG2 reflects the smaller percentage (~25%) of participants that switched to Level 2 charging. None of the participants in TG1 switched to Level 2 charging.

Although the results are statistically significant, the small sample sizes, particularly for TG1, suggest caution in applying these results to program designs.

TABLE 13. WINTER PEAK IMPACTS

Group	N	Off Peak (Hours 1-16, 22-24) *kW (%)*	Peak (Hours 17-22) *kW (%)*	Daily Average (Hours 1-24) *kW (%)*
TG1	11	+0.10* (+6.1%)	-0.26* (-11%)	+0.01 (+0.7%)
TG2	36	+0.10* (+8.2%)	-0.46* (-28%)	-0.04* (-3.2%)
TG3	39	-0.01 (-0.8%)	-0.50* (-25%)	-0.13* (-8.8%)

* Statistically significant, α=0.05.

Table 14 shows the results of a contrast analysis, with values calculated as the difference between impacts. Peak impacts for TG2 and TG3 were statistically indistinguishable from each other, differing by only 0.04 kW – the difference between -0.46 and -0.50 from Table 13.

TABLE 14. WINTER BETWEEN-TREATMENT COMPARISONS

Contrast	Off Peak (Hours 1-16, 22-24)	Peak (Hours 17-22)	Total (Hours 1-24)
TG2 minus TG3	0.11*	0.04	0.09*

* Statistically significant, α=0.05.

SUMMER IMPACTS

This section considers the effect of the three treatments on summer weekday loads. The analysis employed a three-level mixed-effects regression equation, with hours nested within days and days nested within participants, as shown in Equation 4, to model baseline and treatment loads for participants with an EV in both the pretreatment and treatment periods.

EQUATION 3. SUMMER MODEL EQUATION

$$kw_{ijk} = \beta1_k hour_{ijk} + \beta2CDH_{ijk} + \beta3CDD_{ij} + \beta4_{m-1}Treatment\_Period_m + \beta5_{(k-1):(m-1)}(hour_{ijk} * Treament\_Period_m) + r_i + r_{ij} + \varepsilon_{ijk}$$

kw_{ijk}: kilowatt load for customer i on day j at hour k
$hour_{ijk}$: indicator variable for hour of the day (1-24)
CDH_{ijk}: cooling degree hour for customer i on day j at hour k
CDD_{ij}: cooling degree day for customer i on day j
$Treatment\_Period_m$: indicator variables for treatment and pretreatment/baseline period (TG1.baseline, TG1.treatment, TG2.baseline, TG2.treatment, TG3.baseline, TG3.treatment)
r_i: random effects for customer $\sim N(0, \varphi_1)$, assumed to be independent for different i
r_{ij}: random effects for day $\sim N(0, \varphi_2)$, assumed to be independent for different i or j and to be independent of r_i

ε_{ijk}: error terms $\sim N(0, \delta^2 I)$, assumed to be independent for different i or j and to be independent of random effects

The DID approach shown in Equation 2 was then used to estimate the EV impacts.

Survey responses combined with the examination of individual customer loads between 2011 and 2013 pinpointed just 23 participants who had purchased their EVs prior to the summer of 2012. These homes were used to construct the baseline EV load shape and estimate the summer weekday impacts. Due to the small sample sizes, these findings are not considered to be externally valid, and should be used with caution.

Figure 17 plots the modeled treatment and baseline load shapes on summer weekdays for each of the three treatment groups. Figure 18 plots the differences between the baseline and treatment load shapes. Visible particularly in Figure 18 are the large load increases in the early morning hours starting at midnight, and the large reductions in demand starting in the first hour of the Super-peak period (hour ending 17).

FIGURE 17. MODELED SUMMER WEEKDAY HOUSE+EV LOADS, BY TREATMENT

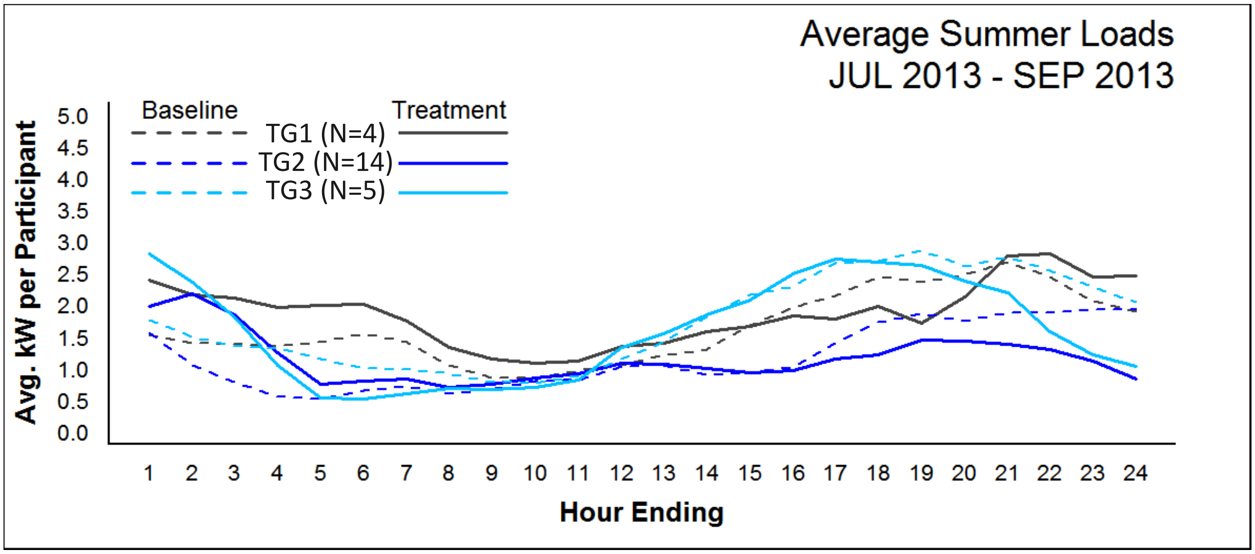


FIGURE 18. MODELED SUMMER WEEKDAY HOUSE+EV IMPACTS, BY TREATMENT

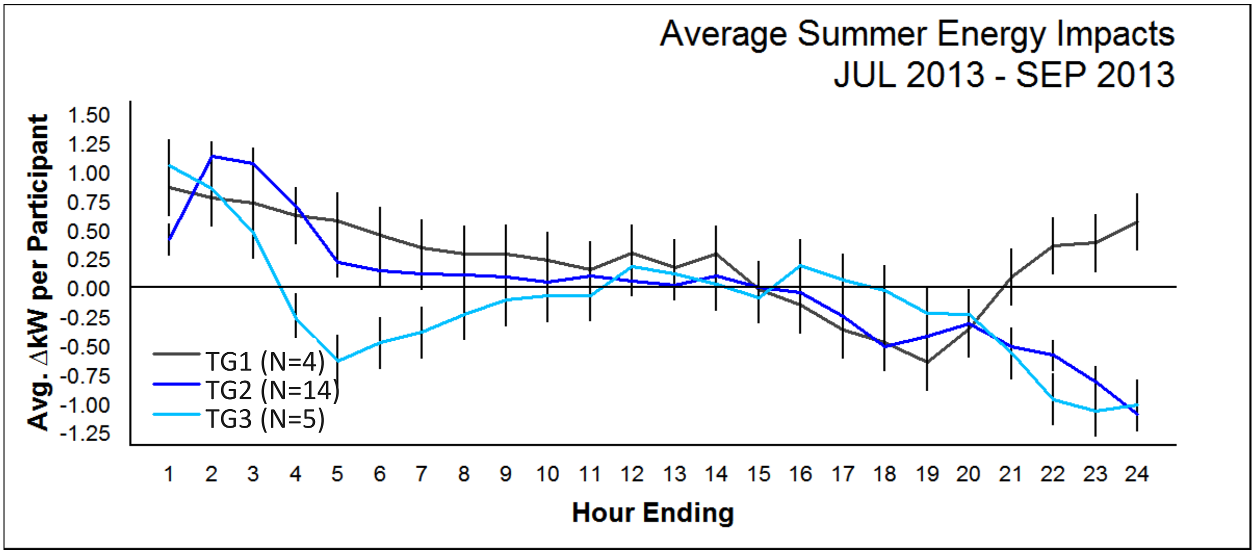


Table 15 (TG1) and Table 16 (TG2 and TG3) indicate that the differences between the treatment and baseline load shapes are statistically significant in most cases. Note that percent (%) impacts represent the percent change from whole-house loads.

Values marked with an asterisk (*) indicate that the impact differs significantly from zero, and that the null hypothesis of the treatment being equal to the baseline load is rejected (α=0.05). Although the results are statistically significant, the very small sample sizes in this case suggest caution in applying these results to program designs.[1]

TABLE 15. SUMMER IMPACTS, TG1

Group	N	Off Peak Hours 1-14 *kW (%)*	Peak Hours 15-16, 20-22 *kW (%)*	Off-Peak Hours 23-24 *kW (%)*	Super Peak Hours 17-19 *kW (%)*	Daily Average *kW (%)*
TG1	4	+0.44* (+35%)	-0.01 (-0.5%)	+0.48* (+24%)	-0.49* (-21%)	+0.23* (+14%)

* Statistically significant, α=0.05.

TABLE 16. SUMMER IMPACTS, TG2 AND TG3

Group	N	Off Peak Hours 1-14 *kW (%)*	Peak Hours 15-16, 20-22 *kW (%)*	Peak Hours 23-24 *kW (%)*	Super Peak Hours 17-19 *kW (%)*	Daily Average *kW (%)*
TG2	14	+0.31* (+37%)	-0.29* (-19%)	-0.95* (-50%)	-0.39* (-24%)	-0.01 (-0.7%)
TG3	5	+0.03 (+2.8%)	-0.33* (-13%)	-1.0* (-48%)	-0.06 (-2.3%)	-0.14* (-8.3%)

* Statistically significant, α=0.05.

Of interest is the difference between the Daily Average impacts for TG2 and TG3. While TG2 showed no appreciable change in overall energy use, participants in TG3 show an average summer energy savings of 8.3%. One possible explanation is that more participants in TG3 switched from Level 1 to Level 2 charging at the beginning of the study. Only about one-quarter of the TG2 participants replaced their Level 1 charger with a Level 2 charger, while all of the TG3 participants replaced their Level 1 charger with a Level 2 charger. It could be that the faster and more efficient Level 2 charging reduced energy use for all participants who switched from Level 1 to Level 2 charging, and that greater savings accrued to TG3 because a much higher percentage of participants did so.

Table 17 shows the results of a contrast analysis, providing between-treatment differences for the TG2 and TG3 impacts shown in Table 16 above. Compared to TG3, TG2 participants had larger load increases in the Off-peak hours (+0.28 kW) and greater savings during the Super Peak hours (-0.33 kW).

TABLE 17. SUMMER BETWEEN-TREATMENT COMPARISONS

Contrast	Off Peak (Hours 1-14)	Peak Hours 15-16, 20-22	Peak Hours 23-24	Super Peak (Hours 17-19)	Daily Average
TG2 minus TG3	+0.28*	+0.04	+0.09	-0.33*	+0.14*

* Statistically significant, α=0.05.

---

[1] Small sample sizes with statistically significant results pose a special set of problems in interpreting those results. First, the samples lack the power to test distribution assumptions, so the t-test applied here may not be appropriate or accurate. Second, removing a single participant's response can have a large effect on the mean, so the results are fragile, hence not generalizable.

CONSERVATION DAY IMPACTS (EVENT DAYS)

The Conservation Day event impact analysis began with an exploration of the EV submeter data for TG2 and TG3. Note that TG1 was not included in this analysis because TG1 participants were not exposed to the Conservation Day events.

Figure 19 shows the actual measured EV loads (not modeled or corrected for weather) for summer event and non-event weekdays. For both treatment groups, the difference between EV charging loads on event days and non-event days was less than 100 watts in every hour, and the difference between treatment impacts appears equally inconsequential (Figure 20).

FIGURE 19. ACTUAL EV LOADS ON EVENT AND NON-EVENT DAYS

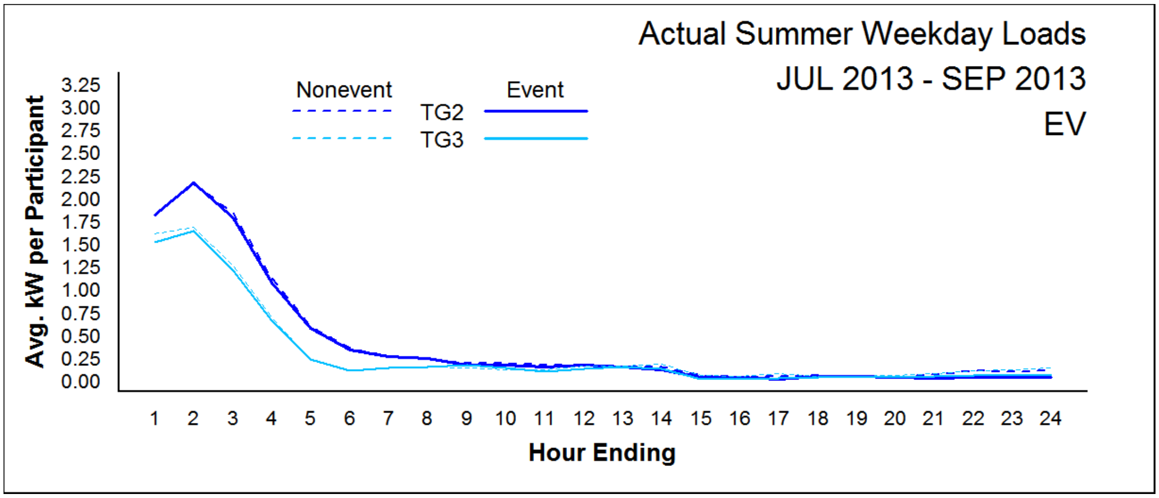
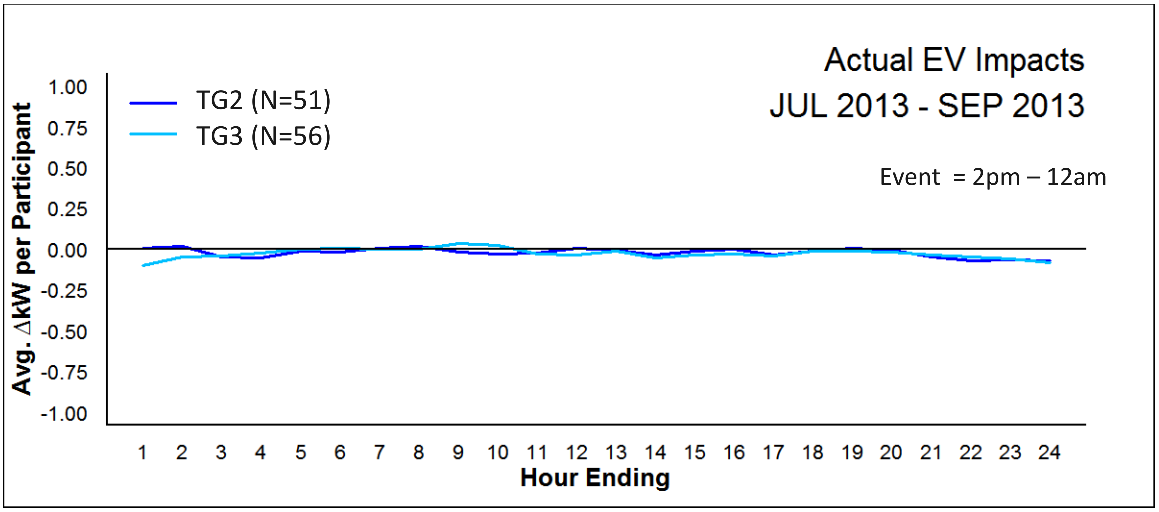


FIGURE 20. DIFFERENCE BETWEEN ACTUAL EV LOADS ON EVENT AND NON-EVENT DAYS



The next analysis employed a three-level mixed effects regression to model the same impacts, using the hourly House+EV and House loads (calculated as the difference between the House+EV and submetered EV loads). Using Equation 4, the hourly House+EV baseline is estimated as the average non-event weekday load shape corrected for temperature effects, while the treatment loads are also modeled to enable statistical comparisons.

EQUATION 4. SUMMER WEEKDAY MODEL EQUATION

$$kw_{ijk} =$$
$$\beta 1_k hour_{ijk} + \beta 2CDH_{ijk} + \beta 3CDD_{ij} + \beta 4_{m-1} Treatment_m + \beta 5DayType + \beta 6LoadType +$$
$$\beta 7_{(k-1):(m-1)}(CDD_{ij} * hour_{ijk} * DayType * LoadType * Treatment_{m-1}) + r_i + \varepsilon_{ijk}$$

kw_{ijk}: kilowatt load for customer i on day j at hour k

$hour_{ijk}$: indicator variable for hour of the day (1-24)

CDH_{ijk}: cooling degree hour for customer i on day j at hour k . If Temperature > 75 for customer i on day j at hour k, then CDH for customer i on day j at hour k is Temperature – 75; otherwise, CDH for customer i on day j at hour k is 0

CDD_{ij}: cooling degree day for customer i on day j. (Sum of 24 CDH values)

$Treatment_m$: indicator variables for treatment (TG2 = reference level, TG3)

$DayType$: indicator variables for day type (event = reference level, nonevent)

$LoadType$: indicator variables for load type (house = reference level, house+ev)

r_i: random effects for customer $\sim N(0, \varphi)$, assumed to be independent for different i

ε_{ijk}: error terms $\sim N(0, \delta^2 I)$, assumed to be independent for different i and to be independent of random effects

The load values modeled are then used to calculate load impact values as the difference between the treatment and baseline load shapes. Modeled EV impacts for each treatment *t* and hour *k* are calculated as the difference-in-differences (DID) between the mean loads on event and nonevent days as shown in Equation 5.

EQUATION 5. AVERAGE HOURLY IMPACT CALCULATION ON EVENT DAYS, BY TREATMENT

$$EV\_Event\_Impact\_kW_{tk} = (House{+}EV\_Event_{tk} - House{+}EV\_NonEvent_{tk}) - (House\_Event_{tk} - House\_NonEvent_{tk})$$

Where, for treatment t at hour *k*:

- $EV\_Event\_Impact\_kW_{tk}$ = average hourly EV impact on event days
- $House{+}EV\_Event_{tk}$ = average hourly House+EV demand on event days
- $House{+}EV\_NonEvent_{tk}$ = average hourly House+EV demand on nonevent days
- $House\_Event_{tk}$ = average hourly House demand on event days
- $House\_NonEvent_{tk}$ = average hourly House demand on nonevent days

The resulting EV load impact estimates, shown in Figure 21, mirror the findings based on the actual EV loads previously shown in Figure 20.

FIGURE 21. MODELED EV IMPACTS ON EVENT DAYS, BY TREATMENT

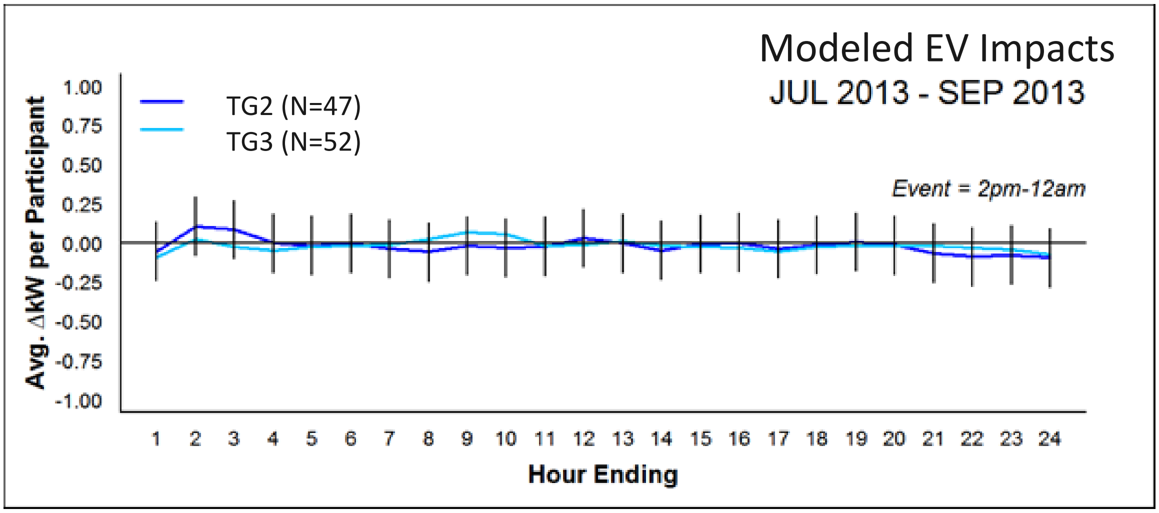


Table 18 formalizes these results through a statistical comparison between nonevent and event day loads, as well as between treatment impacts, showing no statistically significant differences in average loads or impacts during the off-peak, peak, or super-peak periods. Overall energy impacts for TG2 and TG3 on Conservation Days, calculated as the average of impacts for all hours, were likewise statistically indistinguishable from zero and from each other. Note that percent (%) impacts represent the percent change from whole-house loads.

TABLE 18. EV ONLY EVENT IMPACTS

Treatment	N	Off Peak (Hours 1-14) *kW (%)*	Peak (Hours 15-16,20-24) *kW (%)*	Super Peak (Hours 17-19) *kW (%)*	Total (Hours 1-24) *kW (%)*
TG2	47	0.008 (0.4%)	-0.058 (-3.1%)	-0.022 (-1.0%)	-0.015 (-0.8%)
TG3	52	-0.007 (-0.5%)	-0.055 (-2.4%)	-0.033 (-1.1%)	-0.025 (-1.2%)
Difference		0.015	-0.003	+0.011	+0.010

According to SMUD's records, only half of the participant-events were acknowledged by the smart EVSEs installed for TG3. It is possible that this low connectivity rate affected the peak impacts of TG3. Assuming the distribution of connectivity was random across participants, the effect of the DLC during events might have been doubled to -0.11 (-4.8%) during Peak and to -0.066 (-2.2%) during Super Peak, if all EVSEs had received the signal to reduce charging load for all 12 events.

4. CONCLUSIONS

The main findings of this study are as follows:

1. **The TOU rates elicited statistically significant peak period demand reductions.** Average savings during the winter peak period (4-10pm) ranged from 0.26 kW to 0.50 kW. Overall, 94% of RPEV2 charging occurred during the off-peak period (Table 44).
2. **The CPP event impacts were statistically equivalent to the TOU peak impacts.** The lack of incremental savings is likely due to programming of the EVs to charge off peak every day, obviating the effect of the CPP events. This does not indicate that the CPP events were ineffective, because it is unknown what the effects of the TOU would have been without the CPP component of the rate. It is possible that the existence of the intermittent CPP demand charge encouraged programming the EVs to avoid charging during the TOU peak price every day.
3. **Event impacts for the group with smart EVSEs were statistically equivalent to those without smart EVSEs.** Again, this lack of differentiation may be due to programming of the EVs to avoid the TOU peak price every day, obviating the effect of DLC on event days. In addition, failed connectivity for nearly half of the TG3 participants may have stifled the impact of EVSE direct load control. Understanding of this issue would benefit from further field research comparing the use of more mature DLC technology under different rate and incentive structures.
4. **Level 2 charging appears to have saved energy relative to Level 1.** For all three groups, winter energy savings are roughly proportional to the fraction of participants that upgraded to the faster and more efficient level 2 charging at the beginning of the study (Figure 2).

Based on these findings, the authors recommend the following:

1. **Offer TOU or TOU-CPP rates to EV owners.** Although further investigation of system needs and potential effects of new rates is warranted, this study clearly shows that time-varying rates can be used to shift EV charging out of the peak period.
2. **Do not offer a free EVSE to control loads of customers on a TOU-CPP rate without conducting further research.** This study showed that the addition of DLC did not improve the CPP load shed. Future research might test the ability of communicating EVSEs to manage loads under different rates and scenarios. For example, a controllable EVSE could be of benefit when implementing a TOU-CPP rate is not an option.
3. **Conduct vigorous testing of communicating technologies before implementation.** The communication between the SMUD meter and the smart EVSEs used in this study was unreliable. More than half of all event signals were not successfully received.
4. **Determine existing EV charging patterns in the SMUD service territory.** This study examined the effect of time-varying rates on the EV charging patterns for a self-selected sample

of customers in the SMUD service territory. This study did not determine the average load shape of all existing EV drivers, in particular those who purchase electricity under the standard residential rate. Before developing rates and other interventions to change the load shapes of EV charging, it would be prudent to determine the existing charging patterns and impact of those patterns on distribution system assets. To the extent possible, SMUD should identify and maintain a frequently updated database of EV homes as documented by, for example, the Department of Motor Vehicles, and regularly summarize their hourly loads to allow for informed decisions about future rate design.

Suggested issues for further research include:

1. **Does the CPP demand charge encourage daily TOU off-peak charging?** Further field research might compare a TOU rate with and without a CPP demand charge, to determine whether the event day demand charge improves *nonevent* day peak savings through manual response or preprogramming of the charging schedule.
2. **Can smart EVSEs provide effective DLC load management under different incentive structures?** This study was unable to show that smart EVSEs reduced event peak loads when combined with a TOU-CPP rate. Further research might compare the use of a smart EVSE under other incentive structures, such as real-time pricing (RTP), that better align EV charging with system needs.
3. **How can we effectively encourage customers to program their EVs to charge off peak?** This study suggests that scheduled charging played a large role in reducing event and nonevent peak EV charging demand. Further research might compare the use of this strategy with and without a TOU rate. Such a study might incorporate three treatments: (1) an offer of information and help programming the EV charging, (2) the same help and information contingent on acceptance of a TOU rate, and (3) the same help and information with or without the TOU rate, as the customer chooses.

5. EV INNOVATORS - APPENDICES

APPENDIX A. RPEV TARIFF SHEETS

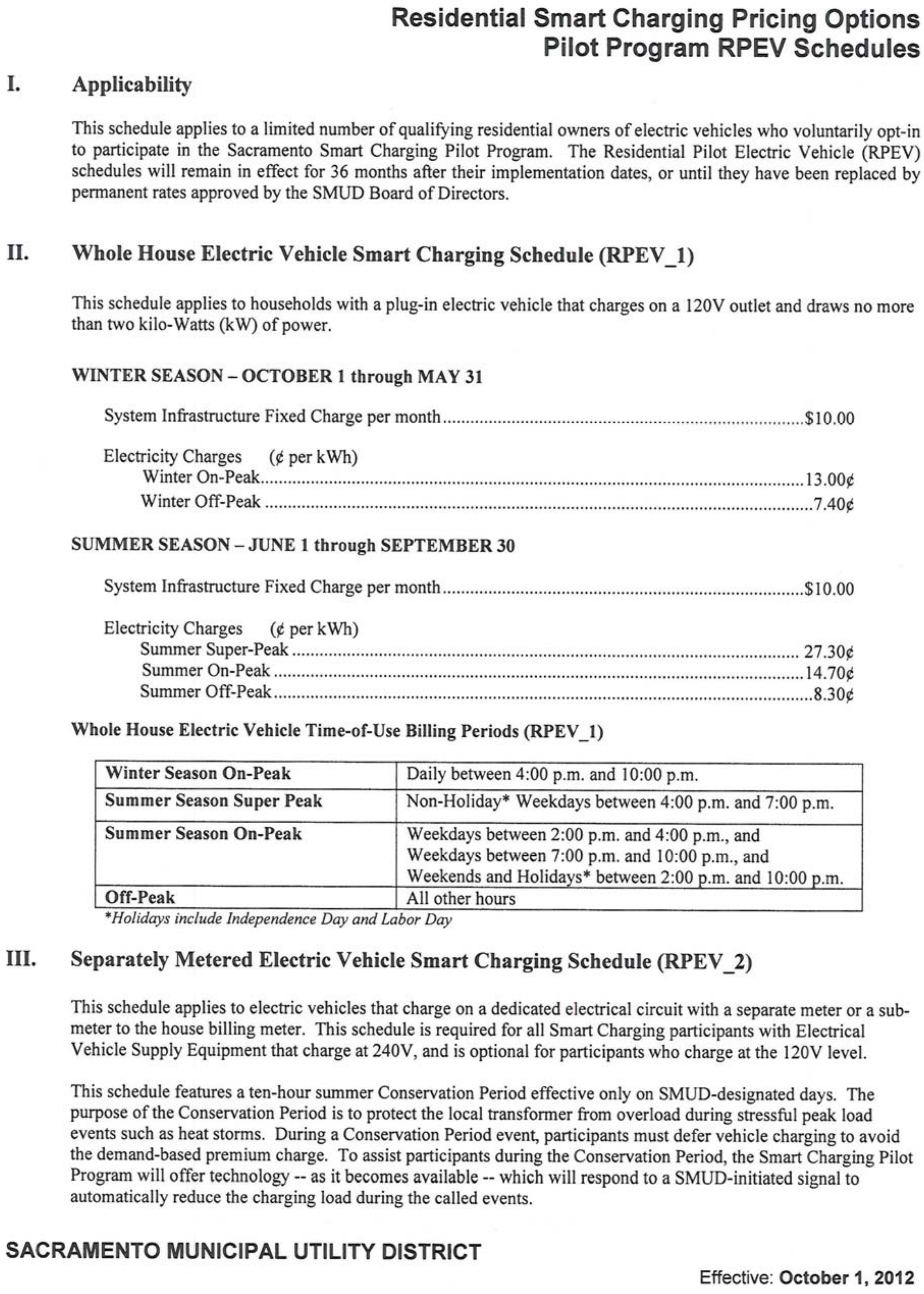
Table 19 outlines some of the utility and customer tools that were considered in designing the experimental rates for the pilot. After extensive deliberation, the team settled on including the underlined items.

TABLE 19. TOOLS FOR ENABLING AND INCENTIVIZING RESPONSIBLE EV CHARGING

Goal	Utility Tools	Customer Tools
Avoid charging during system peak	• Time-based energy rates • Time-based demand rates	• Scheduling
Avoid synchronized (multiple-EV) charging	• Staggered peak rates • Customer notification	• Scheduling
Avoid habitual high-power charging	• Time-based demand rates* with: o Customer chosen kW threshold o Utility chosen kW thresholds	• Choice of charging level
Avoid all high-power charging	• Demand limiting • Monthly demand rates	• Real-time demand notification
Avoid critical peaks	• Customer notification • Dynamic energy rates • Dynamic demand charges • Dynamic load control	• Customer notification • Communicating charger with: o End-of-use charging o Choice of charging level o High price avoidance o Managed charging

- Time-based demand rate refers to a rate with a customer or utility chosen demand (kW) threshold above which a per-kWh premium applies.

FIGURE 22. RPEV TARIFF SHEET



Residential Smart Charging Pricing Options
Pilot Program RPEV Schedules

I. Applicability

This schedule applies to a limited number of qualifying residential owners of electric vehicles who voluntarily opt-in to participate in the Sacramento Smart Charging Pilot Program. The Residential Pilot Electric Vehicle (RPEV) schedules will remain in effect for 36 months after their implementation dates, or until they have been replaced by permanent rates approved by the SMUD Board of Directors.

II. Whole House Electric Vehicle Smart Charging Schedule (RPEV_1)

This schedule applies to households with a plug-in electric vehicle that charges on a 120V outlet and draws no more than two kilo-Watts (kW) of power.

WINTER SEASON – OCTOBER 1 through MAY 31

System Infrastructure Fixed Charge per month	$10.00
Electricity Charges (¢ per kWh)	
Winter On-Peak	13.00¢
Winter Off-Peak	7.40¢

SUMMER SEASON – JUNE 1 through SEPTEMBER 30

System Infrastructure Fixed Charge per month	$10.00
Electricity Charges (¢ per kWh)	
Summer Super-Peak	27.30¢
Summer On-Peak	14.70¢
Summer Off-Peak	8.30¢

Whole House Electric Vehicle Time-of-Use Billing Periods (RPEV_1)

Winter Season On-Peak	Daily between 4:00 p.m. and 10:00 p.m.
Summer Season Super Peak	Non-Holiday* Weekdays between 4:00 p.m. and 7:00 p.m.
Summer Season On-Peak	Weekdays between 2:00 p.m. and 4:00 p.m., and Weekdays between 7:00 p.m. and 10:00 p.m., and Weekends and Holidays* between 2:00 p.m. and 10:00 p.m.
Off-Peak	All other hours

**Holidays include Independence Day and Labor Day*

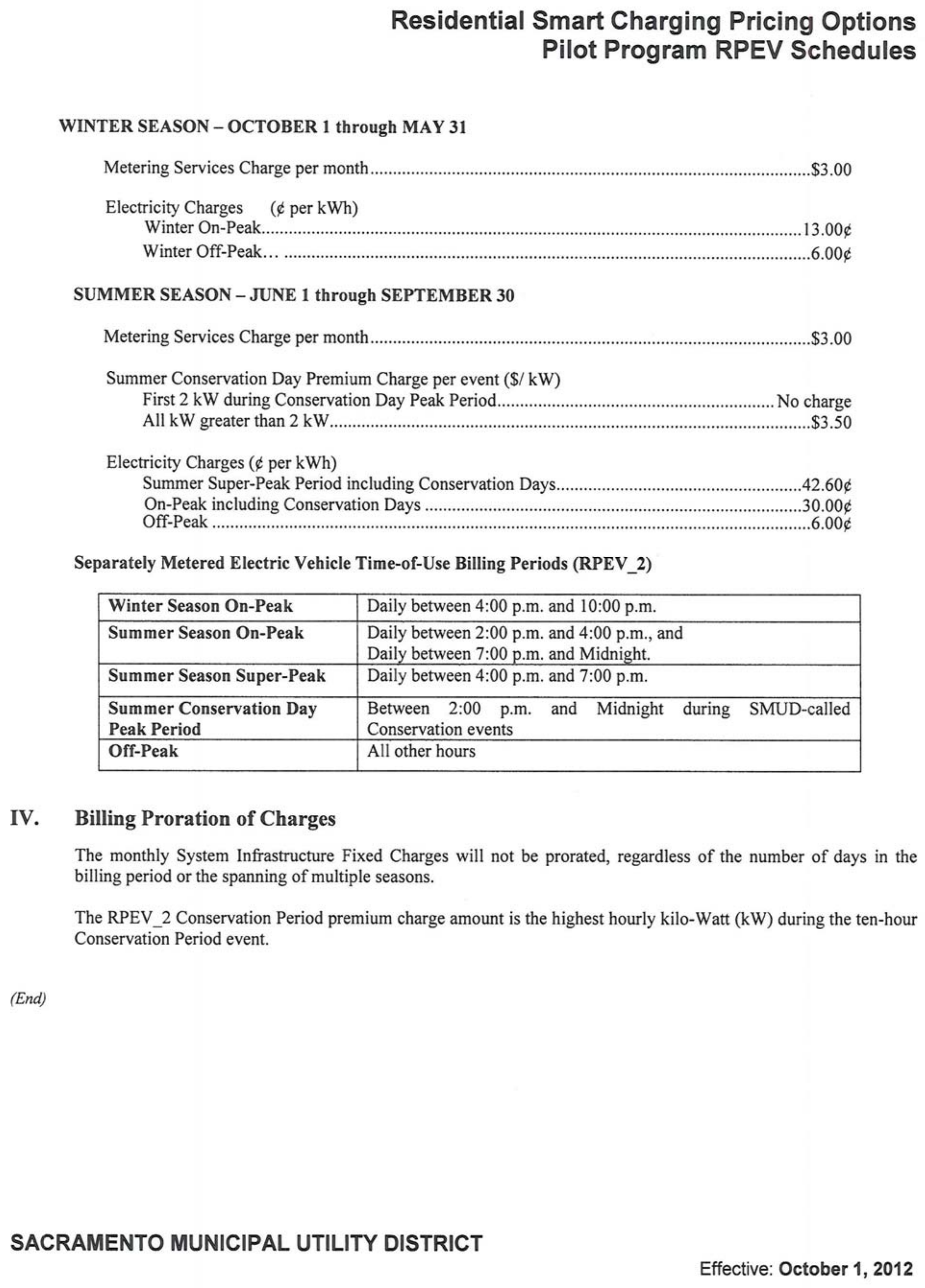
III. Separately Metered Electric Vehicle Smart Charging Schedule (RPEV_2)

This schedule applies to electric vehicles that charge on a dedicated electrical circuit with a separate meter or a sub-meter to the house billing meter. This schedule is required for all Smart Charging participants with Electrical Vehicle Supply Equipment that charge at 240V, and is optional for participants who charge at the 120V level.

This schedule features a ten-hour summer Conservation Period effective only on SMUD-designated days. The purpose of the Conservation Period is to protect the local transformer from overload during stressful peak load events such as heat storms. During a Conservation Period event, participants must defer vehicle charging to avoid the demand-based premium charge. To assist participants during the Conservation Period, the Smart Charging Pilot Program will offer technology -- as it becomes available -- which will respond to a SMUD-initiated signal to automatically reduce the charging load during the called events.

SACRAMENTO MUNICIPAL UTILITY DISTRICT

Effective: **October 1, 2012**



Residential Smart Charging Pricing Options
Pilot Program RPEV Schedules

WINTER SEASON – OCTOBER 1 through MAY 31

Metering Services Charge per month	$3.00
Electricity Charges (¢ per kWh)	
Winter On-Peak	13.00¢
Winter Off-Peak…	6.00¢

SUMMER SEASON – JUNE 1 through SEPTEMBER 30

Metering Services Charge per month	$3.00
Summer Conservation Day Premium Charge per event ($/ kW)	
First 2 kW during Conservation Day Peak Period	No charge
All kW greater than 2 kW	$3.50
Electricity Charges (¢ per kWh)	
Summer Super-Peak Period including Conservation Days	42.60¢
On-Peak including Conservation Days	30.00¢
Off-Peak	6.00¢

Separately Metered Electric Vehicle Time-of-Use Billing Periods (RPEV_2)

Winter Season On-Peak	Daily between 4:00 p.m. and 10:00 p.m.
Summer Season On-Peak	Daily between 2:00 p.m. and 4:00 p.m., and Daily between 7:00 p.m. and Midnight.
Summer Season Super-Peak	Daily between 4:00 p.m. and 7:00 p.m.
Summer Conservation Day Peak Period	Between 2:00 p.m. and Midnight during SMUD-called Conservation events
Off-Peak	All other hours

IV. Billing Proration of Charges

The monthly System Infrastructure Fixed Charges will not be prorated, regardless of the number of days in the billing period or the spanning of multiple seasons.

The RPEV_2 Conservation Period premium charge amount is the highest hourly kilo-Watt (kW) during the ten-hour Conservation Period event.

(End)

Appendix B. Summer Weekday Models

All days except weekends and holidays were included in the analysis.

- Pretreatment = nonevent days from July 1, 2012 through September, 30 2012
- Treatment = 12 event days from July 1, 2013 through September 30, 2013

Model Details

Contrasts

1. *Treatment loads are not different from baseline loads (adjusted for weather)*

$H_0 : L = 0$

$H_a : L \neq 0$

$L = \sum_{i=1}^{12} c_i \mu_i \ where \ \sum_{i=1}^{12} c_i = 0, If \ |t^* = \frac{L}{\sigma^2\{L\}} \ | \leq t(n-p-q), then \ H_0; otherwise, H_a$[2]

For Super peak comparison,

$c_1 through \ c_{12} = {}^1/_3, -{}^1/_3, {}^1/_3, -{}^1/_3, {}^1/_3, -{}^1/_3, -{}^1/_3, {}^1/_3, -{}^1/_3, {}^1/_3, -{}^1/_3, {}^1/_3$

2. *Treatment type has no effect on impacts (adjusted for weather)*

For Super peak comparison,

$c_1 through \ c_{24} = {}^1/_3, -{}^1/_3, {}^1/_3, -{}^1/_3, {}^1/_3, -{}^1/_3, -{}^1/_3, {}^1/_3, -{}^1/_3, {}^1/_3, -{}^1/_3, {}^1/_3,$
$-{}^1/_3, {}^1/_3, -{}^1/_3, {}^1/_3, -{}^1/_3, {}^1/_3, {}^1/_3, -{}^1/_3, {}^1/_3, -{}^1/_3, {}^1/_3, -{}^1/_3$

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[2] n=number of observations, p = number of model parameters associated with fixed effects, q = number of covariance parameters with random effects or correlations

CONTRASTS EXAMPLES

TG2 Super peak impact relative to baseline (adjusted for weather), and comparing TG2 and TG3 treatments Super peak impacts (adjusted for weather and pretreatment differences)

1. *Treatment loads are not different from baseline loads (adjusted for weather)*

$$\hat{L} = \left[\frac{\begin{array}{c}(\hat{\mu}_{TG2.event.House+EV.at.hr17} - \hat{\mu}_{TG2.nonevent.House+EV.at.hr17}) + \\ (\hat{\mu}_{TG2.event.House+EV.at.hr18} - \hat{\mu}_{TG2.nonevent.House+EV.at.hr18}) + \\ (\hat{\mu}_{TG2.event.House+EV.at.hr19} - \hat{\mu}_{TG2.nonevent.House+EV.at.hr19})\end{array}}{3}\right] - \left[\frac{\begin{array}{c}(\hat{\mu}_{TG2.event.House.at.hr17} - \hat{\mu}_{TG2.nonevent.House.at.hr17}) + \\ (\hat{\mu}_{TG2.event.House.at.hr18} - \hat{\mu}_{TG2.nonevent.House.at.hr18}) + \\ (\hat{\mu}_{TG2.event.House.at.hr19} - \hat{\mu}_{TG2.nonevent.House.at.hr19})\end{array}}{3}\right]$$

2. *Treatment type has no effect on impacts (adjusted for weather)*

$$\hat{L} = \left(\left[\frac{\begin{array}{c}(\hat{\mu}_{TG2.event.House+EV.at.hr17} - \hat{\mu}_{TG2.nonevent.House+EV.at.hr17}) + \\ (\hat{\mu}_{TG2.event.House+EV.at.hr18} - \hat{\mu}_{TG2.nonevent.House+EV.at.hr18}) + \\ (\hat{\mu}_{TG2.event.House+EV.at.hr19} - \hat{\mu}_{TG2.nonevent.House+EV.at.hr19})\end{array}}{3}\right] - \left[\frac{\begin{array}{c}(\hat{\mu}_{TG2.event.House.at.hr17} - \hat{\mu}_{TG2.nonevent.House.at.hr17}) + \\ (\hat{\mu}_{TG2.event.House.at.hr18} - \hat{\mu}_{TG2.nonevent.House.at.hr18}) + \\ (\hat{\mu}_{TG2.event.House.at.hr19} - \hat{\mu}_{TG2.nonevent.House.at.hr19})\end{array}}{3}\right]\right) - \left(\left[\frac{\begin{array}{c}(\hat{\mu}_{TG3.event.House+EV.at.hr17} - \hat{\mu}_{TG3.nonevent.House+EV.at.hr17}) + \\ (\hat{\mu}_{TG3.event.House+EV.at.hr18} - \hat{\mu}_{TG3.nonevent.House+EV.at.hr18}) + \\ (\hat{\mu}_{TG3.event.House+EV.at.hr19} - \hat{\mu}_{TG3.nonevent.House+EV.at.hr19})\end{array}}{3}\right] - \left[\frac{\begin{array}{c}(\hat{\mu}_{TG3.event.House.at.hr17} - \hat{\mu}_{TG3.nonevent.House.at.hr17}) + \\ (\hat{\mu}_{TG3.event.House.at.hr18} - \hat{\mu}_{TG3.nonevent.House.at.hr18}) + \\ (\hat{\mu}_{TG3.event.House.at.hr19} - \hat{\mu}_{TG3.nonevent.House.at.hr19})\end{array}}{3}\right]\right)$$

Notes:

$\mu's$ are estimated using regression coefficients with the temperature profile of interest – average temp on event 2013 days.

MODELS COMPARISON

TABLE 20.MODEL COMPARISON, SUMMER WEEKDAY MODEL

	Model	DF	AIC	BIC	logLik	Test	L.Ratio	p-value
Summer weekday model Random Customer	1	387	1014899.4	1019010.6	-507062.7		NA	
FINAL MODEL: Summer weekday model Random Customer AR(1)	2	388	835777.4	839899.2	-417500.7	1 vs 2	179124	<0.0001

TESTS FOR FIXED EFFECTS

TABLE 21.F-TESTS FOR VARIABLES IN THE MODEL, SUMMER WEEKDAY MODEL

Variable	Numerator DF	Denominator DF	F-value	p-value
CDH	1	303460	11322.08	<0.0001
CDD	1	303460	1222.19	<0.0001
hour	24	303460	360.48	<0.0001
DayType	1	303460	0.46	0.4964
Treatment	1	98	1.40	0.2390
LoadType	1	303460	1995.66	<0.0001
CDD:hour	23	303460	58.23	<0.0001
CDD:DayType	1	303460	28.02	<0.0001
hour:DayType	23	303460	2.56	0.0001
CDD:Treatment	1	303460	26.07	<0.0001
hour:Treatment	23	303460	89.93	<0.0001
DayType:Treatment	1	303460	0.49	0.4839
CDD:LoadType	1	303460	0.55	0.4582
hour:LoadType	23	303460	287.08	0.0000
DayType:LoadType	1	303460	1.04	0.3080
Treatment:LoadType	1	303460	28.55	<0.0001
CDD:hour:DayType	23	303460	1.86	0.0072
CDD:hour:Treatment	23	303460	5.51	0.0000
CDD: DayType:Treatment	1	303460	0.04	0.8366
hour:DayType:Treatment	23	303460	1.09	0.3524
CDD:hour:LoadType	23	303460	1.61	0.0317
CDD: DayType:LoadType	1	303460	0.03	0.8665
hour: DayType:LoadType	23	303460	0.52	0.9710
CDD:Treatment:LoadType	1	303460	0.03	0.8581
hour:Treatment:LoadType	23	303460	9.48	<0.0001
DayType:Treatment:LoadType	1	303460	0.01	0.9191
CDD:hour:DayType:Treatment	23	303460	2.39	0.0002
CDD:hour:DayType:LoadType	23	303460	0.20	1.0000
CDD:hour:Treatment:LoadType	23	303460	0.88	0.6214
CDD:DayType:Treatment:LoadType	1	303460	0.31	0.5795

hour:DayType:Treatment:LoadType	23	303460	0.11	1.0000
CDD:hour:DayType:Treatment: LoadType	23	303460	0.45	0.9888

MODEL COEFFICIENTS

Conditional R^2 = 0.3653

Table 22 provides model coefficients for summer weekday model. TG2 is the reference level for treatment, event is the reference level for day type, and house load is the reference level for load type.

TABLE 22. MODEL COEFFICIENTS, SUMMER WEEKDAY MODEL

Variable	Coefficient	Std.Error	DF	t-value	p-value
CDH	0.011807	0.001582	303460	7.47	<0.0001
CDD	0.003514	0.000652	303460	5.39	<0.0001
hour01	0.732771	0.150217	303460	4.88	<0.0001
hour02	0.695151	0.150192	303460	4.63	<0.0001
hour03	0.771072	0.150192	303460	5.13	<0.0001
hour04	0.718225	0.150185	303460	4.78	<0.0001
hour05	0.733295	0.150179	303460	4.88	<0.0001
hour06	0.774939	0.150175	303460	5.16	<0.0001
hour07	0.902673	0.150173	303460	6.01	<0.0001
hour08	0.899521	0.150173	303460	5.99	<0.0001
hour09	0.786462	0.150250	303460	5.23	<0.0001
hour10	0.601914	0.150173	303460	4.01	0.0001
hour11	0.456015	0.150188	303460	3.04	0.0024
hour12	0.440946	0.150246	303460	2.93	0.0033
hour13	0.297704	0.150296	303460	1.98	0.0476
hour14	0.218374	0.150207	303460	1.45	0.1460
hour15	0.129429	0.150182	303460	0.86	0.3888
hour16	0.041993	0.150286	303460	0.28	0.7799
hour17	0.339218	0.150452	303460	2.25	0.0242
hour18	0.620337	0.150490	303460	4.12	<0.0001
hour19	0.717209	0.150480	303460	4.77	<0.0001
hour20	0.928047	0.150332	303460	6.17	<0.0001
hour21	0.959302	0.150186	303460	6.39	<0.0001
hour22	0.918352	0.150219	303460	6.11	<0.0001
hour23	0.827787	0.150289	303460	5.51	<0.0001
hour24	0.640953	0.150264	303460	4.27	<0.0001
nonevent	0.009356	0.125349	303460	0.07	0.9405
TG3	-0.204996	0.206730	98	-0.99	0.3238
HOUSE+EV	2.006617	0.164985	303460	12.16	<0.0001
CDD:hour02	-0.000220	0.000517	303460	-0.42	0.6710
CDD:hour03	-0.001596	0.000671	303460	-2.38	0.0174
CDD:hour04	-0.001724	0.000759	303460	-2.27	0.0231
CDD:hour05	-0.002197	0.000814	303460	-2.70	0.0069

Variable	Coefficient	Std.Error	DF	t-value	p-value
CDD:hour06	-0.002371	0.000849	303460	-2.79	0.0052
CDD:hour07	-0.002362	0.000873	303460	-2.71	0.0068
CDD:hour08	-0.002254	0.000888	303460	-2.54	0.0112
CDD:hour09	-0.001703	0.000900	303460	-1.89	0.0585
CDD:hour10	-0.000839	0.000906	303460	-0.93	0.3541
CDD:hour11	0.000135	0.000910	303460	0.15	0.8819
CDD:hour12	0.000322	0.000913	303460	0.35	0.7242
CDD:hour13	0.001261	0.000916	303460	1.38	0.1687
CDD:hour14	0.001824	0.000919	303460	1.98	0.0472
CDD:hour15	0.003182	0.000921	303460	3.46	0.0005
CDD:hour16	0.005116	0.000922	303460	5.55	<0.0001
CDD:hour17	0.005341	0.000923	303460	5.79	<0.0001
CDD:hour18	0.005160	0.000924	303460	5.58	<0.0001
CDD:hour19	0.005155	0.000924	303460	5.58	<0.0001
CDD:hour20	0.003401	0.000925	303460	3.68	0.0002
CDD:hour21	0.002759	0.000925	303460	2.98	0.0029
CDD:hour22	0.002628	0.000924	303460	2.85	0.0044
CDD:hour23	0.001867	0.000922	303460	2.02	0.0429
CDD:hour24	0.001149	0.000921	303460	1.25	0.2122
CDD:nonevent	-0.000643	0.000766	303460	-0.84	0.4019
hour02:nonevent	0.027022	0.099552	303460	0.27	0.7861
hour03:nonevent	-0.078571	0.129209	303460	-0.61	0.5431
hour04:nonevent	-0.032109	0.146079	303460	-0.22	0.8260
hour05:nonevent	-0.034886	0.156584	303460	-0.22	0.8237
hour06:nonevent	-0.020523	0.163388	303460	-0.13	0.9000
hour07:nonevent	0.008909	0.167888	303460	0.05	0.9577
hour08:nonevent	-0.018930	0.170898	303460	-0.11	0.9118
hour09:nonevent	0.031673	0.173000	303460	0.18	0.8547
hour10:nonevent	0.127113	0.174308	303460	0.73	0.4659
hour11:nonevent	0.294392	0.175238	303460	1.68	0.0930
hour12:nonevent	0.242991	0.175883	303460	1.38	0.1671
hour13:nonevent	0.311318	0.176315	303460	1.77	0.0774
hour14:nonevent	0.309995	0.176616	303460	1.76	0.0792
hour15:nonevent	0.376628	0.176878	303460	2.13	0.0332
hour16:nonevent	0.429381	0.177043	303460	2.43	0.0153
hour17:nonevent	0.170532	0.177158	303460	0.96	0.3358
hour18:nonevent	0.057121	0.177187	303460	0.32	0.7472
hour19:nonevent	0.032413	0.177215	303460	0.18	0.8549
hour20:nonevent	-0.081898	0.177227	303460	-0.46	0.6440
hour21:nonevent	0.040321	0.177229	303460	0.23	0.8200
hour22:nonevent	0.109369	0.177222	303460	0.62	0.5371
hour23:nonevent	0.104249	0.177226	303460	0.59	0.5564
hour24:nonevent	0.116087	0.177233	303460	0.65	0.5125
CDD:TG3	0.000512	0.000892	303460	0.57	0.5662

Variable	Coefficient	Std.Error	DF	t-value	p-value
hour02:TG3	-0.048287	0.127361	303460	-0.38	0.7046
hour03:TG3	-0.136195	0.165304	303460	-0.82	0.4100
hour04:TG3	-0.091637	0.186888	303460	-0.49	0.6239
hour05:TG3	0.028374	0.200327	303460	0.14	0.8874
hour06:TG3	0.157076	0.209030	303460	0.75	0.4524
hour07:TG3	0.180989	0.214784	303460	0.84	0.3994
hour08:TG3	0.305520	0.218636	303460	1.40	0.1623
hour09:TG3	0.245620	0.221287	303460	1.11	0.2670
hour10:TG3	0.279355	0.222996	303460	1.25	0.2103
hour11:TG3	0.479538	0.224194	303460	2.14	0.0324
hour12:TG3	0.386123	0.225010	303460	1.72	0.0862
hour13:TG3	0.535213	0.225567	303460	2.37	0.0177
hour14:TG3	0.667038	0.225948	303460	2.95	0.0032
hour15:TG3	0.821714	0.226209	303460	3.63	0.0003
hour16:TG3	1.191336	0.226386	303460	5.26	<0.0001
hour17:TG3	1.081312	0.226507	303460	4.77	<0.0001
hour18:TG3	0.849823	0.226590	303460	3.75	0.0002
hour19:TG3	0.737886	0.226648	303460	3.26	0.0011
hour20:TG3	0.458279	0.226686	303460	2.02	0.0432
hour21:TG3	0.616825	0.226713	303460	2.72	0.0065
hour22:TG3	0.353204	0.226731	303460	1.56	0.1193
hour23:TG3	0.158303	0.226744	303460	0.70	0.4851
hour24:TG3	0.194209	0.226752	303460	0.86	0.3917
nonevent:TG3	0.149437	0.172247	303460	0.87	0.3856
CDD:HOUSE+EV	-0.000808	0.000920	303460	-0.88	0.3800
hour02:HOUSE+EV	0.680891	0.131042	303460	5.20	<0.0001
hour03:HOUSE+EV	0.080065	0.170080	303460	0.47	0.6378
hour04:HOUSE+EV	-0.817217	0.192288	303460	-4.25	<0.0001
hour05:HOUSE+EV	-1.441970	0.206116	303460	-7.00	<0.0001
hour06:HOUSE+EV	-1.765968	0.215070	303460	-8.21	<0.0001
hour07:HOUSE+EV	-1.810021	0.220991	303460	-8.19	<0.0001
hour08:HOUSE+EV	-1.873962	0.224954	303460	-8.33	<0.0001
hour09:HOUSE+EV	-1.907853	0.227697	303460	-8.38	<0.0001
hour10:HOUSE+EV	-1.844854	0.229439	303460	-8.04	<0.0001
hour11:HOUSE+EV	-1.757449	0.230672	303460	-7.62	<0.0001
hour12:HOUSE+EV	-1.845199	0.231511	303460	-7.97	<0.0001
hour13:HOUSE+EV	-1.787047	0.232085	303460	-7.70	<0.0001
hour14:HOUSE+EV	-1.872205	0.232476	303460	-8.05	<0.0001
hour15:HOUSE+EV	-1.997709	0.232744	303460	-8.58	<0.0001
hour16:HOUSE+EV	-2.001577	0.232927	303460	-8.59	<0.0001
hour17:HOUSE+EV	-2.008269	0.233052	303460	-8.62	<0.0001
hour18:HOUSE+EV	-2.025074	0.233138	303460	-8.69	<0.0001
hour19:HOUSE+EV	-1.980318	0.233196	303460	-8.49	<0.0001
hour20:HOUSE+EV	-2.017099	0.233237	303460	-8.65	<0.0001

Variable	Coefficient	Std.Error	DF	t-value	p-value
hour21:HOUSE+EV	-2.023133	0.233264	303460	-8.67	<0.0001
hour22:HOUSE+EV	-2.006484	0.233283	303460	-8.60	<0.0001
hour23:HOUSE+EV	-2.027809	0.233296	303460	-8.69	<0.0001
hour24:HOUSE+EV	-2.022997	0.233305	303460	-8.67	<0.0001
nonevent:HOUSE+EV	-0.224601	0.177247	303460	-1.27	0.2051
TG3:HOUSE+EV	-0.453694	0.226771	303460	-2.00	0.0454
CDD:hour02:nonevent	-0.000703	0.000609	303460	-1.15	0.2481
CDD:hour03:nonevent	0.000103	0.000790	303460	0.13	0.8960
CDD:hour04:nonevent	-0.000135	0.000893	303460	-0.15	0.8796
CDD:hour05:nonevent	0.000191	0.000957	303460	0.20	0.8419
CDD:hour06:nonevent	0.000111	0.000999	303460	0.11	0.9112
CDD:hour07:nonevent	-0.000068	0.001026	303460	-0.07	0.9472
CDD:hour08:nonevent	0.000326	0.001045	303460	0.31	0.7548
CDD:hour09:nonevent	0.000041	0.001058	303460	0.04	0.9691
CDD:hour10:nonevent	-0.000420	0.001066	303460	-0.39	0.6934
CDD:hour11:nonevent	-0.001476	0.001071	303460	-1.38	0.1684
CDD:hour12:nonevent	-0.000990	0.001075	303460	-0.92	0.3571
CDD:hour13:nonevent	-0.001454	0.001078	303460	-1.35	0.1774
CDD:hour14:nonevent	-0.001347	0.001080	303460	-1.25	0.2123
CDD:hour15:nonevent	-0.001886	0.001081	303460	-1.74	0.0811
CDD:hour16:nonevent	-0.002387	0.001082	303460	-2.21	0.0274
CDD:hour17:nonevent	-0.000607	0.001083	303460	-0.56	0.5754
CDD:hour18:nonevent	-0.000108	0.001083	303460	-0.10	0.9209
CDD:hour19:nonevent	0.000460	0.001084	303460	0.42	0.6715
CDD:hour20:nonevent	0.001085	0.001084	303460	1.00	0.3170
CDD:hour21:nonevent	0.000090	0.001084	303460	0.08	0.9340
CDD:hour22:nonevent	-0.000105	0.001084	303460	-0.10	0.9231
CDD:hour23:nonevent	-0.000030	0.001083	303460	-0.03	0.9776
CDD:hour24:nonevent	-0.000361	0.001083	303460	-0.33	0.7392
CDD:hour02:TG3	-0.000255	0.000709	303460	-0.36	0.7194
CDD:hour03:TG3	0.000480	0.000920	303460	0.52	0.6017
CDD:hour04:TG3	0.000327	0.001040	303460	0.31	0.7531
CDD:hour05:TG3	0.000020	0.001115	303460	0.02	0.9857
CDD:hour06:TG3	-0.000213	0.001163	303460	-0.18	0.8550
CDD:hour07:TG3	-0.000035	0.001195	303460	-0.03	0.9763
CDD:hour08:TG3	-0.000133	0.001217	303460	-0.11	0.9127
CDD:hour09:TG3	-0.000376	0.001232	303460	-0.31	0.7599
CDD:hour10:TG3	-0.000549	0.001241	303460	-0.44	0.6581
CDD:hour11:TG3	-0.001412	0.001248	303460	-1.13	0.2576
CDD:hour12:TG3	-0.000014	0.001252	303460	-0.01	0.9910
CDD:hour13:TG3	0.000295	0.001255	303460	0.23	0.8145
CDD:hour14:TG3	0.000692	0.001257	303460	0.55	0.5820
CDD:hour15:TG3	0.000184	0.001259	303460	0.15	0.8840
CDD:hour16:TG3	-0.001459	0.001260	303460	-1.16	0.2467

Variable	Coefficient	Std.Error	DF	t-value	p-value
CDD:hour17:TG3	-0.000626	0.001260	303460	-0.50	0.6196
CDD:hour18:TG3	0.000052	0.001261	303460	0.04	0.9672
CDD:hour19:TG3	-0.000305	0.001261	303460	-0.24	0.8092
CDD:hour20:TG3	0.001723	0.001261	303460	1.37	0.1720
CDD:hour21:TG3	0.001327	0.001262	303460	1.05	0.2930
CDD:hour22:TG3	0.001352	0.001262	303460	1.07	0.2837
CDD:hour23:TG3	0.001173	0.001262	303460	0.93	0.3525
CDD:hour24:TG3	-0.000107	0.001262	303460	-0.09	0.9322
CDD:nonevent:TG3	-0.000559	0.001049	303460	-0.53	0.5942
hour02:nonevent:TG3	-0.020968	0.136808	303460	-0.15	0.8782
hour03:nonevent:TG3	0.063157	0.177565	303460	0.36	0.7221
hour04:nonevent:TG3	0.000104	0.200750	303460	0.00	0.9996
hour05:nonevent:TG3	-0.077171	0.215186	303460	-0.36	0.7199
hour06:nonevent:TG3	-0.141941	0.224534	303460	-0.63	0.5273
hour07:nonevent:TG3	-0.109458	0.230715	303460	-0.47	0.6352
hour08:nonevent:TG3	-0.065731	0.234852	303460	-0.28	0.7796
hour09:nonevent:TG3	-0.074812	0.237693	303460	-0.31	0.7530
hour10:nonevent:TG3	-0.106580	0.239538	303460	-0.44	0.6564
hour11:nonevent:TG3	-0.342438	0.240822	303460	-1.42	0.1550
hour12:nonevent:TG3	-0.201386	0.241696	303460	-0.83	0.4047
hour13:nonevent:TG3	-0.250531	0.242294	303460	-1.03	0.3011
hour14:nonevent:TG3	-0.284306	0.242703	303460	-1.17	0.2414
hour15:nonevent:TG3	-0.448305	0.242983	303460	-1.85	0.0650
hour16:nonevent:TG3	-0.708895	0.243173	303460	-2.92	0.0036
hour17:nonevent:TG3	-0.471851	0.243303	303460	-1.94	0.0525
hour18:nonevent:TG3	-0.322576	0.243393	303460	-1.33	0.1851
hour19:nonevent:TG3	-0.258304	0.243454	303460	-1.06	0.2887
hour20:nonevent:TG3	-0.009373	0.243496	303460	-0.04	0.9693
hour21:nonevent:TG3	-0.278030	0.243525	303460	-1.14	0.2536
hour22:nonevent:TG3	-0.145732	0.243544	303460	-0.60	0.5496
hour23:nonevent:TG3	-0.024542	0.243558	303460	-0.10	0.9197
hour24:nonevent:TG3	-0.140775	0.243567	303460	-0.58	0.5633
CDD:hour02:HOUSE+EV	-0.001875	0.000731	303460	-2.56	0.0103
CDD:hour03:HOUSE+EV	-0.000497	0.000949	303460	-0.52	0.6001
CDD:hour04:HOUSE+EV	0.000334	0.001073	303460	0.31	0.7556
CDD:hour05:HOUSE+EV	0.000108	0.001150	303460	0.09	0.9252
CDD:hour06:HOUSE+EV	0.000617	0.001200	303460	0.51	0.6070
CDD:hour07:HOUSE+EV	0.000632	0.001233	303460	0.51	0.6080
CDD:hour08:HOUSE+EV	0.001019	0.001255	303460	0.81	0.4167
CDD:hour09:HOUSE+EV	0.001121	0.001271	303460	0.88	0.3776
CDD:hour10:HOUSE+EV	0.000826	0.001280	303460	0.65	0.5186
CDD:hour11:HOUSE+EV	0.000167	0.001287	303460	0.13	0.8968
CDD:hour12:HOUSE+EV	0.000853	0.001292	303460	0.66	0.5091
CDD:hour13:HOUSE+EV	0.000305	0.001295	303460	0.24	0.8135

Variable	Coefficient	Std.Error	DF	t-value	p-value
CDD:hour14:HOUSE+EV	0.000606	0.001297	303460	0.47	0.6402
CDD:hour15:HOUSE+EV	0.000990	0.001298	303460	0.76	0.4460
CDD:hour16:HOUSE+EV	0.000977	0.001299	303460	0.75	0.4523
CDD:hour17:HOUSE+EV	0.000898	0.001300	303460	0.69	0.4895
CDD:hour18:HOUSE+EV	0.001197	0.001301	303460	0.92	0.3573
CDD:hour19:HOUSE+EV	0.000917	0.001301	303460	0.71	0.4807
CDD:hour20:HOUSE+EV	0.001075	0.001301	303460	0.83	0.4086
CDD:hour21:HOUSE+EV	0.001036	0.001301	303460	0.80	0.4259
CDD:hour22:HOUSE+EV	0.001023	0.001301	303460	0.79	0.4317
CDD:hour23:HOUSE+EV	0.001164	0.001301	303460	0.89	0.3711
CDD:hour24:HOUSE+EV	0.001140	0.001302	303460	0.88	0.3811
CDD:nonevent:HOUSE+EV	0.001793	0.001084	303460	1.65	0.0980
hour02:nonevent:HOUSE+EV	-0.086497	0.140781	303460	-0.61	0.5389
hour03:nonevent:HOUSE+EV	0.245751	0.182721	303460	1.34	0.1786
hour04:nonevent:HOUSE+EV	0.284416	0.206579	303460	1.38	0.1686
hour05:nonevent:HOUSE+EV	0.150531	0.221435	303460	0.68	0.4966
hour06:nonevent:HOUSE+EV	0.232441	0.231055	303460	1.01	0.3144
hour07:nonevent:HOUSE+EV	0.182675	0.237415	303460	0.77	0.4416
hour08:nonevent:HOUSE+EV	0.235447	0.241672	303460	0.97	0.3299
hour09:nonevent:HOUSE+EV	0.297003	0.244611	303460	1.21	0.2247
hour10:nonevent:HOUSE+EV	0.226542	0.246495	303460	0.92	0.3581
hour11:nonevent:HOUSE+EV	0.145485	0.247816	303460	0.59	0.5572
hour12:nonevent:HOUSE+EV	0.270090	0.248715	303460	1.09	0.2775
hour13:nonevent:HOUSE+EV	0.183556	0.249330	303460	0.74	0.4616
hour14:nonevent:HOUSE+EV	0.241557	0.249750	303460	0.97	0.3334
hour15:nonevent:HOUSE+EV	0.277496	0.250038	303460	1.11	0.2671
hour16:nonevent:HOUSE+EV	0.258693	0.250234	303460	1.03	0.3012
hour17:nonevent:HOUSE+EV	0.260055	0.250369	303460	1.04	0.2990
hour18:nonevent:HOUSE+EV	0.280059	0.250461	303460	1.12	0.2635
hour19:nonevent:HOUSE+EV	0.226002	0.250524	303460	0.90	0.3670
hour20:nonevent:HOUSE+EV	0.256358	0.250567	303460	1.02	0.3063
hour21:nonevent:HOUSE+EV	0.288320	0.250597	303460	1.15	0.2499
hour22:nonevent:HOUSE+EV	0.322466	0.250617	303460	1.29	0.1982
hour23:nonevent:HOUSE+EV	0.336279	0.250631	303460	1.34	0.1797
hour24:nonevent:HOUSE+EV	0.319651	0.250640	303460	1.28	0.2022
CDD:TG3:HOUSE+EV	0.000678	0.001262	303460	0.54	0.5913
hour02:TG3:HOUSE+EV	-0.372013	0.180116	303460	-2.07	0.0389
hour03:TG3:HOUSE+EV	-0.312136	0.233775	303460	-1.34	0.1818
hour04:TG3:HOUSE+EV	-0.139412	0.264299	303460	-0.53	0.5979
hour05:TG3:HOUSE+EV	0.070904	0.283305	303460	0.25	0.8024
hour06:TG3:HOUSE+EV	0.312198	0.295613	303460	1.06	0.2909
hour07:TG3:HOUSE+EV	0.373968	0.303751	303460	1.23	0.2183
hour08:TG3:HOUSE+EV	0.395011	0.309198	303460	1.28	0.2014
hour09:TG3:HOUSE+EV	0.517083	0.312923	303460	1.65	0.0984

Variable	Coefficient	Std.Error	DF	t-value	p-value
hour10:TG3:HOUSE+EV	0.434136	0.315363	303460	1.38	0.1686
hour11:TG3:HOUSE+EV	0.249247	0.317057	303460	0.79	0.4318
hour12:TG3:HOUSE+EV	0.440214	0.318211	303460	1.38	0.1665
hour13:TG3:HOUSE+EV	0.426655	0.318999	303460	1.34	0.1811
hour14:TG3:HOUSE+EV	0.545446	0.319538	303460	1.71	0.0878
hour15:TG3:HOUSE+EV	0.468659	0.319905	303460	1.46	0.1429
hour16:TG3:HOUSE+EV	0.462368	0.320157	303460	1.44	0.1487
hour17:TG3:HOUSE+EV	0.462455	0.320329	303460	1.44	0.1488
hour18:TG3:HOUSE+EV	0.488643	0.320447	303460	1.52	0.1273
hour19:TG3:HOUSE+EV	0.435122	0.320528	303460	1.36	0.1746
hour20:TG3:HOUSE+EV	0.449076	0.320583	303460	1.40	0.1613
hour21:TG3:HOUSE+EV	0.450788	0.320621	303460	1.41	0.1597
hour22:TG3:HOUSE+EV	0.456697	0.320646	303460	1.42	0.1544
hour23:TG3:HOUSE+EV	0.493212	0.320664	303460	1.54	0.1240
hour24:TG3:HOUSE+EV	0.497111	0.320676	303460	1.55	0.1211
nonevent:TG3:HOUSE+EV	0.322937	0.243587	303460	1.33	0.1849
CDD:hour02:nonevent:TG3	0.000576	0.000833	303460	0.69	0.4892
CDD:hour03:nonevent:TG3	-0.000115	0.001082	303460	-0.11	0.9154
CDD:hour04:nonevent:TG3	0.000205	0.001223	303460	0.17	0.8670
CDD:hour05:nonevent:TG3	0.000224	0.001311	303460	0.17	0.8644
CDD:hour06:nonevent:TG3	0.000598	0.001368	303460	0.44	0.6617
CDD:hour07:nonevent:TG3	0.000177	0.001405	303460	0.13	0.8998
CDD:hour08:nonevent:TG3	-0.000069	0.001431	303460	-0.05	0.9613
CDD:hour09:nonevent:TG3	-0.000125	0.001448	303460	-0.09	0.9313
CDD:hour10:nonevent:TG3	0.000099	0.001459	303460	0.07	0.9458
CDD:hour11:nonevent:TG3	0.001464	0.001467	303460	1.00	0.3183
CDD:hour12:nonevent:TG3	0.000533	0.001472	303460	0.36	0.7173
CDD:hour13:nonevent:TG3	0.000583	0.001476	303460	0.39	0.6930
CDD:hour14:nonevent:TG3	0.001357	0.001478	303460	0.92	0.3588
CDD:hour15:nonevent:TG3	0.002644	0.001480	303460	1.79	0.0740
CDD:hour16:nonevent:TG3	0.004067	0.001481	303460	2.75	0.0060
CDD:hour17:nonevent:TG3	0.002729	0.001482	303460	1.84	0.0655
CDD:hour18:nonevent:TG3	0.002315	0.001482	303460	1.56	0.1185
CDD:hour19:nonevent:TG3	0.001509	0.001483	303460	1.02	0.3088
CDD:hour20:nonevent:TG3	-0.000057	0.001483	303460	-0.04	0.9694
CDD:hour21:nonevent:TG3	0.001205	0.001483	303460	0.81	0.4165
CDD:hour22:nonevent:TG3	0.000739	0.001483	303460	0.50	0.6181
CDD:hour23:nonevent:TG3	-0.000120	0.001484	303460	-0.08	0.9358
CDD:hour24:nonevent:TG3	0.000709	0.001484	303460	0.48	0.6328
CDD:hour02:nonevent:HOUSE+EV	-0.000470	0.000861	303460	-0.55	0.5850
CDD:hour03:nonevent:HOUSE+EV	-0.002457	0.001117	303460	-2.20	0.0278
CDD:hour04:nonevent:HOUSE+EV	-0.002151	0.001263	303460	-1.70	0.0885
CDD:hour05:nonevent:HOUSE+EV	-0.001198	0.001354	303460	-0.89	0.3762
CDD:hour06:nonevent:HOUSE+EV	-0.001798	0.001412	303460	-1.27	0.2030

Variable	Coefficient	Std.Error	DF	t-value	p-value
CDD:hour07:nonevent:HOUSE+EV	-0.001279	0.001451	303460	-0.88	0.3782
CDD:hour08:nonevent:HOUSE+EV	-0.001477	0.001477	303460	-1.00	0.3175
CDD:hour09:nonevent:HOUSE+EV	-0.002124	0.001496	303460	-1.42	0.1556
CDD:hour10:nonevent:HOUSE+EV	-0.001590	0.001507	303460	-1.06	0.2912
CDD:hour11:nonevent:HOUSE+EV	-0.001130	0.001515	303460	-0.75	0.4556
CDD:hour12:nonevent:HOUSE+EV	-0.002266	0.001520	303460	-1.49	0.1362
CDD:hour13:nonevent:HOUSE+EV	-0.001510	0.001524	303460	-0.99	0.3218
CDD:hour14:nonevent:HOUSE+EV	-0.001584	0.001527	303460	-1.04	0.2995
CDD:hour15:nonevent:HOUSE+EV	-0.002075	0.001528	303460	-1.36	0.1747
CDD:hour16:nonevent:HOUSE+EV	-0.002012	0.001530	303460	-1.32	0.1884
CDD:hour17:nonevent:HOUSE+EV	-0.001768	0.001530	303460	-1.16	0.2479
CDD:hour18:nonevent:HOUSE+EV	-0.002051	0.001531	303460	-1.34	0.1804
CDD:hour19:nonevent:HOUSE+EV	-0.001824	0.001531	303460	-1.19	0.2335
CDD:hour20:nonevent:HOUSE+EV	-0.001884	0.001532	303460	-1.23	0.2186
CDD:hour21:nonevent:HOUSE+EV	-0.001765	0.001532	303460	-1.15	0.2493
CDD:hour22:nonevent:HOUSE+EV	-0.001843	0.001532	303460	-1.20	0.2290
CDD:hour23:nonevent:HOUSE+EV	-0.001999	0.001532	303460	-1.30	0.1920
CDD:hour24:nonevent:HOUSE+EV	-0.001778	0.001532	303460	-1.16	0.2460
CDD:hour02:TG3:HOUSE+EV	0.000768	0.001002	303460	0.77	0.4433
CDD:hour03:TG3:HOUSE+EV	0.000142	0.001301	303460	0.11	0.9129
CDD:hour04:TG3:HOUSE+EV	0.000375	0.001471	303460	0.26	0.7985
CDD:hour05:TG3:HOUSE+EV	0.000411	0.001576	303460	0.26	0.7945
CDD:hour06:TG3:HOUSE+EV	-0.000503	0.001645	303460	-0.31	0.7596
CDD:hour07:TG3:HOUSE+EV	-0.000544	0.001690	303460	-0.32	0.7475
CDD:hour08:TG3:HOUSE+EV	-0.000560	0.001721	303460	-0.33	0.7450
CDD:hour09:TG3:HOUSE+EV	-0.001017	0.001742	303460	-0.58	0.5592
CDD:hour10:TG3:HOUSE+EV	-0.000693	0.001755	303460	-0.40	0.6928
CDD:hour11:TG3:HOUSE+EV	0.000283	0.001764	303460	0.16	0.8724
CDD:hour12:TG3:HOUSE+EV	-0.000823	0.001771	303460	-0.46	0.6422
CDD:hour13:TG3:HOUSE+EV	-0.000451	0.001775	303460	-0.25	0.7995
CDD:hour14:TG3:HOUSE+EV	-0.001062	0.001778	303460	-0.60	0.5503
CDD:hour15:TG3:HOUSE+EV	-0.000913	0.001780	303460	-0.51	0.6081
CDD:hour16:TG3:HOUSE+EV	-0.000839	0.001782	303460	-0.47	0.6376
CDD:hour17:TG3:HOUSE+EV	-0.000662	0.001782	303460	-0.37	0.7102
CDD:hour18:TG3:HOUSE+EV	-0.000984	0.001783	303460	-0.55	0.5810
CDD:hour19:TG3:HOUSE+EV	-0.000670	0.001784	303460	-0.38	0.7072
CDD:hour20:TG3:HOUSE+EV	-0.000648	0.001784	303460	-0.36	0.7164
CDD:hour21:TG3:HOUSE+EV	-0.000522	0.001784	303460	-0.29	0.7698
CDD:hour22:TG3:HOUSE+EV	-0.000556	0.001784	303460	-0.31	0.7555
CDD:hour23:TG3:HOUSE+EV	-0.000786	0.001784	303460	-0.44	0.6595
CDD:hour24:TG3:HOUSE+EV	-0.000866	0.001784	303460	-0.49	0.6275
CDD:nonevent:TG3:HOUSE+EV	-0.001836	0.001484	303460	-1.24	0.2160
hour02:nonevent:TG3:HOUSE+EV	-0.093219	0.193473	303460	-0.48	0.6299
hour03:nonevent:TG3:HOUSE+EV	-0.431867	0.251120	303460	-1.72	0.0855

Variable	Coefficient	Std.Error	DF	t-value	p-value
hour04:nonevent:TG3:HOUSE+EV	-0.371278	0.283898	303460	-1.31	0.1909
hour05:nonevent:TG3:HOUSE+EV	-0.226359	0.304314	303460	-0.74	0.4570
hour06:nonevent:TG3:HOUSE+EV	-0.353930	0.317534	303460	-1.11	0.2650
hour07:nonevent:TG3:HOUSE+EV	-0.263321	0.326275	303460	-0.81	0.4196
hour08:nonevent:TG3:HOUSE+EV	-0.259256	0.332125	303460	-0.78	0.4350
hour09:nonevent:TG3:HOUSE+EV	-0.410031	0.336122	303460	-1.22	0.2225
hour10:nonevent:TG3:HOUSE+EV	-0.315637	0.338751	303460	-0.93	0.3515
hour11:nonevent:TG3:HOUSE+EV	-0.158199	0.340569	303460	-0.46	0.6423
hour12:nonevent:TG3:HOUSE+EV	-0.361508	0.341806	303460	-1.06	0.2902
hour13:nonevent:TG3:HOUSE+EV	-0.304531	0.342651	303460	-0.89	0.3741
hour14:nonevent:TG3:HOUSE+EV	-0.347375	0.343229	303460	-1.01	0.3115
hour15:nonevent:TG3:HOUSE+EV	-0.336958	0.343625	303460	-0.98	0.3268
hour16:nonevent:TG3:HOUSE+EV	-0.325935	0.343895	303460	-0.95	0.3432
hour17:nonevent:TG3:HOUSE+EV	-0.306573	0.344080	303460	-0.89	0.3729
hour18:nonevent:TG3:HOUSE+EV	-0.368343	0.344206	303460	-1.07	0.2846
hour19:nonevent:TG3:HOUSE+EV	-0.299889	0.344293	303460	-0.87	0.3837
hour20:nonevent:TG3:HOUSE+EV	-0.292309	0.344352	303460	-0.85	0.3960
hour21:nonevent:TG3:HOUSE+EV	-0.260807	0.344393	303460	-0.76	0.4489
hour22:nonevent:TG3:HOUSE+EV	-0.293302	0.344421	303460	-0.85	0.3944
hour23:nonevent:TG3:HOUSE+EV	-0.299925	0.344440	303460	-0.87	0.3839
hour24:nonevent:TG3:HOUSE+EV	-0.283829	0.344453	303460	-0.82	0.4099
CDD:hour02:nonevent:TG3:HOUSE+EV	0.000881	0.001178	303460	0.75	0.4547
CDD:hour03:nonevent:TG3:HOUSE+EV	0.003250	0.001529	303460	2.12	0.0336
CDD:hour04:nonevent:TG3:HOUSE+EV	0.002462	0.001729	303460	1.42	0.1545
CDD:hour05:nonevent:TG3:HOUSE+EV	0.001260	0.001854	303460	0.68	0.4967
CDD:hour06:nonevent:TG3:HOUSE+EV	0.002127	0.001934	303460	1.10	0.2714
CDD:hour07:nonevent:TG3:HOUSE+EV	0.001292	0.001987	303460	0.65	0.5157
CDD:hour08:nonevent:TG3:HOUSE+EV	0.000909	0.002023	303460	0.45	0.6534
CDD:hour09:nonevent:TG3:HOUSE+EV	0.001842	0.002048	303460	0.90	0.3683
CDD:hour10:nonevent:TG3:HOUSE+EV	0.001235	0.002063	303460	0.60	0.5496
CDD:hour11:nonevent:TG3:HOUSE+EV	0.000741	0.002074	303460	0.36	0.7207
CDD:hour12:nonevent:TG3:HOUSE+EV	0.002367	0.002082	303460	1.14	0.2556
CDD:hour13:nonevent:TG3:HOUSE+EV	0.001620	0.002087	303460	0.78	0.4377
CDD:hour14:nonevent:TG3:HOUSE+EV	0.001789	0.002091	303460	0.86	0.3920
CDD:hour15:nonevent:TG3:HOUSE+EV	0.002045	0.002093	303460	0.98	0.3285
CDD:hour16:nonevent:TG3:HOUSE+EV	0.002055	0.002095	303460	0.98	0.3265
CDD:hour17:nonevent:TG3:HOUSE+EV	0.001845	0.002096	303460	0.88	0.3786
CDD:hour18:nonevent:TG3:HOUSE+EV	0.002195	0.002096	303460	1.05	0.2952
CDD:hour19:nonevent:TG3:HOUSE+EV	0.001851	0.002097	303460	0.88	0.3773
CDD:hour20:nonevent:TG3:HOUSE+EV	0.001660	0.002097	303460	0.79	0.4286
CDD:hour21:nonevent:TG3:HOUSE+EV	0.001152	0.002098	303460	0.55	0.5828
CDD:hour22:nonevent:TG3:HOUSE+EV	0.001268	0.002098	303460	0.60	0.5455
CDD:hour23:nonevent:TG3:HOUSE+EV	0.001478	0.002098	303460	0.70	0.4810
CDD:hour24:nonevent:TG3:HOUSE+EV	0.001448	0.002098	303460	0.69	0.4901

VARIANCE COVARIANCE MATRIX

TABLE 23. VARIANCE COVARIANCE MATRIX, SUMMER WEEKDAY MODEL

	Variance	StdDev
Customer (Intercept)	0.4201643	0.6482008
Residual	1.6531206	1.2857374

CORRECTIONS

AR(1) error structure was the only correction applied.

RESULTS

TABLE 24.SUMMER WEEKDAY IMPACTS, BY TREATMENT

Treatment Group	N	Time Period (hour)	Savings (kWh/h)	Standard Error	95% Confidence Intervals		Reference Load (2013)	% Savings
TG2	47	15-16,20-24	-0.058	0.0646	-0.2028	0.0878	1.82	-3.1%
TG3	52	15-16,20-24	-0.055	0.0614	-0.1933	0.0826	2.36	-2.4%
TG2	47	17-19	-0.022	0.0863	-0.2156	0.1725	2.16	-1.0%
TG3	52	17-19	-0.033	0.0819	-0.2172	0.1513	3.00	-1.1%
TG2	47	1-14	+0.008	0.0560	-0.1180	0.1336	1.59	+0.4%
TG3	52	1-14	-0.007	0.0531	-0.1268	0.1120	1.50	-0.5%
TG2	47	1-24	-0.015	0.0447	-0.1154	0.0855	1.73	-0.8%
TG3	52	1-24	-0.025	0.0424	-0.1199	0.0707	1.94	-1.2%

* Statistically significant, α=0.05

TABLE 25.SUMMER WEEKDAY IMPACTS, BETWEEN-TREATMENT COMPARISONS

Treatment Group	Time Period (hour)	Savings (kWh/h)	Standard Error	95% Confidence Intervals	
TG2 - TG3	15-16,20-24	-0.003	0.0891	-0.2025	0.1981
TG2 - TG3	17-19	+0.011	0.1190	-0.2565	0.2785
TG2 - TG3	1-14	+0.0150	0.0772	-0.1584	0.1884
TG2 - TG3	1-24	+0.0097	0.0616	-0.1288	0.1482

* Statistically significant, α=0.05

EVENT MODELING

FIGURE 23. MODELED HOUSE AND EV LOADS ON EVENT AND NON-EVENT DAYS, BY TREATMENT

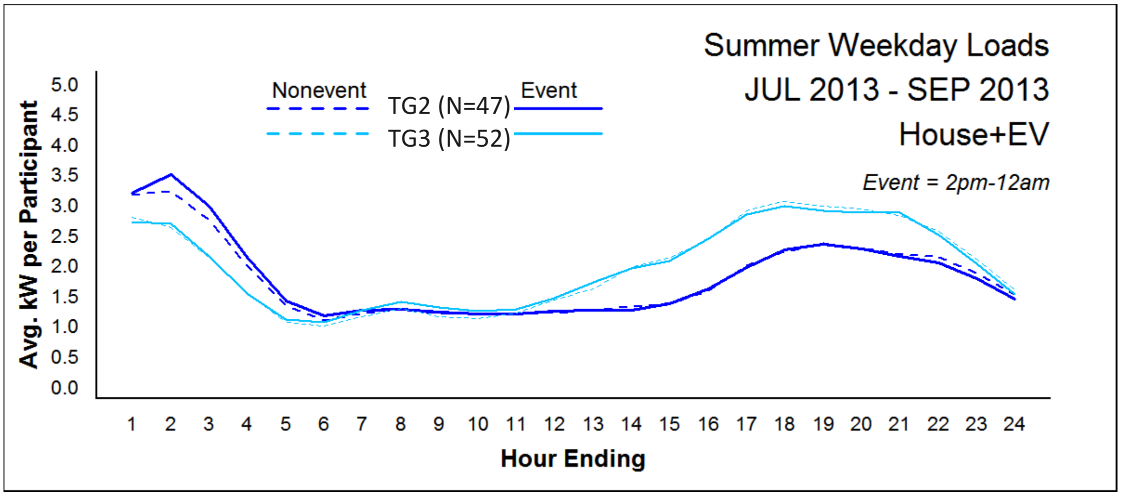

FIGURE 24. MODELED HOUSE AND EV IMPACTS ON EVENT AND NON-EVENT DAYS, BY TREATMENT

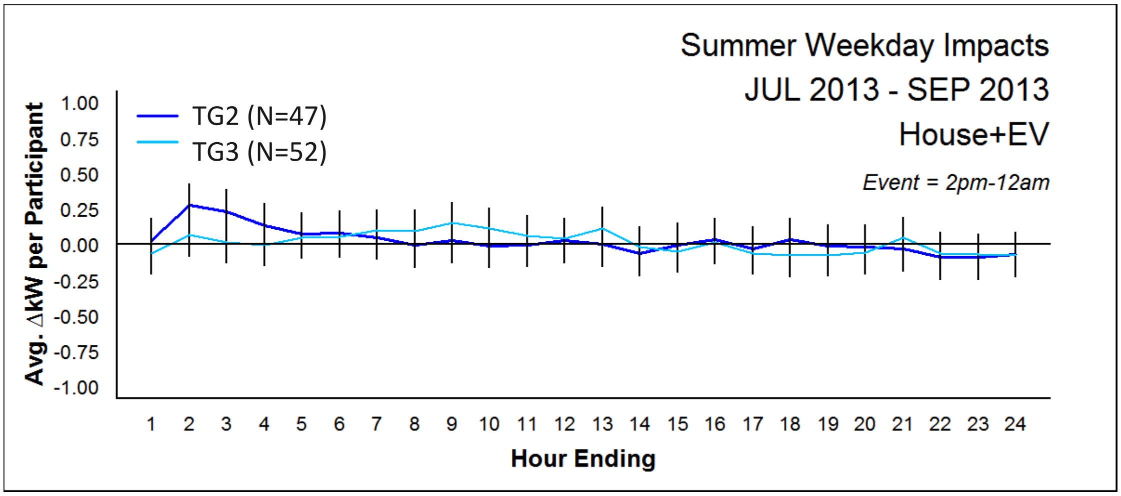

TABLE 26. HOUSE+EV EVENT IMPACTS

Treatment	N	Off Peak (hours 1-14)	Peak (hours 15-16,20-24)	Super Peak (hours 17-19)	Total (hours 1-24)
TG2	47	0.023 (1.4%)	-0.100 (-5.6%)	-0.045 (-2.1%)	-0.022 (-1.2%)
TG3	52	-0.007 (-0.4%)	-0.077 (-3.3%)	-0.023 (-0.8%)	-0.029 (-1.5%)
Difference		0.03	-0.027	-0.022	0.007

FIGURE 25. MODELED HOUSE LOADS ON EVENT AND NON-EVENT DAYS, BY TREATMENT

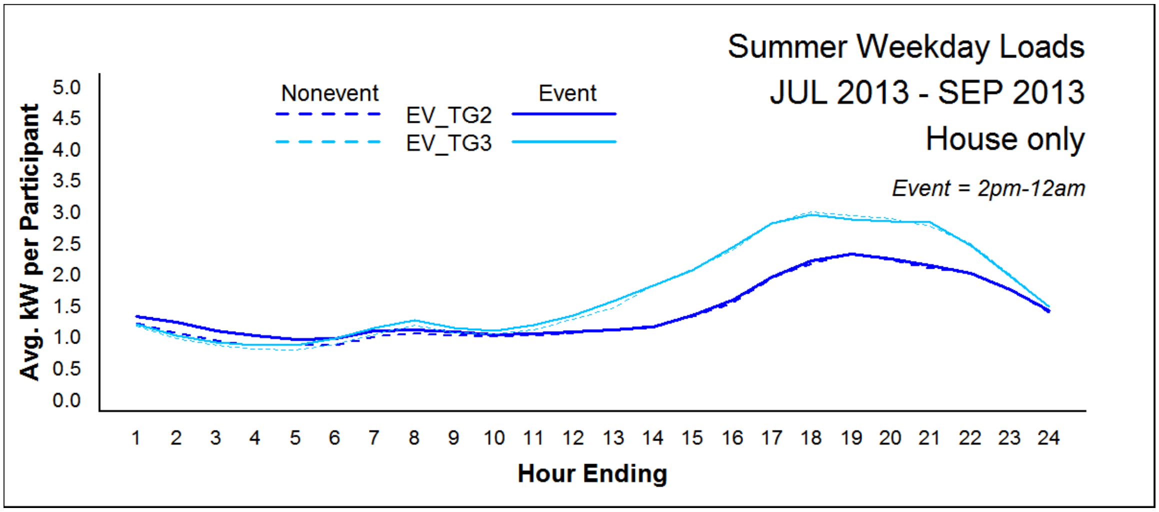

FIGURE 26. MODELED HOUSE IMPACTS ON EVENT AND NON-EVENT DAYS, BY TREATMENT

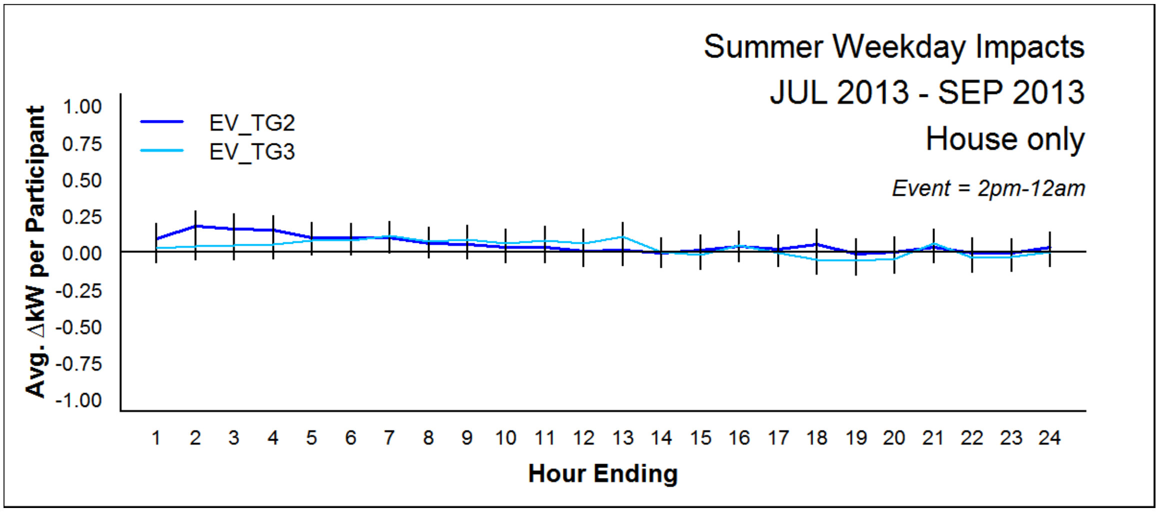

TABLE 27. HOUSE ONLY EVENT IMPACTS

Treatment	N	Off Peak (hours 1-14)	Peak (hours 15-16,20-24)	Super Peak (hours 17-19)	Total (hours 1-24)
TG2	47	0.021 (2.1%)	-0.043 (-2.4%)	-0.016 (-0.7%)	-0.002 (-0.2%)
TG3	52	0.002 (0.2%)	-0.022 (-1.0%)	0.013 (0.4%)	-0.004 (-0.2%)
Difference		0.019	-0.020	-0.029	0.0017

APPENDIX C. SUMMER MODEL

All days except weekends and holidays were included in the analysis.

- Baseline = July 1, 2012 – September, 30 2012
- Treatment = July 1, 2013 – September 30, 2013

MODEL DETAILS

CONTRASTS

1. *Treatment loads are not different from baseline loads (adjusted for weather)*

$H_0: L = 0$

$H_a: L \neq 0$

$L = \sum_{i=1}^{6} c_i \mu_i \; where \; \sum_{i=1}^{6} c_i = 0, If \; |t^* = \frac{L}{\sigma^2\{L\}} \; | \leq t(n-p-q), then \; H_0; otherwise, H_a$[3]

For Super peak comparison, $c_1 through \; c_6 = {}^1/_3, -{}^1/_3, {}^1/_3, -{}^1/_3, {}^1/_3, -{}^1/_3$

2. *Treatment type has no effect on impacts (adjusted for weather)*

For Super peak comparison, $c_1 through \; c_{12} = {}^1/_3, -{}^1/_3, {}^1/_3, -{}^1/_3, {}^1/_3, -{}^1/_3, -{}^1/_3, {}^1/_3, -{}^1/_3, {}^1/_3, -{}^1/_3, {}^1/_3$

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[3] n=number of observations, p = number of model parameters associated with fixed effects, q = number of covariance parameters with random effects or correlations

CONTRASTS EXAMPLES

TG2 Super peak impact relative to baseline (adjusted for weather), and comparing TG2 and TG3 treatments Super peak impacts (adjusted for weather and pretreatment differences)

1. *Treatment loads are not different from baseline loads (adjusted for weather)*

$$\hat{L} = \left[\frac{\begin{matrix}(\hat{\mu}_{TG2.treatment.House+EV.at.hr17} - \hat{\mu}_{TG2.baseline.House+EV.at.hr17}) + \\ (\hat{\mu}_{TG2.treatment.House+EV.at.hr18} - \hat{\mu}_{TG2.baseline.House+EV.at.hr18}) + \\ (\hat{\mu}_{TG2.treatment.House+EV.at.hr19} - \hat{\mu}_{TG2.baseline.House+EV.at.hr19})\end{matrix}}{3}\right]$$

2. *Treatment type has no effect on impacts (adjusted for weather)*

$$\hat{L} = \left(\left[\frac{\begin{matrix}(\hat{\mu}_{TG2treatment.House+EV.at.hr17} - \hat{\mu}_{TG2.baseline.House+EV.at.hr17}) + \\ (\hat{\mu}_{TG2.treatment.House+EV.at.hr18} - \hat{\mu}_{TG2.baseline.House+EV.at.hr18}) + \\ (\hat{\mu}_{TG2.treatment.House+EV.at.hr19} - \hat{\mu}_{TG2.baseline.House+EV.at.hr19})\end{matrix}}{3}\right] - \left[\frac{\begin{matrix}(\hat{\mu}_{TG3.treatment.House.at.hr17} - \hat{\mu}_{TG3.baseline.House.at.hr17}) + \\ (\hat{\mu}_{TG3.treatment.House.at.hr18} - \hat{\mu}_{TG3.baseline.House.at.hr18}) + \\ (\hat{\mu}_{TG3.treatment.House.at.hr19} - \hat{\mu}_{TG3.baseline.House.at.hr19})\end{matrix}}{3}\right]\right)$$

Notes:

$\mu's$ are estimated using regression coefficients) with the temperature profile of interest – average temp weekday summer 2013 days.

MODELS COMPARISON

TABLE 28.MODEL COMPARISON, SUMMER MODEL

	Model	DF	AIC	BIC	logLik	Test	L.Ratio	p-value
Summer weekday **model Random Customer & Day**	1	149	141159	142461.2	-70431			
FINAL MODEL: Summer weekday **model Random Customer & Day AR(1)**	2	150	118322	119632.6	-59011	1 vs 2	22839.36	<0.0001

TESTS FOR FIXED EFFECTS

TABLE 29.F-TESTS FOR VARIABLES IN THE MODEL, SUMMER MODEL

Variable	Numerator DF	Denominator DF	F-value	p-value
CDH	1	44109	1386.10	<0.0001
CDD	1	1896	76.24	<0.0001
hour	24	44109	74.28	<0.0001
Treatment_Period	5	1896	9.06	<0.0001
hour:Treatment_Period	115	44109	17.82	<0.0001

MODEL COEFFICIENTS

conditional R^2 = 0.4229

Table 30 provides model coefficients for summer weekday model. TG1.baseline is the reference level for treatment and period.

TABLE 30. MODEL COEFFICIENTS, SUMMER MODEL

Variable	Coefficient	Std.Error	DF	t-value	p-value
CDH	0.046936	0.002713	44109	17.30	<0.0001
CDD	0.001353	0.000215	1896	6.29	<0.0001
hour01	1.337624	0.373560	44109	3.58	0.0003
hour02	1.243677	0.373587	44109	3.33	0.0009
hour03	1.237462	0.373595	44109	3.31	0.0009
hour04	1.190571	0.373602	44109	3.19	0.0014
hour05	1.272207	0.373607	44109	3.41	0.0007
hour06	1.405358	0.373608	44109	3.76	0.0002
hour07	1.259045	0.373608	44109	3.37	0.0008
hour08	0.894696	0.373609	44109	2.39	0.0166
hour09	0.699646	0.373609	44109	1.87	0.0611
hour10	0.699074	0.373609	44109	1.87	0.0613
hour11	0.821228	0.373607	44109	2.20	0.0279
hour12	0.848056	0.373563	44109	2.27	0.0232
hour13	0.974342	0.373456	44109	2.61	0.0091
hour14	0.959909	0.373372	44109	2.57	0.0101
hour15	1.154406	0.373596	44109	3.09	0.0020
hour16	1.303518	0.374044	44109	3.48	0.0005
hour17	1.386051	0.374510	44109	3.70	0.0002
hour18	1.643525	0.374825	44109	4.38	<0.0001
hour19	1.501654	0.374978	44109	4.00	0.0001

Variable	Coefficient	Std.Error	DF	t-value	p-value
hour20	1.675886	0.374805	44109	4.47	<0.0001
hour21	2.016911	0.374113	44109	5.39	<0.0001
hour22	1.962722	0.373484	44109	5.26	<0.0001
hour23	1.722040	0.373382	44109	4.61	<0.0001
hour24	1.646309	0.373491	44109	4.41	<0.0001
TG1.treatment	0.863412	0.125189	1896	6.90	<0.0001
TG2.baseline	0.022132	0.422510	1896	0.05	0.9582
TG2.treatment	0.439714	0.422596	1896	1.04	0.2982
TG3.baseline	0.224519	0.500043	1896	0.45	0.6535
TG3.treatment	1.280506	0.500135	1896	2.56	0.0105
hour02:TG1.treatment	-0.085114	0.101918	44109	-0.84	0.4037
hour03:TG1.treatment	-0.132390	0.131582	44109	-1.01	0.3144
hour04:TG1.treatment	-0.239927	0.148097	44109	-1.62	0.1052
hour05:TG1.treatment	-0.286291	0.158155	44109	-1.81	0.0703
hour06:TG1.treatment	-0.410091	0.164520	44109	-2.49	0.0127
hour07:TG1.treatment	-0.518756	0.168631	44109	-3.08	0.0021
hour08:TG1.treatment	-0.571700	0.171318	44109	-3.34	0.0008
hour09:TG1.treatment	-0.568043	0.173086	44109	-3.28	0.0010
hour10:TG1.treatment	-0.623879	0.174255	44109	-3.58	0.0003
hour11:TG1.treatment	-0.710069	0.175030	44109	-4.06	<0.0001
hour12:TG1.treatment	-0.565655	0.175542	44109	-3.22	0.0013
hour13:TG1.treatment	-0.689382	0.175897	44109	-3.92	0.0001
hour14:TG1.treatment	-0.570846	0.176208	44109	-3.24	0.0012
hour15:TG1.treatment	-0.872814	0.176524	44109	-4.94	<0.0001
hour16:TG1.treatment	-1.007520	0.176692	44109	-5.70	<0.0001
hour17:TG1.treatment	-1.221498	0.176824	44109	-6.91	<0.0001
hour18:TG1.treatment	-1.331302	0.176922	44109	-7.52	<0.0001
hour19:TG1.treatment	-1.501190	0.176990	44109	-8.48	<0.0001
hour20:TG1.treatment	-1.215722	0.177069	44109	-6.87	<0.0001
hour21:TG1.treatment	-0.764270	0.176970	44109	-4.32	<0.0001
hour22:TG1.treatment	-0.496155	0.176768	44109	-2.81	0.0050
hour23:TG1.treatment	-0.476401	0.176612	44109	-2.70	0.0070
hour24:TG1.treatment	-0.293371	0.176565	44109	-1.66	0.0966
hour02:TG2.baseline	-0.362478	0.081715	44109	-4.44	<0.0001
hour03:TG2.baseline	-0.634554	0.105499	44109	-6.01	<0.0001
hour04:TG2.baseline	-0.806806	0.118740	44109	-6.79	<0.0001
hour05:TG2.baseline	-0.924787	0.126804	44109	-7.29	<0.0001

Variable	Coefficient	Std.Error	DF	t-value	p-value
hour06:TG2.baseline	-0.922395	0.131907	44109	-6.99	<0.0001
hour07:TG2.baseline	-0.714249	0.135203	44109	-5.28	<0.0001
hour08:TG2.baseline	-0.468342	0.137357	44109	-3.41	0.0007
hour09:TG2.baseline	-0.205992	0.138780	44109	-1.48	0.1377
hour10:TG2.baseline	-0.076174	0.139713	44109	-0.55	0.5856
hour11:TG2.baseline	-0.174053	0.140334	44109	-1.24	0.2149
hour12:TG2.baseline	-0.039207	0.140747	44109	-0.28	0.7806
hour13:TG2.baseline	-0.195183	0.141025	44109	-1.38	0.1664
hour14:TG2.baseline	-0.425665	0.141210	44109	-3.01	0.0026
hour15:TG2.baseline	-0.764741	0.141327	44109	-5.41	<0.0001
hour16:TG2.baseline	-0.978941	0.141408	44109	-6.92	<0.0001
hour17:TG2.baseline	-0.772944	0.141462	44109	-5.46	<0.0001
hour18:TG2.baseline	-0.748143	0.141499	44109	-5.29	<0.0001
hour19:TG2.baseline	-0.522018	0.141523	44109	-3.69	0.0002
hour20:TG2.baseline	-0.755749	0.141538	44109	-5.34	<0.0001
hour21:TG2.baseline	-0.822138	0.141550	44109	-5.81	<0.0001
hour22:TG2.baseline	-0.576014	0.141560	44109	-4.07	<0.0001
hour23:TG2.baseline	-0.154661	0.141562	44109	-1.09	0.2746
hour24:TG2.baseline	0.022236	0.141564	44109	0.16	0.8752
hour02:TG2.treatment	0.351646	0.081716	44109	4.30	<0.0001
hour03:TG2.treatment	0.024389	0.105501	44109	0.23	0.8172
hour04:TG2.treatment	-0.523942	0.118743	44109	-4.41	<0.0001
hour05:TG2.treatment	-1.118993	0.126807	44109	-8.82	<0.0001
hour06:TG2.treatment	-1.190920	0.131910	44109	-9.03	<0.0001
hour07:TG2.treatment	-1.013430	0.135206	44109	-7.50	<0.0001
hour08:TG2.treatment	-0.778472	0.137360	44109	-5.67	<0.0001
hour09:TG2.treatment	-0.531704	0.138785	44109	-3.83	0.0001
hour10:TG2.treatment	-0.443250	0.139725	44109	-3.17	0.0015
hour11:TG2.treatment	-0.489548	0.140344	44109	-3.49	0.0005
hour12:TG2.treatment	-0.395399	0.140747	44109	-2.81	0.0050
hour13:TG2.treatment	-0.588518	0.141028	44109	-4.17	<0.0001
hour14:TG2.treatment	-0.743322	0.141278	44109	-5.26	<0.0001
hour15:TG2.treatment	-1.178084	0.141585	44109	-8.32	<0.0001
hour16:TG2.treatment	-1.435486	0.141774	44109	-10.13	<0.0001
hour17:TG2.treatment	-1.437766	0.141907	44109	-10.13	<0.0001
hour18:TG2.treatment	-1.672369	0.141997	44109	-11.78	<0.0001
hour19:TG2.treatment	-1.350669	0.142113	44109	-9.50	<0.0001

Variable	Coefficient	Std.Error	DF	t-value	p-value
hour20:TG2.treatment	-1.484214	0.142215	44109	-10.44	<0.0001
hour21:TG2.treatment	-1.740758	0.142032	44109	-12.26	<0.0001
hour22:TG2.treatment	-1.574248	0.141775	44109	-11.10	<0.0001
hour23:TG2.treatment	-1.381308	0.141618	44109	-9.75	<0.0001
hour24:TG2.treatment	-1.491237	0.141568	44109	-10.53	<0.0001
hour02:TG3.baseline	-0.113476	0.097103	44109	-1.17	0.2426
hour03:TG3.baseline	-0.267632	0.125366	44109	-2.13	0.0328
hour04:TG3.baseline	-0.244837	0.141101	44109	-1.74	0.0827
hour05:TG3.baseline	-0.489847	0.150682	44109	-3.25	0.0012
hour06:TG3.baseline	-0.785357	0.156747	44109	-5.01	<0.0001
hour07:TG3.baseline	-0.644542	0.160664	44109	-4.01	0.0001
hour08:TG3.baseline	-0.359503	0.163223	44109	-2.20	0.0276
hour09:TG3.baseline	-0.292177	0.164908	44109	-1.77	0.0764
hour10:TG3.baseline	-0.303617	0.166022	44109	-1.83	0.0674
hour11:TG3.baseline	-0.308818	0.166761	44109	-1.85	0.0641
hour12:TG3.baseline	-0.128054	0.167251	44109	-0.77	0.4439
hour13:TG3.baseline	-0.021072	0.167578	44109	-0.13	0.8999
hour14:TG3.baseline	0.294921	0.167795	44109	1.76	0.0788
hour15:TG3.baseline	0.265002	0.167942	44109	1.58	0.1146
hour16:TG3.baseline	0.107383	0.168039	44109	0.64	0.5228
hour17:TG3.baseline	0.284803	0.168104	44109	1.69	0.0902
hour18:TG3.baseline	0.024998	0.168147	44109	0.15	0.8818
hour19:TG3.baseline	0.274967	0.168181	44109	1.63	0.1021
hour20:TG3.baseline	-0.089411	0.168204	44109	-0.53	0.5950
hour21:TG3.baseline	-0.141818	0.168209	44109	-0.84	0.3992
hour22:TG3.baseline	-0.125663	0.168212	44109	-0.75	0.4550
hour23:TG3.baseline	0.001398	0.168219	44109	0.01	0.9934
hour24:TG3.baseline	-0.067043	0.168222	44109	-0.40	0.6902
hour02:TG3.treatment	-0.311249	0.097103	44109	-3.21	0.0014
hour03:TG3.treatment	-0.852712	0.125367	44109	-6.80	<0.0001
hour04:TG3.treatment	-1.567138	0.141102	44109	-11.11	<0.0001
hour05:TG3.treatment	-2.175981	0.150685	44109	-14.44	<0.0001
hour06:TG3.treatment	-2.316842	0.156749	44109	-14.78	<0.0001
hour07:TG3.treatment	-2.085456	0.160665	44109	-12.98	<0.0001
hour08:TG3.treatment	-1.645012	0.163225	44109	-10.08	<0.0001
hour09:TG3.treatment	-1.455298	0.164910	44109	-8.82	<0.0001
hour10:TG3.treatment	-1.431816	0.166024	44109	-8.62	<0.0001

Variable	Coefficient	Std.Error	DF	t-value	p-value
hour11:TG3.treatment	-1.432642	0.166762	44109	-8.59	<0.0001
hour12:TG3.treatment	-1.000542	0.167251	44109	-5.98	<0.0001
hour13:TG3.treatment	-0.954369	0.167595	44109	-5.69	<0.0001
hour14:TG3.treatment	-0.732297	0.167918	44109	-4.36	<0.0001
hour15:TG3.treatment	-0.872143	0.168270	44109	-5.18	<0.0001
hour16:TG3.treatment	-0.751081	0.168471	44109	-4.46	<0.0001
hour17:TG3.treatment	-0.700298	0.168612	44109	-4.15	<0.0001
hour18:TG3.treatment	-1.053443	0.168702	44109	-6.24	<0.0001
hour19:TG3.treatment	-1.002532	0.168778	44109	-5.94	<0.0001
hour20:TG3.treatment	-1.374398	0.168861	44109	-8.14	<0.0001
hour21:TG3.treatment	-1.757754	0.168666	44109	-10.42	<0.0001
hour22:TG3.treatment	-2.143961	0.168401	44109	-12.73	<0.0001
hour23:TG3.treatment	-2.117863	0.168261	44109	-12.59	<0.0001
hour24:TG3.treatment	-2.136887	0.168225	44109	-12.70	<0.0001

Variance covariance matrix

Table 31. Variance covariance matrix, summer model

	Variance	StdDev
Customer (Intercept)	5.242019e-01	0.7240179075
Day (Intercept)	2.761882e-08	0.0001661891
Residual	1.309415	1.1442969209

Corrections

AR(1) error structure was the only correction applied.

Results

Table 32.Summer impacts, by treatment

Treatment Group	N	Time Period (hour)	Savings (kWh/h)	Standard Error	95% Confidence Intervals		Reference Load (2012)	% Savings
TG1	4	15-22	-0.01	0.0846	-0.2091	0.1934	2.25	-0.5%
TG2	14	15-22	**-0.29***	0.0462	-0.3954	-0.1756	1.49	-19%
TG3	5	15-22	**-0.33***	0.0765	-0.5090	-0.1450	2.47	-13%
TG1	4	23-24	**+0.48***	0.1143	0.2066	0.7504	1.97	+24%
TG2	14	23-24	**-0.95***	0.0615	-1.0988	-0.8062	1.92	-50%
TG3	5	23-24	**-1.00***	0.1033	-1.2848	-0.7932	2.16	-48%

TG1	4	17-19	**-0.49***	0.1072	-0.7429	-0.2329	2.31	-21%
TG2	14	17-19	**-0.39***	0.0583	-0.5270	-0.2496	1.65	-2%
TG3	5	17-19	-0.06	0.0970	-0.2885	0.1731	2.73	-2.3%
TG1	4	1-14	**+0.44***	0.0686	0.2736	0.6000	1.23	+35%
TG2	14	1-14	**+0.31***	0.0375	0.2218	0.4002	0.83	+37%
TG3	5	1-14	+0.03	0.0620	-0.1127	0.1822	1.19	+2.8%
TG1	4	1-24	**+0.23***	0.0547	0.1020	0.3622	1.64	+14%
TG2	14	1-24	-0.01	0.0301	-0.0776	0.0657	1.16	-0.7%
TG3	5	1-24	**-0.14***	0.0495	-0.2594	-0.0238	1.73	-8.3%

* Statistically significant, α=0.05

Table 33.Summer impacts, between-treatment comparisons

Treatment Group	Time Period	Savings (kWh/h)	Standard Error	95% Confidence Intervals	
TG2 vs TG3	15-22	+0.04	0.0880	-0.1674	0.2514
TG2 vs TG3	23-24	+0.09	0.1196	-0.1985	0.3705
TG2 vs TG3	17-19	**-0.33***	0.1118	-0.5960	-0.0640
TG2 vs TG3	1-14	**+0.28***	0.0713	0.1104	0.4496
TG2 vs TG3	1-24	**+0.14***	0.0567	0.0051	0.2749

* Statistically significant, α=0.05

APPENDIX D. WINTER MODEL

All days including weekends and holidays were included in the analysis

- Baseline = October 1, 2012 – January, 31 2013
- Treatment = October 1, 2013 – January 31, 2014

MODEL DETAILS

CONTRASTS

1. *Treatment loads are not different from baseline loads (adjusted for weather)*

$H_0: L = 0$

$H_a: L \neq 0$

$L = \sum_{i=1}^{12} c_i \mu_i \ where \ \sum_{i=1}^{12} c_i = 0, If \ |t^* = \frac{L}{\sigma^2\{L\}} | \leq \ t(n-p-q), then \ H_0; otherwise, H_a$[4]

For winter peak comparison,
$c_1 through \ c_{12} = {}^1\!/_6, -{}^1\!/_6, {}^1\!/_6, -{}^1\!/_6, {}^1\!/_6, -{}^1\!/_6, {}^1\!/_6, -{}^1\!/_6, {}^1\!/_6, -{}^1\!/_6, {}^1\!/_6, -{}^1\!/_6$

2. *Treatment type has no effect on impacts (adjusted for weather)*

For winter peak
comparison,$c_1 through \ c_{24} = {}^1\!/_6, -{}^1\!/_6, {}^1\!/_6, -{}^1\!/_6, {}^1\!/_6, -{}^1\!/_6, {}^1\!/_6, -{}^1\!/_6, {}^1\!/_6, -{}^1\!/_6, {}^1\!/_6, -{}^1\!/_6,$
$-{}^1\!/_6, {}^1\!/_6, \quad -{}^1\!/_6, {}^1\!/_6, -{}^1\!/_6, {}^1\!/_6, -{}^1\!/_6, {}^1\!/_6, \quad -{}^1\!/_6, {}^1\!/_6, -{}^1\!/_6, {}^1\!/_6$

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[4] n=number of observations, p = number of model parameters associated with fixed effects, q = number of covariance parameters with random effects or correlations

CONTRASTS EXAMPLES

TG2 winter peak impact relative to baseline (adjusted for weather), and comparing TG2 and TG3 treatments winter peak impacts (adjusted for weather and pretreatment differences)

1. *Treatment loads are not different from baseline loads (adjusted for weather)*

$$\hat{L} = \left[\frac{\begin{array}{c}(\hat{\mu}_{TG2.treatment.House+EV.at.hr17} - \hat{\mu}_{TG2.baseline.House+EV.at.hr17}) + \\ (\hat{\mu}_{TG2.treatment.House+EV.at.hr18} - \hat{\mu}_{TG2.baseline.House+EV.at.hr18}) + \\ (\hat{\mu}_{TG2.treatment.House+EV.at.hr19} - \hat{\mu}_{TG2.baseline.House+EV.at.hr19}) + \\ (\hat{\mu}_{TG2.treatment.House+EV.at.hr20} - \hat{\mu}_{TG2.baseline.House+EV.at.hr20}) + \\ (\hat{\mu}_{TG2.treatment.House+EV.at.hr21} - \hat{\mu}_{TG2.baseline.House+EV.at.hr21}) + \\ (\hat{\mu}_{TG2.treatment.House+EV.at.hr22} - \hat{\mu}_{TG2.baseline.House+EV.at.hr22})\end{array}}{3}\right]$$

2. *Treatment type has no effect on impacts (adjusted for weather)*

$$\hat{L} = \left(\left[\frac{\begin{array}{c}(\hat{\mu}_{TG2treatment.House+EV.at.hr17} - \hat{\mu}_{TG2.baseline.House+EV.at.hr17}) + \\ (\hat{\mu}_{TG2.treatment.House+EV.at.hr18} - \hat{\mu}_{TG2.baseline.House+EV.at.hr18}) + \\ (\hat{\mu}_{TG2.treatment.House+EV.at.hr19} - \hat{\mu}_{TG2.baseline.House+EV.at.hr19}) + \\ (\hat{\mu}_{TG2treatment.House+EV.at.hr20} - \hat{\mu}_{TG2.baseline.House+EV.at.hr20}) + \\ (\hat{\mu}_{TG2.treatment.House+EV.at.hr21} - \hat{\mu}_{TG2.baseline.House+EV.at.hr21}) + \\ (\hat{\mu}_{TG2.treatment.House+EV.at.hr22} - \hat{\mu}_{TG2.baseline.House+EV.at.hr22})\end{array}}{3}\right] - \left[\frac{\begin{array}{c}(\hat{\mu}_{TG3.treatment.House.at.hr17} - \hat{\mu}_{TG3.baseline.House.at.hr17}) + \\ (\hat{\mu}_{TG3.treatment.House.at.hr18} - \hat{\mu}_{TG3.baseline.House.at.hr18}) + \\ (\hat{\mu}_{TG3.treatment.House.at.hr19} - \hat{\mu}_{TG3.baseline.House.at.hr19}) + \\ (\hat{\mu}_{TG3.treatment.House.at.hr20} - \hat{\mu}_{TG3.baseline.House.at.hr20}) + \\ (\hat{\mu}_{TG3.treatment.House.at.hr21} - \hat{\mu}_{TG3.baseline.House.at.hr21}) + \\ (\hat{\mu}_{TG3.treatment.House.at.hr22} - \hat{\mu}_{TG3.baseline.House.at.hr22})\end{array}}{3}\right]\right)$$

Notes:

$\mu's$ are estimated using regression coefficients with the temperature profile of interest – average temp weekday winter 2013 days.

MODELS COMPARISON

TABLE 34.MODEL COMPARISON, WINTER MODEL

	Model	DF	AIC	BIC	logLik	Test	L.Ratio	p-value
Winter weekday **model Random Customer & Day**	1	151	1244740	1246385	-622219.1			
FINAL MODEL: Winter weekday **model Random Customer & Day AR(1)**	2	152	1052155	1053811	-525925.6	1 vs 2	192587	<0.0001

TESTS FOR FIXED EFFECTS

TABLE 35.F-TESTS FOR VARIABLES IN THE MODEL, WINTER MODEL

Variable	Numerator DF	Denominator DF	F-value	p-value
CDH	1	380827	11.22	0.0008
HDH	1	380827	952.01	<0.0001
CDD	1	16473	18.93	<0.0001
HDD	1	16473	391.62	<0.0001
hour	24	380827	366.19	<0.0001
Treatment_Period	5	16473	10.01	<0.0001
hour:Treatment_Period	115	380827	57.67	<0.0001

MODEL COEFFICIENTS

conditional R^2 = 0.3242

Table 36 provides model coefficients for summer weekday model. TG1.baseline is the reference level for treatment and period.

TABLE 36. MODEL COEFFICIENTS, WINTER MODEL

Variable	Coefficient	Std.Error	DF	t-value	p-value
CDH	0.0043815	0.0028344	380827	1.55	0.1222
HDH	0.0044734	0.0007780	380827	5.75	<0.0001
CDD	0.0026248	0.0002919	16473	8.99	<0.0001
HDD	0.0006054	0.0000423	16473	14.30	<0.0001
hour01	1.2156283	0.1741397	380827	6.98	<0.0001
hour02	1.1325956	0.1741456	380827	6.50	<0.0001
hour03	1.1072124	0.1741536	380827	6.36	<0.0001

Variable	Coefficient	Std.Error	DF	t-value	p-value
hour04	1.0460221	0.1741617	380827	6.01	<0.0001
hour05	1.1689268	0.1741704	380827	6.71	<0.0001
hour06	1.5239154	0.1741798	380827	8.75	<0.0001
hour07	1.6590658	0.1741873	380827	9.52	<0.0001
hour08	1.7822629	0.1741958	380827	10.23	<0.0001
hour09	1.4321235	0.1741921	380827	8.22	<0.0001
hour10	1.4907881	0.1741479	380827	8.56	<0.0001
hour11	1.5938030	0.1741242	380827	9.15	<0.0001
hour12	1.4996571	0.1741401	380827	8.61	<0.0001
hour13	1.4445990	0.1741770	380827	8.29	<0.0001
hour14	1.3452394	0.1742157	380827	7.72	<0.0001
hour15	1.3366498	0.1742428	380827	7.67	<0.0001
hour16	1.4237654	0.1742572	380827	8.17	<0.0001
hour17	1.5198311	0.1742541	380827	8.72	<0.0001
hour18	1.9439013	0.1742229	380827	11.16	<0.0001
hour19	2.1939720	0.1741709	380827	12.60	<0.0001
hour20	2.2032731	0.1741380	380827	12.65	<0.0001
hour21	2.3026808	0.1741226	380827	13.22	<0.0001
hour22	2.2407122	0.1741210	380827	12.87	<0.0001
hour23	1.9904073	0.1741240	380827	11.43	<0.0001
hour24	1.4518328	0.1741296	380827	8.34	<0.0001
TG2.baseline	-0.1988176	0.1979781	16473	-1.00	0.3153
TG3.baseline	0.0023269	0.1970975	16473	0.01	0.9906
TG1.treatment	0.2595705	0.0494568	16473	5.25	<0.0001
TG2.treatment	0.6080681	0.1979820	16473	3.07	0.0021
TG3.treatment	0.5804858	0.1971002	16473	2.95	0.0032
hour02:TG2.baseline	-0.1061435	0.0326270	380827	-3.25	0.0011
hour03:TG2.baseline	-0.2111439	0.0420979	380827	-5.02	<0.0001
hour04:TG2.baseline	-0.2519870	0.0473575	380827	-5.32	<0.0001
hour05:TG2.baseline	-0.3853620	0.0505528	380827	-7.62	<0.0001
hour06:TG2.baseline	-0.6367133	0.0525695	380827	-12.11	<0.0001
hour07:TG2.baseline	-0.6004584	0.0538685	380827	-11.15	<0.0001
hour08:TG2.baseline	-0.6865490	0.0547150	380827	-12.55	<0.0001
hour09:TG2.baseline	-0.3852098	0.0552707	380827	-6.97	<0.0001
hour10:TG2.baseline	-0.4433008	0.0556370	380827	-7.97	<0.0001
hour11:TG2.baseline	-0.5133627	0.0558792	380827	-9.19	<0.0001
hour12:TG2.baseline	-0.3780790	0.0560396	380827	-6.75	<0.0001

Variable	Coefficient	Std.Error	DF	t-value	p-value
hour13:TG2.baseline	-0.3439170	0.0561461	380827	-6.13	<0.0001
hour14:TG2.baseline	-0.2907070	0.0562171	380827	-5.17	<0.0001
hour15:TG2.baseline	-0.2964831	0.0562644	380827	-5.27	<0.0001
hour16:TG2.baseline	-0.3357698	0.0562960	380827	-5.96	<0.0001
hour17:TG2.baseline	-0.2782993	0.0563168	380827	-4.94	<0.0001
hour18:TG2.baseline	-0.4982281	0.0563303	380827	-8.84	<0.0001
hour19:TG2.baseline	-0.5959124	0.0563385	380827	-10.58	<0.0001
hour20:TG2.baseline	-0.5781256	0.0563423	380827	-10.26	<0.0001
hour21:TG2.baseline	-0.3310630	0.0563403	380827	-5.88	<0.0001
hour22:TG2.baseline	-0.2743197	0.0563426	380827	-4.87	<0.0001
hour23:TG2.baseline	-0.0967045	0.0563443	380827	-1.72	0.0861
hour24:TG2.baseline	0.1119374	0.0563456	380827	1.99	0.0470
hour02:TG3.baseline	-0.0678703	0.0335309	380827	-2.02	0.0430
hour03:TG3.baseline	-0.1264101	0.0432641	380827	-2.92	0.0035
hour04:TG3.baseline	-0.1233373	0.0486694	380827	-2.53	0.0113
hour05:TG3.baseline	-0.2888436	0.0519527	380827	-5.56	<0.0001
hour06:TG3.baseline	-0.6097077	0.0540251	380827	-11.29	<0.0001
hour07:TG3.baseline	-0.5815996	0.0553600	380827	-10.51	<0.0001
hour08:TG3.baseline	-0.6374860	0.0562299	380827	-11.34	<0.0001
hour09:TG3.baseline	-0.3598832	0.0568009	380827	-6.34	<0.0001
hour10:TG3.baseline	-0.4065872	0.0571776	380827	-7.11	<0.0001
hour11:TG3.baseline	-0.4805171	0.0574264	380827	-8.37	<0.0001
hour12:TG3.baseline	-0.4249368	0.0575910	380827	-7.38	<0.0001
hour13:TG3.baseline	-0.3932301	0.0577004	380827	-6.82	<0.0001
hour14:TG3.baseline	-0.3009497	0.0577731	380827	-5.21	<0.0001
hour15:TG3.baseline	-0.3362746	0.0578217	380827	-5.82	<0.0001
hour16:TG3.baseline	-0.3343286	0.0578542	380827	-5.78	<0.0001
hour17:TG3.baseline	-0.1855410	0.0578762	380827	-3.21	0.0013
hour18:TG3.baseline	-0.2777404	0.0578907	380827	-4.80	<0.0001
hour19:TG3.baseline	-0.3652535	0.0578989	380827	-6.31	<0.0001
hour20:TG3.baseline	-0.3395170	0.0579014	380827	-5.86	<0.0001
hour21:TG3.baseline	-0.3708776	0.0578996	380827	-6.41	<0.0001
hour22:TG3.baseline	-0.3676069	0.0579023	380827	-6.35	<0.0001
hour23:TG3.baseline	-0.3691769	0.0579041	380827	-6.38	<0.0001
hour24:TG3.baseline	-0.0852579	0.0579053	380827	-1.47	0.1409
hour02:TG1.treatment	-0.0387238	0.0404804	380827	-0.96	0.3388
hour03:TG1.treatment	-0.0155182	0.0522324	380827	-0.30	0.7664

Variable	Coefficient	Std.Error	DF	t-value	p-value
hour04:TG1.treatment	0.0893985	0.0587606	380827	1.52	0.1282
hour05:TG1.treatment	-0.0230505	0.0627268	380827	-0.37	0.7133
hour06:TG1.treatment	-0.1917692	0.0652295	380827	-2.94	0.0033
hour07:TG1.treatment	-0.2002162	0.0668428	380827	-3.00	0.0027
hour08:TG1.treatment	-0.1686215	0.0678938	380827	-2.48	0.0130
hour09:TG1.treatment	-0.0246669	0.0685818	380827	-0.36	0.7191
hour10:TG1.treatment	-0.0891988	0.0690258	380827	-1.29	0.1963
hour11:TG1.treatment	-0.2337825	0.0693412	380827	-3.37	0.0007
hour12:TG1.treatment	-0.2603538	0.0695813	380827	-3.74	0.0002
hour13:TG1.treatment	-0.3691795	0.0697449	380827	-5.29	<0.0001
hour14:TG1.treatment	-0.2555623	0.0698488	380827	-3.66	0.0003
hour15:TG1.treatment	-0.2476022	0.0699170	380827	-3.54	0.0004
hour16:TG1.treatment	-0.4120125	0.0699623	380827	-5.89	<0.0001
hour17:TG1.treatment	-0.4857855	0.0699929	380827	-6.94	<0.0001
hour18:TG1.treatment	-0.4712383	0.0700015	380827	-6.73	<0.0001
hour19:TG1.treatment	-0.5427303	0.0699710	380827	-7.76	<0.0001
hour20:TG1.treatment	-0.5038420	0.0699442	380827	-7.20	<0.0001
hour21:TG1.treatment	-0.5473894	0.0699274	380827	-7.83	<0.0001
hour22:TG1.treatment	-0.5742415	0.0699167	380827	-8.21	<0.0001
hour23:TG1.treatment	-0.2588830	0.0699100	380827	-3.70	0.0002
hour24:TG1.treatment	-0.0923666	0.0699082	380827	-1.32	0.1864
hour02:TG2.treatment	0.0348966	0.0326301	380827	1.07	0.2849
hour03:TG2.treatment	-0.2513162	0.0421037	380827	-5.97	<0.0001
hour04:TG2.treatment	-0.5890902	0.0473675	380827	-12.44	<0.0001
hour05:TG2.treatment	-1.0177115	0.0505655	380827	-20.13	<0.0001
hour06:TG2.treatment	-1.3424059	0.0525832	380827	-25.53	<0.0001
hour07:TG2.treatment	-1.3616289	0.0538843	380827	-25.27	<0.0001
hour08:TG2.treatment	-1.5249340	0.0547315	380827	-27.86	<0.0001
hour09:TG2.treatment	-1.2365066	0.0552865	380827	-22.37	<0.0001
hour10:TG2.treatment	-1.3094754	0.0556386	380827	-23.54	<0.0001
hour11:TG2.treatment	-1.4187573	0.0558945	380827	-25.38	<0.0001
hour12:TG2.treatment	-1.3610391	0.0561025	380827	-24.26	<0.0001
hour13:TG2.treatment	-1.3140061	0.0562439	380827	-23.36	<0.0001
hour14:TG2.treatment	-1.2021479	0.0563302	380827	-21.34	<0.0001
hour15:TG2.treatment	-1.1786933	0.0563900	380827	-20.90	<0.0001
hour16:TG2.treatment	-1.2603979	0.0564302	380827	-22.34	<0.0001
hour17:TG2.treatment	-1.3686950	0.0564603	380827	-24.24	<0.0001

Variable	Coefficient	Std.Error	DF	t-value	p-value
hour18:TG2.treatment	-1.5833324	0.0564701	380827	-28.04	<0.0001
hour19:TG2.treatment	-1.7320377	0.0564386	380827	-30.69	<0.0001
hour20:TG2.treatment	-1.7591969	0.0564025	380827	-31.19	<0.0001
hour21:TG2.treatment	-1.9192241	0.0563790	380827	-34.04	<0.0001
hour22:TG2.treatment	-1.9455449	0.0563617	380827	-34.52	<0.0001
hour23:TG2.treatment	-1.3543443	0.0563499	380827	-24.03	<0.0001
hour24:TG2.treatment	-0.8450107	0.0563459	380827	-15.00	<0.0001
hour02:TG3.treatment	-0.0067895	0.0335327	380827	-0.20	0.8395
hour03:TG3.treatment	-0.5018658	0.0432678	380827	-11.60	<0.0001
hour04:TG3.treatment	-0.8881792	0.0486759	380827	-18.25	<0.0001
hour05:TG3.treatment	-1.0452141	0.0519614	380827	-20.12	<0.0001
hour06:TG3.treatment	-1.3104611	0.0540348	380827	-24.25	<0.0001
hour07:TG3.treatment	-1.2465325	0.0553711	380827	-22.51	<0.0001
hour08:TG3.treatment	-1.2403289	0.0562418	380827	-22.05	<0.0001
hour09:TG3.treatment	-1.0858034	0.0568138	380827	-19.11	<0.0001
hour10:TG3.treatment	-1.2343265	0.0571784	380827	-21.59	<0.0001
hour11:TG3.treatment	-1.3006822	0.0574421	380827	-22.64	<0.0001
hour12:TG3.treatment	-1.1393396	0.0576532	380827	-19.76	<0.0001
hour13:TG3.treatment	-1.0405303	0.0578052	380827	-18.00	<0.0001
hour14:TG3.treatment	-0.8771366	0.0579067	380827	-15.15	<0.0001
hour15:TG3.treatment	-0.8958658	0.0579780	380827	-15.45	<0.0001
hour16:TG3.treatment	-0.9197370	0.0580210	380827	-15.85	<0.0001
hour17:TG3.treatment	-1.0334668	0.0580471	380827	-17.80	<0.0001
hour18:TG3.treatment	-1.1906866	0.0580458	380827	-20.51	<0.0001
hour19:TG3.treatment	-1.4208176	0.0579955	380827	-24.50	<0.0001
hour20:TG3.treatment	-1.4747004	0.0579563	380827	-25.45	<0.0001
hour21:TG3.treatment	-1.6063284	0.0579321	380827	-27.73	<0.0001
hour22:TG3.treatment	-1.6819925	0.0579172	380827	-29.04	<0.0001
hour23:TG3.treatment	-1.0502849	0.0579087	380827	-18.14	<0.0001
hour24:TG3.treatment	-0.7291311	0.0579064	380827	-12.59	<0.0001

VARIANCE COVARIANCE MATRIX

TABLE 37. VARIANCE COVARIANCE MATRIX, WINTER MODEL

	Variance	StdDev
Customer (Intercept)	3.187732e-01	0.5646000365
Day (Intercept)	2.348236-08	0.0001532395
Residual	1.439045	1.1996019766

CORRECTIONS

AR(1) error structure was the only correction applied.

RESULTS

TABLE 38. WINTER IMPACTS, BY TREATMENT

Treatment Group	N	Time Period	Savings (kWh/h)	Standard Error	95% Confidence Intervals		Reference Load (2012)	% Savings
TG1	11	17-22	**-0.26***	0.0359	-0.3467	-0.1759	2.32	-11%
TG2	36	17-22	**-0.49***	0.0197	-0.5320	-0.4382	1.69	-28%
TG3	39	17-22	**-0.50***	0.0220	-0.5577	-0.4531	2.00	-25%
TG1	11	1-16,23-24	**0.10***	0.0232	0.0493	0.1597	1.70	6.1%
TG2	36	1-16,23-24	**0.10***	0.0127	0.0721	0.1325	1.18	8.2%
TG3	39	1-16,23-24	-0.01	0.0142	-0.0437	0.0238	1.37	-0.8%
TG1	11	1-24	0.01	0.0213	-0.0377	0.0637	1.85	0.7%
TG2	36	1-24	**-0.04***	0.0117	-0.0724	-0.0167	1.30	-3.2%
TG3	39	1-24	**-0.13***	0.0130	-0.1647	-0.1029	1.53	-8.8%

* Statistically significant, α=0.05

TABLE 39. WINTER IMPACTS, BETWEEN-TREATMENT COMPARISONS

Treatment Group	Time Period (hour)	Savings (kWh/h)	Standard Error	95% Confidence Intervals	
TG2 vs TG3	17-22	0.04	0.0294	-0.0499	0.0899
TG2 vs TG3	1-16,23-24	**0.11***	0.0190	0.0648	0.1552
TG2 vs TG3	1-24	**0.09***	0.0175	0.0474	0.1306

* Statistically significant, α=0.05

APPENDIX E. SUBMETER LOAD DATA SUMMARY CHARTS

The following sections summarize the submetered load data collected during 2013.

TIME OF DAY

Figure 27 and Figure 28 show the distribution of hourly charging periods for 120V and 240V charging, respectively (Data, TG2 and TG3 groups only), indicating that 240V charging is focused between midnight and 4 am.

FIGURE 27. CHARGING TIME OF DAY, 120V

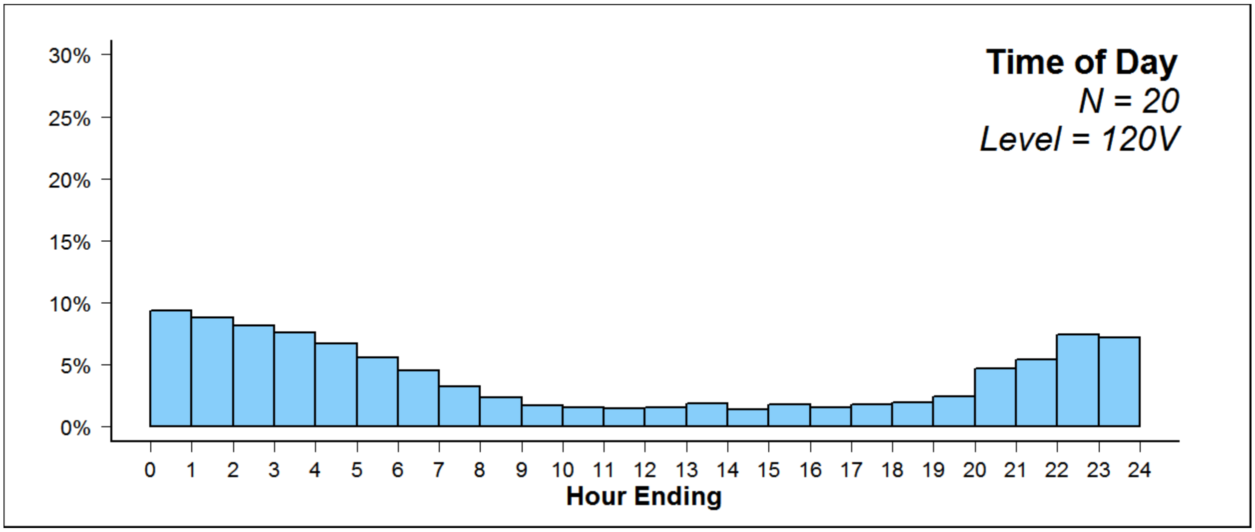
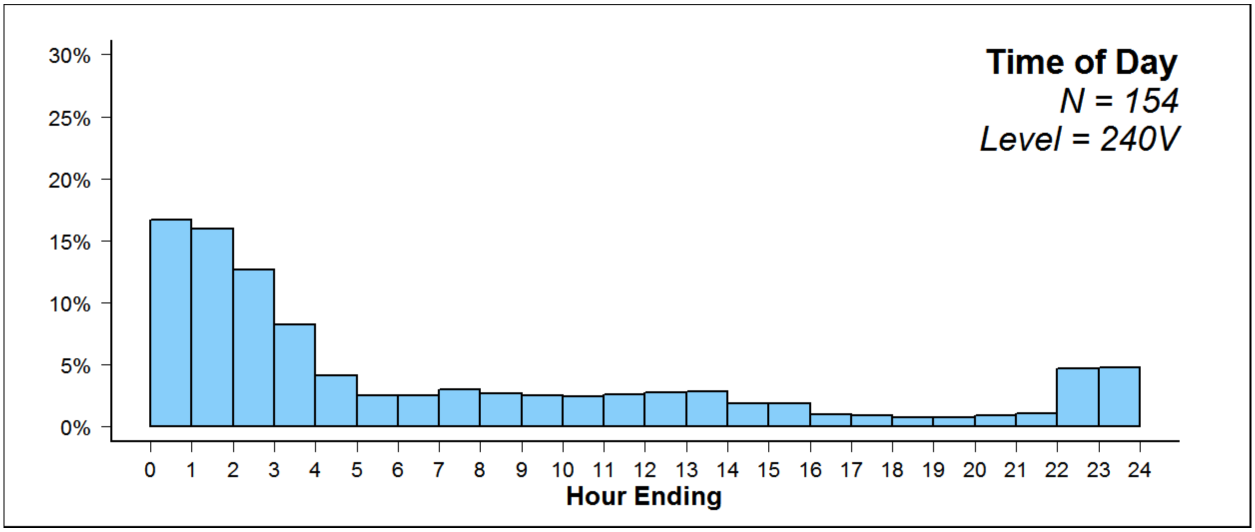


FIGURE 28. CHARGING TIME OF DAY, 240V



RATE OF CHARGE

Figure 29 and Figure 30 show the distribution of charging rates for 120V and 240V charging, respectively (Data, TG2 and TG3 groups only), indicating no 120V charging beyond 1.5 kW and the presence of 240V charging exceeding 10 kW.

FIGURE 29. RATE OF CHARGE, 120V

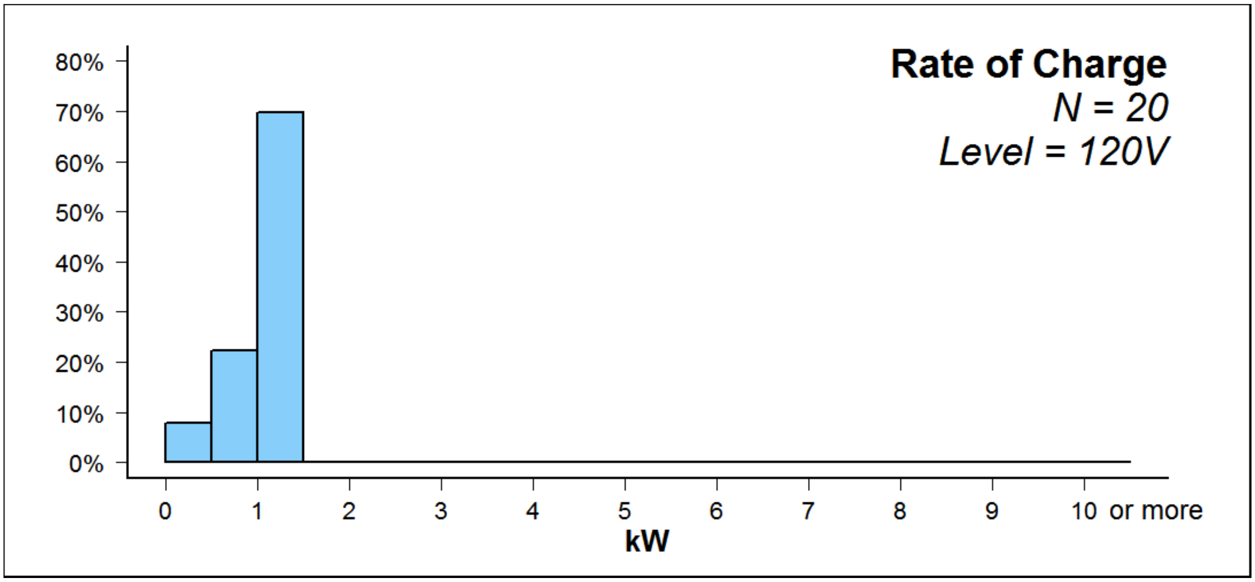
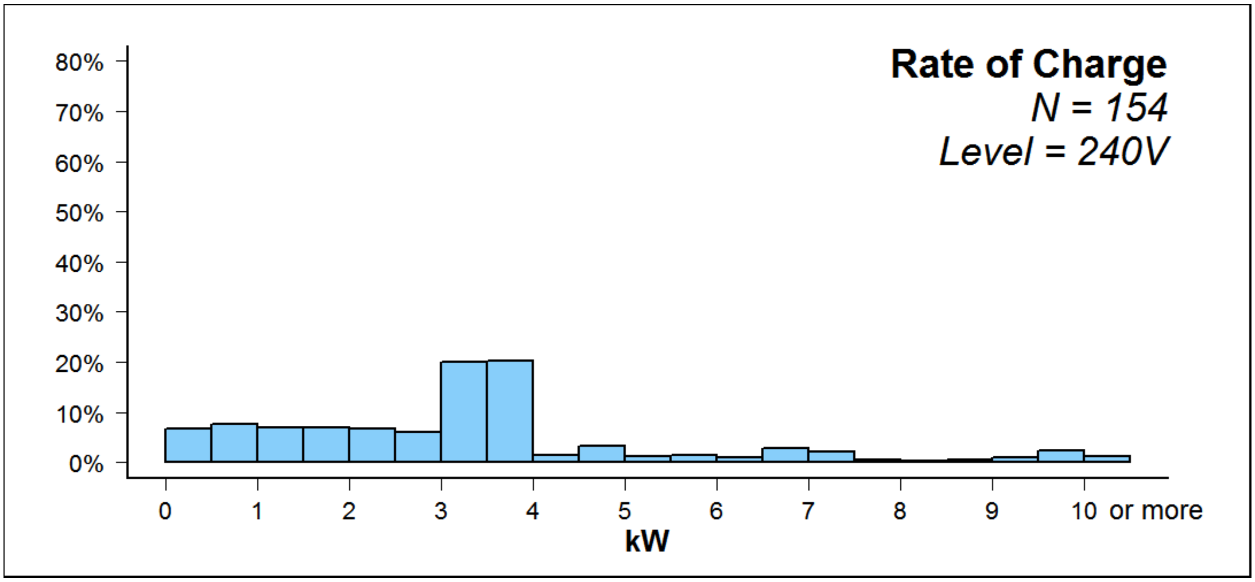


FIGURE 30. RATE OF CHARGE, 240V



DURATION OF CHARGE

Figure 31 and Figure 32 show the distribution of charge durations for 120V and 240V charging, respectively (Data, TG2 and TG3 groups only), indicating generally shorter charge times for 220V charging relative to 110V charging, as would be expected.

FIGURE 31. DURATION OF CHARGE, 120V

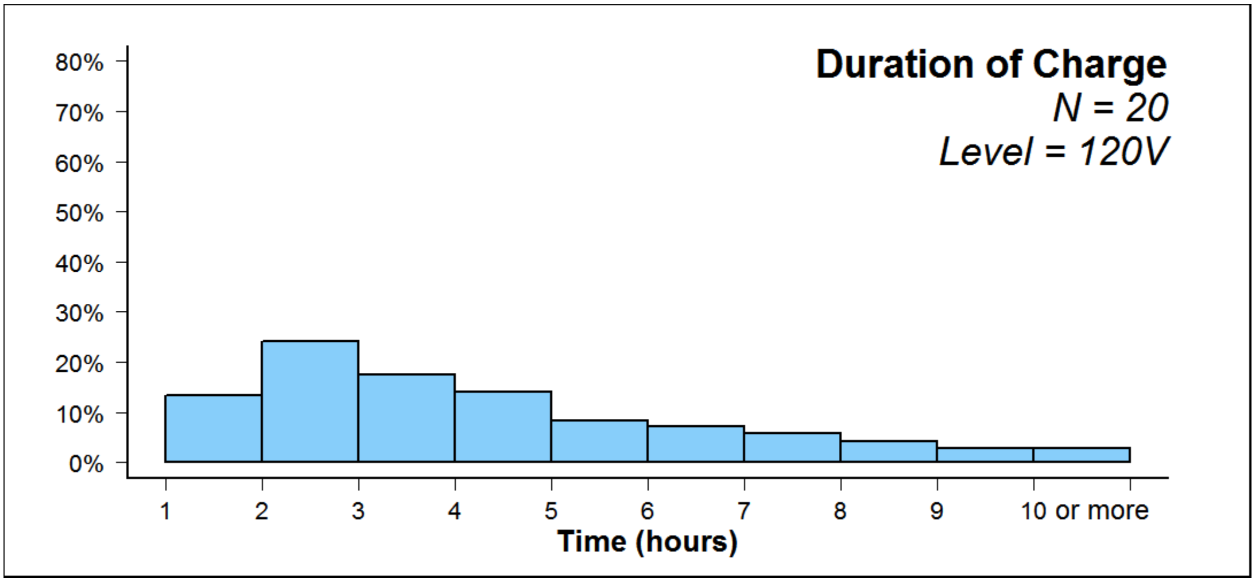
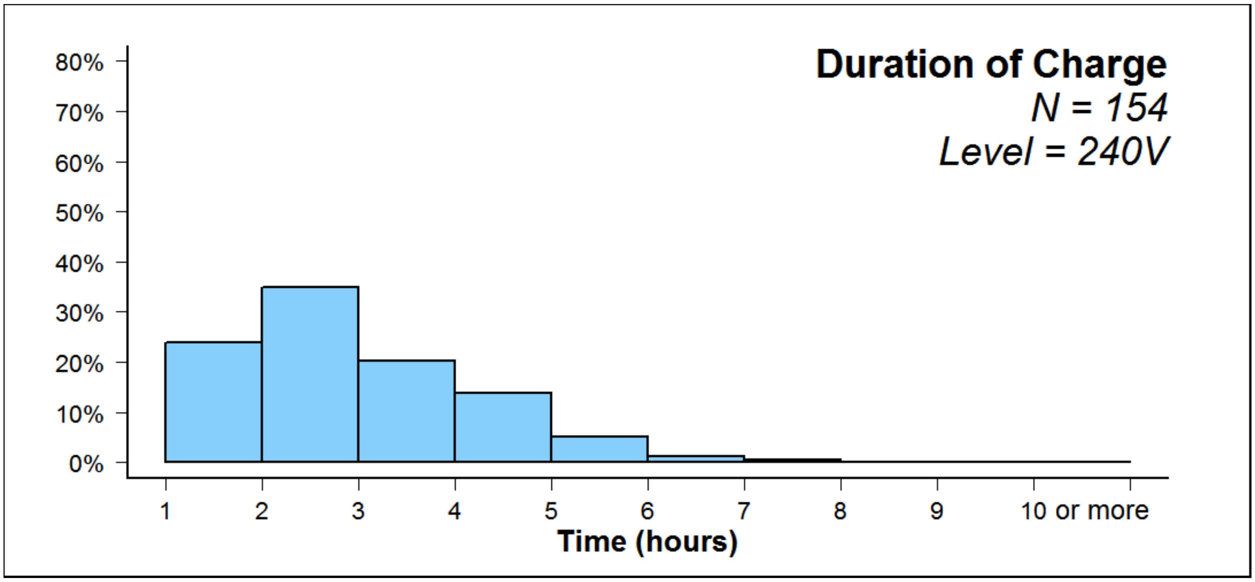


FIGURE 32. DURATION OF CHARGE, 240V



FREQUENCY OF CHARGING

Figure 33 and Figure 34 show similar distributions of charge frequencies for 120V and 240V charging, respectively (Data, TG2 and TG3 groups only), with a slight tendency for 110V charging to be more frequent in terms of number of charges per week.

FIGURE 33. FREQUENCY OF CHARGING, 120V

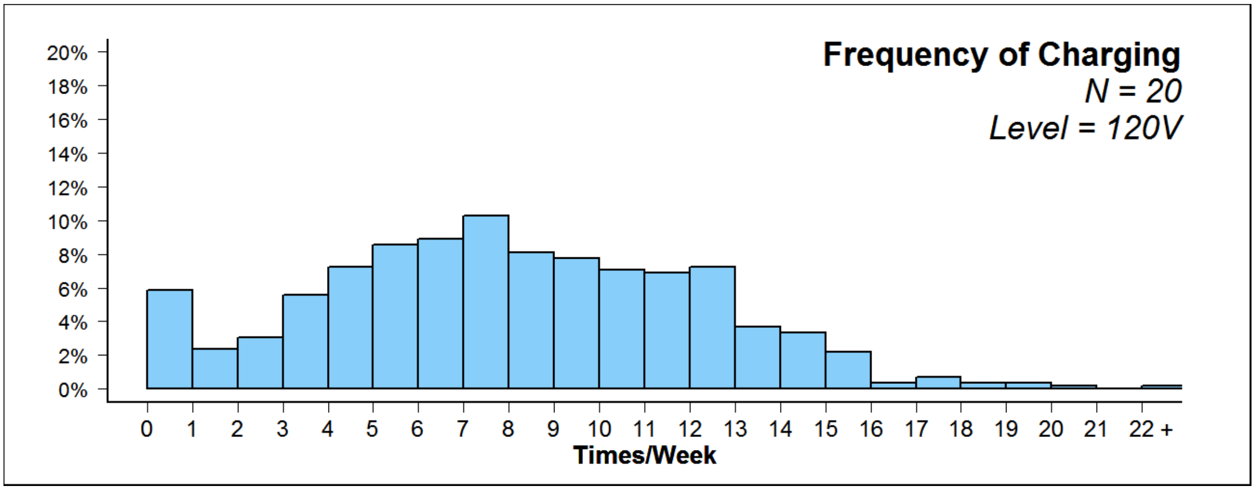
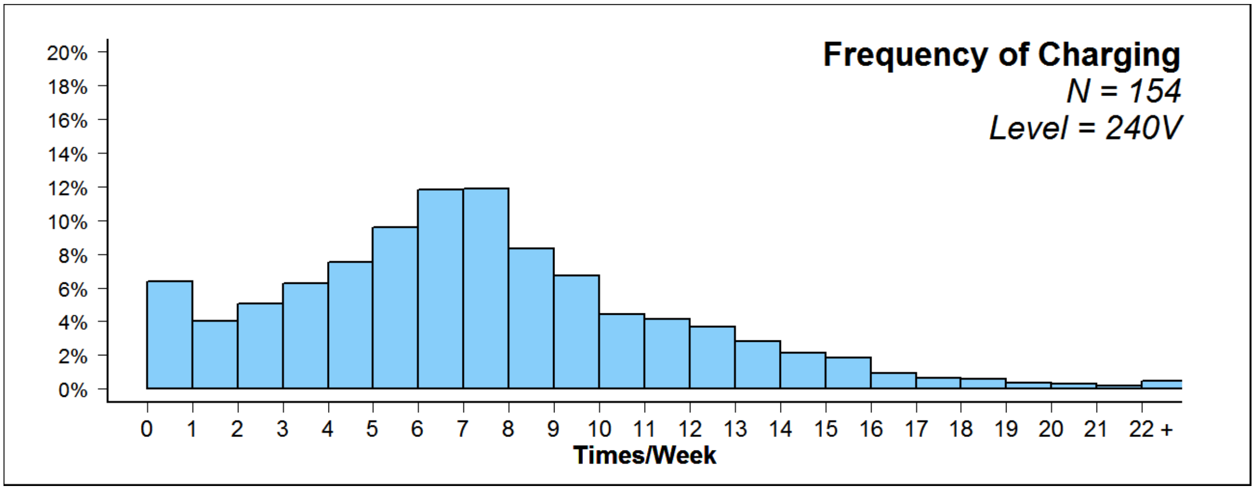


FIGURE 34. FREQUENCY OF CHARGING, 240V



NUMBER OF CHARGES PER DAY, BY DAY OF WEEK

Figure 35 and Figure 37 illustrate the average number of charges per day of the week for 120V and 240V charging, respectively (Data, TG2 and TG3 groups only). Where 110V charging appears more frequent on Friday and Saturday, 220V charging shows relatively stable charging throughout the week, with slight dips on Sunday and Monday.

FIGURE 35. NUMBER OF CHARGES PER DAY, BY DAY OF WEEK, 120V

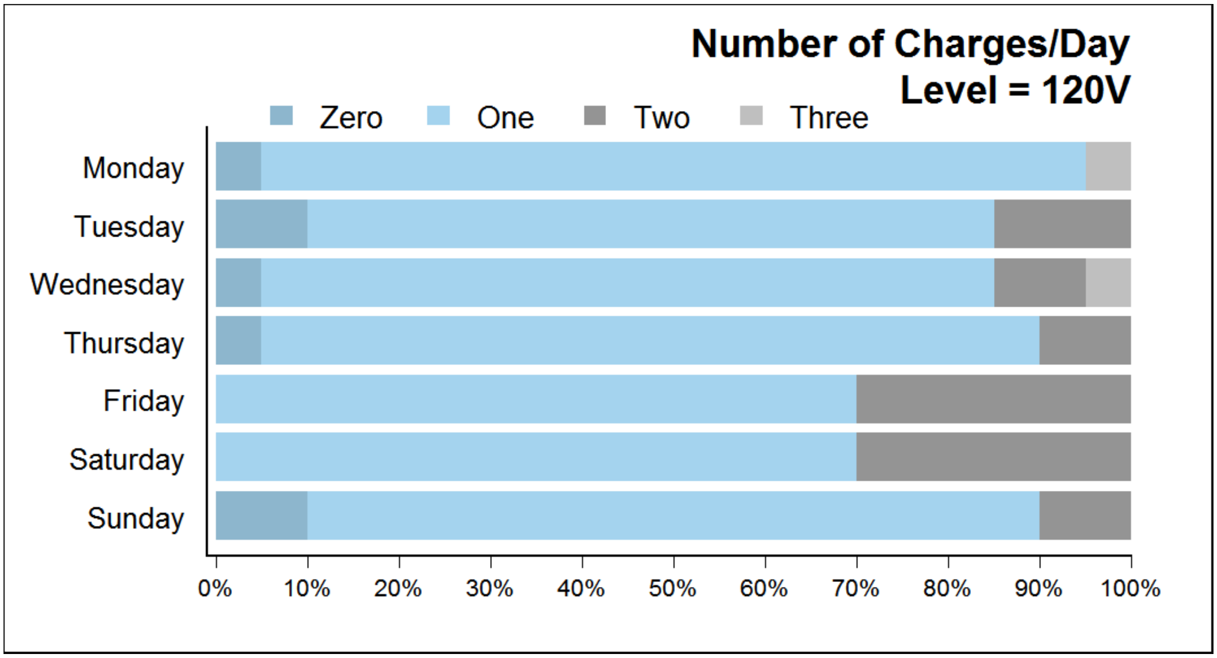
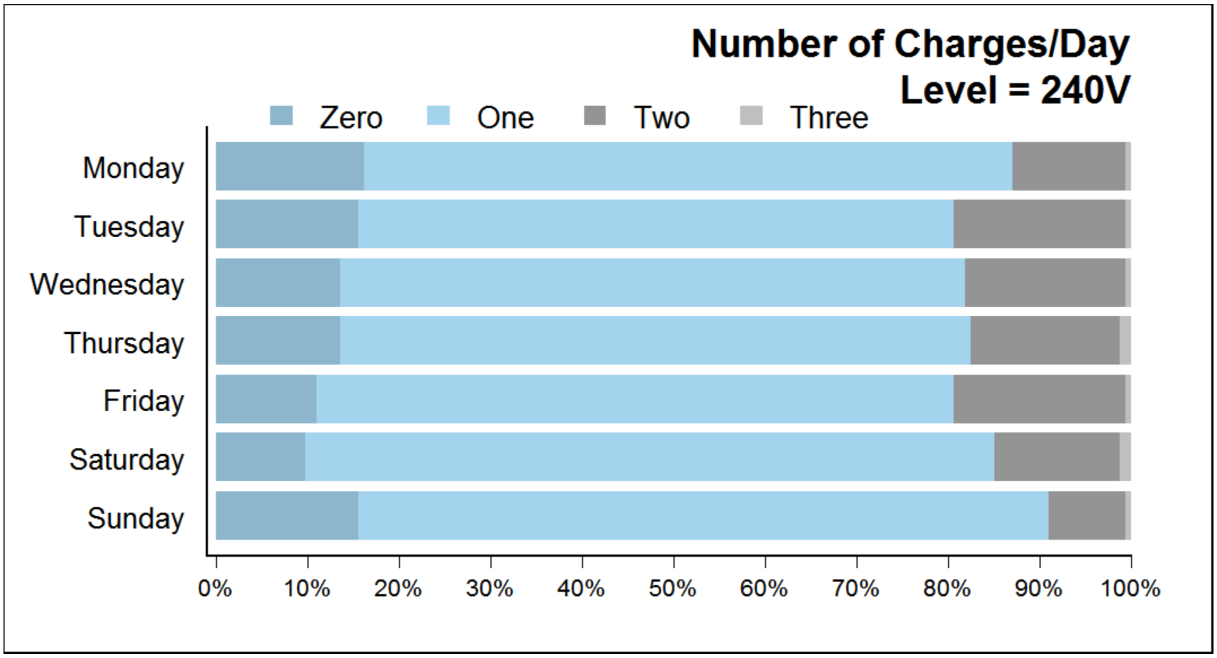


FIGURE 36. NUMBER OF CHARGES PER DAY, BY DAY OF WEEK, 240V



NUMBER OF CHARGES PER DAY: WEEKDAY VS. WEEKEND

Figure 37 and Figure 38 illustrate the average number of charges per weekday and weekend for 120V and 240V charging, respectively (Data, TG2 and TG3 groups only). As above, 110V charging increases during the weekend, but this trend is not seen for 220V charging.

FIGURE 37. NUMBER OF CHARGES PER DAY, WEEKDAY VS. WEEKEND, 120V

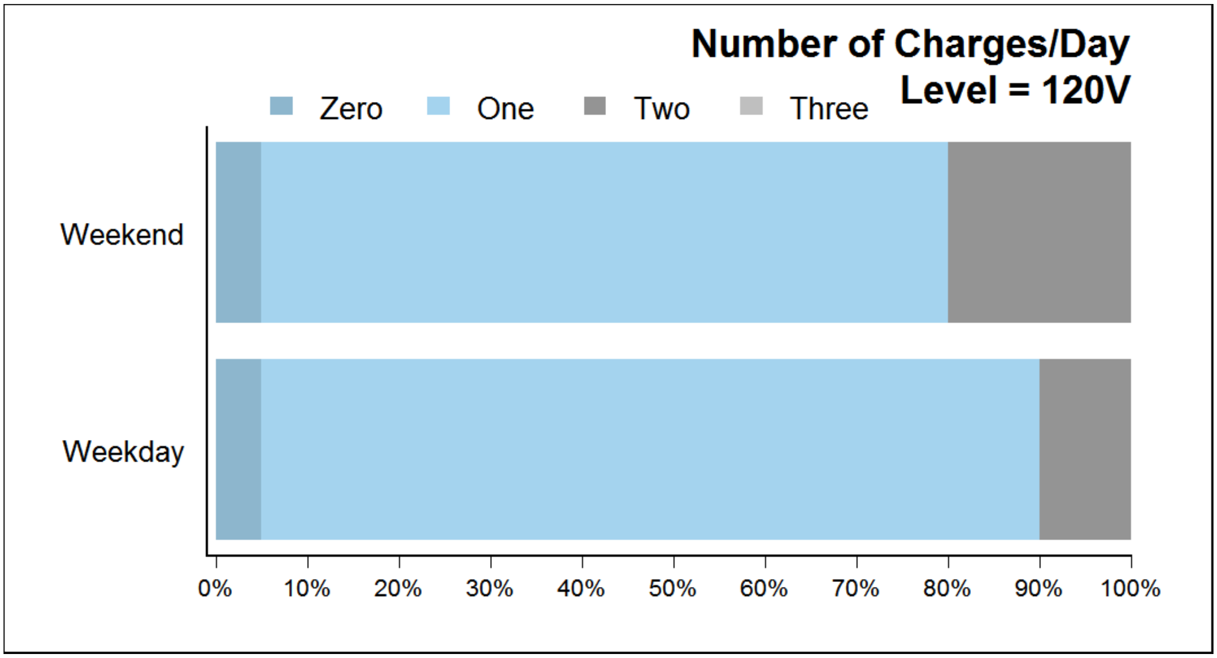
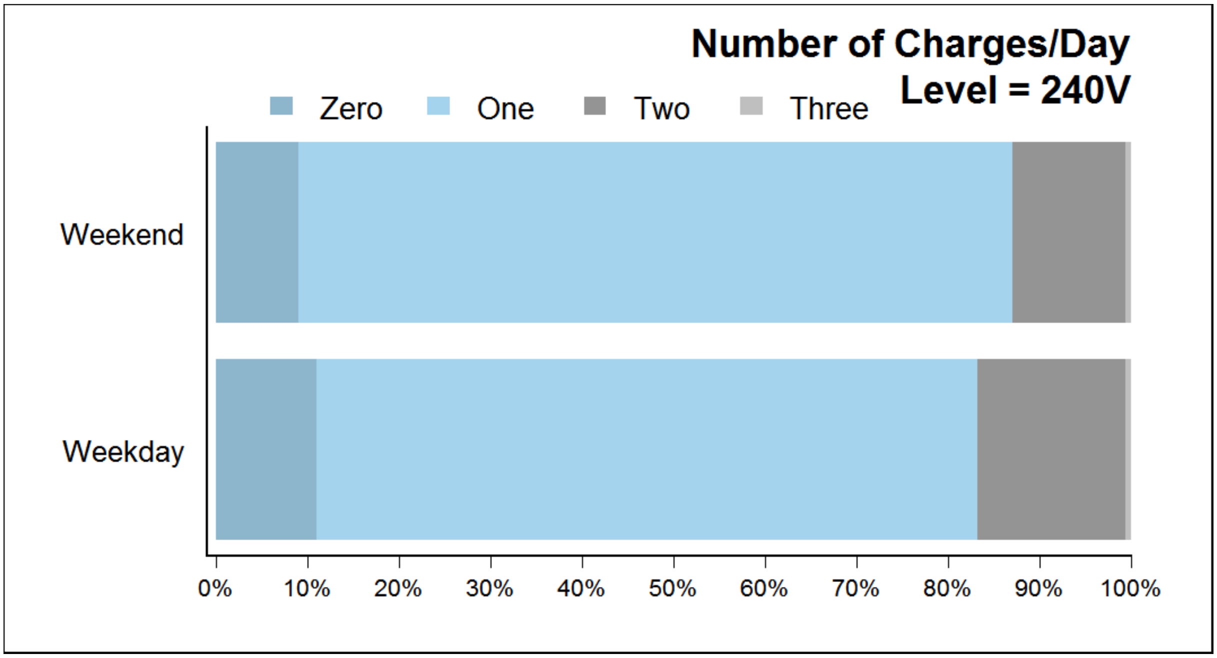


FIGURE 38. NUMBER OF CHARGES PER DAY, WEEKDAY VS. WEEKEND, 240V



CHARGING KWH PER DAY

Figure 39 shows the distribution of daily energy needs for the Data, TG2 and TG3 groups by model. In general, values do not appear to vary widely except where a Model S or multiple EVs are present.

FIGURE 39. CHARGING KWH PER DAY, BY MODEL

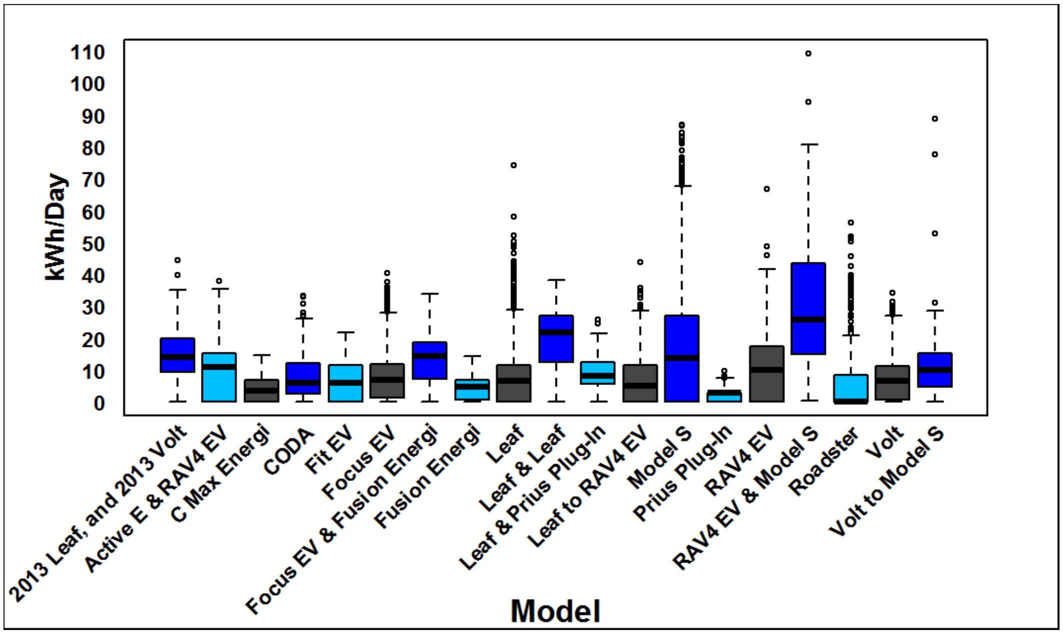
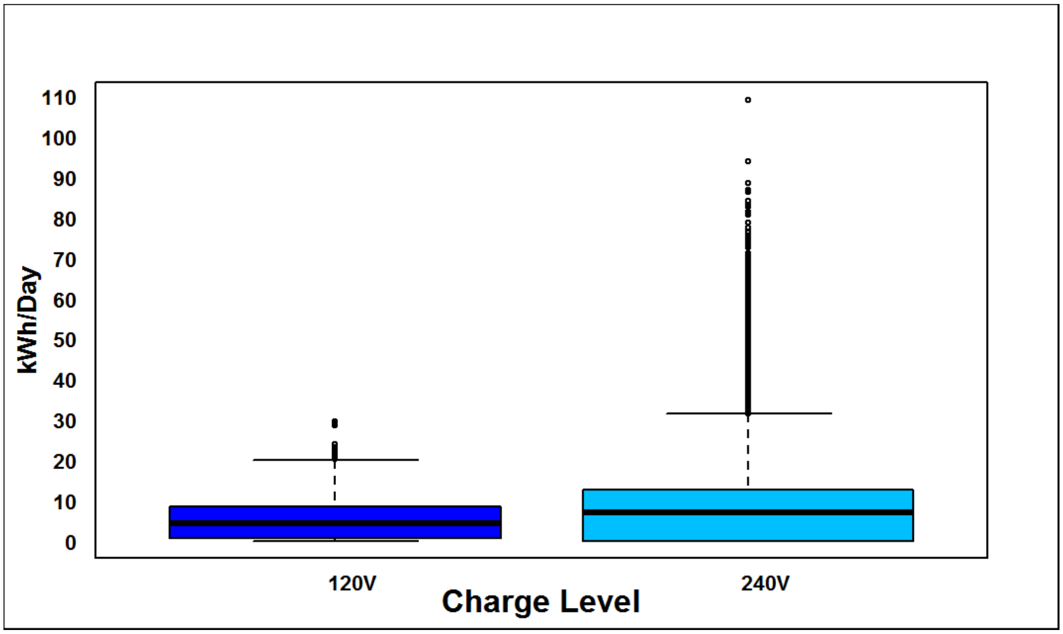


Figure 40 shows the distribution of daily energy needs for Data, TG2 and TG3 by charge level, indicating higher energy needs for EVs charging at 240V.

FIGURE 40. CHARGING KWH PER DAY, BY CHARGE LEVEL



RATE OF CHARGE, BY MODEL

Figure 41 through Figure 57 illustrate the average rate of charge (kW) for EV models participating in the Data, TG2 and TG3 groups. Graphs are divided into 110V and 220V charging where appropriate.

FIGURE 41. RATE OF CHARGE, C MAX ENERGI 120V

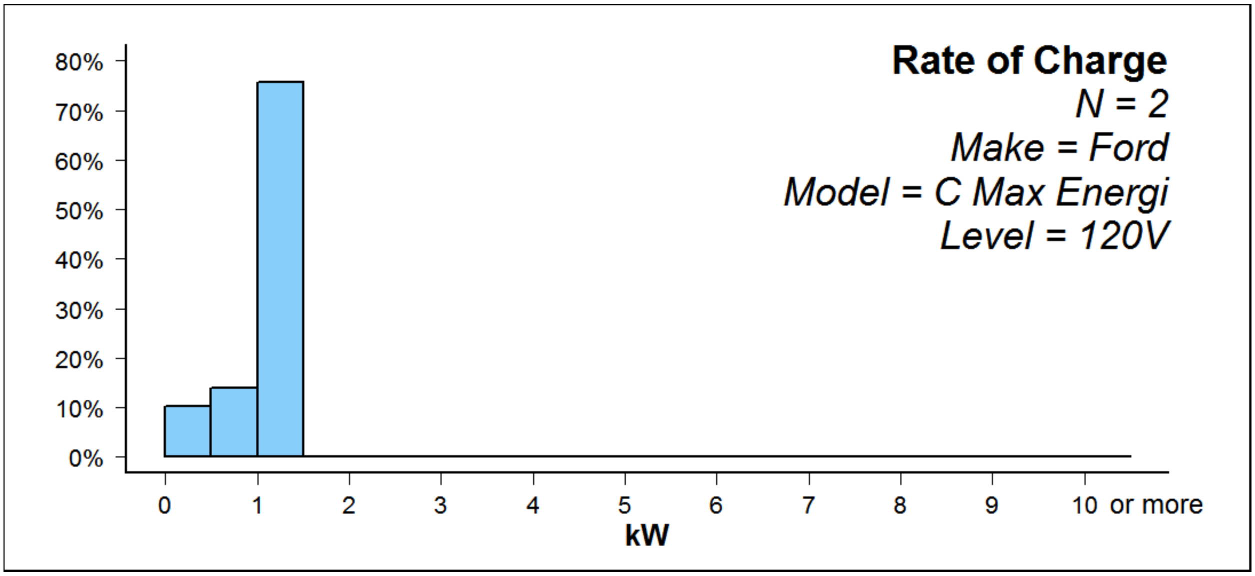


FIGURE 42. RATE OF CHARGE, C MAX ENERGI 240V

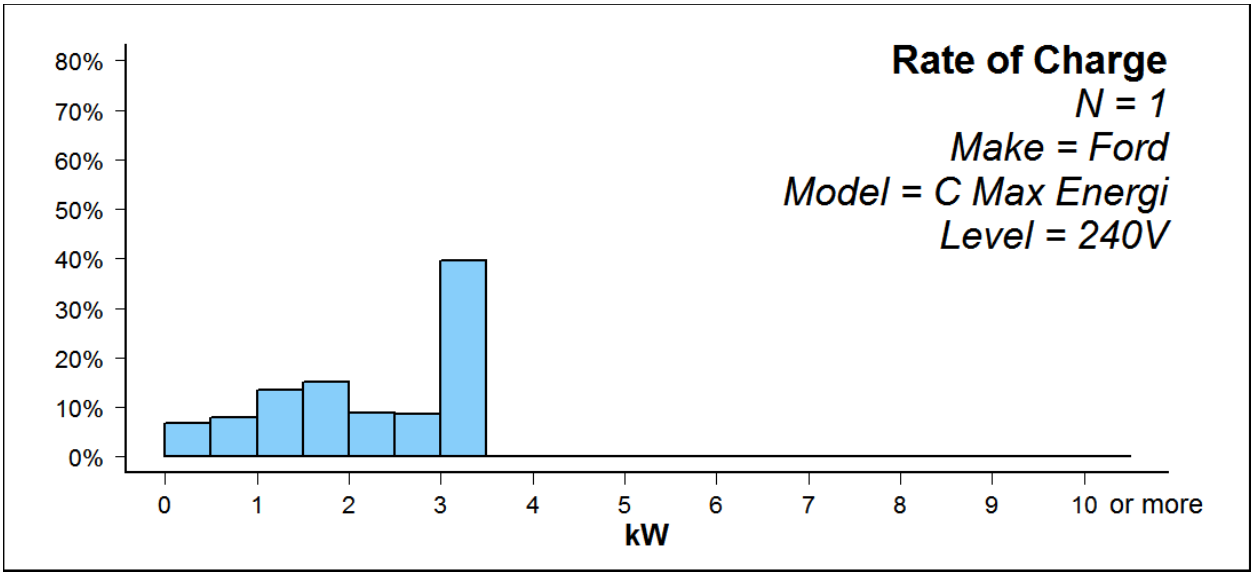


FIGURE 43. RATE OF CHARGE: CODA 240V

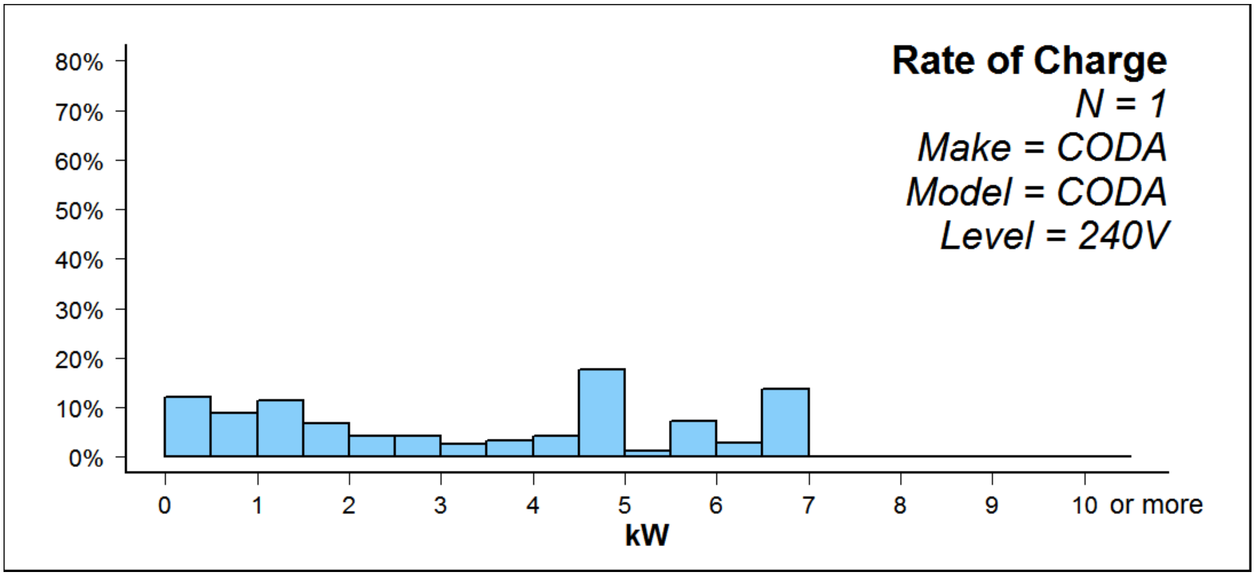


FIGURE 44. RATE OF CHARGE: HONDA FIT EV 240V

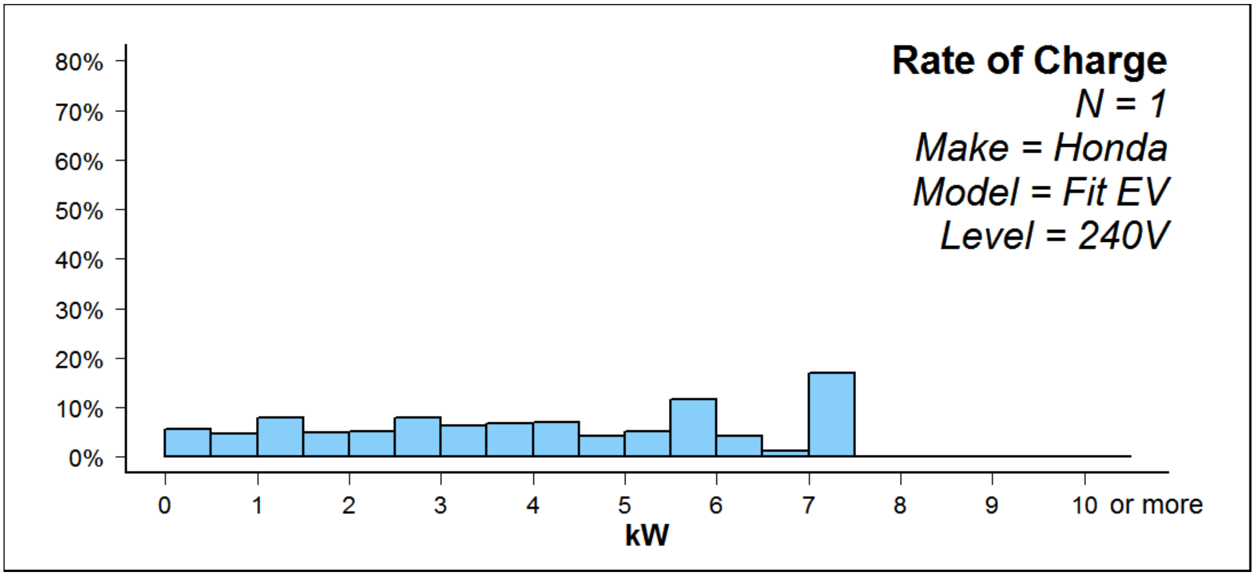


FIGURE 45. RATE OF CHARGE: FORD FOCUS EV, 120V

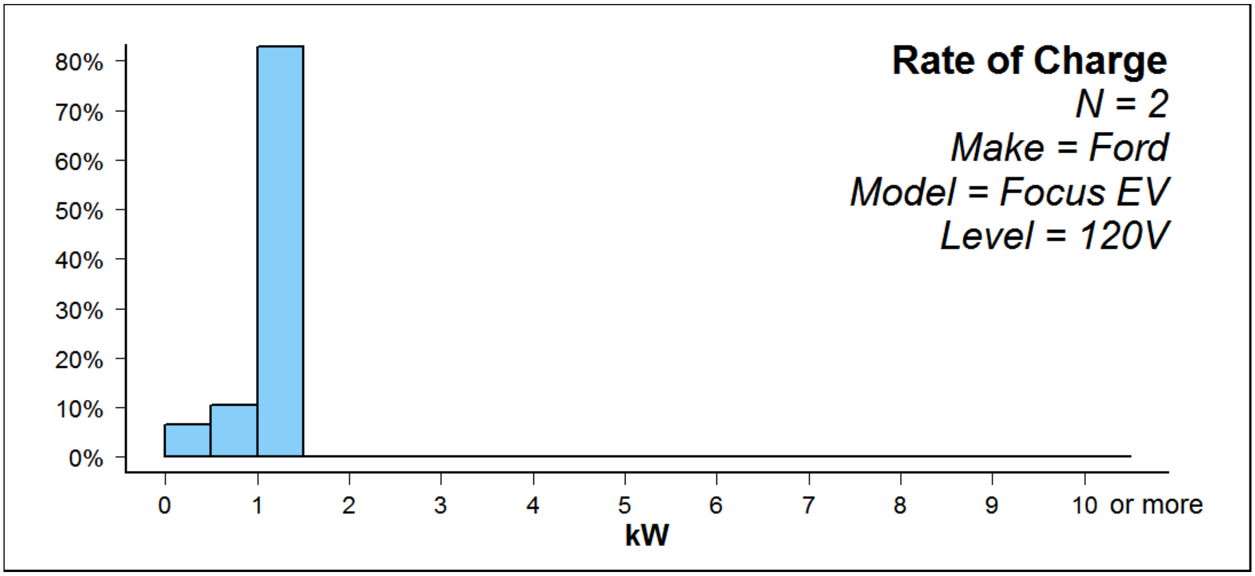


FIGURE 46. RATE OF CHARGE: FORD FOCUS EV, 240V

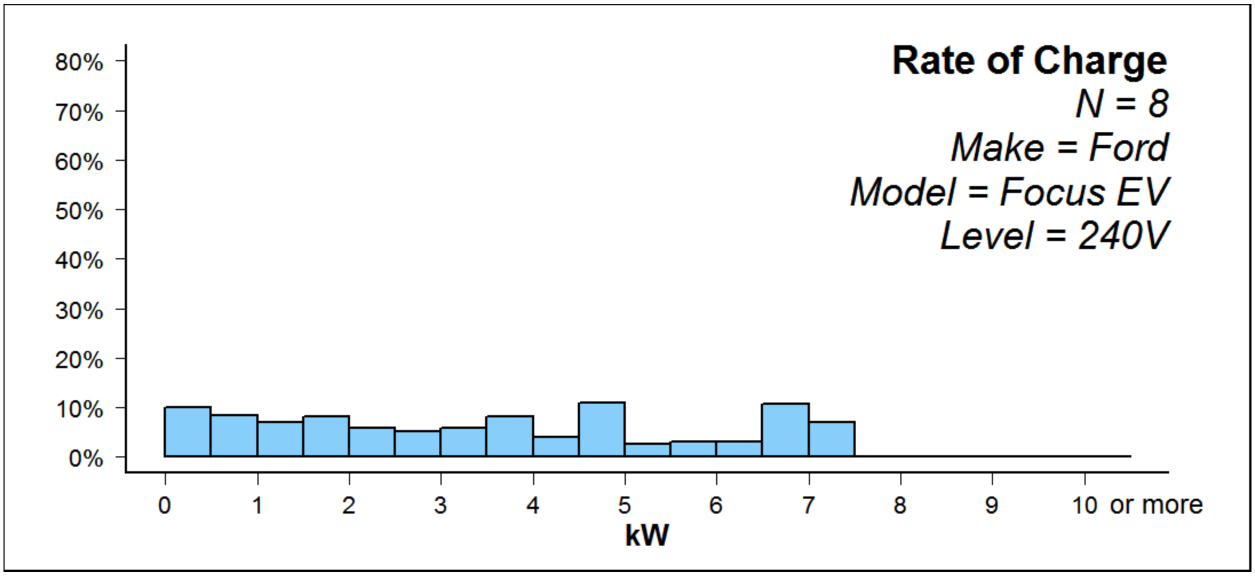


FIGURE 47. RATE OF CHARGE: FORD FUSION ENERGI, 120V

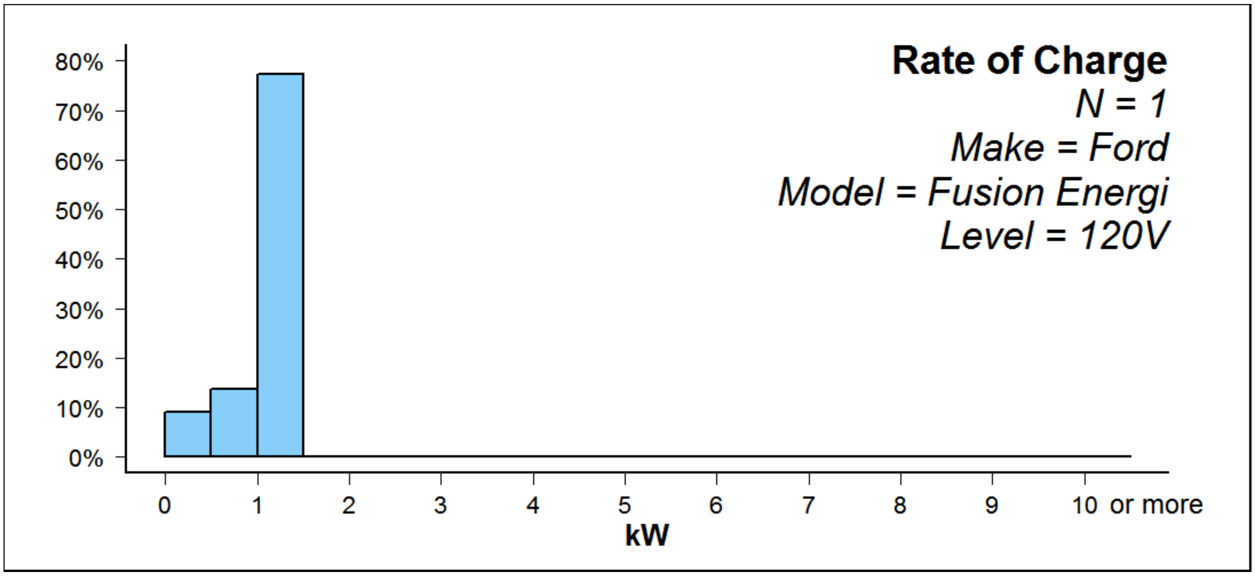


FIGURE 48. RATE OF CHARGE: FORD FUSION ENERGI, 240V

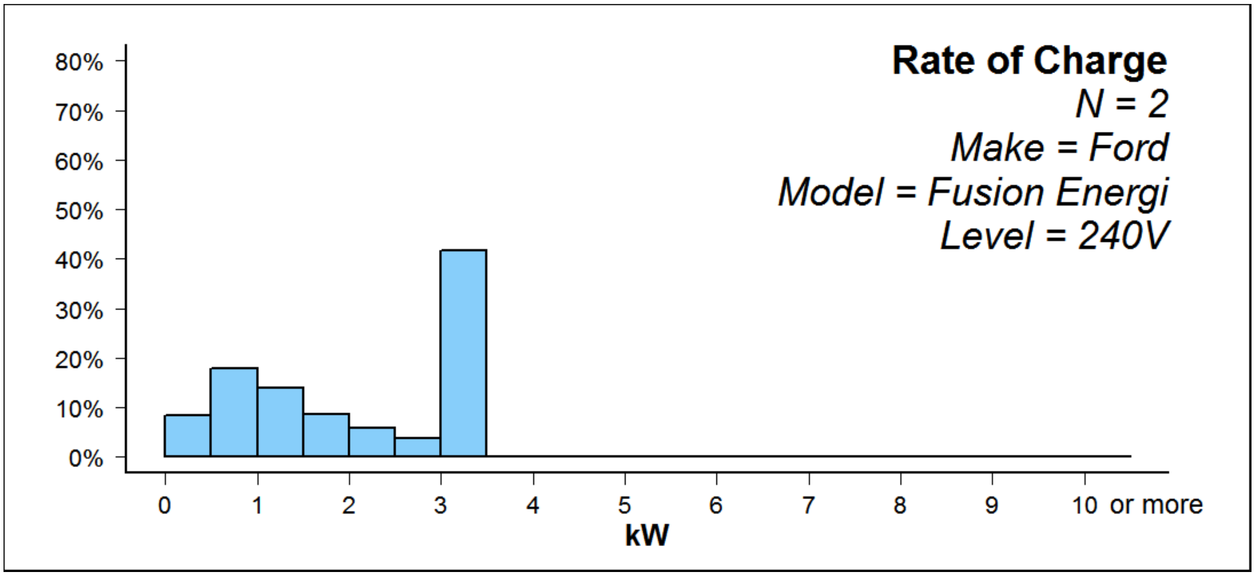


FIGURE 49. RATE OF CHARGE: NISSAN LEAF, 120V

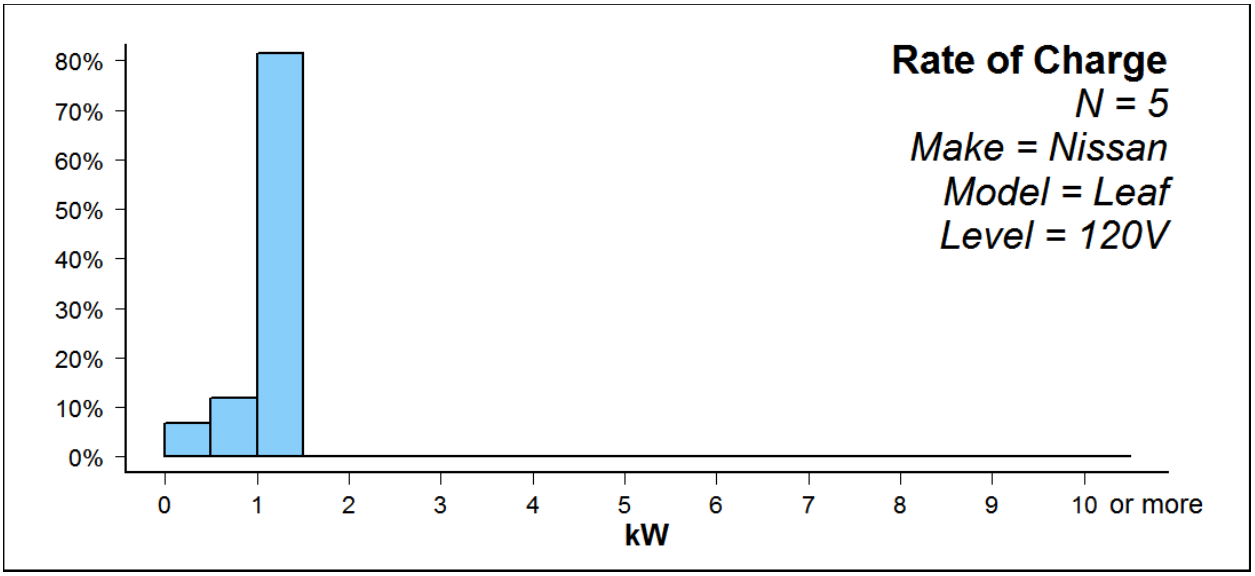


FIGURE 50. RATE OF CHARGE: NISSAN LEAF, 240V

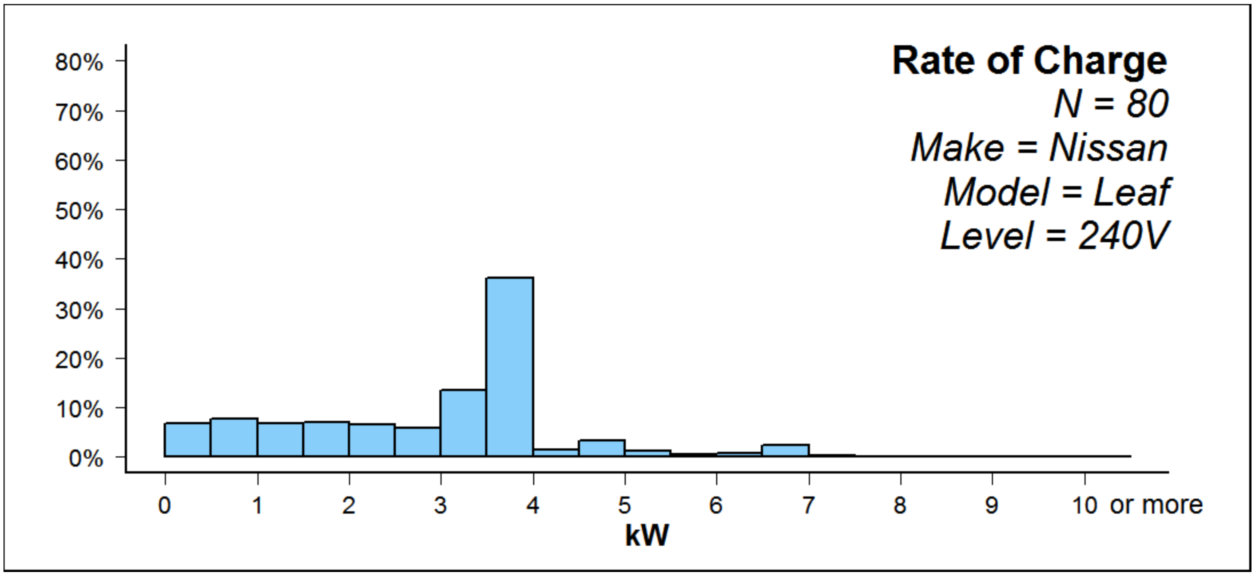


FIGURE 51. RATE OF CHARGE: TESLA MODEL S, 240V

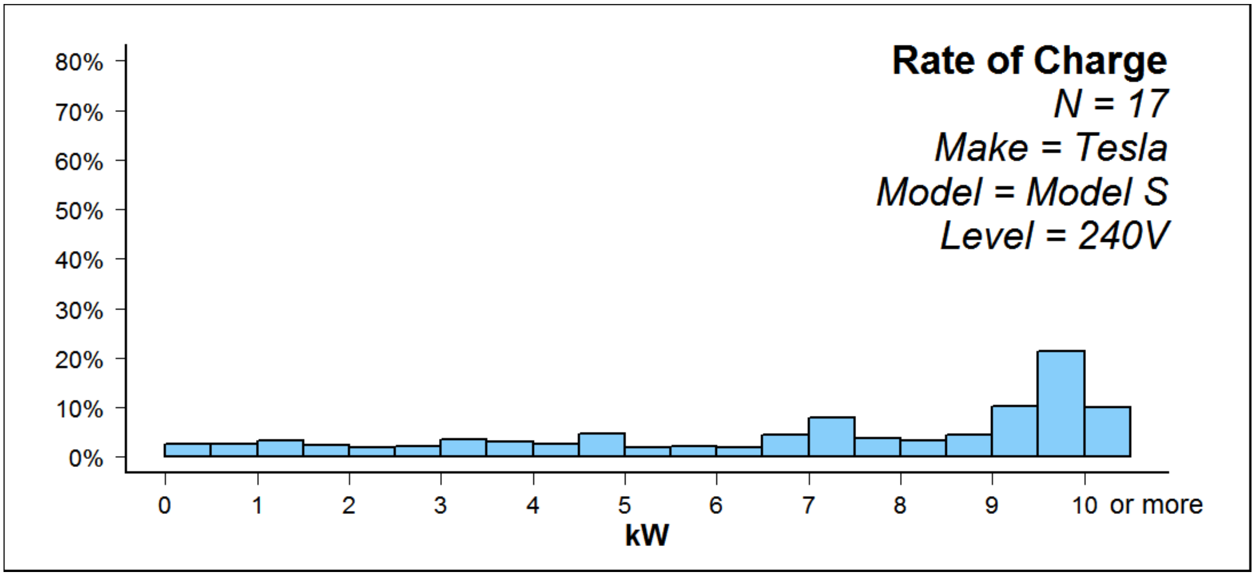


FIGURE 52. RATE OF CHARGE: TESLA ROADSTER, 240V

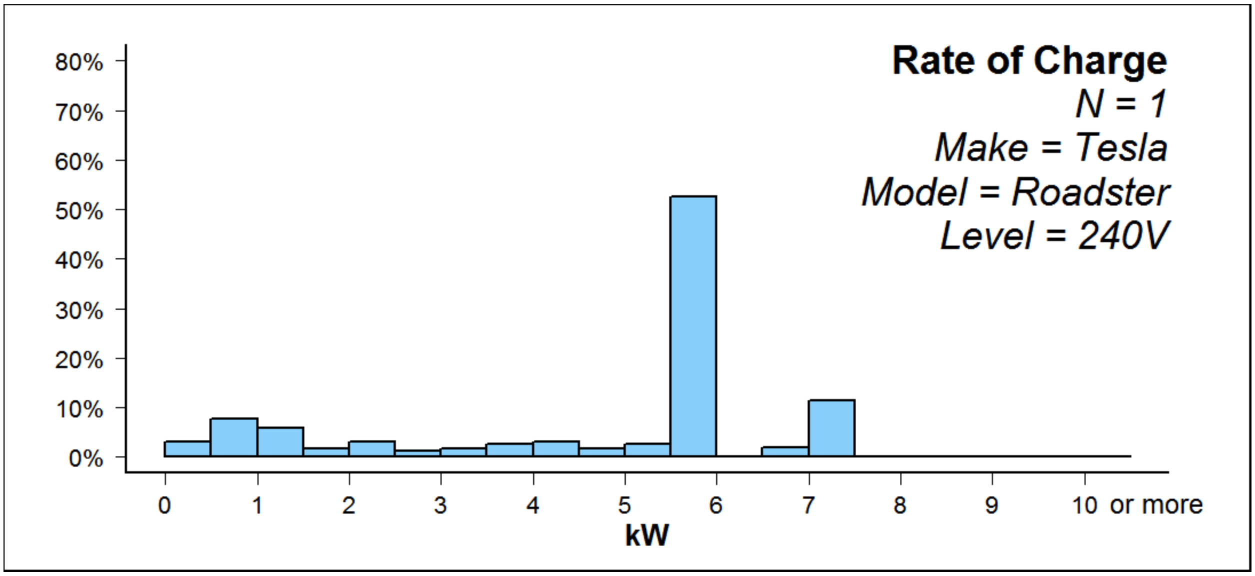


FIGURE 53. RATE OF CHARGE: TOYOTA PRIUS PLUG-IN, 120V

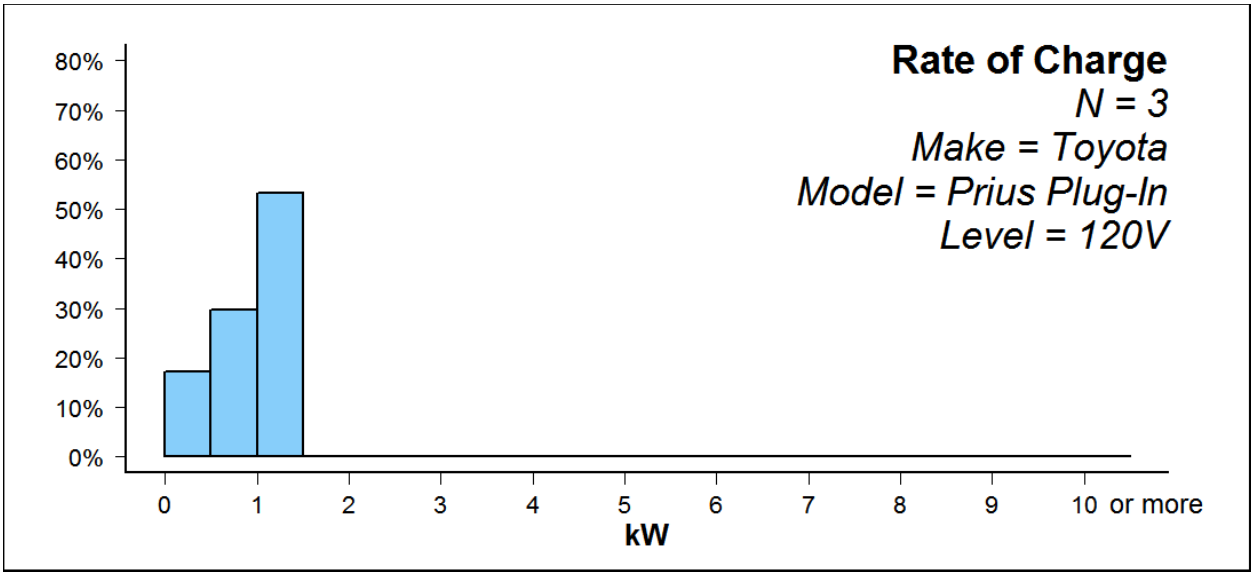


FIGURE 54. RATE OF CHARGE: TOYOTA PRIUS PLUG-IN, 240V

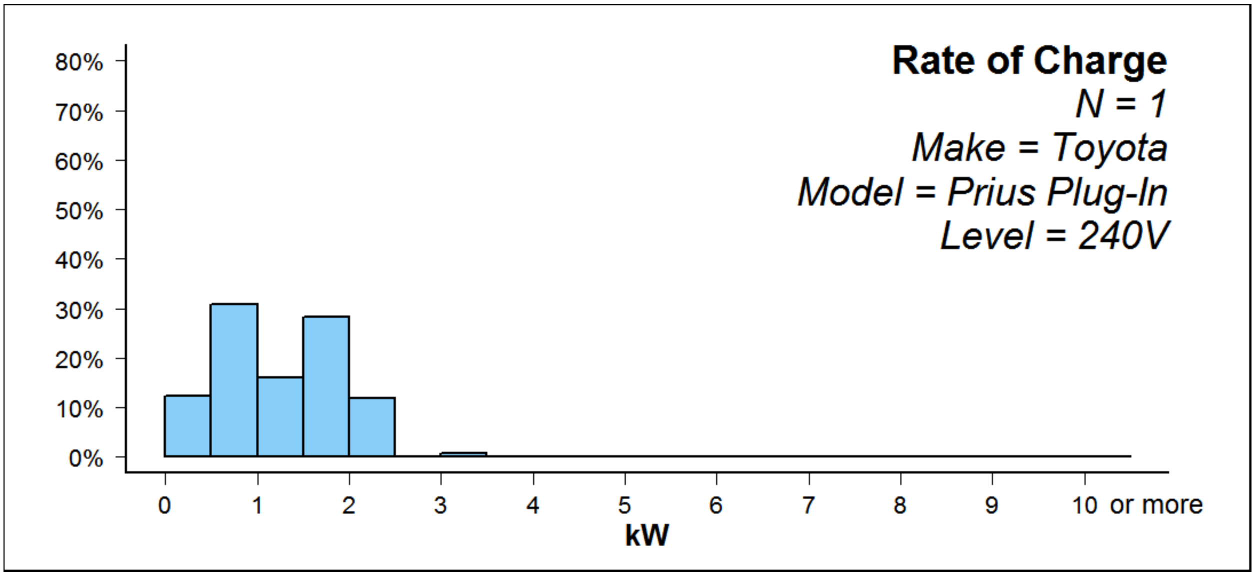


FIGURE 55. RATE OF CHARGE: CHEVY VOLT, 120V

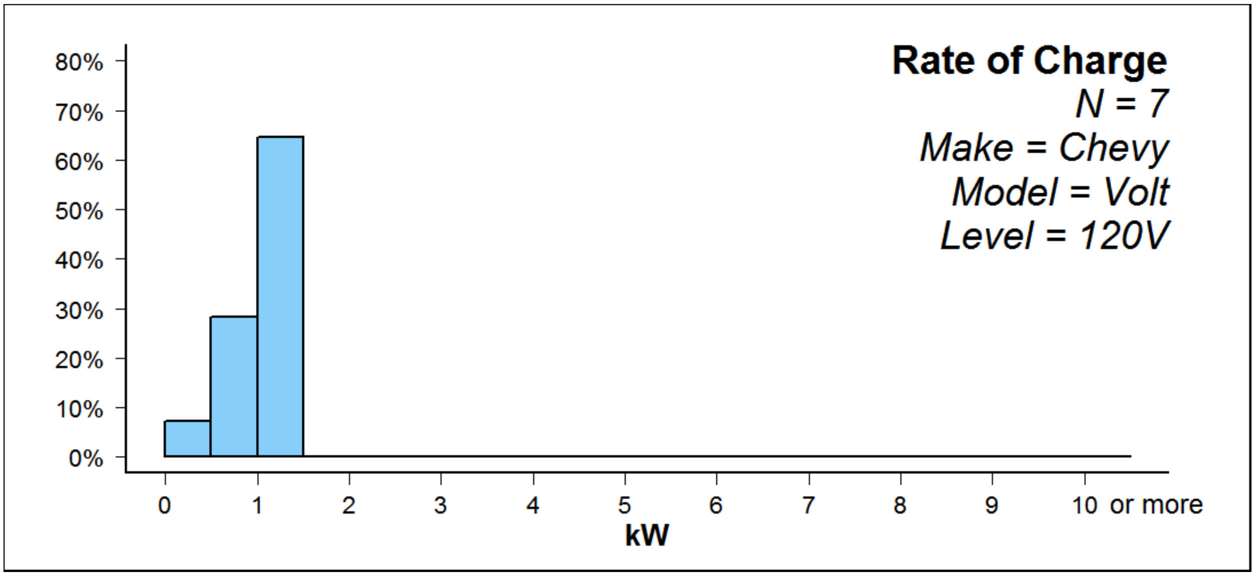


FIGURE 56. RATE OF CHARGE: CHEVY VOLT, 240V

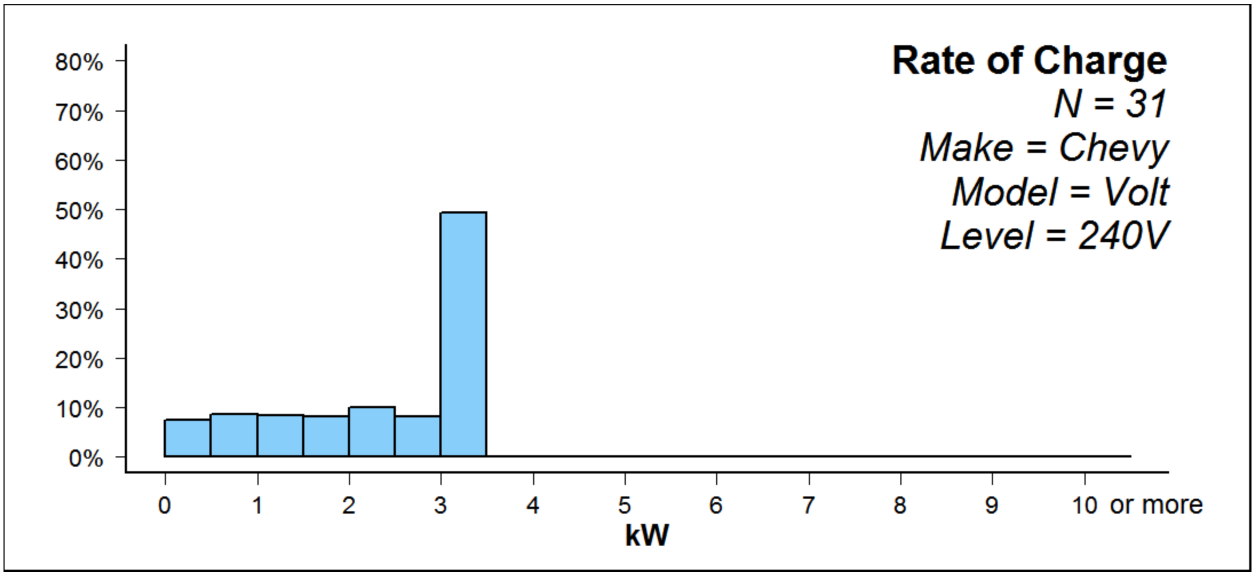
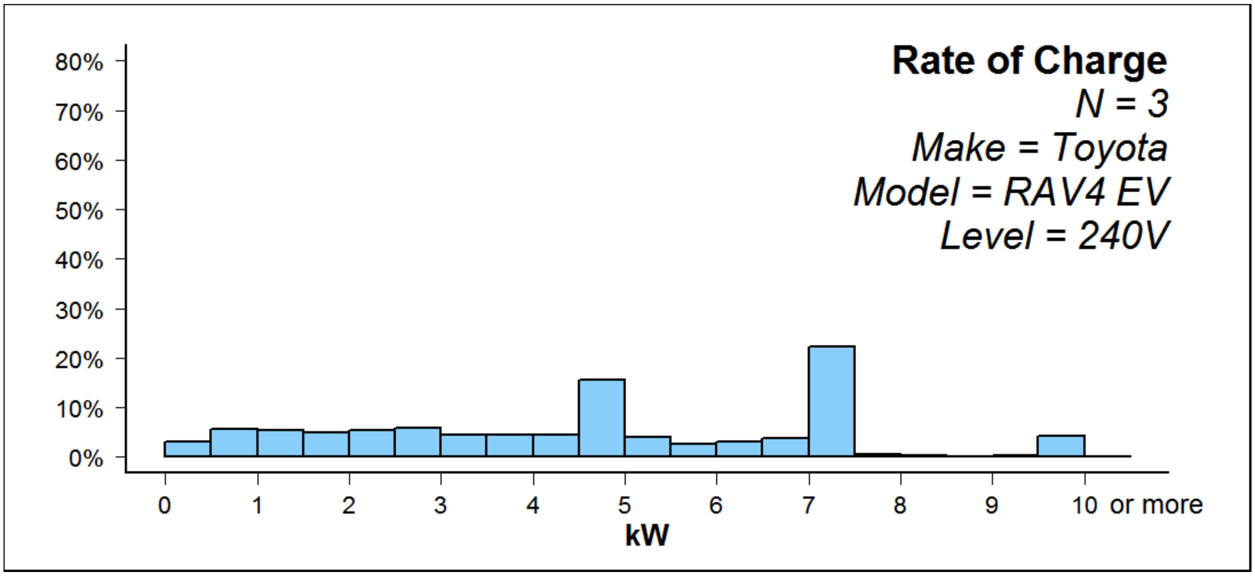


Figure 57. Rate of charge: Toyota RAV4 EV, 240V



APPENDIX F. LOAD DATA SUMMARY TABLES

TABLE 40. LEVEL 1 CHARGING DURATION, BY MONTH, BY SEASON, AND ANNUALLY

PHEV (Data Only plus TG2 L1)	**Month**								**Summer**	**Winter**	**Annual**
Period	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Overall	Overall	**Overall**
Number of participants at end of period	9	9	10	12	12	12	12	12	12	12	**13**
Avg. duration of charge (# of hours >200 W)	4.23	4.38	4.12	3.85	3.32	3.59	3.52	3.36	3.94	3.43	**3.56**
BEV (Data Only plus TG2 L1)	**Month**								**Summer**	**Winter**	**Annual**
Period	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Overall	Overall	**Overall**
Number of participants at end of period	3	4	5	6	7	6	6	7	6	7	**7**
Avg. duration of charge (# of hours >200 W)	4.02	4.43	4.24	4.56	4.11	4.39	4.41	3.94	4.08	4.22	**4.18**
PHEV + BEV (Data Only plus TG2 L1)	**Month**								**Summer**	**Winter**	**Annual**
Period	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Overall	Overall	**Overall**
Number of participants at end of period	12	13	15	18	19	18	18	19	18	19	**20**
Avg. duration of charge (# of hours >200 W)	4.18	4.39	4.16	4.09	3.61	3.85	3.82	3.57	3.99	3.72	**3.78**

TABLE 41. TG1 DATA SUMMARY

PHEV (TG1)	Month								Summer	Winter	Annual
Period	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Overall	Overall	**Overall**
Number of participants at end of period	15	17	18	19	19	19	19	19	19	19	**19**
Avg. non-coincident max monthly Off-peak kW (HOUSE)	3.69	4.05	3.62	3.39	3.14	3.17	3.55	3.21	3.69	3.27	**3.46**
Avg. non-coincident max monthly On-peak kW (HOUSE)	3.73	4.46	4.06	3.50	2.68	2.77	3.17	2.82	3.95	2.86	**3.37**
BEV (TG1)	Month								Summer	Winter	Annual
Period	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Overall	Overall	**Overall**
Number of participants at end of period	11	16	17	18	17	17	17	17	18	17	**18**
Avg. non-coincident max monthly Off-peak kW (HOUSE)	3.79	3.90	3.67	3.45	3.25	3.62	4.61	3.93	3.67	3.85	**3.77**
Avg. non-coincident max monthly On-peak kW (HOUSE)	3.41	3.77	3.40	2.95	2.41	2.80	3.40	2.97	3.29	2.90	**3.12**
PHEV + BEV (TG1)	Month								Summer	Winter	Annual
Period	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Overall	Overall	**Overall**
Number of participants at end of period	26	33	35	37	36	36	36	36	37	36	**37**
Avg. non-coincident max monthly Off-peak kW (HOUSE)	3.74	3.98	3.64	3.42	3.19	3.38	4.05	3.55	3.68	3.54	**3.61**
Avg. non-coincident max monthly On-peak kW (HOUSE)	3.59	4.13	3.74	3.23	2.55	2.78	3.28	2.89	3.63	2.88	**3.25**

TABLE 42. TG2 DATA SUMMARY

PHEV (TG2)	Month								Summer			Winter	Annual
Period	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Overall	CD	non CD	Overall	**Overall**
# of participants at end of period (EV)	5	12	13	19	21	22	22	22	19	n/a	n/a	22	**22**
# of participants at end of period (HOUSE)	5	11	12	17	19	20	20	20	17	n/a	n/a	20	**20**
# charge events Off-peak	79	300	366	562	716	718	811	862	1307	145	1162	3108	**4415**
# charge events On-peak	17	42	24	33	47	46	65	58	116	15	101	216	**332**
% Charges Off-Peak	82%	88%	94%	94%	94%	94%	93%	94%	92%	91%	92%	94%	93%
% Charges On-Peak	18%	12%	6%	6%	6%	6%	7%	6%	8%	9%	8%	6%	7%
Avg. kWh per participant Off-peak	97	163	200	194	178	169	179	193	178	21	157	180	**179**
Avg. kWh per participant On-peak	4.8	8.1	5.2	3.3	5.4	6.6	7.5	7.9	5.1	0.8	4.4	6.9	**6.2**
% kWh Off-Peak	95%	95%	97%	98%	97%	96%	96%	96%	97%	96%	97%	96%	97%
% kWh On-Peak	5%	5%	3%	2%	3%	4%	4%	4%	3%	4%	3%	4%	3%
Avg. charge duration Off-peak (# hours >200 W)	2.18	2.86	3.05	2.83	2.45	2.39	2.44	2.43	2.83	3.02	2.81	2.41	**2.48**
Avg. charge duration On-peak (# hours >200 W)	1.09	1.35	2.55	1.45	1.74	1.80	1.70	1.40	1.70	1.44	1.75	1.62	**1.56**
Avg. max monthly Off-peak kW (EV)	1.17	1.73	1.97	2.16	2.05	2.04	2.04	2.18	2.06	1.88	2.08	2.09	**2.02**
Avg. max monthly On-peak kW (EV)	0.13	0.14	0.08	0.08	0.10	0.12	0.14	0.14	0.10	0.12	0.09	0.12	**0.12**
Avg. max monthly Off-peak kW (HOUSE)	3.64	3.61	3.42	3.65	3.35	3.48	3.65	3.66	3.60	3.76	3.58	3.55	**3.55**
Avg. max monthly On-peak kW (HOUSE)	3.11	3.67	3.05	2.62	1.61	1.74	2.13	1.88	2.98	3.63	2.88	1.84	**2.28**
Avg. kWh per charge off-peak (>200 W)	6.17	6.50	7.10	6.56	5.08	5.02	4.76	4.81	6.67	7.04	6.63	4.91	**5.42**
Avg. kWh per charge on-peak (>200 W)	1.41	2.32	2.82	1.88	2.43	3.16	2.52	2.98	2.17	2.48	2.12	2.76	**2.55**
BEV (TG2)	Month								Summer			Winter	Annual
Period	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Overall	CD	non CD	Overall	**Overall**
# of participants at end of period (EV)	23	38	48	63	71	75	75	75	64	n/a	n/a	75	**75**
# of participants at end of period (HOUSE)	22	37	47	63	69	73	73	73	63	n/a	n/a	73	**74**
# charge events Off-peak	567	978	1191	1618	2032	2078	2329	2328	4354	525	3829	8767	**13121**
# charge events On-peak	75	163	124	110	99	117	175	139	472	32	440	530	**1002**
% Charges Off-Peak	88%	86%	91%	94%	95%	95%	93%	94%	90%	94%	90%	94%	93%
% Charges On-Peak	12%	14%	9%	6%	5%	5%	7%	6%	10%	6%	10%	6%	7%
Avg. kWh per participant Off-peak	328	313	293	304	317	280	295	286	306	36	270	294	**299**
Avg. kWh per participant On-peak	27.1	32.1	22.5	10.9	8.8	9.2	14.1	13.5	21.0	1.1	19.9	11.4	**14.9**
% kWh Off-Peak	92%	91%	93%	97%	97%	97%	95%	96%	94%	97%	93%	96%	95%
% kWh On-Peak	8%	9%	7%	3%	3%	3%	5%	4%	6%	3%	7%	4%	5%
Avg. charge duration Off-peak (# hours >200 W)	2.70	2.67	2.74	2.75	2.68	2.58	2.50	2.42	2.72	2.66	2.72	2.54	**2.59**
Avg. charge duration On-peak (# hours >200 W)	1.82	2.16	2.08	1.85	1.76	1.56	1.81	1.96	1.95	1.98	1.96	1.74	**1.82**
Avg. max monthly Off-peak kW (EV)	3.90	3.88	3.80	4.00	4.05	3.79	3.71	3.81	3.94	4.04	3.93	3.82	**3.86**
Avg. max monthly On-peak kW (EV)	0.47	0.46	0.32	0.19	0.15	0.19	0.25	0.25	0.30	0.15	0.32	0.21	**0.25**
Avg. max monthly Off-peak kW (HOUSE)	5.00	2.24	5.16	5.27	5.19	5.04	5.40	5.22	5.31	5.55	5.28	5.19	**5.21**
Avg. max monthly On-peak kW (HOUSE)	3.21	3.58	3.42	2.82	1.95	2.09	2.61	2.27	3.27	3.50	3.24	2.23	**2.59**

Avg. kWh per charge off-peak (>200 W)	13.30	12.15	11.80	11.86	10.93	9.99	9.29	9.04	12.10	11.87	12.13	9.77	**10.53**
Avg. kWh per charge on-peak (>200 W)	8.31	7.48	8.69	6.24	6.31	5.88	6.02	7.26	7.64	5.78	7.78	6.37	**6.97**
PHEV + BEV (TG2)	Month								Summer			Winter	Annual
Period	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Overall	CD	non CD	Overall	**Overall**
# of participants at end of period (EV)	28	50	61	82	92	97	97	97	83	n/a	n/a	97	**97**
# of participants at end of period (HOUSE)	27	48	59	80	88	93	93	93	80	n/a	n/a	93	**94**
# charge events Off-peak	646	1278	1557	2180	2748	2797	3140	3190	5661	670	4991	11875	**17536**
# charge events On-peak	92	205	148	143	146	163	240	197	588	47	541	746	**1334**
% Charges Off-Peak	88%	86%	91%	94%	95%	94%	93%	94%	91%	93%	90%	94%	93%
% Charges On-Peak	12%	14%	9%	6%	5%	6%	7%	6%	9%	7%	10%	6%	7%
Avg. kWh per participant Off-peak	287	277	273	279	286	255	268	265	278	33	245	268	**272**
Avg. kWh per participant On-peak	23.1	26.4	18.8	9.1	8.0	8.6	12.6	12.2	17.5	1.0	16.5	10.4	**13.0**
% kWh Off-Peak	93%	91%	94%	97%	97%	97%	96%	96%	94%	97%	94%	96%	95%
% kWh On-Peak	7%	9%	6%	3%	3%	3%	4%	4%	6%	3%	6%	4%	5%
Avg. charge duration Off-peak (# hours >200 W)	2.62	2.71	2.81	2.77	2.63	2.54	2.49	2.42	2.75	2.74	2.74	2.51	**2.56**
Avg. charge duration On-peak (# hours >200 W)	1.71	1.92	2.18	1.73	1.75	1.61	1.77	1.83	1.89	1.77	1.91	1.72	**1.77**
Avg. max monthly Off-peak kW (EV)	3.41	3.36	3.41	3.57	3.60	3.40	3.33	3.44	3.51	3.55	3.50	3.42	**3.44**
Avg. max monthly On-peak kW (EV)	0.41	0.38	0.27	0.17	0.14	0.17	0.22	0.22	0.25	0.14	0.27	0.19	**0.22**
Avg. max monthly Off-peak kW (HOUSE)	4.75	4.86	4.80	4.92	4.79	4.71	5.02	4.89	4.95	5.17	4.92	4.84	**4.85**
Avg. max monthly On-peak kW (HOUSE)	3.19	3.60	3.35	2.78	1.88	2.01	2.51	2.18	3.21	3.53	3.16	2.14	**2.53**
Avg. kWh per charge off-peak (>200 W)	12.43	10.83	10.70	10.49	9.39	8.69	8.12	7.89	10.84	10.83	10.85	8.49	**9.24**
Avg. kWh per charge on-peak (>200 W)	7.04	6.43	7.74	5.24	5.06	5.11	5.07	6.00	6.56	4.73	6.72	5.32	**5.87**

CD Event #	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	Total
# times exceeding 2.5kW during CD peak (EV)	2	7	7	6	0	6	3	0	0	1	2	1	35

TABLE 43. TG3 DATA SUMMARY

PHEV (TG3)	Month								Summer			Winter	Annual
Period	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Overall	CD	non CD	Overall	Overall
# of participants at end of period (EV)	13	14	15	15	15	15	14	14	15	n/a	n/a	15	15
# of participants at end of period (HOUSE)	13	14	15	15	15	15	15	15	15	n/a	n/a	15	15
# charge events Off-peak	338	397	434	380	543	535	554	569	1549	154	1395	2201	3750
# charge events On-peak	63	80	96	40	39	44	39	38	279	17	262	160	439
% Charges Off-Peak	84%	83%	82%	90%	93%	92%	93%	94%	85%	90%	84%	93%	90%
% Charges On-Peak	16%	17%	18%	10%	7%	8%	7%	6%	15%	10%	16%	7%	10%
Avg. kWh per participant Off-peak	171	191	202	173	203	175	207	211	185	19	166	199	192
Avg. kWh per participant On-peak	16.6	23.7	29.7	7.0	7.6	10.1	7.6	10.9	19.3	1.1	18.2	9.0	14.1
% kWh Off-Peak	91%	89%	87%	96%	96%	95%	96%	95%	91%	95%	90%	96%	93%
% kWh On-Peak	9%	11%	13%	4%	4%	5%	4%	5%	9%	5%	10%	4%	7%
Avg. charge duration Off-peak (# hours >200 W)	2.61	2.62	2.70	2.68	2.27	2.10	2.24	2.15	2.66	2.74	2.65	2.16	2.34
Avg. charge duration On-peak (# hours >200 W)	1.57	1.67	2.03	1.75	2.11	1.95	1.53	1.60	1.80	1.88	1.80	1.97	1.85
Avg. max monthly Off-peak kW (EV)	2.14	2.24	2.33	2.15	2.38	2.33	2.24	2.45	2.21	2.23	2.21	2.33	2.28
Avg. max monthly On-peak kW (EV)	0.22	0.31	0.39	0.12	0.15	0.24	0.15	0.19	0.30	0.14	0.32	0.18	0.22
Avg. max monthly Off-peak kW (HOUSE)	3.55	3.63	3.52	3.30	3.39	3.57	3.77	3.82	3.48	3.68	3.46	3.64	3.57
Avg. max monthly On-peak kW (HOUSE)	3.38	3.84	3.50	2.95	2.13	2.15	2.29	2.22	3.40	3.78	3.36	2.20	2.79
Avg. kWh per charge off-peak (>200 W)	6.59	6.75	6.99	6.84	5.42	4.68	5.02	4.94	6.81	6.96	6.79	5.01	5.73
Avg. kWh per charge on-peak (>200 W)	3.43	4.15	4.63	2.62	2.92	3.43	2.71	4.03	3.93	3.67	3.95	3.27	3.69
BEV (TG3)	**Month**								**Summer**			**Winter**	**Annual**
Period	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Overall	CD	non CD	Overall	Overall
# of participants at end of period (EV)	38	40	42	42	42	42	42	42	42	n/a	n/a	42	42
# of participants at end of period (HOUSE)	37	38	40	40	40	40	40	40	40	n/a	n/a	40	40
# charge events Off-peak	809	899	1074	1032	1293	1320	1464	1376	3814	379	3435	5453	9267
# charge events On-peak	79	108	152	131	73	119	141	135	470	31	439	468	938
% Charges Off-Peak	91%	89%	88%	89%	95%	92%	91%	91%	89%	92%	89%	92%	91%
% Charges On-Peak	9%	11%	12%	11%	5%	8%	9%	9%	11%	8%	11%	8%	9%
Avg. kWh per participant Off-peak	182	187	217	196	230	215	227	211	196	19	177	221	209
Avg. kWh per participant On-peak	12.5	19.2	22.4	22.2	9.5	15.4	20.4	19.8	19.2	0.8	18.4	16.3	17.7
% kWh Off-Peak	94%	91%	91%	90%	96%	93%	92%	91%	91%	96%	91%	93%	92%
% kWh On-Peak	6%	9%	9%	10%	4%	7%	8%	9%	9%	4%	9%	7%	8%
Avg. charge duration Off-peak (# hours >200 W)	2.94	2.75	2.79	7.79	2.61	2.45	2.43	2.40	2.78	2.74	2.79	2.45	2.58
Avg. charge duration On-peak (# hours >200 W)	1.70	2.08	1.95	2.24	1.91	1.73	2.07	1.80	2.01	2.83	1.97	1.85	1.94
Avg. max monthly Off-peak kW (EV)	2.16	2.29	2.53	2.45	2.63	2.72	2.66	2.55	2.37	2.34	2.37	2.64	2.51
Avg. max monthly On-peak kW (EV)	0.19	0.29	0.31	0.28	0.17	0.26	0.31	0.30	0.28	0.09	0.30	0.26	0.27
Avg. max monthly Off-peak kW (HOUSE)	4.05	4.35	4.25	4.00	3.93	4.11	4.35	4.05	4.17	4.38	4.15	4.11	4.13
Avg. max monthly On-peak kW (HOUSE)	4.00	4.71	4.20	3.49	2.12	2.32	2.80	2.45	4.09	4.63	4.03	2.43	3.25

Avg. kWh per charge off-peak (>200 W)	8.56	8.34	8.47	7.98	7.31	6.64	6.27	6.19	8.32	8.24	8.33	6.58	7.29
Avg. kWh per charge on-peak (>200 W)	6.03	7.11	6.19	7.11	5.44	5.44	6.06	6.17	6.63	4.40	6.79	5.84	6.23
PHEV + BEV (TG3)	**Month**								**Summer**			**Winter**	**Annual**
Period	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Overall	CD	non CD	Overall	Overall
# of participants at end of period (EV)	51	54	57	57	57	57	56	56	57	n/a	n/a	57	57
# of participants at end of period (HOUSE)	50	52	55	55	55	55	55	55	55	n/a	n/a	55	55
# charge events Off-peak	1147	1296	1508	1412	1836	1855	2018	1945	5363	533	4830	7654	13017
# charge events On-peak	142	188	248	171	112	163	180	173	749	48	701	628	1377
% Charges Off-Peak	89%	87%	86%	89%	94%	92%	92%	92%	88%	92%	87%	92%	90%
% Charges On-Peak	11%	13%	14%	11%	6%	8%	8%	8%	12%	8%	13%	8%	10%
Avg. kWh per participant Off-peak	179	188	213	190	223	204	222	211	193	19	174	215	204
Avg. kWh per participant On-peak	13.6	20.4	24.3	18.2	9.0	14.0	17.2	17.6	19.2	0.9	18.3	14.4	16.8
% kWh Off-Peak	93%	90%	90%	91%	96%	94%	93%	92%	91%	95%	90%	94%	92%
% kWh On-Peak	7%	10%	10%	9%	4%	6%	7%	8%	9%	5%	10%	6%	8%
Avg. charge duration Off-peak (# hours >200 W)	2.85	2.71	2.76	2.76	2.52	2.35	2.38	2.33	2.75	2.74	2.75	2.37	2.52
Avg. charge duration On-peak (# hours >200 W)	1.66	1.94	1.98	2.09	1.97	1.81	1.92	1.75	1.95	2.48	1.92	1.89	1.92
Avg. max monthly Off-peak kW (EV)	2.15	2.28	2.48	2.37	2.57	2.61	2.56	2.53	2.33	2.31	2.33	2.56	2.45
Avg. max monthly On-peak kW (EV)	0.20	0.30	0.33	0.23	0.17	0.26	0.27	0.27	0.29	0.10	0.31	0.24	0.25
Avg. max monthly Off-peak kW (HOUSE)	3.92	4.16	4.05	3.81	3.78	3.96	4.19	3.99	3.98	4.19	3.96	3.98	3.98
Avg. max monthly On-peak kW (HOUSE)	3.84	4.47	4.01	3.34	2.12	2.27	2.66	2.39	3.90	4.40	3.85	2.36	3.12
Avg. kWh per charge off-peak (>200 W)	7.98	7.85	8.04	7.68	6.75	6.06	5.92	5.82	7.89	7.87	7.89	6.13	6.84
Avg. kWh per charge on-peak (>200 W)	4.88	5.85	5.59	6.06	4.56	4.89	5.34	5.70	5.63	4.14	5.73	5.18	5.42

TABLE 44. TG2+TG3 DATA SUMMARY

PHEV (TG2-3)	Month								Summer			Winter	Annual
Period	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Overall	CD	non CD	Overall	**Overall**
# of participants at end of period (EV)	18	26	28	34	36	37	36	36	34	n/a	n/a	37	**37**
# of participants at end of period (HOUSE)	18	25	27	32	34	35	35	35	32	n/a	n/a	35	**35**
# charge events Off-peak	417	697	800	942	1259	1253	1365	1431	2856	299	2557	5308	**8164**
# charge events On-peak	80	122	120	73	86	90	104	96	395	32	363	376	**771**
% Charges Off-Peak	84%	85%	87%	93%	94%	93%	93%	94%	88%	90%	88%	93%	91%
% Charges On-Peak	16%	15%	13%	7%	6%	7%	7%	6%	12%	10%	12%	7%	9%
Avg. kWh per participant Off-peak	151	178	201	185	188	172	190	200	182	20	162	187	**185**
Avg. kWh per participant On-peak	13.3	16.5	18.3	4.9	6.3	8.0	7.5	9.1	12.7	0.9	11.8	7.7	**9.8**
% kWh Off-Peak	92%	92%	92%	97%	97%	96%	96%	96%	93%	95%	93%	96%	95%
% kWh On-Peak	8%	8%	8%	3%	3%	4%	4%	4%	7%	5%	7%	4%	5%
Avg. charge duration Off-peak (# hours >200 W)	2.50	2.73	2.86	2.77	2.37	2.27	2.37	2.32	2.76	2.89	2.74	2.31	**2.42**
Avg. charge duration On-peak (# hours >200 W)	1.48	1.54	2.25	1.58	1.92	1.88	1.62	1.49	1.75	1.64	1.77	1.80	**1.69**
Avg. max monthly Off-peak kW (EV)	1.87	2.01	2.16	2.16	2.19	2.16	2.11	2.29	2.12	2.03	2.14	2.19	**2.14**
Avg. max monthly On-peak kW (EV)	0.20	0.23	0.25	0.10	0.12	0.16	0.14	0.16	0.19	0.13	0.19	0.15	**0.16**
Avg. max monthly Off-peak kW (HOUSE)	3.58	3.62	3.47	3.49	3.37	3.52	3.70	3.73	3.54	3.72	3.52	3.59	**3.56**
Avg. max monthly On-peak kW (HOUSE)	3.30	3.77	3.30	2.77	1.84	1.91	2.20	2.02	3.18	3.70	3.10	1.99	**2.53**
Avg. kWh per charge off-peak (>200 W)	6.51	6.64	7.04	6.68	5.23	4.87	4.86	4.86	6.75	7.00	6.72	4.95	**5.56**
Avg. kWh per charge on-peak (>200 W)	3.00	3.52	4.27	2.29	2.65	3.29	2.59	3.40	3.41	3.11	3.44	2.98	**3.20**
BEV (TG2-3)	Month								Summer			Winter	Annual
Period	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Overall	CD	non CD	Overall	**Overall**
# of participants at end of period (EV)	61	78	90	105	113	117	117	117	106	n/a	n/a	117	**117**
# of participants at end of period (HOUSE)	59	75	87	103	109	113	113	113	103	n/a	n/a	113	**114**
# charge events Off-peak	1376	1877	2265	2650	3325	3398	3793	3704	8168	904	7264	14220	**22388**
# charge events On-peak	154	271	276	241	172	236	316	274	942	63	879	998	**1940**
% Charges Off-Peak	90%	87%	89%	92%	95%	94%	92%	93%	90%	93%	89%	93%	92%
% Charges On-Peak	10%	13%	11%	8%	5%	6%	8%	7%	10%	7%	11%	7%	8%
Avg. kWh per participant Off-peak	237	248	257	261	285	257	270	259	253	28	225	268	**261**
Avg. kWh per participant On-peak	18.0	25.5	22.4	15.4	9.0	11.4	16.3	15.7	20.1	1.0	19.2	13.2	**16.1**
% kWh Off-Peak	93%	91%	92%	94%	97%	96%	94%	94%	93%	97%	92%	95%	94%
% kWh On-Peak	7%	9%	8%	6%	3%	4%	6%	6%	7%	3%	8%	5%	6%
Avg. charge duration Off-peak (# hours >200 W)	2.85	2.71	2.76	2.77	2.65	2.53	2.47	2.41	2.75	2.69	2.75	2.51	**2.59**
Avg. charge duration On-peak (# hours >200 W)	1.75	2.12	2.02	2.01	1.81	1.62	1.90	1.90	1.98	2.39	1.97	1.78	**1.87**
Avg. max monthly Off-peak kW (EV)	2.81	3.06	3.21	3.38	3.53	3.41	3.33	3.36	3.32	3.37	3.31	3.39	**3.30**
Avg. max monthly On-peak kW (EV)	0.30	0.37	0.32	0.22	0.16	0.22	0.27	0.27	0.29	0.12	0.31	0.23	**0.26**
Avg. max monthly Off-peak kW (HOUSE)	4.41	4.79	4.74	4.77	4.73	4.71	5.03	4.81	4.87	5.09	4.84	4.81	**4.77**
Avg. max monthly On-peak kW (HOUSE)	3.70	4.15	3.78	3.08	2.01	2.17	2.68	2.33	3.59	3.94	3.55	2.30	**2.86**

Avg. kWh per charge off-peak (>200 W)	10.51	10.32	10.22	10.35	9.52	8.67	8.11	7.97	10.33	10.35	10.33	8.53	**9.18**
Avg. kWh per charge on-peak (>200 W)	7.14	7.33	7.31	6.72	5.94	5.65	6.04	6.72	7.14	5.10	7.28	6.12	**6.61**

PHEV + BEV (TG2-3)	Month								Summer			Winter	Annual
Period	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Overall	CD	non CD	Overall	**Overall**
# of participants at end of period (EV)	79	104	118	139	149	154	153	153	140	n/a	n/a	154	**154**
# of participants at end of period (HOUSE)	77	100	114	135	143	148	148	148	135	n/a	n/a	148	**149**
# charge events Off-peak	1793	2574	3065	3592	4584	4651	5158	5135	11024	1203	9821	19528	**30552**
# charge events On-peak	234	393	396	314	258	326	420	370	1337	95	1242	1374	**2711**
% Charges Off-Peak	88%	87%	89%	92%	95%	93%	92%	93%	89%	93%	89%	93%	92%
% Charges On-Peak	12%	13%	11%	8%	5%	7%	8%	7%	11%	7%	11%	7%	8%
Avg. kWh per participant Off-peak	218	231	244	243	262	236	251	245	236	26	210	249	**243**
Avg. kWh per participant On-peak	17.0	23.2	21.5	12.9	8.4	10.6	14.2	14.2	18.4	1.0	17.4	11.9	**14.6**
% kWh Off-Peak	93%	91%	92%	95%	97%	96%	95%	95%	93%	96%	92%	95%	94%
% kWh On-Peak	7%	9%	8%	5%	3%	4%	5%	5%	7%	4%	8%	5%	6%
Avg. charge duration Off-peak (# hours >200 W)	2.77	2.71	2.79	2.77	2.59	2.47	2.45	2.39	2.75	2.74	2.75	2.46	**2.55**
Avg. charge duration On-peak (# hours >200 W)	1.68	1.92	2.08	1.88	1.83	1.69	1.84	1.79	1.92	2.11	1.91	1.78	**1.83**
Avg. max monthly Off-peak kW (EV)	2.60	2.80	2.96	3.08	3.20	3.11	3.05	3.11	3.03	3.04	3.03	3.10	**3.02**
Avg. max monthly On-peak kW (EV)	0.28	0.34	0.30	0.19	0.15	0.20	0.24	0.24	0.27	0.12	0.28	0.21	**0.24**
Avg. max monthly Off-peak kW (HOUSE)	4.21	4.50	4.44	4.47	4.40	4.43	4.71	4.55	4.55	4.77	4.53	4.52	**4.48**
Avg. max monthly On-peak kW (HOUSE)	3.61	4.05	3.67	3.01	1.97	2.11	2.57	2.26	3.49	3.88	3.44	2.23	**2.78**
Avg. kWh per charge off-peak (>200 W)	9.58	9.33	9.39	9.38	8.33	7.63	7.25	7.10	9.41			7.55	**8.21**
Avg. kWh per charge on-peak (>200 W)	5.73	6.15	6.39	5.69	4.84	5.00	5.19	5.86	6.04			5.26	**5.64**

Appendix G. Electric Vehicles Available for Purchase by 2013

Table 45. Electric vehicles available for purchase by 2013

Make and Model	Type	Model Year(s)	Estimated time to fully charge *(hours)*		Max Amps		Max kW		Estimated Battery kWh	Estimated Range[1] *(miles)*
					120V	*240V*	*120V*	*240V*		
Chevy Volt	EREV[2]	2011/12/13	8.3	3.6	12	14	1.4	3.3	12	34
Nissan Leaf	BEV[3]	2011/12	15.3	5.7	12	16	1.4	3.8	22	73
Nissan Leaf	BEV	2013	15.3	3.1	12	28	1.4	6.7	22	73
Ford CMAX Energi	PHEV[4]	2013	5.3	2.0	12	16	1.4	3.8	7.6	22
Ford Focus EV	BEV	2012/13	15.3	3.1	12	30	1.4	7.2	22	73
Ford Fusion	PHEV	2013	5.3	2.0	12	16	1.4	3.8	7.6	22
Tesla Model S	BEV	2012/13	59.0	4.4	12	80	1.4	19.2	85	243
Tesla Roadster	BEV	2008-11	36.1	3.1	12	70	1.4	16.8	52	208
Toyota Prius	PHEV	2012/13	2.8	1.4	12	12	1.4	2.8	4	11
Toyota RAV4	BEV	2012	29.2	4.4	12	40	1.4	9.6	42	120
BMW Active E	BEV	2011	22.2	3.3	12	40	1.4	9.6	32	107
Coda	BEV	2012	21.5	4.3	12	30	1.4	7.2	31	103
Honda Fit EV	BEV	2013	13.9	2.8	12	30	1.4	7.2	20	67

[1] Range varies depending on driving pattern

[2] Extended Range Electric Vehicle

[3] Battery Electric Vehicle

[4] Plug in Hybrid Electric Vehicle