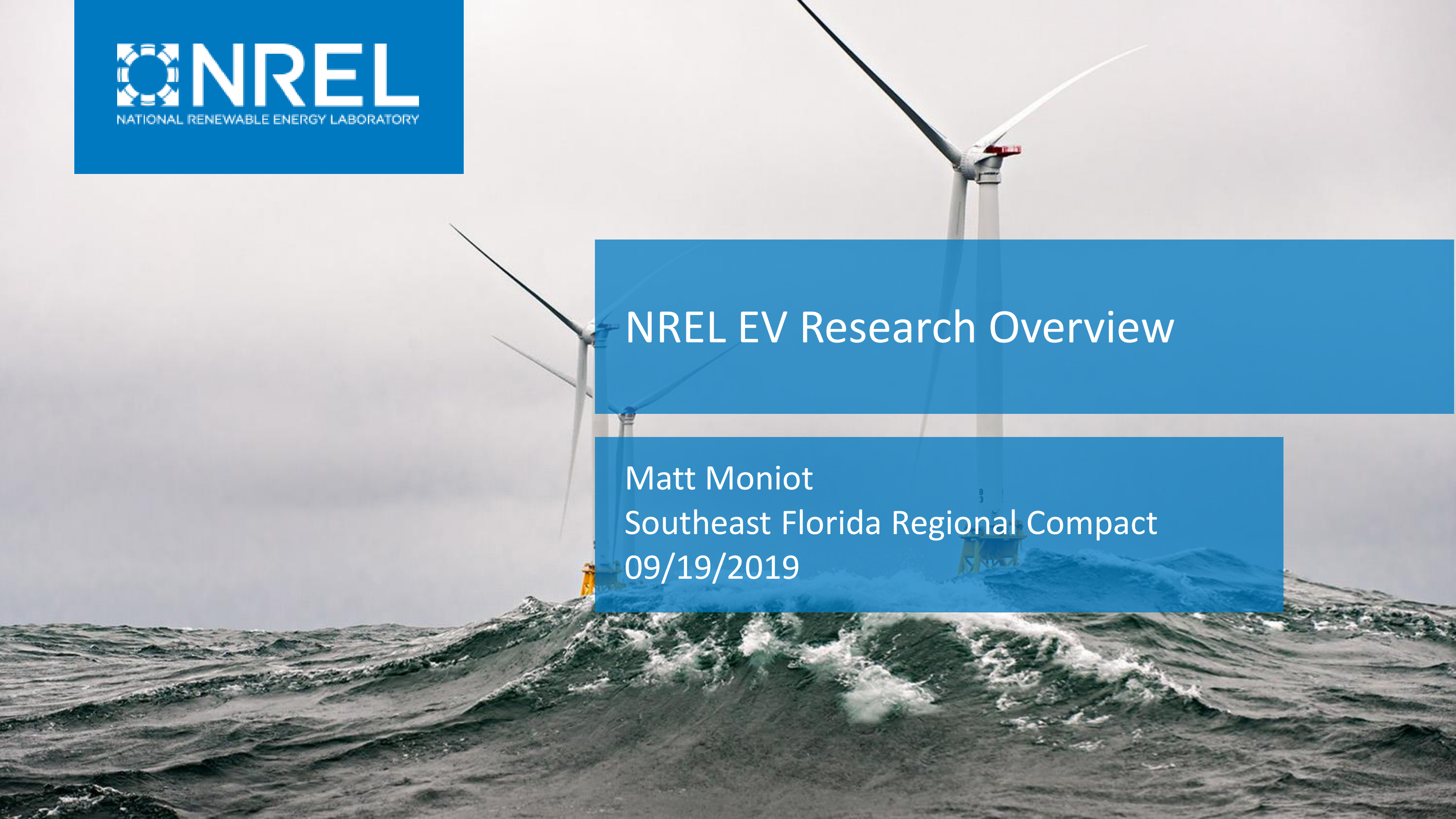

NREL EV Research Overview

Matt Moniot

Southeast Florida Regional Compact

09/19/2019

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US Department of Energy National Lab System

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PEV Charging Analysis – NREL Objective

Inform regional/national stakeholders on plug-in electric vehicle (PEV) charging infrastructure, focusing on non-residential applications to:

- Reduce range anxiety as a barrier to increased PEV sales
- Enhance charging options to maximize eVMT and enable greater PEV adoption
- 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)
Columbus, OH (2017)
National PEV Infrastructure Analysis (2017)
Maryland (2018)
Columbus Yellow Cab (2019)

National PEV Infrastructure Analysis Report (2017)

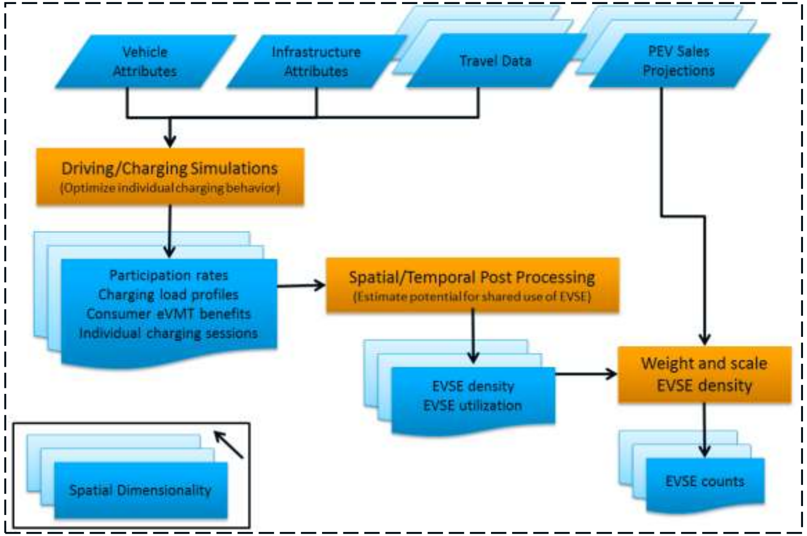
- NREL analysis was published in September 2017 as a Department of Energy **EERE Report**.
- This study was supported by the U.S. Department of Energy's **Vehicle Technologies Office**.
- Report projects charging infrastructure necessary to support a fleet of vehicles at the national level.
- https://www.nrel.gov/docs/fy17osti/69031.pdf


U.S. DEPARTMENT OF
ENERGY
Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

National Plug-In Electric Vehicle Infrastructure Analysis

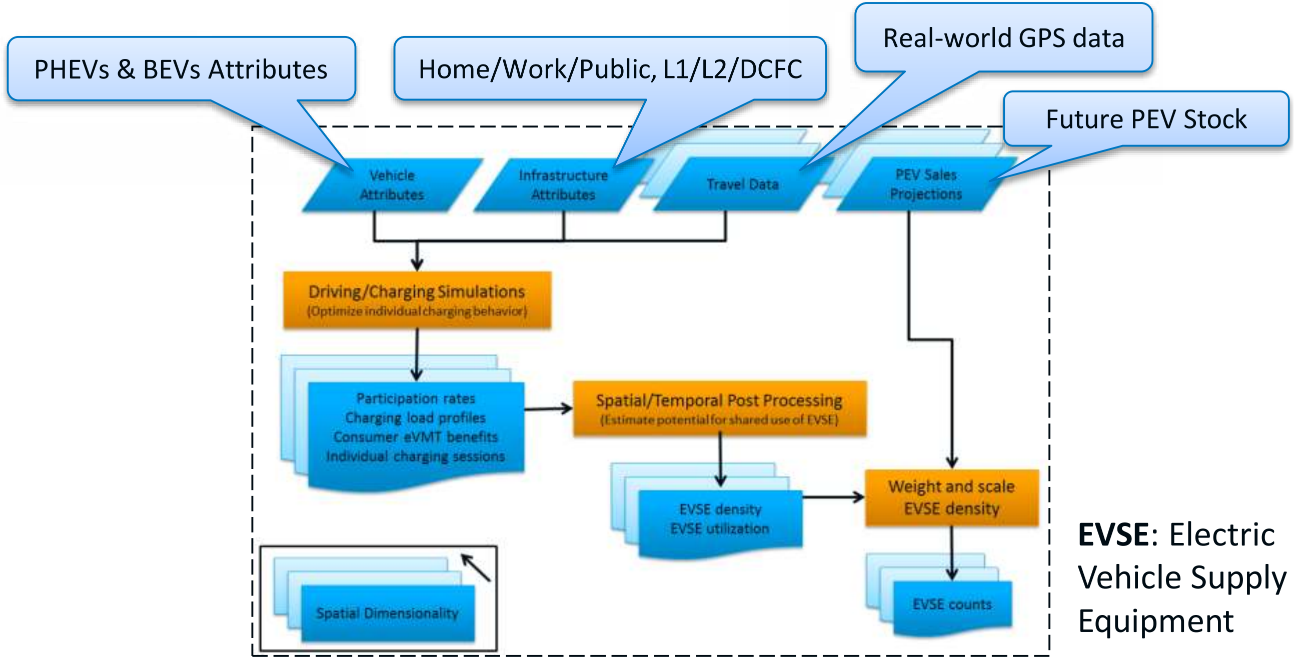
September 2017

Electric Vehicle Infrastructure Projection Tool (**EVI-Pro**)



EVSE: Electric Vehicle Supply Equipment

Electric Vehicle Infrastructure Projection Tool (**EVI-Pro**)



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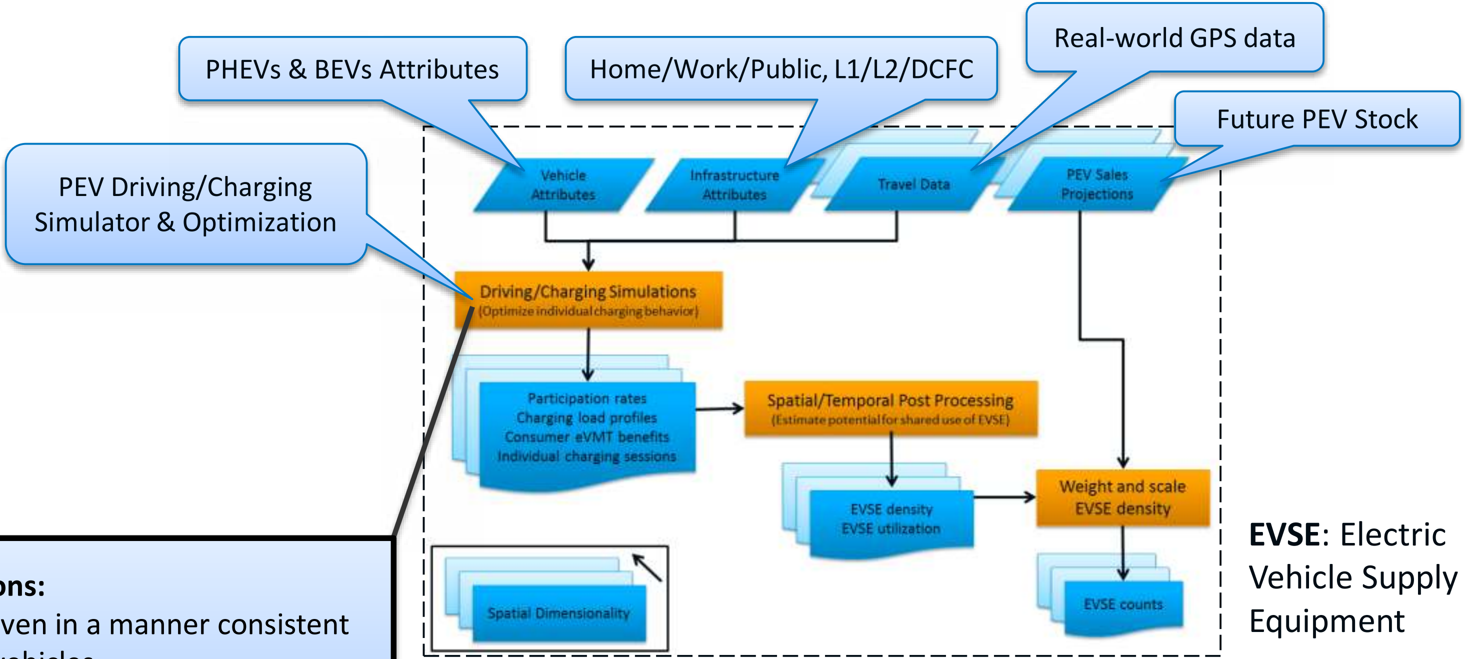

EVSE: Electric Vehicle Supply Equipment

Foundational assumptions:
- Future PEVs will be driven in a manner consistent with today's gasoline vehicles
- Consumers prefer to perform the majority of charging at their home location
- Charging at non-residential stations will be used to maximize eVMT

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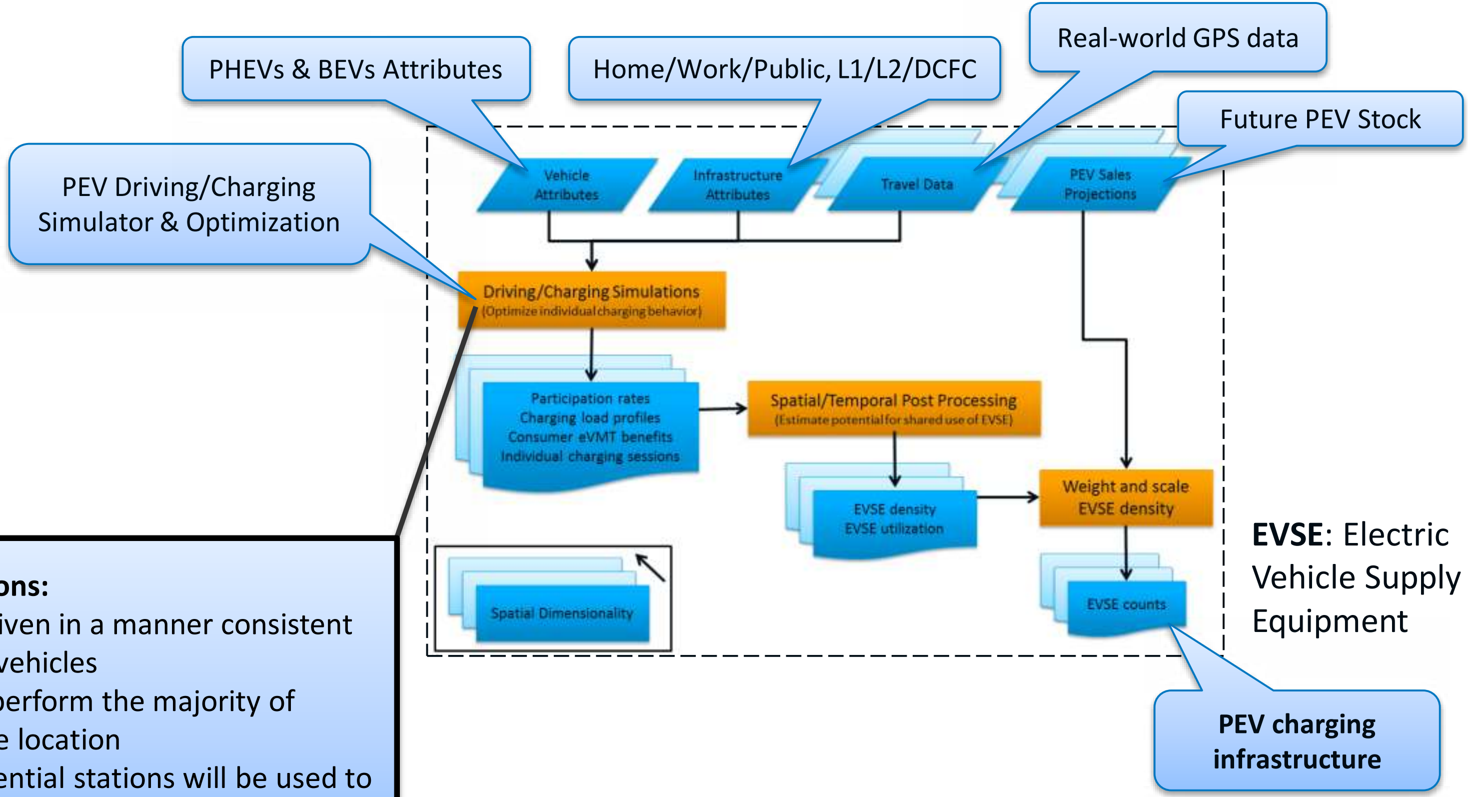

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EVSE: Electric Vehicle Supply Equipment

Electric Vehicle Infrastructure Projection Tool (**EVI-Pro**)

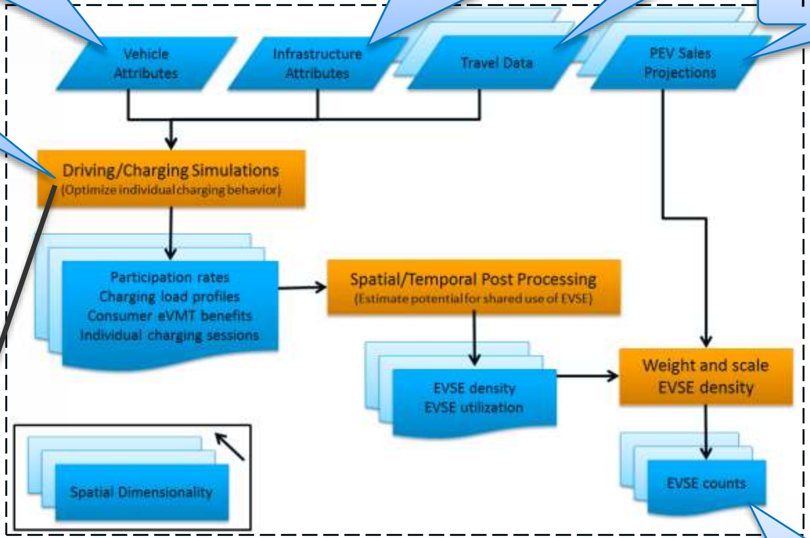
PHEVs & BEVs Attributes

Home/Work/Public, L1/L2/DCFC

Real-world GPS data

Future PEV Stock

PEV Driving/Charging Simulator & Optimization



EVSE: Electric Vehicle Supply Equipment

PEV charging infrastructure

Developed in collaboration with California Energy Commission!

Foundational assumptions:
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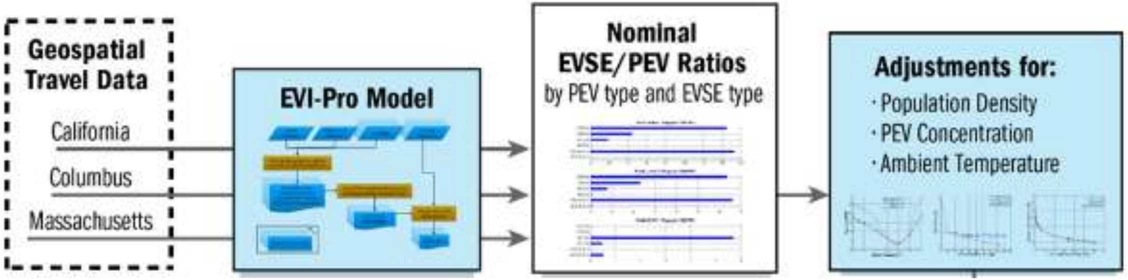
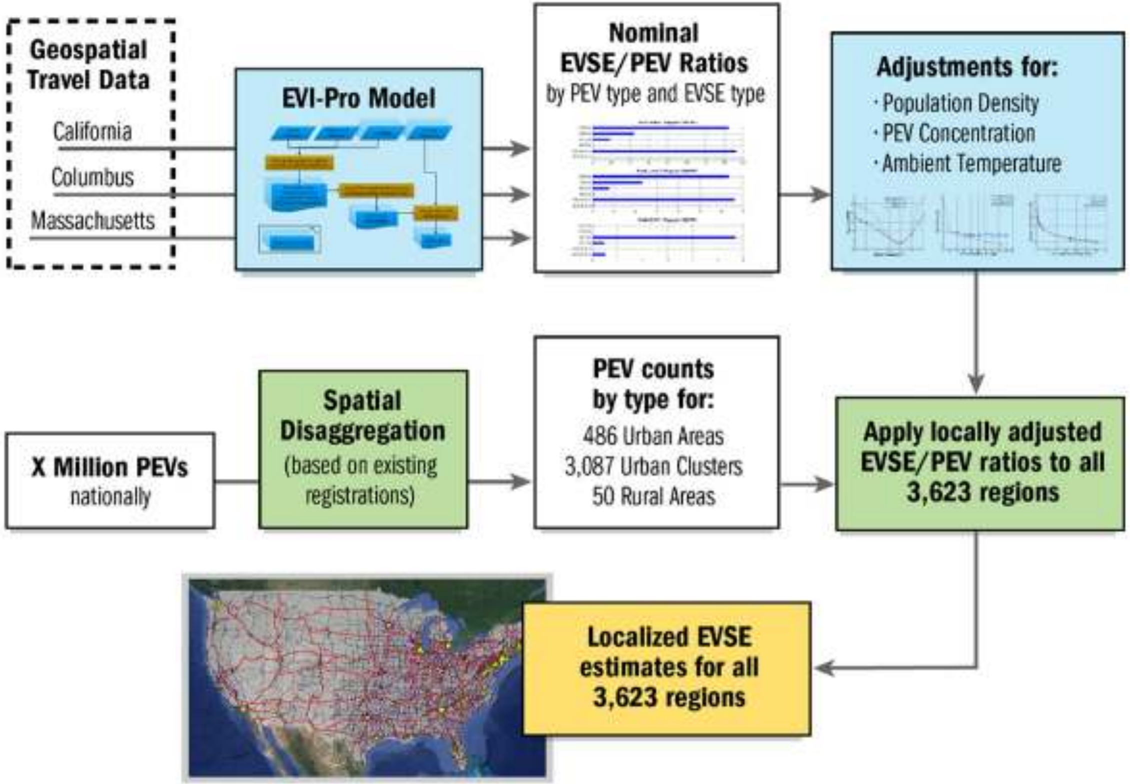
National Modeling Approach

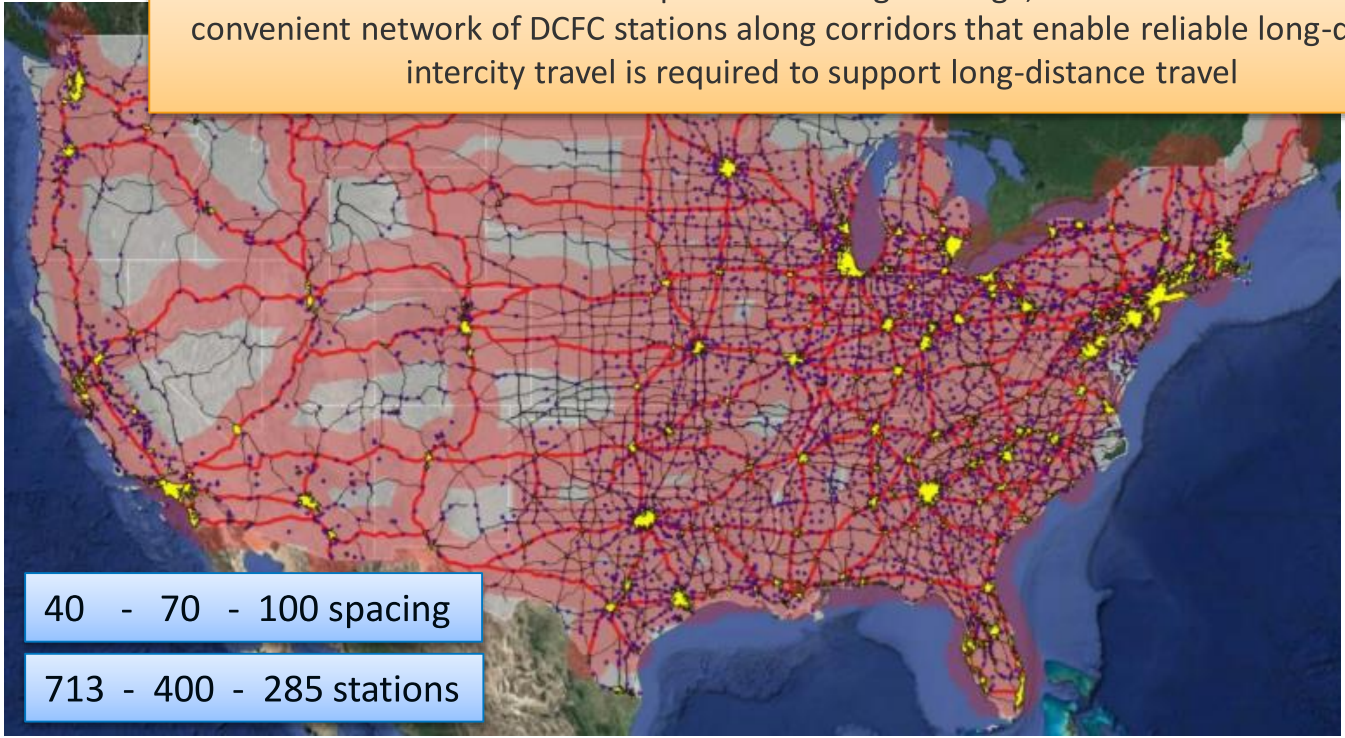


National Modeling Approach



Interstate Corridors Station Siting

While most travels can be completed on a single-charge, access to an extensive and convenient network of DCFC stations along corridors that enable reliable long-distance intercity travel is required to support long-distance travel



40 - 70 - 100 spacing

713 - 400 - 285 stations

Results – Central Scenario & Sensitivity 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	---
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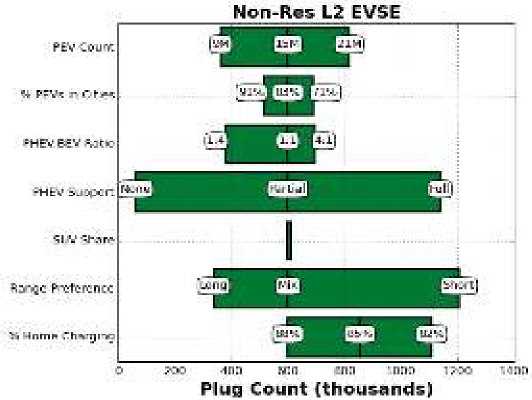
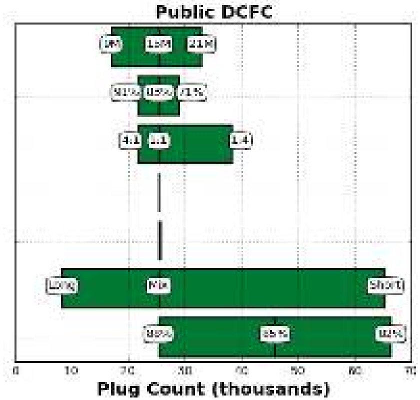
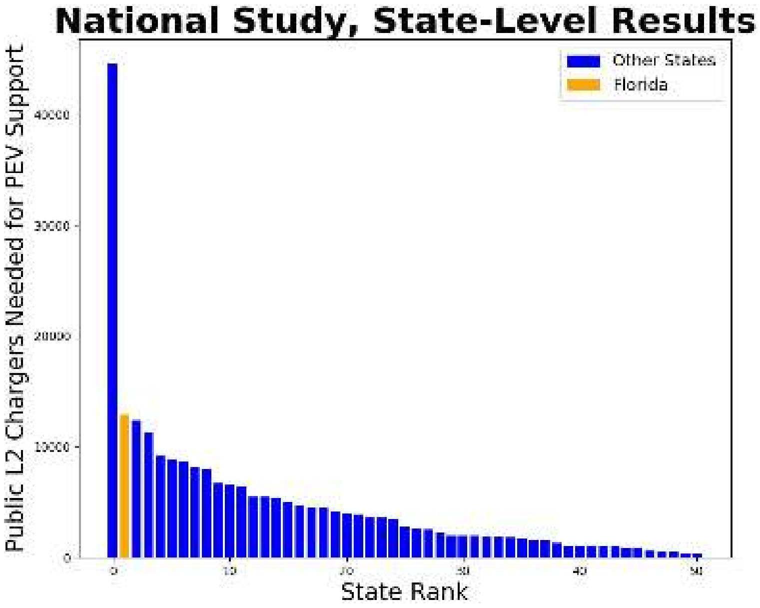
Estimated requirements for PEV charging infrastructure are heavily dependent on:
1) evolution of the PEV market, 2) consumer preferences, and 3) technology development

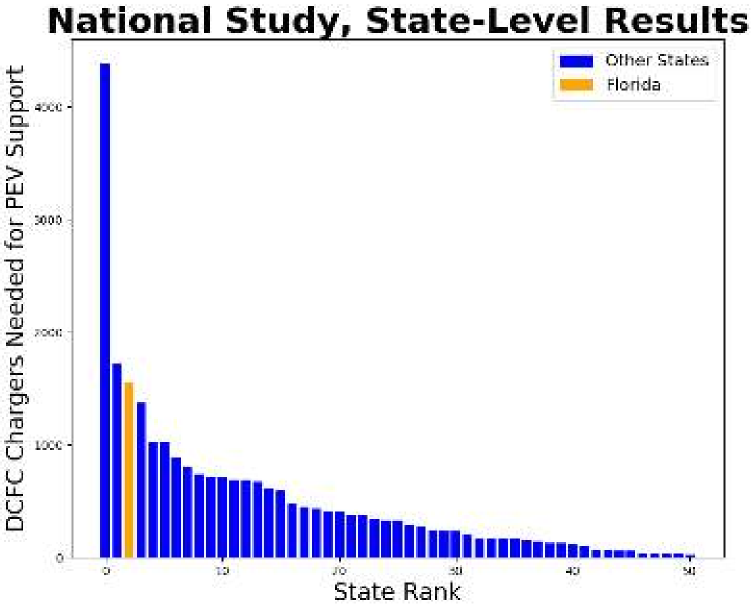
Sensitivity Analysis





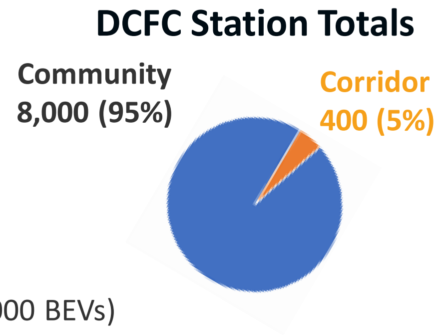
Florida Results, Central Scenario





National Analysis Insights and Conclusions

- **Communities** are expected to have significantly larger charging infrastructure requirements (coverage) than **interstate corridors**
    - Analysis also produced 550,000 community- based L2 plugs in baseline scenario



- Demand for non-residential plugs for a **15-million PEV market**:
    - 25,000 DCFC plugs in communities (approximately 3.4 plugs per 1,000 BEVs)
    - 600,000 L2 plugs (approximately 40 plugs per 1,000 PEVs

- Sensitivity analysis indicates a **strong relationship between the evolution of the PEV and EVSE markets**

Understanding **driving patterns**, **PEV characteristics** (range, charging power), and **charging behavior** and then prioritizing corridors and setting station spacing accordingly could help **optimize the utility and economics of charging stations**

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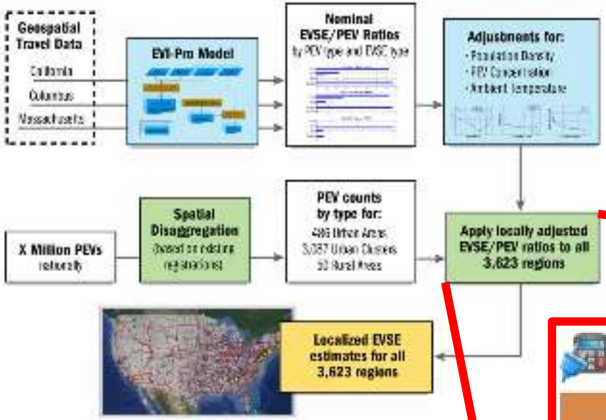
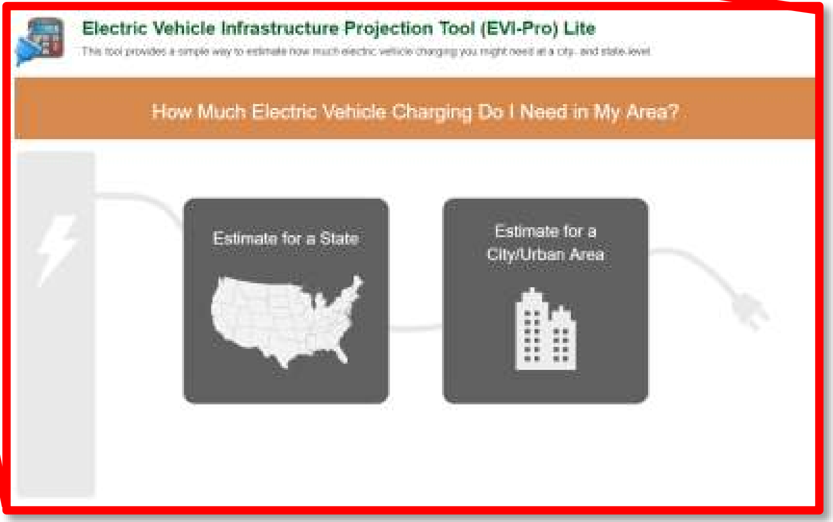
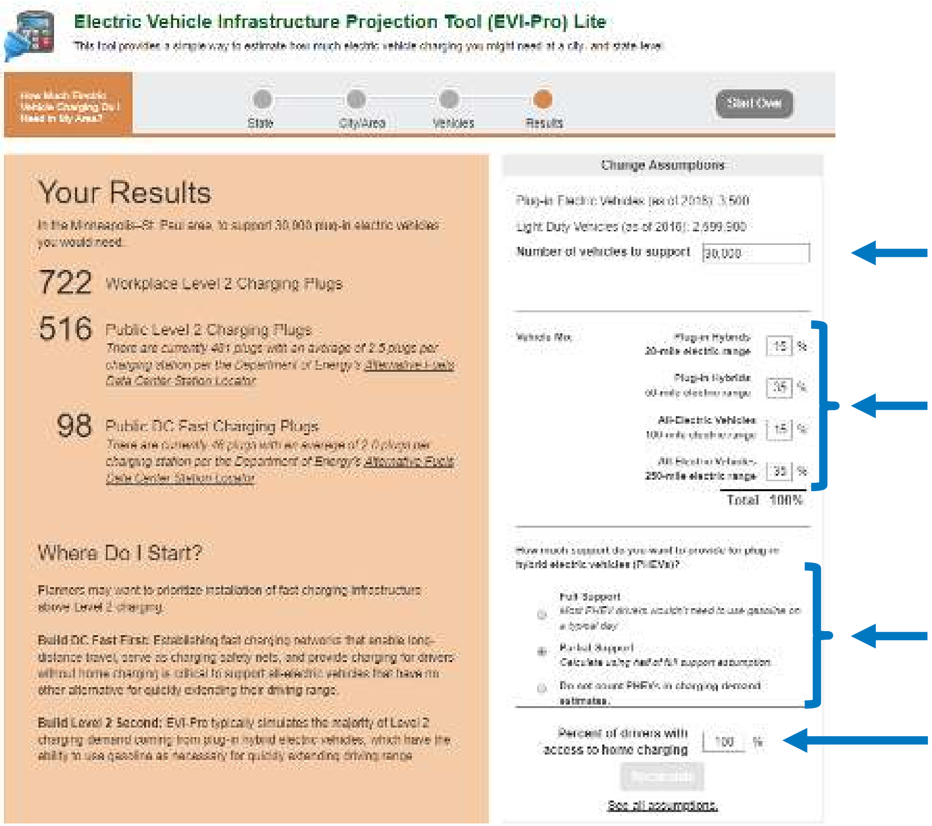
EVI-Pro Lite



NREL created a free, web-based tool allowing users to leverage the variable relationships employed in the study



EVI-Pro Lite, cont.



https://afdc.energy.gov/evi-pro-lite

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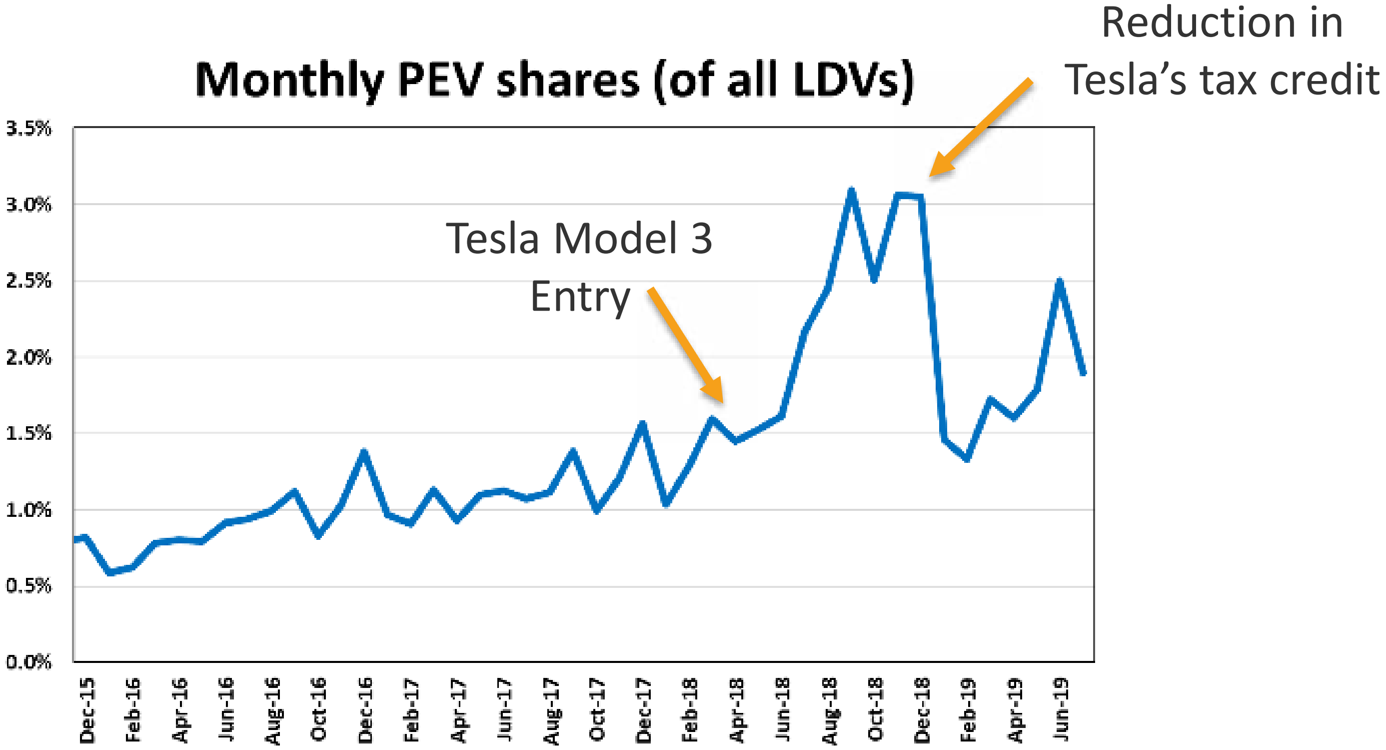
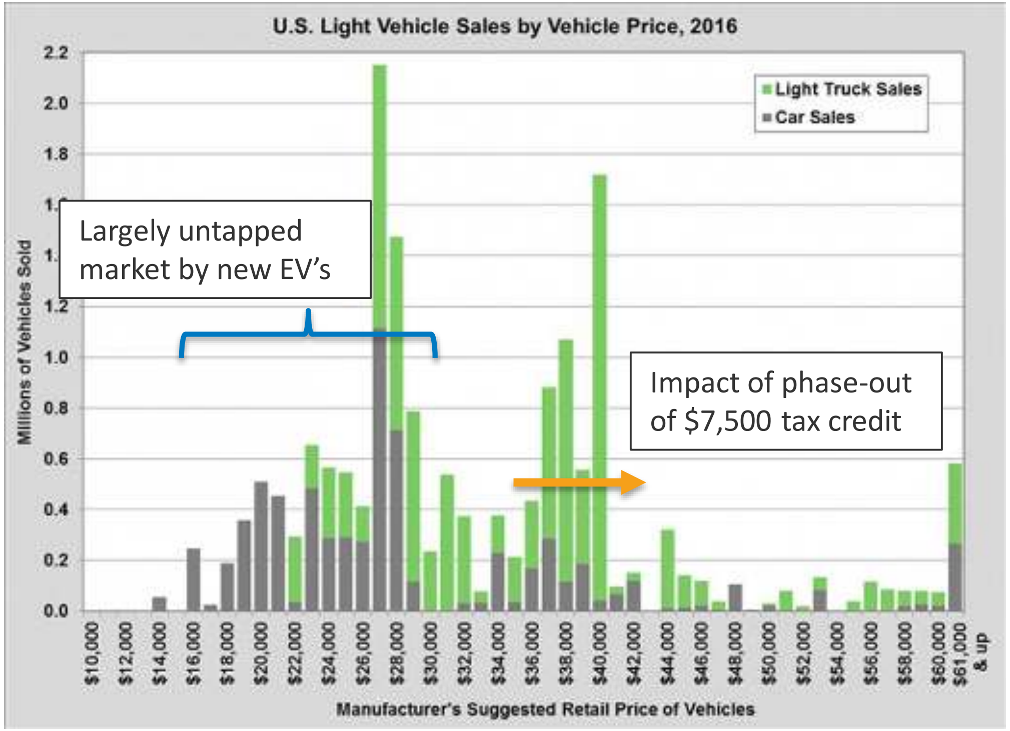
Plug-In Electric Vehicle Sales Trends

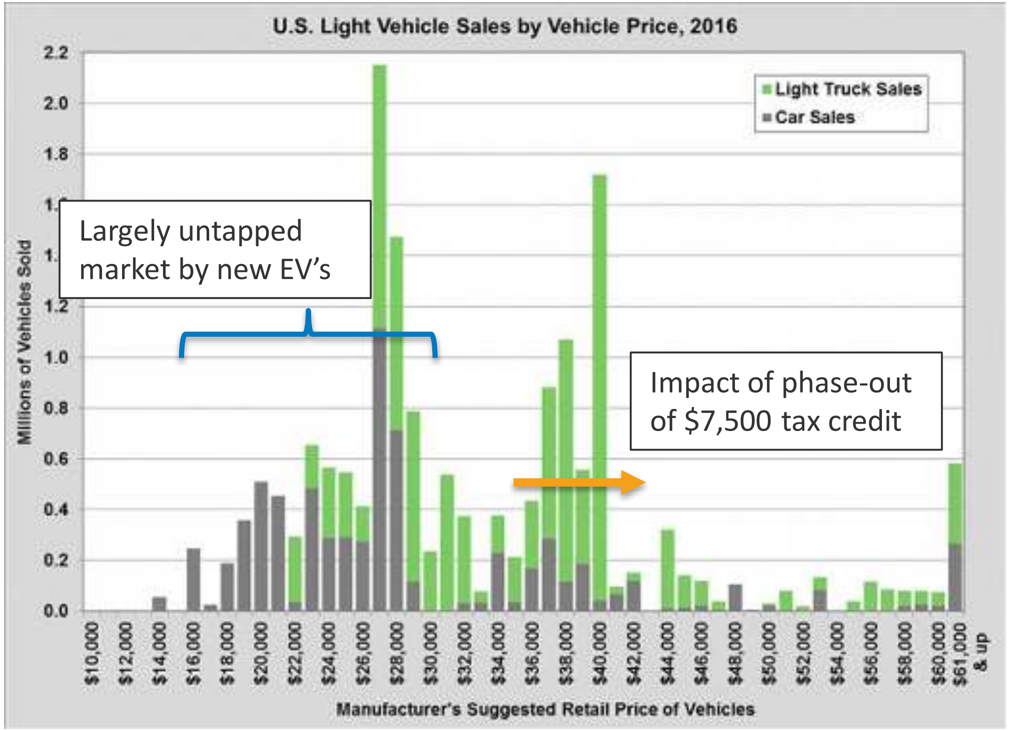


Sales Frequency by Price, 2016



Source: US DOE Office of Energy Efficiency and Renewable Energy

Sales Frequency by Price, 2016



Georgia Electric Car Sales Drop ~90% In ~6 Months

Twitter | LinkedIn | Facebook

January 27th, 2016 by Cynthia Shahan

Source: US DOE Office of Energy Efficiency and Renewable Energy

Major Takeaways

- Many factors influence necessary EV infrastructure
  - Fleet characteristics, **presence of home charging**
- DCFC is more than just interstates and highways
- Workplace charging often overlooked. Workplace plugs represent 2/3 of projected L2 infrastructure in analysis
- EV’s must be planned for, but they are not imminent!
  - Incentives and infrastructure access continue to influence sales. If there’s a tipping point, we’re not there yet!

Thanks! Questions?

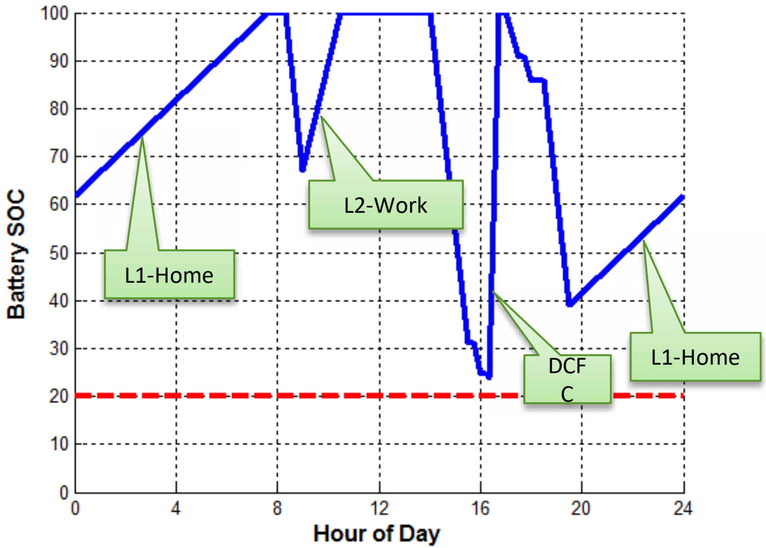
This work was funded by the US Department of Energy Vehicle Technologies Office.

EVI-Pro
Modeling Approach

Driving/Charging Simulations

Simulated charging behavior for a BEV100 under an example travel day

Destination	Departure	Arrival	Drive Miles	Dwell Hours	Simulated Charging
Work	8:20 AM	9:00 AM	32.8	5.00	L2
Non-Res	2:00 PM	3:30 PM	68.9	0.25	---
Non-Res	3:45 PM	4:00 PM	6.3	0.25	---
Non-Res	4:15 PM	4:20 PM	0.9	0.67	DCFC
Non-Res	5:00 PM	5:30 PM	9.2	0.25	---
Non-Res	5:45 PM	6:00 PM	5.0	0.50	—
Home	6:30 PM	7:30 PM	46.8	12.83	L1



Bottom-up simulations based on travel behavior are used to produce a variety of charging scenarios.

Optimal charging behavior is assumed to investigate spatial and temporal charging demand and to estimate:

- non-residential infrastructure requirements
- aggregate load profiles

Central Scenario and Sensitivity Analysis

15M PEVs Nationally

Preference for long range PEVs

Equal shares of PHEV & BEV

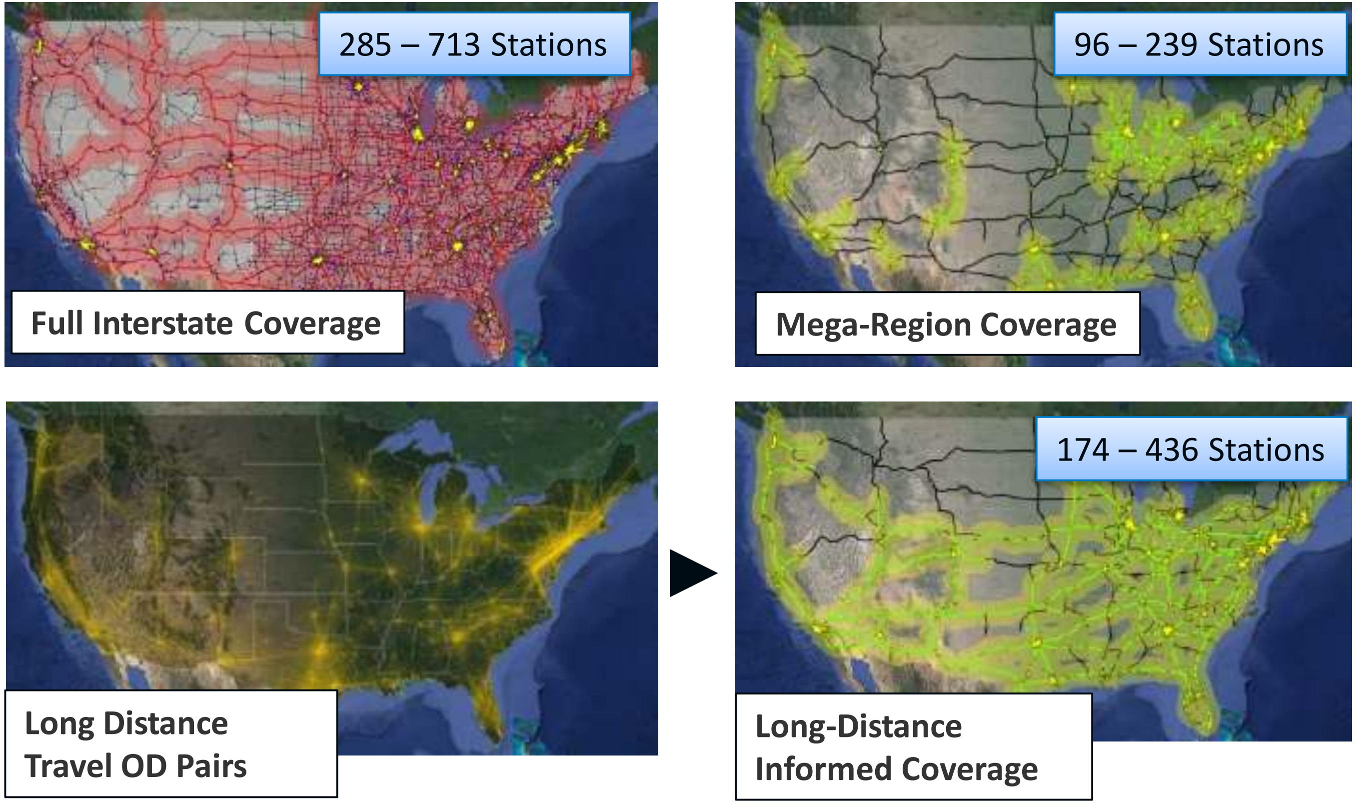
Majority of charging at home locations

Full corridor coverage

Variable	Central Scenario	Sensitivity
PEV Total	15M (linear growth to 20% of LDV sales in 2030)	9M (growth to 10% of 2030 sales) 21M (growth to 30% of 2030 sales)
PEV Mix (range preference)	Mix PHEV20 10% PHEV50 35% BEV100 15% BEV250 30% PHEV20-SUV 5% BEV250-SUV 5%	Long / Short PHEV20 0% / 40% PHEV50 50% / 0% BEV100 0% / 50% BEV250 40% / 0% PHEV20-SUV 0% / 10% BEV250-SUV 10% / 0%
Share of PEVs in Cities (pop. > 50k)	83% (based on existing HEVs)	71% (based on existing LDVs) 91% (based on existing PEVs)
PHEV:BEV Ratio	1:1	4:1 to 1:4
PHEV Support	Half of full support	No PHEV support to full support
SUV Share	10%	5% to 50%
% Home Charging	88%	88%, 85%, and 82%
Interstate Coverage	Full Interstate	Mega-regions to Full Interstate
Corridor DCFC Spacing	70 miles	40 to 100 miles
DCFC Charge Time	20 minutes (150 kW)	10 to 30 minutes (400 to 100 kW)

GPS Travel Data

Interstate Corridors Station Siting



Also considered: Link counts from Highway Performance Monitoring Region