



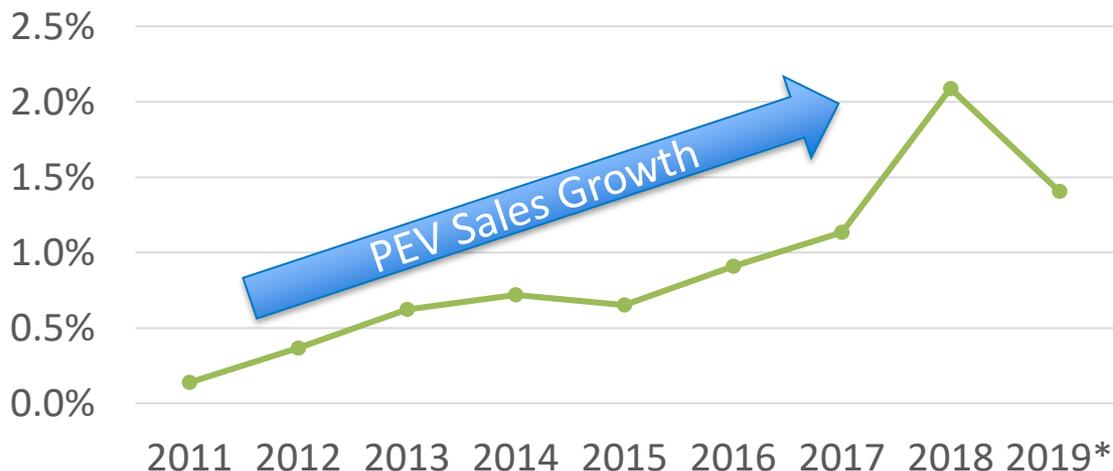
US EV Infrastructure: Analysis and Projections

Prepared for National Academies Webinar
"The Future of Electric Vehicle Infrastructure in the U.S."

Eric Wood – May 2019

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

PEV Share of LDV Sales



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

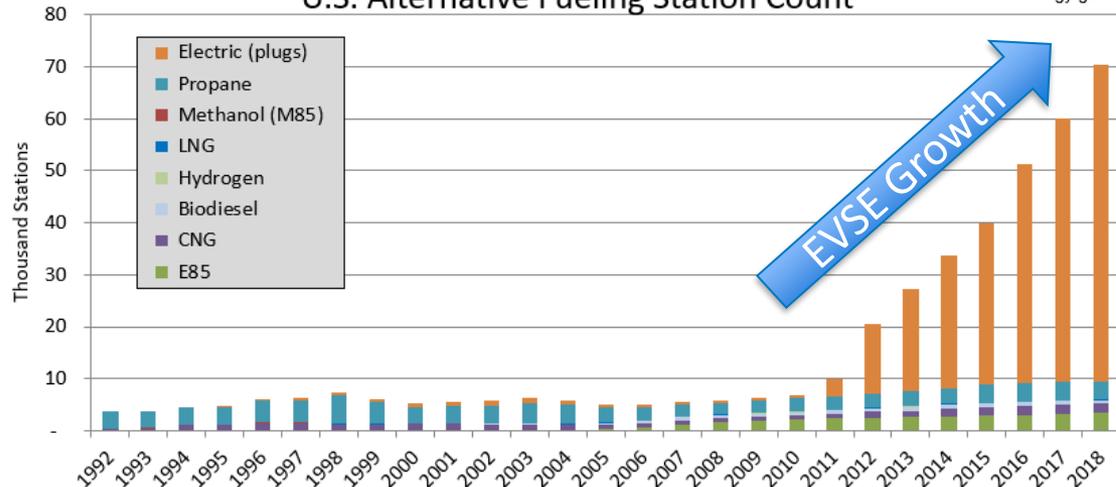
LDV: light-duty vehicle

LNG: liquid natural gas

PEV: plug-in electric vehicle

U.S. Alternative Fueling Station Count

www.afdc.energy.gov/data/



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

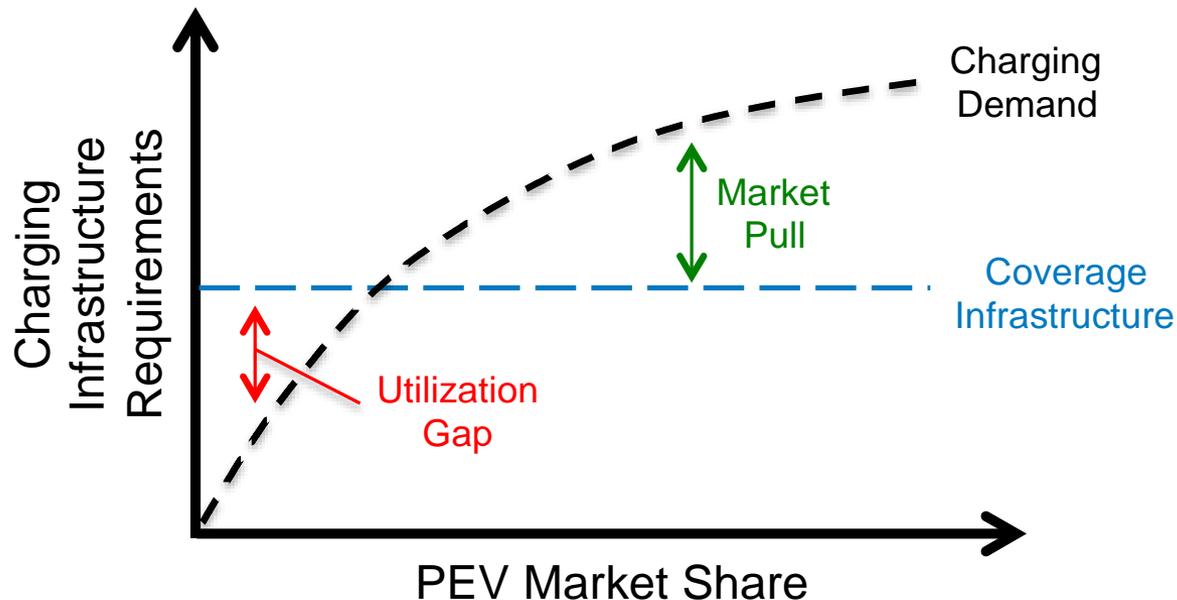
California (2014)
Seattle, WA (2015)
Massachusetts (2017)
Colorado (2017)
National Analysis (2017)
Columbus, OH (2018)
California (2018)
Maryland (2019)

How many?

What kind?

Where?

Conceptual Representation of PEV Charging Requirements



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”

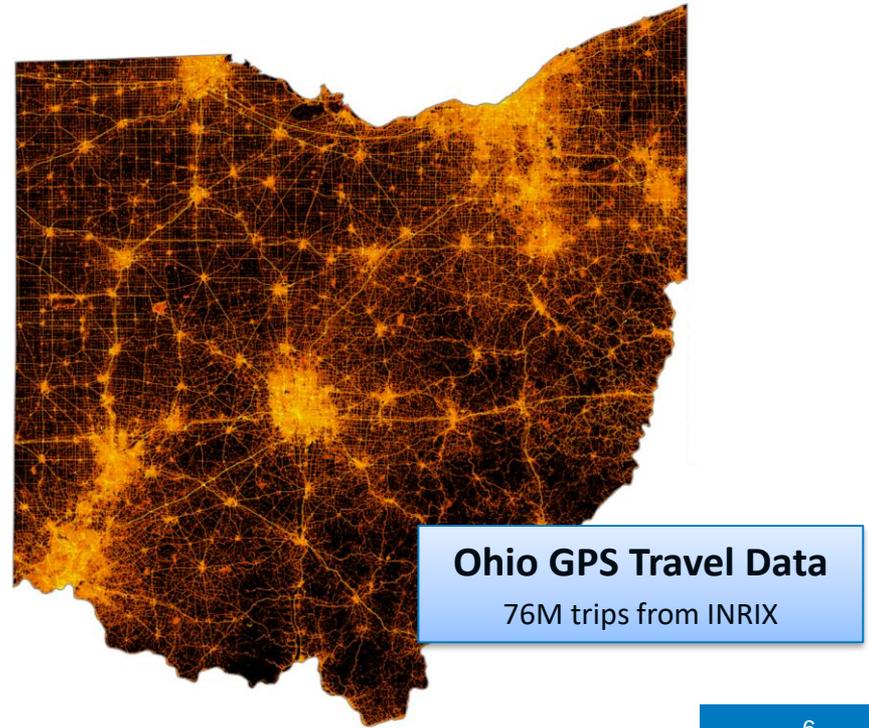
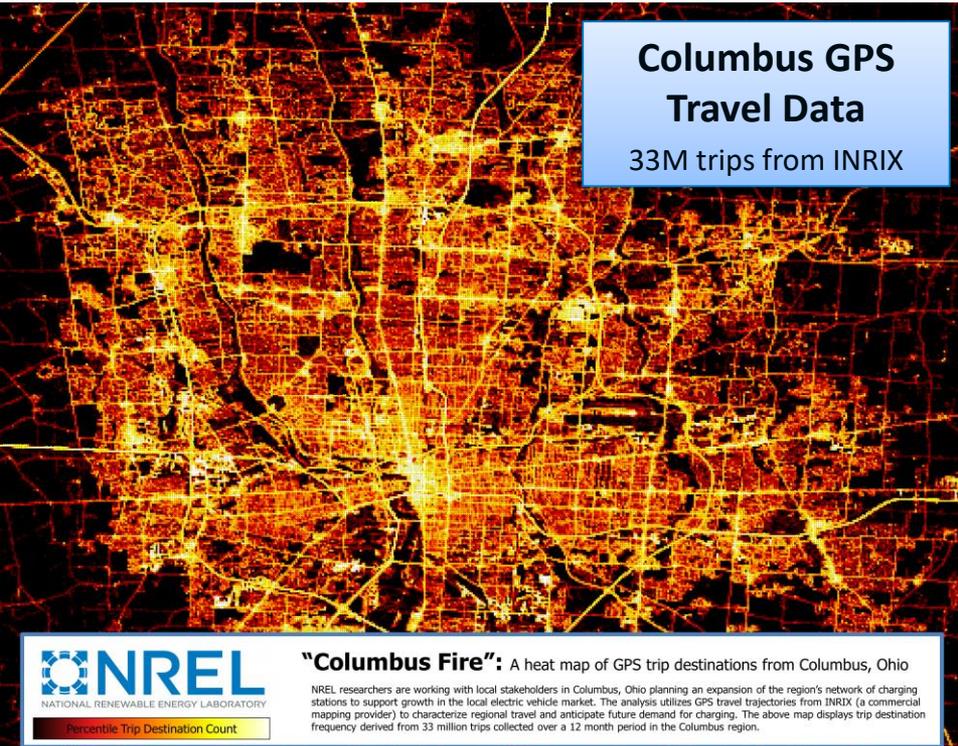
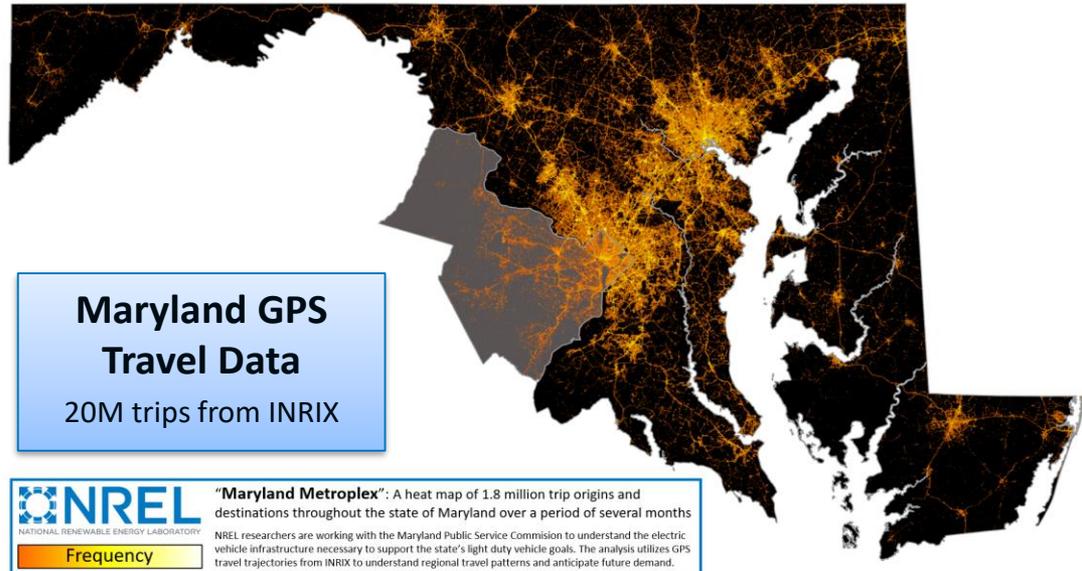
A “utilization gap” persists in a low vehicle density environment making it difficult to justify investment in new stations when existing stations are poorly utilized

How to estimate future
infrastructure needs?

Consumer Travel Data

Big Data...

NREL has acquired numerous travel data sets for use in simulating consumer charging requirements by power level, location, and time of day.

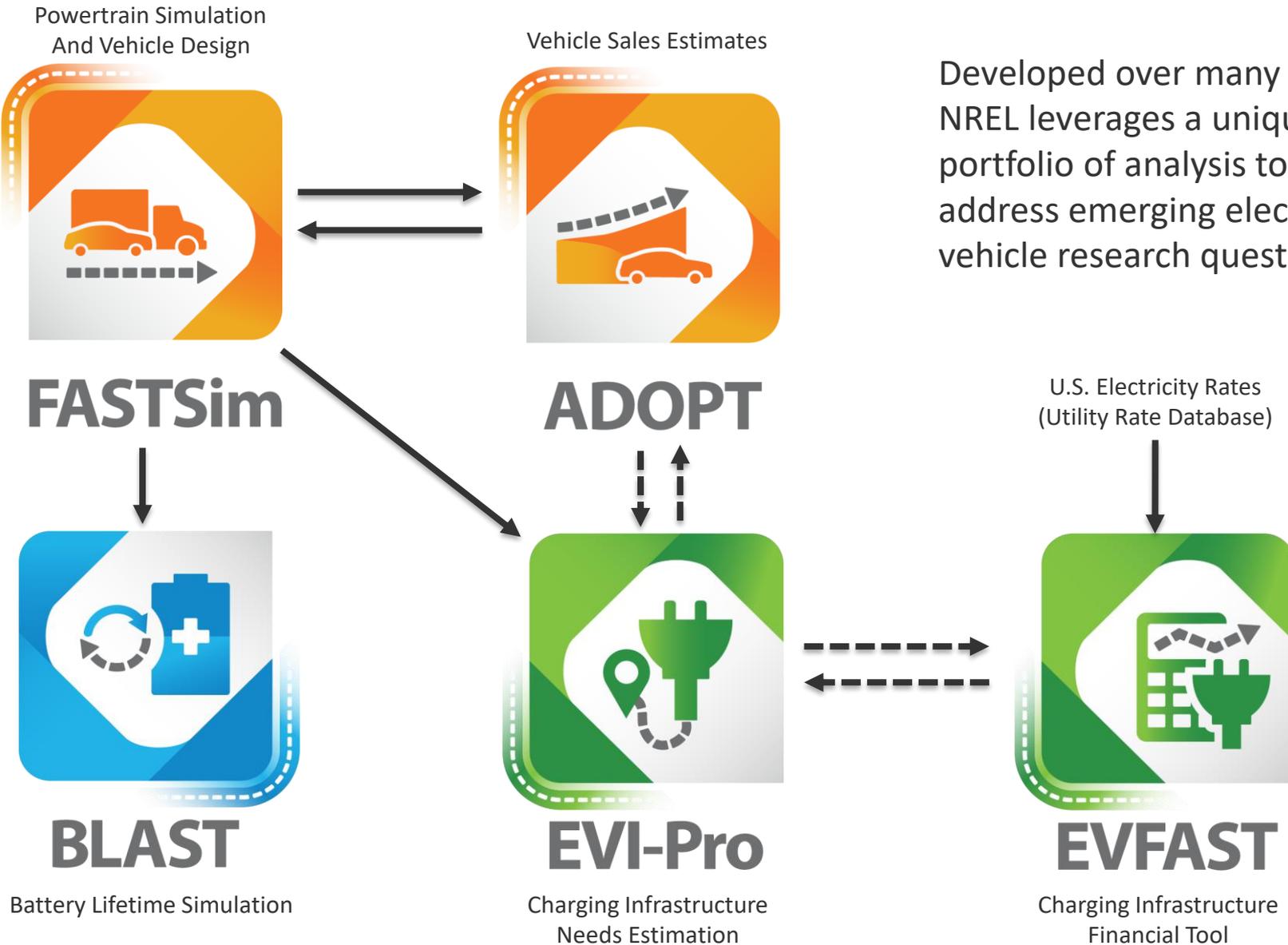


Consumer Travel Data

...High Resolution
Zoom of trip destinations
from Seattle data set.



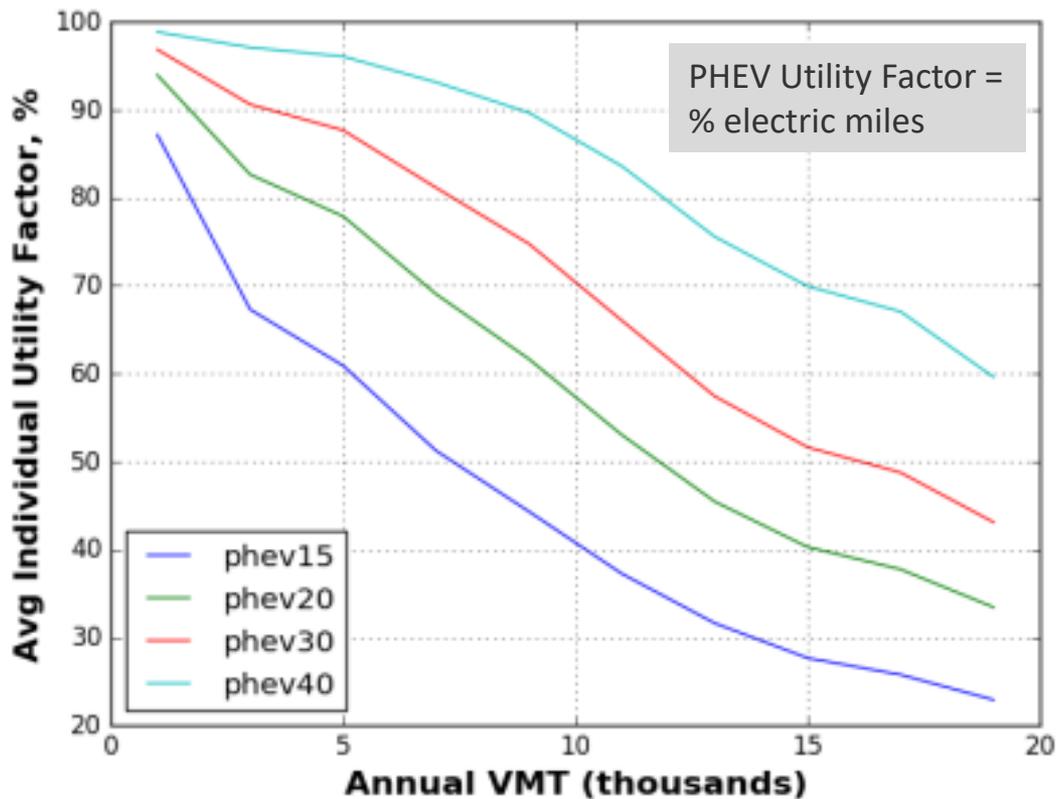
NREL Core Analytic Methods & Data



What have we learned
from this approach?

PHEV Fuel Economy

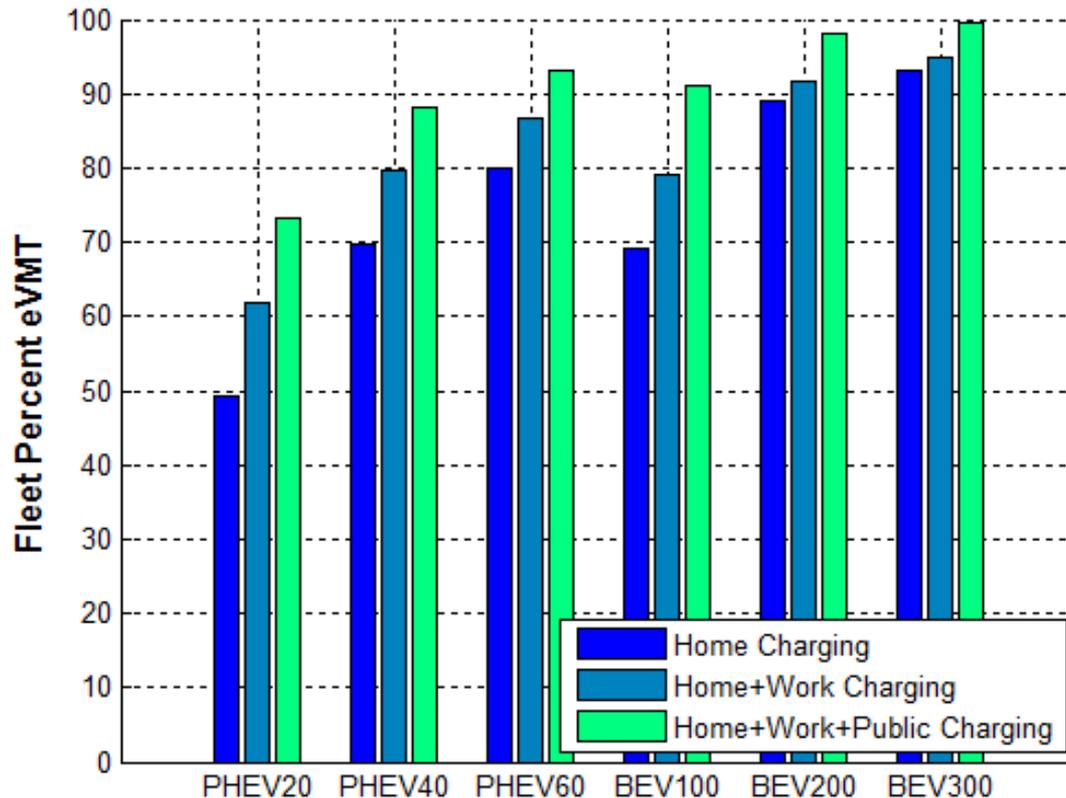
High VMT drivers and short electric range leads to fewer electric miles... assuming consumers regularly plug-in overnight!



(2016) National Economic Value Assessment of Plug-In Electric Vehicles: Volume 1
<https://www.nrel.gov/docs/fy17osti/66980.pdf>

eVMT & Workplace/Public Charging

Access to workplace/public charging can increase electric vehicle miles traveled (eVMT)... assuming consumers use it!

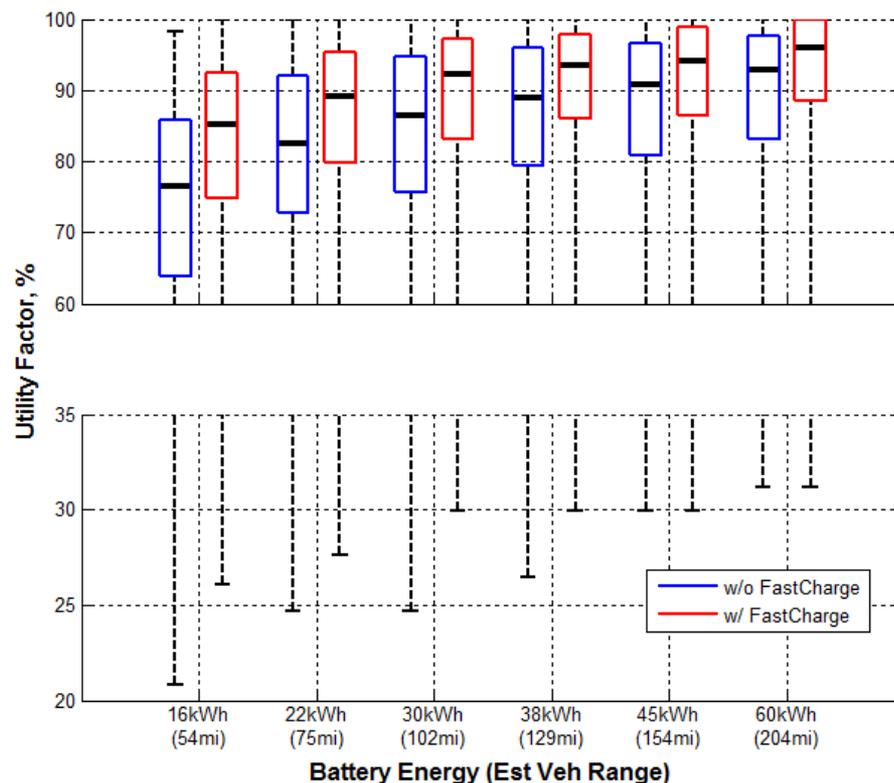


(2017) Regional Charging Infrastructure for PEVs: A Case Study of Massachusetts

<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?

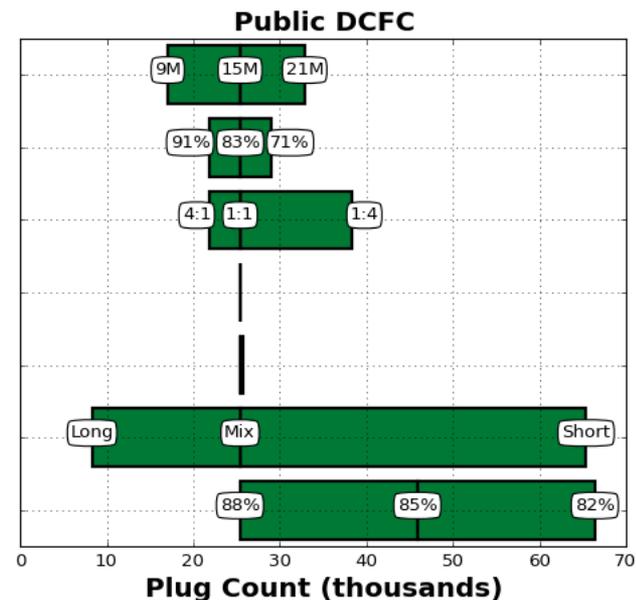
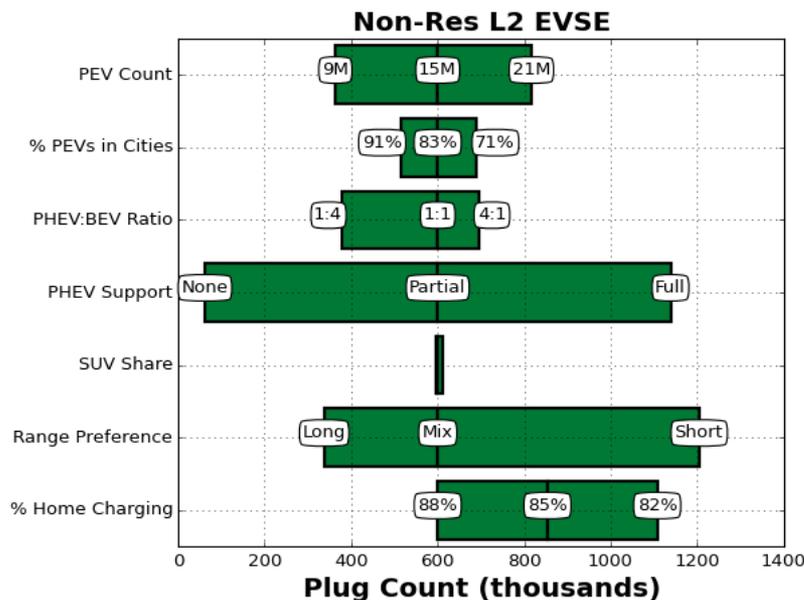
National PEV Infrastructure Analysis

Central Scenario

		Cities	Towns	Rural Areas	Interstate Corridors
PEVs		12,411,000	1,848,000	642,000	---
DCFC	Stations (to provide coverage)	4,900	3,200	---	400
	Plugs (to meet demand)	19,000	4,000	2,000	2,500
	Plugs per station	3.9	1.3	---	6.3
	Plugs per 1,000 PEVs	1.5	2.2	3.1	---
Non-Res L2	Plugs (to meet demand)	451,000	99,000	51,000	---
	Plugs per 1,000 PEVs	36	54	79	---

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

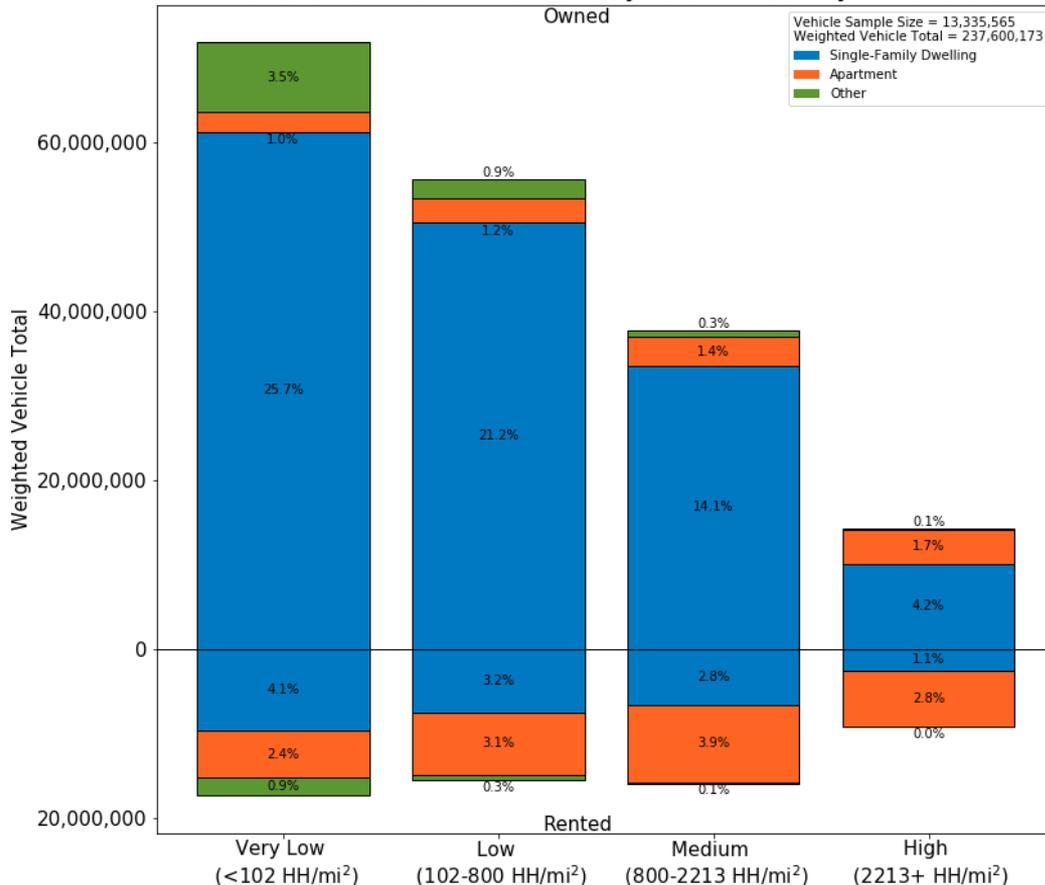


Residential Access to PEV Charging

Estimate of U.S. LDV stock by:

- Housing density, residence type, and tenure

ACS 2012-2016 PUMA Vehicle Counts By Household Density: United States



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

Analysis Highlights:

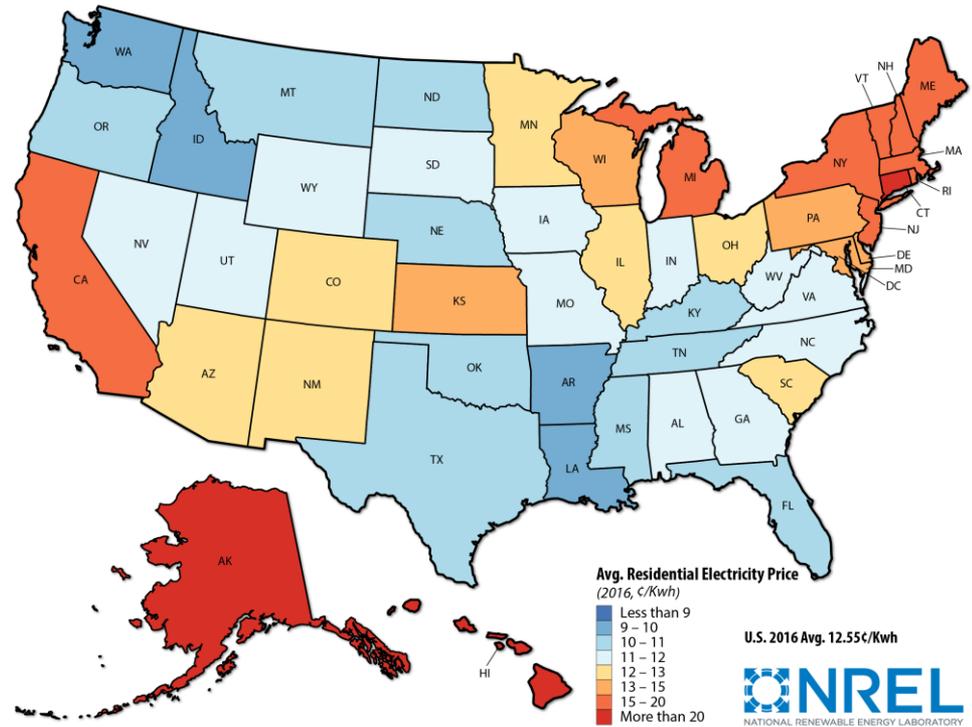
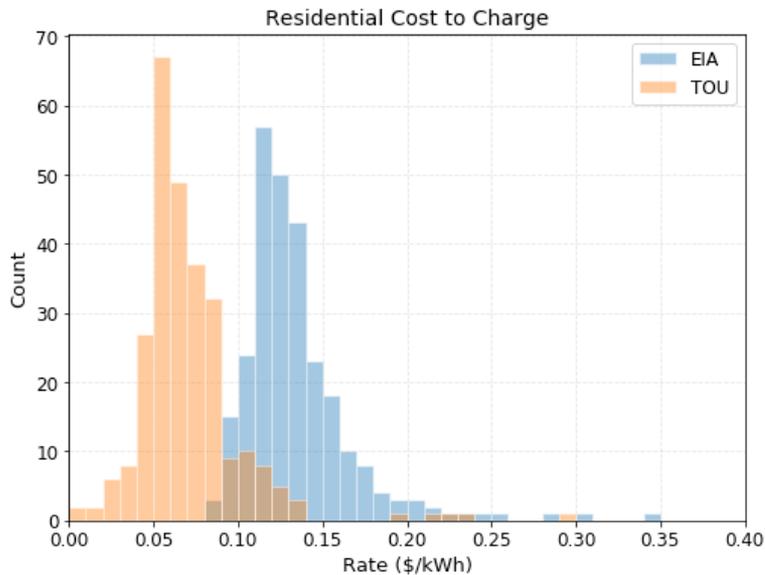
- 25% of LDV stock is owned by renters who may not have authority to install residential charging
- 17% of LDV stock is owned by residents of apartments, and 10% of LDV stock is in high density neighborhoods; both groups may not have a consistent location to park their vehicle for overnight charging
- Significant share of LDV stock uses on-street parking, including residents of single family homes

How much does it cost to
drive on electricity?

Financial Analysis of PEV Charging (E-FAST) (w/ INL)

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.

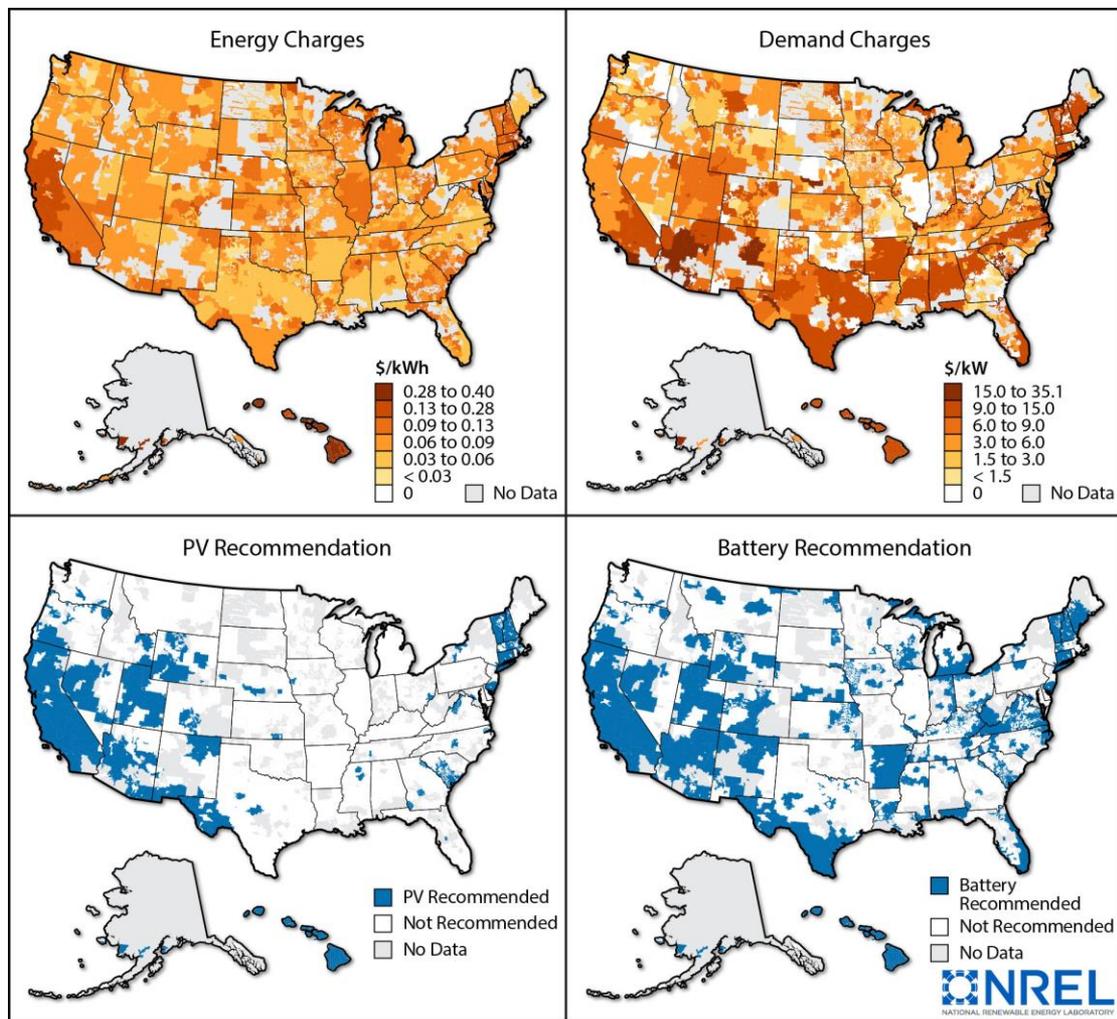


Technology Solutions to Reduce Cost of DCFC

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

<https://www.sciencedirect.com/science/article/pii/S0306261919304581>

Are EVs going to
break the grid?

Are EVs Going to Break the Grid?

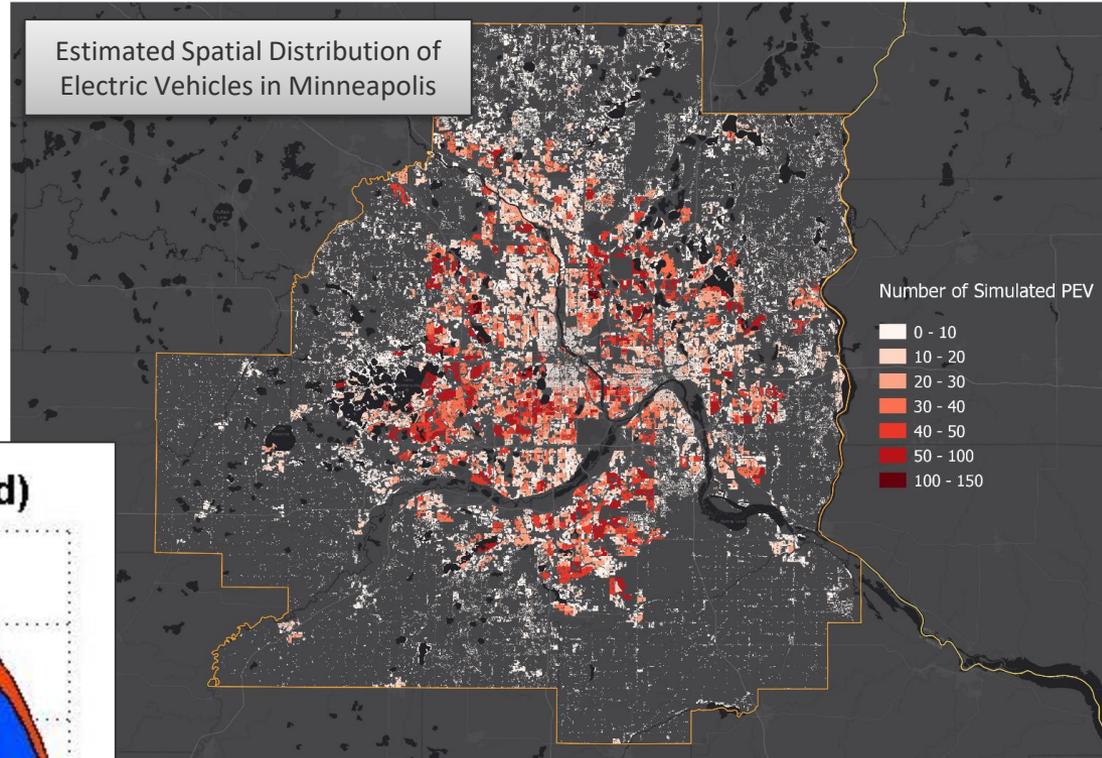
Supporting multiple on-going grid studies on EV impacts to:

Capacity expansion (years-decades)

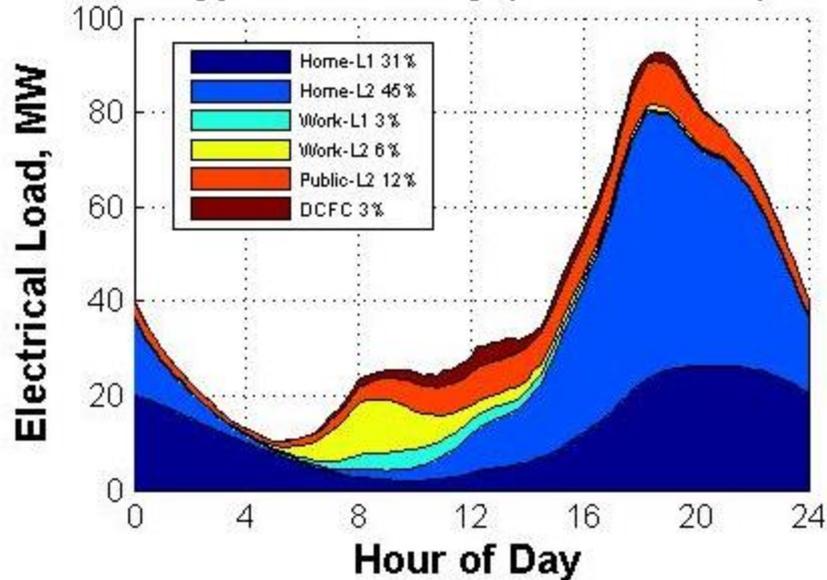
Unit commitment (hours-days)

Distribution power flow (secs-mins)

Estimated Spatial Distribution of Electric Vehicles in Minneapolis



Typical Weekday (uncontrolled)



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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