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Electric Vehicle Infrastructure Projection Tool (EVI-Pro)

California Energy Commission (CEC)
August 6, 2020

Eric Wood, Dong-Yeon (D-Y) Lee, Nicholas Reinicke,
Yanbo Ge, and Erin Burrell
What is EVI-Pro?

• Simulation model to:
  • Estimate charging demand from light-duty PEVs
  • Design supply of workplace and public charging infrastructure capable of meeting demand

• Originally developed through CEC/NREL collaboration and applied to estimate statewide infrastructure needs aligned with California ZEV goals

PEV = plug-in electric vehicle
ZEV = zero emission vehicle
EVI-Pro 1

• In 2018, **EVI-Pro 1** was applied to three scenarios to estimate infrastructure necessary to enable CA drivers to maximize eVMT.

• Pursuant to AB2127, evolving market and technology conditions warrant updated assessments at least every two years.

• CEC, with support from NREL, UC Davis, and other state agencies, set out to refine **EVI-Pro 2** to reflect:
  – Increasing PEV market size
  – Evolving vehicle/charging technology
  – Observed charging behavior
## EVI-Pro 1 vs EVI-Pro 2

<table>
<thead>
<tr>
<th></th>
<th>EVI-Pro 1 (2025)</th>
<th>EVI-Pro 2 (2030)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero emission vehicles</td>
<td>1.5M</td>
<td>5.0M</td>
</tr>
<tr>
<td>Charging Behavior Objective</td>
<td>Maximize eVMT</td>
<td>Mirror observed behavior</td>
</tr>
<tr>
<td>PHEV/BEV Split</td>
<td>45%/55%</td>
<td>32%/68%</td>
</tr>
<tr>
<td>Avg BEV Range</td>
<td>210 miles</td>
<td>280 miles</td>
</tr>
<tr>
<td>PEVs w/ home charging</td>
<td>92%</td>
<td>82%</td>
</tr>
<tr>
<td>Infrastructure utilization</td>
<td>Assumed</td>
<td>Observed</td>
</tr>
<tr>
<td>Long-distance travel</td>
<td>No</td>
<td>Simulated (EVI-Pro RoadTrip)*</td>
</tr>
<tr>
<td>Transportation network companies</td>
<td>No</td>
<td>Simulated (UC Davis’ WIRED)*</td>
</tr>
<tr>
<td>Medium/heavy-duty vehicles</td>
<td>No</td>
<td>Simulated (LBNL’s HEVI-Pro)*</td>
</tr>
</tbody>
</table>

*Preliminary values. Subject to review.*

*To be shown in subsequent presentations*

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PHEV = plug-in hybrid electric vehicle  
BEV = battery electric vehicle  
eVMT = electric vehicle miles traveled
PEV Fleet Forecast

- Combination of forecasts from CEC’s Energy Assessments Division and CARB’s Mobile Sources Strategy used to determine primary scenario for CA LDV PEV fleet composition in 2030

<table>
<thead>
<tr>
<th></th>
<th>EVI-Pro 1</th>
<th>EVI-Pro 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA Fleet Size</td>
<td>1.3M PEVs</td>
<td>5.0M PEVs</td>
</tr>
<tr>
<td>PHEV/BEV ratio</td>
<td>45%/55%</td>
<td>32%/68%</td>
</tr>
<tr>
<td>Sedan Share</td>
<td>100%</td>
<td>71%</td>
</tr>
</tbody>
</table>

Assumed 2030 CA LDV PEV Fleet
Marker size proportional to fleet size

Preliminary values. Subject to review.
Using an online panel, NREL administered a survey to CA residents asking for information on:

- Vehicle ownership
- Electrical access by parking option
- Residential parking options

Results from 1,252 respondents indicate that residential charging access is a strong function of residence type and behavior.

Surveyed Residential Charging Access by Residence Type

- Single Family (detached): 32% Existing Access, 49% Potential Access, 87% Potential access (w/ behavior mod)
- Single Family (attached): 29% Existing Access, 45% Potential Access, 72% Potential access (w/ behavior mod)
- Apartments: 16% Existing Access, 27% Potential Access, 35% Potential access (w/ behavior mod)

Preliminary values. Subject to review. Additional survey info in Appendix
Estimating Residential Charging Access

• Using survey results, a PEV likely adopter model is applied to estimate evolution of residential access as a function of PEV fleet size (at right)

• Based on these results, the following assumptions are applied in EVI-Pro 2:

<table>
<thead>
<tr>
<th>CA PEV Fleet Size</th>
<th>Res Access</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000,000</td>
<td>88%</td>
</tr>
<tr>
<td>2,800,000</td>
<td>87%</td>
</tr>
<tr>
<td>5,000,000</td>
<td>82%</td>
</tr>
</tbody>
</table>

*EVI-Pro 1 assumed 92% from 2017-2025

• Gaps between scenarios (at right) suggest that education, investment, and behavior modification all play a role to play in improving residential charging access

Preliminary values. Subject to review.

~5M PEVs in CA
EVI-Pro 2 Simulations

- Charging behavior logic in EVI-Pro 2 has been calibrated based on revealed preference survey data from UC Davis*

- Relative to EVI-Pro 1:
  - Less “home-only” charging
  - More “work-only” charging
  - More “no charge” days

Recent EVSE Utilization
Jan 2016 to March 2020

• EVI-Pro 1 relied on a theoretical approach to estimating sharing potential of public chargers
• EVI-Pro 2 will rely on observed utilization rates to inform forward-looking assumptions
• EVSPs have provided CEC/NREL with event-level data from networked L2 and DCFC units across the US (including in CA)
• Fluctuations in CA DCFC utilization are believed to stem from evolving use of BEVs in ride-hailing fleets

<table>
<thead>
<tr>
<th>Feature</th>
<th>US (incl CA)</th>
<th>CA only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station Count</td>
<td>3,036</td>
<td>1,151</td>
</tr>
<tr>
<td>Plug Count</td>
<td>6,372</td>
<td>3,524</td>
</tr>
<tr>
<td>Unique ZIP Codes</td>
<td>1,703</td>
<td>529</td>
</tr>
<tr>
<td>Individual Charge Events</td>
<td>~7.2M</td>
<td>~5.2M</td>
</tr>
</tbody>
</table>
2030 Infrastructure Estimates (5M PEVs)

Key Assumptions

- 82% of PEVs with residential access
- PEV share by residence type
  - Single family detached = 77%
  - Single family attached = 8%
  - Apartments = 15%
- Non-residential EVSE utilization
  - Level 2 (workplace, public) = 1-2 events/plug/day
  - DCFC = 6-9 events/plug/day

### Preliminary values. Subject to review.

<table>
<thead>
<tr>
<th></th>
<th>Plug Lower Bound</th>
<th>Plug Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>While-at-home</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Family</td>
<td>3,461,285</td>
<td>3,807,413</td>
</tr>
<tr>
<td>(L1 + L2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apartments (L2)</td>
<td>150,144</td>
<td>300,289</td>
</tr>
<tr>
<td>While-at-work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 2</td>
<td>178,954</td>
<td>357,907</td>
</tr>
<tr>
<td>While-in-public</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 2</td>
<td>206,671</td>
<td>413,341</td>
</tr>
<tr>
<td>DCFC</td>
<td>28,924</td>
<td>43,386</td>
</tr>
<tr>
<td>Total (w/o Single Family)</td>
<td>564,693</td>
<td>1,114,923</td>
</tr>
</tbody>
</table>

### Key Assumptions

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### Charts

- CA Public L2 Plugs
- CA DCFC Plugs
In Conclusion

Uncertainty persists...

• Preliminary results presented today; refinement on-going and feedback welcome!
• Charging behavior continues to co-evolve with technology maturation. On-going research remains necessary.
• While residential charging access may remain high in the near-term, in the long-term residential charging gaps could be addressed through education, investment, and behavior modification (nudges).
• Ride-hailing electrification can bring about sudden and dramatic charging demand, but the market remains fluid.
• Impacts of COVID-19 have not been addressed thus far. What effects of the pandemic will “stick” in the long-term? And how should they be reflected in this analysis?

... but the takeaway is consistent.

• Significant infrastructure growth remains paramount to meeting ZEV goals.
• Investment is needed in residential, destination, and fast charging infrastructure.
• An infrastructure gap could limit California's ability to achieve 5 million ZEVs by 2030.
Thanks! Questions?

www.nrel.gov
Results

Travel Surveys

GPS Data

Direct Enumeration

Discrete Choice Models

PEV Efficiency (RouteE)

PEV Fleet Size & PEV Attributes

CEC/EAD, CARB/MSS

ADOPT, MA3T

EVI-Pro 2

Driving Behavior

Charging Behavior

Direct Enumeration

Discrete Choice Models

Network Design

Hierarchical Clustering

Utilization Data

Results

Stations
Plugs
Utilization
Load Profiles

Installation Constraints

Levelized Cost of Charging

Residential Access, PUMS

3rd Party Data/Simulations (e.g. POLARIS, BEAM, HIVE)

EV-FAST + URDB

Charging Demand

EVI-Pro

ADOPT, MA3T

EVI-Pro 2

Charging Behavior

Network Design

Results

Levelized Cost of Charging

Residential Access, PUMS

3rd Party Data/Simulations (e.g. POLARIS, BEAM, HIVE)

EV-FAST + URDB
Competing factors

• BEV electric range is forecasted to increase while residential access decreases... how does this impact demand for fast charging?

• EVI-Pro 2 simulations suggest that as the BEV fleet grows, residential charging access drives increased demand for fast charging, despite increases in electric range

Preliminary values. Subject to review.

Residential access to be explored further via sensitivity analysis
EVI-Pro 2 Simulations

- While magnitude of simulated load has increased significantly between EVI-Pro 1 and 2, load shape remains relatively consistent.
- Fleet projections shifting towards more BEVs elevates significance of:
  - Home L2 (multi-day charging for those with residential access) and
  - DCFC (for those without residential access)
- Note that as of now, no scenarios have been developed to shift load to favorable times of day:
  - Plots represent “ASAP” charging
  - Future work will explore load flexibility opportunities
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