Integrating Plug-In Electric Vehicles with the Grid in California

Toward 250,000 Chargers by 2025

Noel Crisostomo
California Energy Commission
Smart Charging Webinar Series | December 17, 2019
Newcastle University – Center for Energy Systems Integration / Alan Turning Institute / Supergen Energy Networks
California must electrify transportation to meet its climate and air quality goals

- Economy-wide carbon neutrality by 2045
- 5 million Zero-Emission Vehicles by 2030
- 250,000 EV chargers by 2025
- Half of in-state GHG emissions come from vehicles, oil extraction, and oil refining
  - 25% of emissions come from Light Duty Vehicles
- Trucks, Buses, & Off-Road Vehicles produce 68% of NOx
Research Question & Model Objectives

“How many of each charger type are needed in California to ensure that both BEVs and PHEVs can drive mostly on electricity by 2025?”

- Target enabling travel for BEVs
- Provide PHEVs the opportunity for maximizing their electric miles
- Consider mainstream demographics for expanding the PEV market
- Consider consumers' ability to reduce the infrastructure cost by efficient sharing
Electric Vehicle Infrastructure Projection (EVI-Pro) Tool
- Wide variation in EV:EVSE “connector” ratio.
- Isolating for technology shows that increased demand for public chargers (a single DCFC serving fewer BEVs) is proportional to the prevalence of apartments.
EV Charging “Dragon Curve”

Statewide Light Duty PEV Charging Load Profile in 2025

- Residential L1
- Residential L2
- Work L2
- Public L2
- DCFC

Weekday Load, MW

Time of Day

Electricity Market Trends Drive both Grid-Integration and Independence

36% incr. in southern CA coastal AC demand 1985-2015

Aging distribution grids overloaded by 2018 record heatwaves

Extreme wholesale price variations with evening ramp (Q2 2019)

50% growth in Cooling Degree Days by 2050

https://laist.com/2018/07/09/las_heat_wave_left_more_than_50000_without_power_and_broke_an_electricity_use_record.php
https://laist.com/2018/07/25/living_at_the_beach_no_longer_means_no_ac_needed.php
https://cal-adapt.org/tools/degree-days
Vehicle-to-grid technology is revving up

Elise Wenzel
Tuesday, November 12, 2019 - 2:06am

GreenBiz

Will Your EV Keep the Lights On When the Grid Goes Down?
Home battery systems can help during power outages. So can the battery packs rolling around in electric vehicles.

Justin Gerdes
November 08, 2019

GRID EDGE

Could Electric Vehicles Really Help Prevent Forest Fires?
If you think the increased risk of power outages due to disasters argues against the purchase of an electric vehicle, you’d be wrong, says Dan Neil. Here’s why EVs might actually be your best option during emergencies.

CHARGED UP California added 750,000 plug-in electrics in 2018, and the state has a goal of putting 15 million EVs on its roads by 2025. ILLUSTRATION: DAVID MOORE

All The Energy Storage The Grid Needs Will Soon Be Under Our Noses

Jeff McMahon
Contributor @
Green Tech
From Chicago, I write about climate change, green technology, energy.

November 8, 2019 - 6:03 PM ET
Heard on All Things Considered

With Blackouts, California’s Electric Car Owners Are Finding New Ways To Charge Up

FORBES

61,766 views | Nov 12, 2019, 12:00am

EV battery packs are functionally similar to stationary systems but much larger.
Codes & standards are essential for:
- Interoperable PEVs, EVSE, and communication networks
- Sending industry predictable investment requirements for them to achieve scale economies

The market must evolve to support the vision where *Any PEV can plug into any EVSE, anywhere, anytime and they are able to function without special effort.*

**Global interoperability requires ...**
Interoperability will provide standardized devices that are capable of functioning as intended with each other — without special effort by the user.

**Key Standards**
- AC L1&L2 charge communication
- DC communication
- Interoperability
- Wireless charging

**Compatible Enabling Technologies**
- metrology/sub-metering
- communication controllers & messaging protocols
- charge couplers

**European Commission Joint Research Center / U.S. Department Of Energy - Argonne National Lab, EV-Smart Grid Interoperability Centers**
RDD&D to advance smart and efficient Electric Vehicle charging technologies

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<th>Application or Commodity Being Measured</th>
<th>Acceptance Tolerance</th>
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<td>AC electricity as a vehicle fuel</td>
<td>1.0 %</td>
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<tr>
<td>DC electricity as a vehicle fuel</td>
<td>2.5 %</td>
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Maintenance Tolerance = 2x Acceptance Tolerance. For DC electricity, 2.5% Acceptance Tolerance for installations before 1/1/33 and 1% afterward. California Department of Food & Agriculture Proposed EVSE Regulation.
Open Standards-Based Network Communications provide both implementation and load flexibility

Multiple viable uses of protocols, dependent on purpose and situation, for each EVSE

- Utility Direct or Aggregator – managed demand response or resource controls
- Presence of other EVSEs, non-EV loads, and/or an Energy Management System
- Transfer information across networks (direct btw. networks or via clearing houses)
- Asset protection for potential use across EV Service Provider networks

- OpenADR 2.0b & SEP 2.0b (Demand & Price Signals)
  1. Utility Direct Load Control
  2. Energy Management System
  3. Aggregator Managed

- OCPP 1.6J, 2.0 & Others IEC 63110 (Equipment Management)
- OCPI or OICP (Inter-network Billing)

Adapted from CPUC Energy Division VGI Communications Protocol Report, 2018
Implementing a common, unique EV/EVSE communications protocol based on ISO 15118 is crucial for seamless charging interoperability to reduce EVSP network software costs and site hosts’ utility operational costs.
Networked residential AC electric vehicle supply equipment are competitive on a first cost basis (excluding tariff savings).

Estimates of charger costs should normalize for the features (e.g. payment interfaces, communications, weatherization, plug v. hardwire, cord length & management, etc.) often bundled to support commercial or public-facing operations.

Unitize by Ampacity to ensure the functional unit is substantially similar across models.

Ideally, consider year of introduction and analyze by sales weights (if available).

CEC analysis of EVSE product pages, work papers, and OEM interviews.
Conservatively, ISO 15118 enabling circuits cost <$10/unit at scale. Assuming that the Level 2 EVSE is networked, the transceiver marginal cost is about $1.5/unit.

Source: Energy Commission March 2019 analysis of supply equipment charge controllers and wholesale electronics suppliers.
With economies of scale production, including a transceiver adds de minimis upfront costs to a L2 EVSE (excl. proprietary design, engineering, and software integration).

Using conservative assumptions for driver willingness to pay and higher-end component costs demonstrates net value for OEMs at volumes <1k units.
Drivers want low costs, but requiring user input overly complicates interactions and limits capacity management.

Text message-based user inputs of planned departure time and energy (kWh or mi)\(^2\)
Participation rate = 48%

Histogram of error in user-requested kWh\(_3\)
74% request > delivered, 26% request < delivered
\[\text{Mode}_{\text{BEV}} - \text{Mode}_{\text{PHEV}} = 2.5 \text{ kWh in excess}\]

Maximum % Reduction in EV Load for different reserve SOC values without adversely impacting mobility, for DR events beginning at different hours\(^4\)
~65% reduction possible with \(\frac{1}{2}\) of battery reserved

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3) https://ieeexplore.ieee.org/document/8450227,
Efforts with agency partners toward Vehicle-Grid Integration in California

- Interconnecting Alternating Current Vehicle-to-Grid EVs
- Medium and Heavy Duty Vehicle Infrastructure Projections
- Distributed Generation and Storage for Charging
- Analyzing benefits to customers, site hosts, aggregators, and utilities
- Tariff and market reforms enabling distribution and wholesale services
- [Vehicle-Grid Integration Roadmap](#) (multi-agency planning)
Thank You!

Questions?

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