Significant Public/Private Investments Being Made in EVs & Charging Infrastructure

Disparate group of stakeholders** require consistent approach for intelligently informing infrastructure investments to grow the PEV market and improve domestic energy security

*Partial-year sales percentage

**Automotive manufacturers, electric utilities, charging networks, transportation network companies, state/local governments

CNG: compressed natural gas
EV: electric vehicle
EVSE: electric vehicle supply equipment
E85: 85% ethanol, 15% gasoline
LDV: light-duty vehicle
LNG: liquid natural gas
PEV: plug-in electric vehicle
PEV Charging Analysis – NREL Objective

Provide guidance on PEV charging infrastructure to regional/national stakeholders to:

- Reduce range anxiety as a barrier to increased PEV sales
- Ensure effective use of private/public infrastructure investments

Some key questions related to investment in PEV charging stations...

Recent Studies

- California (2014)
- Seattle, WA (2015)
- Massachusetts (2017)
- Colorado (2017)
- National Analysis (2017)
- Columbus, OH (2018)
- California (2018)
- Maryland (2019)
Infrastructure providers make capacity-driven investments
“Increase supply of stations proportional to utilization”

Consumers demand for PEV charging is coverage-based
“Need access to charging anywhere their travels lead them”

A “utilization gap” persists in a low vehicle density environment making it difficult to justify investment in new stations when existing stations are poorly utilized.
How do we estimate future infrastructure needs?
Big Data...
NREL has acquired numerous travel datasets for use in simulating consumer charging requirements by power level, location, and time of day.

**Columbus GPS Travel Data**
33M trips from INRIX

**Maryland GPS Travel Data**
20M trips from INRIX

**Ohio GPS Travel Data**
76M trips from INRIX
Consumer Travel Data

...High Resolution
Zoom of trip destinations from Seattle dataset.
Developed over many years, NREL leverages a unique portfolio of analysis tools to address emerging EV research questions.
What have we learned from this approach?
High VMT drivers and short electric range leads to fewer electric miles… assuming consumers regularly plug in overnight!

(2016) *National Economic Value Assessment of Plug-In Electric Vehicles: Volume 1*
https://www.nrel.gov/docs/fy17osti/66980.pdf
Access to workplace/public charging can increase electric vehicle miles traveled (eVMT)... assuming consumers use it!

(2017) Regional Charging Infrastructure for PEVs: A Case Study of Massachusetts
https://www.nrel.gov/docs/fy17osti/67436.pdf
Fast Charging Support for Battery EV eVMT

Fast charging and long-range battery EVs (BEVs) are both options for increasing eVMT... and perhaps consumers desire both!

(2015) Quantifying the Effect of Fast Charger Deployments on Electric Vehicle Utility and Travel Patterns via Advanced Simulation
https://www.nrel.gov/docs/fy15osti/63423.pdf
How much infrastructure do we need?

(2017) National Plug-In Electric Vehicle Infrastructure Analysis
https://www.nrel.gov/docs/fy17osti/69031.pdf
National PEV Infrastructure Analysis

<table>
<thead>
<tr>
<th></th>
<th>Cities</th>
<th>Towns</th>
<th>Rural Areas</th>
<th>Interstate Corridors</th>
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<tr>
<td>PEVs</td>
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<td>Direct Current Fast Charging (DCFC)</td>
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<td>Plugs (to meet demand)</td>
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<td>Plugs per station</td>
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<td>Plugs per 1,000 PEVs</td>
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<td>Plugs per 1,000 PEVs</td>
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Estimated requirements for PEV charging infrastructure are heavily dependent on:
1) evolution of the PEV market, 2) consumer preferences, and 3) technology development

Sensitivity Analysis

Non-Res L2 EVSE
- PEV Count
- % PEVs in Cities
- PHEV:BEV Ratio
- PHEV Support
- SUV Share
- Range Preference
- % Home Charging

Public DCFC
- PEV Count
- % PEVs in Cities
- PHEV:BEV Ratio
- PHEV Support
- SUV Share
- Range Preference
- % Home Charging
Residential Access to PEV Charging

Despite residential electricity being relatively affordable, some U.S. households have limited ability to charge at home

Analysis Highlights:
• 25% of LDV stock is owned by renters who may not have authority to install residential charging
• 17% of LDV stock is owned by residents of apartments, and 10% of LDV stock is in high density neighborhoods; both groups may not have a consistent location to park their vehicle for overnight charging
• Significant share of LDV stock uses on-street parking, including residents of single-family homes
How much does it cost to drive on electricity?
Residential electricity rates in most of U.S. make PEV operating costs competitive on a per-mile basis.

Service territories offering time-of-use rates for overnight charging can further reduce cost of residential charging.
Analysis examines **over 7,500 electricity rates** to understand DCFC costs and mitigation opportunities.

**Demand charges** are a significant cost for low-utilization stations but become much less important as utilization increases.

Technology solutions are **effective at reducing electricity cost** for DCFC.


Are EVs going to break the grid?
Are EVs Going to Break the Grid?

Supporting multiple on-going grid studies on EV impacts to:

- **Capacity expansion** (years-decades)
- **Unit commitment** (mins-hours)
- **Distribution power flow** (secs-mins)

![Estimated Spatial Distribution of Electric Vehicles in Minneapolis](image)

![Typical Weekday (uncontrolled)](image)
Summary

• Increasing access to charging can increase electric miles
  – Dependent on consumer behavior
• Estimated requirements for PEV charging infrastructure are heavily dependent on:
  – 1) evolution of the PEV market, 2) consumer preferences, and 3) technology development
• Low cost electricity is available in much of the U.S. if consumers can access/install residential charging
  – Fast charging is expensive in low-utilization scenarios, but cost can be mitigated with technology
Thanks! Questions?