SDG&E Vehicle-Grid Integration Electric Vehicle Charging Data

Feb 2016

Background

In late 2010, electric vehicles (EVs) began their introduction into SDG&E's service territory. In preparation and anticipation of future market penetration of EVs, SDG&E began exploring options to best integrate this potentially significant new load to the grid. In 2011, SDG&E installed separate residential meters to collect charging data of over 400 EV owners who volunteered to participate in a study to observe charging behavior in response to several variable time-of-use pricing options. In part, this effort was launched to test the price elasticity of electricity as a transportation fuel; specifically, to explore if EV drivers would schedule charging activities to take advantage of lower prices, and avoid higher prices.[1] SDG&E observed that drivers responded with an increasing preference of charging in response to lower priced energy as the gap between low and high price options increased.

Building off this effort, in 2014, SDG&E began testing a dynamic hourly price with employees at the workplace based upon grid and circuit conditions, as well as variable commodity price. The SDG&E campus pilot featured a pricing structure designed to encourage drivers to charge at times favorable to system and local circuit conditions by utilizing a day-ahead hourly dynamic rate to test driver charging flexibility and ability to respond to these pricing signals. If drivers are able to respond effectively to such price signals, it would enable SDG&E to support increasing EV charging loads without significant system capacity investments to support grid stability and to encourage charging when high renewable resources are present.

The SDG&E campus pilot became the basis for SDG&E's VGI proposal filed with the CPUC in April 2014, which was subsequently approved by the Commission on January 28, 2016 (issued February 4, 2016 in Decision 16-01-045).[2]

Methodology

The base price per kWh for the SDG&E campus pilot is composed of three (3) elements:

1. Utility distribution charges and CAISO[3] hourly day ahead energy market forecasts;
2. A price adder during the highest periods of circuit congestion; and,
3. A price adder during the highest periods of system congestion.

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[1] http://www.sdge.com/sites/default/files/documents/1681437983/SDGE%20EV%20%20Pricing%20%26%20Tech%20Study.pdf?nid=10666

[2] http://docs.cpuc.ca.gov/SearchRes.aspx?docformat=ALL&DocID=158241020

[3] California Independent System Operator sets various statewide wholesale energy market prices

During circuit or system pricing events[4] the adders created medium and high pricing which can be seen in Table 1. Pricing events may be independent (middle pricing option) or combined (highest pricing option).

Electric Vehicle Supply Equipment (EVSE, or “the charger”) consists primarily of 3 kW chargers (roughly 10 miles of refueling per hour); there are also 1 kW, 4 kW and 7 kW charging units. Consumption data collection utilized revenue grade metering recorded at 15 minute consumption intervals.

A complex rate of this nature can only be implemented with the use of enabling technology in order to transmit the hourly pricing on a day-ahead basis, capture the employees charging needs, fulfill these charging needs, and record and send the usage data for billing and analysis. These components were a critical part of the campus pilot.

Employee EV drivers used a website or phone application to influence the system’s scheduling of their charging sessions through choosing how much energy they wanted, at what price and by when. Charging was enabled through the driver’s choice of a website, a user phone application or a local keypad. Pricing data was provided to drivers around dinner time for the next day. The heart of the system is a server managing the access control, billing, charging schedule, employee settings and relay and metering system between the chargers and electrical supply.

Analysis and Conclusions

The analysis of the energy used for EV charging by time of day suggested that drivers were responsive to the hourly pricing options, that is, they demonstrated a preference to charge during the lowest priced hours of the year on the order of 95% of consumption (see Table 1). This is even more impressive given workplace charging on SDG&E campuses represents only 37% of the hours in a year[5] and has less opportunity for the lowest prices than on the annual basis since prices rise throughout the workday and pricing events only occur during typical working hours, not evenings or mornings. This may mean fleets and residential customers have a larger opportunity to utilize lowest price charging if based on such a rate.

A typical day sees charging load increase along with employee arrival to work (see Chart 1) between 6AM-10AM, which represents almost 2/3 of kWh consumption (see Chart 2). A second peak demand typically occurs after lunch around 1PM. The system’s responsive load drop to a pricing event is shown in Chart 3. Charging load curtailment in the afternoon of pricing events typically ranges from 30-70%.[6] Pricing events (typical of hot days) occurred more often in the afternoon than morning as shown in

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[4] Pricing events are either Local Circuit Congestion (top 200 hours annually; typically several hours in length up to 10 hours) or statewide Demand Response CPP hours (per the top 150 hours annually, always 11AM-6PM)

[5] 13 hours (5AM through 5PM) for 250 business days; 3,250 hours; 37% of the year

[6] Current methodology to establish percent load curtailment looks at a range of two or more weeks’ typical charging loads and compares that against the load curtailment resulting from higher pricing. This is an assumption because we do not know what the load would have been without high pricing.

Chart 4. It is interesting to note that single event pricing (300-400% increased pricing) appears to reduce daily consumption only modestly while double event pricing (500-600% increased pricing) reduces consumption further (Table 1).[7]

It should be noted that results observed should be considered within the context of additional environmental variables related to the state of available enabling technology in use by the study at the time. Charging requests or supply may have experienced interruptions due to hardware issues such as keypads in rainy weather, cellular communications, software bugs, or system design and human behavior/judgement. For example, to resolve such system issues, anecdotal evidence suggests many employees requested much more energy than their vehicles can store which in turn influenced the system to charge immediately rather than wait several hours or more to commence charging.

[7]Single Event pricing is either Local Circuit Congestion or Demand Response CPP while Double Event Pricing is a combination of both.

Appendix

2015 kWh Sales					
"Time Periods"	Unit Cost $/ kWh	Total kWh Sold	% of Total kWh Sold	% of Hours of the Year	Typical Time Periods
Off Peak Night/Early Morning	$0.13-$0.20	74,103	89.85%	78.62%	10PM-7AM
Off Peak Morning/Afternoon	$0.20-$0.25	4,467	5.42%	18.31%	7AM-10PM
Single Pricing Event	$0.55-$0.85	3,717	4.51%	2.74%	9AM-3PM
Double Pricing Event	$1.15-$1.25	189	0.23%	0.33%	9AM-3PM
	Total	82,476[8]	100%	100%	

Table 1 – Time of Use kWh Sales

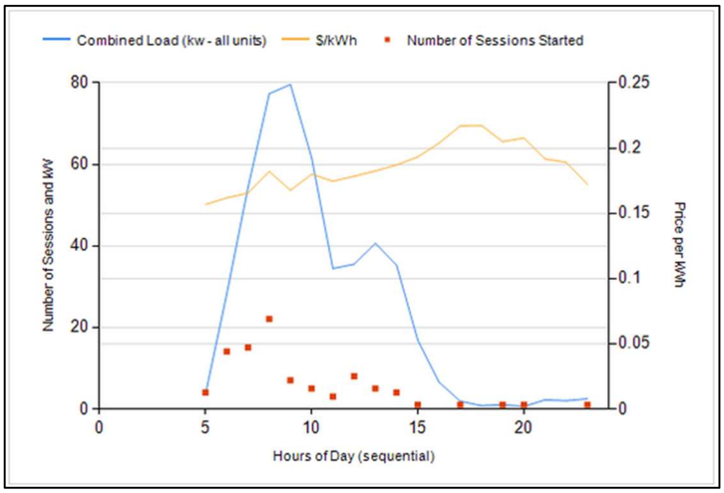

Chart 1 – Typical Daily EV Charging Load Curve

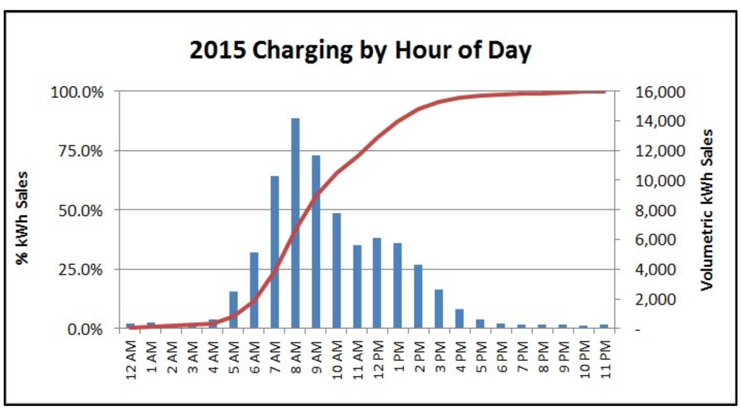

Chart 2 – Hourly Consumption by Percent and Volume

[8] This includes an estimated 1,300 kWh (1.6%) more than recorded due to missed hours of pricing data and sales.

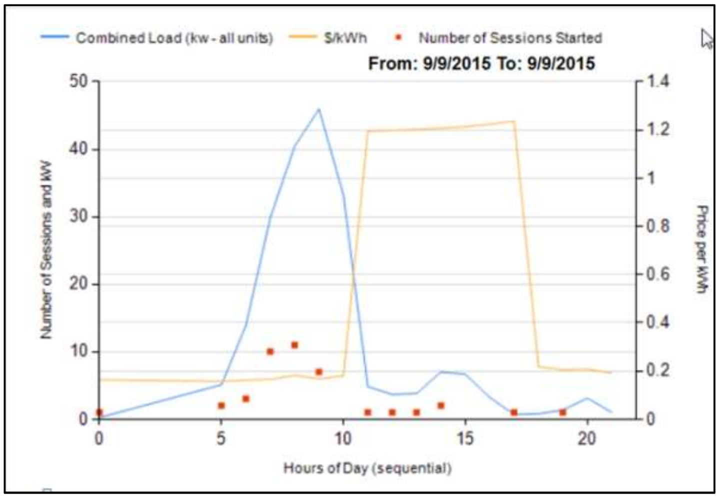

Chart 3 – Load Curtailment Due to Day Ahead Pricing

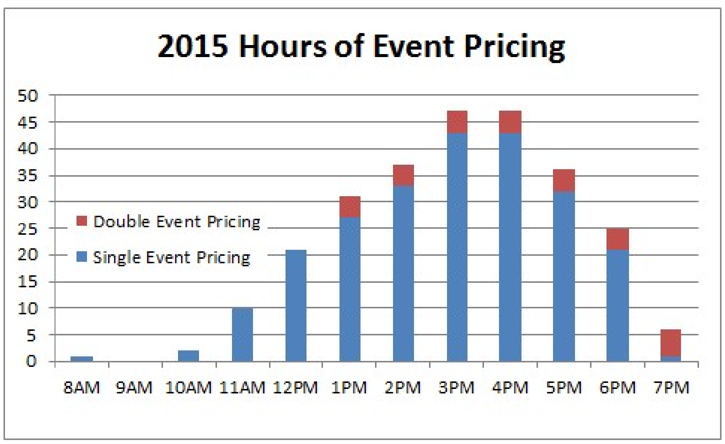

Chart 4 – Hours of Event Pricing in 2015