Load Shapes Project
Electric Vehicle Load Shapes
Planning & Status

a presentation for

The Demand Analysis Working Group

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Agenda

- **IOU Load Shape Project Overview**

- **Load Shape Generators**

- **Vehicle shapes vs. charger shapes**

- **Electric Vehicle Load Shapes**

- **Next Steps**

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IOU Load Shapes Update Project Goals

- **Provide load shapes for electric end-uses addressed by the CEC Forecast Model**

- **Provide Energy Efficiency Impact Load Shapes to address how load shapes may be impacted by upcoming efficiency standards, <u>by market and technology changes</u>, and by utility sponsored energy efficiency programs**

- **Enable projection of load shapes at least through year 2030, accounting for how changes in electric energy usage will impact the load shapes**

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IOU Load Shapes Update Project

- **Update over 180 preexisting load shapes for each of 13 forecasting zones**

- **Add load shapes for PV generation and EV**

- **Enable scenario analysis related to additional energy efficiency, codes and standards, and market changes**

- **Develop software to replace the Hourly Electric Load Model (HELM)**

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IOU Load Shape Development Process

1. **Obtain aggregated whole-building load shape by sector, building type, and climate zone**

2. **Isolate and non-HVAC component**

3. **Disaggregate non-HVAC component in to end-use load shapes**
   - Use pre-existing load shapes from CEUS, residential metering studies to help disaggregate

4. **Provide load shapes to EnergyPlus simulations**

5. **Run hundreds of simulations per building**

6. **Calibrate to aggregated whole-building load shape by assigning weights to different calibration runs**

7. **Run regressions to covert each end-use load shape output by EnergyPlus into a Load Shape Generator**

8. **Develop a software executable that can perform scenario analysis using load shape generators**

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What about EV and PV?

- **Solar power and electric vehicle charging are treated as a la carte load profiles**

  - They do not "interact" with other end-use profiles in our model

  - They are developed independently of the other profiles

- **PV load profiles are generated in the SAM model**

- **EV load profiles are in the early stages of construction**

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What kinds of EV shapes are we modeling?

- **Historically, the Hourly Electric Load Model has been "building centric"**

- **EV and PV may be "behind the meter", but they can be forecasted and modeled separately than other building loads**

- **We model EV charging shapes by sector, not by vehicle:**

  - Residential

  - Non-Residential (try to break out into Com/Ind/TCU/Ag)

Is it Possible to Build a Model by Vehicle Type?

- **Yes! But not in the timeframe and budget of our study**

- **The IOUs will soon launch 15 Transportation Electrification projects that will provide a wealth of data:**

  - Delivery Trucks, School Busses, Transit Busses, Shuttles, Forklifts, Airport GSE, Gantry Cranes and Yard Tractors, Urban DCFC, Truck Stop Electrification

  - All of the above … with Grid Integrated Rates

- **How can this information get into HELM?**

Electric Vehicle Load Shape Development Process

- **Literature Review**

- **Data Availability Review**

- **Data request memo to participating Utilities**

- **Load Profile Modeling**

- **Converting from Vehicle Miles Traveled to kWh in various customer sectors**

Literature Review and lessons learned

Electric Vehicles (EVs) usage and the associated energy loads will only increase over time due to:

- **Legislated mandates for emission reductions**

- **Legislated mandates for infrastructure support to enable emission reductions**

- **EVs and EV charging becoming mainstream:**

  - Battery size and range continue to increase

  - Available types and models of EVs continue to increase as they look / act like gasoline models

  - Fast charging becomes more widespread in the infrastructure

  - Time of Use (TOU) billing is implemented, IOUs will develop novel Grid Integrated Rates over the next few years

ADM's approach to this EV Load Shapes study for Residential and Commercial, continued

- ADM is not trying to recreate or even update any historical studies, but rather to make an EV load shape model that can readily absorb changes and be flexible for changing inputs.

- This model will be by location of the charger, not by the vehicle, so that forecasting may be made by location.

- Additionally, as more solar power comes into the CA system, TOU will become a more critical tool for utilities to control loads. ADM's EV Load Shape HELM will allow for flexible TOU rates to be part of the input.

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Data types and availability

Data Type	Description
DMV Data	• List from DMV of commercial businesses that have registered EVs. Besides business name, list includes only address, number of leased vehicles, and total EVs.
Data from IOUs	• Estimated number of EV rebates by customer sector, by rebated equipment, and by year. • For participants in EV rebate programs, whole house meter data for one year prior and one year after purchase/install, including the participant's electricity rates before and after the purchase/install. • Interval meter data for customers that are known to have EV charging, preferably one year before and up to one year after the EV purchase, as available including the date of load change due to EV charging. • Customer rate classifications before and after the EV rebate, since time of use can impact the EV charging load profile. • Meter data from customers that are/were known to have dedicated meters for EV chargers.
Third Party Data	**ChargePoint:** by port (per individual charger) • Anonymized session data of 2,000 commercial (public and private) ports and 500 residential ports that include city, county, zip code, driver zip code, port connector type, circuit max power, and POI category (Workplace, Fleet, Retail, etc.). • Vehicle information includes EV make (for example, "Nissan Leaf"), EV Type (BEV or PHEV), and battery capacity. • Session information includes start and stop times, session time, charging time, whether a full charge, kWh, and $ fee paid (if any).
CEC provided Data	• PEV Survey Data: is useful to analyze behavioral factors of PEV owners.

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Why purchase ChargePoint data?

- **Electric vehicle charging load profiles in the nonresidential sector cannot be determined solely through whole building load profile analysis.**

- **The ChargePoint Data has several advantages that will benefit the project:**

  - Data are more current than other sources, and are thus more likely to be representative of future load impacts related to electric vehicle charging.

  - The cost for each charger-month of data is $5, whereas manual direct monitoring is estimated to cost over $550 per site.

  - The ChargePoint data exceeds other potential sources in sample size, geographic distribution, and duration of observations.

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Data Request Memo to IOUs

- **Our initial plan called for determining residential EV load profiles from IOU data**

  - Separately metered data

  - Single-metered data (can use regression analysis to back out EV shape)

- **Initial talks with SCE were very helpful**

  - SCE, and other IOUs, have already performed the above analyses

  - Data are published in the Joint IOU EV Report

  - We may not issue the data request after all
    - We may ask for exact hourly values behind some charts

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Aside

- **What's wrong with ordinary load shapes?**

Available Load Shapes Are Static Arrays

- **The week day to calendar day correspondence is correct only for some years**

  - 1991, 2002, ~~2008~~, 2013 …

- **Any weather-related effects will reflect only the weather scenario that was used in load shape development**

  - Prevailing conditions during metering

  - TMY2 or TMY3 "normalized" weather

- **Economic and technological states are "baked in" to load shapes**

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What is a Dynamic Load Shape Generator?

- **One can run regressions on load shapes, with day types, weather conditions, even economic and technological variables as predictors:**

- **Let *h* be an hour of day, from 1 to 24…**

$$L_h = CDD_h \times \alpha_h + HDD_h \times \beta_h + WD_h \times \gamma_h + Rate_h \times \delta_h + GSP_h \times \epsilon_h \ldots$$

- **The constants $\alpha_h, \beta_h, \gamma_h, \delta_h, \epsilon_h$ all correspond to variables that are used in scenario analysis**

- **Weather conditions, week day type, utility rates, economic activity, etc.**

- **If we determine and store the constants $\alpha_h, \beta_h, \gamma_h, \delta_h, \epsilon_h$, then we can "reconstitute" load shapes for an arbitrary year, weather scenario, etc.**

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How Does This Apply to EV Load Shapes?

- **Historical data on EV load profiles reflect a number of conditions that may not prevail in the forecast period**

  - Time of Use rates will change

  - Charging time (minutes/mile of range) will change

  - Availability of public, fast chargers may change when and where cars are charged

- **Speculative load shapes may serve better than accurately determined historical load shapes**

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Example: How do Rates Affect Charging at Home?

- The Joint IOU EV Report provides data on TOU rate structure and charging behavior

- We can use rates as a predictor for when charging starts

- We can use rates and other information (miles/minute of charging, etc.) to *guess* when charging will end
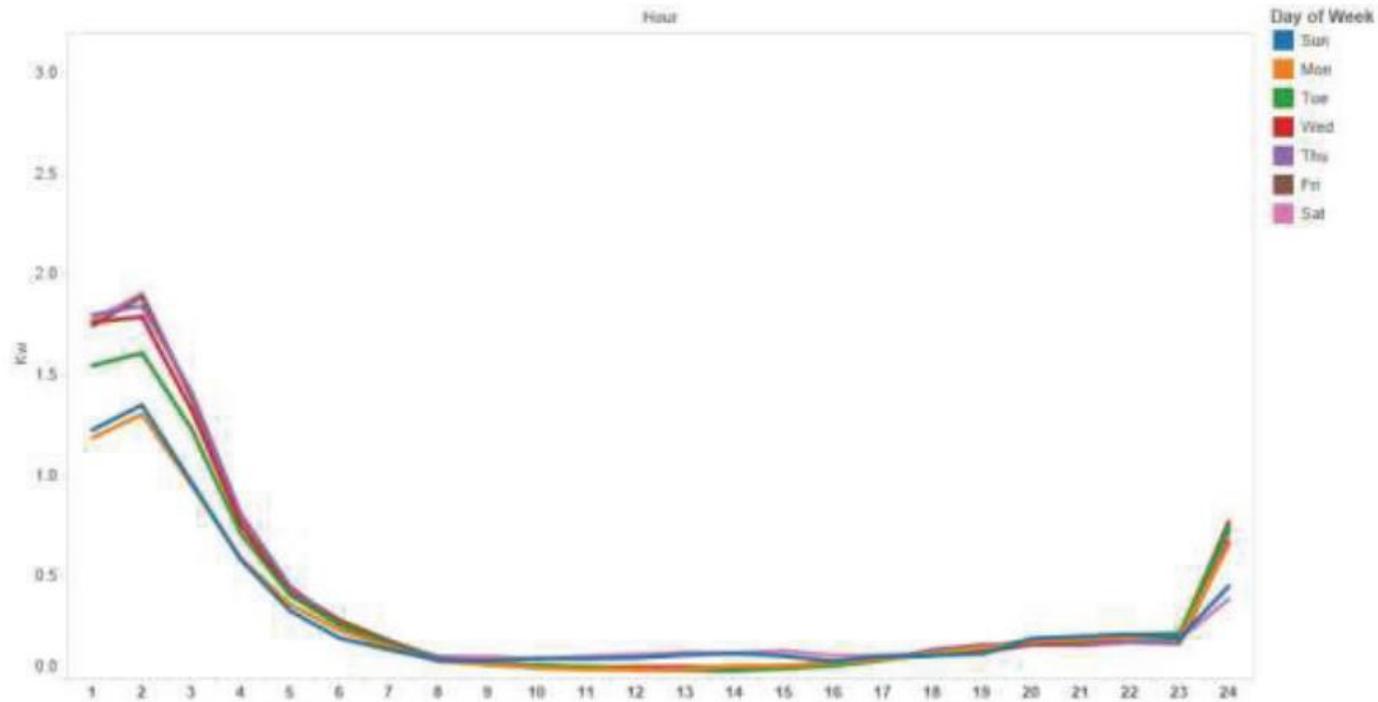
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SCE Low Price Period: 9 PM to noon

Chart SCE – 8: Separate Meter (TOU-EV-1) –
Average Hourly Load Profile for Each Day of the Week
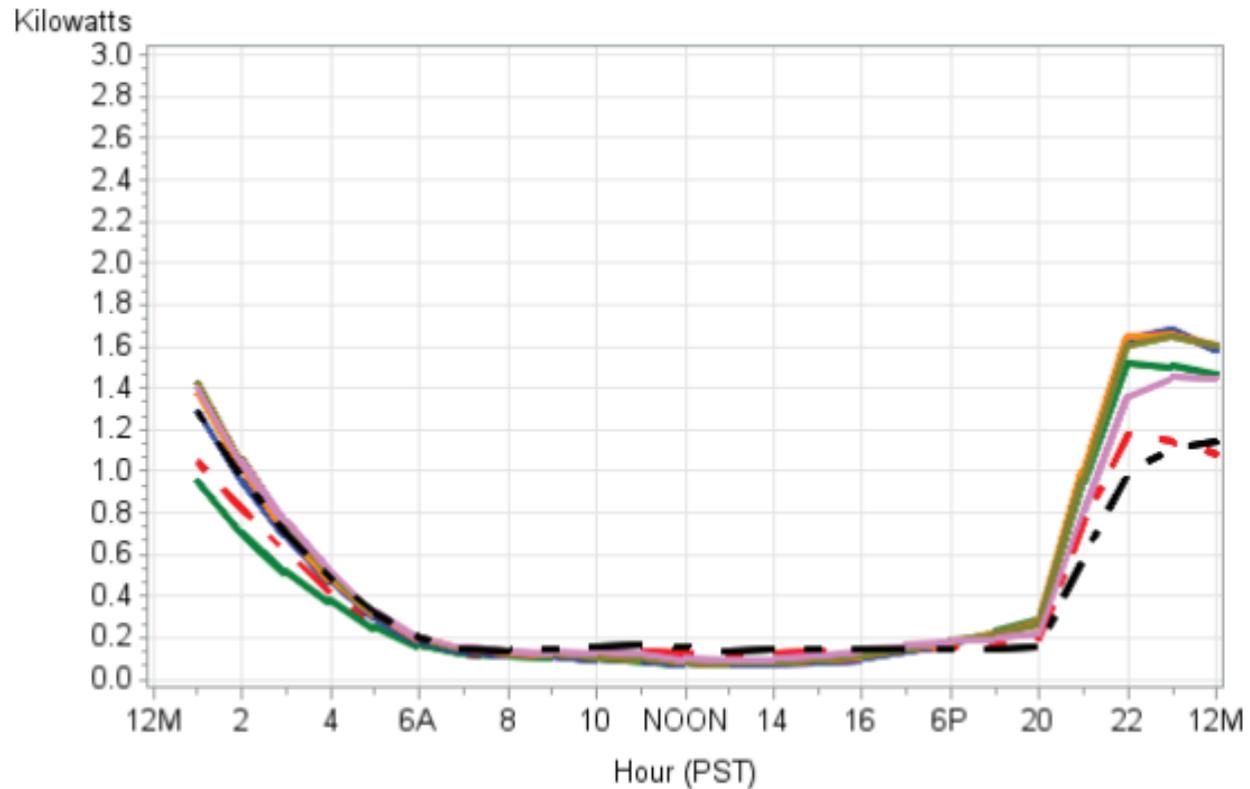
SCE Low Price Period: 9 PM to noon

Chart SCE – 8: Separate Meter (TOU-EV-1) –
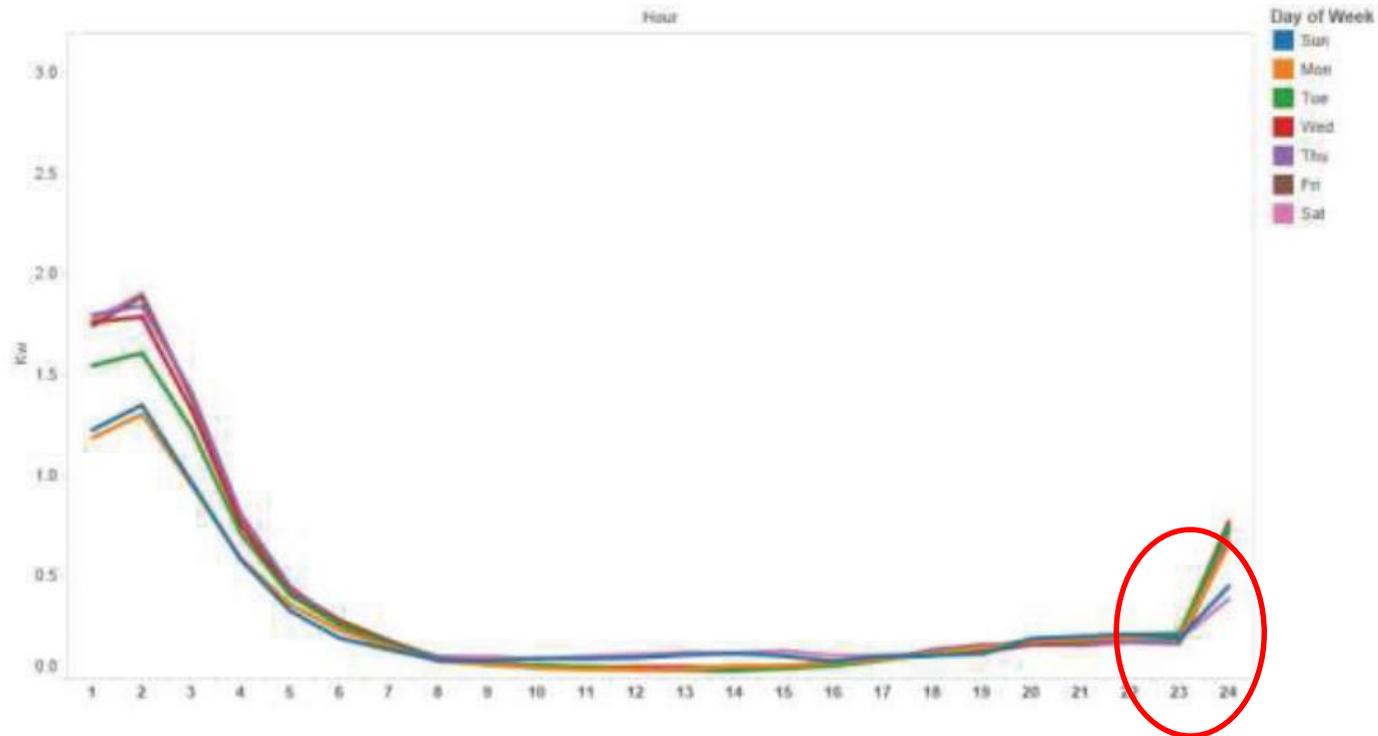Average Hourly Load Profile for Each Day of the Week
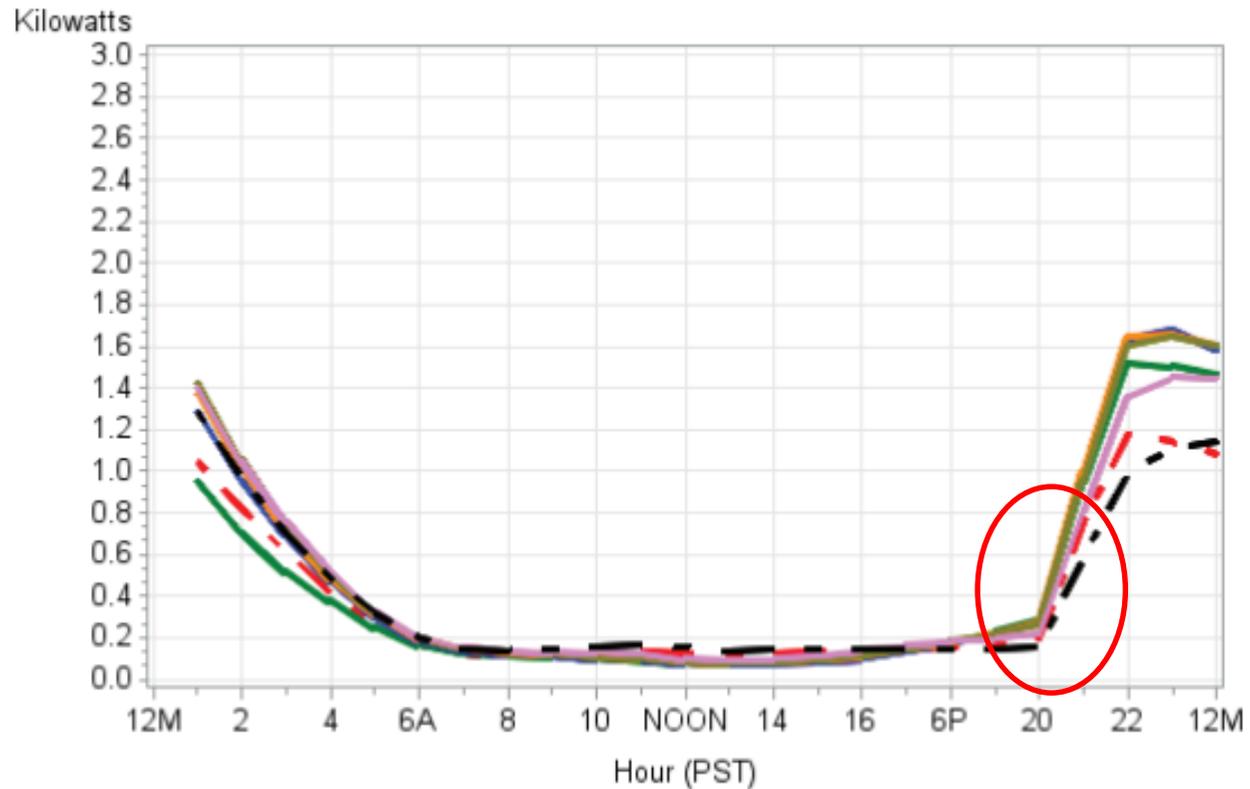
PG&E Low Price Period: 11 PM to 7 AM

Chart PG&E-8a: Average Load Profile for SF Separate Metering (EV-B) by Day of the Week
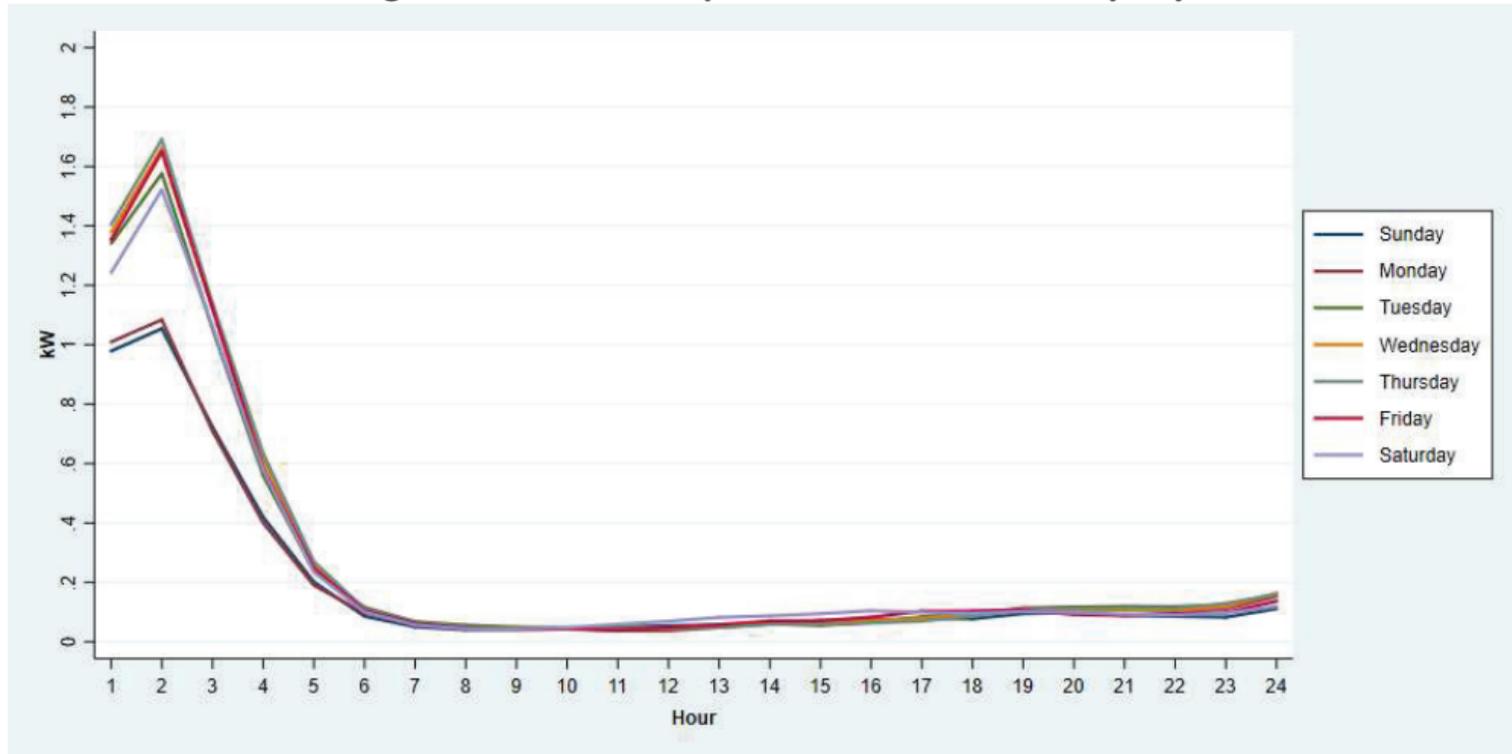
PG&E Low Price Period: 11 PM to 7 AM

Chart PG&E-8a: Average Load Profile for SF Separate Metering (EV-B) by Day of the Week
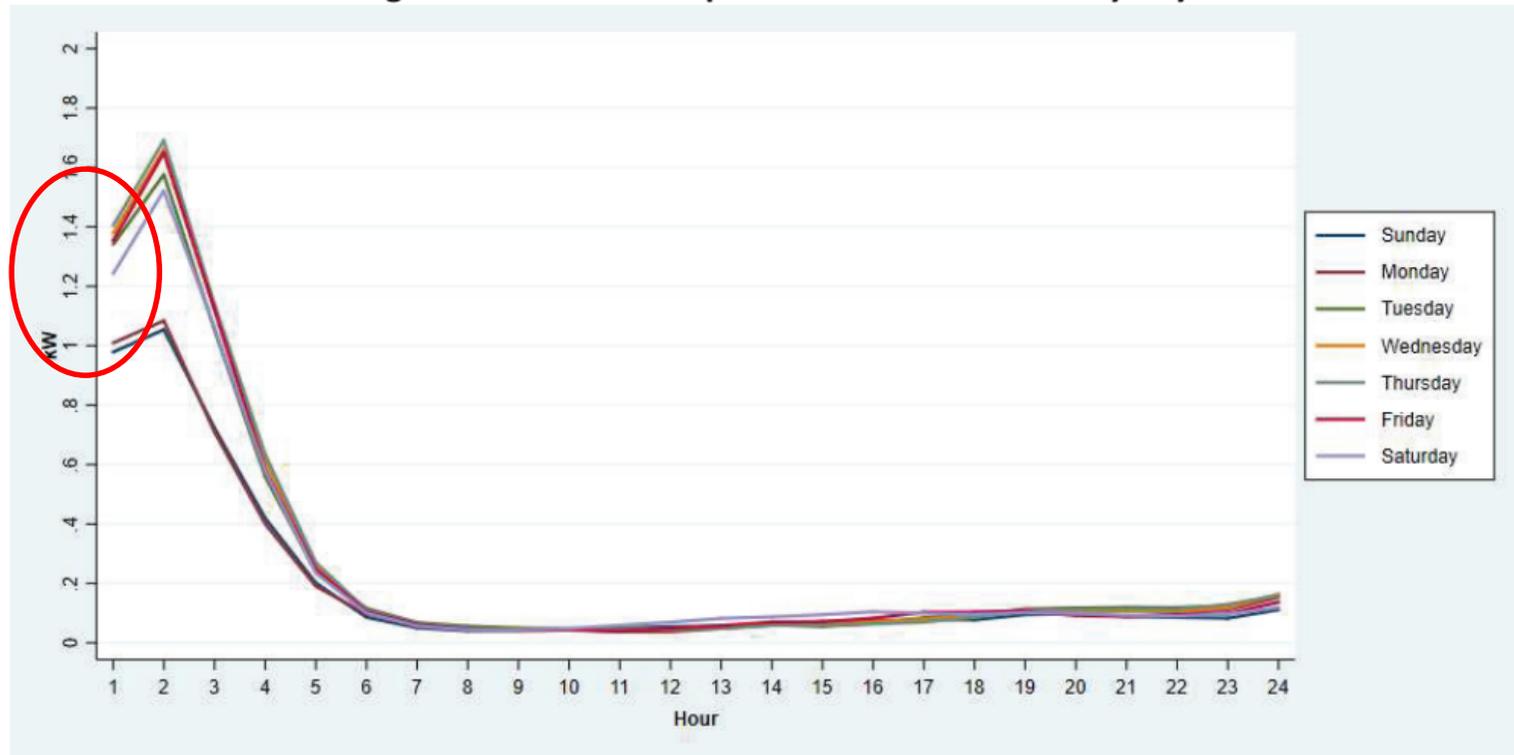
SDG&E Low Price Period: Midnight to 5 AM

SDG&E Chart 8: Average Load Profile for Separate-Meter Customers by Day of the Week

# *SDG&E Low Price Period: Midnight to 5 AM*

SDG&E Chart 8: Average Load Profile for Separate-Meter Customers by Day of the Week

Observations

- **Customers are quite responsive to TOU structure**

- **Huge load increase in first low-price hour**

- **Duration is influenced by end of low-price period**

- **At present charging rates (miles/minute), the IOUs have room to "smooth out" the EV load at night, if desired**

- **The peak/off-peak price ratio can also be used as a predictor, but the present data set may not be very illuminating**

  - They all seem to work fine

- **No acute seasonality in EV charging**

SCE: *Relatively Stable Monthly Consumption*

Chart SCE – 5: Separate Meter (TOU-EV-1) – Average Monthly Usage
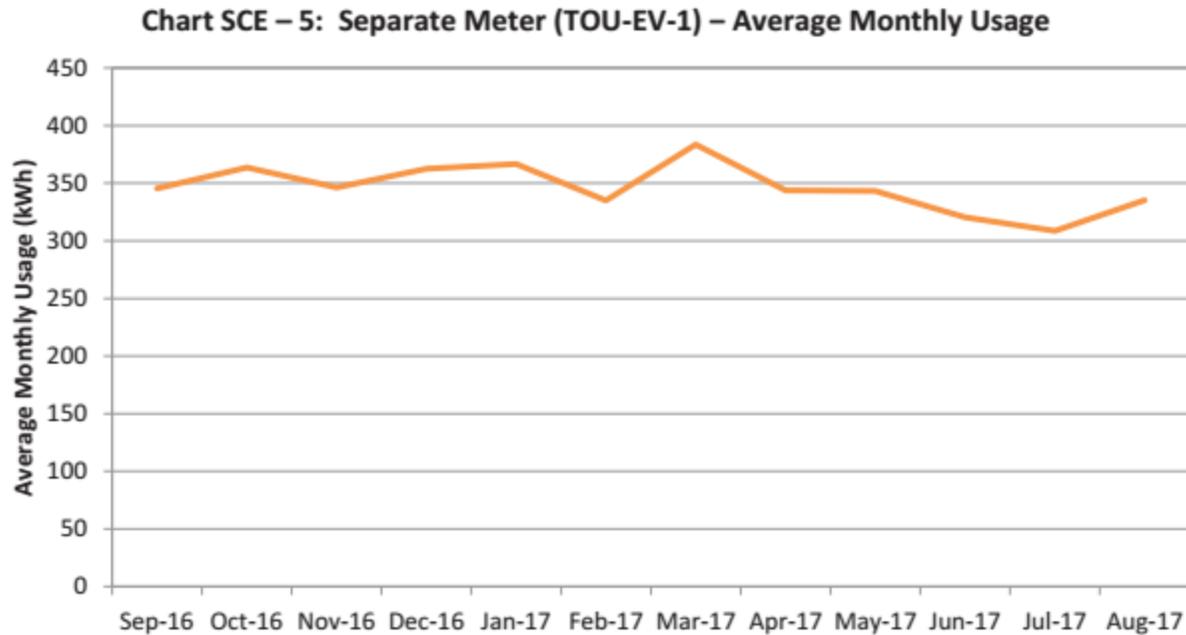
SDGE: *Confirms Stable Monthly Consumption*

SDG&E Chart 3: Average Monthly Usage for Separate-Meter Customers
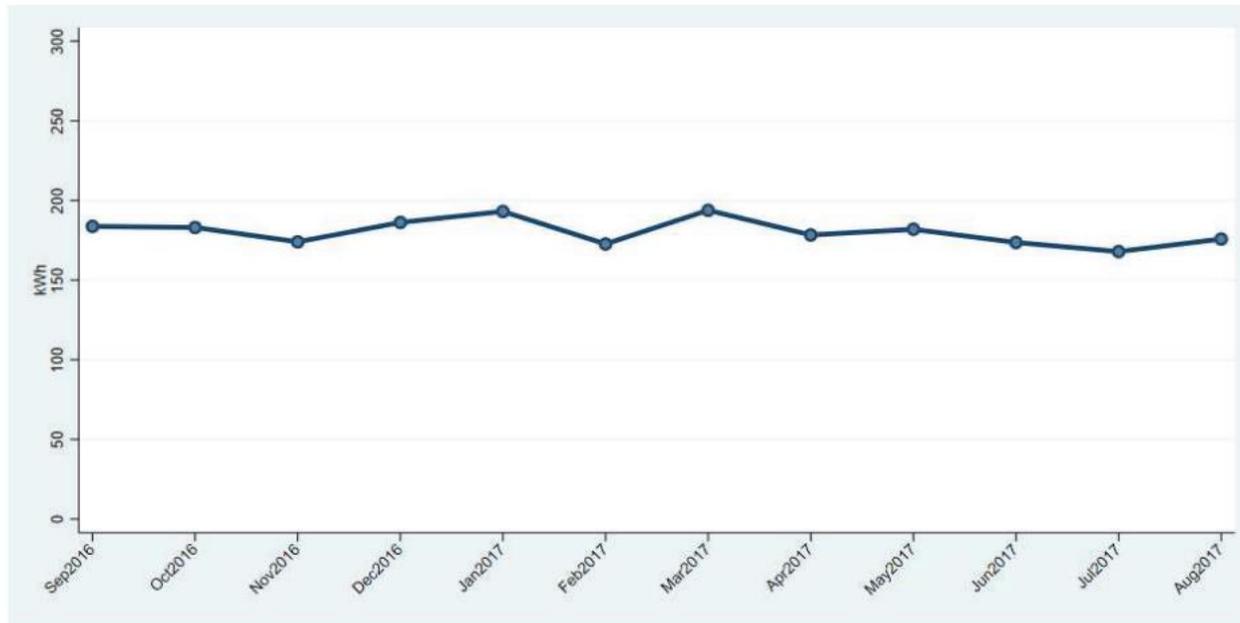
What About Nonresidential Profiles

- **We rely first on Chargepoint data**

- **We compare with DMV data to identify significant gaps in coverage**

- **We may sub-meter if there are significant gaps (e.g., if fleets are underrepresented)**

- **We may request rate structure for a set of addresses (fewer than 2,000 statewide) to see how TOU affects nonresidential charging**

  - We will get rates by account in the CEUS data, and will likely avoid this request

Stay Tuned for Results!

- **We hope to have initial load profile generators by late summer**

- **The most important aspect is to include functionality to describe grid integrated rates going forward**

- **We will research potential ways to develop a feedback loop from the SB350 TE Priority Review Project reports to the load shape generators**

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