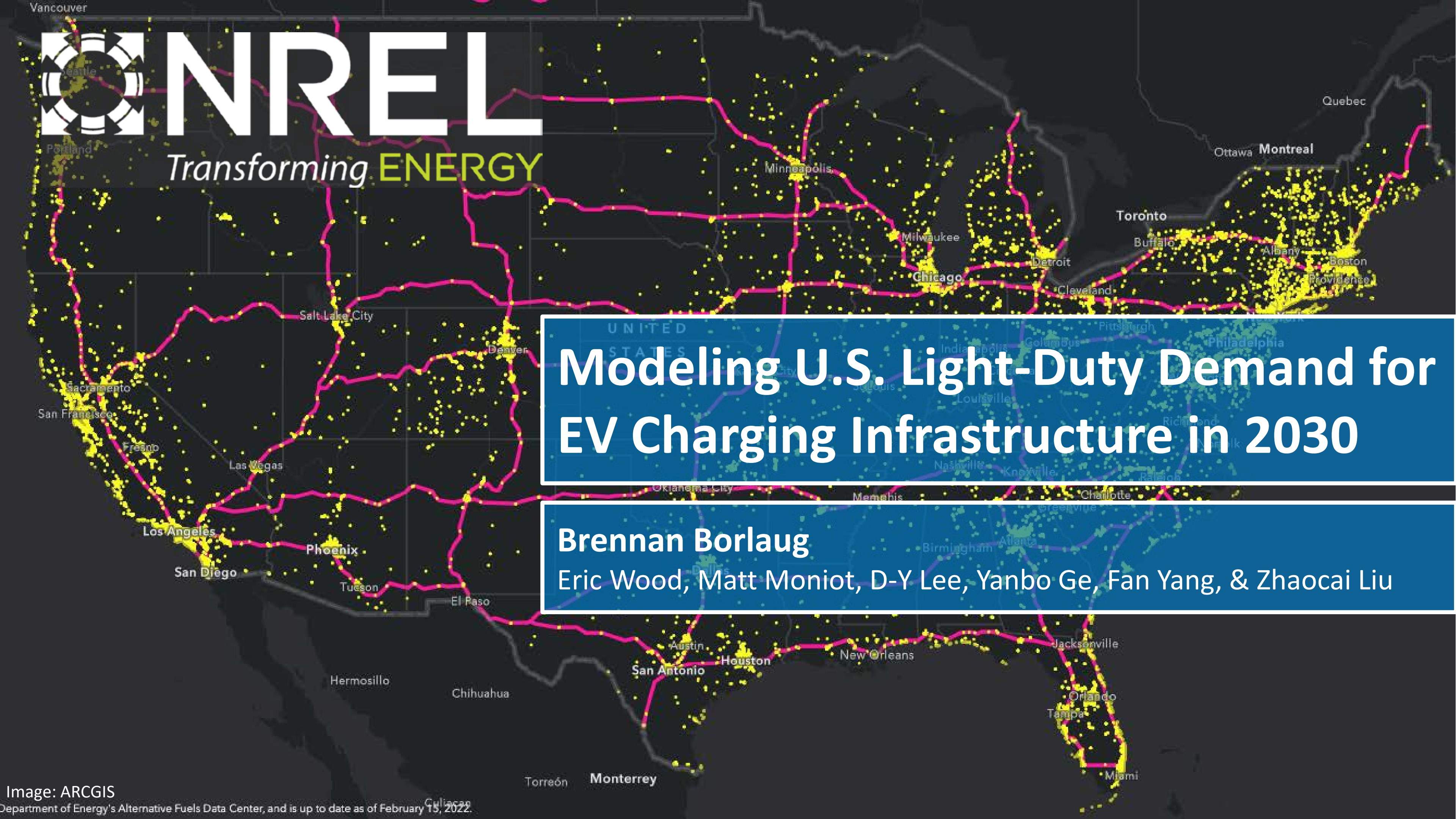


Transforming ENERGY

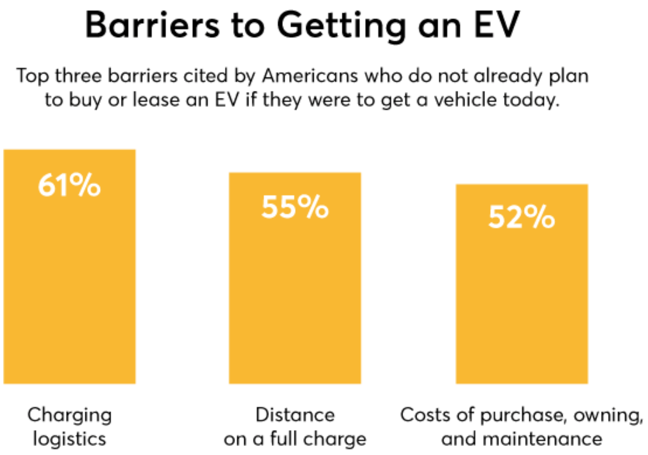
Modeling U.S. Light-Duty Demand for EV Charging Infrastructure in 2030

Brennan Borlaug
Eric Wood, Matt Moniot, D-Y Lee, Yanbo Ge, Fan Yang, & Zhaocai Liu

Image: ARCGIS
Department of Energy's Alternative Fuels Data Center, and is up to date as of February 15, 2022.

Charging a Major Concern for Potential PEV Buyers

- Recent survey shows that **6 in 10 Americans who aren't yet sold on PEVs were concerned about where and when they would charge** (61%) and how far that charge will take them (55%), i.e., "range anxiety".
- Early charging patterns are home-dominant (>80% of charging), but **many future PEV owners may not have access to a home charger**.
- Recent study shows **EV "discontinuance" related to dissatisfaction with the convenience of charging** and not having level 2 (240-volt) charging at home.



Source: Consumer Reports survey of 8,027 U.S. adults in early 2022

nature energy

Understanding discontinuance among California's electric vehicle owners

Scott Hardman & Gil Tal

https://doi.org/10.1038/s41560-021-00814-9

EV Charging a Priority for Federal Government

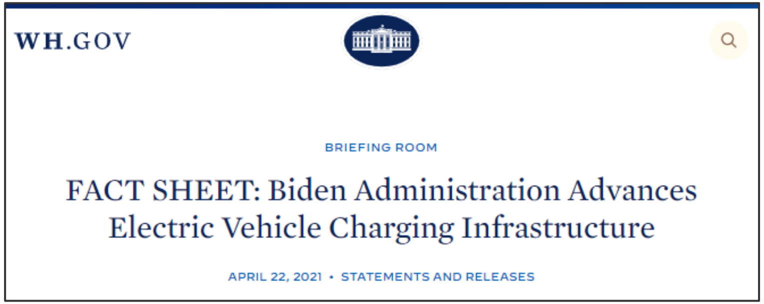
Ambitious goals to **grow domestic EV and EV charging markets** through 2030:

- 500,000 PEV chargers
- 50% of LDV sales as ZEV

Backed by **new federal policies and support**:

- 2021 Bipartisan Infrastructure Law includes $7.5 billion to build out a national network of EV chargers.
- 2022 Inflation Reduction Act provides federal tax credits for EV infrastructure, EV purchases, and domestic mining and manufacturing.

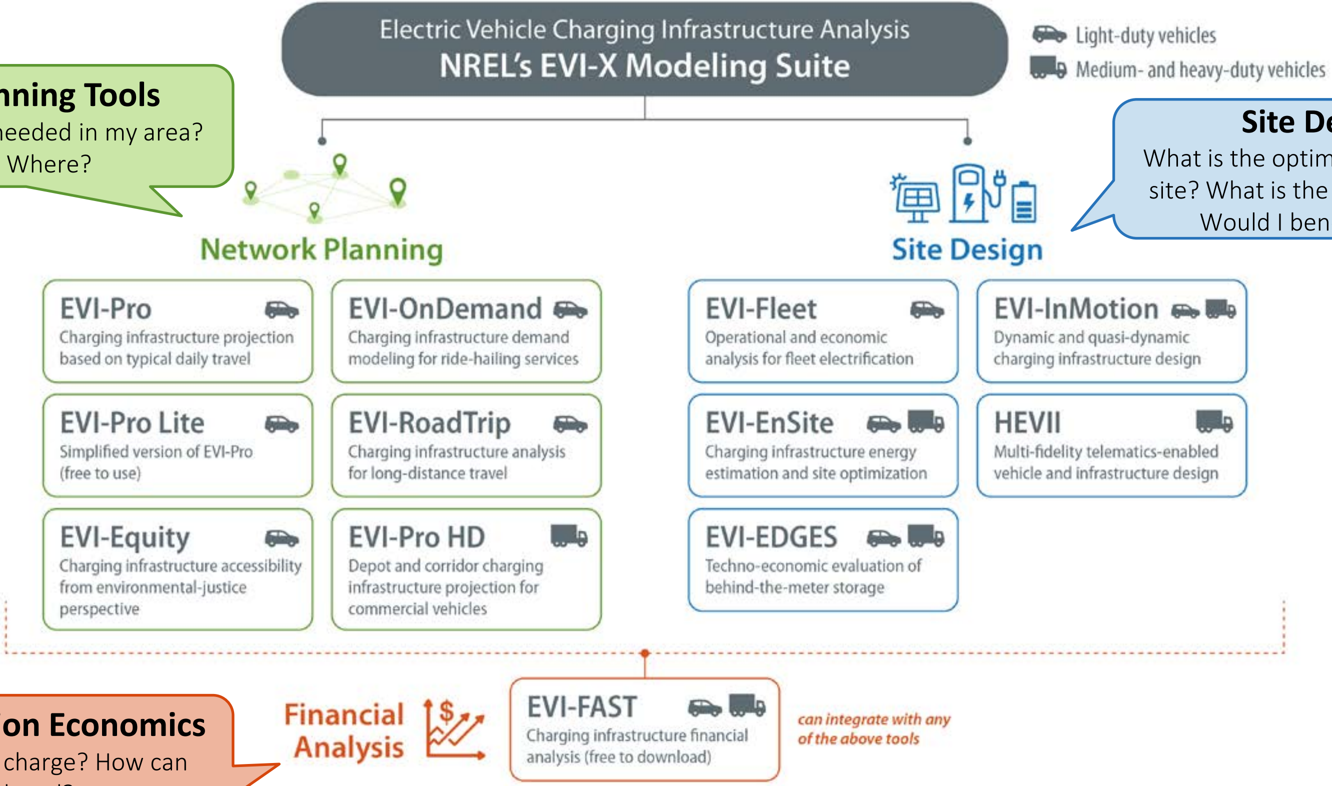
Major Uncertainty: EV charging infrastructure requirements are hard to predict over time; challenging to plan for...



EVI-X: Modeling Tools for Forward Looking Analysis

Network Planning Tools
How many ports are needed in my area? What kind? Where?

Site Design Tools
What is the optimal configuration for my site? What is the expected load profile? Would I benefit from storage?



Network & Station Economics
What does it cost to charge? How can this be reduced?

https://www.nrel.gov/transportation/evi-x.html

EVI-X: **Network Planning**

EVI-Pro is a simulation model that:

- Models **typical daily charging demands** for EVs
- Designs **supply of infrastructure** to meet demand

Models EV driver charging behaviors for a given set of assumptions around EVSE access and charging preferences.

Originally developed through a collaboration with the California Energy Commission, EVI-Pro has been applied in multiple city-, state-, and national-level studies

EVI-Pro

https://www.nrel.gov/transportation/evi-pro.html

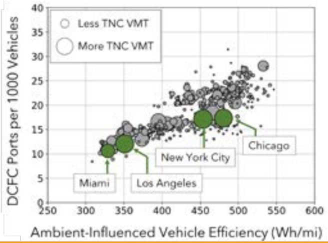
EVI-RoadTrip estimates EV charging demands along highway corridors for **long-distance travel** (road trips).

EVI-RoadTrip

https://www.nrel.gov/transportation/evi-roadtrip.html

EVI-OnDemand estimates DC fast charging infrastructure requirements for **ride-hail EVs** considering:

- Local weather/driving conditions
- Typical driver shift lengths
- Home charging access for ride-hail drivers



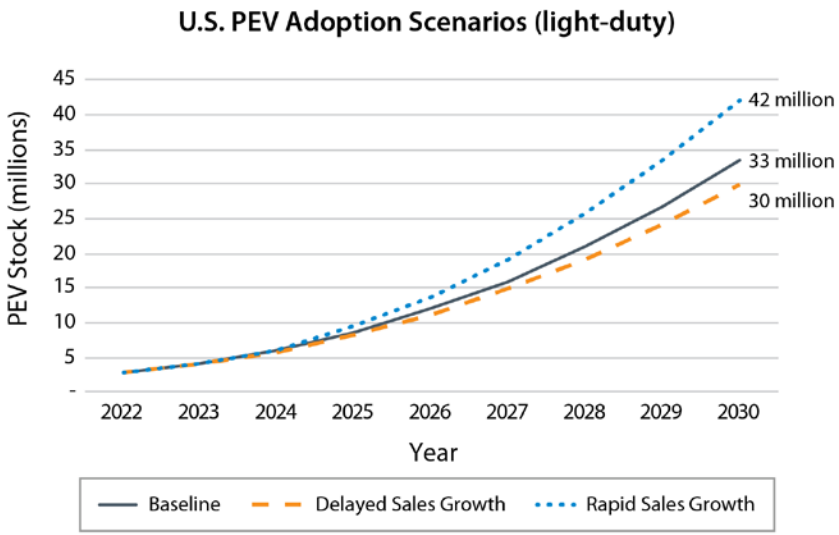
“The 2030 National Charging Network” Study

Study Objective

Major Uncertainty: EV charging infrastructure requirements are hard to predict over time; challenging to plan for...

Primary Research Questions:

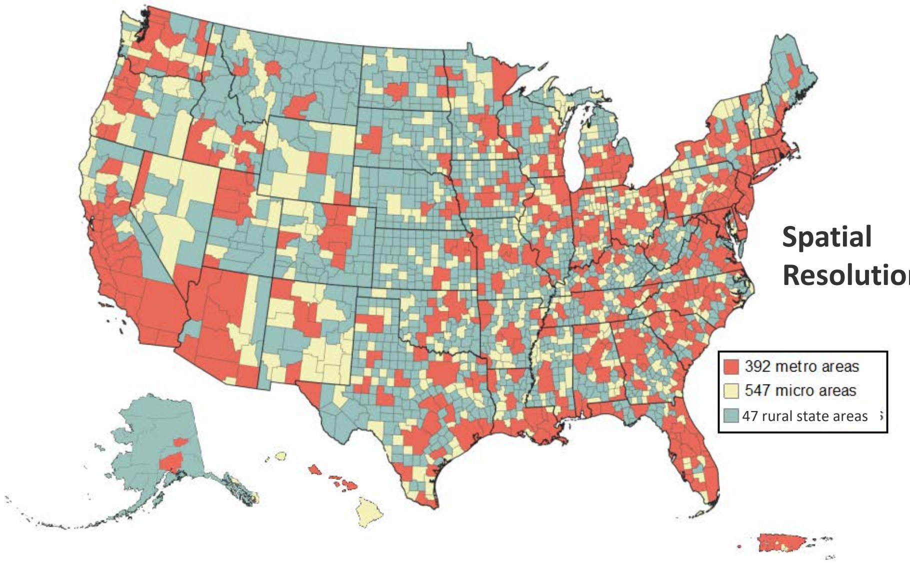
- What are the charging demands and how much charging infrastructure is needed to support **high levels of EV adoption by 2030**?
- Which types of EVSE should be prioritized and where?
- What will it cost to build out the EVSE network over time?



TEMPO-modeled national light-duty PEV adoption trajectories

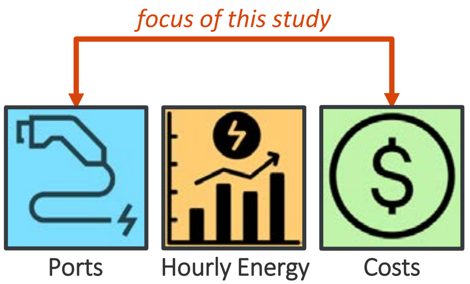
Scope of Modeling

Outputs:	EVSE port counts and costs
Vehicle Segment:	Personally-owned light-duty vehicles
Timeframe:	2022 - 2030
Spatial Resolution:	986 CBSAs/rural-state areas (see below)
EVSE Types:	(see EVSE Taxonomy table)



Spatial Resolution

Outputs:



by...

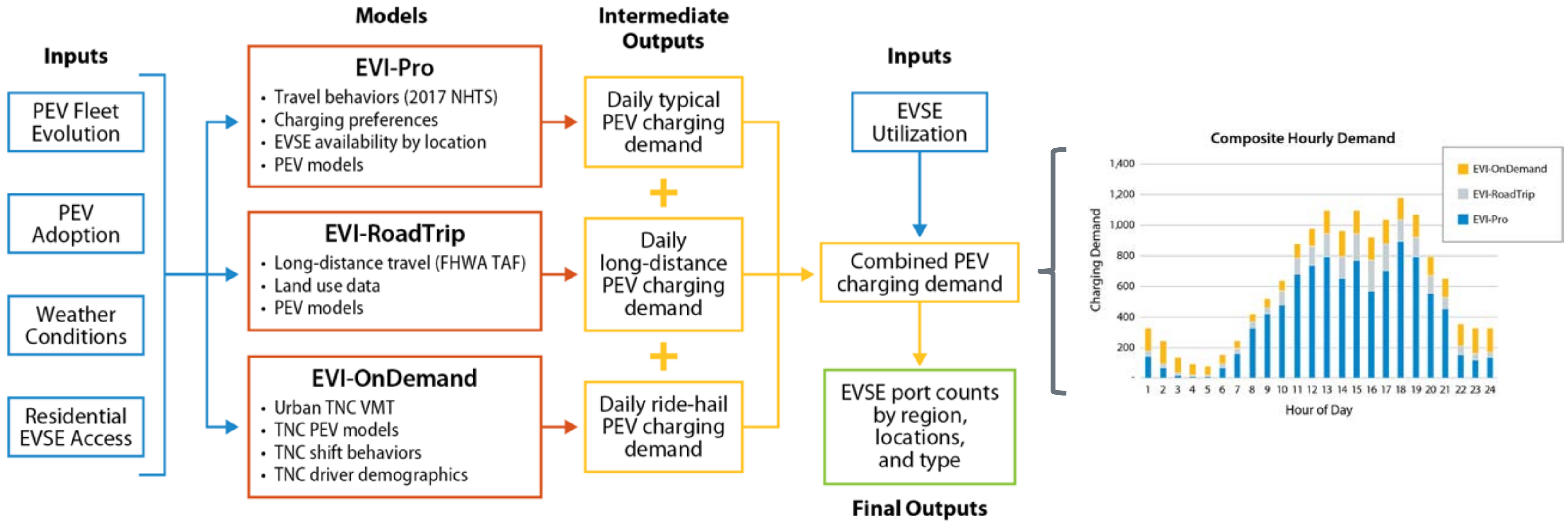
EVSE Taxonomy

Access Type	Public	Private
Location Type	Home: SFH	Recreational
	Home: MFH	Healthcare
	Neighborhood	School
	Workplace	Community Center
	Office	Transit Hub
	Retail	
EVSE Type	Level 1	DC 150 kW
	Level 2	DC 250 kW
	DC 50 kW	DC 350+ kW

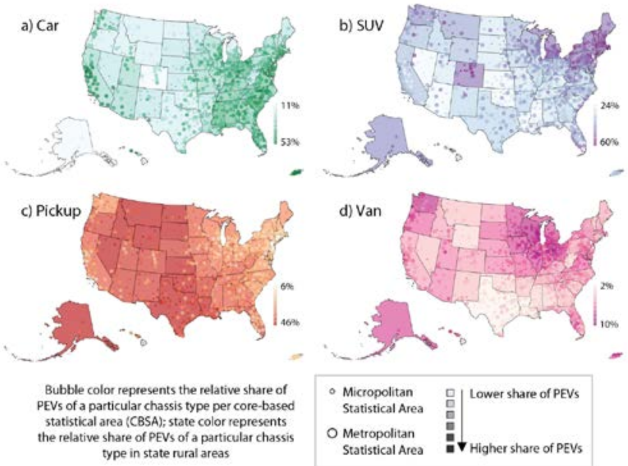
Modeling Approach

National modeling framework standardizes inputs and combines outputs for each of the light-duty EVI- demand models.

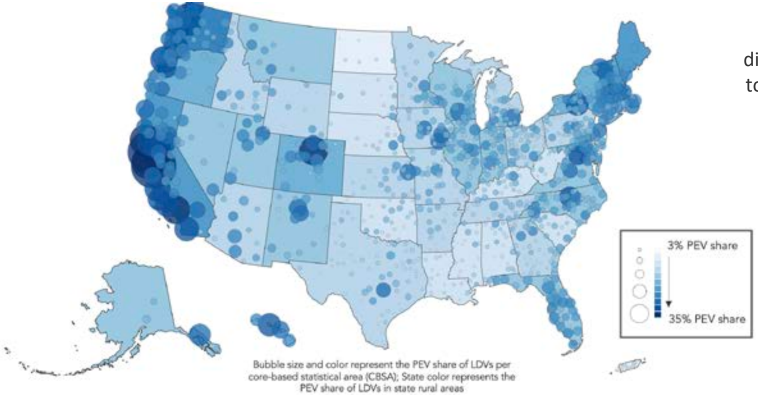
Captures regional differences in EV charging demands and port requirements due to differences in travel patterns, residential charging access, PEV adoption rates, vehicle type preferences, and weather conditions.



Baseline Assumptions



2030 PEV chassis mix = new LDVs (MY2019-22)

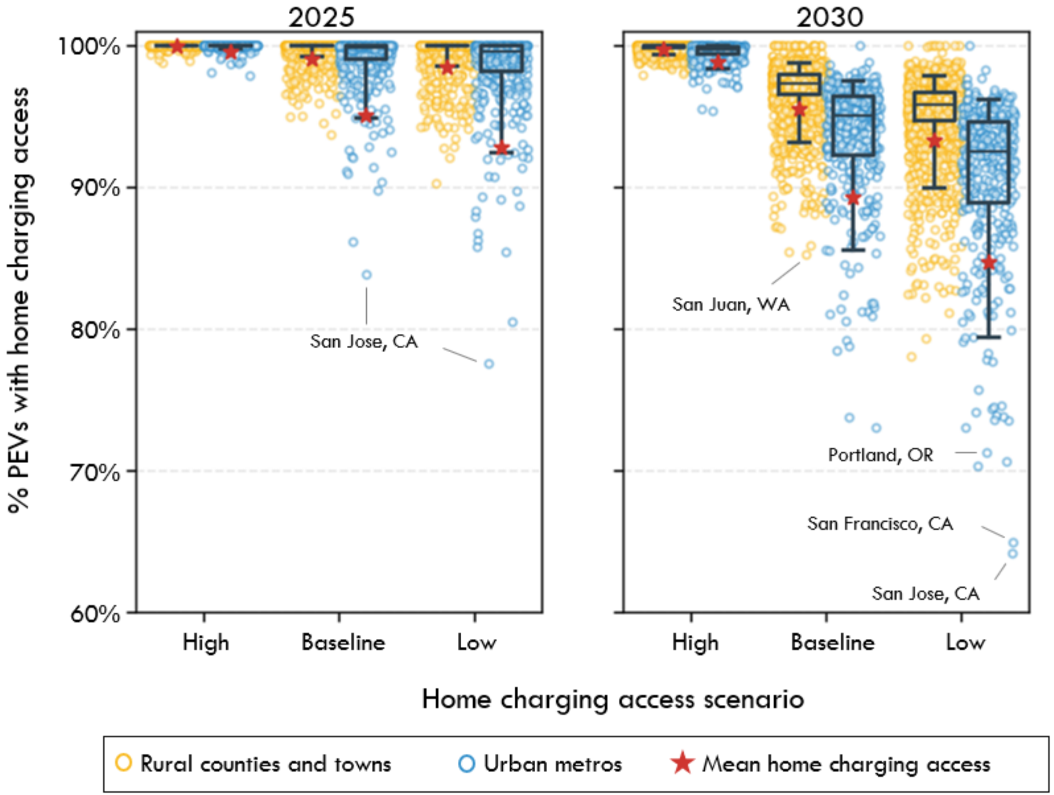


2030 PEV spatial distribution skewed toward 2022 PEV & HEV distribution

Demand-Side Assumptions: Baseline Scenario

Modeling Parameter	2030 Nominal Assumption
PEV fleet size (LDV only)	33 million (2.7 million registered as of 2022)
PEV powertrain shares	BEV = 90% (2022: 72%) PHEV = 10% (2022: 28%)
PEV body type distribution	Sedan = 24% (2022: 58%) C/SUV = 56% (2022: 40%) Pickup = 17% (2022: 0%) Van = 3% (2022: 2%)
Average PEV electric range (model year 2030)	BEV = 300 miles PHEV = 45 miles
BEV minimum DC charge time (model year 2030; 20%–80% state of charge [SOC])	20 minutes [a]
Maximum DC power rating (per port)	350+ kW
Geographical distribution	Scaled proportional to existing PEV and gasoline-hybrid registrations with a ceiling of 35% of LDVs on the road in 2030 as PEVs in high adoption areas and a floor of 3% in low adoption areas
PEVs with reliable access to residential charging	90%
Weather conditions	Typical ambient conditions are used for each simulated region, impacting electric range accordingly
Driving behavior	EVI-Pro: Consistent with Federal Highway Administration (FHWA) 2017 National Household Travel Survey (NHTS) EVI-RoadTrip: Directly applies FHWA Traveler Analysis Framework (TAF) EVI-On Demand: Consistent with Balding et al. (2019)
Charging behavior	All models attempt to maximize use of home charging (when available) and utilize charging away from home only as necessary. When fast charging is necessary, BEVs prefer the fastest option compatible with their vehicle, up to 350+ kW.

Home Charging Access



https://www.nrel.gov/docs/fy22osti/81065.pdf

Home Access Scenarios:

Low: Scenario 2 – only PEV drivers with existing electrical access where the vehicle is parked can charge at home (Ge et al.)

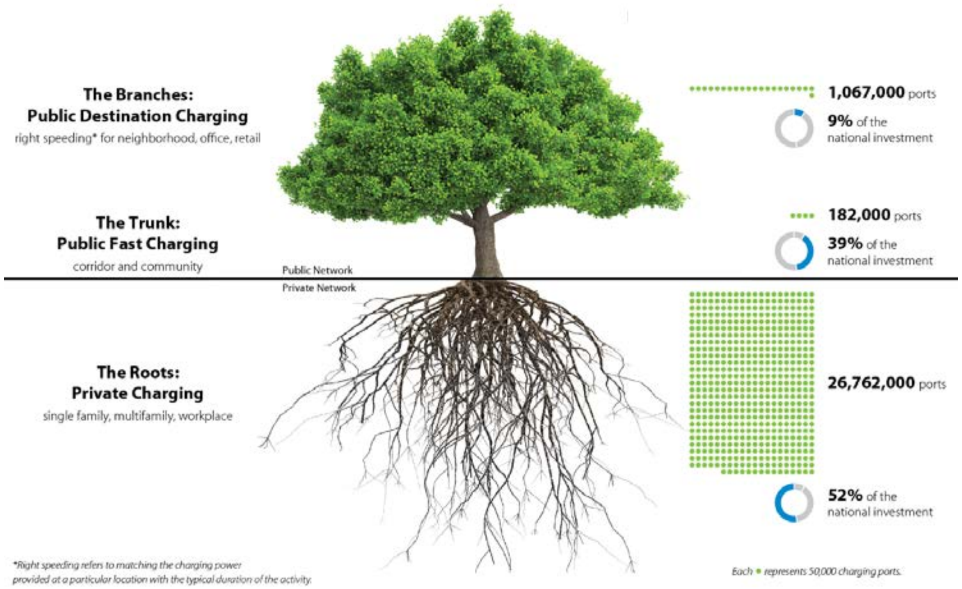
Baseline: 50% Scenario 2, 50% Scenario 3 (Ge et al.)

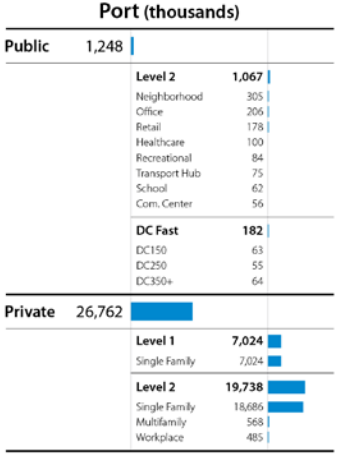
High: Scenario 5 – Assumes all PEV drivers who can park their vehicle in a location where electrical access can be installed can charge at home (Ge et al.)

Key Findings (1/5)

Convenient and affordable charging at/near home is core to the ecosystem but must be complemented by reliable public charging:

- **26.8 million Level 1 and Level 2 charging ports** in **privately accessible locations** [96% of ports, 52% of investment]
  (single-family homes, multifamily properties, and restricted access workplaces)
- **1 million Level 2 charging ports** in **publicly accessible locations** [4% of ports, 9% of investment]
  (near high-density neighborhoods, public access workplaces, and other long-dwell locations)
- **182,000 fast charging ports** in **publicly accessible locations** [<1% of ports, 39% of investment]
  (grocery stores, convenience stores, and other short-dwell locations)



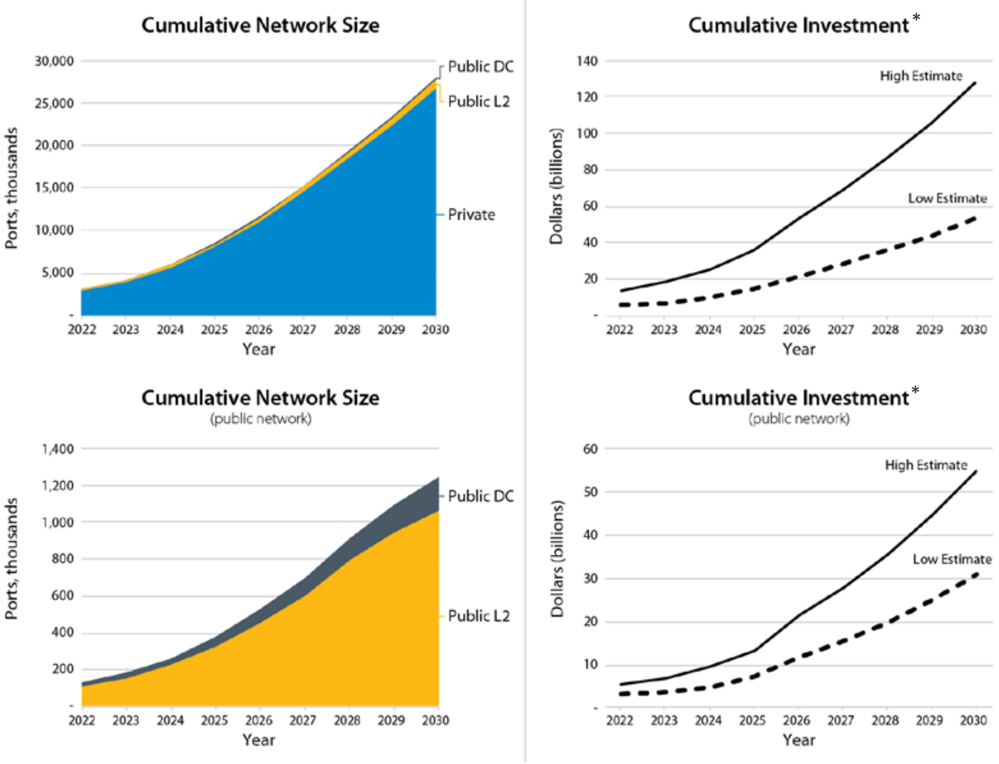


Key Findings (2/5)

Continued growth and investment in the EV charging network will be required to meet 2030 sales targets.

- High uncertainty around cost requirements due to significant site-level variability in EVSE equipment and installation costs.
- Significant public and private investments in EV charging have already been made and will need to continue through the end of the decade.

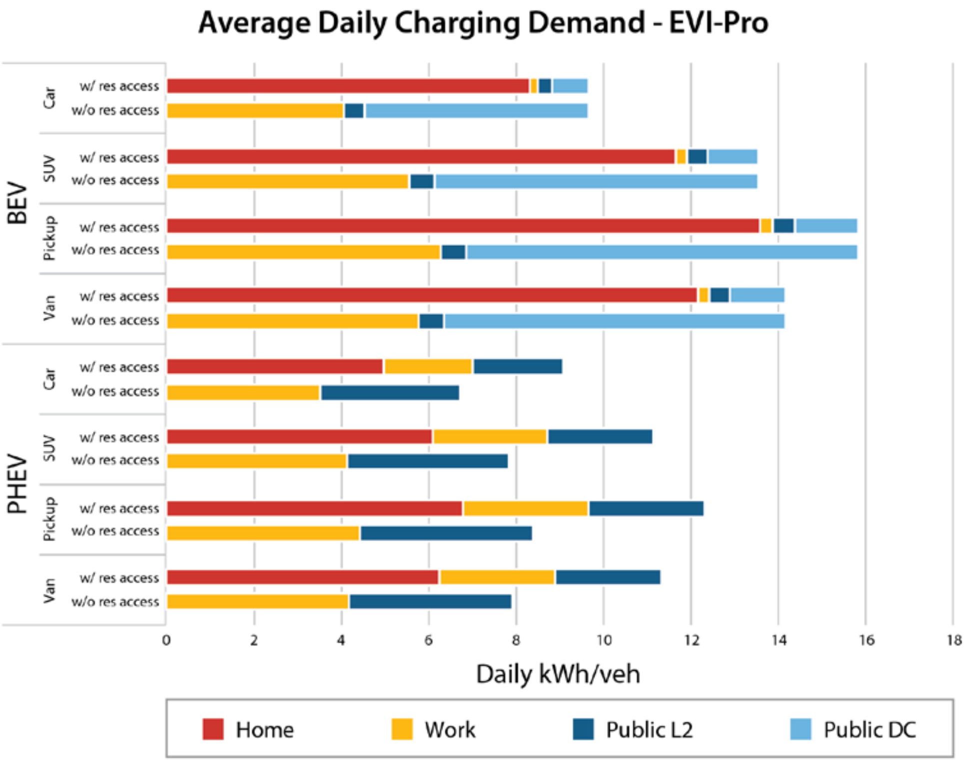
*Cumulative Investment is defined as capital expenses for equipment and installation necessary to support EV charging. Costs of grid upgrades and distributed energy resources have been excluded from these estimates; however, these can be significant and will ultimately be critical for building out the national charging network.



Key Findings (3/5)

Charging demands and infrastructure requirements vary by vehicle type and for those with/without home charging.

- Larger vehicles = higher energy demands
- PHEVs have lower electricity demands (smaller batteries) than BEVs and may rely more on public L2 charging*
- Without home charging, drivers rely more on workplace and public charging networks for daily travels.

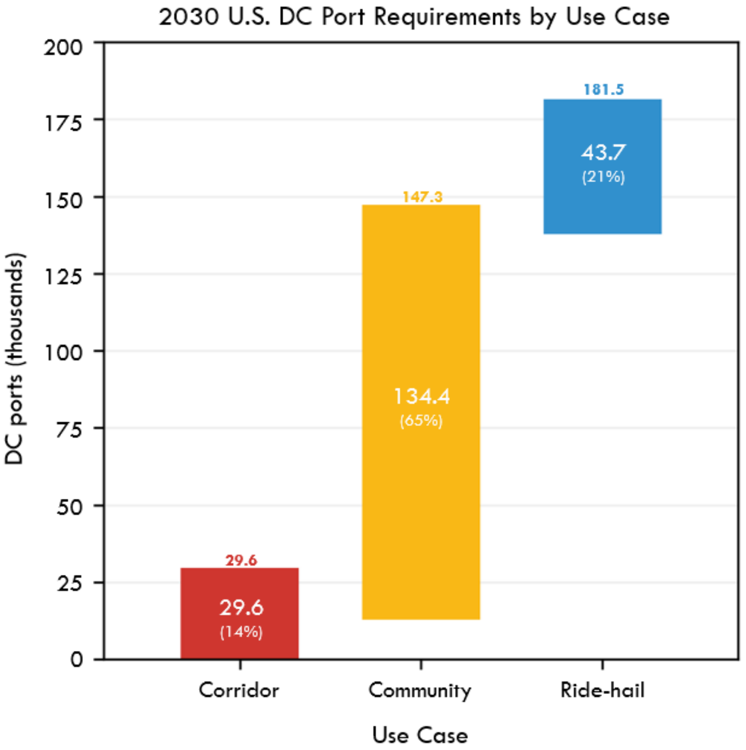


*this study assumes that PHEVs are incapable of DC fast charging

Key Findings (4/5)

The public DC fast charging network will serve multiple use cases:

- The majority (**65%**) of demand is in support of **daily travel (community charging)**, particularly for those without reliable home or workplace charging.
- **21%** of demand from **ride-hail** EVs, a disproportionate share compared to other LDVs.
- **14%** of demand from **long-distance travel (corridor charging)**, though these stations are critical for providing comprehensive national coverage (reducing ”range anxiety”).

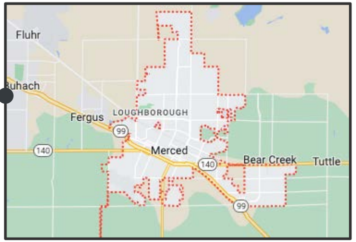


Key Findings (5/5)

The composition of the public charging network will vary regionally.

- Densely populated areas will require significant investments to support those in multi-family homes without a home charger and for ride-hailing electrification.
- More rural areas will require fast charging along highways to support long-distance travel for those passing through (see below).

CBSA	PEVs	DC Ports	DC Ports per 1,000 PEVs
Merced, CA	26,000	349	13.2
Redding, CA	24,000	236	9.7
Bakersfield, CA	83,000	639	7.7
El Paso, TX	50,000	365	7.3
Lafayette, LA	24,000	173	7.2
St. George, UT	27,000	191	7.1
Gainesville, FL	29,000	202	6.9
Duluth, MN	24,000	161	6.8
Green Bay, WI	27,000	177	6.6
Youngstown-Warren-Boardman, OH-PA	31,000	202	6.5
Top 200 CBSAs	**27,621,000**	**110,000**	**4.0**



Google Maps

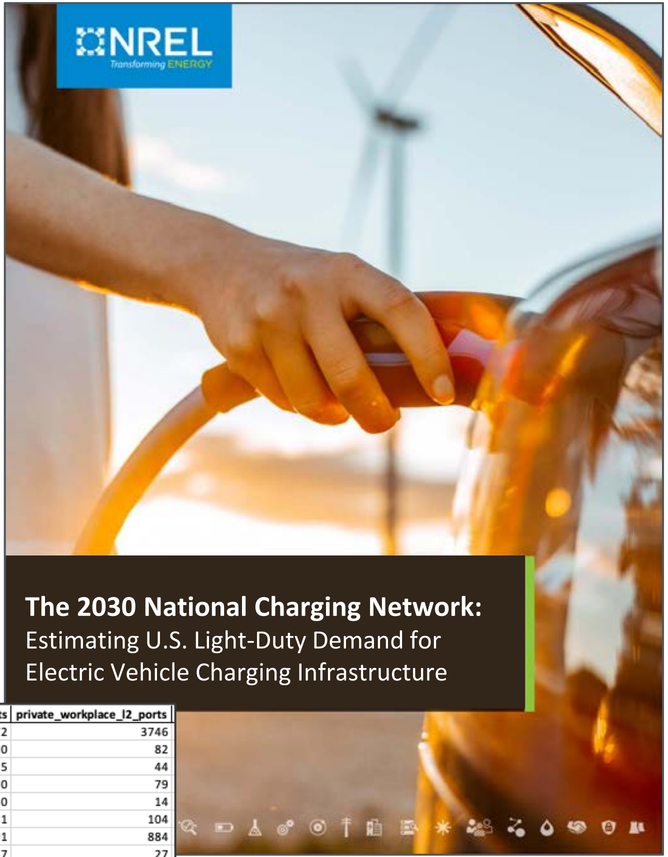
Higher share of charging demand from road-trippers passing through the region

Report Available Now!

https://www.nrel.gov/docs/fy23osti/85654.pdf

Also includes:

- Detailed results and discussion for baseline and 11 sensitivity scenarios.
- **Downloadable** data files containing detailed results (PEVs and port counts) at the state- or CBSA-level for all scenarios (2025 and 2030).



Example data file (2030 baseline – Alabama)

region_type	region_id	region_name	year	pevs	bevs	phevs	private_sfh_l2_ports	private_sfh_l1_ports	private_mud_l2_ports	private_workplace_l2_ports
State	1	Alabama	2030	312143	279339	32804	193417	72854	872	3746
Micropolitan Statistical Area	10700	Albertville, AL Micropolitan Statistical Area	2030	6232	5576	656	3858	1454	0	82
Micropolitan Statistical Area	10760	Alexander City, AL Micropolitan Statistical Area	2030	3390	3028	362	2120	800	5	44
Metropolitan Statistical Area	11500	Anniston-Oxford, AL Metropolitan Statistical Area	2030	6716	6000	716	4204	1586	0	79
Micropolitan Statistical Area	12120	Atmore, AL Micropolitan Statistical Area	2030	1591	1427	164	1011	380	0	14
Metropolitan Statistical Area	12220	Auburn-Opelika, AL Metropolitan Statistical Area	2030	10726	9588	1138	6692	2523	31	104
Metropolitan Statistical Area	13820	Birmingham-Hoover, AL Metropolitan Statistical Area	2030	70337	62978	7359	43589	16404	391	884
Metropolitan Statistical Area	17980	Columbus, GA-AL Metropolitan Statistical Area	2030	2892	2591	301	1779	669	7	27
Micropolitan Statistical Area	18980	Cullman, AL Micropolitan Statistical Area	2030	5618	5039	579	3523	1325	0	69
Metropolitan Statistical Area	19300	Daphne-Fairhope-Foley, AL Metropolitan Statistical Area	2030	20243	18065	2178	12258	4625	150	237
Metropolitan Statistical Area	19460	Decatur, AL Metropolitan Statistical Area	2030	9333	8334	999	5824	2200	16	110
Metropolitan Statistical Area	20020	Dothan, AL Metropolitan Statistical Area	2030	9394	8395	999	5848	2207	6	117
Micropolitan Statistical Area	21460	Enterprise, AL Micropolitan Statistical Area	2030	3698	3308	390	2309	870	0	44
Micropolitan Statistical Area	21640	Eufaula, AL-GA Micropolitan Statistical Area	2030	1165	1038	127	735	278	2	9
Metropolitan Statistical Area	22520	Florence-Muscle Shoals, AL Metropolitan Statistical Area	2030	8935	7992	943	5629	2122	3	97
Micropolitan Statistical Area	22840	Fort Payne, AL Micropolitan Statistical Area	2030	4405	3945	460	2799	1053	0	50

Thank You!

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Photo from iStock-627281636

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