Plug-in Electric Vehicles (PEV) in San Diego
Clean Transportation Program
SDG&E

Growth in Charging Equipment

- 2,465 PEV (year end 2012)*
  - OEM data from Nissan, Car2Go (300), BMW, Mitsubishi, Coda and Legacy/Conversion EV rate customers
  - Estimated for GM, Ford, Fisker, Tesla, Toyota, and Honda
  - Subject to change, per OEMs adjustments month to month

EV Project Summary

- 1,164 Commercial EVSE installed or in progress
- 365 EVSE at 106 locations operational
- 887 Residential operational
  - 668 Leaf
  - 219 Volts
- 15 DC Fast Chargers in progress (one is operational)

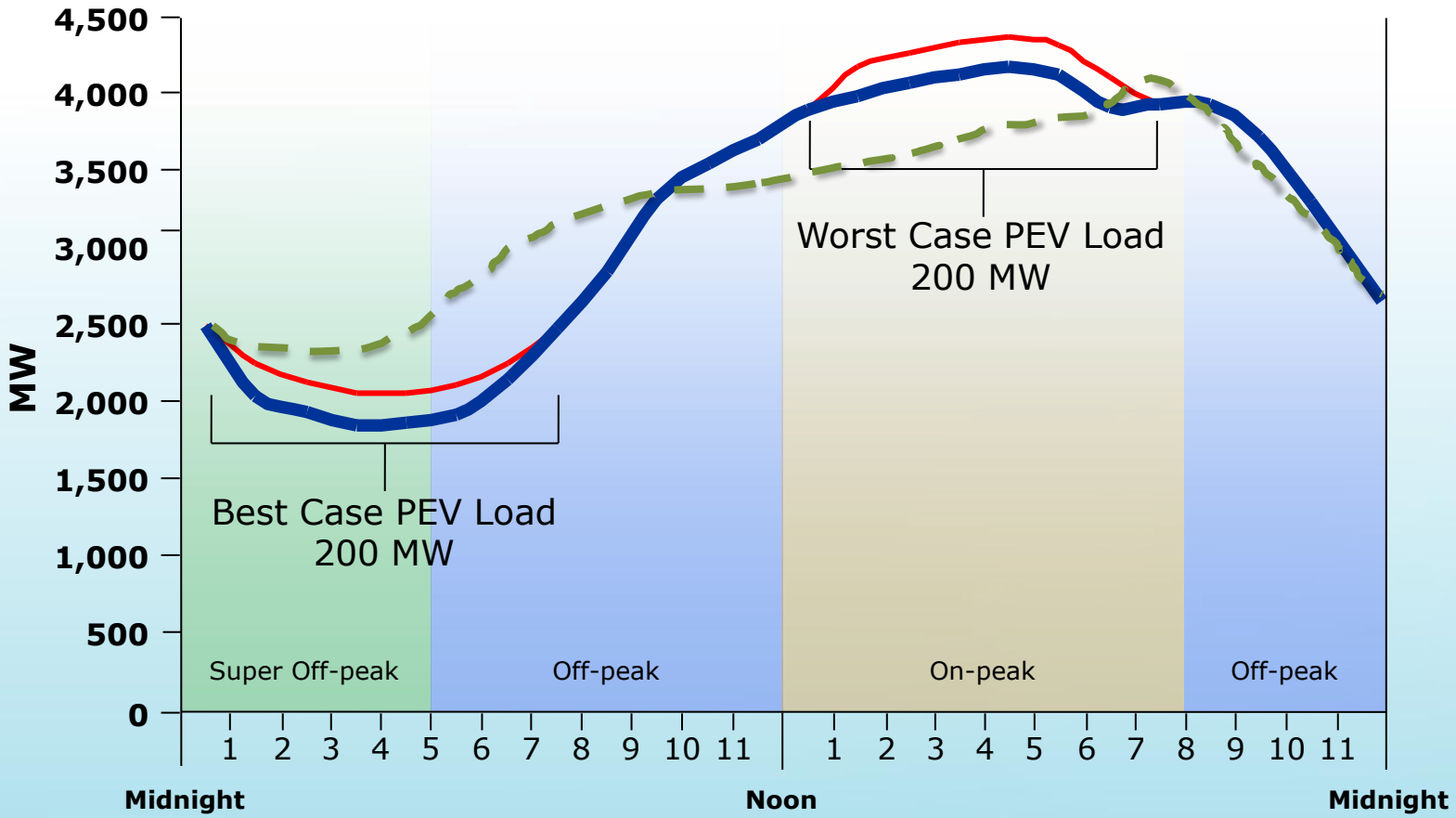
PEV & the Smart Grid

Vision & Focus

- **2015 – Significant deployment in public & workplace charging facilities**
- **2020 – Ubiquitous charging facilities**

- Impacts of charging by time of day on the grid?
- What drives PEV consumer charging time decisions?
- Can we achieve the efficient integration of charging loads?
  - Grid-to-Vehicle today with demand response
  - Prepare for Vehicle-to-Grid tomorrow with stationary batteries

Impacts on the Grid



Example Summer Daily Load Profile

PEVs (Plug-in Electric Vehicles) Generic for **ALL** plug-ins

that use **grid electricity** to charge a battery for transportation

- **EV** (Electric Vehicle) or BEV (Battery Electric Vehicle) – 100% electric drive
  ELECTRIC FUEL ONLY – NO TAILPIPE

- **PHEVs** (Plug-in Hybrid Electric Vehicles) – Internal Combustion Engine (ICE) + Electric Motor(s) + Grid Stored Electricity
  GASOLINE + ELECTRIC FUEL – TAILPIPE + PLUG

NEVs (Neighborhood Electric Vehicles) – EVs/BEVs limited to low speeds/range ELECTRIC FUEL ONLY – NO TAILPIPE – SMALL/SLOW

Charging

EVSE – (Electric Vehicle Supply Equipment)

AC – Alternating Current (what is delivered to your home) – converted to DC on board vehicle

- **AC Level 1** (120 VAC – 20 A circuit) - Simple cord set that plugs into 3 prong plug wall outlet – comes with car (GFCI/sep. circuit)

  Slower charging - approx. 2X the time of AC Level 2 (~4-6 miles of range/hr of charging)

- **AC Level 2** (208 -240 VAC – 30/40/50/80 A) - Wall or pedestal mounted EVSE requires electrician (residential/workplace/"destination" charging (Low 3.3 kW; Med 6.6 kW; High 9.6 kW; Highest 19.6 kW)

  Medium charging – standard charging rates in specs

  ~8 -12 miles of range/hr of charging (Low – 3.3 kW)
  ~16 - 24 miles of range/hr of charging (Med – 6.6 kW)
  ~ 32 – 48 miles of range/hr of charging (High – 9.6 kW)

DC – Direct Current (AC converted to DC in off vehicle charging unit –DC required to charge the battery

- **DC Fast Charge** (DC Level 2 - 480 VAC – 100 A) – EVSE provides converted DC direct to vehicle High voltage/high price (~$40-50K for hardware) NOT LEVEL 3 CHARGING !

"Fast/Quick" charging - "trip continuation" charging (e.g. highway corridors, etc.)

can charge 20% > 80 % of 24kWh battery in less than 30 min (~60 miles of range)

Grid Impacts from Vehicle Charging

- AC Level 1 (120v at 12 – 16 Amps)
  - Typically adds 4-6 miles of range per hour
  - Most cars come with AC Level 1 Cordset
  - Will run on standard 15/20 amp circuit

  - **Advantage: Can be used anywhere**
  - **Disadvantage: Slower charging**
  - **Grid Impact: Mild**

Grid Impacts from Vehicle Charging

- AC Level 2 (208-240v at 3.3kW, 6.6kW, 9.6kW, & 19.2kW)
  - Early cars mostly using AC Level 2 draw 3.3kW (LEAF, Volt)
  - Many newer models will draw 6.6kW (2013+)
    Coda, Focus EV, Active E & PHEV Honda Accord

    Adds ~ 8-24 miles of range per hour (3.3 – 6.6 kW)
    - Toyota RAV4 EV will draw 9.6kW (32-48 mi/hr range)
    - Tesla Model S can draw up to 19.2kW
  - AC L2 - Needs a dedicated 208-240v circuit
  - **Advantage: Faster Charging**
  - **Disadvantage: Higher Cost**
  - **Grid Impact: Moderate**

DC Fast Charge - Commercial/Public

- DC Fast Charge (208 or 440v/3-phase – up to 100 kW)

US Standard & European Vehicles (2014) - SAE Std
(SAE Combo Connector)

Nissan LEAF, Mitsubishi "i" use CHAdeMO (2010-2013)
Japanese Standard

Tesla Connector (Tesla only)

- **Advantage: Convenient (time)**
- **Disadvantage: Expensive (use & install)**
- **Grid Impact: High**

SAE Terminology

SAE Charging Configurations and Ratings Terminology

SAE International

AC level 1
(SAE J1772™)

PEV includes on-board charger
120V, 1.4 kW @ 12 amp
120V, 1.9 kW @ 16 amp
Est. charge time:
PHEV: 7hrs (SOC* - 0% to full)
BEV: 17hrs (SOC – 20% to full)

DC Level 1
(SAE J1772™)

EVSE includes an off-board charger
200-500 V DC, up to 40 kW (80 A)
Est. charge time (20 kW off-board charger):
PHEV: 22 min. (SOC* - 0% to 80%)
BEV: 1.2 hrs. (SOC – 20% to 100%)

AC level 2
(SAE J1772™)

PEV includes on-board charger (see below for different types)
240 V, up to 19.2 kW (80 A)
Est. charge time for 3.3 kW on-board charger
PEV: 3 hrs (SOC* - 0% to full)
BEV: 7 hrs (SOC – 20% to full)
Est. charge time for 7 kW on-board charger
PEV: 1.5 hrs (SOC* - 0% to full)
BEV: 3.5 hrs (SOC – 20% to full)
Est. charge time for 20 kW on-board charger
PEV: 22 min. (SOC* - 0% to full)
BEV: 1.2 hrs (SOC – 20% to full)

DC Level 2
(SAE J1772™)

EVSE includes an off-board charger
200-500 V DC, up to 100 kW (200 A)
Est. charge time (45 kW off-board charger):
PHEV: 10 min. (SOC - 0% to 80%)
BEV: 20 min. (SOC – 20% to 80%)

Voltages are nominal configuration voltages, not coupler ratings
Rated Power is at nominal configuration operating voltage and coupler rated current
Ideal charge times assume 90% efficient chargers, 150W to 12V loads and no balancing of Traction Battery Pack

Notes:
1) BEV (25 kWh usable pack size) charging always starts at 20% SOC, faster than a 1C rate (total capacity charged in one hour) will also stop at 80% SOC instead of 100%
2) PHEV can start from 0% SOC since the hybrid mode is available.

ver. 100312

Levels of Charging
Society of Automotive Engineers (SAE)

SDGE connected
A Sempra Energy utility

Proposed SAE Charging Configurations and Ratings Terminology

- **AC L1**: 120V AC single phase
  - Configuration current 12, 16 amp
  - Configuration power 1.44, 1.92kw
- **AC L2**: 240V AC single phase
  - Rated Current ≤ 80 amp
  - Rated Power ≤ 19.2kw
- **AC L3**:TBD
  - AC single or 3ϕ ?

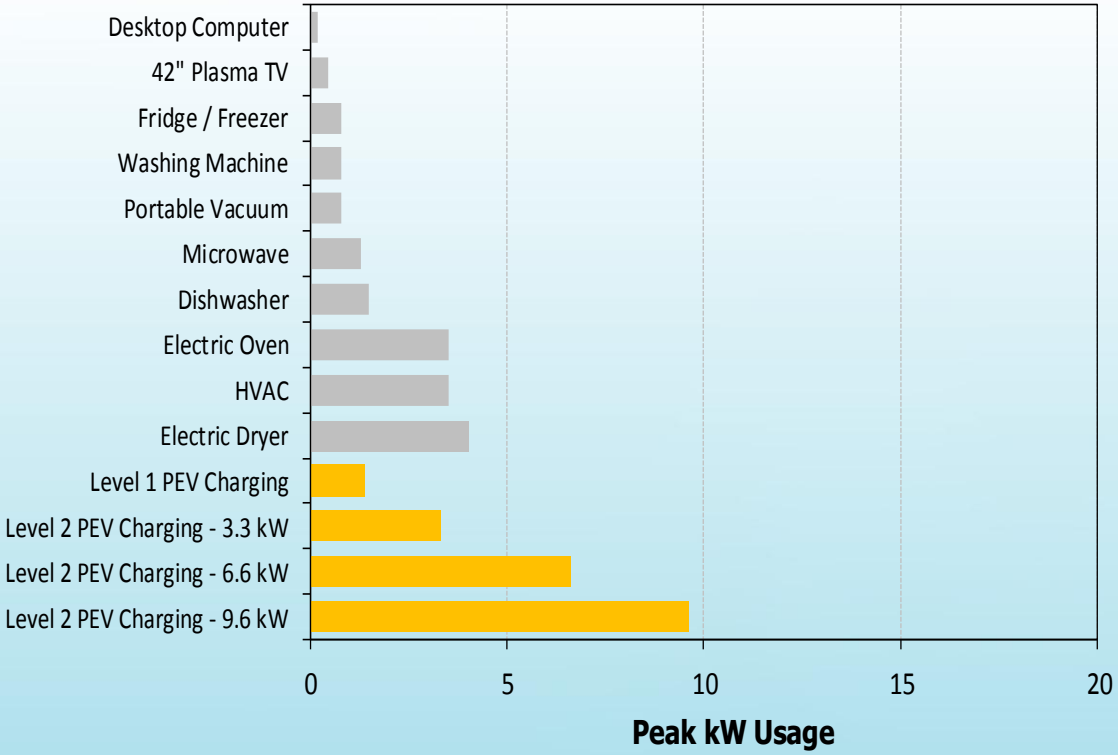
- **DC L1**: 200 – 450V DC
  - Rated Current ≤ 80 amp
  - Rated Power ≤ 36kw
- **DC L2**: 200 – 450V DC
  - Rated Current ≤ 200 amp
  - Rated Power ≤ 90kw
- **DC L3**: TBD
  - 200 – 600V DC ?
  - Rated Current ≤ 400 amp?
  - Rated Power ≤ 240kw?

Voltages are nominal configuration operating voltages, not coupler rating.
Rated power is at nominal configuration operating voltage and coupler rated current.

Examples of charging load

- PEV charging may introduce significant load as compared with typical household appliances. The highest proposed level of charging may easily double or triple a household's prior peak load. These high levels of charging may impact distribution infrastructure that is not sized to handle the new load requirements.

- SDG&E serves 3.4 million consumers (2.2 million smart meters)

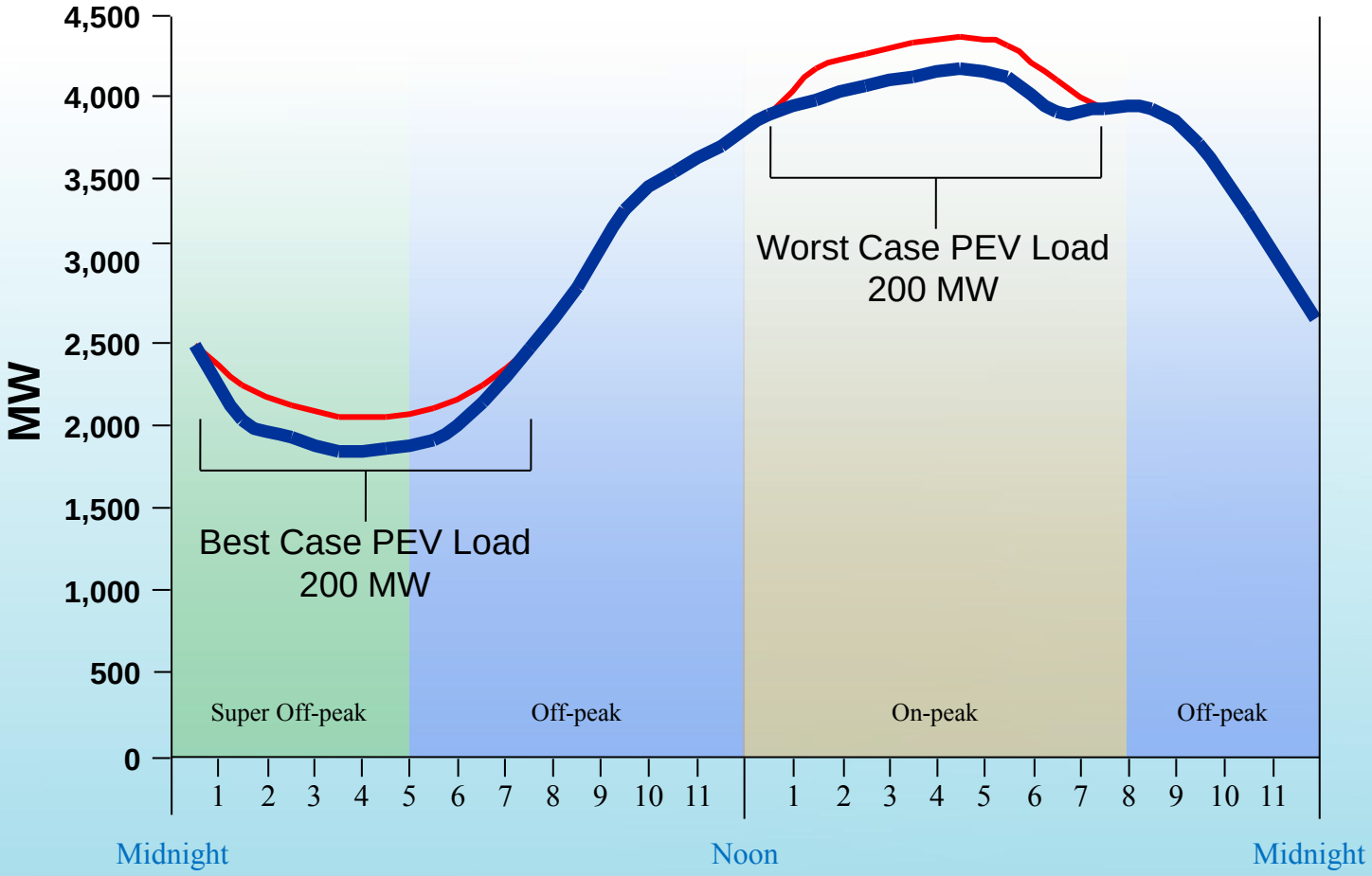


Grid load levels as seen by the utility can be higher (e.g. 6.6 kW charging can result in actual load of 7.7 kW)

With Super Off-Peak Charging
No New Power Plants Needed

SDGE connected
A Sempra Energy utility℠

Example Summer Daily System-wide Load Profile

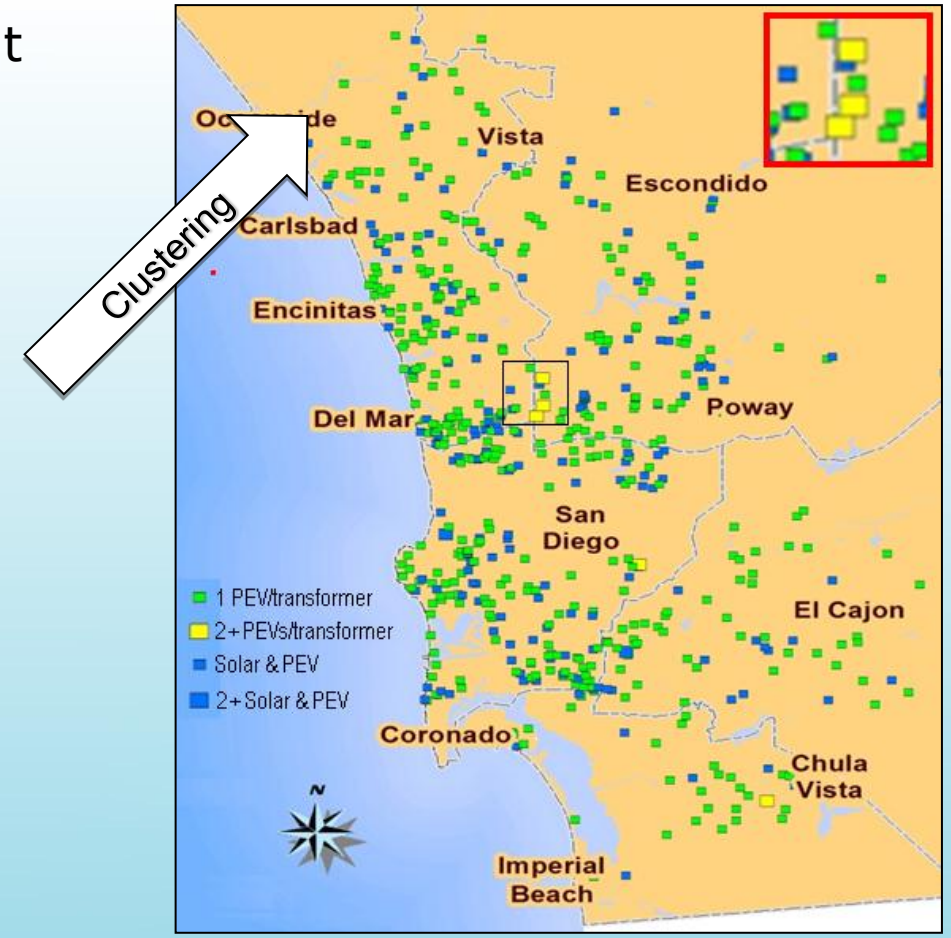


System & PEV charging load profile are for illustrative purposes only, and not intended for forecasting.

Low Rates - Minimizing "on peak" Charging

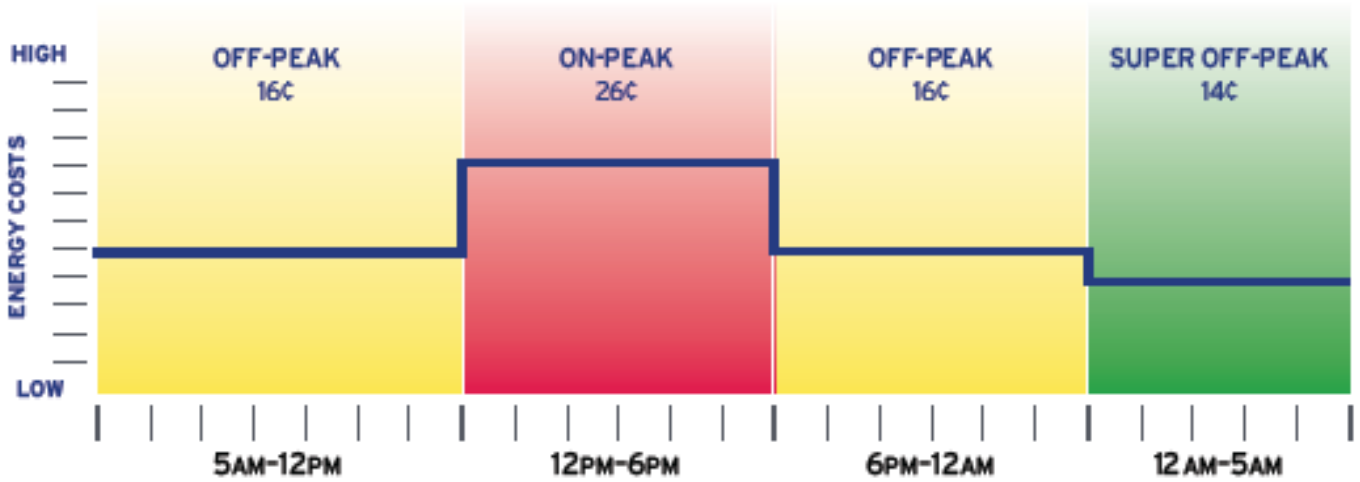
Through outreach & education, and time-variant rates, SDG&E is helping reduce charging impacts from PEV clustering

- Smart grid load management automation will reduce charging impacts from PEV clustering
- Must understand charging impacts on system down to transformer level
- Long-term expectations
  - Ubiquitous charging
  - Staying "plugged-in" enables G2V and V2G options & incentives



Electric Vehicle Time-Of-Use Rates

It matters when you charge your electric car.



Rate prices listed represent the summer EV-TOU-2 rate as of October 20, 2012. Find current rates at *sdge.com/evrates*.

Sign up for your EV rate today at *sdge.com/ev*.

Summer Peak

Rate Options

Residential Accounts (Time-of-use discount - Individuals)

Separate Vehicle Meter (EV TOU) - Vehicle use on TOU

(subtractive TOU billing from primary tiered meter)

Whole House (EV TOU2) single meter – all use (home & car) is now TOU

(no longer pushing use into more expensive higher tiers)

Commercial Accounts (Community Managed)

< 20 kW – Non Demand/Non TOU – add to existing or new account

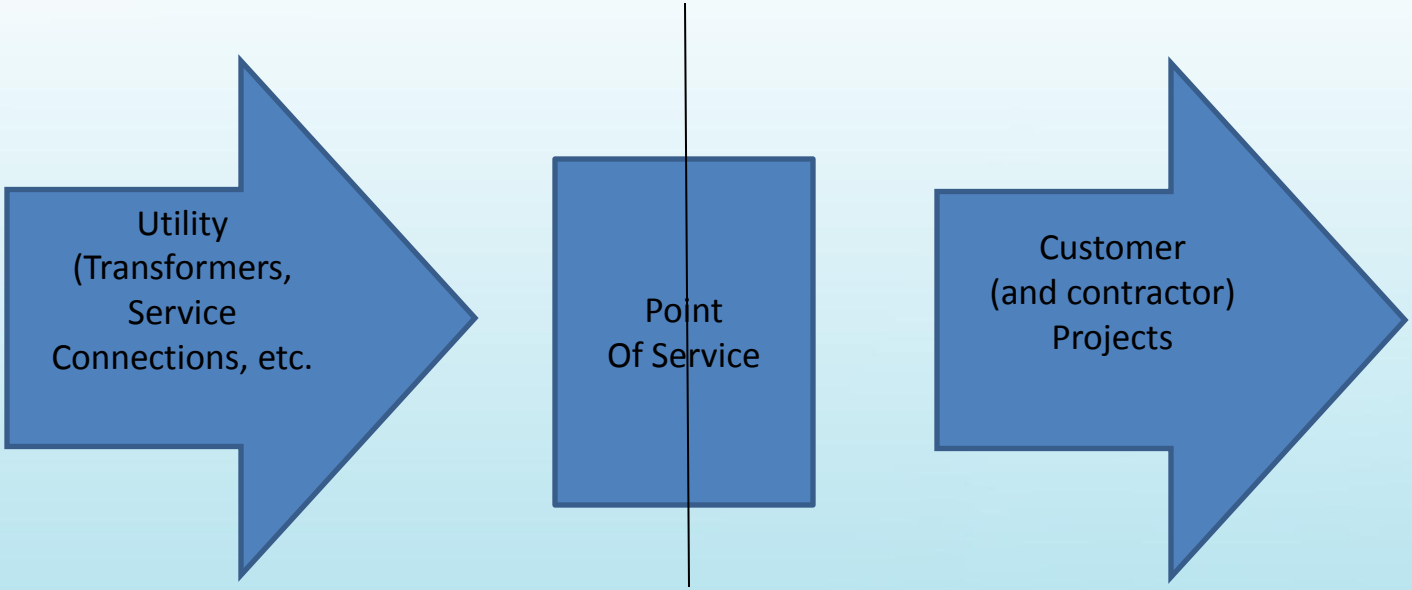
> 20 kW – Demand/TOU - add to existing or new account

* Exception – Shared Common Walls – Residential Rate Option (common use)

Demarcation point for Utility

Utility

Customer



Range of Charging Technology

AC Level 1
110/120VAC
Cordset
(with vehicle)

1.4 kW

AC Level 2
220/240VAC
Non
Communicating

AC Level 2
220/240VAC
Communicating

3.3 and 6.6 kW

AC Level 2
220/240VAC
Advanced
Communicating
& Scheduling

3.3 and 6.6 kW

GoElectricDrive.com - http://www.goelectricdrive.com/index.php/find-an-ev-charger

NRTL/UL Approved Equipment List

2012 – Entry of AC Level 2 vehicles @ 9.6 kW and 19.2 kW charging

Future - DC Level 1 and/or DC Level 2 (fast charge) as a community resource?

Workplace charging as a substitute?

PEV Business Landscape

- SDG&E PEV Policy Team: regulatory, legislative & strategic
- 2012 GRC: clean transportation, electric T&D, charging equipment
- CPUC AFV OIR: Phase 1 (D.10-07-044) decision (jurisdiction & regulation) and Phase 2 (D.11-07-029) decision (implementation)
  - Electric Vehicle Education & Outreach (all stakeholders)
  - Notification (to inform SDG&E of PEVs in service area)
  - Submetering Protocol (allows others to own EV load meters)
  - Load Research & Cost Tracking (load impacts and costs)
  - Rate Design (evaluate demand charges)
  - Ownership of charging equipment (SDG&E is prohibited)
- CPUC GHG OIR: Treatment of Low Carbon Fuel Standards Credits
  - CARB wants to maximize credits and return value to PEV customers

Smart Grid Deployment Plan

- PEV Rate Experiment
- PEV Transformer Impacts Modeling (Smart Transformer)
- Vehicle-to-Grid (Proxy) Pilot
- Electric Vehicle Education & Outreach (market development)
- Charging Equipment & Demand Response Technology
- Plug-in Vehicle Infrastructure Upgrade – Cost Tracking
- Secondary Use of EV Batteries
- Flexible Demand Initiative (leverage existing micro-grid work)
- Vehicle-to-Home

What Drives Charging Time Decisions?

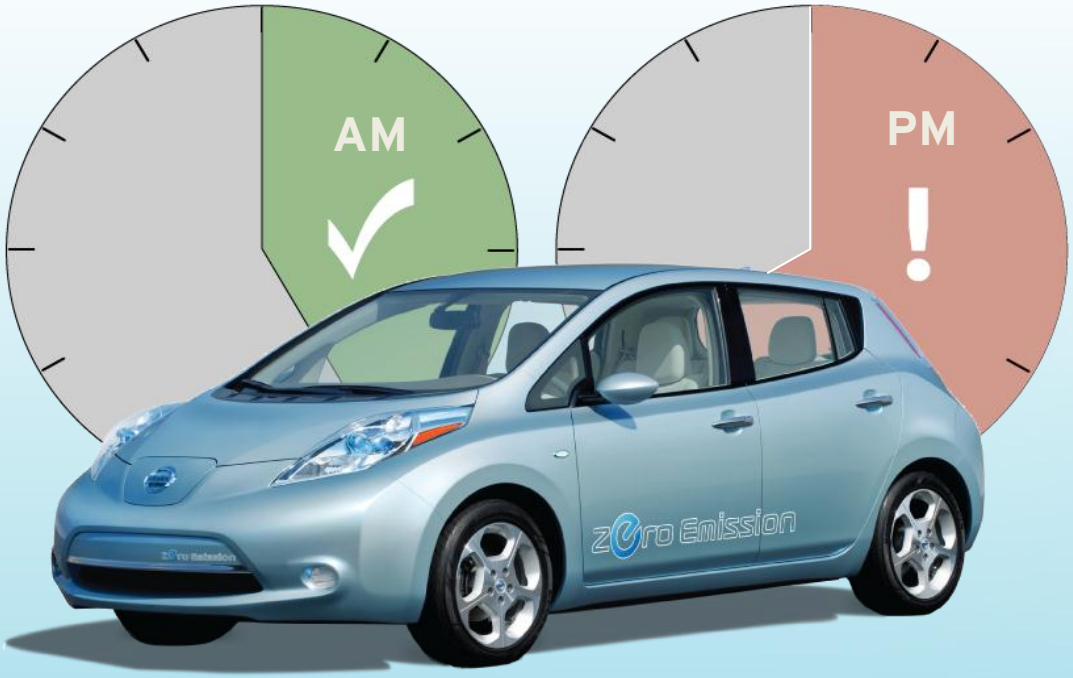
PEV Rates & Technology Study – CPUC approved experimental PEV rates for EV Project & Nissan deployment

- **Price – Fuel Savings?**

  Low Super Off-peak rates
- **Technology & Information – "Set & Forget"?**

  On-board Leaf technology
- **Convenience & Lifestyle – Do Travel Needs Rule?**

  Schedule



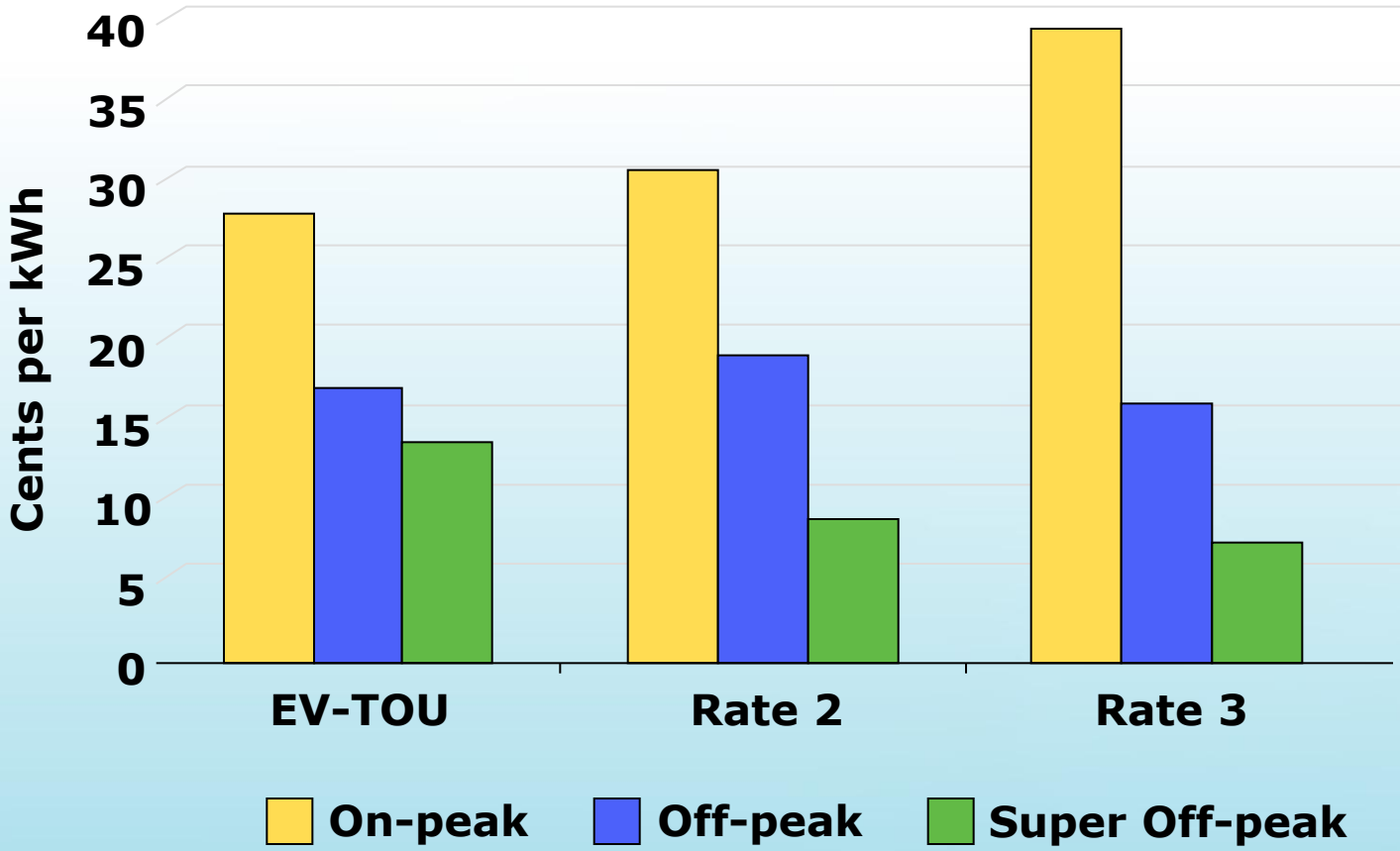
PEV Rate Experiment – 1st Yr. Evaluation

- **A randomized pricing experiment:**
  - Three Time-of-Use rates for PEV charging
  - Coordinated with The EV Project and LEAF rollout
  - EV Timers uses to encourage Super Off-Peak charging

- **Participant results to date:**
  - 8.3 kWh/day average for home PEV charging
  - Roughly 80% of kWh used in Super Off-Peak period (Midnight to 5:00 AM daily)
  - Even the mildest TOU price differential resulted in 78% of kWh used during Super Off Peak

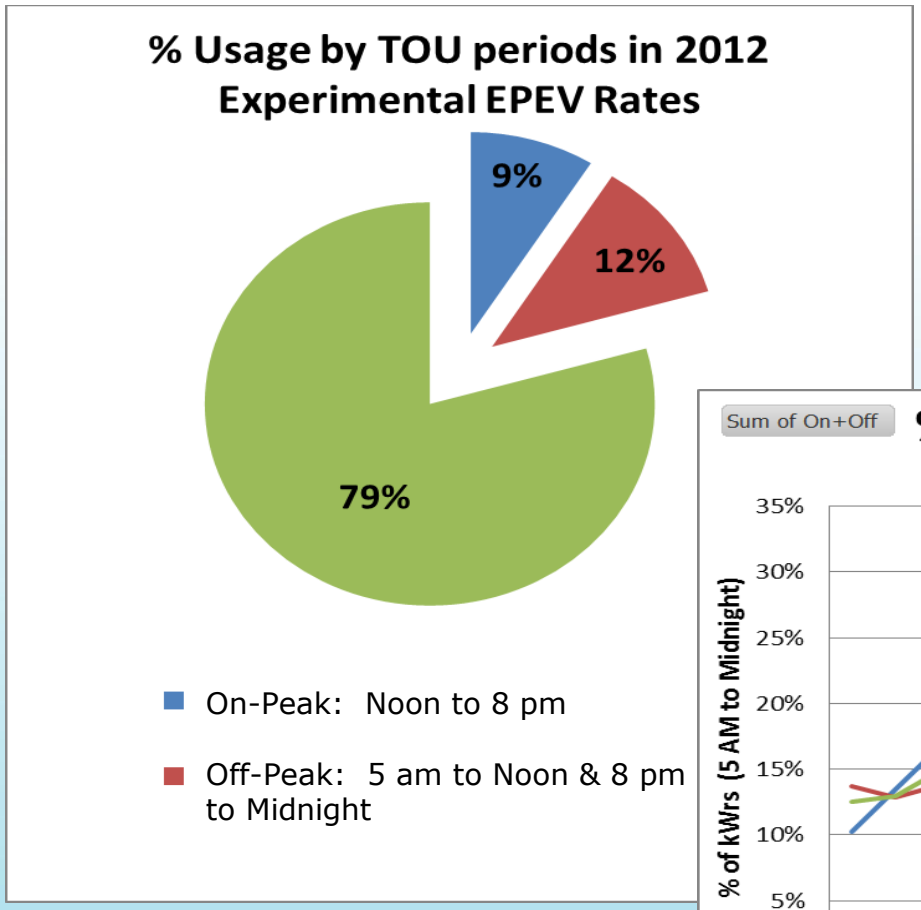
- **Experiment continues in 2013:**
  - Observe if PEV charging patterns persist
  - Estimate price elasticities using additional data
  - Refine charging behavior model

SDG&E Experimental PEV Rates



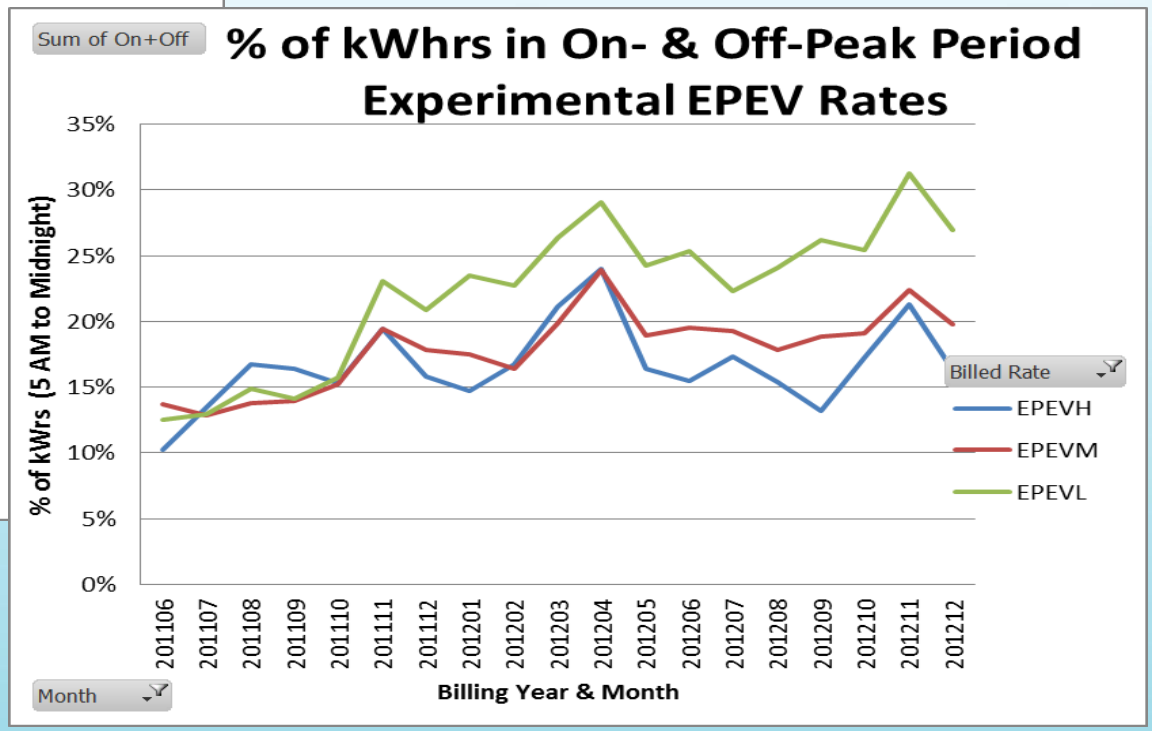
Summer example – Separately metered experimental EV rates (EPEV-X, EPEV-Y, EPEV - Z) "on-peak" is noon to 8pm, and "super off- peak" for all EV rates is midnight to 5am. All other times are "off-peak".

Super Off-Peak Charging at Home is Encouraged by TOU rates



Three experimental PEV rate groups total PEV kWh usage combined

- About 8 kWh per day
- On-peak usage varies
- Data: July 2011 to Dec 2012

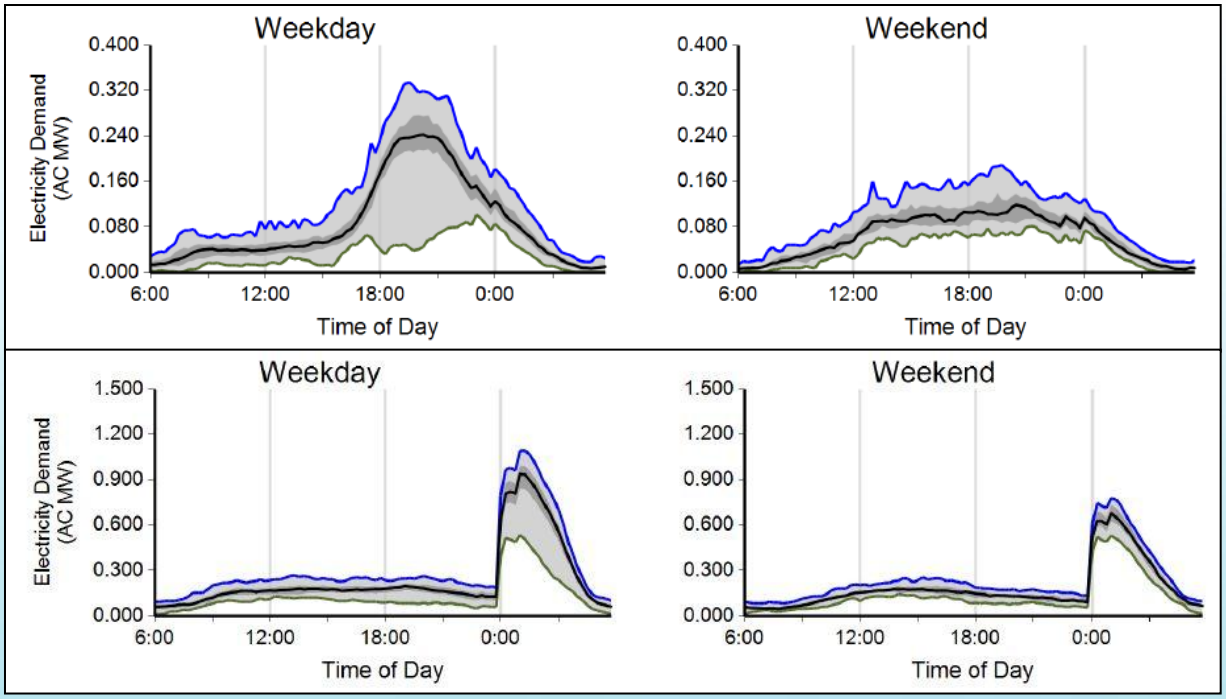


TOU Rates Influence PEV Charging Q3 2012

TOU rates encourage off-peak charging vs. a flat rate

Nashville Electric Svc, TN
- 307 residential EVSE
- Base Charge: $13.43 / mo.
- Summer: $0.0999 / kWh
- Winter: $0.0971 / kWh

SDG&E, CA
- 581 residential EVSE
- TOU rates
- Super off-peak:
  midnight to 5am



Source: INL http://avt.inel.gov/pdf/EVProj/EVProjInfrastructureQ32012.pdf

Implications

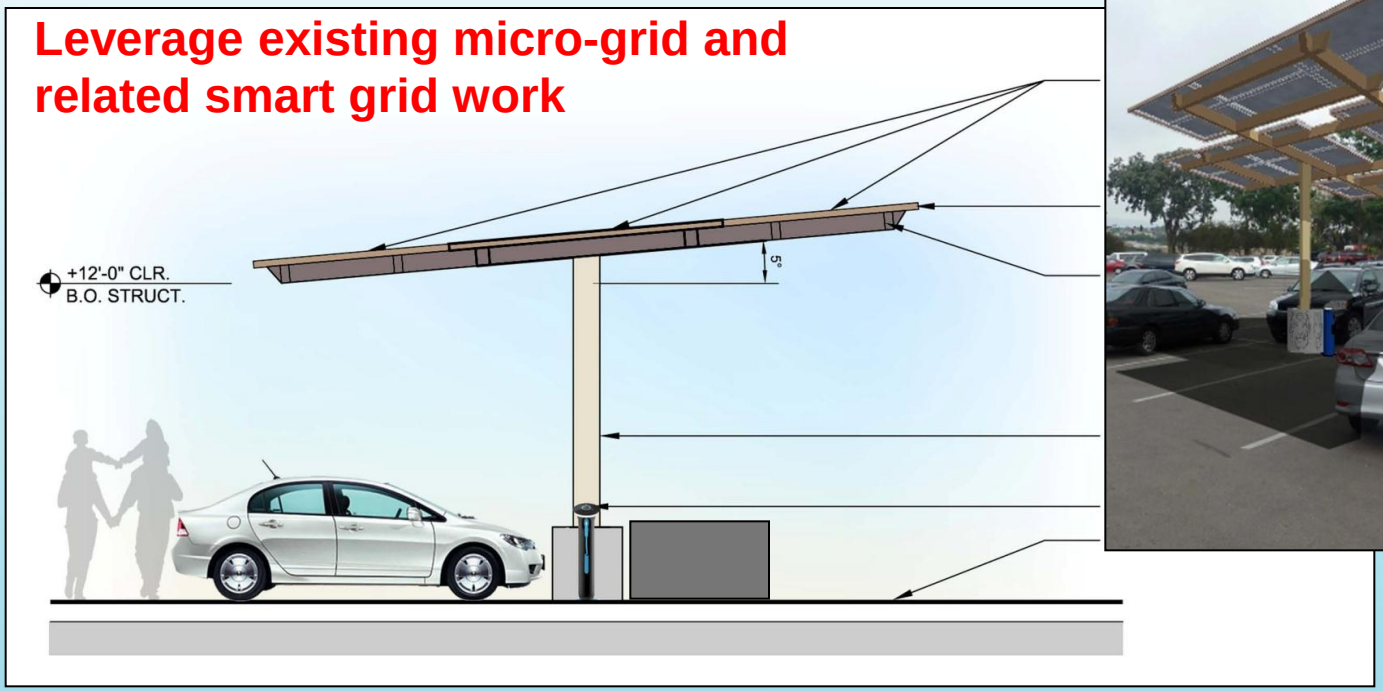
- Small pricing incentives influence home time-of-day charging
- Convenience technology works – implies smart grid technology must be simple "set and forget"
- Home charging kWh sales aligns with average San Diego commuting distances (~24 miles per day)

Efficient Integration with the Grid

Solar-to-PEV Charging – PV & battery integrated PEV charging at Zoo

- Pilots G2V (DR) today, and V2G applications when OEMs are ready
- Meets CAISO needs in ancillary service market – demonstrate controls & communications technology needed for regulation services

Leverage existing micro-grid and related smart grid work



Education & Outreach – Key Messages

- Call us first or visit sdge.com/ev
- PEV rates will help you pay the lowest price for your EV fuel when charging between midnight and 5 a.m.
- Driving an PEV reduces your carbon footprint, and shows you support energy independence and reduced petroleum imports.
- SDG&E supports the adoption of PEVs while ensuring safe and reliable service
- Multi-unit Dwelling and Workplace Charging - Workshops
- *Call-to-Action in 2013* – Attend Plug-in 2013, Public Day

Governor's Environmental & Economic Leadership Award: City of San Diego

- Best "Plug-in Vehicle Adoption Program"
- City named leader for plug-in EV infrastructure, education and adoption
- 1st city in the nation to support an all-electric car sharing fleet – car2go
- Streamlined its permitting process for home and public charging
- Developed an Information Bulletin that describes step-by-step permitting and inspection process for charging station installation
- The City of San Diego is the:
  - Administration hub via CA Center for Sustainable Energy of Clean Vehicle Rebate Program
  - San Diego Regional Clean Fuels Coalition
  - EV Project public charging station hub
  - Founding member of Smart City San Diego, along with SDG&E, UC San Diego, GE and CleanTECH San Diego

Education & Outreach Collaboration

Collaborate with partners to disseminate our key messages

- Employees: Green Driving Challenge
- Executives: Green Driving Experience – Toyota EV Rav4
- Smart City San Diego
- Dealerships & New Car Dealers Association of San Diego County
- Apartment/Condo associations
- Workplace candidates
- National and statewide organizations
- Technology vendors
- Fleet industry
- Environmental Community
- Media

PEV Trade Organizations

- Electric Drive Transportation Association
- California Electric Transportation Coalition (CalETC)
- California Plug-in Electric Vehicle Collaborative
- San Diego Region Clean Cities Coalition
- Society of Automotive Engineers
- Plug-in America
- GridWise Alliance
- Electric Power Research Institute (EPRI): Electric Transportation Program, Infrastructure Working Council and the Battery Committee
- U.C. Davis: Plug-in Hybrid and Electric Vehicle Research Center of California Advisory Board, Institute of Transportation Studies and NextSTEPS Program

Support

- Special Projects Support (e.g. TheEVProject, NRG, ChargePoint, etc.)
  - Electrical Engineer on staff
  - Transformer Review
  - Facilitation with SDG&E Project Management

- Multi-unit Projects – site walk throughs – case study documentation

Multi-Unit Dwelling Vehicle Charging

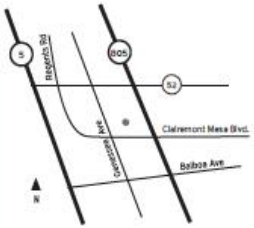
Tuesday
February 26, 2013

(Seminar)

Time:
9 a.m. - 10:30 a.m.
(8:45 a.m. check-in)

Cost:
No Fee

Location:
San Diego Gas & Electric®
Energy Innovation Center
4760 Clairemont Mesa Blvd
San Diego, CA 92117



It's easy to register:

Internet:
seminars.sdge.com

Email:
seminars@sdge.com

Phone:
1-800-613-8970

Pre-registration is encouraged.

What's Involved When Residents Want to Charge a Plug-In Vehicle Within a Multi-Unit Dwelling Community?

Learn about the stakeholders involved, the decision process flow and possible issues for multi-unit dwelling communities interested in the installation of vehicle charging units for electric cars.

Seminar Highlights

- Provide an overview of vehicle and charging equipment coming to market
- Define and address concerns of property managers/owners, homeowners/renters, and electrical contractors regarding the installation of charging equipment
- Describe the steps needed to help you craft your community's site-specific policy
- Identify talking points for when someone in the community asks, "Where will I plug-in?"

Who Should Attend?

- Property Managers/Owners
- HOAs and Rental Associations
- Residents of multi-unit dwelling communities interested in plug-in vehicles
- Electrical contractors

You Will Learn

- The suggested steps involved
- Who needs to be involved
- What types of vehicles and charging equipment are coming to market
- Industry-specific terminology

Speaker

Joel Pointon is the Manager of Electric Transportation for SDG&E® and has initiated a national emphasis program on plug-in electric vehicle charging for multi-unit dwellings. He serves on a number national advisory panels for electric transportation and has presented on this topic extensively in California and the U.S.

Also

- **Workplace Charging Seminar**

March 21st

9-10:30 AM

Plug-In 2013 Conference and Exposition

- **Plug-In 2013** will bring together key industry stakeholders to discuss, debate and, ultimately, answer these questions and more, such as:
- What is the **current thinking** on technology and policy?
- **What have we learned** over the last three years – where do we think the electric highway is taking us?
- **What is the current risk assessment**? What are the risks and value propositions today and what will they be in the next three to five years? How do we sell a new value proposition?
- **2013 will be the year for real data, real-world reporting and a serious analysis of what's next for the electric highway**

Plug-in Electric Vehicles & the Smart Grid

SDGE connected

A Sempra Energy utility℠

SDGE.COM/EV

EV@SDGE.COM