

# *Crossborder Energy*

*Comprehensive Consulting for the North American Energy Industry*

## MEMORANDUM

TO: Steve Douglas  
*Alliance of Automobile Manufacturers*

FROM: R. Thomas Beach  
*Principal Consultant*  
Patrick G. McGuire  
*Policy Advisor*  
Andrew B. Peterson  
*Energy Analyst*

DATE: April 15, 2016

RE: A Survey of Electric Rates for Electric Vehicle Charging in California

---

The Auto Alliance asked us to prepare a detailed survey of the cost of electricity to charge electric vehicles (EVs) or partial electric vehicles (PEVs) in California. We surveyed the five largest electric utilities in California, who together supply more than 80% of the electricity consumed in California, based on 2014 California Energy Commission data:

- Pacific Gas & Electric (PG&E)
- Southern California Edison (SCE)
- San Diego Gas & Electric (SDG&E)
- Sacramento Municipal Utilities District (SMUD)
- Los Angeles Department of Water & Power (LADWP).

For each of these five utilities we calculated the average yearly cost for a kWh of electricity used to charge a typical electric vehicle for both the specific residential EV charging rates as well as the other major residential electric rate schedules. We then converted this \$/kWh cost into the \$/gallon equivalent for an EV or PEV, assuming an equivalent gasoline vehicle with a certain gas mileage (e.g. 40 mpg).

We also compiled prices of public charging stations owned or operated by ChargePoint, eVgo, Blink, and SemaConnect. We collected this data for the cities of Los Angeles, San Francisco, Sacramento, and San Diego. We also convert these prices into \$/gallon equivalents.

The results of our survey are compiled into the attached Excel spreadsheet, which calculates the \$/kWh charging rate and its \$/gallon equivalent based on the user's selection of EV/PEV, utility or public charging provider, rate schedule, charging time & schedule, and the mileage of the equivalent gas vehicle. The results show a wide range of charging prices, highlighting the importance of electric rate design in determining the costs of EV/PEV charging.

## Survey of EV Charging Rates in California

April 15, 2016

Page 2

The remainder of this memo illustrates the results of our survey and responds to three specific questions posed by the Auto Alliance, and then discusses the details of our survey methodology.

**1. Determine highest and lowest EV charging rates for the major California utilities, for both time-of-use (TOU) and flat rates.**

Generally, the least-expensive charging rates are the off-peak or super-off-peak rates that apply at night in the utilities' TOU rates designed specifically for EV charging. The highest TOU rates are the on-peak and mid-peak TOU rates that apply during the afternoon hours. For the "flat" rates that do not vary by time but that have usage "tiers" (with progressively higher rates in the higher usage tiers), the highest charging rates apply to those high-usage customers, whose marginal usage is in the most expensive rate tier for the highest usage. As an example, **Table 1** below shows the highest and lowest charging rates for PG&E.

**Table 1: Highest and Lowest PG&E EV Charging Rates (\$/kWh)**

TOU rates			Flat rates		
Utility/Rate	Time	Avg. Rate (\$/kWh)	Utility/Rate	Usage	Avg. Rate (\$/kWh)
PG&E: E-6	Day	0.391	PG&E: E-1	Average/High	0.364
PG&E: EV (A or B)	Night	0.116	PG&E: E-1	Low	0.286

**2. Convert cost to equivalent dollars per gallon of gasoline for the battery electrics (BEV, i.e. Nissan LEAF) and plug-in hybrids (PHEV i.e. Chevy Volt), again highest and lowest.**

We convert the PG&E \$/kWh charging rates into equivalent costs in \$/gallon of gas assuming that the EV is a Nissan Leaf and calculating the gasoline use for a similar car driving the same distance with a mileage of 40 mpg. **Table 2** below shows the conversion of the Table 1 charging rates for PG&E into \$/gallon.

**Table 2: Highest and Lowest PG&E EV Charging Rates (\$/gallon)**

TOU rates			Flat rates		
Utility/Rate	Time	\$/gallon gas	Utility/Rate	Usage	\$/gallon gas
PG&E: E-6	Day	4.47	PG&E: E-1	Average/High	4.16
SDG&E: EV (A or B)	Night	1.33	PG&E: E-1	Low	3.27

**3. Determine the costs of electricity from the providers of public charging - Charge Point, eVgo, Blink, and SemaConnect.**

We collected data on public charging station rates from publically available sources including individual company websites and ChargePoint's "Find Station" tool.<sup>1</sup> While there was

<sup>1</sup> See [https://na.chargepoint.com/charge\\_point](https://na.chargepoint.com/charge_point).

## Survey of EV Charging Rates in California

April 15, 2016

Page 3

not enough publicly available information to determine an accurate average price, we were able to gather a general range of prices. For example, ChargePoint's "Find Station" tool contains data on prices at every charging station in California; however, the interface does not allow the user to view more than one station price at a time and recording all of the stations manually was beyond the scope of this project. We also gathered information from the eVgo and Blink websites.

**Table 3: Public Charging Station Rates**

Company	\$/hr	\$/kWh	Subscription	Notes
ChargePoint	1.00 - 2.00	0.13 - 0.69	None	Station owners set prices
Blink	-	0.49	None	Free account required
eVgo	1.00 - 1.50	-	\$5.95/month	\$1/hr with subscription, \$1.50/hr without
SemaConnect	Variable	Variable	None	Station owners set prices, TOU pricing

#### 4. Methodology

This section provides details on the approach that we used in our survey. Basically, we determined an average yearly cost (in \$/kWh) for the electricity used to charge an EV or PEV and converted this to an equivalent cost for a gallon of gas (in \$/gallon gas). There are two major steps in this process:

- a. Determine an average yearly cost for a kWh of electricity used for vehicle charging, based on the utility (or public charging provider) and the rate plan. Key assumptions include:
  - EV charging is a marginal load.
  - For the flat rate schedules with usage tiers, customers fall into one of two usage categories: Low (usage = 130% to 200% of baseline allocation), Average or High (usage = over 200% of baseline allocation).<sup>2</sup> These usage assumptions reflect the fact that adding an EV will significantly increase your electric usage. For example, the typical baseline allocation<sup>3</sup> of electricity in coastal climate zones is about 10 kWh per day, or 300 kWh per month. A Nissan Leaf that is driven 10,000 miles per year will use about 2,800 kWh per year or 230 kWh per month, or about 77% of the baseline allowance for coastal customers. Thus, for example, a PG&E low usage electric customer who consumes between 100% and 130% of baseline (in PG&E's Tier 2) will charge their EV at the rate for usage between 130% and 200% of baseline (in PG&E's Tier 3).
  - Customers on TOU rates charge their cars at the same time on every day of the year.

<sup>2</sup> These assumptions are represented as easily changeable parameters in the Excel model.

<sup>3</sup> California law requires electric utilities to offer residential customer a "baseline" quantity of electricity to meet essential needs, at a lower, affordable rate. See, generally, Public Utilities Code Section 739. The baseline quantity is required to be in the range of 50% to 60% of the average customer's usage in each climate zone in California. Current baseline quantities tend to be toward the lower end of the range, i.e. near 50% of average usage. Thus, a customer using 200% of baseline is using roughly the average amount of electricity for a residential customer of that utility in that climate zone.

## Survey of EV Charging Rates in California

April 15, 2016

Page 4

- b. Convert \$/kWh to \$/equivalent gallon gas for a specific EV or PEV and an equivalent gas powered car. Assumptions:

- Cars run on battery only (we did not take into account the Volt's range extender).
- A EV's efficiency can be accurately calculated with the following formula:

$$\text{Efficiency (miles/kWh)} = \text{Range (miles)} / \text{Battery Size (kWh)}^4$$

- A comparison gas fueled car gets 40 mpg.<sup>5</sup>

### A. Utility Rates for Residential Home Charging

California residential rate plans fall into one of the following two categories: flat or time-of-use (TOU). Flat rate plans charge customers a flat rate that depends on the customer's usage and, in some cases, the utility's season (summer or winter) but not the time of day. In contrast, TOU rates depend on the time of day, day of the week, and utility seasons. Tiered rates charge different rates for different blocks or "tiers" of a customer's monthly usage. Both flat and TOU rates can be tiered by usage. The rates included in this study are either tiered flat rates, tiered TOU rates or non-tiered TOU rates. The methodology we used for each of these three categories is explained below.

**Tiered Flat Rates.** Tiered flat rates are divided into price tiers based on a customer's baseline usage. Baseline usage is a daily allocation of kWh that represents "essential" electric needs and that depends on a customer's "climate zone," the customer's geographical location within a utility's service area. For example, LADWP has two different zones. LADWP's Zone 1 is the cooler coastal areas of the city, while Zone 2 includes the hotter inland neighborhoods. Customers in Zone 2 have a higher baseline amount because they have to run air conditioning more often, and hotter temperatures cause electrical appliances to consume more electricity. LADWP's tiers are shown in **Table 4**.<sup>6</sup>

**Table 4: kWh allocation for each tier for LADWP**

Usage Tier	Zone 1	Zone 2
<b>Tier 1</b>	First 350 kWh	First 500 kWh
<b>Tier 2</b>	Next 700 kWh	Next 1,000 kWh
<b>Tier 3</b>	Above 1,050 kWh	Above 1,500 kWh

The values in Table 4 can also be represented as percentages of a baseline kWh value. For LADWP the baseline kWh values for Zones 1 and 2 are 350kWh and 500kWh respectively.

<sup>4</sup> This assumption can be changed in the Excel model. The model also has pre-loaded efficiencies for the Chevy Volt and Nissan Leaf.

<sup>5</sup> This assumption can be changed in the Excel model.

<sup>6</sup> From the LADWP website: [https://ladwp.com/ladwp/faces/wcnav\\_externalId/r-cs-elect-rate](https://ladwp.com/ladwp/faces/wcnav_externalId/r-cs-elect-rate).

## Survey of EV Charging Rates in California

April 15, 2016

Page 5

**Table 5** shows the same information as Table 4 represented as percentages of baseline values.

**Table 5: LADWP tiers as a percent of the baseline kWh**

Usage Tier	Zone 1	Zone 2
<b>Tier 1</b>	100% or less of baseline	100% or less of baseline
<b>Tier 2</b>	101% to 300% of baseline	101% to 300% of baseline
<b>Tier 3</b>	Over 300% of baseline	Over 300% of baseline

A final note: prices do not always change between tiers. LADWP's Tier 2 and Tier 3 have the same winter price. The three investor-owned utilities (PG&E, SCE, and SDG&E) will be reducing the number of tiers in their residential rates over next several years, and by 2018 there should be only two tiers in most flat rates in California.

Calculating an average \$/kWh rate for tiered flat rates requires two important assumptions: (1) the electricity put into the vehicle is a marginal load and (2) there are two types of customers based on usage (Low and Average/High). The marginal load assumption means that the customer's vehicle charging is the load served after all other electric use. As a result, the electricity used for vehicle charging falls into the highest rate tier that the customer reaches. The two types of customers define the rate tier assumed for vehicle charging. Low use customers will charge their EVs in the rate tier between 130% and 200% of their baseline allocation, while Average/High customers will charge in the rate tier for usage over 200% of their baseline allocation.

Once the tier is determined, an average kWh price can be calculated. The reported average kWh prices for tiered flat rates is a weighted average (based on number of days) of summer and winter prices.

**TOU (Tiered and Non-Tiered) Rates.** TOU rates depend on some or all of the following: time of day, day of the week, and current month. This study defines four different possible "types of days" that can occur throughout the year: Summer Weekdays, Summer Weekends, Winter Weekdays, and Winter Weekends. Each of these types of days is divided into three or four time periods. For example, LADWP divides days into: base times, low peak times, and peak times. The names of the time periods vary between utilities. It is important to note that electricity prices vary with both time periods and seasons, but not weekdays versus weekends. LADWP's R-1B TOU rates and schedule of time periods are shown in **Tables 6 and 7**.

**Table 6: Prices for LADWP R-1B TOU Schedule**

TOU Period	Summer	Winter
High Peak	0.31673	-
Low Peak	0.23756	0.21784
Base	0.17767	0.17814

## Survey of EV Charging Rates in California

April 15, 2016

Page 6

**Table 7: TOU periods for LADWP's R-1B schedule**

Hour	LADWP: R-1B			
	Summer		Winter	
	Weekday	Weekend	Weekday	Weekend
0	Base	Base	Base	Base
1	Base	Base	Base	Base
2	Base	Base	Base	Base
3	Base	Base	Base	Base
4	Base	Base	Base	Base
5	Base	Base	Base	Base
6	Base	Base	Base	Base
7	Base	Base	Base	Base
8	Base	Base	Base	Base
9	Base	Base	Base	Base
10	Low Peak	Base	Low Peak	Base
11	Low Peak	Base	Low Peak	Base
12	Low Peak	Base	Low Peak	Base
13	High Peak	Base	Low Peak	Base
14	High Peak	Base	Low Peak	Base
15	High Peak	Base	Low Peak	Base
16	High Peak	Base	Low Peak	Base
17	Low Peak	Base	Low Peak	Base
18	Low Peak	Base	Low Peak	Base
19	Low Peak	Base	Low Peak	Base
20	Base	Base	Base	Base
21	Base	Base	Base	Base
22	Base	Base	Base	Base
23	Base	Base	Base	Base

TOU tiered rates are a combination of a TOU schedule and tiered prices. Tiers are chosen with the same method discussed above in the tiered flat rate section.

Calculating an average kWh price for TOU rates requires an additional assumption. The vehicle load is still marginal and, if necessary, a tier is still chosen based on the customer's usage, but an assumption is added about when the car is charging. We first assumed that cars would charge overnight during off-peak or even special super-off-peak "EV charging" hours. While night charging is by far the cheapest, we also calculated the cost for other time periods and our model can calculate costs based on an arbitrary charging schedule.

To calculate an average yearly price, we calculate an average price during each of the four "types of days" and then average these prices weighted by how many of each type of day are in a year.

## Survey of EV Charging Rates in California

April 15, 2016

Page 7

**B. Public Charging Stations**

The public charging stations we surveyed fell into one of four different price models: per hour, per kWh, monthly subscription, or monthly subscription + per hour.<sup>7</sup> The following formulas were used to calculate dollars per gallon equivalents for each price model.

**Per Hour:**

$$\text{Cost (\$/gallon)} = \frac{\text{Charging Cost (\$/hr)} * \text{Comparison Fuel Economy (miles/gallon)}}{\text{Charging Rate (kW)} * \text{Efficiency (miles/kWh)}}$$

**Per kWh:**

$$\text{Cost (\$/gallon)} = \frac{\text{Charging Cost (\$/kWh)} * \text{Comparison Fuel Economy (miles/gallon)}}{\text{Efficiency (miles/kWh)}}$$

**Subscription:**

$$\text{Cost (\$/gallon)} = \frac{\text{Charging Cost (\$/month)} * 12 \text{ (months/year)} * \text{Comparison Fuel Economy (miles/gallon)}}{\text{Total Yearly Driving (miles)}}$$

**Subscription + Per Hour:**

$$\text{Cost (\$/gallon)} = \text{Cost (standalone subscription)} + \text{Cost (standalone per hour)}$$

---

<sup>7</sup> No companies in California offer a solely subscription-based payment model. However, Aerovironment provides a large subscription charging network in the states of Oregon and Washington.

## Survey of EV Charging Rates in California

April 15, 2016

Page 8

## 5. Results

Our survey results are reported on an Excel spreadsheet that documents and provides links to where we obtained the electric rates, so that this work can be updated as rates and TOU periods change. Attached to this report is a set of instructions for using the spreadsheet.

The following results for home charging use the following parameters: Average/High usage customer, a Tier 2 (220V) home charger, charging at night (12:00AM to 4:00AM), and a comparison car that gets 40 mpg. We highlight the highest and lowest charging rates statewide. The results show the importance of TOU and special EV charging rates in order to provide the most economical charging for EV/PEV drivers. Rates that are tiered by usage impose higher costs for the significant marginal use of electricity that customers add when they acquire an electric vehicle.

**Table 8: Electrical rates and dollars per gallon equivalent values**

Nissan Leaf				Chevy Volt		
Utility/Rate plan	Ave rate (\$/kWh)	\$/gallon gas		Utility/Rate plan	Ave rate (\$/kWh)	\$/gallon gas
PG&E: E-6	0.333	3.802	TOU Rates	PG&E: E-6	0.333	4.619
PG&E: E-TOU Option A	0.289	3.302		PG&E: E-TOU Option A	0.289	4.013
PG&E: E-TOU Option B	0.218	2.486		PG&E: E-TOU Option B	0.218	3.021
PG&E: EV-A	0.116	1.328		PG&E: EV-A	0.116	1.614
PG&E: EV-B	0.116	1.323		PG&E: EV-B	0.116	1.608
SCE: TOU-D	0.122	1.393		SCE: TOU-D	0.122	1.693
SCE: TOU-D-T	0.253	2.891		SCE: TOU-D-T	0.253	3.513
SCE: TOU-D-TEV	0.100	1.146		SCE: TOU-D-TEV	0.100	1.393
SCE: TOU-EV-1	0.126	1.439		SCE: TOU-EV-1	0.126	1.749
SDG&E: DR-TOU	0.371	4.235		SDG&E: DR-TOU	0.371	5.146
SDG&E: EV-TOU	0.182	2.078		SDG&E: EV-TOU	0.182	2.525
SDG&E: EV-TOU-2	0.182	2.078		SDG&E: EV-TOU-2	0.182	2.525
SDG&E: TOU-DR	0.372	4.247		SDG&E: TOU-DR	0.372	5.160
SMUD: R-TOU	0.073	0.838		SMUD: R-TOU	0.073	1.018
LADWP: R-1B	0.203	2.320		LADWP: R-1B	0.203	2.819
LADWP: R-1B (EV)	0.178	2.034		LADWP: R-1B (EV)	0.178	2.472
PG&E: E-1	0.364	4.159	Flat Rates	PG&E: E-1	0.364	5.053
SCE: D	0.302	3.456		SCE: D	0.302	4.199
SDG&E: DR	0.393	4.489		SDG&E: DR	0.393	5.454
SMUD:R	0.190	2.171		SMUD:R	0.190	2.638
LADWP: R-1A	0.243	2.779		LADWP: R-1A	0.243	3.377

## Survey of EV Charging Rates in California

April 15, 2016

Page 9

The following results for public station charging stations use the following parameters: Nissan Leaf, a Tier 2 (220V) charger, 10,000 miles yearly driving, and a comparison car that gets 40 mpg.

**Table 9:** *Public charging rates in for a Nissan Leaf expressed in \$/gallon*

Payment method	Hourly	Usage	Subscription + Hourly
ChargePoint	1.73 - 3.46	1.49 - 7.89	-
Blink	-	5.60	-
eVgo	2.60		2.02

Finally, we caution that the design of electric rates is continuing to evolve in California, and this survey will not be able to anticipate all future changes in how electric rates may be structured. In addition, overall electric rates in the state are expected to increase by 2.5% to 3% per year (i.e. slightly faster than inflation) going forward.

Please do not hesitate to contact us if you have questions about this work.

Attachments: Directions for using the spreadsheet  
Spreadsheet with Survey Results

## Survey of EV Charging Rates in California

April 15, 2016

Page 10

## Model Instructions

**1. Introduction**

This model simulates the annual cost of electricity for an electric vehicle from both home charging and public charging stations, in terms of \$ per gallon for an equivalent gasoline car.

**2. Home charging model (first tab)****Parameters**

**Vehicle make/model** – Sets the make and model of the electric car that you want to model, sets battery size (kWh), charging rate (kW), range (miles), and efficiency (miles/kWh).

- Nissan Leaf
- Chevy Volt
- Custom Car (set all vehicle parameters manually)

**Home charger** – set the home charger, determines max charging rate possible

- Tier 1 (charging rate capped at 1.15kW)
- Tier 2 (charging rate capped by car model)
- 

**Charging schedule** – choose when the car is charging

- Night only (charges 12:00AM – 4:00AM)
- Day only (charges 12:00PM – 4:00PM)
- Custom (set your own charging schedule, supports fractional hours, so 0 = not charging, 0.01 to 1.00 = charging for the given fraction of an hour)

**Total yearly driving** – used to determine total energy usage, total cost, and average daily charging time

**Electricity usage** – choose whether a customer uses a low, average, or high amount of electricity, used to determine where a customer falls on tiered rate plans

- Low (customer uses 130% of their baseline allocation for other electric consumption, and from 130% to 200% of baseline for EV charging)
- Average / High (customer uses at least 200% of their baseline allocation for other electric consumption, and over 200% of baseline for EV charging)

**Utility and rate plan** – choose a utility and a rate plan, used for the “short summary” section

**Fuel Economy** – the mpg value of the comparison gas car, used to calculate the dollars per gallon equivalent

## Survey of EV Charging Rates in California

April 15, 2016

Page 11

**Short Summary**

**Total energy (kWh)** – the total energy used to charge the vehicle

**Total cost (\$)** – the total cost of energy used to charge the vehicle

**Average daily charging time (hrs)** – the average daily time needed to charge the car to drive the “total yearly driving” input value

**Average utility rate (\$/kWh)** – the average price of electricity used to charge the vehicle

**Equiv \$/gallon gas (\$/gallon)** – the average price of electricity used to charge the vehicle expressed as equivalent dollars per gallon of gas

**Complete Summary**

The complete summary lists average utility rates and dollars per gallon equivalent values for all utilities and rate plans.

**3. Charging Station Model (second tab)**

**Vehicle make/model** – sets the make and model of the electric car that you want to model, sets battery size (kWh), charging rate (kW), range (miles), and efficiency (miles/kWh).

- Nissan Leaf
- Chevy Volt
- Custom Car (set all vehicle parameters manually)
- 

**Station cost/fee** – set the type of fee and the amount

- Hourly
- per kWh
- Subscription
- Combo (set a monthly fee and hourly fee, ex. eVgo charges \$5.95/month to charge at \$1.00/hr instead of \$1.50/hr)

**Total yearly driving** – used to determine the equivalent dollars per gallon gas for subscription and combo plans.

**Fuel Economy** – the mpg value of the comparison gas car, used to calculate the dollars per gallon equivalent.

**Summary**

The summary lists dollars per gallon equivalent values for all types of fees.