Xcel Energy®

414 Nicollet Mall
Minneapolis, Minnesota 55401

May 31, 2019

—Via Electronic Filing—

Daniel P. Wolf
Executive Secretary
Minnesota Public Utilities Commission
121 7th Place East, Suite 350
St. Paul, MN 55101

RE: COMPLIANCE FILING
RESIDENTIAL ELECTRIC VEHICLE CHARGING TARIFF
DOCKET NO. E002/M-15-111 AND E002/M-17-817

Dear Mr. Wolf:

Northern States Power Company, doing business as Xcel Energy, submits this filing in compliance with the Minnesota Public Utilities Commission's June 22, 2015 ORDER APPROVING TARIFFS AND REQUIRING FILINGS in Docket No. E002/M-15-111, Orders dated October 26, 2017 and September 11, 2018 in Docket No. E002/M-15-111, Order dated May 9, 2018 in Docket No. E002/M-17-817 and Order dated February 1, 2019 in Docket No. E002/M-17-879. As specified by Order point 8 in the June 22, 2015 Order, Xcel Energy is to provide the following:

8. Annually, by June 1st, each utility must file an Electric Vehicle Tariff Report in its electric vehicle tariff docket. Each utility must include, on a per-quarter basis and in addition to the information required by Minn. Stat. § 216B.1614, subd. 3(1) and (2), the following information in its reports:

   a. The amount of energy sold in on- and off-peak periods, if applicable;
   b. A brief description of all development and promotional activities and their costs;
   c. The number of customers choosing the renewable-source option;
   d. The status of the communications costs tracker account, if applicable; and
   e. Copies of any EV promotional materials distributed to customers.

In addition, Order point 2 of the Commission's September 11, 2018 ORDER ACCEPTING 2018 ANNUAL REPORTS AND ESTABLISHING REQUIREMENTS FOR NEXT ANNUAL REPORTS required the Company to provide a breakdown of costs by educational and outreach initiatives, including where possible, a separation of costs used to promote the off peak charging tariff versus EV adoption in general.

Attachment A filed with this report provides a reference guide highlighting where all required order points are discussed in the annual report.

We have electronically filed this document with the Commission, and copies have been served on the parties on the attached service list.

If you have any questions regarding this filing, please contact Carl Cronin at carl.cronin@xcelenergy.com or (612) 215-4669.

Sincerely,

/s/

AMY A. LIBERKOWSKI
DIRECTOR, REGULATORY PRICING & ANALYSIS

Enclosure
cc: Service List

STATE OF MINNESOTA
BEFORE THE
MINNESOTA PUBLIC UTILITIES COMMISSION

Katie J. Sieben	Chair
Dan Lipschultz	Commissioner
Valerie Means	Commissioner
Matthew Schuerger	Commissioner
John A. Tuma	Commissioner

IN THE MATTER OF NORTHERN STATES POWER COMPANY'S ANNUAL REPORT ON RESIDENTIAL ELECTRIC VEHICLE (EV) CHARGING TARIFF AND RESIDENTIAL EV SERVICE PILOT	DOCKET NOS. E002/M-15-111 E002/M-17-817 **ANNUAL REPORT**

INTRODUCTION

Northern States Power Company, doing business as Xcel Energy, submits to the Minnesota Public Utilities Commission this Annual Report regarding our Residential Electric Vehicle (EV) Charging Tariff and Residential EV Service Pilot for the period ending April 30, 2019. We submit this Report pursuant to the Commission's Orders dated June 22, 2015 and October 26, 2017 in Docket No. E002/M-15-111 and Order dated May 9, 2018 in Docket No. E002/M-17-817. We request the Commission accept our 2019 Annual Report.

In its 2015 Order in Docket No. E002/M-15-111, the Commission required that each utility file an Annual EV Tariff Report, including the following information on a per quarter basis:

- the number of customers who have arranged to purchase electricity under the tariff;
- the total amount of electricity sold under the tariff;
- the amount of energy sold in on- and off-peak periods, if applicable;
- a brief description of all development and promotional activities and their costs;
- the number of customers choosing the renewable-source option;
- the status of the communications costs tracker account, if applicable; and
- copies of any EV promotional materials distributed to customers.

Order point 2 of the Commission's September 11, 2018 ORDER ACCEPTING 2018 ANNUAL REPORTS AND ESTABLISHING REQUIREMENTS FOR NEXT ANNUAL REPORTS in Docket No. E002/M-15-111 required the Company to provide a breakdown of costs by educational and outreach initiatives, including where possible, a separation of costs used to promote the off peak charging tariff versus EV adoption in general.

Our Residential EV Service Pilot was launched in 2018 as an additional EV charging option that leverages smart charging technology to lower initial costs of participating in the dedicated EV Charging Rate. The pilot is designed to test the potential for cost savings and customer experience improvements through a combination of new equipment deployment and off-peak rate design.

Order point 8 in the Commission's May 9, 2018 ORDER APPROVING PILOT PROGRAM, GRANTING VARIANCE, AND REQUIRING ANNUAL REPORTS required the Company to file an annual report on the pilot, including the following information:

- The number of participating customers and amount of electricity sold in the program, reported on a monthly basis;
- Tracker balances;
- Analyses of customer cost savings;
- Lessons learned regarding customer experience and pilot performance under Xcel's safety and reliability standards;
- The number of customers choosing the bundled option;
- The costs and revenues associated with the bundled option;
- The types of electric vehicle supply equipment (EVSE) that are chosen by the participants;
- The contractors' estimated second-meter installation costs;
- The extent to which wireless connections impacted pilot participation;
- How often wireless connectivity issues prevented billing under the Pilot; and
- Analysis of the effectiveness of car-dealer incentives

Order Point 9 in the Commission's May 9, 2018 Order also required the Company to include a plan to transition the pilot into a permanent EV Service option in this Annual Report.

Order Point 12 in the Commission's February 1, 2019 ORDER MAKING FINDINGS AND REQUIRING FILINGS in Docket No. 17-879, the Commission required the Company to file, as a part of this annual EV report, an EV promotional cost recovery mechanism.

For ease of reviewing this filing, the Company provides a compliance matrix as Attachment A. This attachment lists the various order points mentioned above and where the information required by each order point can be found in this annual report.

Included with this filling are the following attachments:

Attachment A	Compliance Matrix
Attachment B	EV Promotional Materials
Attachment C	Upfront Cost Savings Details
Attachment D	Bill Savings Calculation Details

ANNUAL REPORT

I. EV CHARGING RATE TARIFF

Our Residential EV Charging Service (EV Rate or EV Charging Rate) was launched on August 1, 2015 as a voluntary option to provide residential customers an incentive to charge their EVs during off-peak hours. This rate requires the installation of a second meter at the customer's premises and provides customers with on-peak and off-peak electric rates for EV charging. This section provides the annual report of required information related to the operations under this tariff.

A. Customer Participation and Usage

Customers billed on the Residential EV Charging Rate and the corresponding energy usage history by month is summarized below in Table 1.

Table 1
Total Customer Participation and Energy Usage[1]

		Monthly KWH		
Date	Customers	On-Peak	Off-Peak	Total
Oct-15	8	0	1,741	1,741
Nov-15	7	77	1,967	2,044
Dec-15	9	128	3,008	3,136
Jan-16	14	404	5,883	6,287

[1] Monthly information shown in Table 1 is based on general billing month indicator from our billing system. This is consistent with the presentation of monthly participation and energy usage from previous reports.

Feb-16	13	189	5,497	5,686
Mar-16	17	314	6,959	7,273
Apr-16	20	528	6,779	7,307
May-16	31	896	9,230	10,126
Jun-16	32	663	11,563	12,226
Jul-16	34	987	12,219	13,206
Aug-16	43	749	15,426	16,175
Sep-16	44	708	14,406	15,114
Oct-16	58	1,289	17,764	19,053
Nov-16	54	1,605	17,963	19,568
Dec-16	66	2,482	23,288	25,770
Jan-17	78	2,697	33,871	36,568
Feb-17	79	2,132	31,805	33,937
Mar-17	102	3,144	36,046	39,190
Apr-17	93	1,734	29,733	31,467
May-17	103	2,452	34,036	36,488
Jun-17	111	2,231	38,674	40,905
Jul-17	117	2,992	37,505	40,497
Aug-17	137	2,705	39,750	42,455
Sep-17	140	5,345	48,673	54,018
Oct-17	161	3,761	51,198	54,959
Nov-17	151	4,443	54,809	59,252
Dec-17	193	5,804	66,058	71,862
Jan-18	189	8,385	87,471	95,856
Feb-18	164	6,821	70,404	77,225
Mar-18	217	9,135	80,902	90,037
Apr-18	206	4,771	68,931	73,702
May-18	226	6,114	68,988	75,102
Jun-18	229	5,266	69,401	74,667
Jul-18	243	4,875	72,610	77,485
Aug-18	260	4,348	74,174	78,522
Sep-18	258	5,023	76,492	81,515
Oct-18	301	5,777	95,406	101,183
Nov-18	302	8,239	107,968	116,207
Dec-18	322	10,914	136,044	146,958
Jan-19	375	13,637	164,208	177,845
Feb-19	346	15,931	151,111	167,042
Mar-19	428	15,322	169,253	184,575
Apr-19	473	10,522	155,319	165,841

Table 2 below provides the EV Charging Rate customer counts by quarter (and for the single month of April 2019).

Table 2
Total Customer Participation by Quarter[2]

Date	Customers
Dec-15	9
Mar-16	17
Jun-16	32
Sep-16	46
Dec-16	64
Mar-17	94
Jun-17	112
Sep-17	139
Dec-17	157
Mar-18	201
Jun-18	232
Sep-18	261
Dec-18	325
Mar-19	418
Apr-19	446

The monthly average percentage of charging during the off-peak period (9:00 p.m. to 9:00 a.m., holidays and weekends), under the Residential EV Charging Rate, has ranged from 90 to 94 percent for the last two years, with an average monthly off-peak share of 93 percent.

B. Development and Promotional Activities

In the last year, the Company has made EV-related proposals in order to support continued EV penetration in our service territory and develop greater options for our customers. The proposals included a Fleet EV Service Pilot and a Public Charging Pilot.[3] The Company has also proposed a Residential EV Subscription Service Pilot[4] and a Residential Smart Charging Pilot (*Charging Perks*)[5] since our last Annual Report, and both pilots are pending regulatory review.

[2] Customer count in Table 2 is based on calendar month at the end of each listed quarter.
[3] Submitted in Docket No. E002/M-18-643.
[4] Submitted in Docket No. E002/M-19-186
[5] Submitted as a modification to our current CIP Plan in Docket No. E,G002/CIP-16-115

Beyond the development of new EV-related offerings, the Company has continued its educational campaigns about EVs. The Company's EV-related educational efforts span multiple communication channels including sponsorship of public events, digital media, and dynamic communications. In general, digital outreach creates awareness about Xcel Energy's offerings and the EV market, and public events enable education through an accessible format that addresses complex questions. Our education campaigns supply useful information on the benefits of EV ownership and Xcel Energy's EV offerings to customers who are considering buying an EV or already own an EV. In compliance with the Commission's Order, copies of our EV promotional materials distributed to customers are provided in Attachment B.

Industry outreach is also a key component of the Company's promotional strategy for EV resources. By engaging industry partners directly, the Company aims to enable a positive customer experience by coordinating communications with two key groups: auto dealers and electricians.

1. *Public Events*

The Company selects events strategically to engage relevant audiences. Xcel Energy promoted our EV service options at nearly ten public events since our last compliance filing. These included large-scale showcase events such as the Twin Cities Auto Show in Minneapolis in March 2019 and local community gatherings such as Edina Open Streets and White Bear Lake Marketfest in 2018. Xcel Energy also sponsored the first ever dedicated Electric Vehicle Test Drive at the Twin Cities Auto Show. Teaming up with the Company's industry partners, White Bear Lake Mitsubishi, Nissan, Midwest EVOLVE, and Carsoup.com, the Xcel Energy Electric Test Drive provided over 1,000 test drives to customers. Additionally, Xcel Energy participated in multiple meetings and workshops with local stakeholders such as Drive Electric Minnesota and Cities Charging Ahead.

2. *Digital Media*

The Company has developed a number of digital educational initiatives, including the creation of short animated videos to introduce the benefits of electric vehicle options. The 60-second videos can be found on YouTube[6]. We sought to drive engagement through search engine marketing and social media posts directing customers to the video and the Company's online resources for EV information. The EV Rate

[6] https://www.youtube.com/watch?v=4F1IrBTRvlw

webpage on the Company's website provides information about the EV charging rate, equipment installation guidelines, and provides an online enrollment option at: www.xcelenergy.com/EVElectricPricing.

Through our Xcel Energy ConnectBlog, the Company has provided timely, useful information to inform the public on EV-related issues. The blog provides digestible information in a familiar tone on topics including home and business energy solutions, clean energy, and more. In December 2018, the blog featured a discussion about the growth in EV model options and improvements in EV driving range, recapped the various charging options offered by the Company, and increases in public charging locations.[7] In September 2018, a post on the blog shared information to refute common myths about EVs.[8] The Company promotes EV content in the ConnectBlog through social media links. The Company also fields questions on EVs directly from customers through a dedicated email address, ElectricVehicles@xcelenergy.com.

3. EV Advisor Online Tool

New to Xcel Energy's communications portfolio as of January 2019, the Company's EV Advisor tool fosters awareness and education of electric vehicles by providing personalized recommendations for EV models and rate options that are a best fit.

The EV Advisor widget provides customers with recommendations, in the form of a score, about how well they match certain EV options. The recommendations will be based on answers provided by the customers to a series of lifestyle questions. Once the scores are calculated, customers will be able to view the details behind their scores in order to get a better understanding of why they are or are not a good candidate for EVs.

Additionally, the EV Advisor will include content to educate consumers on EVs, including information about:

- EVs available in the market;
- Environmental impact of EVs;
- Costs and benefits of EVs, including about fuel and maintenance costs;
- Available incentives for purchasing or driving an EV; and

[7] https://stories.xcelenergy.com/Clean%20Energy/Electric%20Vehicle%20Recap%202018:%20Paving%20the%20Road%20Ahead

[8] https://stories.xcelenergy.com/Clean%20Energy/Five%20Electric%20Car%20Myths%20Shattered

- Rate recommendations.

After answering the questions in the EV Advisor, this content will be personalized to the individual customer's situations.

Xcel Energy will continue to enhance this current online resource as it expands its service offerings with an easy customer experience. The EV Advisor can be found at: www.xcelenergy.com/EV.

4. Auto Dealer Outreach

Sellers of electric vehicles are a key information resource for consumers to learn not only about electric vehicles models, but also other aspects of the electric vehicle experience, including charging options, rates, and renewable offerings. In 2019, concurrent with the Twin Cities Auto Show, the Company partnered with Mitsubishi and Nissan dealerships in the Twin Cities area to offer special incentives on the purchase of EV and plug-in hybrid EV models to Xcel Energy customers. This special incentive was advertised at the auto show, through dealer websites, and by communications from sales personnel at the dealerships. As a result, we were able to leverage the dealers as an additional source of information to encourage EV purchases. This collaboration was the first of-its-kind for Mitsubishi, and our dealer partner White Bear Lake Mitsubishi sold 43 units of the plug-in hybrid Outlander as a part of this special incentive.

Xcel Energy is committed to maintaining strong relationships with dealers. Over the last year, the Company has met with and established a community of over 75 dealerships to create the Xcel Energy EV Trade Partner Network. Partnering and communicating with dealers is important to ensure that customers receive accurate information about charging options and electric costs, and will continue to be a key part of Xcel Energy's EV initiatives.

5. Electrician Trade Allies and Trainings

Working in parallel with our auto dealer outreach strategy, we hosted an on-site training for electricians who were interested in installing EV equipment and associated components. The training included information about the EV market, Xcel Energy rates and renewable programs, and specific metering standards and considerations. On a rolling basis, this training content is also available online to electricians who are interested in joining Xcel Energy's EV Trade Partner Network but were unable to

attend in person.[9] We have incorporated feedback from the electricians into customer communications and will continue to work with these allies to streamline our service offerings. Customers can now access the list of over 10 EV knowledgeable electricians on the portion of the Company's website dedicated to EV information.[10]

C. Renewable Program Participation

As of March 2019, 38 customers were enrolled in Windsource along with the EV Charging Rate. As of March 2019, no EV rate customers were enrolled in the Company's Renewable*Connect program.

D. Electric Vehicle Program Cost Tracker

Costs associated with EV Rate education and outreach activities are recorded to a tracker account that was established in 2015, of which $285,998 was attributed to the EV Tracker account between May 1, 2018 and April 30, 2019. These costs support the strategies described in the Development and Promotional Activities section above including sponsorship and participation in community events, digital media and videos, print materials, and other customer and industry communications.

Consistent with Minn. Stat. Section 216B.1614, subd. 2(2), the Company expanded the message of educational initiatives to include general EV information, as well as EV Rate specific information. Costs associated with this outreach were attributed to the EV Tracker. As EV adoption increases, the Company will continue to tailor messaging and educational efforts to provide relevant information about EVs through appropriate channels.

In compliance with Order Point 2 of the Commission's September 11, 2018 Order, Table 3 below provides our promotional education and outreach costs, broken down by major activities. In addition, we also separate general education and outreach costs from costs related to our Residential EV Service Pilot.

[9] https://www.xcelenergy.com/energy_portfolio/innovation/electric_vehicles/ev_trade_partner_resource_center
[10] https://www.xcelenergy.com/energy_portfolio/innovation/electric_vehicles/charging_your_electric_vehicle

Table 3
EV Tracker Balance Costs – May 1, 2018 – April 30, 2019

Public Events	$81,948
Digital Media	$17,842
EV Advisor Online Tool	$142,500
Collateral	$5,853
Trade Allies (Dealers and Electricians)	$34,500
EV Service Pilot Education	$3,355
Total	**$285,998**

Costs that are added to the tracker are currently being deferred for future rate recovery consideration.

II. Residential EV Service Pilot

The Company's Residential EV Service Pilot offers an opportunity for customers who own or lease an EV to save upfront costs that are normally required to take service under the EV Rate tariff. With EVSE that can provide billing quality data of on and off peak charging, customers are able to avoid the high cost of having a second meter on their premises. The pilot seeks opportunities for cost savings compared to the Company's current customer offerings and also seeks to improve the customer experience while maintaining safe and reliable electric service. This offering is a key feature of the Company's broader activities related to transportation electrification.

A. Customer Participation and Usage

As ordered by the Commission, participation in the Residential EV Service Pilot was capped at 100 customers. From the launch of the pilot in August 2018, interest in participation was strong with 81 applications submitted in the first two days. Enrollment ultimately was closed in February 2019 after we received over 160 applications for participation. 100 of those applicants were accepted and 99 are currently participating in the pilot. Table 4 below summarizes the number of participating customers and amount of energy usage, by month, since the pilot launch.

Table 4
Total Pilot Participation and Energy Usage

Date[11]	Customers	Monthly KWH Usage		
		On-Peak	Off-Peak	Total
Oct-18	12	23	2,134	2,157
Nov-18	40	249	13,213	13,462
Dec-18	54	542	19,129	19,671
Jan-19	87	1,989	39,193	41,182
Feb-19	87	1,772	33,599	35,371
Mar-19	97	1,785	38,850	40,635
Apr-19	97[12]	977	32,423	33,400
Total		7,337	178,541	185,878

B. Residential EV Service Pilot Cost Tracker

In connection with Pilot operations, we have added $3,355 in costs to the EV Cost Tracker authorized by the Commission. Of those costs, $2,455 are related to events and collateral, and $900 are for our dealer referral incentive.

C. Customer Cost Savings

1. Upfront Costs

One goal of the Residential EV Service Pilot is to study the program's effectiveness in reducing the upfront costs needed to participate in our EV Charging Rates. Our current EV Charging Tariff requires the installation of a second meter and service. The pilot does not, reducing the upfront costs of a second meter and second service installation.

At the time of charging equipment installation, the contracted electrician installers were asked to estimate the cost of premises wiring and other hardware that would be necessary to participate in the traditional separately-metered EV Charging Rate. To determine the upfront cost savings, these estimates were compared to the actual cost of installation[13] for the Residential EV Service Pilot. Data from the electrician

[11] Date represents billing month

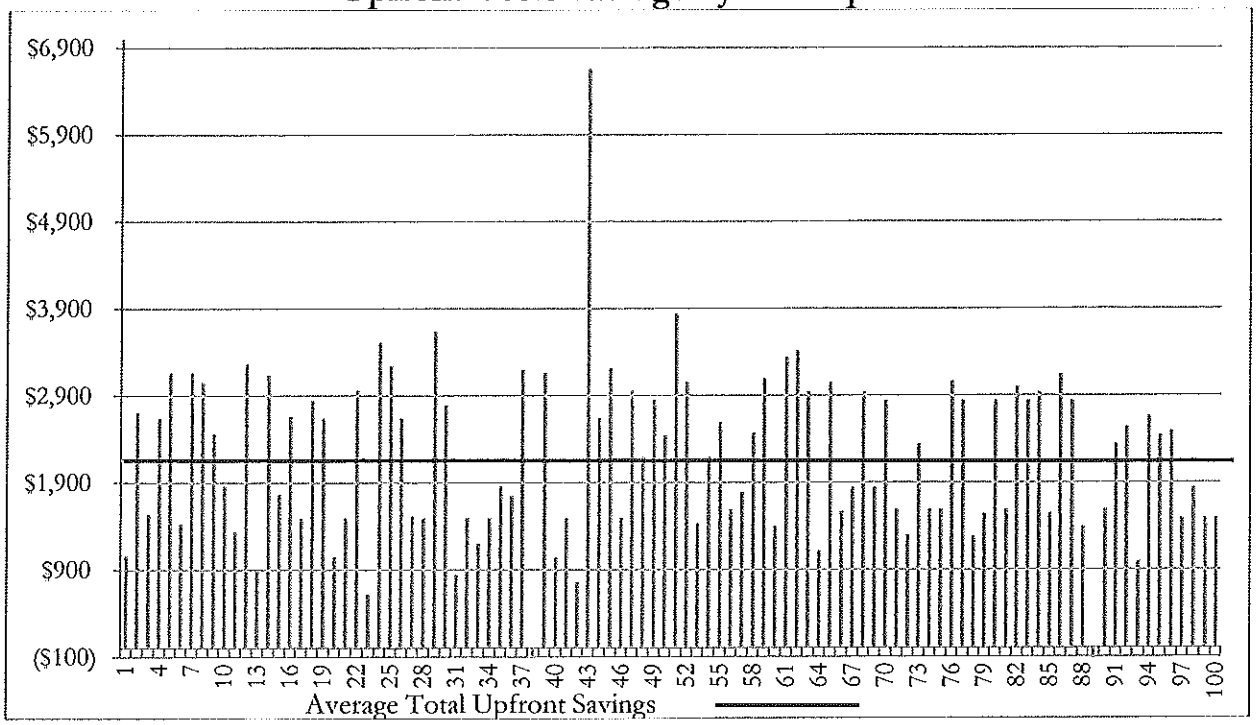
[12] Only 97 customers were invoiced in April 2019. Two customers did not have bills in April due to billing cycle timing and one customer left the program since they moved out of our service territory. Additionally, some customers joined the program prior to acquiring an EV, and therefore have had zero kWh usage for some months over the course of the pilot.

[13] Premises wiring, EVSE, and hardwiring

estimates for the separately metered EV Charging service and actual costs to install EVSE for the pilot were analyzed for each participant to understand what the typical costs are for a given installation scenario, and identify upfront cost savings provided by the pilot's delivery model.

Average upfront cost savings are displayed at a comprehensive level for all 100 pilot participants in Figure 1. Cost savings varied due to differences in installation scenario. Some major differences included availability of an existing 240 volt dedicated circuit needed to power the level 2 charger, installation in an attached or detached garage, and the general location of the nearest supply panel in comparison to the charging location. However, under each of these different types of scenarios, customers experienced upfront cost savings in aggregate.

Figure 1
Upfront Costs Savings by Participant



In all, the pilot saved participants $219,618 in upfront costs. The average savings per customer was $2,196. It is important to note the distribution in the upfront cost savings data. The upfront cost savings realized for each project is entirely determined on the participants' garage type (attached versus detached), panel location (basement versus garage), and circuit pathway (trenching, furnished or unfurnished walls).

Attachment C provides figures showing the average estimated installation costs for installations related to the standard EV Charging Rate and actual installation costs for

the pilot, broken down by scenario. These figures highlight the variability in customer costs savings based on specific installation parameters, but also that the Residential EV Service Pilot can provide significant upfront cost savings to customers.

a. Outlier Installation Experiences

There are a handful of atypical situations shown in Figure 1. One installation showed an estimated upfront cost savings of $6,664, over three times the average savings. This home did not have an existing dedicated circuit to the installation site and did not have a basement to run new conduit. The nearest supply panel to the installation site was 100 feet away from the attached garage on the opposite side of the house. These issues contributed to difficulty in setting up the home with a second meter for the standard EV Charging Rate. The contractor was able to retrofit an existing circuit pathway that allowed for installation of the EVSE equipment in a much simpler alignment and for much lower install costs than would have been incurred under the standard EV Charging Rate.

There also were two situations where installation of the EVSE for the Residential EV Service pilot appears to be slightly more expensive (around $200 each) than the installation of a second meter. Both scenarios were installations in detached garages, where the separately metered option was impractical but estimated to be a lower cost for electrical work on the customer's side of the meter. For instance, for one location, the nearest overhead utility service pole was over 300 feet away and across the street from the detached garage. Because of that distance, a new utility pole would most likely need to be dropped behind the garage. Although the customer's cost for electrical work on the customer's side of the meter would have been lower, this solution was impractical and would have resulted in significant expense on the utility's side of the meter. In these situations, the customer was comfortable with the expense and opted to participate in the pilot.[14]

2. Electric Rate Savings

The Residential EV Service Pilot tariff offers time-of-use charging rates for participating customers. As was shown in Table 4 above, approximately 96 percent of customers' charging occurred during off-peak times. Based on that usage profile, the Company expects customers to see a fair level of savings compared to what they would have been billed on the standard residential rate. Table 5 summarizes this

[14] In some cases, based on assessments by contracted installers, applicants were recommended to instead set up home charging via the EV Rate Service since the respective install costs were less than those identified for participating in the pilot.

savings expectation based the program-to-date level of off-peak charging and a wide range of monthly kWh usage levels. Based on the assumption of 350 kWh of usage per month and the current level of average off-peak charging, customers enrolled in the pilot would save $9.76 per month or $117.12 per year. Attachment D contains the calculation supporting this bill saving summary. The analysis in Table 5 excludes the upfront cost of the charger and installation to facilitate an apples-to-apples cost comparison of the tariffed pricing.

Table 5
Bill Savings of EV Charging on the EV Service Pilot Tariff

Monthly EV Usage Assumption (kWh)	150	275	350	425	500
Monthly Bill of EV Charging on the Standard Residential Tariff	$19.80	$36.31	$46.23	$56.14	$66.04
Monthly Bill of EV Charging on the EV Service Pilot Tariff	$19.70	$30.18	$36.47	$42.76	$49.06
Bill Savings per Month[15]	$0.10	$6.13	$9.76	$13.38	$16.98
Annual Savings Per Customer	$1.20	$73.56	$117.12	$160.56	$203.76

D. Customer Experience and Pilot Performance Lessons Learned

1. Customer Experience

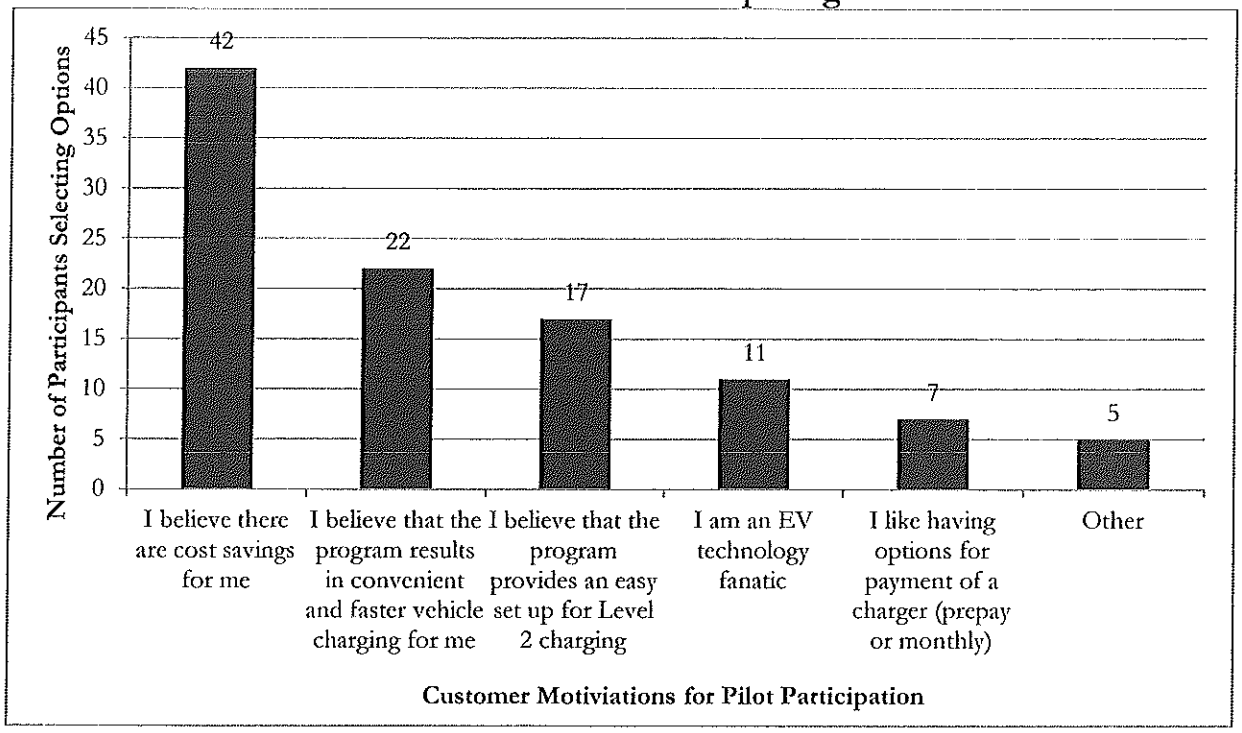
The Company solicited feedback concerning the pilot from customers via a post-installation survey. This allowed for the immediate collection of customer feedback when the experience was most top of mind for the participants. 63 of 100 Pilot participants responded to the survey. The post-installation survey measured customer satisfaction on a number of pilot elements, including education about the pilot, how the pilot works, and quality of equipment installation. The learnings will inform our customer communications on EV adoption, charging services, and rate options.

[15] Assumes monthly service charge for Pre-Pay option. This represents costs that all customers pay. Bundled option additional cost is for installation and EVSE equipment.

a. Customer motivations for Pilot enrollment

As shown in Figure 2 below, our survey results revealed that customers participating in the Residential EV Service Pilot were motivated by the costs savings they hoped to realize, along with the opportunity for faster, more convenient charging.

Figure 2
Customer Motivations for Participating in the Pilot

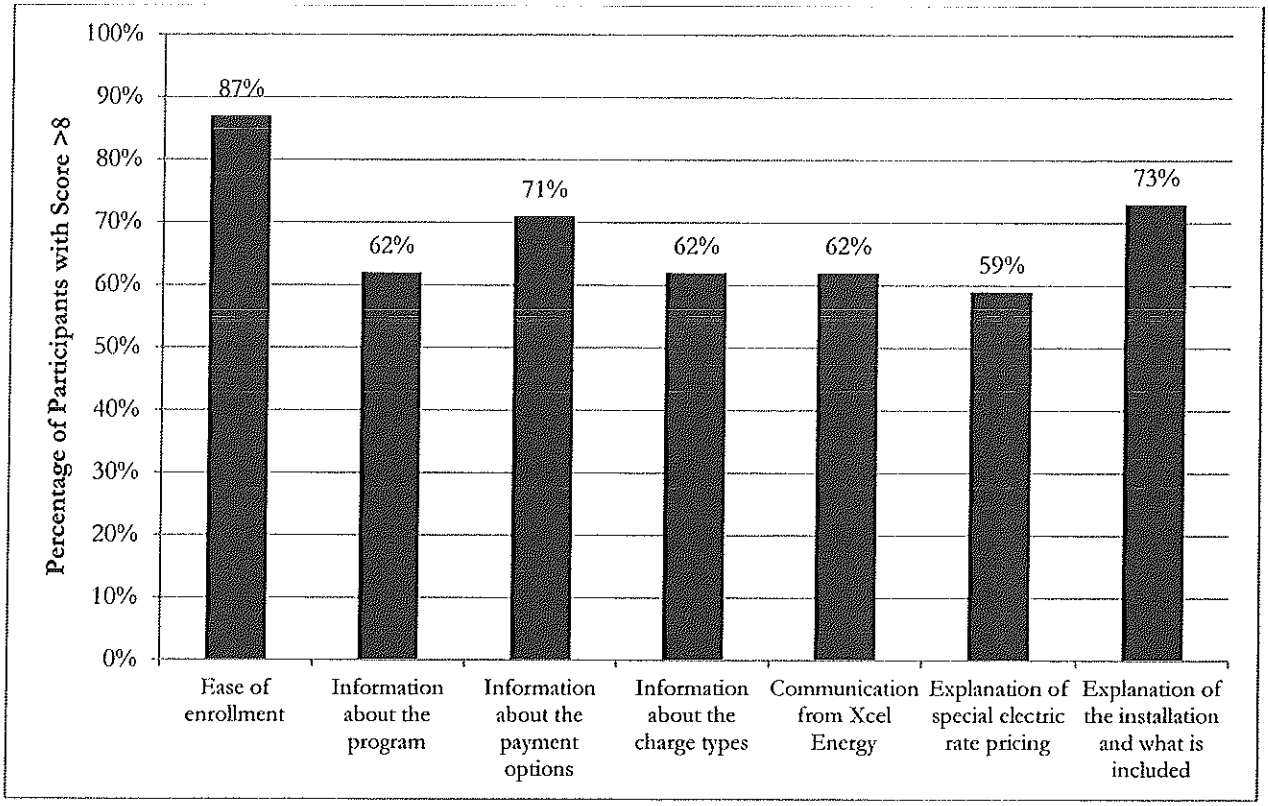


b. Online Enrollment Experience

Figure 3 below shows satisfaction scores related to online enrollment.[16] The overall "Ease of enrollment" was well received with a satisfaction score of 87 percent. Although all elements of the online enrollment experience received positive scores overall, the scores for certain aspects, including "Explanation of special electric rate pricing," "Communication from Xcel Energy," and "Information about the charger types," reveal opportunities for improvement. These scores and related comments show that some customers were confused by the TOU rate prices, charger types, and had a desire for more communication from Xcel Energy.

[16] Satisfaction score represents the percentage of customers who rated a factor as an eight or higher on a scale from one to ten.

Figure 3
Satisfaction with Online Enrollment

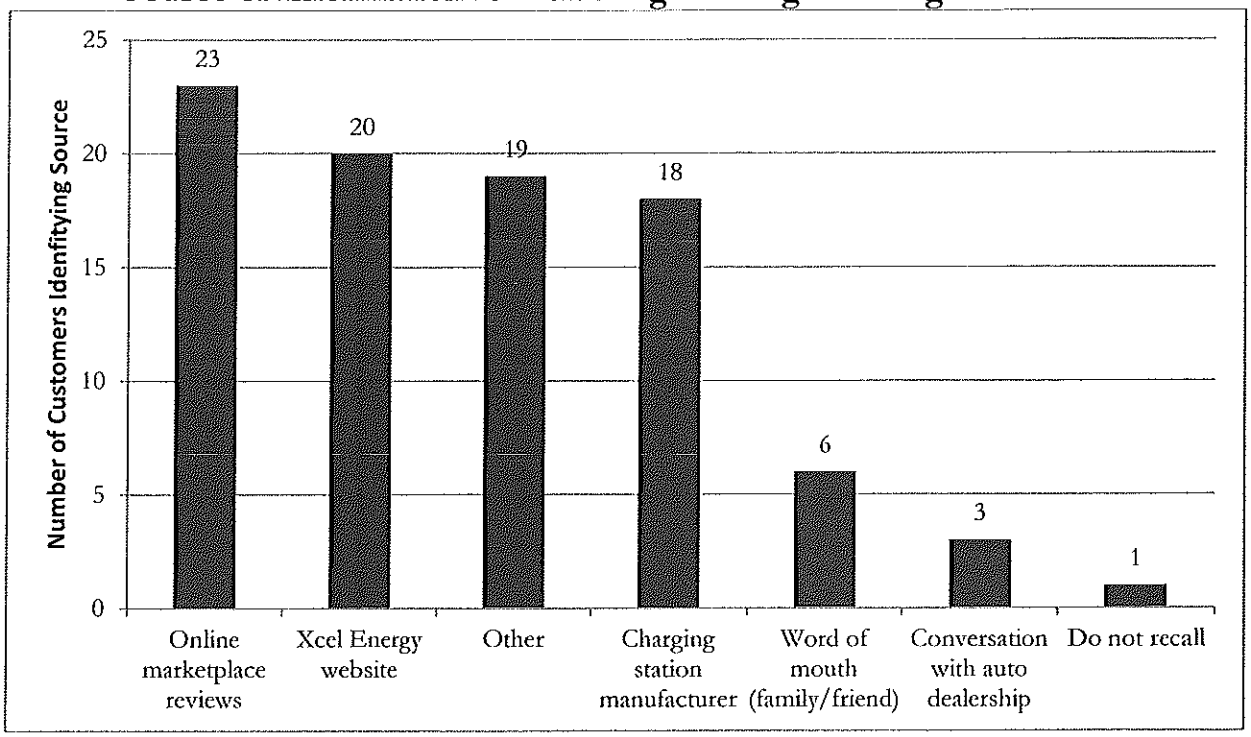


For example, "Explanation of special electric rate pricing" with only a 59 percent satisfaction score is one of the more notable improvement areas for future EV services. This element of the pilot was a focal point in correspondence with customers. Our general summary of direct customer feedback through the surveys and follow-up phone and email conversations is that participants understood and recognized the pricing signal, in that charging their electric vehicle during off-peak hours is cheaper and provides benefit. However, confusion surrounded how the pricing works, components of the rate and on-bill presentation, as well as what could be expected for fuel savings and an overall payback timeframe.

Some participants developed their own calculations and assumptions for their electric fueling scenario and rate participation, and sought accuracy confirmation from the Company. Based on this experience, we believe that pilot participants as a group likely have an interest in understanding more details on the costs and benefits of the Company's various rates. Moving forward from the pilot to a full scale offering, and as the industry builds a deeper understanding of EV charging behavior, the Company plans to leverage digital tools and more comprehensive energy consumption data in order to provide customers with better data regarding the possible benefits they could realize through different Company offerings and rates.

In selecting their charging stations, pilot participants sought information from various sources, including online market place reviews and Xcel Energy's pilot website. The sources of information customers used to select charging equipment are shown in Figure 4 below.

Figure 4
Source of Information for Selecting a Charger during Enrollment

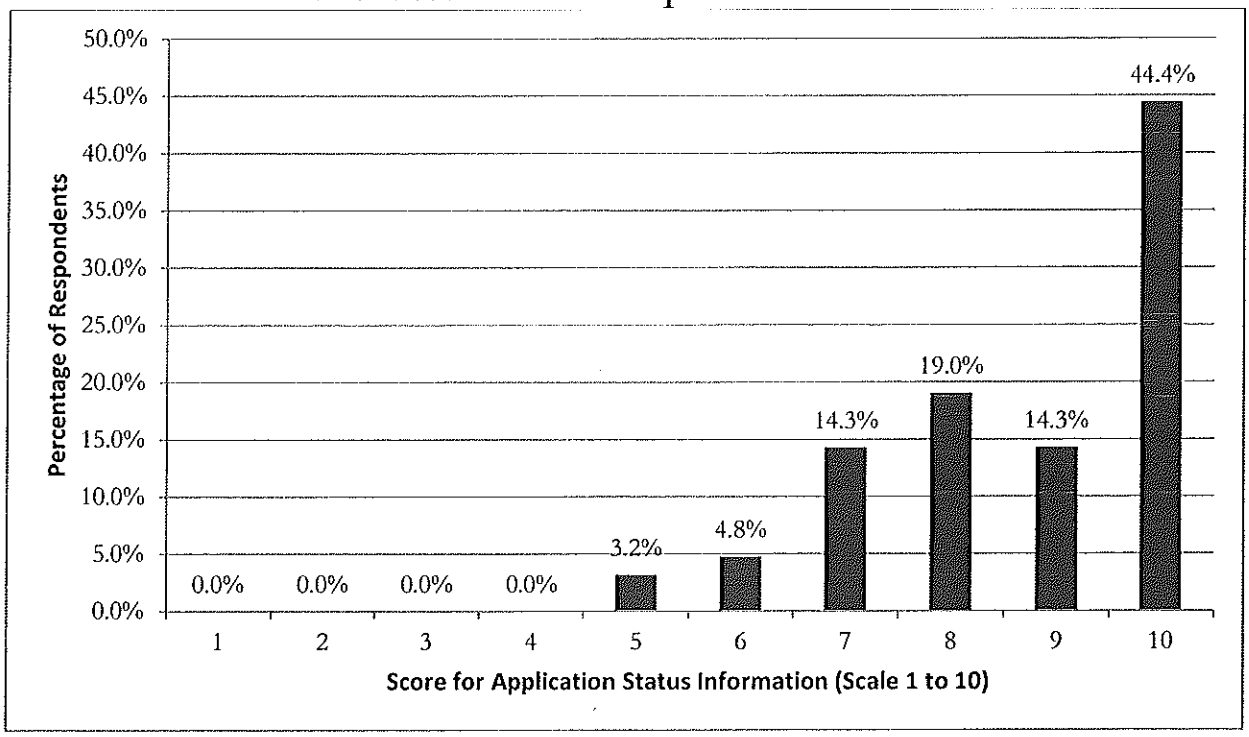


Finally, we are continuing to work on improving the experience for our customers who are exploring acquiring an EV. For example, the Company has deployed an EV Advisor tool that helps customers understand their EV and rate options available to them. The findings and data collected in this pilot will be layered into the tool to better educate customers about charging in the home, rate options and benefits, to provide them with accurate information that informs their choices.

c. Participation and Installation Timeline Experience

Participants received an application status notification after their enrollment was accepted. 78 percent of respondents gave a score eight or higher on a scale from one to ten that the information they received about their application status met their expectations. The overall results of this score are shown in Figure 5 below.

Figure 5
Timeliness of Pilot Acceptance Notification



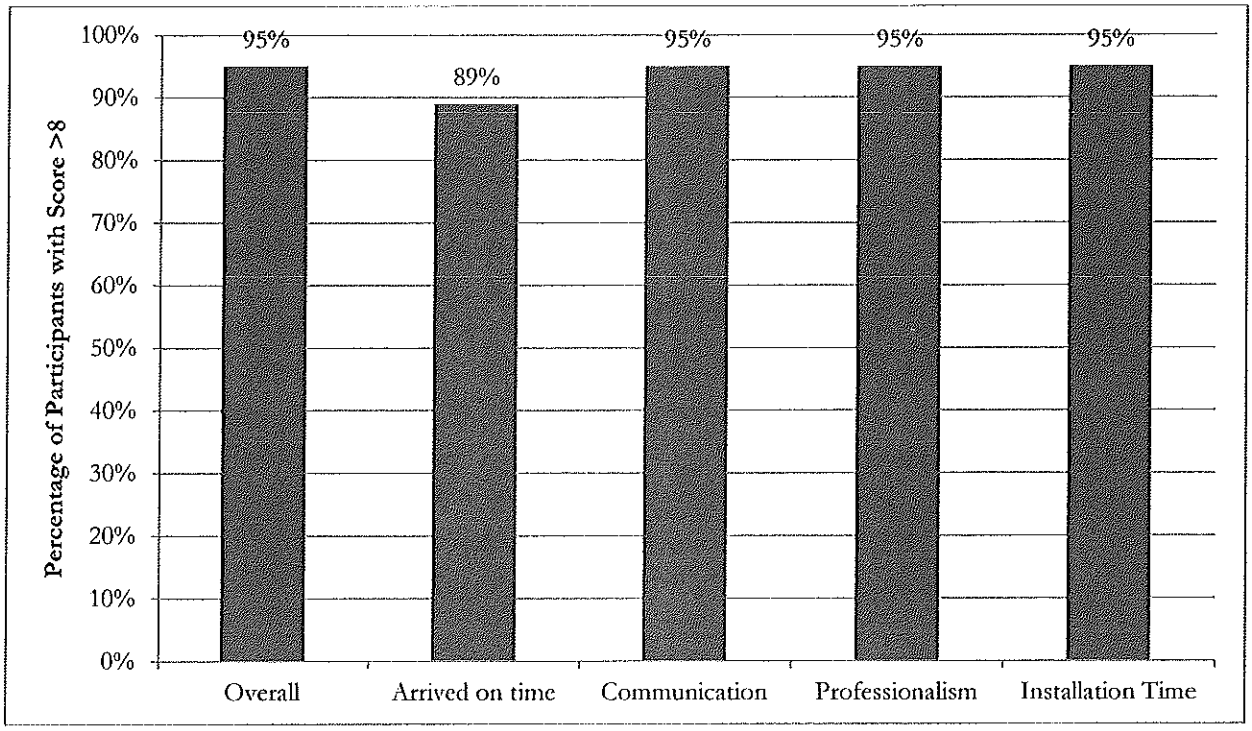
Throughout the six-month enrollment period, we received 164 online applications, and ultimately enrolled 100 customers in the pilot. Although the pilot was limited to 100 participants, we accepted more than 100 applications because some applicants withdrew before having any EVSE installed. Of the 64 applicants who withdrew their applications, 19 did so based on advice from the installers that the existing EV Rate Service was a better economic option for them. The other applicants who withdrew did so for a variety of reasons, including because they (1) already had and were using a level 2 charger, (2) decided their EV charging behavior did not warrant faster charging with a level 2 charger, (3) perceived program costs as being too high, (4) were ineligible,[17] and (5) simply did not respond to the installer. 99 of the 100 customers who were initially enrolled in the pilot are still participating at this time. The one customer who no longer is enrolled moved out of our service territory and was removed from the pilot at that time. In this case, the Company was able to efficiently work with the customer to uninstall the equipment and return it to the Company's possession.

[17] Reasons for a customer ineligibility included having participating in net-metering programs, residing in mutli-family housing, and not having an EV.

In regards to time of enrollment to time of install, we note that the Company was able to decrease the average number of days from enrollment to installation of equipment by 33 days, and the last wave of installs occurred on average within 23 days of enrollment. This was due primarily to a clearing of the backlog from the first two days of pilot launch. In addition, we were able to solve firmware issues that caused some early delays in completing installations in the first wave.

The two installers used by the Company for the pilot both received high satisfaction scores from respondents. Customer satisfaction scores related to installation are shown in Figure 6 below. As the Company continues to administer this pilot and bring forward future EV programs, the Company intends to continually measure and improve customer satisfaction by working closely with industry partners and contractors.

Figure 6
Installation Satisfaction Scores



d. Operational challenges

In connection with our assessment of pilot operations, we discovered that a particular electric car model was not compliant with standard electrical connector standards for electric vehicles in North America, and occasionally the vehicle would charge less than expected after being plugged in for a full night. The Company worked with charging equipment vendors to develop a workaround to this issue. Affected customers

disengaged the TOU schedule from the charging equipment's mobile application and, instead, scheduled their charging through their vehicle's interface. This workaround has resolved the issue by bypassing a possible communication gap between the charging equipment and vehicle. All participants who may be impacted have been informed of this issue and the workaround.

2. Safety and Reliability

The Company conducted a request for proposal (RFP) process for charging equipment that met detailed technical requirements necessary for maintaining safety, reliability, and billing accuracy. Both vendors selected through the RFP process were able to demonstrate documentation that their products were certified by UL, LLC, a global safety certification company. This listing is an industry standard that indicates charging equipment has met specific and defined requirements of UL's published and nationally recognized safety standards. The vendors also implemented controls that prevent energy consumption data tampering, ensuring proper data security and safety. Prior to pilot launch, they both successfully integrated into a secure data transfer process that enabled 15-minute interval energy usage data to be securely exchanged from the vendor's server to the Company's billing system. Currently, once data files from the charging vendors are received by the Company, they are manually uploaded into the billing system. As we move from pilot to scale, this process will be automated and simplified in order to achieve efficient program administration.

All of the charging equipment deployed through the pilot was installed by the program's contract installers who complied with industry best practices and National Electric Code Standards. For installations that required premises wiring with the installation of a new 240 volt circuit, contract installers received permits when required by local building codes.

The pilot relied on participant Wi-Fi networks for billing purposes. Upon installation, charging equipment was set up and connected to the premises' Wi-Fi by the contract installers. Using customer Wi-Fi for billing purposes continues to appear to be a reasonable option going forward. Only one customer had any notable difficulty, and ultimately we were able to resolve that issue. That participant's Wi-Fi network had a firewall enabled that blocked the equipment vendor's application from successfully obtaining energy usage data for billing purposes. The equipment vendor's customer support was able to troubleshoot with the participant to resolve the issue so that accurate billing data can be exchanged.

Additionally, on some occasions, low Wi-Fi strength at the charging location made it difficult for contract installers to connect the equipment to the network, resulting in

longer installation times. Moving forward, the Company will explore ways in which Wi-Fi strength can be measured on-site during installation, as well as work with the equipment vendors to proactively report on Wi-Fi readings to alleviate potential issues that impact participation or inhibit program benefits.

In the event that the charging equipment is not connected to Wi-Fi or transmitting energy usage data, both equipment vendors did commit to enabling their devices with capacity for 90 days of data storage. This minimum requirement is currently being confirmed through on-site product testing in the Company's facilities. Results of this testing will be conveyed at a later time.

3. Billing Accuracy

Through on-site product testing, both vendors' charging equipment met the requirement for metering data at an accuracy of plus or minus two percent, a standard that is enforced by the Commission for traditional metering technology.

Although the data provided by the charging equipment is sufficiently accurate, formatting the data so that it can be received by the Company and successfully uploaded to the billing system required significant collaboration between the Company and vendors. In some situations these issues initially resulted in delayed billing. The issues were generally resolved in less than three weeks from when they were identified.

The pilot also uncovered charging equipment firmware issues that required remediation and impacted the Company's ability to retrieve energy usage data for billing purposes. These firmware issues also resulted in billing delays and either slight over or undercharging of customers since the issue inhibited accurate time-stamped energy usage data transmittance. We encountered this firmware issue in late October and early November 2018. It was remediated by the vendor in February 2019 with a firmware update over-the-air. We were able to recover the data from this period and we are in process crediting customer accounts accordingly. For the 23 customers impacted, this equates to nearly $114 in bill adjustments in total.

Moving forward, the Company will identify pathways to better assimilate data formatting so that procedures are consistent and robust to ensure accurate and timely billing for EV programs at scale. In the near-term, we can begin scaling with our existing architecture as we have now successfully integrated with these two vendors and have been able to deal with the handful of issues that have arisen. However, as participation increases to 1,000+ units, and as we add equipment options, we will need more automation, resources, and most likely a different solution. We also expect

that when we identify a solution that enables easier upfront integration with the needs listed above, we will be able to bring in additional vendors and partners that can bring additional choice to customers.

4. EVSE Equipment Choice

The selected charging equipment vendors for the pilot are ChargePoint and eMotorWerks. Initially, the Company purchased 50 home charging devices from each vendor, totaling 100 units. Customers were able to choose their preferred vendor as long as we still had units available. Customers chose the units from each vendor at roughly the same rate, so we did not notice a strong preference for one type of equipment over the other.

5. Effectiveness of Car-Dealer Incentives

The Company partnered with four dealerships to refer new EV buyers to the pilot program. These dealerships agreed to and signed the referral incentive program agreement, and their sales personnel underwent pilot-specific training in order to properly describe the program to their customers at the point-of-sale.[18]

Overall, the point-of-sale experience was successful, and twelve participants were referred to the pilot during their EV purchase by dealerships. One dealership in particular demonstrated notable success accounting for two-thirds of the total referrals.

Three of the twelve referrals came from dealers who were not participating in the incentive program. These dealers were a part of the Company's EV Trade Partner Network. This experience suggests that dealers support this customer solution and the Company's EV services, and that the Company's efforts to train dealer sales personnel about electric transportation and utility EV programs are valuable to customers.

The Company plans to enhance this element of the customer experience by bringing additional advisory services to dealers, including tools that can help customers calculate their savings from driving electric and choose the EV option that is right for

[18] During the sales process, dealerships referred customers to the pilot and filled out an EV Service Pilot Information Form. The dealerships made copies of these forms and sent them to the Company for documentation. Upon enrolling in the pilot, customers were asked if a dealership referred them, and if so, they were instructed to specify which dealership. This customer entry confirmed the referral. If a referred customer participated in the pilot with a charger install, the dealership received a $100 incentive.

their needs. We will also continue to forge new industry alliances while expanding existing relationships. Through the pilot and other experiences we will continue to measure and assess the viability of dealer incentives.

E. Bundled Option Statistics

Generally, participants in the EV Service Pilot preferred to pay for the charging equipment and installation through a bundled monthly charge instead of the pre-payment option. 73 participants chose to pay for the equipment through the bundled monthly charge. Although a limited sample, this data indicates that customers prefer a bundled approach for their EV services that reduces upfront cost barriers and simplifies participation. Moving forward, the Company plans to incorporate this feedback into its pilot and program designs and experiment with subscription and bundled payment models to align with our customers' preferences.

To date, the Company has incurred $77,119[19] in costs related to operating the pilot for customers who chose the bundled option. Table 6 below shows costs broken down by capital, operations and maintenance (O&M) costs, marketing and communication costs, and research and development (R&D) costs. The marketing and communications costs will be added to the EV Tracker Account.

Table 6
Bundled Option Costs

Capital Costs	$67,529
O&M Costs	$5,425
Marketing and Communications	$2,449
R&D Costs[20]	$1,716
Total Costs	**$77,119**

During pilot operations, the Company brought in $6,010 in revenues from the monthly service charge from customers who chose the bundled option. In addition, we brought in $6,787 in revenues from energy usage charges.

F. Pre-Pay Option Statistics

As noted above, customers preferred the bundled option to pay for the EVSE over the pre-pay option. Only 27 customers chose to pre-pay for the EVSE at installation.

[19] To arrive at the split costs between the Bundled and Pre-pay options, the total costs were multiplied by the percentage of customers who participated in each option.
[20] Includes costs for equipment testing and installer training

To date, the Company has incurred $28,523 in costs related to operating the pilot for customers who chose the bundled option. Table 7 below shows costs broken down by capital, O&M costs, marketing and communication costs, and R&D costs. The marketing and communications costs will be added to the EV Tracker Account.

Table 7
Pre-Pay Option Costs

Capital Costs[21]	$24,977
O&M Costs	$2,006
Marketing and Communications	$906
R&D Costs	$635
Total Costs	**$28,523**

In addition to the pre-payment for installed charging equipment, during pilot operations, the Company brought in $951 in revenues from the monthly service charge from customers who chose the pre-pay option. In addition, we brought in $2,232 in revenues from energy usage charges.

G. Plan to Transition from Pilot to Permanent Offering

In the May 9, 2018 Order approving our Residential EV Service Pilot, the Commission ordered the Company to include in this Annual Report a plan to transition the pilot to a permanent offering.

Based on the results of the pilot to date and the learnings discussed in this report, the Company is in position to bring an expanded Residential EV Service offering forward. We intend to bring forward a proposal to expand our Residential EV Service to more customers in summer 2019.

III. Cost Recovery Mechanisms

Order Point 12 of the Commission's February 1, 2019 Order in Docket No. 17-879 requires the Company to file an EV promotional cost recovery mechanism consistent with Minn. Stat. § 216B.1614, subd. 2(c)(2). The Statute states that the Commission may approve EV tariff as long as the tariff includes a mechanism to allow the recovery of costs, including,

[21] Capital costs included here as they were initially incurred by the Company. Customers under pre-pay option have paid for all applicable capital costs at their enrollment and the Company will not include any of these capital costs in rate base.

costs to inform and educate customers about the financial, energy conservation, and environmental benefits of electric vehicles and to publicly advertise and promote participation in the customer-optional tariff.

The Company's approved Residential EV Service tariff notes that these costs are being deferred in a tracker account, but we have yet to present a recovery mechanism for these costs.

In the February 1, 2019 Order, the Commission acknowledged that the Statute allows for utilities to recover the cost of education efforts beyond just encouraging enrollment in an EV tariff. The Commission also stated that utilities are "uniquely situated" to provide education to the public about EV adoption benefits.[22]

In light of the important role the Commission sees utilities playing in educating the public, the Company intends to seek recovery of our EV promotional costs in our next general electric rate case.

CONCLUSION

We respectfully request the Commission accept this 2019 Annual Report in compliance with its June 22, 2015, October 26, 2017, and September 11, 2018 Orders in this Docket.

Dated: May 31, 2019

Northern States Power Company

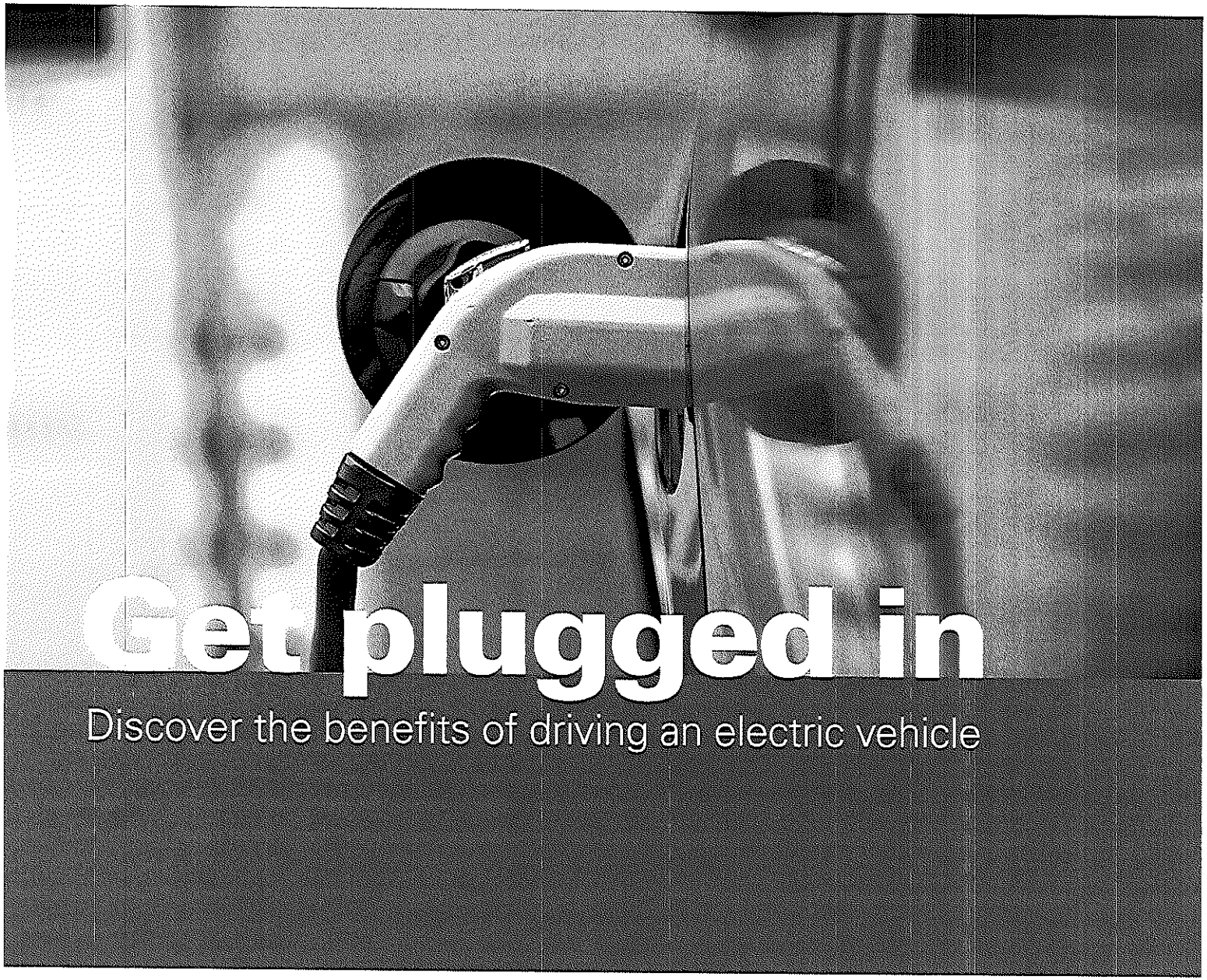
[22] See Page 6 of the Order

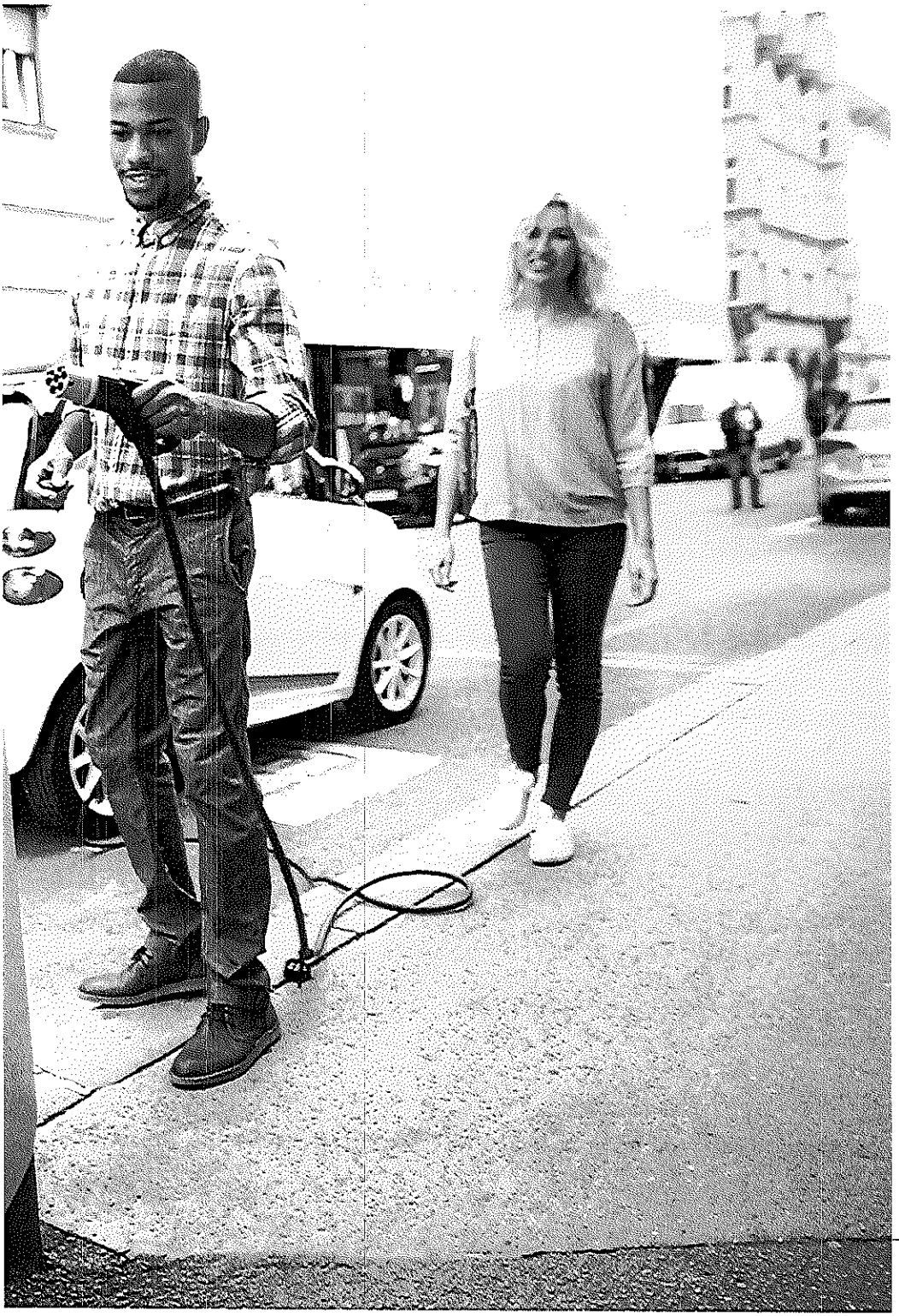
Docket No.	Order Date	Order Point Requirement	Reference in Annual Report
15-111	June 22, 2015	Annually, by June 1st, each utility must file an Electric Vehicle Tariff Report in its electric vehicle tariff docket. Each utility must include, on a per-quarter basis and in addition to the information required by Minn. Stat. § 216B.1614, subd. 3(1) and (2), the following information in its reports: a. The amount of energy sold in on- and off-peak periods, if applicable; b. A brief description of all development and promotional activities and their costs; c. The number of customers choosing the renewable-source option; d. The status of the communications costs tracker account, if applicable; e. Copies of any EV promotional materials distributed to customers.	Subd.3 (1) – Customers on Tariff & Electricity Sold on Tariff – Tables 1 and 2 a: Table 1 b: Activities – Section I.B Costs – Section I.D c: Section I.C d: Section I.D e: Attachment C
15-111	October 26, 2017	Xcel shall file in next year's annual report a compliance report with correction of data anomalies within 30 days and an assessment of current and forecasted EV penetration in Xcel's service territory, including an analysis of current and forecasted tariffs in use and charging practices.	Filed with 2018 Annual Report – Submitted June 1, 2019
15-111	September 11, 2018	2. Required the utilities, in subsequent reports, to provide a breakdown of costs by educational and outreach initiatives, including, where possible, a separation of costs used to promote the off peak charging tariff versus EV adoption in general.	Attachment B
17-817	May 9, 2018	8. Beginning in 2019, Xcel shall file, by June 1, an annual report on the pilot, including at a minimum: a. the number of participating customers and amount of electricity sold in the program, reported on a monthly basis; b. tracker balances; c. analyses of customer cost savings; d. lessons learned regarding customer experience and pilot performance under Xcel's safety and reliability standards; e. the number of customers choosing the bundled option; f. the costs and revenues associated with the bundled option; g. the number of customers choosing the pre-pay option; h. the costs and revenues associated with the pre-pay option;	 8a. Section II.A 8b. Section II.B 8c. Section II.C, Attachment D 8d. Sections II.D.1 and II.D.2 8e. Section II.E 8f. Section II.E 8g. Section II.F 8h. Section II.F

Docket No.	Order Date	Order Point Requirement	Reference in Annual Report
		i. the types of EVSE equipment that are chosen by the participants; j. the contractors' estimated second-meter installation costs; k. the extent to which wireless connections impacted pilot participation; l. how often wireless connectivity issues prevented billing under the pilot; and m. analysis of the effectiveness of car-dealer incentives. 9. Xcel shall, in its June 1, 2019 annual report, include a plan to transition the pilot into a permanent program.	8i. Section II.D.4 8j. Section II.C 8k. Section II.D.2 8l. Section II.D.2 8m. Section II.D.5 9. Section II.G
17-879	February 1, 2019	12. Minnesota Power, Otter Tail Power, and Xcel Energy shall file EV promotional cost recovery mechanisms consistent with Minn. Stat. § 216B.1614, subd. 2(c)(2), and the Commission's above Findings in this docket, as part of their annual EV reports filed June 1, 2019.	Section III

Ex. AA-D-41

Xcel Energy®





More than a new wa
a better way to drive

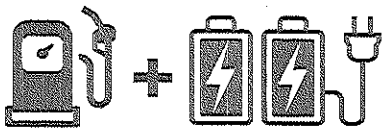
With the growth of clean energy, the fu
becoming a reality in your home, at bus
Fueling your car with electricity can be
Xcel Energy supports your electric vehi
pricing and renewable energy options.

You're in the driver's seat, and we want
information you need to drive electric.

t's right for you

e two main categories of plug-in electric
electric vehicles (PHEVs) or all-electric
battery electric vehicles (BEVs).

In EVs



Plug-in Hybrid EV

A plug-in hybrid can operate on electric battery power as well as on gasoline. When the battery depletes, the gas-powered engine turns on.

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to drive electric

ons keep growing

acturers making more EV and hybrid models, you have a wider hich helps create more competitive pricing.

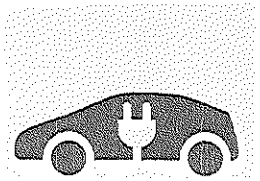
ing options are increasing in retail locations, town centers and ridors.

vill tell you they are smooth shifting, quiet and offer an invigorating rience.

reak for our environment

car with electricity can reduce emissions to about one-third of l vehicles.*

dd renewable energy or enroll in one of Xcel Energy's renewable rams, you can drive with 100-percent clean energy.



All electric vehicles on U.S. grid

Conventional car

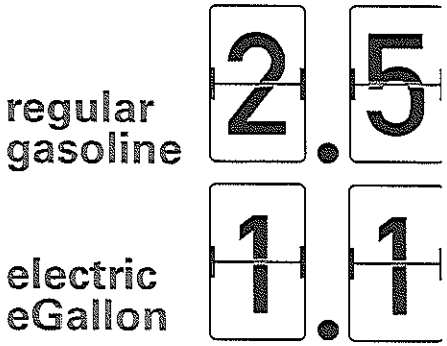
ergy.gov/afdc/vehicles/electric_emissions.php.

3

Cost savings that add up

- Federal tax credits, local vehicle inc of used vehicles help make EVs mc
- Reduced maintenance costs for EV changes, tune-ups and other stand
- With our low, off-peak prices, drivin about $1 per gallon of gasoline.

Compare costs



Department of Energy www.energy.gov/eGallon
The eGallon price is calculated using the most recen prices. The state gasoline price above is either the st regional average price reported by EIA.

EV, there are
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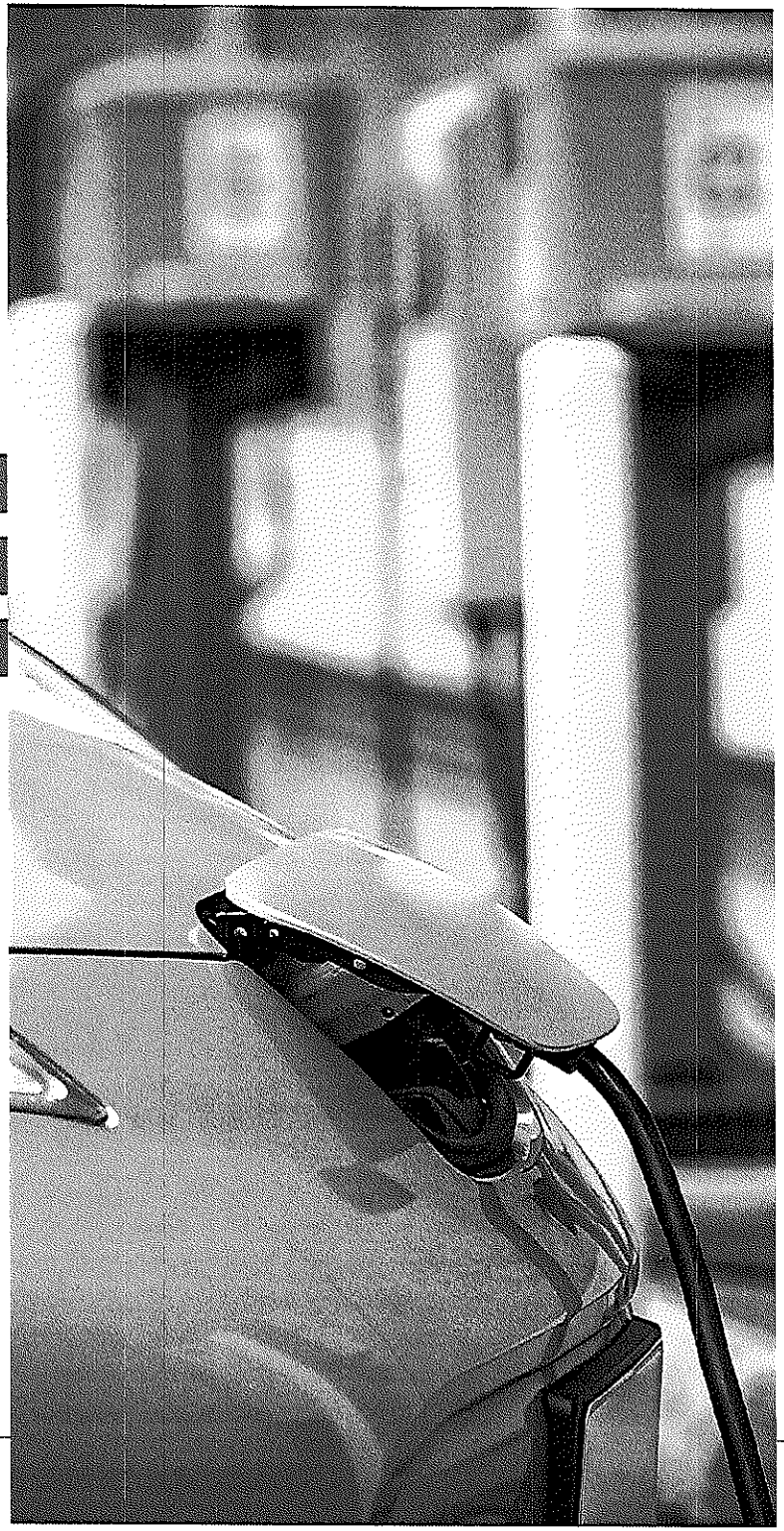
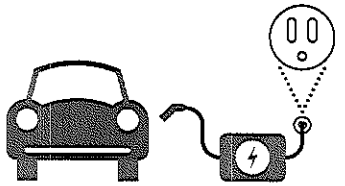
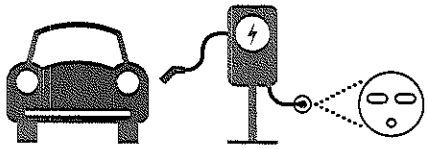


Getting charged up

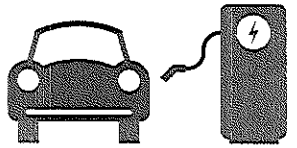
For charging at home, Level 1 and 2 cha
options that offer various charging spee
lifestyle and vehicle type. Level 3 fast c
used for public charging, which are com
city center locations.



Level 1 Char
- 120-volt cor
- Dedicated c
- Can provide
charging ov

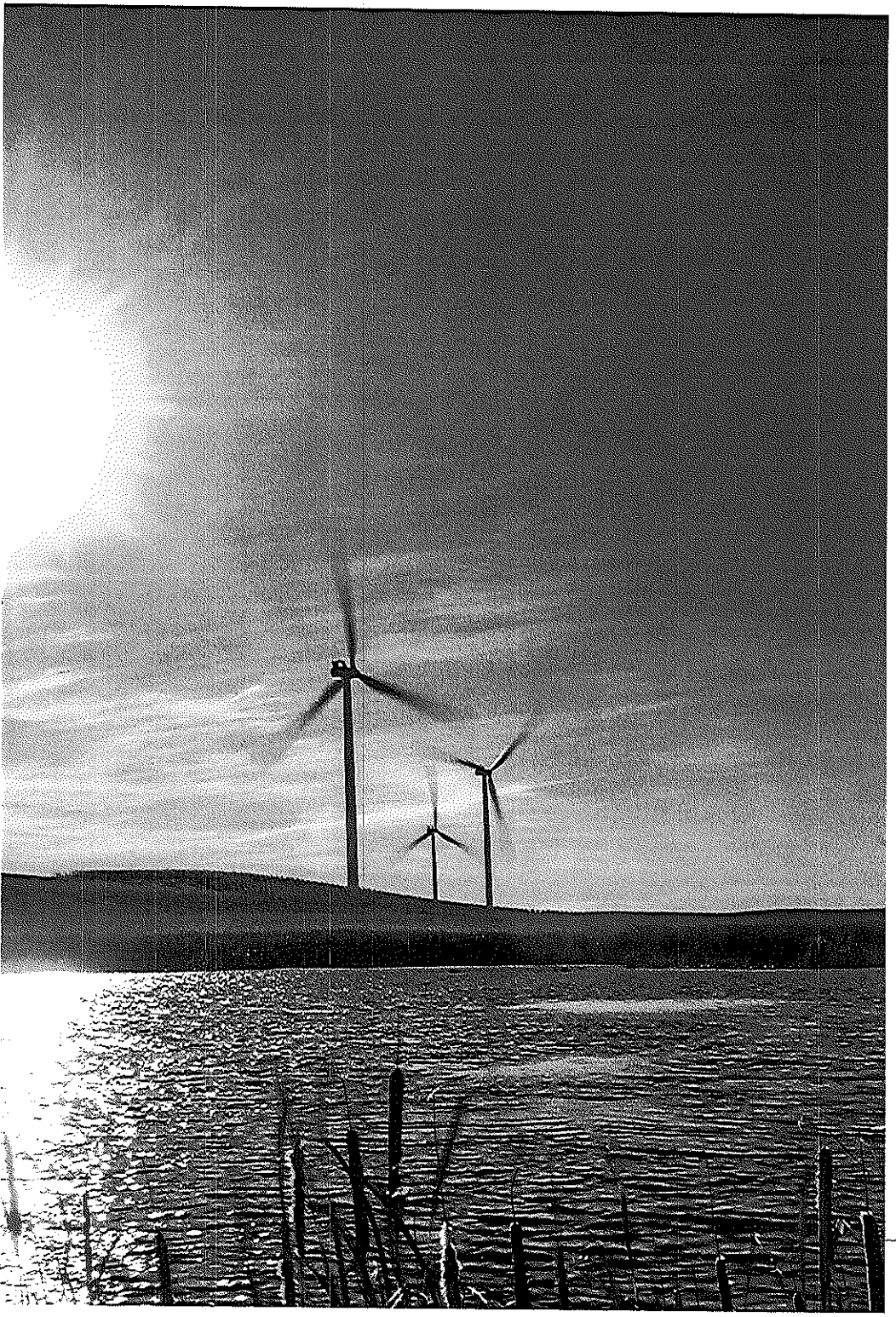


Level 2 Char
- Requires 2(
- An electrici
wiring for a
service pan
- Can provide
hour of cha



Level 3 DC F
- Typically use
- Not for plug
electric veh
- Typically rec
- Can provide
10 minutes

Range depends
and other facto



Fuel up with clean e

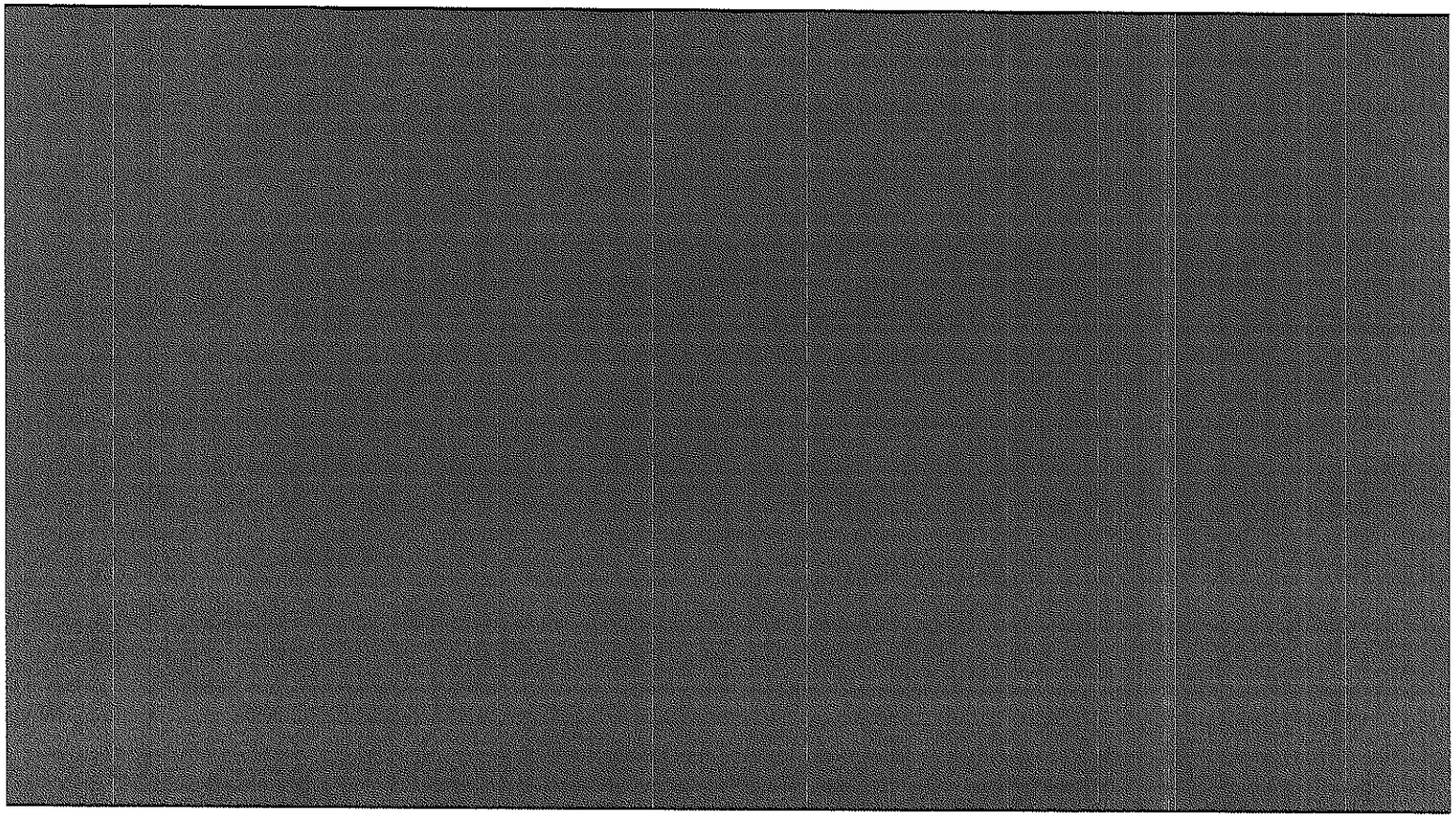
Currently, more than a quarter of the e
renewable sources. If you're interested
driving, an easy way to feel good about
with clean wind energy through our Wi

Windsource subscriptions are available

We're here to help

Our energy advisors can answer questi
pricing plan and charger installation opt

Visit **xcelenergy.com/EV** for more on E
ways to get started. If you would like to
pricing or installation, call **800.895.499**
ElectricVehicles@xcelenergy.com.



Xcel Energy®

RESPONSIBLE BY NATURE®

Ex. AA-D-41

Xcel Energy®

Electric Pricing Options
for EV Drivers

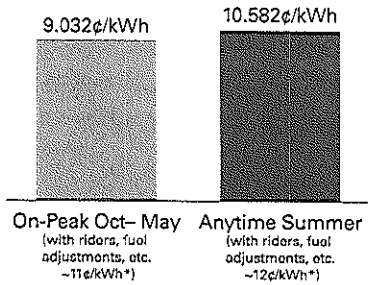
MN

Xcel Energy's affordable electric prices provide a significant savings opportunity compared to gasoline for our electric vehicle (EV) customers. We offer three different plans, providing flexibility to charge at a time and price that's convenient for you.

Standard Residential Pricing

Provides flexibility to charge anytime with the same price during the day and at night.

- One meter for home and vehicle electric use



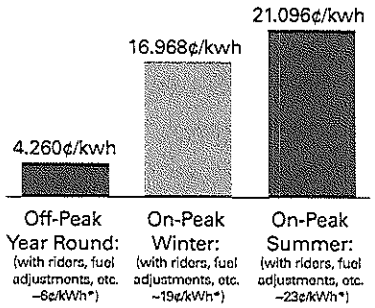
*Prices are subject to resource and/or fuel adjustments, city fees and taxes where applicable. Plans may change upon PUC approval.

For more information, visit xcelenergy.com/EV

Time of Day Pricing

Your off-peak plan (between 9 p.m. and 9 a.m. daily, plus holidays and weekends) is less than half of the standard residential prices, which is great for charging at night.

- One meter for home and vehicle electric use
- Monthly charge: $2 premium over standard plans

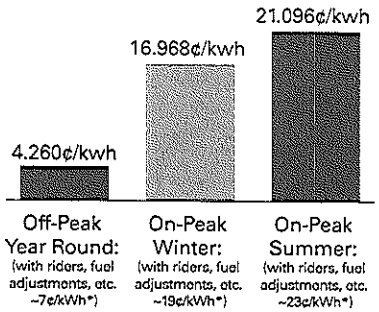


Trial period: three months — If you're not satisfied, we'll recalculate your bill at the standard pricing. There is a $20 charge to remove the off-peak meter if you cancel.

EV Pricing Plan

If you can charge your vehicle after 9 p.m., but can't shift your home energy to the evening hours, this is a great plan for saving on your driving costs.

- Two meters: one for home and one for vehicle electric use
- Monthly charge: $4.95, plus the home service charges



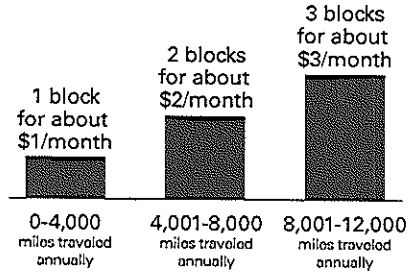
Customer must hire a licensed electrician to install a meter socket — and potentially an additional breaker — to connect appliances to the off-peak meter.

Ex. AA-D-41

Power your EV with renewable energy! Windsource® for EVs*

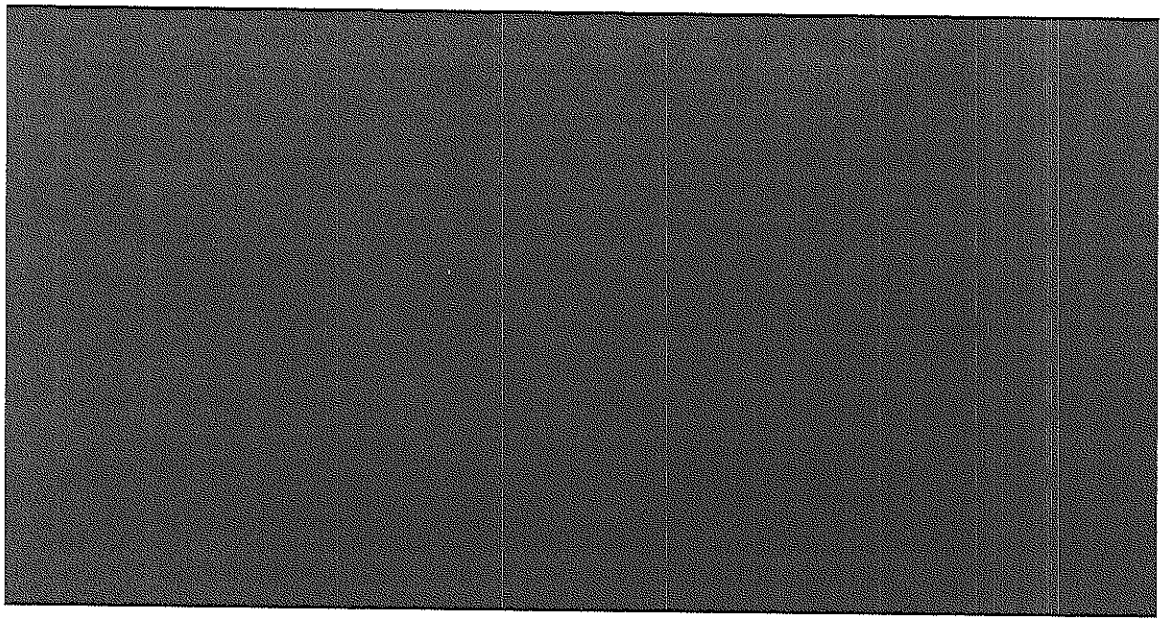
Take your environmentally-friendly vehicle to the next level and support renewable energy by purchasing Windsource to power it.

- When you do, you're supporting:
  - Lower vehicle fuel and operating costs
  - Air quality and environmental improvements because EVs produce lower greenhouse gas and tailpipe emissions
  - Affordable and domestic renewable energy production that promotes electricity price stability



*Windsource is sold in block of 100 kWh. The cost per block is $3.53/month, less a credit for fuel costs. In 2017, the average fuel cost credit for a residential customer was $2.53, making the net charge for Windsource $1.00 per block. For more information visit xcelenergy.com/Windsource.

Ex. AA-D-41



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RESPONSIBLE BY NATURE®

Xcel Energy®

Electric Vehicle Pricing Plan

Contractor Set-Up Guide

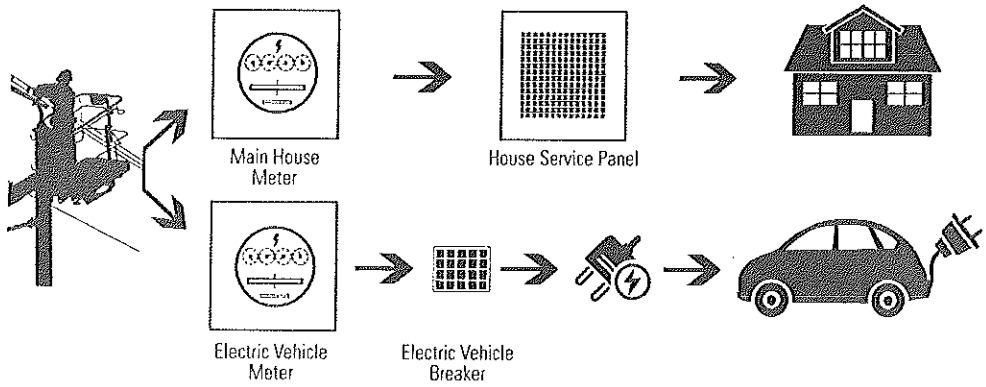
Contractor's Set-Up Guide: Overview

Pricing Plan Summary

Our special EV Pricing plan makes it easy for electric vehicle owners to save on charging costs. Customers who participate will get a reduced price for the electricity they use to charge their vehicle during off-peak hours (between 9:00 p.m. and 9:00 a.m. on weekdays, or anytime on weekends and holidays).

	Metering Set-Up	Monthly Charge	Off-Peak (9 p.m.–9 a.m., holidays & weekends)	On-Peak (9:00:01 a.m.–8:59:59 p.m., weekdays)
EV Pricing Plan	Separate Meter for the EV Only	$4.95	$0.04260/kWh	$0.16968/kWh (other months) $0.21096/kWh (June–Sept.)

*Prices apply to single phase – secondary voltage use only. Prices are subject to resource and/or fuel adjustments, city fees and taxes where applicable. Prices may change upon PUC approval. Prices include the Variable Fuel Cost Charge.



Customer enrollment process:

1. Customer calls Xcel Energy at **800.895.4999** so we can help determine which pricing plan will work best.
2. If a fast charger is being installed, customer contacts builders.call.line@xcelenergy.com to check the load increase.
3. Customer contacts an electrician for an estimate on the meter housing equipment installation.
4. When the meter housing is installed, inspected and energized, customer visits xcelenergy.com/EVElectricPricing and completes the application form.
5. Customer sends the completed inspection document to builders.call.line@xcelenergy.com.
6. We'll visit the customer's home and install an off-peak meter next to the existing meter.
7. Once the meter is installed the customer can start charging and saving.

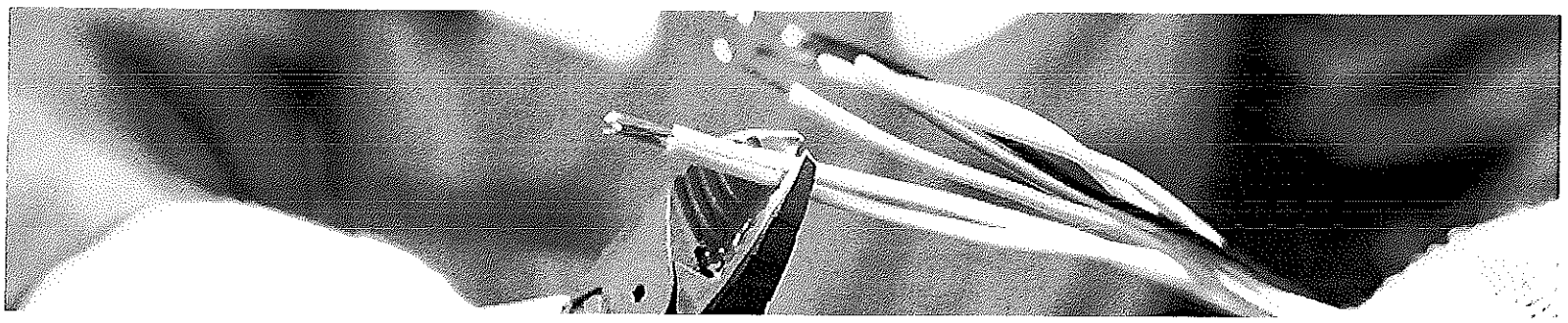
Who provides what for the installation?

Xcel Energy provides:

- EV Billing Meter

Customer installs:

- Meter socket(s) (with a lever bypass)
- Conduit and wiring
- EV charger or dedicated wall outlet



Service Connection Options

Quick Reference Guide for Service Connection:

1. Choose a service connection option.
2. Contact the Builder's Call Line at **800.628.2121** to schedule a line drop and reconnect. If there is a large load increase, speak with a designer to determine if the service entrance conduit is still valid.
   a. Duplex meter sockets require a simple disconnect and reconnect.
   b. Overhead service requires a splice in the conductor past the weather head, which is made by Xcel Energy. Customers need to provide an adequate length of wire to make this connection.
   c. Underground service requires a connection in the wire below the meter sockets, in the same location that the conduit entered the meter socket. Customers need to supply the junction and route conductor from the point of delivery to the two individual meter sockets. The junction box requires a sealable hasp.
3. Customer visits xcelenergy.com/EVElectricPricing and completes the application form, and sends a completed inspection form to the Builder's Call Line, builders.call.line@xcelenergy.com.

Service Connection Option 1:
Duplex Meter Socket, Underground or Overhead Service

DRAWING EV-10

EV SERVICE METERING MN ONLY

Duplex Underground/Overhead

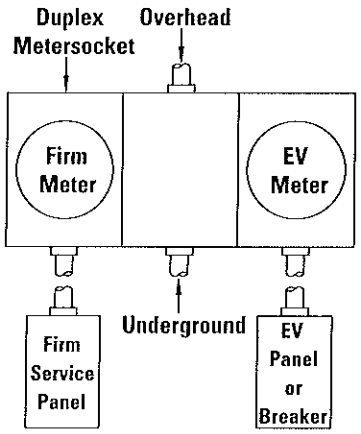


Table of Responsibility

Drawing EV-10

Item material or work description	Party to furnish, own and maintain	Party to install
Permits and Inspections	Customer	N/A
Service Entrance Conductor*	Customer	Customer
Underground Service Lateral	Xcel Energy	Xcel Energy
Service Entrance Conduit	Customer	Customer
Duplex Meter Socket	Customer	Customer
Billing Meter	Xcel Energy	Xcel Energy
Load Side Conduit/ Conductor/Panels	Customer	Customer

Point of Delivery:

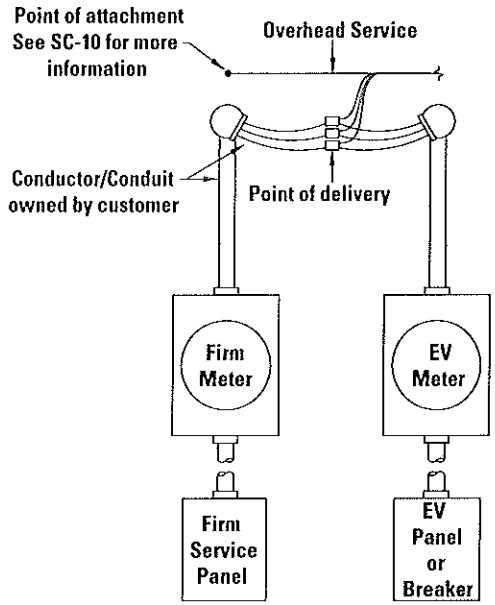
- Point where Xcel Energy's facilities are first connected to the electric facilities of the customer.

*The service entrance conductor refers to the conductor going through the mast between the line side of the meter socket, through the weather head, and to the point of delivery.

Service Connection Option 2: Separate Socket, Overhead Service

DRAWING EV-20

OVERHEAD SERVICE



SEPARATE SOCKET OPTION

NOTES:
1. Riser conduit and conductor supplied and installed by customer/electrician.
2. Point of delivery in service loop.

Table of Responsibility
Drawing EV-20

Item material or work description	Party to furnish, own and maintain	Party to install
Permits and Inspections	Customer	N/A
Service Entrance Conductor*	Customer	Customer
Junction in Drip Loop	Xcel Energy	Xcel Energy
Self-Contained Meter Socket	Customer	Customer
Billing Meter	Xcel Energy	Xcel Energy
Load Side Conduit/ Conductor/Panels	Customer	Customer

Point of Delivery:

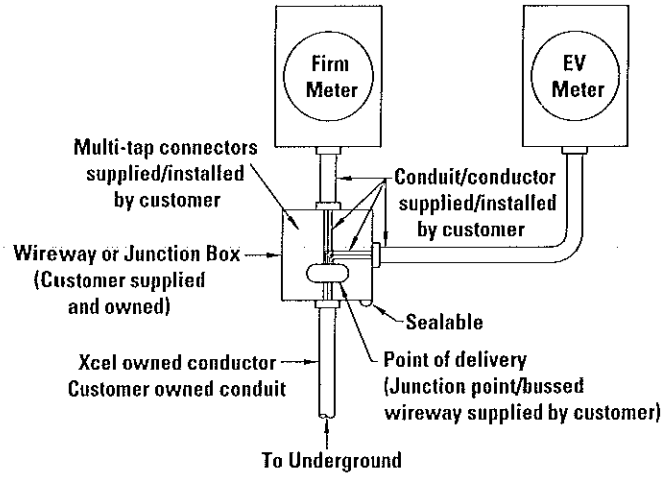
- Overhead Service Residential – Point where Xcel Energy's facilities are first connected to the electric facilities of the customer.
- The junction is made in the drip loop between the conductor exiting the weather head and the overhead service drop. The connection will be made by Xcel Energy.

*The service entrance conductor refers to the conductor going through the mast between the line side of the meter socket, through the weather head, and to the point of delivery.

Service Connection Option 3: Separate Socket, Underground Service

DRAWING EV-30

UNDERGROUND SERVICE



NOTES:
1. Need to coordinate disconnect/reconnect with Xcel builders line.
2. Point of delivery in wireway, conductors after that point supplied by customer.
3. Junction point or bussed wireway supplied by customer.

Table of Responsibility
Drawing EV-30

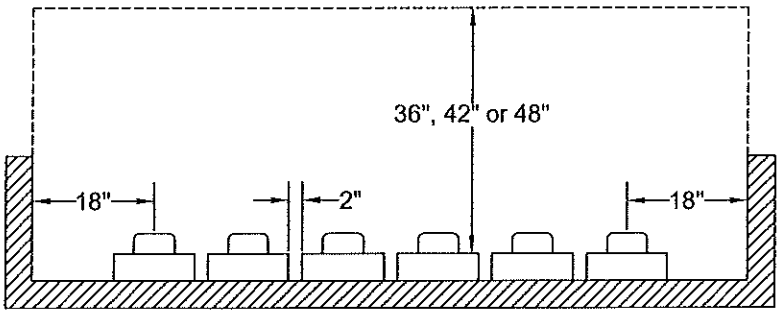
Item material or work description	Party to furnish, own and maintain	Party to install
Permits and Inspections	Customer	N/A
Underground Service Lateral	Xcel Energy	Xcel Energy
Junction Box/ Wire way	Customer	Customer
Point of Connection	Customer	Customer
Self-Contained Meter Socket	Customer	Customer
Billing Meter	Xcel Energy	Xcel Energy
Load Side Conduit/ Conductor/Panels	Customer	Customer

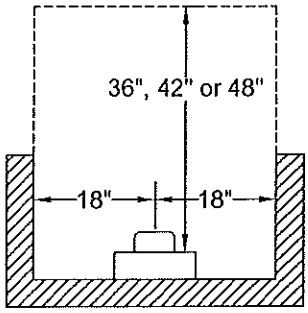
Point of Delivery:

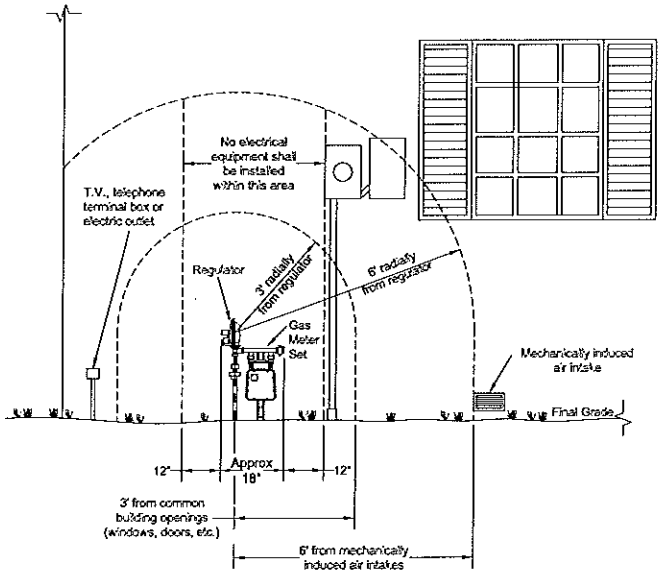
- Underground Service Residential – Point where Xcel Energy's facilities are first connected to the electric facilities of the customer.
- Occurs inside wireway or junction box. Connection is made via connectors supplied and installed by the customer.

Where do I install the meter socket and service box?

The second meter socket or duplex meter socket must be installed outside and grouped by the existing meter socket at a vertical height of 4'–6', measured from final grade to the center of the meter. The minimum horizontal dimensions of the platform shall meet the National Electrical Code® requirements for working space, as specified under "Meter Clearances" in the Standards for Electric Installation and Use manual. Additionally, clearances around the gas meter should be met. Refer to the following diagrams and Drawing CR-10, in that publication for reference.







1. Area within dashed lines shall be clear of all obstructions.
2. 18" clearance shall be maintained to either side of the center line of the meter socket per NEC.
3. 36", 42" or 48" clearance shall be maintained in front of meter socket per NEC.
4. Height of working clearance shall be per NEC.
5. The meter socket must be located within 2' of the existing meter.

Does it have to be a duplex meter socket?

No. For new construction, a duplex meter socket may be a good option. But, it is not required on an existing premises. If two separate sockets are being used, they should be next to each other with the two masts for an overhead service as close to each other as possible. The second meter socket should be vertically aligned, (from the center point) with the existing socket and within 24" horizontally, from the main house meter.

Installation FAQs

Can I install this as a sub-meter?

No. Industry best practice for safety is a dedicated service.

Is a lever bypass meter socket required?

Yes. The meter socket for the EV must be a lever bypass from a manufacturer on our approved list. It must also conform to all other standards as depicted in section 4.13 from our Standard for Electrical Installation and Use.

What voltage charging equipment can I install for the EV Pricing Plan?

EV chargers that use 120V, 240V or 208V (network) are all allowed. Available voltage will be dependent on existing distribution facilities in the area.

Can I install the meter socket on a detached garage?

There are two options for customers wishing to charge their vehicle in a detached garage:

1. The customer may participate in the EV Pricing Plan by installing the EV meter within 2' of the existing meter. If the main-house meter is not on the garage, a line can be run to the detached garage.

2. The customer may participate in Time of Day pricing instead of the EV Pricing Plan, and install a Time of Day meter on the detached garage. In this case, the panel can be used for additional charges besides an electric vehicle. A second service would need to be requested and started at an extra cost to the customer.

Can I install a fast charger?

Yes. Prior to installing a DC fast charger or an AC Level 2 charger, please call the Builder's Call Line at 800.628.2121 to check if a significant load increase will necessitate a service upgrade. With prior notification, we can make the necessary system modifications to continue to reliably serve the EV customer and surrounding community.

Who do I call at Xcel Energy to confirm the meter specifications?

- **Technical metering questions? Call 800.422.0782.**
- **General questions?** We're available 24 hours a day at **800.895.4999.**

Need more guidance? Consult the Standard for Electric Installation and Use manual.

Key sections related to the EV Pricing Plan including (but are not limited to):

- 4.10.3 Meter installation & Ownership
- 4.13 Meter Sockets
- 4.14.2 Meter Installation
- 4.15.5 Meter Socket Identification Requirements
- 4.15 Meter Mounting Heights

Get the latest details and information. Visit xcelenergy.com/EVElectricPricing.

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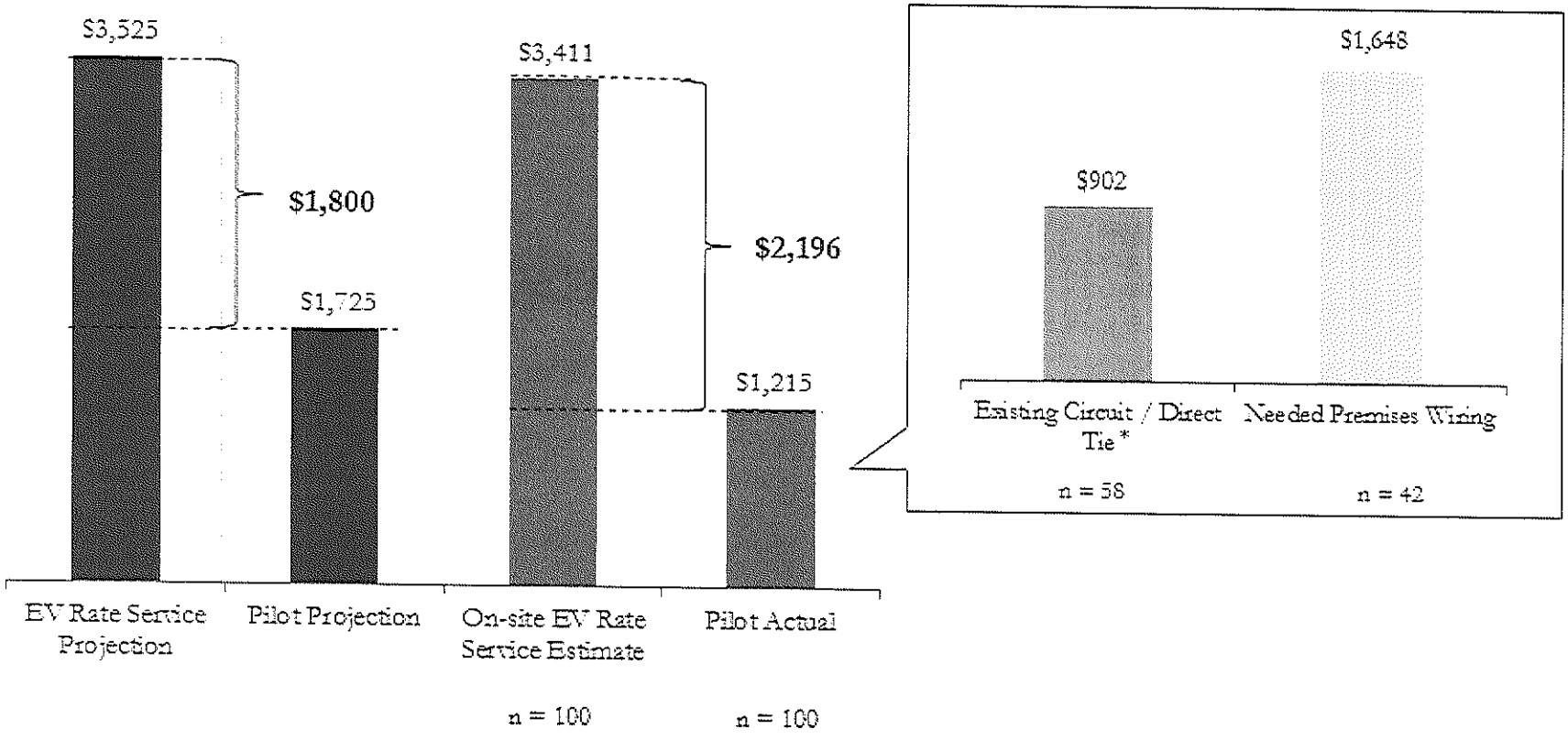
RESPONSIBLE BY NATURE®



*Direct tie refers to an install scenario in which a customer's charging location was adjacent to their service panel, allowing the charger to be directly hardwired into the panel.

Bill Savings of EV Charging on EV Service Pilot tariff compared Standard Residential tariff

In dollars, except where specified

EV Service Pilot Tariff - Average Bill Calculation - 350 kWh

	Rate	KWh	EV Service Pilot	Notes
Level 2 Charger Cost			Pre-Paid	
Incremental Customer Charge			$7.10	
Energy Charges				
Off-Peak	$0.043780	336.0	$14.71	
On-peak (Summer)	$0.215200	4.5	$0.97	
On-peak (Winter)	$0.173280	9.5	$1.64	
Sub-Total Energy Charges		350.0	$17.32	
Fuel Clause Rider	$0.027353	350.0	$9.57	
Other Riders Charges				
Transmission Cost Recovery	$0.003503	350.0	$1.23	
Renewable Development Fund	$0.001417	350.0	$0.50	
Conservation Improvement Program	$0.001813	350.0	$0.63	
Renewable Energy Standard	0.497%		$0.12	
Sub-Total Other Rider Charges			$12.05	
Total Monthly Charge			$36.47	(A)

Standard Residential Tariff - Average Bill Calculation - 350 kWh

	Rate	KWh	Standard	Notes
Level 2 Charger Cost			Pre-paid	
Incremental Customer Charge			$0.00	
Energy Charges				
Summer	$0.108150	113.1	$12.23	
Winter	$0.092410	236.9	$21.90	
		350.0	$34.13	
Fuel Clause Rider	$0.027353	350.0	$9.57	
Other Riders Charges				
Transmission Cost Recovery	$0.003503	350.0	$1.23	
Renewable Development Fund	$0.001417	350.0	$0.50	
Conservation Improvement Program	$0.001813	350.0	$0.63	
Renewable Energy Standard	0.497%		$0.17	
Sub-Total Other Rider Charges			$12.10	
Total Monthly Charge			$46.23	(B)
Bill Savings			$9.76	(B) - (A)

CERTIFICATE OF SERVICE

I, Paget Pengelly, hereby certify that I have this day served copies or summaries of the foregoing documents on the attached list(s) of persons.

xx by depositing a true and correct copy thereof, properly enveloped with postage paid in the United States Mail at Minneapolis, Minnesota

or

xx electronic filing

Docket No. E002/M-15-111 & E999/CI-17-879

Dated this 31st day of May 2019

/s/

_____

Paget Pengelly
Regulatory Administrator

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REPORT

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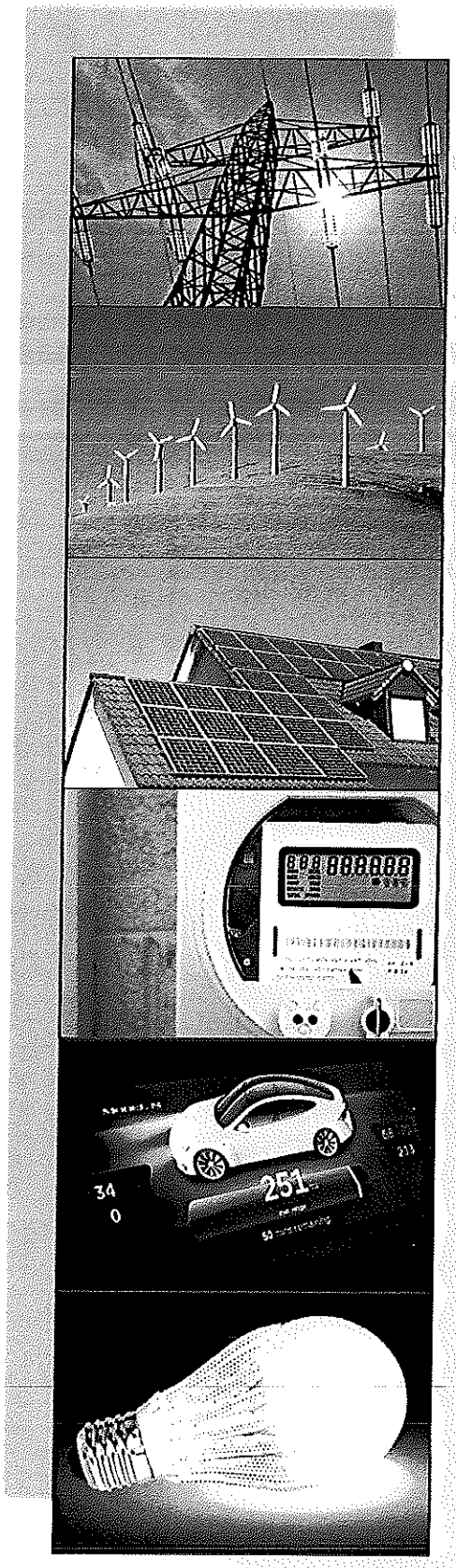

California Statewide PEV Submetering Pilot – Phase 1 Report

April 1, 2016

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California Public Utilities Commission

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Table of Contents

1 Executive Summary

1.1 Introduction

The California Plug-in Electric Vehicle (PEV) Submetering Pilot was designed to test the implementation and customer experience associated with submetering solutions for residential and commercial customers. Submetering allows customers to access TOU rates for PEVs without installing a separate Investor Owned Utility (IOU)[1] revenue grade meter. A key feature of the pilot was that the submetering hardware and service was provided by third party Submeter Meter Data Management Agents (MDMAs), while billing was handled by the utilities. Three third party MDMA suppliers actively participated in Phase 1 of the pilot—NRG eVgo (NRG), Ohmconnect, and eMotorWerks (eMW). These MDMAs were responsible for managing customer relationships during the pilot, which included recruitment, coordinating submeter installations, enrolling customers in the pilot, and providing customer service and support. MDMAs measured PEV electricity usage through the submeters and delivered data to the utilities on a daily basis for billing purposes.

The enrollment period for Phase 1 of the pilot began on September 1, 2014 and was conducted on a first-come, first-served basis[2] subject to an enrollment limit of 500 submeters for each IOU divided equally among the participating MDMAs. Due to delays associated with submeter certification, the enrollment period was extended six months to August 31, 2016. Total enrollment consisted of 241 customers—132 at PG&E, 92 at SCE, and 17 at SDG&E. The majority of participating customers enrolled through either eMW (192) or Ohmconnect (45). Approximately 25% of participants have solar PV systems with a net metering arrangement[3] in addition to their electric vehicle—43 in PG&E, 13 in SCE, and 3 in SDG&E. Phase 1 enrollment is summarized in Table 1-1, which also lists the submeter rates that are available to pilot participants in each territory.

[1] The three Investor Owned Utilities in California are Pacific Gas & Electric (PG&E), Southern California Edison (SCE) and San Diego Gas & Electric (SDG&E).

[2] The first three months of enrollment were an "Exclusivity Period" during which the MDMAs had "Exclusivity Rights" to their share of the total participants in each IOU's territory. An "Open Period" of enrollment began in the fourth month during which MDMAs were allowed to enroll additional customers beyond their exclusivity rights and up to the 500 submeter limit on a first-come, first-serve basis.

[3] Net metered customers are allowed to make up a maximum of 20% of total pilot enrollments in each service territory.

Table 1-1: Phase 1 Enrollment

Utility	Total Enrollment	NEM Customers Enrolled	Enrollments by MDMA			Submeter Rate for Pilot Participants
			EMW	Ohmconnect	NRG	
PG&E	132	43	109	22	1	EV-B (Residential) $20 bill credit (Commercial)
SCE	92	13	71	19	2	TOU-EV-1 (Residential) TOU-EV-3 & 4 (Commercial)
SDG&E	17	3	12	4	1	EV-TOU (Residential) $20 bill credit (Commercial)
Total	**241**	**59**	**192**	**45**	**4**	**N/A**

In order to participate in the pilot, customers were required to enroll by submitting a Customer Enrollment Agreement signed by the customer and their MDMA to their IOU and install a submeter. The pilot was designed to allow both stand-alone submeters and submeters integrated with Level 2 charging stations, but almost all Phase 1 participants used eMW's stand-alone WattBox™. The WattBox™ is Wi-Fi enabled to transmit recorded usage data from the submeter to the MDMA—and ultimately to the IOU. MDMAs assisted customers with signing up for the TOU rate with their IOU and also helped them to schedule an appointment for the installation of the submeter by a licensed electrician.[4] For their participation, eMW customers received a full rebate for the WattBox™ in addition to incentive payments of $100 after installation and $50 after the first successful data transfer. The maximum duration for participation in Phase 1 was 12 months and customers were allowed to withdraw from the pilot at any time.[5]

After contacting an MDMA to express interest in the pilot, customers created an online account[6] and went through a pre-qualification check to make sure that they met the eligibility criteria for the pilot and could have a submeter successfully installed at their premise. After having their submeter installed, customers formally enrolled in the pilot by completing a customer enrollment application (CEA) with assistance from the MDMA, who submitted them to the appropriate IOU for approval. Upon approval of the CEAs, MDMAs began sending submeter data to the IOUs on a daily basis for billing.

[4] eMW provided customers with a choice of having the installation performed by an eMW-contracted electrician for free or contributing up to $100 towards an installation performed by an electrician of the customer's choosing.

[5] At the time of this report, 12 PG&E participants and 10 SCE participants had withdrawn from the pilot.

[6] This step was not necessary for existing eMW customers.

1.2 Components of Evaluation

Phase 1 of the pilot focused on situations having a "single customer of record" in which the same customer was responsible for paying for all electricity consumption—including the submeter—at their service premise.[7] The evaluation objectives for Phase 1 were to:

- Identify the different submetering services provided by MDMAs;
- Evaluate the customer experience to determine customer benefits under submetering;
- Evaluate customer demand for submetering services; and
- Evaluate the potential impacts submetering can have on supporting the State's ZEV goals of reducing the costs of PEV home charging, simplifying metering options, and establishing the submetering protocol to help homeowners access PEV time of use rates.

These research questions were addressed by organizing the Phase 1 evaluation into four principal components. First, a careful analysis of the business processes used by the MDMAs and IOUs was conducted based on interviews with the MDMAs and IOUs to understand how submetering was offered to consumers in the context of the pilot. Second, a sample of customers was selected from the pilot to install independent data loggers for the purposes of assessing the accuracy of the submeter measurements. Third, participants were surveyed to gather information about the pilot experience and their satisfaction with the submetering service provided. Finally, PEV customers who are not currently submetered were surveyed to assess customer preferences for submetering and the primary factors that will affect future submetering uptake using an Adaptive Choice-Based Conjoint (ACBC) methodology.[8]

1.3 Summary of Results

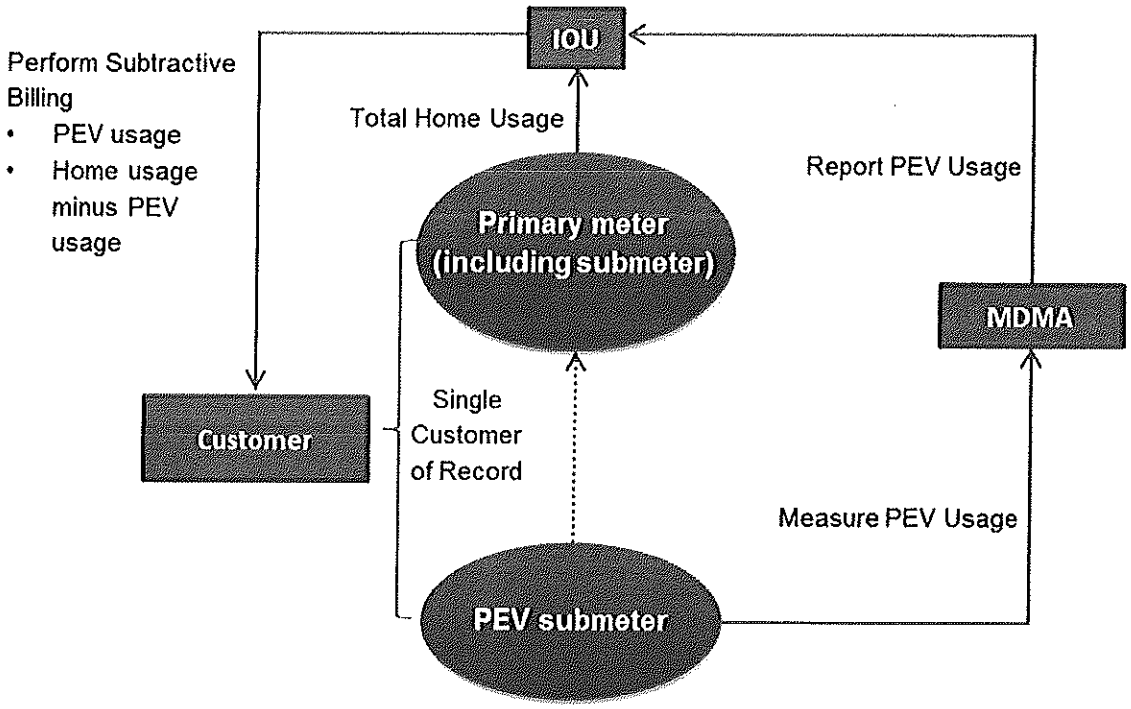
Providing submetering service to pilot participants during Phase 1 required a significant amount of coordination and information transfer between the MDMAs and IOUs. The data flows and communications between pilot stakeholders are shown in Figure 1-1. The primary role of the MDMA was to provide the IOU with accurate measurements of PEV electricity usage in a format that was compatible with the premise's primary meter—15 minute intervals. The IOU then took the PEV usage in each interval and subtracted it from the primary meter to identify the amount of electricity used by the rest of the house and calculate a bill for each source using the appropriate rate—subtractive billing. Once the two bills were calculated, they were combined into a single document and sent to the customer at the end of their billing cycle.[9]

[7] Phase 2 of the pilot will focus on submetering in situations where there are "multiple customers of record," i.e., circumstances where the customer of record for the consumption of the submeter is different from the customer of record for the rest of the premise.

[8] This methodology is described in Appendix C.

[9] Depending on the timing of enrollment, there was often a lag of 1 to 2 months between when a customer enrolled in the pilot and received their first bill.

Figure 1-1: Data Flows and Communication between Stakeholders in Phase 1



1.3.1 Submeter Accuracy

In order for submetering to be successful from both a business and customer satisfaction perspective, the submeters must be able to provide accurate measurements of PEV charging usage to the utilities for subtractive billing. Nexant assessed submeter accuracy by installing loggers for a sample of 34 submeters in the pilot—31 eMW submeters and 3 NRG submeters—for a period of two months. Due to technical issues[10] with some of the installed loggers and 3 submeters having spotty data coverage or being entirely offline during the study period,[11] only 14 logger-submeter pairs were available for analysis. In addition, a software issue with eMW's data server resulted in 24 hour time shifts for some submeters during the first month of the study period. Because these measurement errors would have overwhelmed the 5% accuracy threshold for any affected submeters, the analysis was limited to the second half of the study period—January 9 through February 12.

Submeter accuracy was formally assessed by conducting equivalence tests using a regression approach in which submeter measurements were regressed against logger readings. The tests consisted of the following steps:

1. Establish 5% region of equivalence for the slope ($\beta 1$) equal to (0.95, 1.05).
2. Fit linear regression using the logger as the independent variable and the submeter observations as the dependent variable.

[10] These included not properly synchronizing logger clocks with submeter clocks, being unable to record one time measurements needed to convert recorded amps to kW and loggers that stopped recording data midway through the study period.

[11] Due to the missing data, these 3 submeters would not have met the 5% accuracy requirement.

3. Test the slope for equality to 1 by calculating two one-sided confidence intervals for the slope using the regression output and determine whether this interval is contained within the region of equivalence.

Results for the individual submeter tests are presented in Table 1-2 and show that most submeters for which data were available are able to meet the 5% accuracy requirement. The exception is submeter number 5, which stopped recording usage partway through the study period. Combined with the data issues experienced by some submeters in the sample, these results indicate that while most submeters were able to accurately measure PEV charging usage, some experienced measurement issues that affected customer bills and may account for some of the dissatisfaction customers expressed about billing accuracy.

Table 1-2: Equivalence Test Results Using Regression

Unique ID	Regression Coefficient	Standard Error	95% Lower	95% Upper	Reject Test of >5% Error	Count
1	1.00	0.00	1.00	1.01	Yes	479
2	1.02	0.00	1.01	1.02	Yes	349
3	1.03	0.00	1.02	1.04	Yes	100
4	1.03	0.00	1.02	1.03	Yes	385
5	0.24	0.05	0.16	0.33	No	445
6	0.99	0.00	0.99	1.00	Yes	364
7	1.00	0.00	0.99	1.00	Yes	247
8	1.01	0.00	1.01	1.02	Yes	274
9	1.00	0.00	1.00	1.01	Yes	447
10	0.96	0.00	0.95	0.97	Yes	723
11	1.02	0.00	1.01	1.02	Yes	411
12	1.04	0.00	1.03	1.04	Yes	375
13	1.00	0.00	1.00	1.00	Yes	132
14	1.00	0.01	0.99	1.01	Yes	114

1.3.2 Customer Experience

A survey of customers participating in Phase 1 found that more than 80% of participants reported that being able to pay a lower price for charging their PEV, getting an incentive for the submeter, and having the ability to measure the amount of electricity used by their PEV were either extremely important or somewhat important in their decision to participate in the pilot. Most customers (72%) said that they were "extremely satisfied" or "somewhat satisfied" with the submetering service provided during the pilot, while 15% of respondents rated their level of satisfaction as "somewhat dissatisfied" or "extremely dissatisfied."

Customer satisfaction ratings for specific aspects of the pilot are shown in Table 1-3. Aspects that produced high levels of customer satisfaction included the reliability of the charging station, installation of the submeter, and remote access to information about whether and when a customer's PEV was charging. The aspects with the lowest satisfaction scores were customer service provided by the IOUs and the enrollment process.

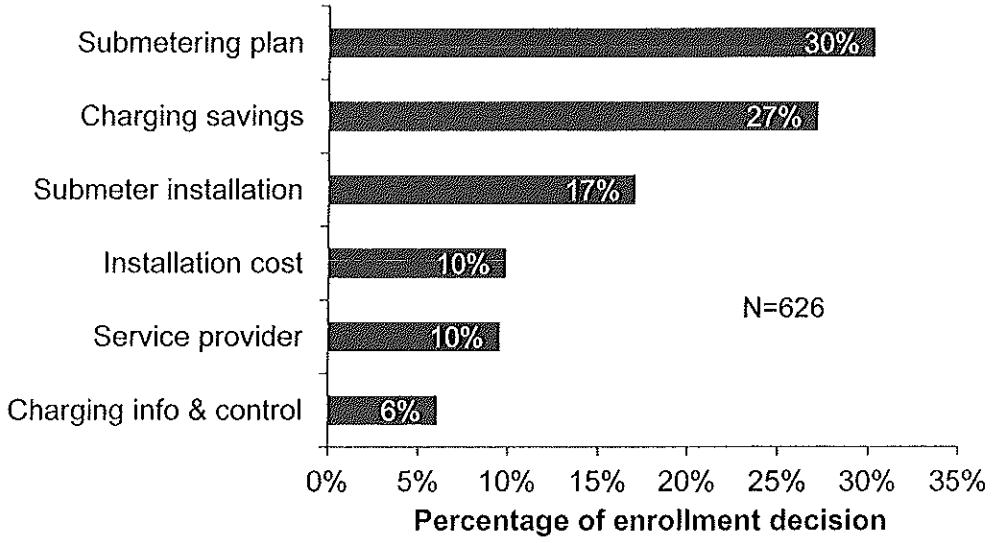
Table 1-3: Satisfaction Ratings for Specific Aspects of Phase 1 Pilot

Please rate the following aspects of your submetering service		No Experience	Poor	Fair	Good	Very Good	Excellent	Top 2 Box
Reliability of my charging station		10%	2%	5%	7%	18%	68%	86%
Safety of my charging station		17%	1%	2%	15%	20%	62%	82%
Accuracy of the measurement of electricity used by my PEV		24%	8%	8%	13%	24%	48%	72%
Installation		45%	6%	8%	17%	20%	49%	69%
Access to information about whether and when my vehicle is charging remotely		30%	7%	7%	18%	28%	39%	67%
Scheduling the installation of the meter or charging station		39%	4%	9%	24%	21%	42%	63%
Customer service provided by (insert MDMA name) after the meter or charging station was installed		14%	12%	6%	21%	20%	40%	60%
Accuracy of the PEV portion of my bill		27%	18%	7%	18%	22%	36%	58%
Ability to control my charging station remotely		58%	15%	7%	25%	19%	35%	54%
Signing up for the PEV rate	PG&E	5%	11%	19%	26%	19%	25%	44%
	SCE	1%	21%	10%	26%	23%	20%	43%
	SDG&E	0%	7%	13%	13%	20%	47%	67%
	All IOUs	**3%**	**15%**	**15%**	**25%**	**21%**	**25%**	**46%**
Customer service provided by IOU after PEV rate started	PG&E	33%	28%	18%	18%	17%	18%	36%
	SCE	32%	23%	18%	27%	18%	14%	32%
	SDG&E	27%	18%	18%	18%	9%	36%	45%
	All IOUs	**32%**	**25%**	**18%**	**22%**	**17%**	**18%**	**35%**

1.3.3 Factors Affecting Future Submetering Adoption

In addition to analyzing the experience of customers who enrolled in the pilot, the Phase 1 evaluation also explored the factors that will affect the future uptake of submetering by conducting a conjoint survey among PEV customers who did not have submeters. Results from the conjoint survey showed that the most important factors when considering submetering are the type of submetering plan—e.g., discounted rate or flat charging fee—the magnitude of charging cost savings, and type of submeter installation—e.g., plug-in, mobile, professionally installed submeter or submeter plus Level 2 charging station. These factors account for 74% of the enrollment decision and are summarized in Figure 1-2. Installation cost, service provider, and charging information comprise a second tier of attributes which drive the remaining 26% of the decision.

Figure 1-2: Relative Attribute Importance



One key area that is informed by the analysis of the conjoint survey is the demand for submetering in the population of existing PEV owners. Table 1-4 shows estimated enrollment likelihoods for all combinations of the attributes tested as part of the survey. For analysis purposes, a baseline offering (shaded) was defined to resemble the submetering offer available in Phase 1 as closely as possible within the constraints of the model. This baseline serves as an anchor point to interpret the remaining results. The enrollment likelihood in each cell corresponds to a submetering offer consisting of that specific attribute level and the baseline levels for all other attributes. This allows differences between cells to be interpreted as the marginal effect of each level on the likelihood of enrollment holding all other attributes constant.

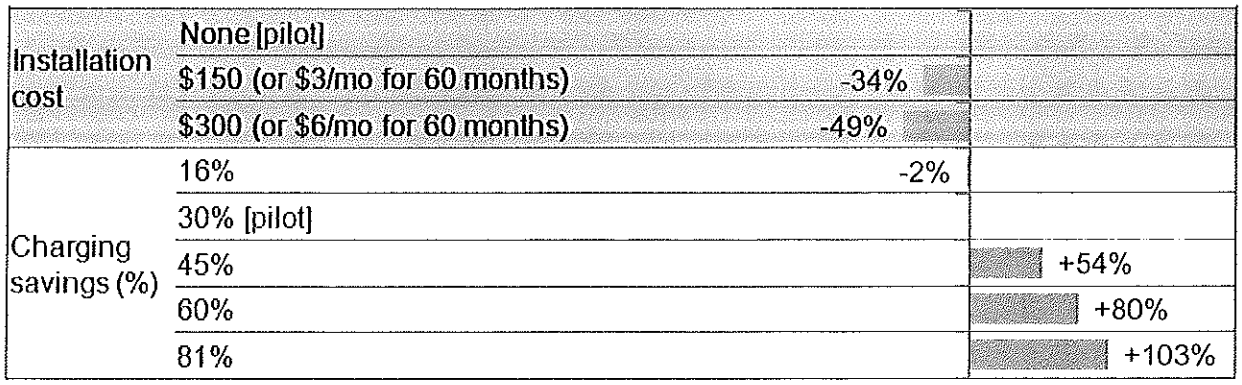
Table 1-4: Demand for Submetering Services in Existing PEV Customer Population

Attribute	Level	Baseline level	Enrollment Likelihood	Pref. share as % change over baseline
Submetering Plan	Flat monthly fee (charge anywhere)		30%	-26%
	Flat monthly fee (charge at home)		34%	-18%
	Electricity discount	•	41%	0%
	Electricity discount + grid services		29%	-28%
Charging Info & Control	Bill only		36%	-12%
	Info	•	41%	0%
	Info + control		46%	12%
Service Provider	Utility logo		61%	48%
	Car brand name (or logo)		49%	18%
	Independent EV charging company	•	41%	0%
Submeter Installation	Simply plug-in		50%	23%
	Mobile (in-car)		54%	32%
	Meter (pro-install)	•	41%	0%
	Meter (pro-install) + Level 2 charger [Add $600 (or $12/mo) to submeter cost]		32%	-23%
Installation Cost	None	•	41%	0%
	$150 (or $3/mo for 60 months)		27%	-34%
	$300 (or $6/mo for 60 months)		21%	-49%
Charging savings	16% (min tested)		40%	-3%
	30%	•	41%	0%
	45%		63%	54%
	60%		74%	80%
	81% (max tested)		83%	103%

Within the context of the survey, 41% of current PEV customers said that they would enroll in the Phase 1 submetering offer if it was made available to them. Several caveats are necessary for this important result. The most important caveat is that the enrollment likelihood likely suffers from "hypothetical bias" that often exists with stated preference surveys since there is often a difference between what survey respondents say they will do and what they will actually do. Hypothetical bias is generally positive, meaning that survey respondents would be prone to overstate their true likelihood of enrolling in submetering. Another important caveat is that there is no guarantee that the current population of PEV owners will resemble the population of PEV owners that may exist in the future when some attributes may become available.

Despite the limitations of the absolute enrollment likelihood, changes in enrollment likelihoods can be analyzed to estimate the relative influence of different submetering attributes. Figure 1-3 summarizes the financial attributes included in the survey and shows that increasing the costs of submetering[12] to participants by $150 could reduce enrollment likelihood—compared to the likelihood of enrolling at zero installation cost—by about a third (34%), while increasing submetering installation costs to $300 could reduce the likelihood of enrolling in a submetering program by 50%.

Figure 1-3: Relative impact of Financial Attributes on Enrollment Likelihood



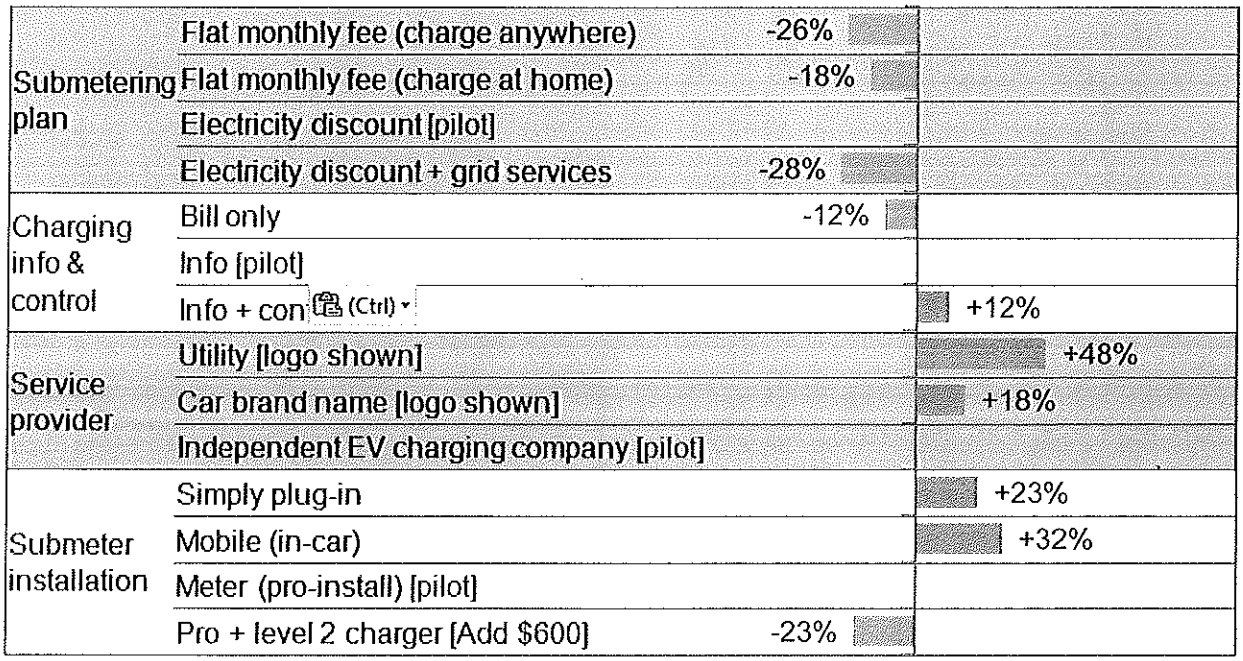
Charging savings[13] also have a significant impact on enrollment likelihood and the results of the conjoint suggest that there is a minimum amount of savings needed to attract interest in submetering. There is very little variation in uptake between 0 and 30% savings, but there is a substantial 54% enrollment increase for a similar increase in percent savings from 30% to 45%. This indicates that somewhere between 30% and 45% there is a threshold beyond which savings become meaningful. Increased savings beyond 45% by similar margins produces diminishing enrollment impacts.

In addition to the financial aspects of submetering, four attributes relating to business models and participant experience attributes—plan type, charging info & control, service provider, submetering installation—were also tested as part of the choice survey. Figure 1-4 shows the impacts of these attributes on the likelihood of enrollment relative to the attributes of Phase 1.

[12] It is important to clarify that this attribute was conceptually designed to test participant costs and so is not meant to distinguish between actual hardware and installation costs. The survey also controlled for underlying respondent preferences for upfront versus monthly payments, as recognition that reducing upfront costs may reduce the burden for some participants.

[13] In the context of the survey, charging savings were defined as a percentage reduction in the cost of charging a PEV each month. Each respondent's monthly charging cost was estimated based on self-reported monthly miles driven, percent of charging done at home, a marginal electricity price estimate based on each respondent's current electricity rate, and a conversion factor of miles to kWh for the respondent's PEV category collected earlier in the survey. To ensure the most numerically and cognitively valid estimates, respondents were given a choice of how to estimate miles driven—weekly average or age of vehicle and mileage—asked to confirm the estimate, and then finally given the opportunity to change the estimate to a manually entered value within a reasonable range. The average monthly cost was $53 with standard deviation of $49, which suggests that most monthly charging cost estimates fell between $0 and $100.

Figure 1-4: Relative Impact of Business Model and Participant Experience Attributes



Reduced charging costs were the most preferred business model, while charging information/analytics and the ability to control charging remotely increased the likelihood of enrollment by 14 to 28%. Respondents had a preference for IOUs and PEV manufacturers as submetering providers and mobile metering solutions increased the likelihood of enrollment by 38% relative to submeters that require installation by certified professional electricians.

1.4 Conclusions and Recommendations for Phase 2

Phase 1 of the PEV Submetering pilot successfully established third party submetering service for 241 customers throughout California. The three primary motivations for customers to participate in the pilot were the opportunity to pay a lower rate for electricity used by the PEV, the availability of an incentive for the PEV submeter, and the ability to monitor the amount of electricity used by PEVs. During the course of the pilot, several technical and customer service-oriented challenges were encountered by the participating MDMAs and IOUs that demonstrate areas where submetering operations and customer service can be improved in the future.

By all accounts, the enrollment process for Phase 1 was cumbersome and required a large number of manual processes and repeated customer interactions, which resulted in long processing times for CEAs and frustrations for customers, MDMAs, and IOUs alike. Only 46% of participants rated the process of signing up for the pilot as either very good or excellent. Customers needed assistance from the MDMAs to complete the required forms, which were submitted to IOUs via email as attached PDFs and regularly needed to be sent back for revisions due to missing or incomplete information. Numerous interactions between customers, MDMAs, and IOUs were required to successfully enroll a customer and all of these interactions were initiated manually by one of the stakeholders. Streamlining the enrollment process should be a priority for Phase 2 and include efforts to improve communication between the MDMAs and

IOUs regarding what is required from the customer as well as an investigation into whether infrastructure can be set up for CEAs to be completed more efficiently. This infrastructure could include the development of a website accessible by the MDMAs that creates a structured data environment for CEAs that is less prone to error than the manual process used in Phase 1.

Once customers were able to successfully enroll in the pilot, most (72%) said that they were satisfied with the overall service they received. However, 15% of participants reported being dissatisfied with their submetering service and highlighted areas where submetering operations could be improved. The primary causes of dissatisfaction were billing issues and poor customer service from the MDMA and/or IOU. Thirty percent of customers who responded to the participant survey reported experiencing a problem with their bills—delays were the most common description—and half of these customers said that their issues had not yet been resolved. When asked how to improve the pilot experience, the most common response from participants was for the IOUs/MDMAs to provide better support and communication.

The billing issues experienced by Phase 1 participants were likely a result of several different factors. First, the IOU subtractive billing processes created for the pilot existed outside the robust billing systems used for standard billing operations. Submeter data from the MDMAs was transferred manually to the IOUs via SFTP and required cleaning and processing before being combined with interval data from the IOUs' internal systems. Early in Phase 1, the IOUs spent significant effort educating the MDMAs about the intricacies of customer billing protocols and the data format necessary to ensure accurate billing. Despite these efforts, significant oversight from the IOUs was necessary throughout Phase 1 to ensure timely and correct data deliveries. Due to the manual nature of these steps and the amount of back and forth between IOUs and MDMAs, errors occurred at a higher rate than normal and the amount of time required for preparing customer bills increased. To the extent that these processes can be automated, the timeliness and accuracy of subtractive billing would improve.

Another factor that has an impact on the accuracy of customer bills is the accuracy of the submeters. Analysis comparing a sample of submeters to independently installed loggers revealed that most submeters were able to accurately record PEV usage data, but that 10 to 20% likely experienced some kind of accuracy problem during Phase 1. These problems resulted from spotty data coverage, submeters going offline for a period of time, and a server software malfunction that caused time shifts in the data for some submeters. All three of these events caused delays in billing and some resulted in erroneous bills being delivered to customers. For Phase 2, Nexant recommends that additional submeter accuracy testing be conducted using a threshold of +/- 1% in order to improve billing accuracy and reduce the number of billing disputes with participants. This testing would preferably be done in a laboratory setting prior to installation to avoid the difficulties and limitations associated with measuring accuracy in the field and should include tests to ensure that submeter clocks are capable of proper time synchronization with IOU AMI systems. New metering standards and testing protocols related to submeters currently being developed by the National Institute of Standards and Technology (NIST) and the California Division of Measurement Standards may be able to be leveraged as a guide for best practices.

In addition to analyzing the processes, customer experiences, and accuracy that were specific to Phase 1, Nexant also surveyed approximately 600 non-submetered PEV customers to analyze customer preferences for different submetering features and identify factors that are likely to drive future uptake of submetering. This analysis showed that the type of submetering plan—e.g., discounted rate or flat charging fee—magnitude of charging cost savings, and type of submeter installation—e.g., plug-in, mobile, professionally installed submeter, or submeter plus Level 2 charger—are the most important factors that influence submetering adoption decisions and that about 40% of current PEV customers would sign up for the submetering arrangement offered during Phase 1. For submetering to be attractive, a minimum amount of charging savings of 30-45% is needed and installation costs need to be kept low. Depending on the price differentials established for the opt-out TOU rates that will be rolled out to residential customers beginning in 2019, submetering plans with charging savings of 30-45% may be difficult to offer.

Installation cost, service provider, and charging information comprise a second tier of attributes that affect submetering adoption decisions. A mobile metering option was particularly popular among SDG&E respondents (+49% enrollment impact) and PG&E respondents (+41%), but had less of an impact on SCE respondents (+31%). While there was a preference for the utility or the PEV manufacturer to play the role of service provider, this was less pronounced for PG&E respondents than the other two IOUs. Nexant recommends offering additional submetering plans and pricing structures in Phase 2 along with exploring partnerships between MDMAs and IOUs as a way to provide more seamless service to the customer and achieve stronger brand equity.

2 PEV Submetering Pilot Background

As the adoption of PEVs continues to accelerate in California, PEV charging patterns will become an increasingly important end-use in the state's electricity system. In a future where PEVs make up a significant share of California's vehicle fleet, charging loads will need to be well-managed to avoid having PEVs exacerbate system peaks or negatively impact grid reliability in other ways. One effective tool for incentivizing charging during the most beneficial times is Time-Of-Use (TOU) electricity pricing. Customers can access PEV TOU rates in one of two ways—either by enrolling their entire house or facility into a TOU rate or by installing separate electrical service and meter dedicated to PEV charging. According to a recent survey of participants in the Clean Vehicle Rebate Program, a majority of drivers (65-80%) are aware of the special rates for PEV charging, and 62% use them.[14]

The California Plug-in Electric Vehicle (PEV) Submetering Pilot was designed to test the implementation and customer experience associated with submetering solutions for residential and commercial customers. A key feature of the pilot was that the submetering hardware and service was provided by third party Meter Data Management Agents (MDMAs),[15] while billing was handled by the utilities. This division of labor required coordination by the MDMAs and IOUs on pilot enrollment and data transfer in order to provide customers with accurate and timely bills for the electricity usage of their PEV and the rest of their home.

The remainder of this section provides a brief overview of the policy context and history related to the pilot, detailed descriptions of the services that were provided by the MDMAs and IOUs, and a summary of Phase 1 enrollment.

2.1 Policy Framework and Evaluation Goals

To proactively help manage PEV charging loads, California has established goals to provide customers with the proper incentives to charge their PEVs in a way that minimizes their negative impacts on the grid and maximizes their fuel and cost savings. Submetering is seen as an important contributor to both of these goals since it avoids the need to install a costly second meter, increases access to TOU rates that incentivize off-peak charging, and allows customers to potentially reduce their monthly bills by scheduling their charging for off-peak times. Furthermore, it was determined that allowing submetering solutions provided by third parties—i.e., non-utilities—may result in additional benefits to the PEV market by increasing customer choice and technological innovation.[16]

Discussions about a pilot program for PEV submetering date back to a 2011 workshop on the topic organized by CPUC Energy Division, which jumpstarted work on a roadmap report to outline potential submetering scenarios and assess the feasibility in the context of PEVs. The IOUs produced a draft report in early 2012 that was followed by a series of workshops and

[14] See http://public.tableau.com/profile/research.department#!/vizhome/shared/NJBH7MSDS.

[15] Customers were given the opportunity to own submeters as a result of CPUC Decision 11-07-029 (see p. 40-41).

[16] Besides increasing access to TOU rates, submetering also has potential applications as a distributed energy resource (DER) that can be aggregated and participate in CAISO demand response markets. See http://www.caiso.com/Documents/AgendaPresentation-DistributedEnergyResourceProvider-DraftFinalProposal.pdf

revised reports to develop rules for incorporating customer-owned submeters into IOU billing and metering systems—denoted the "PEV Submetering Protocol". A key outcome of this work was Resolution E-4651 in 2014, which approved a two phase pilot to better understand the costs and benefits of PEV submetering.[17]

The PEV submetering pilot was organized into two sequential phases to demonstrate and evaluate different potential submetering arrangements. Phase 1 focused on situations having a "single customer of record" in which the same customer was responsible for paying for all electricity consumption (including the submeter) at their service premise and is the focus of this interim report.[18] The evaluation objectives[19] for Phase 1 were to:

- Identify the different submetering services provided by MDMAs;
- Evaluate the customer experience to determine customer benefits under submetering;
- Evaluate customer demand for submetering services; and
- Evaluate the potential impacts submetering can have on supporting the State's ZEV goals of reducing the costs of PEV home charging, simplifying metering options, and establishing the submetering protocol to help homeowners access PEV time of use rates.

In addition to these stated goals, it is important to identify any findings from Phase 1 that could potentially inform or improve the execution of Phase 2. This report highlights these findings where appropriate and provides recommendations for how they can best be leveraged going forward.

2.2 Submetering Services Provided by MDMAs and IOUs

Three third party MDMA suppliers actively participated in Phase 1 of the pilot[20]—NRG, Ohmconnect, and eMotorWerks (eMW). These MDMAs were responsible for managing the customer relationship during the pilot—including recruitment, coordinating submeter installations, and providing customer service and support—accurately measuring PEV electricity usage and delivering data to the utilities on a daily basis for billing purposes. Throughout Phase 1, Ohmconnect and eMW worked as partners, with eMW supplying the submeter hardware and Ohmconnect providing software to provide customers with charging analytics and deliver data to the IOUs for billing.

The principal responsibilities of the three IOUs included processing enrollment applications and performing subtractive billing for pilot participants. Subtractive billing requires taking the submetered PEV usage data from the MDMAs, subtracting it from the whole-house usage, and

[17] Resolution E-4651 also approved a pro forma rate schedule for use in the pilot (PEVSP).See http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M097/K049/97049639.PDF for additional details.

[18] Phase 2 of the pilot will focus on submetering in situations where there are "multiple customers of record", i.e. circumstances where the customer of record for the consumption of the submeter is different from the customer of record for the rest of the premise.

[19] See CPUC Decision D.13-11-002

[20] Additional parties such as Tesla, FleetCarma and ChargePoint have expressed interest in becoming involved in Phase 2 of the pilot, but have not committed to participate.

providing the customer with a bill that reflected the appropriate rates for each of the two usage streams. Because all participants in Phase 1 were single customers of record, the bill was sent to customers as a single document that showed the breakdown between each of the two components—PEV and rest-of-house.

Staffing during Phase 1 was generally comprised of small teams at the MDMAs and IOUs. Ohmconnect estimated that 1.5 full-time employees (FTE) were actively involved in Phase 1 on average, with 4 to 6 FTE involved during peak periods of activity—e.g., enrollment and data transfer testing. For eMW, the average amount of labor required during Phase 1 was 0.5 FTE and 2 FTE were required for 2 to 3 months of peak activity. For each IOU, 3 to 5 FTE were required during project setup and enrollment, while 1 to 2 FTE were involved in performing the work associated with data transfer and billing.

In order to participate in the pilot, customers were required to enroll by submitting a Customer Enrollment Agreement signed by the customer and their MDMA to their IOU and install a submeter. Although the pilot was designed to allow both stand-alone submeters and submeters embedded in Level 2 chargers, almost all participants used eMW's stand-alone WattBox™ for Phase 1.[21] MDMAs assisted customers through the enrollment process, signed the customer up for the TOU rate with their IOU, and also helped to schedule an appointment for the installation of the submeter by a licensed electrician.[22] The WattBox™ is Wi-Fi enabled to transmit recorded usage data from the submeter to the MDMA—and ultimately to the IOU. For their participation, customers received a full rebate for the WattBox in addition to incentive payments of $100 after installation and $50 after the first successful data transfer.

2.3 Phase 1 Enrollment

The enrollment period for Phase 1 of the pilot began on September 1, 2014 and was conducted on a first-come, first-served basis[23] subject to an enrollment limit of 500 submeters for each IOU divided equally among the participating MDMAs. Due to delays associated with submeter certification, the enrollment period was extended six months to August 31, 2016.

In addition to recruiting participants from their existing customer bases, MDMAs also marketed the pilot through EV technology events and online forums for individual EV brands or models—LEAF, Tesla, etc. To enroll, customers were required to fill out a customer enrollment agreement (CEA)[24] with their utility, coordinate submeter installation with their MDMA, and

[21] eMW also offers an integrated submeter with its Level 2 electric vehicle service equipment (EVSE) known as JuiceBox™, but this product was still in the process of receiving UL certification during the enrollment period and therefore did not qualify for use in Phase 1.

[22] eMW provided customers with a choice of having the installation performed by an eMW-contracted electrician for free or contributing up to $100 towards an installation performed by an electrician of the customer's choosing.

[23] The first three months of enrollment were an "Exclusivity Period" during which the MDMAs had "Exclusivity Rights" to their share of the total participants in each IOU's territory. An "Open Period" of enrollment began in the fourth month during which MDMAs were allowed to enroll additional customers beyond their exclusivity rights and up to the 500 submeter limit on a first-come, first-serve basis.

[24] CEAs were similar for each IOU and contained the terms and conditions of the pilot, a list of eligibility criteria, a description of the duties and obligations of the participant and IOU and a form to provide information related to the submeter. CEAs could be rejected by the IOU if customers did not meet the eligibility criteria or if the CEA contained any missing, incorrect or crossed-out information.

create any online accounts needed for the MDMA to verify utility account information—eMW participants only.

Total participation at the end of the enrollment period consisted of 241 customers—132 at PG&E, 92 at SCE, and 17 at SDG&E—who nearly all enrolled during a six month extension to the enrollment period.[25] The majority of participating customers enrolled through either eMW (192) or Ohmconnect (45). Approximately 25% of participants had solar PV systems with a net metering arrangement[26] in addition to their electric vehicle—43 in PG&E, 13 in SCE, and 3 in SDG&E. Phase 1 enrollment is summarized in Table 2-1, which also includes the submeter rates that are available to pilot participants in each territory. The maximum duration for participation in Phase 1 was 12 months and customers were allowed to withdraw from the pilot at any time.[27]

Table 2-1: Phase 1 Enrollment

Utility	Total Enrollment	NEM Customers Enrolled	Enrollments by MDMA			Submeter Rate for Residential Pilot Participants
			EMW	Ohmconnect	NRG	
PG&E	132	43	109	22	1	EV-B (Residential) $20 bill credit (Commercial)
SCE	92	13	71	19	2	TOU-EV-1 (Residential) TOU-EV-3 & 4 (Commercial)
SDG&E	17	3	12	4	1	EV-TOU (Residential) $20 bill credit (Commercial)
Total	**241**	**59**	**192**	**45**	**4**	**N/A**

Enrollment in each IOU territory was significantly below the limit of 500 customers, despite the six month extension to the enrollment period. In response to the lower-than-anticipated enrollment, CPUC and the IOUs considered extending the enrollment deadline for a second time from August 31 to September 30, but ultimately decided to uphold the deadline of the first extension. As such, MDMAs were required to submit all completed CEAs to the IOUs and complete all submeter installations prior to 11:59 PM August 31 in order for customers to participate in Phase 1.

[25] No enrollment took place in the first six months of the enrollment period due to delays associated with submeter UL certification.

[26] Net metered customers are allowed to make up a maximum of 20% of total pilot enrollments in each service territory.

[27] At the time of this report, 12 PG&E participants and 10 SCE participants had withdrawn from the pilot.

3 Evaluation Methodology

There are four principal components of the Phase 1 evaluation. First, a careful analysis of the business processes used by the MDMAs and IOUs was done to understand how submetering was offered to consumers in the context of the pilot. Second, a sample of customers was selected from the pilot to install independent data loggers for the purposes of assessing the accuracy of the submeter measurements. Third, participants were surveyed to gather information about the pilot experience and their satisfaction with the submetering service provided. And finally, PEV customers who are not currently submetered were surveyed to assess customer preferences for submetering and the primary factors that will affect future submetering uptake. This section discusses the evaluation approach for each of these four components in greater detail.

3.1 Submetering Business Models and Operations

For an emerging industry such as electric vehicles, many of the details about the structure of business models and available opportunities involving third party submeters are either new or have yet to be determined. This portion of the analysis involved gathering information on the services offered by each MDMA, characterizing the interactions between the MDMA, utility, and customer and defining the business model employed by each stakeholder under submetering. Due to there being only three commercial participants, this component of the analysis was limited to residential customers.

In order to analyze the business models that were employed by MDMAs—and could potentially be employed in the future—t was necessary to collect information about several aspects of their business operations, including:

- Charging devices and metering technologies offered during Phase 1—including relevant certifications for safety and meter accuracy;
- Business processes required to establish the submetered service—including explanations of:
    - How the submetering device was installed at customers' sites;
    - How MDMAs and utilities coordinated data transfer for customer billing;
    - The systems maintained by both IOUs and MDMAs;
    - The ongoing services provided to customers; and
    - How utilities and/or MDMAs communicated with customers to address questions and concerns.
- Marketing strategies and tactics employed by MDMAs in Phase 1;
- Billing protocols utilized by the IOUs; and
- Additional PEV services offered by MDMAs (if any).

The above information was collected through data requests and phone interviews conducted with representatives from each MDMA and IOU individually. The stakeholders who were interviewed for this part of the evaluation are shown in Table 3-1.

Table 3-1: Stakeholder Interviews Conducted for Phase 1 Evaluation

Organization	Person(s) Interviewed	Title/Role	Interview Date
Ohmconnect	Matt Duesterberg	Co-Founder/CEO	11/10/15
eMW	Val Miftakhov	Founder/CEO	11/6/15
	George Betak	VP, Business Development & Community	
	Alan White	EVP, Energy Markets	
NRG	Paul Glenney	Project Manager for Submetering Pilot	11/3/15
	Mehr Kouhkan	Marketing, EVgo	
PG&E	Morgan Davis	Project Manager for Submetering Pilot	11/10/15
	Terri Olson[28]	Consultant	
	Ryan Mullikin	Billing Operations	
SDG&E	J.C. Martin	Project Manager for Submetering Pilot	11/5/15
SCE	Al Shepetuk	Project Manager for Submetering Pilot	11/6/15

Interviews lasted for 30 to 60 minutes and focused primarily on the operations, marketing activities, and customer service of the IOU/MDMAs during Phase 1 of the pilot—including enrollment. Additional topics of interest included how each stakeholder interacted with customers, the effectiveness of MDMA/IOU cooperation, and any particular challenges that were encountered during the pilot. Separate banks of interview questions were prepared for the MDMAs and IOUs, which are provided in Appendix A.

After completing each interview, notes were compiled and cross-checked against other interviews for potential areas of consensus and/or disagreement. Further analysis summarized the most challenging aspects of the pilot for each stakeholder and the areas where operations could be improved for Phase 2. Finally, information on business models and future service offerings served as the basis for assessing conflicting incentives among stakeholders that were present and new applications for PEV submetering services that may become available to customers. The information gathered during the interviews was not only valuable for analyzing business models, but also informed the development of the surveys used to evaluate the customer's experience during the pilot.

[28] Ms. Olson was the PG&E project manager for the submetering pilot until December 2014. She currently works at the consulting firm Utilligent.

3.2 Submeter Accuracy

For Phase 1, a threshold of +/- 5% was set to be the maximum allowable error tolerance for participating submeters.[29] There were two distinct submeters involved in Phase 1—one offered by eMW/Ohmconnect (WattBox™) and a second offered by NRG. To evaluate the accuracy of these devices, data loggers were installed at a sample of 34 participant premises to determine whether each device met the +/- 5% accuracy threshold. In addition to assessing individual submeters, the entire sample was used to estimate the proportion of submeters in the pilot population that met the accuracy requirement. Because NRG had only three residential customers enrolled in the pilot, all NRG customers were included as part of the accuracy sample.

Early on, MDMAs were able to successfully deliver data for installed submeters, but not without some data quality issues. Two issues that were specifically mentioned by the IOUs were that submeters measured higher usage than their upstream whole-house meter and that submeters were not always appropriately synchronized with the utility whole-house meter. In light of these early integration issues, two months of submeter data from late in Phase 1 were used to achieve the best estimate of long run submeter accuracy. Analysis was performed at the individual customer level and results for individual submeters were pooled to provide an estimate of the fraction of all installed submeters that do not meet the 5% accuracy threshold.

3.2.1 Logger Installation and Recovery

A fleet of Onset Hobo HK-22 Microstation data loggers configured to measure current flowing on 50 amp circuits—i.e., 240 volt circuits that are normally used to supply residential and commercial AC loads—was used for accuracy assessment. These devices are capable of measuring the electric load on circuits to within plus or minus approximately 1% at intervals ranging from seconds to hours over a period of up to one year. Loggers were set to collect data at 15 minute intervals to match the interval of participating customers' whole-house meters and submeters.

Customer recruitment and installation scheduling were managed by Nexant's PRS laboratory, while logger installation and retrieval were performed by Nexant engineering staff. Recruitment began in November 2015 and installations occurred on a rolling basis during December 2015. Prior to installation, all loggers in the study were inspected, bench tested, and calibrated for accuracy. As part of this process, new batteries were installed in each logger to ensure that it was in good working order and would operate throughout the expected duration of the field test. Engineers returned to pick up the loggers in late February 2016 and sent them to Nexant's San Francisco office in March, where the recorded data was downloaded and combined with submeter usage information provided by MDMAs in preparation for analysis.

3.2.2 Accuracy Measurement

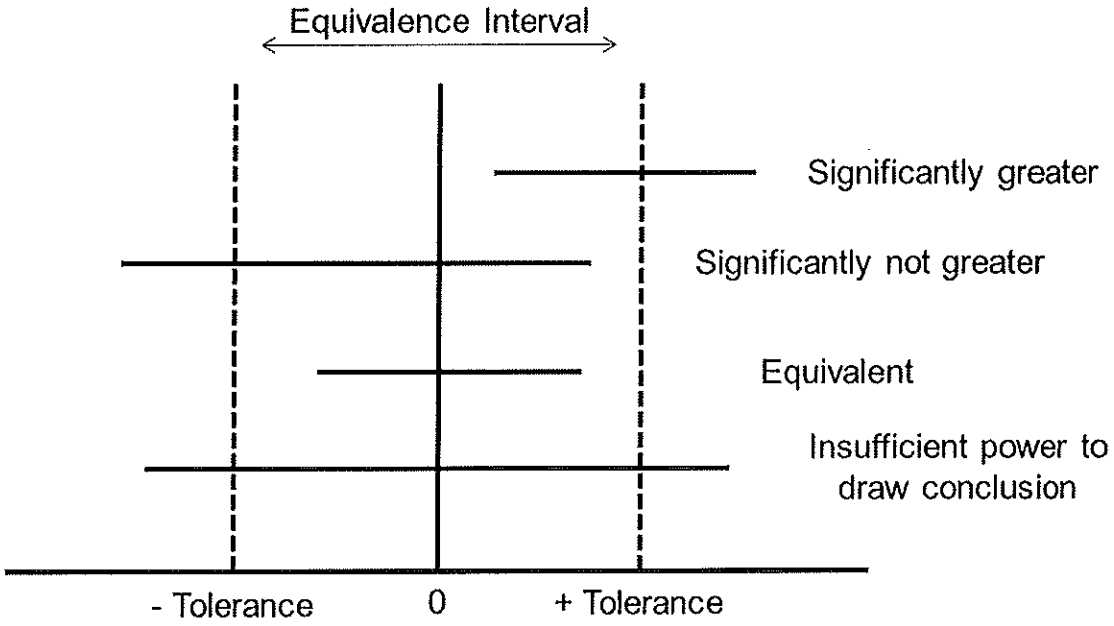
Meter accuracy was determined for each submeter by comparing the information obtained from the logger for the relevant measurement period with the usage measurements for the same

[29] This 5% accuracy tolerance is a significantly lower bar than the 0.5% tolerance that exists for residential utility meters.

period supplied by the MDMAs.[30] The analysis utilized an equivalence testing approach for kWh measurements in which the null hypothesis was that MDMA submeters were *not* accurate to within +/-5% and the alternative hypothesis was that they did meet the accuracy threshold.[31] Such an approach was better suited to accuracy assessment than more traditional hypothesis testing because it placed the burden of proof on the new meters and used the data to confirm the outcome of interest rather than fail to reject it.[32]

Equivalence tests were conducted using mean values and repeated measures to assess accuracy on a meter-by-meter basis. Using means, an equivalence band of +/- 5% was defined within which the submeter would be considered accurate. Based on the equivalence band, a confidence interval was calculated for the difference between the mean submeter and logger measurements. In situations where confidence interval lied entirely within the equivalence band, the null hypothesis (inaccuracy) was rejected and a submeter was classified as accurate. This approach is equivalent to conducting two one-tailed hypothesis tests simultaneously[33] and is shown graphically in Figure 3-1.

Figure 3-1: Conceptual Depiction of Equivalence Testing for Two Means



[30] This is the same data that was transferred to the IOUs for billing purposes.

[31] For a primer on equivalence testing, see Rogers et al. (1993) "Using Significance Tests to Evaluate Equivalence between Two Experimental Groups".

[32] In a traditional hypothesis testing framework, the null hypothesis would have been that there was no difference between the logger and the submeter measurements. The p-value associated with such a test can be interpreted as the probability that any observed difference occurred by chance. A high p-value above the standard 0.05 or 0.10 thresholds does not confirm that the null hypothesis is true, but rather fails to provide evidence that it is false (statistically, these two things are not equivalent). Equivalence testing avoids this problem by setting up the problem up in such a way that a small p-value provides more direct evidence that that the submeter is accurate within the acceptable range.

[33] The two tests are that the mean difference between submeter and logger readings is greater than the lower bound of the equivalence band and less than the upper bound.

To conduct the equivalence test using the full set of repeated measurements for the logger and the submeter, logger measurements were regressed on submeter measurements.[34] In this case, a confidence interval for the estimated slope coefficient from the regression was compared to an equivalence band of +/- 5% defined around the 45 degree line. Similar to the means case, a confidence interval that lied entirely within the equivalence band for both parameters resulted in rejecting the null hypothesis and concluding that a submeter was accurate to within +/-5%. Using the accuracy results at the individual submeter level, the fraction of submeters in the population that met the 5% accuracy threshold can be estimated as the total number of submeters in the sample classified as accurate divided by the sample size.

3.3 Customer Experience

To evaluate the customer experience, web-based surveys were used to collect information on various aspects of the pilot, including motivations for signing up for submetering, knowledge of submetering processes, customer service, problems encountered, and whether or not customers were satisfied with their submetering service. These topics are shown in Table 3-2.

Table 3-2: Topics for Customer Experience Survey

Topic	Evaluation Metrics
PEV Characteristics	Number of PEVs, make/model/year, miles driven per week and charging details
Motivations for Submetering	Identify the motivations the customer has to use submetering of PEV
Customer Knowledge	Measure the level of customer understanding of the submetering processes and TOU rates
Customer Satisfaction	Measure customer satisfaction with the submetering services provided by MDMAs and IOUs as well as their overall satisfaction with the Pilot
Issue Resolution	Identify the number, frequency and type of customer issues related to metering accuracy, data accessibility and billing
	Evaluate ability of Submeter MDMAs and IOUs to resolve customer issues

Due to the limited enrollment in Phase 1, it was necessary to recruit as many customers as possible for the participant survey to in order to obtain statistically valid results. To avoid overexposing participants to recruitment efforts for the different components of the evaluation and achieve the high response rates needed for the analysis, recruitment activities for the participant surveys and accuracy assessment were conducted jointly.

[34] For a primer on these methods, see Robinson, et al. (2005), "A regression-based equivalence test for model validation: shifting the burden of proof".

3.3.1 Survey Implementation

The participant survey was announced by a letter[35] delivered to all Phase 1 pilot participants by U.S. Mail. The letter was posted on November 18, 2015 and invited Phase 1 participants to complete two surveys online—one in 2015 and another in 2016—about their experience in the pilot. Customers were informed that they would receive a $25 check for completing each survey. Because email addresses were available for all pilot participants, invitations containing links directing the participant to the survey were sent via email as a follow-up on November 20. Reminder emails were sent to customers who had not yet completed the survey by December 1 and December 8. Additionally, customers who had not completed the survey by December 2 received a telephone call to remind them to complete the survey.

As of December 15, 2015—25 days after launch—a total of 210 surveys had been completed out of a total of 241 survey invitations sent for an 87% response rate. Response rate varied only slightly across the three IOUs with the highest response rate at SCE (89%) and the lowest at PG&E (86%). Table 3-3 presents a summary of participant survey response rates by IOU. The median completion time for the survey was approximately 12 minutes.

Table 3-3: Pilot Participant Survey Response Rates by IOU

IOU	Surveys Sent	Surveys Completed	Response Rate
PG&E	132	113	85.6%
SCE	92	82	89.1%
SDG&E	17	15	88.2%
Total	**241**	**210**	**87.1%**

Nearly all Phase 1 pilot participants (97%) had their submeters installed by the end of September 2015. The results presented in Section 4 therefore reflect Phase 1 pilot participants' experiences and opinions after at least two and a half months—and up to eight months for some participants—of enrollment in the pilot. The follow-up survey in 2016 will collect similar information in order to evaluate how, if at all, the customer experience in these areas changed during the course of the pilot. A copy of the full participant survey instrument is provided in Appendix B.

At the conclusion of the customer experience survey, respondents were provided information about the accuracy assessment portion of the evaluation and given an opportunity to declare their interest in participating by providing their name and phone number. Customers who provided their information were used as the recruiting pool for the accuracy assessment and were contacted by Nexant via phone at the number provided to schedule a data logger installation (see Section 3.2.1).

[35] The invitation letter contained CPUC and Nexant co-branding and signatures.

3.4 Factors Affecting Future Submetering Adoption

In addition to evaluating the experience of participants, Phase 1 of the pilot provided a unique opportunity to study the features that will drive the future uptake of submetering arrangements in California. At present, experience marketing PEV submetering is very limited and there is almost no information about how PEV owners think about EV-TOU rates and submetering. To address this, surveys were designed to allow for a conjoint analysis capable of producing quantitative estimates of the relationships between different submetering characteristics and the probability of a customer enrolling in a submetering plan with a TOU rate for their PEV.[36] The survey was targeted at current PEV owners for each the three IOUs. In total, 8,001 qualified current residential customers in this group were invited to complete the PEV survey in February 2016. The survey was closed in early March 2016, at which time 626 qualified respondents had completed it.

In order to address all of the key research questions defined above, it was necessary to test many submetering plan options. To accommodate this complexity, an adaptive conjoint design was chosen. A detailed description of the adaptive conjoint design used for Phase 1 along with the methodology used for analysis is provided in Appendix C. The remainder of this section describes the overall design of the survey and its implementation.

3.4.1 Conjoint Survey Implementation

Sampling

The survey was targeted at a portion of the IOU residential population consisting of customers who were likely to own PEVs, not currently enrolled in a special EV rate, and did at least some amount of charging at home. These customers were identified with the help of datasets from the IOUs consisting of likely EV customers based on analyses of load shape patterns and customers who contacted the IOUs but were not participating in the Phase 1 Pilot. These datasets largely excluded multi-family residences but included net metered customers since a non-negligible portion of likely PEV owners are also net metered. Each utility classified these customers by PEV ownership likelihood and a group of 8,001 (2,667 from each IOU) randomly sampled customers was selected for use in the research study.

Survey Fielding and Response Rates

Table 3-4 summarizes the implementation timeline for the PEV survey. Development of the survey instrument itself included a thorough vetting process, which included Nexant research experts and PEV stakeholders. Nexant programmed the survey, including thorough testing of data recording and logic by survey fielding specialists. The language and appearance of recruiting materials and survey instrument were carefully reviewed by the core project team.

[36] Often, the choices observed in a conjoint study are calibrated to observed choices in the real world before they are used to forecast future customer adoption decisions. Due to the limited amount of data available, however, calibration of the stated preference approach in each IOU territory was not possible so responses were calibrated to anchor questions in the survey about the likelihood of enrolling in submetering.

Table 3-4: Implementation Timeline for Survey

Implementation protocol	Date
Mailed letter invites including a $20 contingent incentive	Sent 2/17, arrived 2/19-2/20
Reminder email to incompletes and non-responders (PG&E and SDG&E only)	2/24
Reminder email to incompletes and non-responders (SDG&E only)	3/3
Survey closed	3/8

The research was designed to provide statistically reliable results with 200 responses in each segment (IOU). While response rates can be quite high with small non-contingent incentives of $2 to $5, research also shows that response rates are much higher when contingent incentives of much higher amounts—e.g., $20—are used. Because of the short fielding timeline and the possibility that a majority of customers solicited would not qualify for the survey,[37] invitees were offered a $20 contingent incentive check from Nexant in return for completing the survey.

The responses for SCE surpassed the target of 200 within the first day of the survey due to a high qualify rate. After this point, new entrants to the survey from SCE received an over quota message and were not able to begin the survey. To bring responses closer to the target 200 for the other IOUs, email reminders were sent to the subset of PG&E and SDG&E customers with email addresses on file. The survey remained open until March 8, 2016 at which point sufficient sample had been collected for all test cells.

Table 3-5 summarizes responses for the PEV survey overall and within each test cell. Table 3-6 summarizes the response rates, qualify rates, and completion rates for the survey. Nexant received 626 responses from participants including over 200 each from PG&E and SCE and 184 from SDG&E.[38]

Table 3-5: Response Summary for PEV Survey

Test Cell	PG&E	SCE	SDG&E	Total
Invitations sent	2,667	2,667	2,667	8,001
Responses received	452	691	584	1,727
Over-quota	1	419	0	420
Disqualified	193	11	328	532
Incomplete	49	28	72	149
Complete	209	233	184	626

[37] To qualify respondents needed to be current PEV owners that do at least some of their charging at home

[38] This was close enough to 200 to yield statistically significant results.

As shown in Table 3-6, the overall response rate was 22%. Response rate was highest for SCE customers despite the fact that this group did not receive any email reminders. Because email reminders were not sent to customers of all utilities, response rates cannot be compared between utilities. Furthermore, it is important to keep in mind that the survey only remained open for 18 days due to the constrained project schedule. Nexant typically keeps surveys open for longer periods of time—e.g., for four to six weeks—which usually results in much higher response rates. Despite the short fielding duration, response rates are still high enough to assuage concerns of response bias.

Table 3-6: Response Rate Summary for PEV Survey[39]

Test Cell	PG&E	SCE	SDG&E	Total
Response rate	17%	26%	22%	22%
Qualify rate	57%	96%	44%	59%
Complete rate (among qualified)	81%	89%	72%	81%

As noted above, the sample target for SCE was filled within two days of fielding. An assessment of qualify rates provides a possible explanation. At 96%, qualify rates for SCE invitees were nearly twice as high as they were for the invitees from the other two utilities. While it is not possible to know for sure, it is possible that response rates were higher for EV owners than for non-EV owners. If nearly all SCE invitees were EV owners compared with roughly half of customers from the other two IOUs, it is plausible that this explains the higher response and qualify rates for this group.

Survey Mode

As detailed above, an adaptive, computer-based design was chosen to support the complexity of the attribute levels being tested. The adaptive design means that the survey is uniquely tailored to each respondent so that the choices made in certain questions influence what is shown in following questions. The computer based design also incorporated interactive features such as establishing an estimated monthly charging cost for each respondent. This was based on each respondent's estimated marginal electricity rate—the middle tier of each respondent's rate—and a set of questions used to estimate monthly miles driven. Because of its adaptive, computer-based nature, the survey could only be administered via the internet—and not via a paper booklet or over the phone. Due to the complexity of some tasks that would have been too burdensome to read, customers were also not able to call in and complete the survey over the phone.

The advantages of the adaptive design were deemed to outweigh any potential selection bias that could result from single mode fielding because the population of interest—customers with PEVs—is likely to be familiar with digital technology and regularly use the internet. Moreover,

[39] See Table 3-5 for sample sizes pertaining to each row. For example, the relevant sample sizes for response rate are in the "Invitations sent" row.

the fielding protocol was designed to reduce survey coverage error as respondents were recruited through the mail and were still able to call-in to ask questions or receive assistance in accessing the survey. Any customers who did not have internet access were encouraged to call a designated hotline. Of the 8,001 customers invited to complete the survey only 1 called in to report a lack of internet access.

An additional feature of the survey was that it was mobile friendly. Because EV owners are typically more tech savvy than the general population, additional care was given to ensure that the survey experience was fully mobile compatible, including testing on medium sized smart phone screens. Table 3-7 summarizes the operating systems used by respondents. Operating systems are compared for respondents who completed the survey as compared to all other respondents to identify any significant differences. The percent of respondents accessing the survey from a mobile device was virtually the same for completing respondents (18%) as for all other respondents (19%), which validated the development effort put into this feature.

Table 3-7: Percent of Respondents Using Different Operating Systems

Type of Operating System	Operating System	Completes	All other responses[40]
Mobile Operating Systems	Android	3%	3%
	Chrome	1%	1%
	iPad	9%	7%
	iPhone	5%	9%
Desktop Operating Systems	Linux	1%	0%
	Mac OS	31%	26%
	Windows	50%	54%

3.4.2 Survey Instrument Design

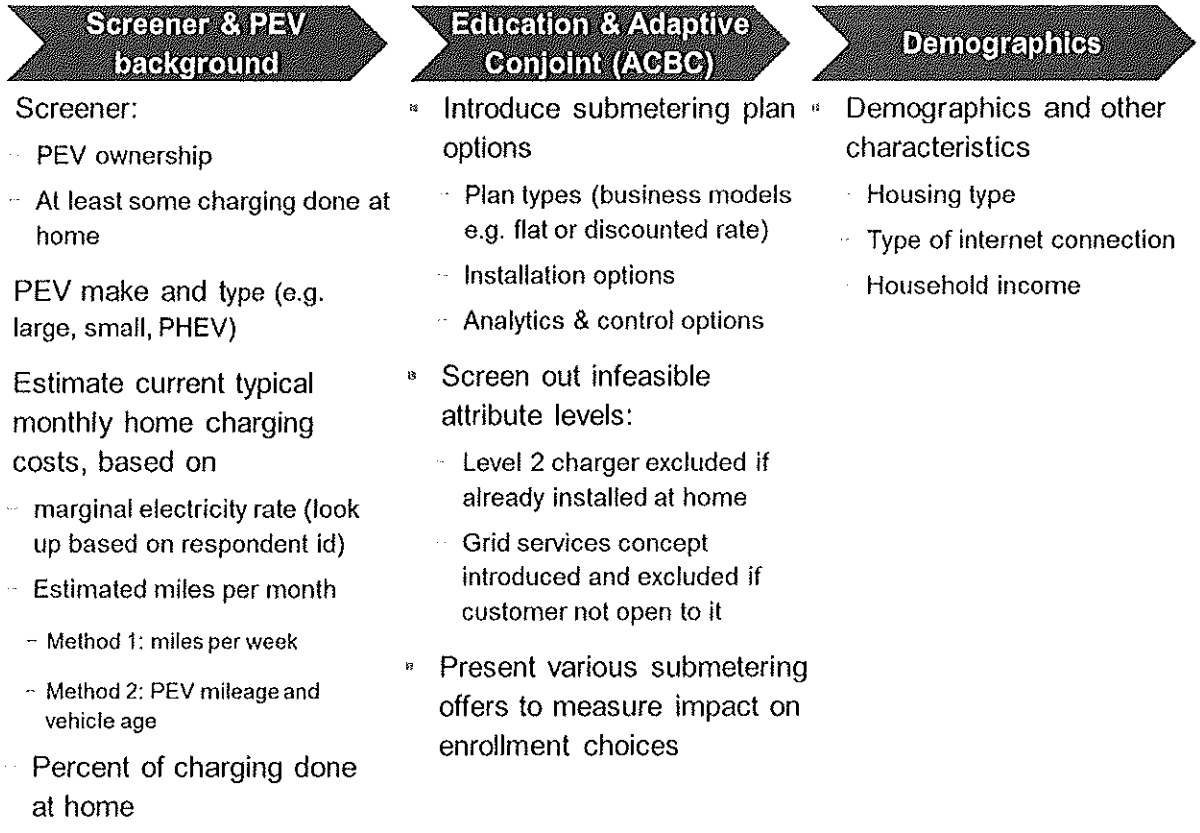
The PEV survey instrument used a computer-based, adaptive design to collect data on customer preferences for a variety of potential submetering plan design parameters. In order to collect valid data it was necessary to ensure all respondents had a basic level of understanding and familiarity with both the general concept of submetering and the specific parameters respondents were being asked to evaluate. As such, the survey instrument included the sections shown in Figure 3-2, with the following purposes:

- **Screener & PEV background**:
  - Screen out respondents who do not currently own a PEV or who do not do at least some charging at home
  - Background on type of PEV and typical miles driven to estimate typical monthly charging cost—respondents were asked to confirm validity of estimate and allowed to change it, including reducing to $1

[40] Includes incompletes, over-quota, and disqualified respondents

- **Education and Adaptive Conjoint**:
  - Introduce submetering options to ensure respondent familiarity with the parameters to be tested in the conjoint
  - Filter out unfeasible levels for each respondent
  - Use adaptive choice-based conjoint (ACBC) exercise to gauge enrollment choice impact of each option for each attribute
- **Demographic questions:**
  - Collect key demographic data and household background relevant to submetering

Figure 3-2: Overview of Survey Design



4 Results

The evaluation activities for Phase 1 produced a large amount of primary data to investigate the research questions described in Sections 2 and 3. This section presents and discusses the results for each of the four primary components of the evaluation.

4.1 Submetering Business Models and Operations

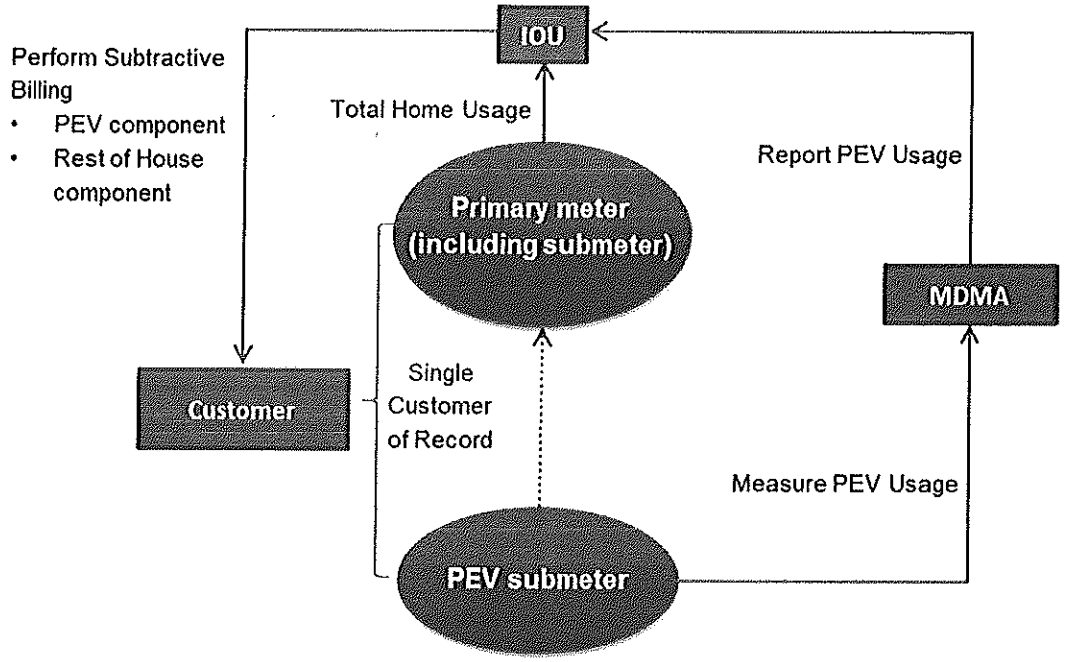
A crucial part of evaluating potential business models and opportunities was to understand the relationships between each stakeholder and identify relevant incentive structures. Figure 4-1 depicts these relationships for Phase 1 of the pilot in which a single customer of record was responsible for paying for all of the electricity consumption at a premise.[41] Participating customers in Phase 1 were almost entirely[42] residential customers living in a single/multi-family homes.

Electricity consumption data at a premise with submetering comes from two sources—the submeter and the primary meter for the premise, which includes the PEV usage. For the purposes of billing, the primary role of the MDMA was to provide the IOU with accurate measurements of PEV electricity usage in a format that was compatible with the premise's primary meter—15 minute intervals. The IOU then took the PEV usage in each interval and subtracted it from the primary meter to identify the amount of electricity used by the rest of the house and calculate a bill for each source using the appropriate rate. This process is known as subtractive billing, and once the two bills have been calculated, they were combined into a single document and sent to the customer for payment.

[41] Master metered premises were not eligible for Phase 1 of the pilot.

[42] One commercial customer enrolled in Phase 1 of the pilot, but was excluded from the analysis for obvious statistical reasons.

Figure 4-1: Activities and Responsibilities for Submetering Stakeholders in Phase 1



It is possible to have a PEV enrolled in a TOU rate and the rest of the home on a different rate without submetering; however, this requires customers to install a second utility-grade meter at their premise. Second meters cost thousands of dollars[43] and as a result, enrollment in separately metered rates has been low. Most PEV customers chose between one of two options for paying for their charging at home:

1. Remain on the same rate as before acquiring a PEV (typically a tiered rate); and
2. Enroll in a TOU rate that applies to the entire home (including the PEV).

These two options represent a tradeoff between gaining access to a low off-peak price beneficial for PEV charging and avoiding high prices during peak times that would increase the cost of afternoon and early evening usage that can't be shifted. Giving PEV customers a third option that eliminated this tradeoff at low cost was one of the primary motivations for conducting the pilot and including non-utility submeter providers.

Providing the submetering service, transferring the data, and performing the subtractive billing for the 241 participants in Phase 1 required substantial effort and coordination between the MDMAs and IOUs. The remainder of this section provides detailed descriptions of how each of the core tasks was carried out by the MDMAs and IOUs along with the challenges that were encountered.

[43] This cost likely varies substantially for different customers, but includes the cost of the meter itself, all applicable permits, compliance with electrical codes and the labor costs associated with installation.

4.1.1 Technology Development

A prerequisite for providing submetering service is having a submetering product available for customers to install that is low-cost, safe, and reliable. All hardware for the pilot was required to be UL-certified to ensure the safety of pilot participants. UL-certified submeters for PEV charging were not on the market at the outset of the pilot and needed to be designed, built, and certified by the MDMAs. eMW and NRG took different approaches to technology development, which resulted in different experiences for each company. These experiences are presented as case studies below.

eMW

eMW is a privately held company based in San Carlos, CA that operates a network of distributed load control devices used to provide grid stabilization services to Independent System Operators (ISOs), utilities, and large commercial electricity consumers. The company's current offerings include EV charging stations with grid management and user-facing control features that are managed through a proprietary cloud-based platform. The grid management services provided by eMW include demand response, frequency regulation, peak shaving, and local load balancing to help utilities and ISOs better manage the grid volatility and increased EV adoption.

For the submetering pilot, eMW developed a standalone submetering product in-house called the WattBox-200, which featured Wi-Fi data telemetry and secure data storage. The built-in Wi-Fi transferred usage data from the submeter to eMW's servers and also provided access to several advanced energy management features such as access to real-time and historical energy use data via website or Smartphone and automatic notifications for when power exceeded/fell below a given threshold or energy use occurred outside of prescribed hours.[44] eMW estimated that the production of its WattBox™ submeter cost approximately $200/unit with additional overhead costs of $50/unit. These costs were approximately offset[45] by a one-time incentive payment of $212/unit and recurring incentive of $17.50 per month from the IOUs during Phase 1.

In addition to the WattBox, eMW also manufactures an integrated submeter with Level 2 EVSE called the JuiceBox™. Launched through a successful Kickstarter campaign in 2013, the JuiceBox provides high-power, Level 2 charging capable of up to 10kW and 40 Amp output with Wi-Fi remote telemetry, direct user controls, and advanced smart grid optimization features.[46] Although eMW hoped to offer the JuiceBox to customers in the pilot alongside the WattBox, it was still going through the UL-certification process during the enrollment window and was therefore not eligible for Phase 1.

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[44] See https://emotorwerks.zendesk.com/hc/en-us/article_attachments/203870048/WattBox_Installation_Instructions_Draft_v26.pdf for a full list of WattBox-200 features.

[45] The submetering pilot was revenue neutral to slightly negative for eMW.

[46] See http://emotorwerks.com/index.php/juicebox for additional details.

eMW learned of the submetering pilot soon after beginning a partnership with Ohmconnect, an energy services company that monitors real-time power market conditions and participates in CAISO's ancillary services markets by aggregating load reductions from smart thermostats, smart plugs and electric vehicles in its customer network.

NRG

NRG currently operates the largest DC fast-charging network in the United States (eVgo) and has established business relationships with large auto original equipment manufacturer (OEM) dealerships including Nissan, Ford, and BMW. New Nissan LEAF owners are eligible to participate in the "no charge to charge" program where they receive 24 months of free access to the eVgo charging network. New Ford and BMW EV owners have similar programs available to them. Through these business relationships, NRG gained experience with a UL-certified Level 2 EVSE charging unit manufactured by Lite-On that contained integrated metering and 3G wireless communication capabilities.

After learning about the submetering pilot,[47] NRG contacted Lite-On about supplying EVSEs that could be offered to customers as part of Phase 1. NRG's strategy for recruitment was to initially offer these EVSEs internally to NRG and Gridscape[48] employees to test their functionality and assess the associated customer experience. After this small-scale initial deployment, the plan was to roll them out to the mass market through their existing OEM dealer relationships.

After receiving the EVSE charging units with integrated submeters from Lite-On for internal participants, NRG identified several performance issues with the devices. The delivered EVSEs were only capable of 2G communications instead of the 3G communications capability that was expected. A significant problem with the 2G technology is that it is being phased out by many communications providers and is scheduled to become entirely defunct on January 1, 2017. As a consequence, the charging stations supplied by Lite-On were already technically obsolete when they were delivered and will be completely unusable 18 months after delivery. In addition, NRG employees testing the Lite-On charger experienced irregular charging performance when the chargers stopped charging unpredictably, would not adhere to a set timer program, and created other "unsafe" charging experiences.

As a result of these issues, NRG replaced all of the existing Lite-On charging units in their eVgo network—approximately 500 EVSEs—and suspended their plans to offer submetering services to additional customers in Phase 1—internal participants remained in the pilot. This was done to avoid the risk of negative customer experiences with a new product that could negatively affect the company's brand. High customer satisfaction is central to the company's business model and the risk of damaging it outweighed any potential benefits of offering the integrated submeters to external customers. Despite the technical issues encountered in Phase 1, NRG remains very interested in participating in Phase 2 of the pilot, as are its OEM dealership partners.

[47] NRG received a lot of interest in the pilot from customers who learned about it from CPUC/IOU websites.

[48] Gridscape is a 3rd party partner of NRG's that supplies the cloud services used to transfer data back and forth between the EVSE and the utility.

4.1.2 Pilot Enrollment and Establishing Submeter Service

Due to NRG's decision to limit Phase 1 participation to its own employees, analysis of the enrollment process is focused on the experience of eMW/Ohmconnect and the three IOUs. Recruitment of pilot participants was conducted by the MDMAs, who then also helped customers through a formal enrollment process with their IOU. Although eMW and Ohmconnect proactively reached out to their existing customers and advertised for the pilot through online PEV forums, the majority of Phase 1 participants found out about the pilot through dedicated pages on the CPUC/IOU websites and initiated contact with the MDMAs and IOUs.[49]

To be eligible to participate in the pilot, customers were required to complete a CEA and meet the following criteria:

- Have an active service account with their IOU;
- Have an eligible interval data recorder meter—i.e., smart meter;
- Charge a PEV at their account;
- Have an approved submeter installed for the exclusive use of tracking the energy used to charge the customer's PEV;
- Be a bundled service customer or community choice aggregation (CCA) customer; and
- Not participate in any automatic payment plan options[50] offered by the IOU.

The enrollment process consisted of several manual steps, which combined with the division of labor between the MDMAs and differing legal interpretations by the IOUs, led to frustrations between stakeholders and/or processing delays for customers. After contacting an MDMA to express interest in the pilot, customers first created an online account[51] and went through a pre-qualification check to make sure that they met the eligibility criteria and could have a submeter successfully installed at their premise. Once this sign-up was completed and a customer purchased a submeter, the MDMA arranged a submeter installation appointment and emailed the customer a blank CEA to complete.[52]

After having their submeter installed, customers formally enrolled in the pilot by completing a customer enrollment application (CEA) with assistance from the MDMA, who submitted them to the appropriate IOU for approval. Applications were submitted to the IOUs via email as scanned

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[49] See http://www.pge.com/en/myhome/saveenergymoney/pev/submetering/index.page (PG&E), https://www.sce.com/wps/portal/home/residential/electric-cars/residential-rates/ev-submeter-pilot/!ut/p/b1/hdDLboMwEAXQr2GLLzYNTndGscAuDU2hKfGmIhUlVARHhIbfL42y6Xt2Mzp3pBliSEFMV56auhwa25XtR29mT1othBf5VlFrCZGxVIZJTEH9CWwmgF9K4L_8IzFn4vFlxCqDih5yARUuQi--VcDS_wp4HskJ3GC-vqPMD4JvG-4DCqXXMkIDj4LTC5hHkLFOJ5CvGBRbYZkJwYDZBfxxhSambu32_JGN6LaM18TO1UvVV7371k_j3TAcjtcOHIzj6NbW1m3IPtu9g58iO3scSPFZksO-QKNer9pTlt4B8sQsyQ!!/dl4/d5/L2dBISEvZ0FBIS9nQSEh/ (SCE), http://www.sdge.com/clean-energy/ev-driver-pilot-program (SDG&E), and http://www.cpuc.ca.gov/general.aspx?id=5938 (CPUC).

[50] These include the "Balance Payment Plan" or "Automatic Payment Plan" options offered by PG&E, the "Level Pay Plan" or "Direct Pay Plan" options offered by SCE and the "Level Pay Plan" or "Online Automatic Payment" options offered by SDG&E. Customers who were enrolled in any of these programs could de-enroll temporarily in order to participate in the pilot.

[51] This step was not necessary for existing eMW customers.

[52] Customers were also encouraged to sign up for Ohmconnect's standard service at this time.

PDF documents. The IOUs reviewed the completed CEAs and communicated any problems/issues back to the MDMA, who would then relay the message to their customers.

Due to differing interpretations of the CEA's legal importance for each IOU and the lack of an automated online system to process applications, submitted CEAs often needed to be sent back to customers for revisions[53] because they were incomplete or required corrections to minor issues such as improper address abbreviations, using shortened versions of a customer's name—e.g., "Bill" rather than "William"—or not submitting the pages of the CEA containing the terms and conditions, liability waiver, warranty disclaimer, etc. that did not require explicit responses from the customer. These errors occurred in spite of training that was provided to the MDMAs by the IOUs to help guide the completion of the CEAs. Resubmitting CEAs required additional back and forth between MDMAs, customers, and the IOUs. Given these complex logistics and the small number of MDMA/IOU employees participating in the pilot, the enrollment process took anywhere from several days to several weeks to complete.

4.1.3 Data Transfer and Subtractive Billing

To become an official MDMA in Phase 1 of the pilot, the MDMAs were required to go through testing with each of the three IOUs to demonstrate their ability to deliver data in a format that could be used for billing. Data transfer protocols during the testing phase mirrored the actual data transfer process in many respects. Individual data files were sent for each customer via secure file transfer protocol (SFTP) containing usage data for the submeter in 15 minute intervals along with a unique universal ID number attached to every interval.

Pre-pilot testing uncovered a variety of issues that needed to be addressed and as a result took six to eight months to complete. Obstacles included difficulties in setting up the SFTP, transferring data in a format that was compatible with IOU billing processes, clock synchronization issues with submeter intervals, and a rogue de-enrollment process[54] that was triggered when accessing certain customer accounts. Resolution of these issues required extended efforts by the IOUs to educate MDMAs that contributed to the long duration of the testing period, but by the end of the testing phase the MDMAs were able to successfully transfer data to each IOU.

Upon approval of the CEAs, the MDMAs began sending submeter data to the IOUs on a daily basis. The IOUs inspected the data to verify it was in the correct format and not missing any intervals. In the event that any issues were discovered, the IOUs would notify the MDMA of the problem and work with them to find a solution. Completed CEAs also established an official pilot "start date" for each customer based on their individual billing cycle. Because enrollments naturally occurred in the middle of billing cycles, customers received their first bill containing the submeter usage after their first full bill cycle in the pilot.[55] Launching a subtractive billing process

[53] 56 of the 92 customer agreements for SCE needed to be resubmitted by the MDMAs.

[54] This issue affected only 7 customers at SDG&E and was quickly resolved.

[55] For example, if a customer's CEA was accepted on July 21 and their current bill cycle ended on July 29, then the first bill that included submetering would not be sent until after the following bill cycle (e.g. July 29-August 31).

was an upfront investment for each IOU that was not built into existing billing processes for practical reasons.[56]

As a result, each IOU built systems to incorporate data from the MDMAs into a subtractive billing process that was conducted outside of their core billing systems. Given the uniqueness of each IOU's systems, different solutions were implemented with varying degrees of automation, but a common experience was the need to educate MDMAs about how the billing process works[57] and the associated data requirements. The following subsections detail the experience of each IOU in performing subtractive billing during Phase 1.

PG&E

PG&E leveraged a rarely used feature of their customer information system (CIS) as the basis for designing a new computer program to perform subtractive billing calculations.[58] The new routine involved several manual steps that were outside normal billing operations, including the subtraction itself, which was done for every 15 minute interval. Performing subtractive billing at the 15 minute interval level required the data for all intervals to be in the same format,[59] which required additional data validation steps for both the submeter data provided by the MDMA and interval data from PG&E's meter data management system.

The construction of the subtractive billing process was an iterative effort that required fixes early on in the pilot to address data issues that were uncovered. As the pilot continued, PG&E was able to automate several steps of the process to improve speed and reliability, but some steps remained mostly manual—e.g., dealing with estimated meter reads in whole-house data. In PG&E's assessment, additional automation will be needed to further improve the reliability of the subtractive billing process.

SCE

Similar to PG&E, subtractive billing was an entirely new process for SCE. Unlike PG&E, however, SCE managed the new stream of submetering data in a more automated fashion rather than performing the majority of tasks manually. This involved software changes within SCE's data system and setting up a new account for each pilot participant to manage PEV submeter usage and whole-house usage separately. While much of the data management was able to be automated, the subtractive billing process itself was still performed manually by a member of the project team. SCE estimates that fully automating the subtractive billing process would cost tens of millions of dollars and take several years to complete.

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[56] As stated in R.09-08-009, "Prior to making significant capital upgrades to the utility billing process, the Commission wants to understand the demand for submetering, evaluate the costs of a billing system, and determine how that cost will be assigned."

[57] This included the timing of when customers would receive their first submetered bill, helping customers understand what rate they were on and whether changes were being made to their account, specific data formatting necessary to integrate with IOU billing systems, electronic vs. paper bills, etc.

[58] The referenced CIS feature had previously been used only with monthly data, not 15 minute interval data.

[59] This was an issue for the small percentage of intervals from PG&E smart meters that contain estimated meter reads for the whole-house as well as any missing submeter reads.

During the course of Phase 1, SCE encountered a synchronization issue with the submeter clocks when compared to the whole house meter clocks.[60] This led to some 15 minute intervals showing submeter measurements that were larger than the whole house measurements. As a rule, SCE rejected any submeter measurements where this occurred and billed all usage for those intervals on the whole house rate. Per the PEVSP tariff, any incorrect bills due to data errors of this kind were not updated retroactively in the event that the submeter data was corrected at a later time.[61]

SDG&E

Unlike PG&E and SCE, SDG&E had some previous experience with submetered PEVs prior to the pilot from another pilot that was conducted for estimating the impacts of TOU pricing on EV charging behavior.[62] Because of this, much of the subtractive billing process for Phase 1 fit into SDG&E's existing systems. The key new development work needed consisted of adapting the existing system to incorporate a new data stream from the MDMAs. Data received from the MDMAs was not integrated into SDG&E's other data systems—per the rules of the pilot—and was therefore stored on a separate server from the whole-house data recorded by SDG&E's smart meters.

The subtractive billing calculation itself was automated and triggered manually by a member of the SDG&E pilot team based on the end dates of customers' billing cycles. Like SCE, SG&E rejected any submeter measurements where the measured PEV charging usage during the 15 minute interval is greater than the whole house usage during the same interval. SDG&E estimated that such synchronization issues affected less than 5% of the total kWh recorded by the submeters of participants in Phase 1. After completing the subtractive billing, SDG&E sends each customer a bill containing two sections[63]—one for their normal SDG&E electric account, excluding the PEV and a separate service point for the PEV that is billed according to the EV TOU rate.

By SDG&E's own assessment, the internal system created for Phase 1 was somewhat brittle due to a large number of manual interventions that were required and a low level of expected enrollment. For Phase 2, SDG&E's goal is to fully automate the process to improve reliability and timeliness and support subtractive billing for a larger number of customers.

4.2 Submeter Accuracy

In order for submetering to be successful from both a business and customer satisfaction perspective, submetering devices must be able to provide accurate measurements of PEV charging usage to the utilities for subtractive billing. As part of the Phase 1 evaluation, Nexant

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[60] Ohmconnect estimated that this issue potentially affected 5% of customers in Phase 1.

[61] SCE is investigating changing this practice for Phase 2.

[62] See "Final Evaluation for San Diego Gas & Electric's Plug-in Electric Vehicle TOU Pricing and Technology Study" (2014) - https://www.sdge.com/sites/default/files/documents/1681437983/SDGE%20EV%20%20Pricing%20%26%20Tech%20Study.pdf

[63] Net metered customers received their PEV bill as a component of their monthly gas bill because many produce enough electricity from PV systems so that they owe nothing to SDG&E.

installed data loggers for a sample of 34 submeters at participating customers' premises for the period December 14 through February 12 to independently measure PEV charging loads. The accuracy sample included 31 eMW submeters and three NRG submeters.

Data collected from the loggers was compared to submetering data over the same period to assess the accuracy of the submeters. During the data collection period, however, eMW experienced server-side data processing software issues that caused erroneous measurements for 16 to 24% of PEV charging loads for some pilot participants. The most serious issue occurred as an unintended side effect of eMW's server migration that took place on October 26, causing a 24 hour shift for some 15 minute data intervals. eMW was notified of the problem in December through customer complaints of overbilling[64] and resolved the issue on January 8 and 9 via fixes to the server. Because of this known issue and the fact that any measurement errors resulting from affected loggers would have overwhelmed the 5% accuracy threshold, the analysis dataset was split into two periods—December 14 through January 8 and January 9 through February 12. Unless otherwise stated, the results and figures presented in this section utilize the second half of the study period when the eMW software issue was not a concern.

In addition to the server malfunction, eMW also reported two submeters in the accuracy sample that had sporadic data coverage and one that was completely offline during the study period. Due to the missing data, these submeters would not have met the 5% accuracy requirement and were dropped from the analysis. Nexant also experienced some attrition in its logger sample due to technical and fielding issues. Out of the initial sample of 34 loggers, 3 were not usable because the amps recorded by the logger could not be converted to kW, 2 stopped recording data in the middle of the study period, 2 did not pass data validation checks, and 11 were installed without properly synchronizing the logger clock with the smart meter or submeter clock. Combining the remaining 16 loggers with the eMW/NRG submeters with reliable data resulted in 14 logger-submeter pairs that were available for analysis.

A time plot of these 14 submeters for one week in January is shown in Figure 4-2, where each colored line represents an individual submeter. As seen in the graph, the nature of PEV charging loads is essentially on/off—the PEV is either plugged in and consuming electricity at a steady rate or it is not plugged in and usage is zero. Because PEVs are charging for only a few hours each day—if at all—most of the 15 minute intervals have 0 kWh of consumption.

[64] Across the 3 to 5 initial complaints in December, customers generally reported apparent overbilling by $20 to $30/month.