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U.S. EV Infrastructure:
Analysis and Projections

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

Eric Wood, May 2, 2019

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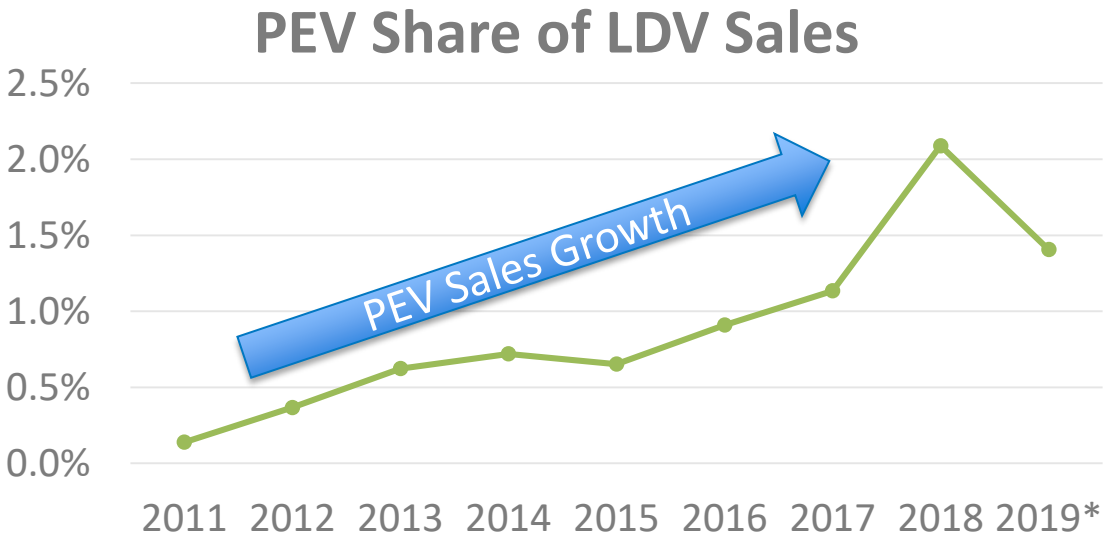
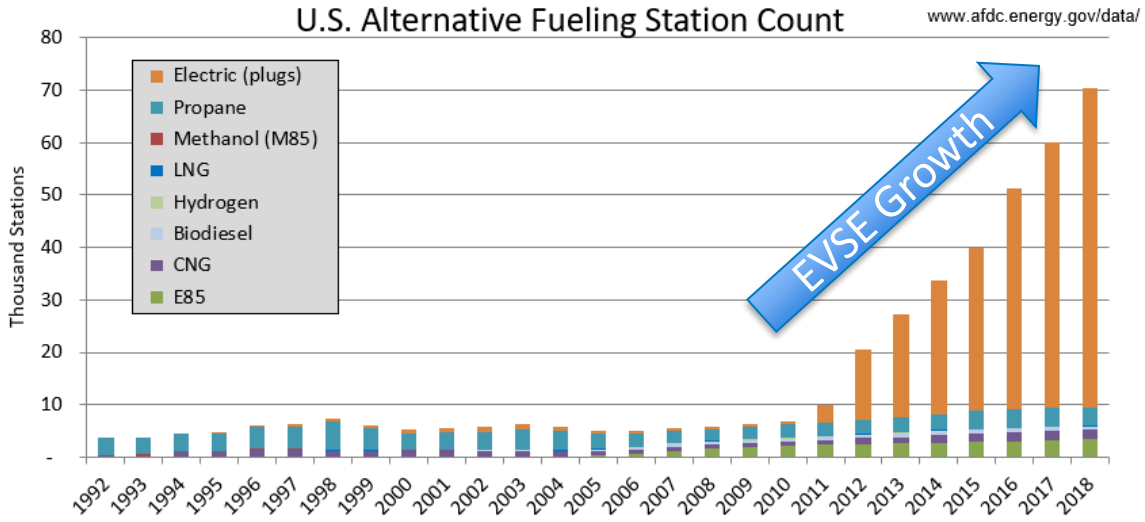
Significant Public/Private Investments Being Made in EVs & Charging Infrastructure





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…

How many?

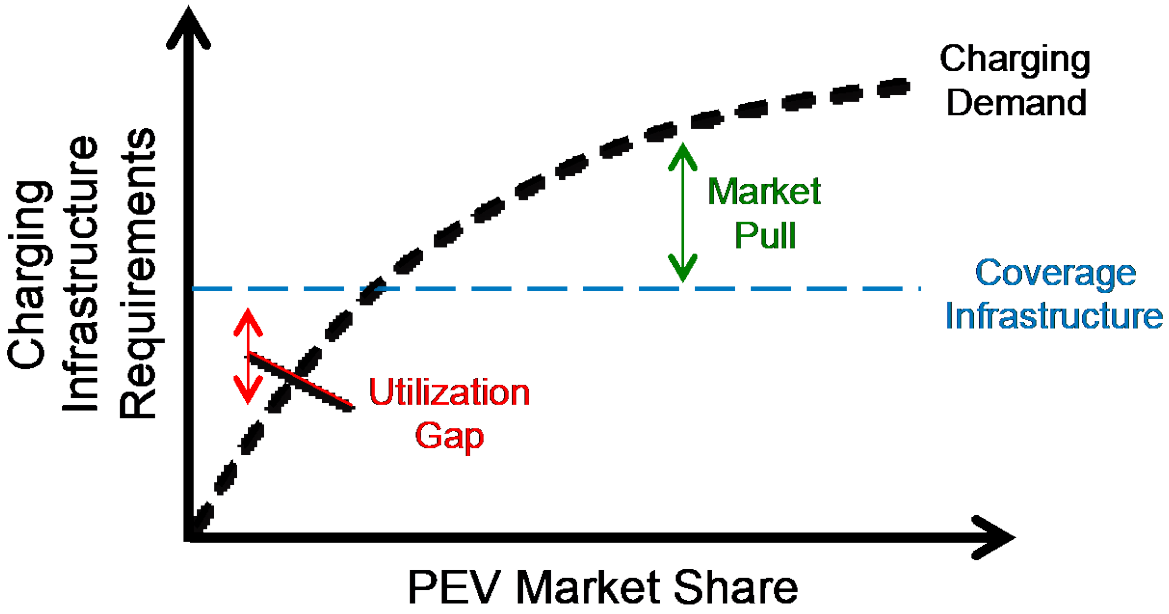
What kind?

Where?

Recent Studies

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

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"

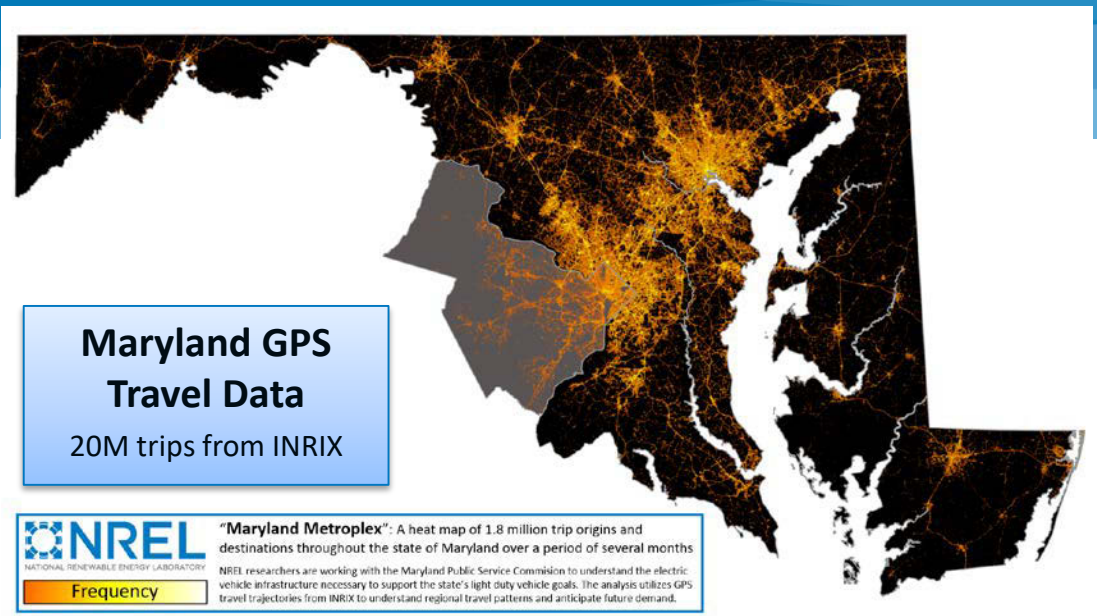
A "utilization gap" persists in a low vehicle density environment making it difficult to justify investment in new stations when existing stations are poorly utilized

How do we estimate future infrastructure needs?

Consumer Travel Data

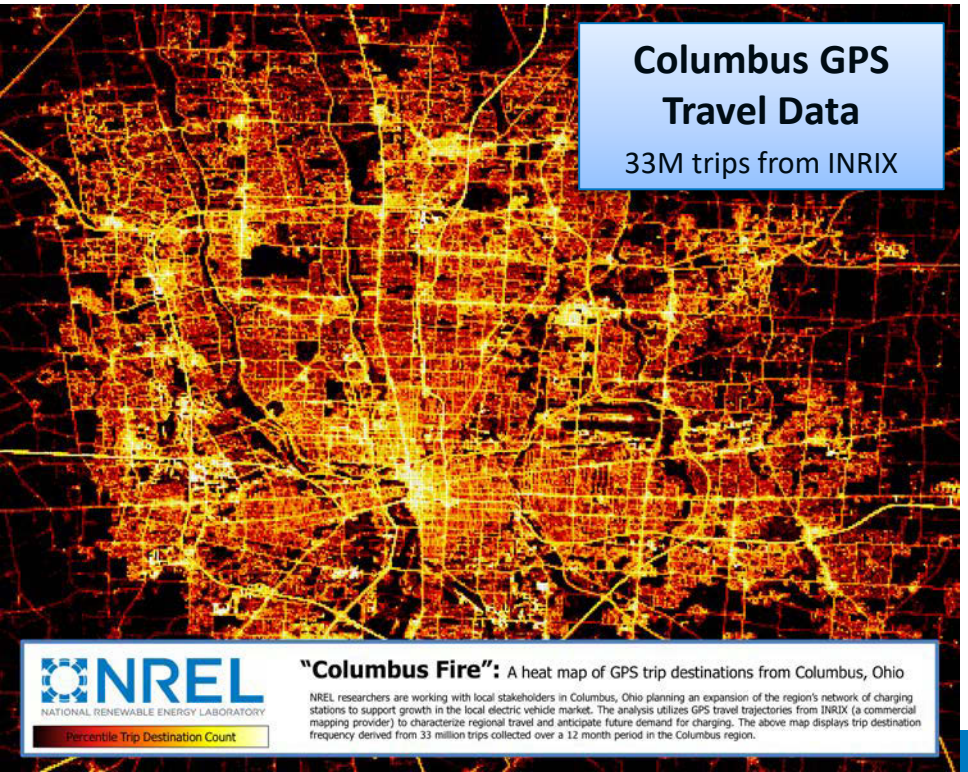
Big Data…

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



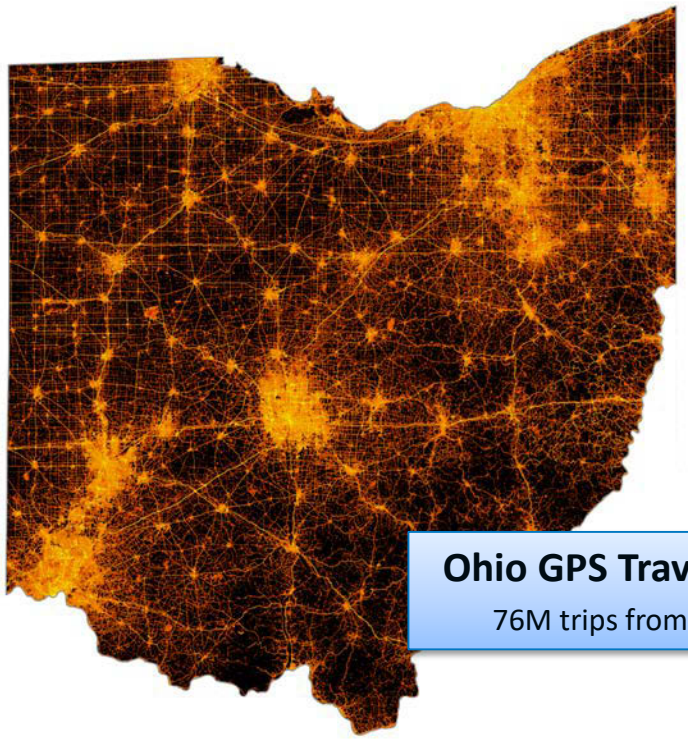
Maryland GPS Travel Data

20M trips from INRIX



Columbus GPS Travel Data

33M trips from INRIX



Ohio GPS Travel Data

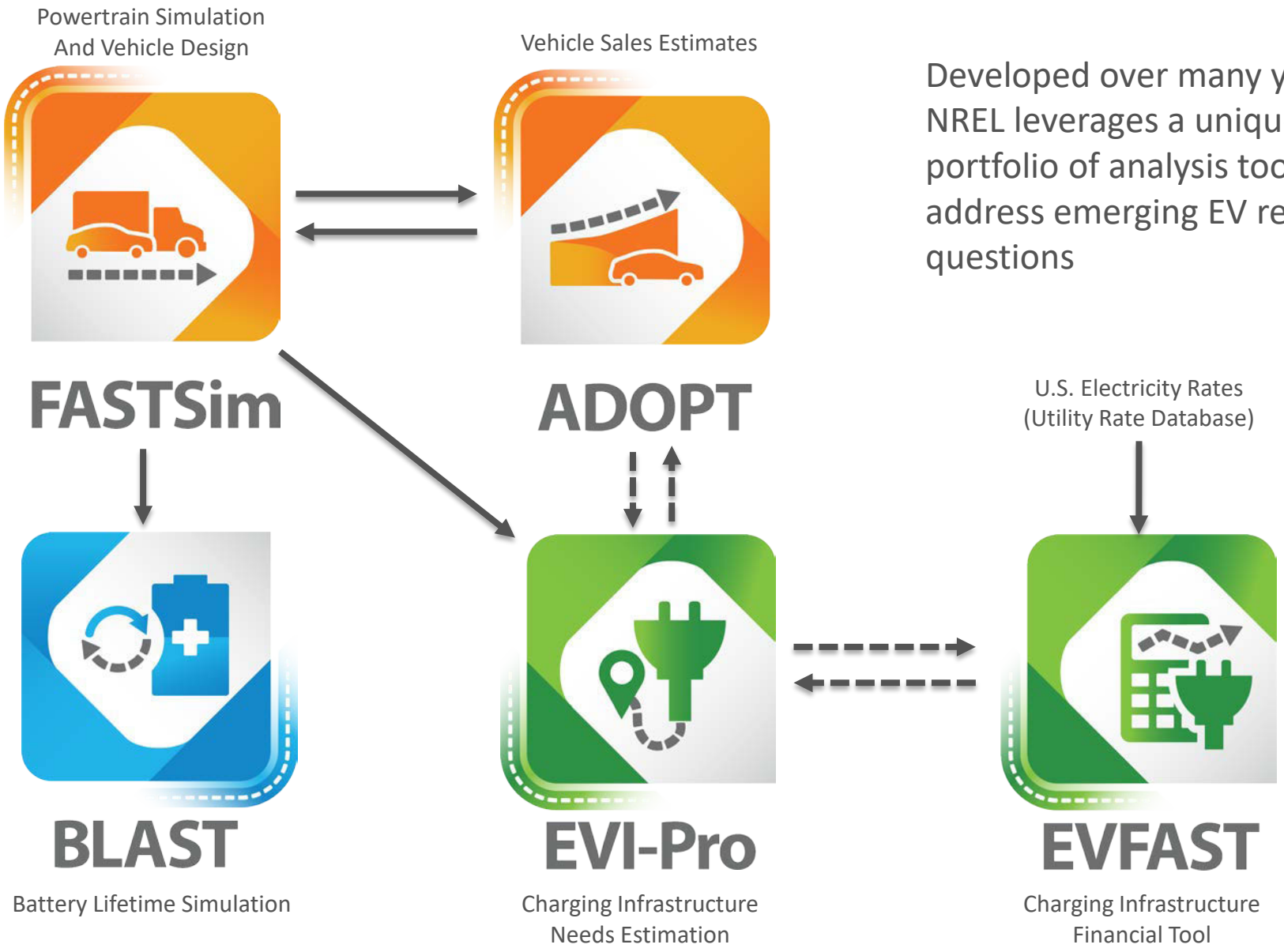
76M trips from INRIX

Consumer Travel Data

NREL's Core Analytic Methods and Data

Existing Data Flow

Under Development

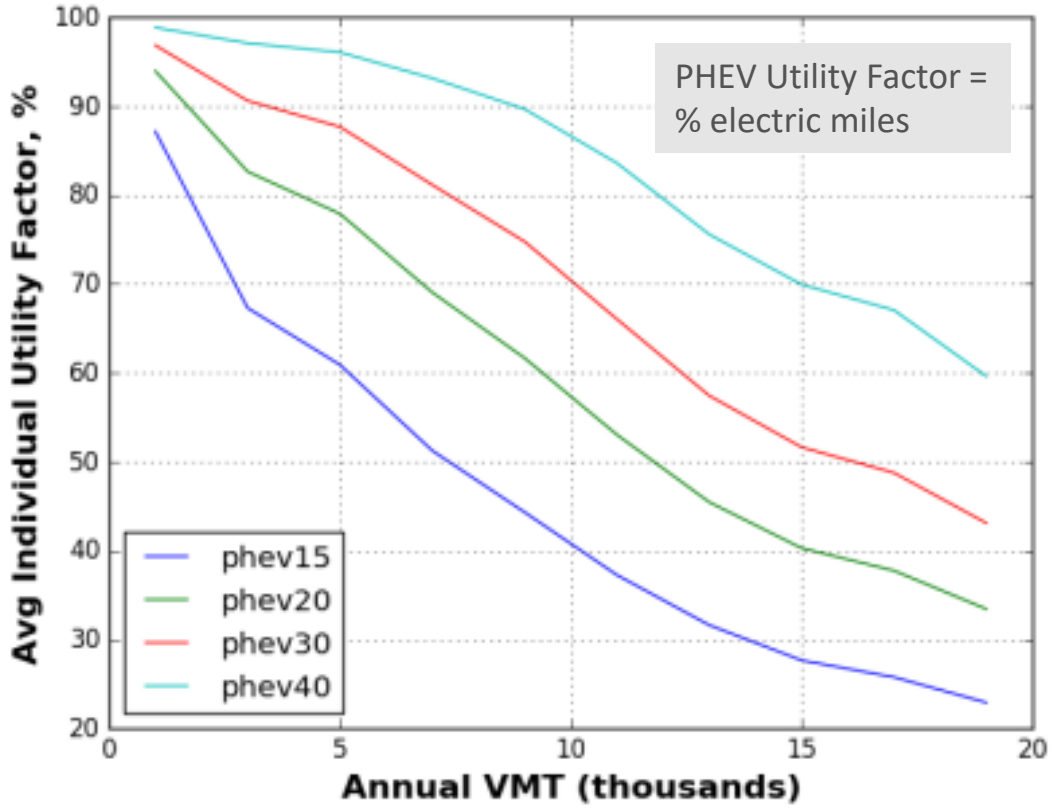


Developed over many years, NREL leverages a unique portfolio of analysis tools to address emerging EV research questions

What have we learned from this approach?

PHEV Fuel Economy

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

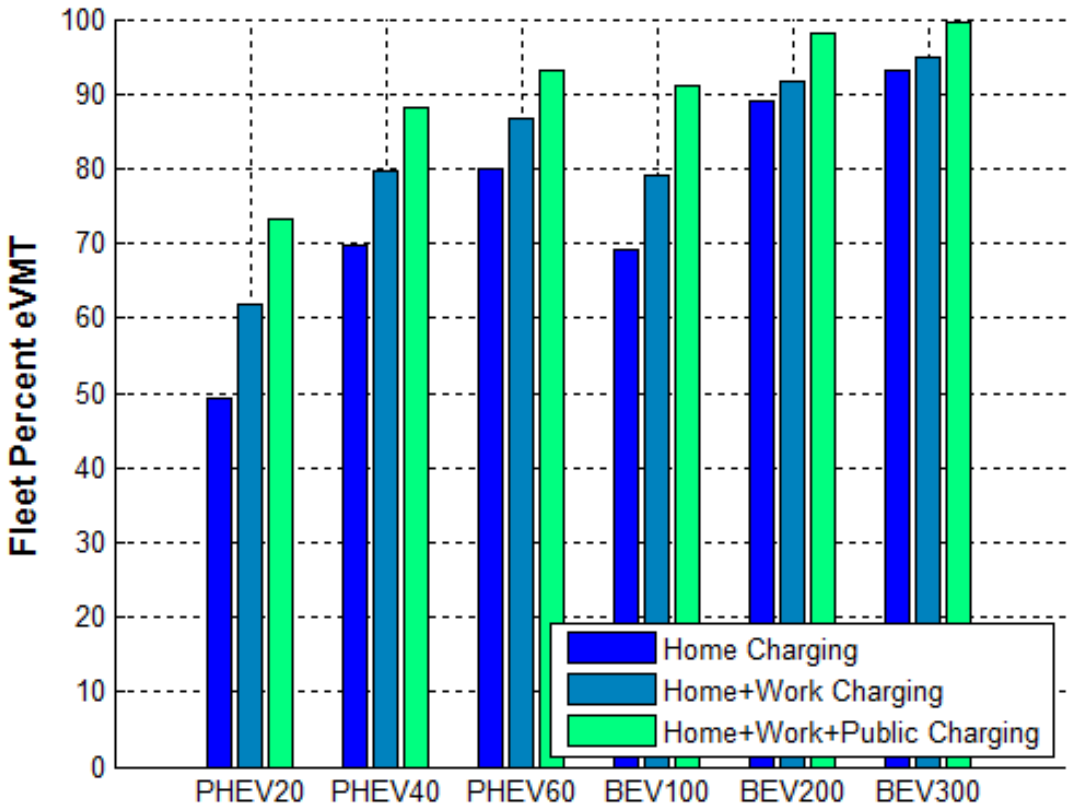


PHEV: plug-in electric vehicle
VMT: vehicle miles traveled

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

eVMT and Workplace/Public Charging

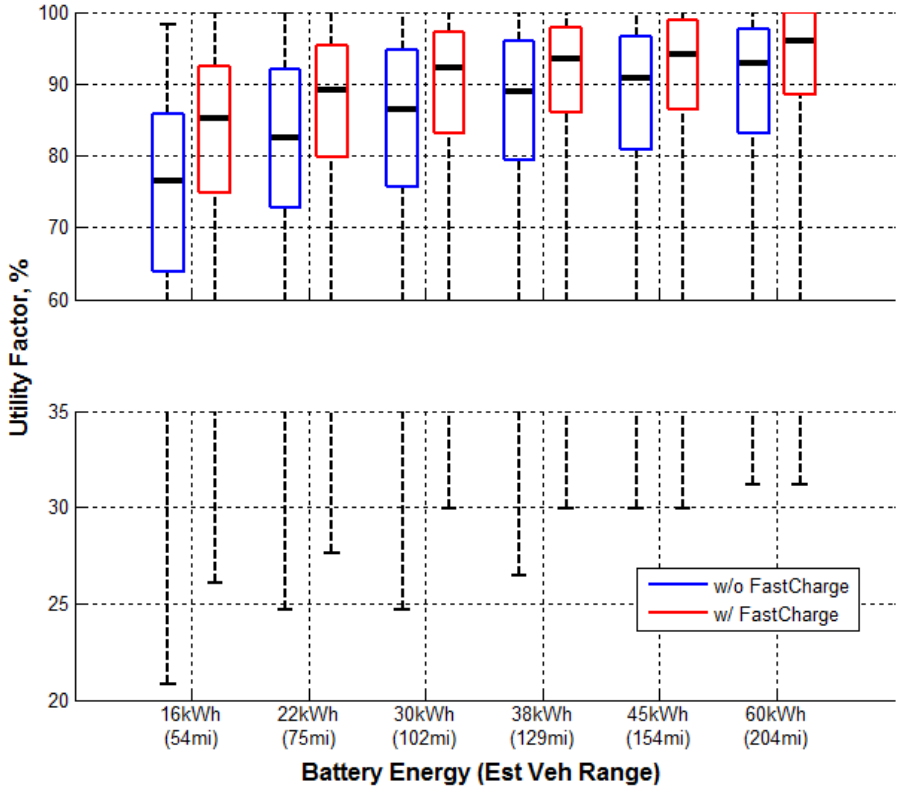
Access to workplace/public charging can increase electric vehicle miles traveled (eVMT)… assuming consumers use it!



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

Fast Charging Support for 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

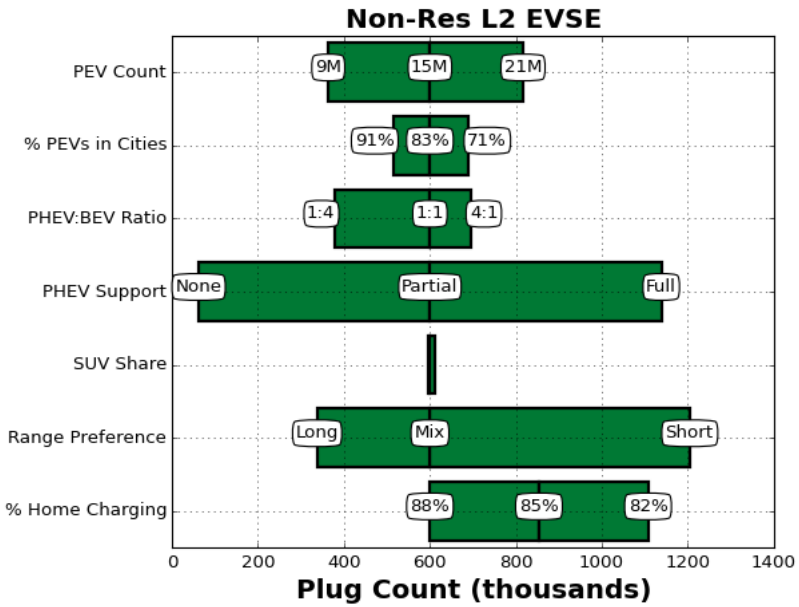
National PEV Infrastructure Analysis

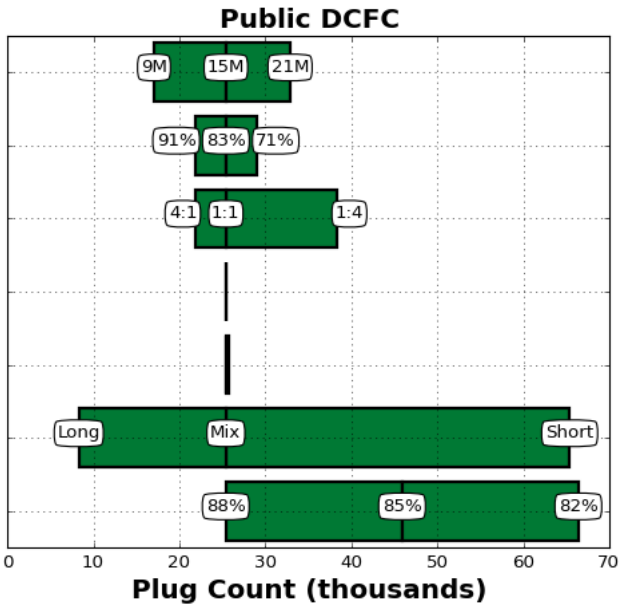
Central Scenario

		Cities	Towns	Rural Areas	Interstate Corridors
PEVs		12,411,000	1,848,000	642,000	---
Direct Current Fast Charging (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-Residential 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

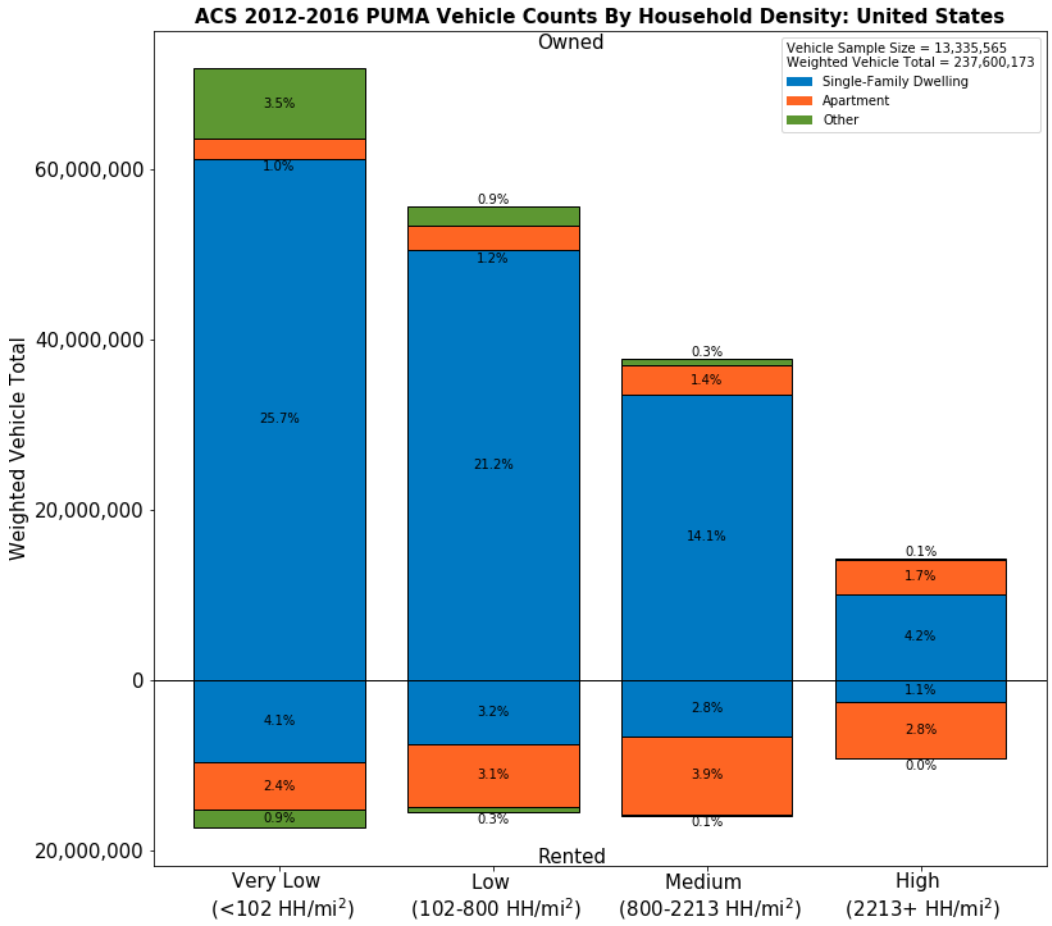




Residential Access to PEV Charging

Estimate of U.S. LDV stock by:

- Housing density, residence type, and tenure



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

Analysis Highlights:

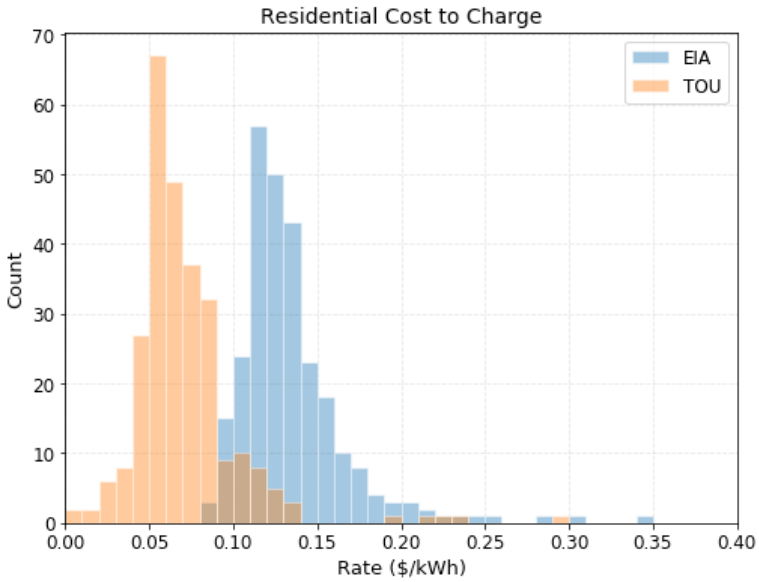
- 25% of LDV stock is owned by renters who may not have authority to install residential charging
- 17% of LDV stock is owned by residents of apartments, and 10% of LDV stock is in high density neighborhoods; both groups may not have a consistent location to park their vehicle for overnight charging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

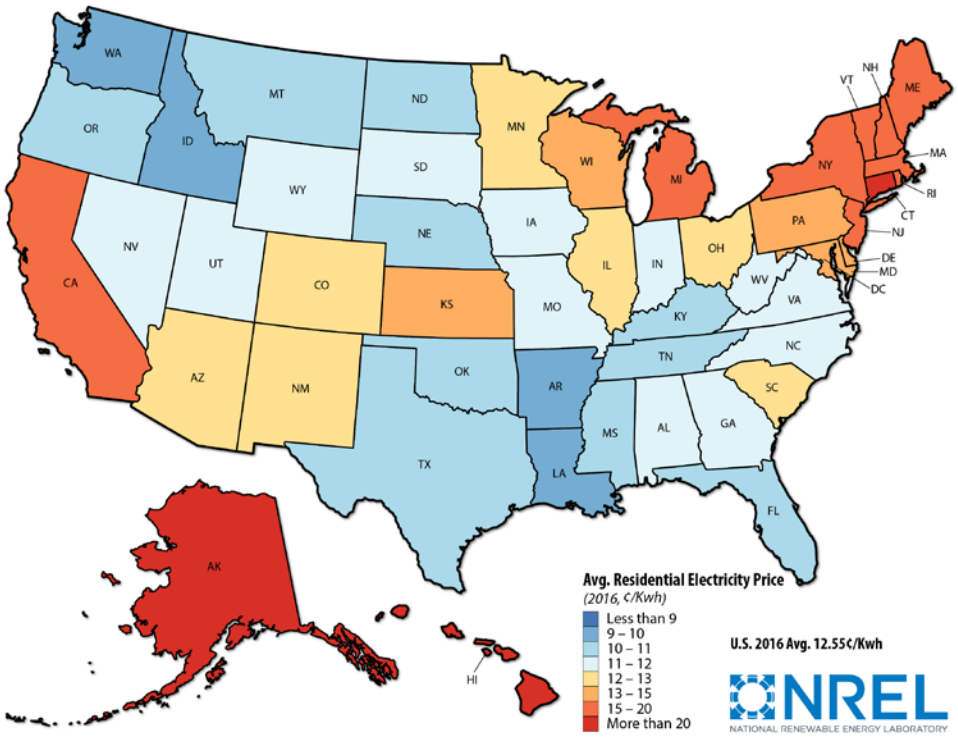
How much does it cost to drive on electricity?

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

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.





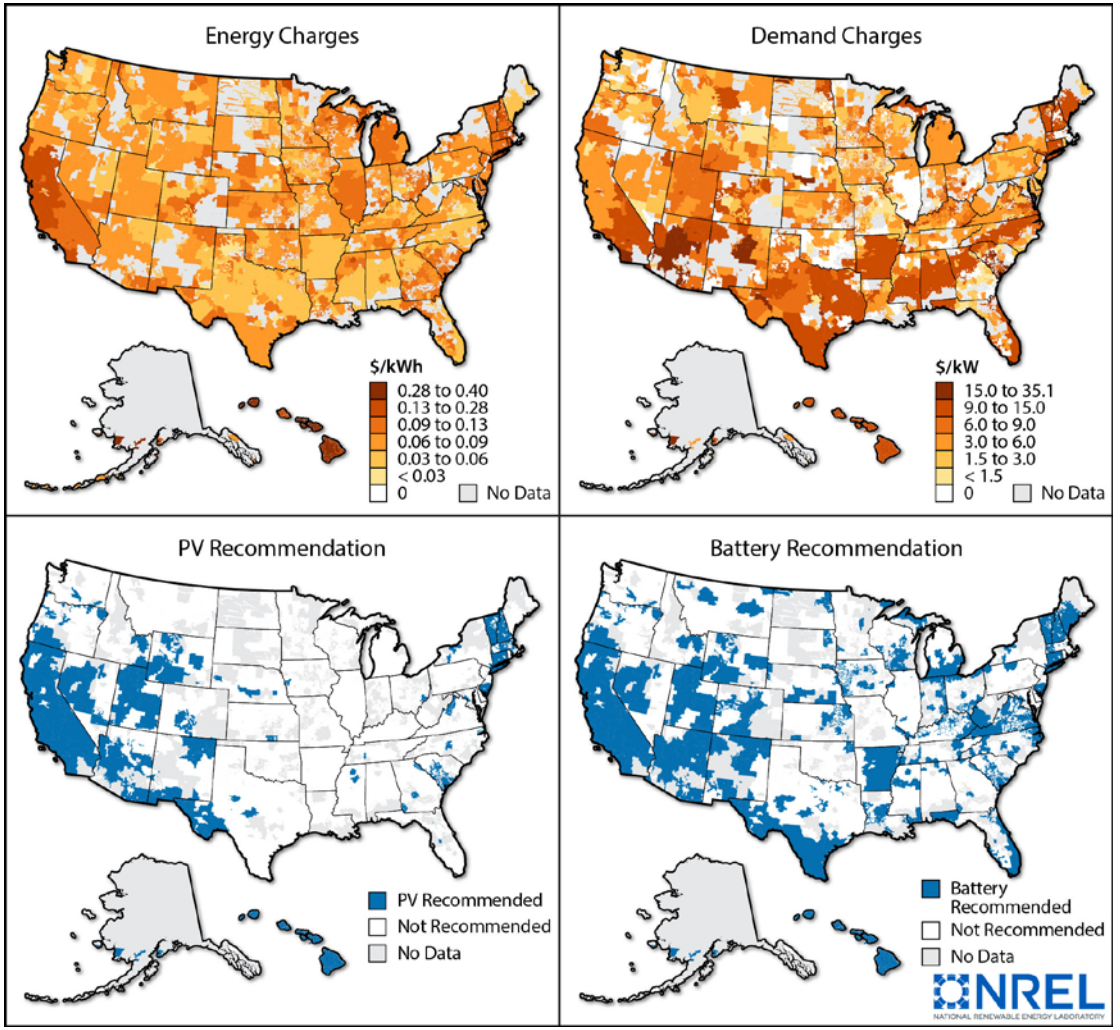
INL: Idaho National Laboratory

Technology Solutions to Reduce Cost of DCFC

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



(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?

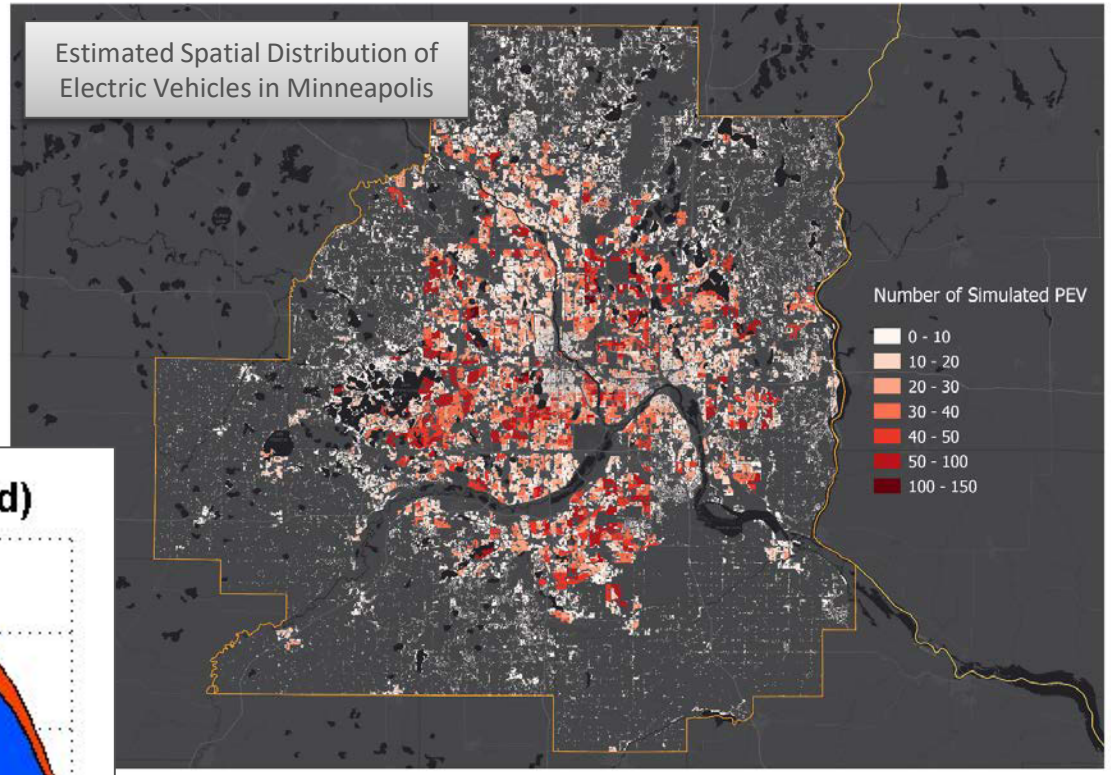
Are EVs Going to Break the Grid?

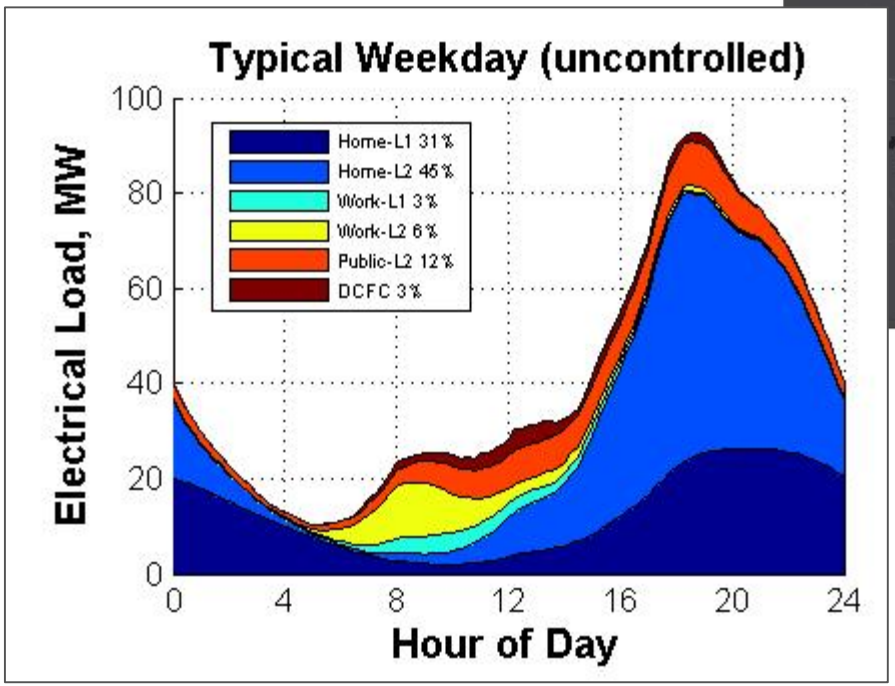
Supporting multiple on-going grid studies on EV impacts to:

Capacity expansion (years-decades)

Unit commitment (mins-hours)

Distribution power flow (secs-mins)

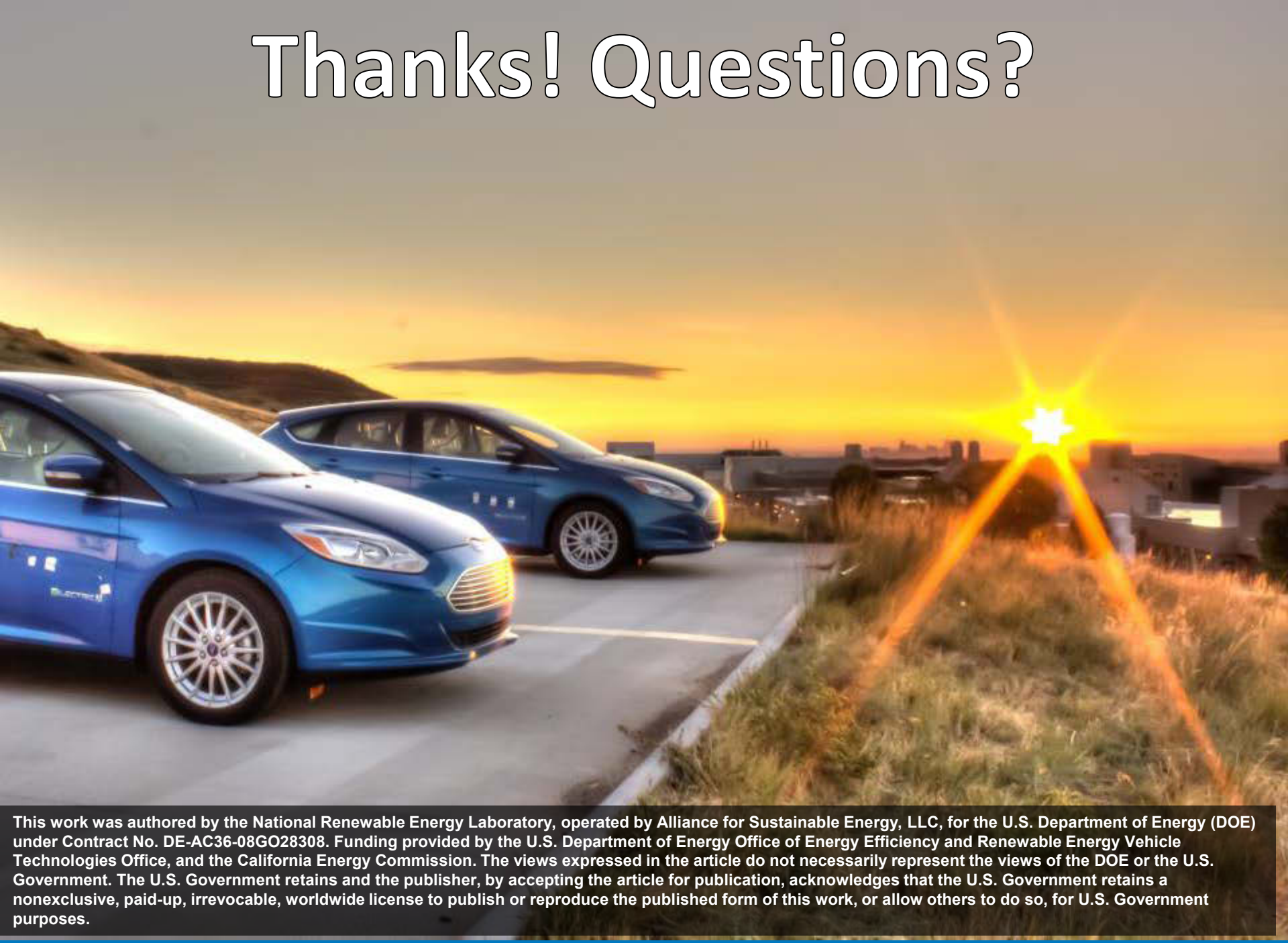




Summary

- 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?



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