US EV Infrastructure: Analysis and Projections


Eric Wood – May 2019
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
EVSE: electric vehicle supply equipment
LDV: light-duty vehicle
LNG: liquid natural gas
PEV: plug-in electric vehicle
PEV Charging Analysis – NREL Objective

Provide guidance on plug-in electric vehicle (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 to estimate future infrastructure needs?
Big Data...
NREL has acquired numerous travel data sets for use in simulating consumer charging requirements by power level, location, and time of day.

**Consumer Travel Data**

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

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

“**Columbus Fire**”: A heat map of GPS trip destinations from Columbus, Ohio. NREL researchers are working with local stakeholders in Columbus, Ohio, planning an expansion of the region’s network of charging stations to support growth in the local electric vehicle market. The analysis utilizes GPS travel trajectories from INRIX (a commercial mapping provider) to characterize regional travel and anticipate future demand for charging. The above map displays trip destination frequency derived from 33 million trips collected over a 12-month period in the Columbus region.

“**Maryland Metropolex**”: A heat map of 1.8 million trip origins and destinations throughout the state of Maryland over a period of several months. NREL researchers are working with the Maryland Public Service Commission to understand the electric vehicle infrastructure necessary to support the State’s light-duty vehicle goals. The analysis utilizes GPS travel trajectories from INRIX to understand regional travel patterns and anticipate future demand.
Consumer Travel Data

...High Resolution
Zoom of trip destinations from Seattle data set.
Developed over many years, NREL leverages a unique portfolio of analysis tools to address emerging electric vehicle research questions.

- **FASTSim**: Powertrain Simulation and Vehicle Design
- **BLAST**: Battery Lifetime Simulation
- **ADOPT**: Vehicle Sales Estimates
- **EVI-Pro**: Charging Infrastructure Needs Estimation
- **EVFAST**: Charging Infrastructure Financial Tool
- **U.S. Electricity Rates**: (Utility Rate Database)
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!

PHEV Utility Factor = % electric miles

(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 BEV eVMT

Fast charging and long-range 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
Estimated requirements for PEV charging infrastructure are heavily dependent on:
1) evolution of the PEV market, 2) consumer preferences, and 3) technology development
Despite residential electricity being relatively affordable, some US 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 US 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 significant cost for low-utilization stations but become much less important as utilization increases.

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

(2019) Technology Solutions to Mitigate Electricity Cost for Electric Vehicle DC Fast Charging
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** (hours-days)

**Distribution power flow** (secs-mins)

Estimated Spatial Distribution of Electric Vehicles in Minneapolis

**Typical Weekday (uncontrolled)**

- **Home-L1**: 31%
- **Home-L2**: 45%
- **Work-L1**: 3%
- **Work-L2**: 6%
- **Public-L2**: 12%
- **DCFC**: 3%

![Graph showing electrical load by hour of day](image)

- **Electrical Load, MW**
- **Hour of Day**

![Map showing spatial distribution of EVs](image)

- **Number of Simulated PEV**
  - 0 - 10
  - 10 - 20
  - 20 - 30
  - 30 - 40
  - 40 - 50
  - 50 - 100
  - 100 - 150
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 US, if consumers can access/install residential charging
  – Fast charging is expensive in low utilization scenarios, but cost can be mitigated with technology
Thanks! Questions?

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