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AB 2127 Electric Vehicle Charging Infrastructure Assessment

Lead Commissioner Workshop
February 4, 2021, 1:00-4:30 p.m.

Opening Remarks

Commissioner Patty Monahan

Introduction

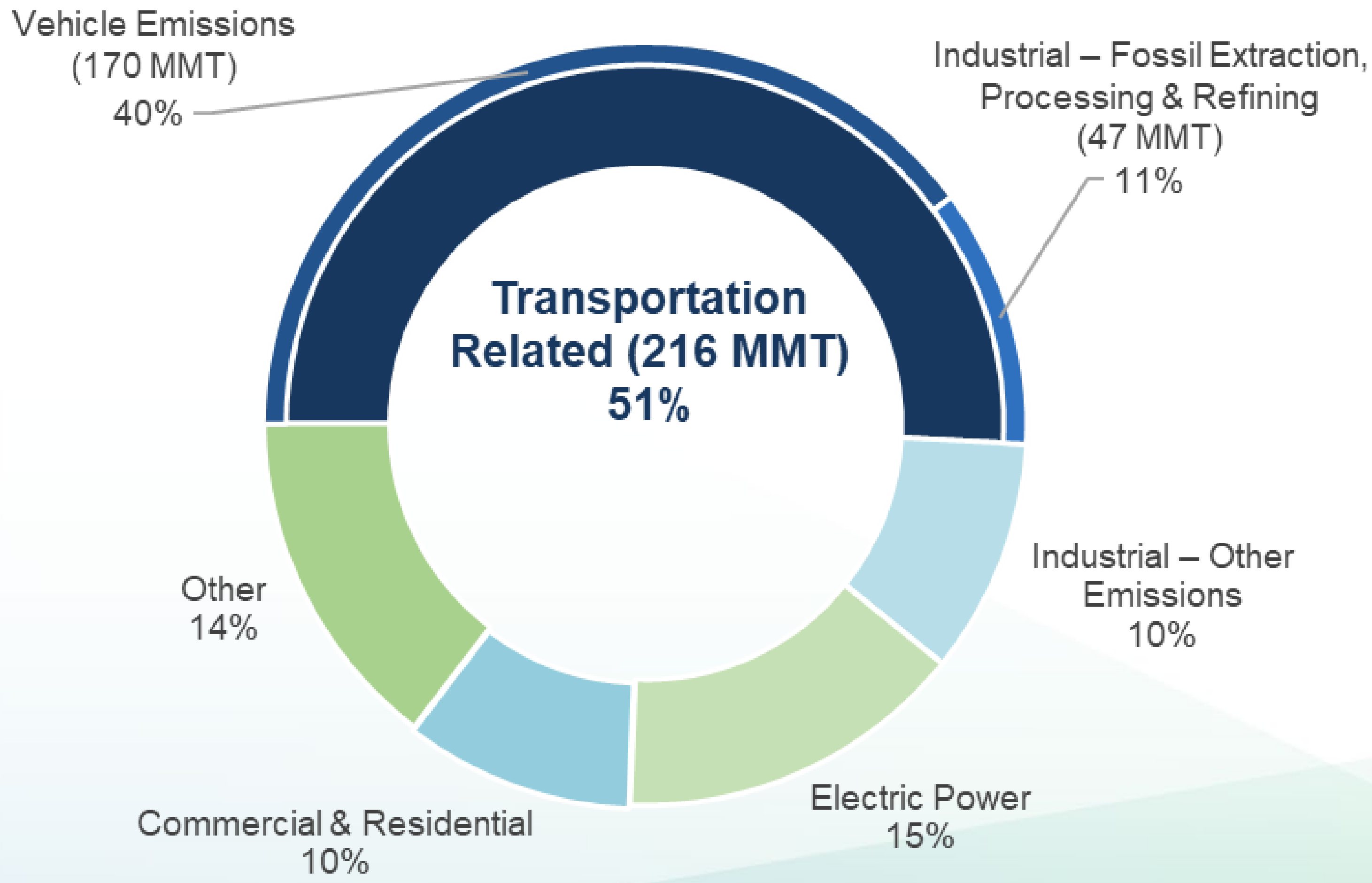
Raja Ramesh

Air Pollution Specialist

Agenda

- 1:00: **Opening Remarks**, Commissioner Patty Monahan
- 1:10: **Introduction**, Raja Ramesh
- 1:25: **Counting Chargers**, Thanh Lopez
- 1:40: **Charger Distribution Analysis (SB 1000)**, Tiffany Hoang
- 1:55: *Break*
- 2:05: **EVI-Pro 2** and **EVI-RoadTrip**, Matt Alexander, followed by **Q&A**
- 3:05: **WIRED**, Alan Jenn, UC Davis, followed by **Q&A**
- 3:35: *Break*
- 3:40 **HEVI-LOAD**, Noel Crisostomo
- 3:55: **Off-Road Charging**, Jeffrey Lu, followed by **Q&A**
- 4:30: **Adjourn**

Transportation Emissions

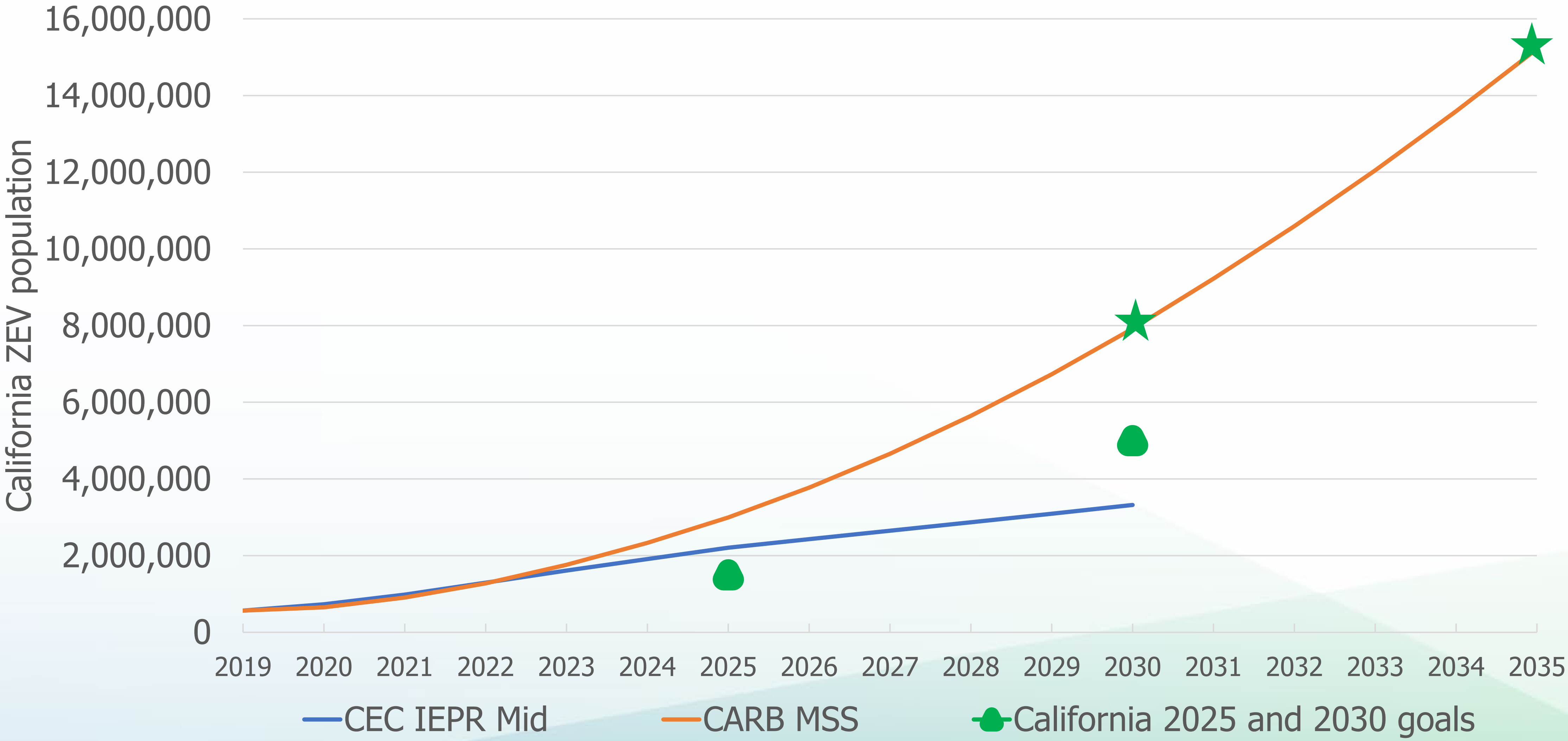


Assessment Goals

Electric vehicle charging infrastructure needed to support:

- Assembly Bill 2127
  - By 2030, at least 5 million zero-emission vehicles (ZEVs)
  - By 2030, reduce greenhouse gas emissions to 40% below 1990 levels
- Executive Order N-79-20
  - By 2035, 100 percent ZEV sales for new passenger vehicles and 100% ZEV operations for drayage trucks and off-road vehicles and equipment
  - By 2045, 100 percent ZEV operations for medium- and heavy-duty vehicles, where feasible

Light-Duty ZEV Trajectories



…Consider All Necessary Charging Infrastructure, Including, but Not Limited to:

	Road and Highway Electrification				Other EVs
Existing Chargers	***Counting Chargers***				
	Including in Low-income Communities ***(SB 1000)***				
Future Chargers	***Electric Vehicle Infrastructure Projections (EVI-Pro 2)***	***Electric Vehicle Infrastructure for Road Trips (EVI-RoadTrip)***	***Widespread Infrastructure for Ride-hailing EV Deployment (WIRED)***	***Medium- and Heavy-Duty EV Infrastructure Load, Operation, and Deployment (HEVI-LOAD)***	***Off-Road, Port and Airport Electrification***

Charging Hardware and Software ***(Equipment Components, Standards, and Interoperability)***

Make-Ready Electrical Equipment ***(Community-Centric Plans, Building Codes, and Grid Evaluation)***

Other Programs to Accelerate the Adoption of Electric Vehicles ***(Incentives, Investments, and Others)***

Actions to Support Widespread Deployment of Charging Infrastructure

1. Continue public support for charger deployment, using public funds to leverage private funds, and eventually transition to a self-sustaining private market.

2. Continue the quantitative modeling efforts to project the quantities, locations, and load curves of chargers needed to meet statewide travel demand, including for MD/HD vehicles.

3. Support innovative charging solutions and financing mechanisms.

4. Support local efforts to prepare for transportation electrification.

5. Ensure equitable distribution of charger deployment throughout the State.

6. Align charging with renewable generation and grid needs.

7. Prioritize standardized charger connectors and communications protocols.

An Evolving Report for a Changing Field

- **January 7, 2021**: Staff Report published (draft for comment)
- **February 4-5**: Workshop on Staff Report and discussion on additional modeling out to 2035
- **Spring**: Revisions and publication of Commission Report (final draft) that will be presented at a Business Meeting
- **Ongoing in 2021**: Staff/Consultant Methodology Reports
  - Four Infrastructure Models
  - Hardware-Software Standardization
  - Off-Road
- **Every two years**: Updated AB 2127 Charging Infrastructure Assessments

A Collaborative Effort

- Contributors from 3 CEC Divisions
  - Significant independent research stemming from a range of efforts
- Analytical expertise from NREL, LBNL, and UC Davis, as well as coordination with Stanford, PNNL, and ANL
- Interagency coordination with CPUC, CARB, Caltrans, SCAQMD

Thanks Also To

- Stakeholders across industry, advocacy, and government
  - IOUs
  - POUs
  - Auto manufacturers
  - Electric vehicle service providers
  - Charger manufacturers
  - Environmental
  - Environmental justice
  - Local jurisdictions
- Especially for participation in our workshops

Thank you! Questions or Comments?

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Webpage:

https://www.energy.ca.gov/programs-and-topics/programs/electric-vehicle-charging-infrastructure-assessment-ab-2127

Counting Chargers

Thanh Lopez
Air Pollution Specialist

Counting Chargers Background

PURPOSE: Aggregated count of public and shared private chargers in California

1) Track progress towards the state's 250,000-charger goal by 2025
2) Inform and improve public and private investment decisions

METHOD:

1) Conduct quarterly surveys
2) Provide information through public-facing Zero-Emission Vehicle and Infrastructure Dashboard

Use Consistent Terminology To Count

CHARGING STATION

A physical address with one or multiple EVSEs.

CONNECTOR

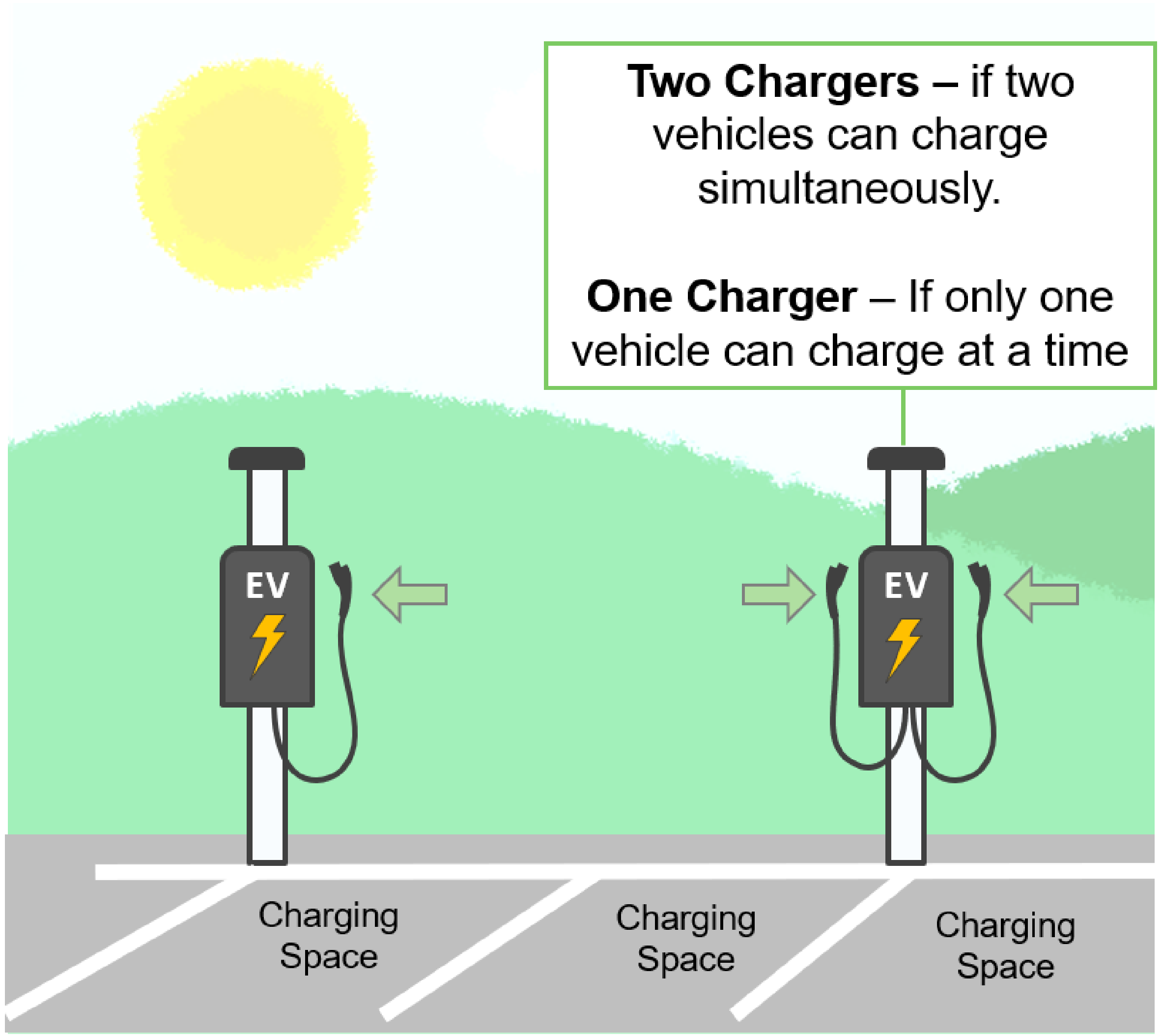
A specific socket or cable assembly available for the electric vehicle to use. A charger may have multiple connectors.

CHARGER = EVSE

The device that controls the power supply to a single electric vehicle in a single session.

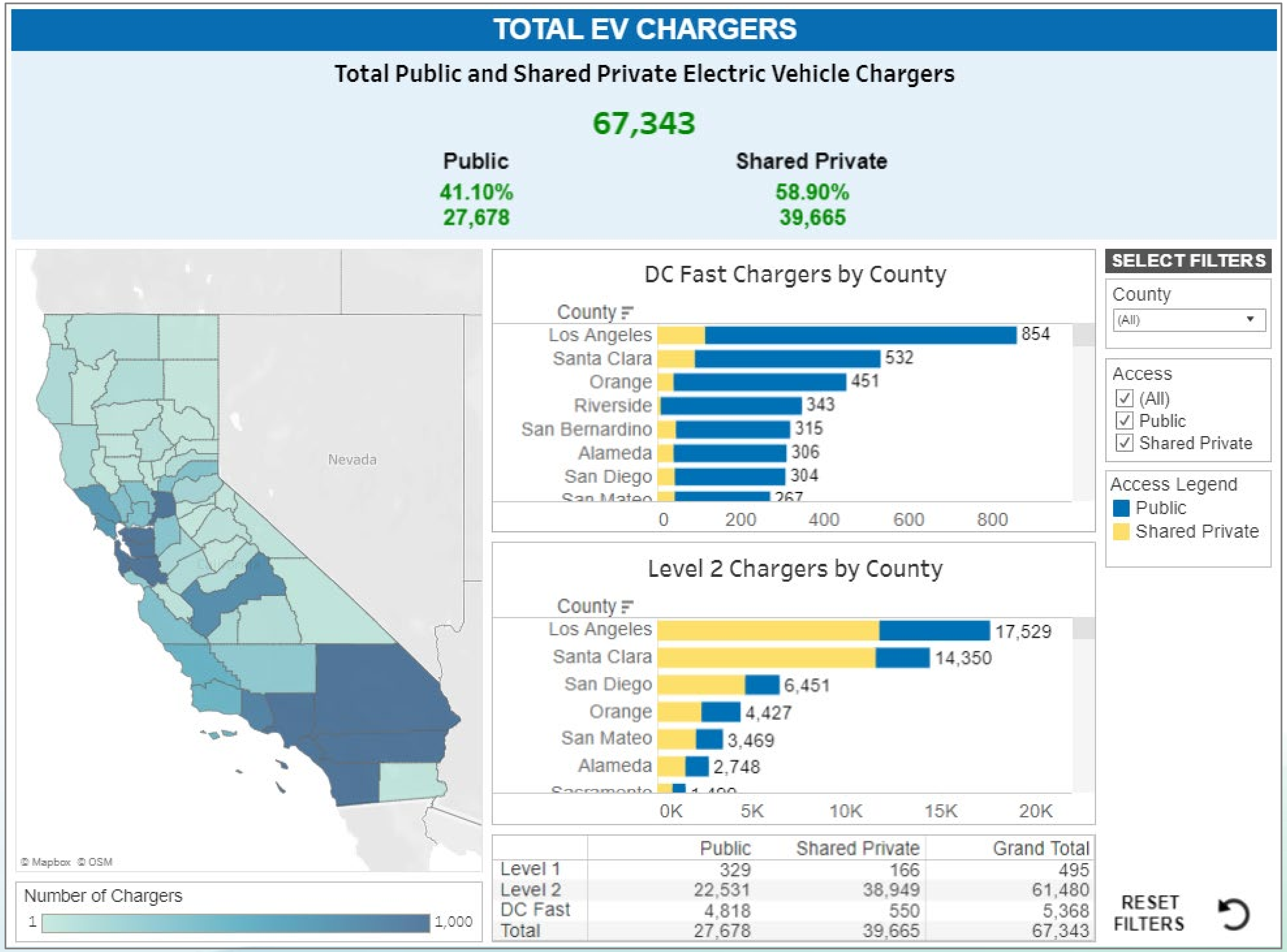
COUNTING CHARGERS

The number of vehicles that can charge at a single charger simultaneously, regardless of the number of connectors.



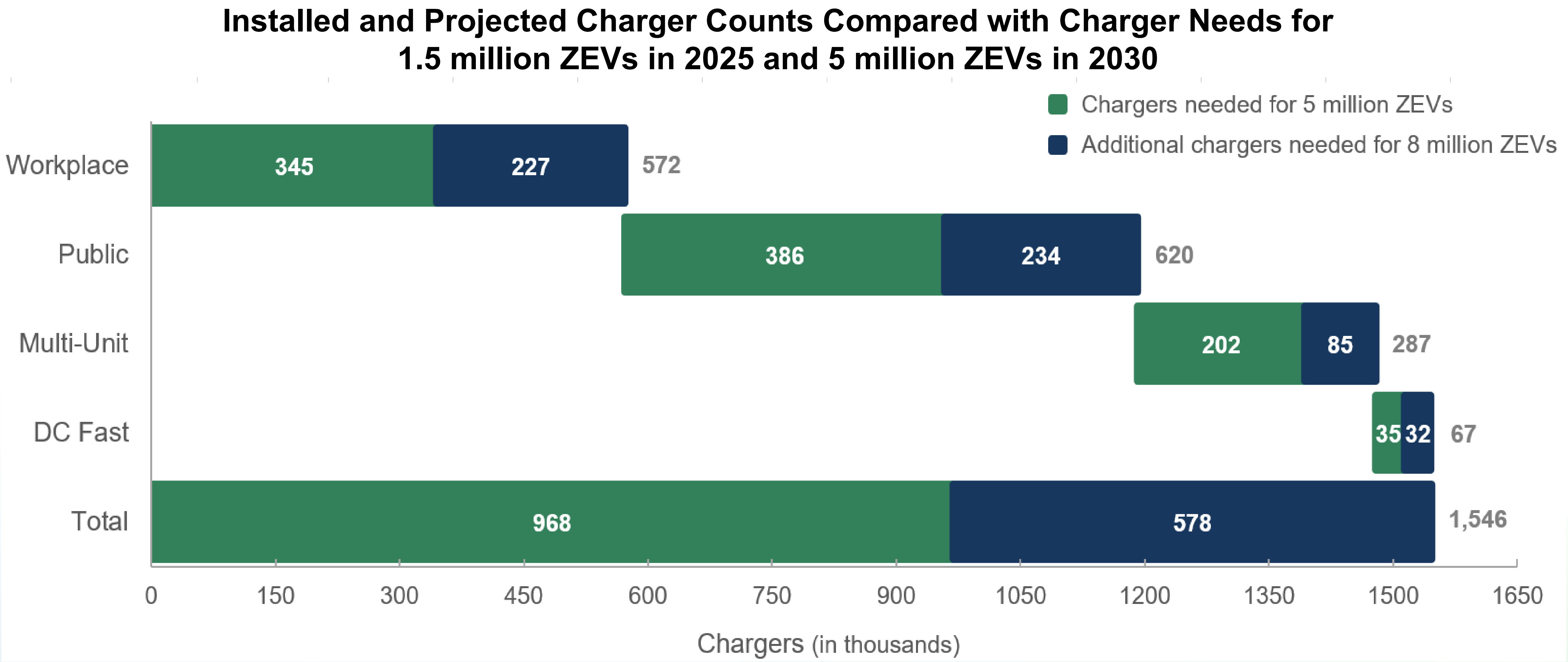
Provide Information on California Chargers

Zero Emission Vehicle & Infrastructure Statistics Dashboard



Source: https://www.energy.ca.gov/zevstats

Analyze Charger Needs, 2025 and 2030



Source: [Assembly Bill 2127 Electric Vehicle Charging Infrastructure Assessment: Analyzing Charging Needs to Support Zero-Emission Vehicles in 2030](#).

Existing Charger Distribution Analysis (SB 1000)

Tiffany Hoang

Air Pollution Specialist

Agenda

- Background on Senate Bill (SB) 1000
- Objectives
- Results
- Next Steps

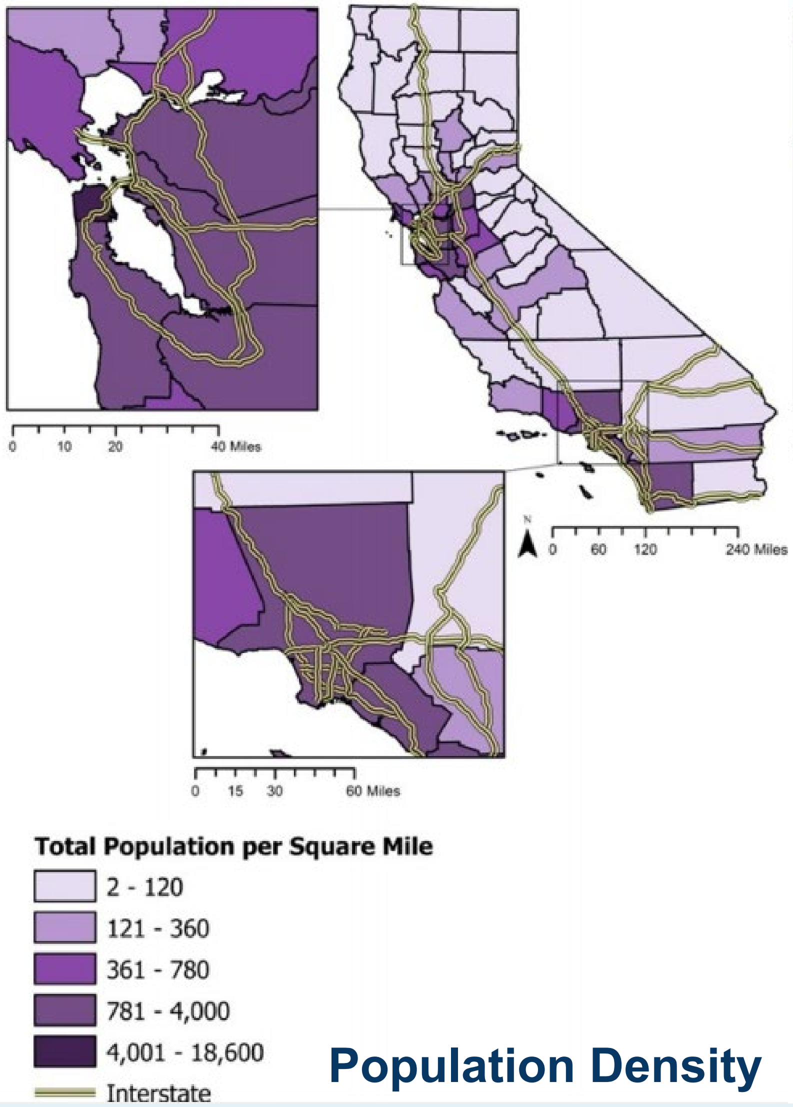
Background

- Are plug-in electric vehicle charging stations disproportionately deployed by population density, geographical area, or population income level?
- Are direct current fast charging stations disproportionately distributed and is access to these charging stations disproportionate?
- Results will inform Clean Transportation Program (CTP) investments
  - 2020 analysis and results are published in a new staff report
  - Future analyses will inform CTP Investment Plan Updates

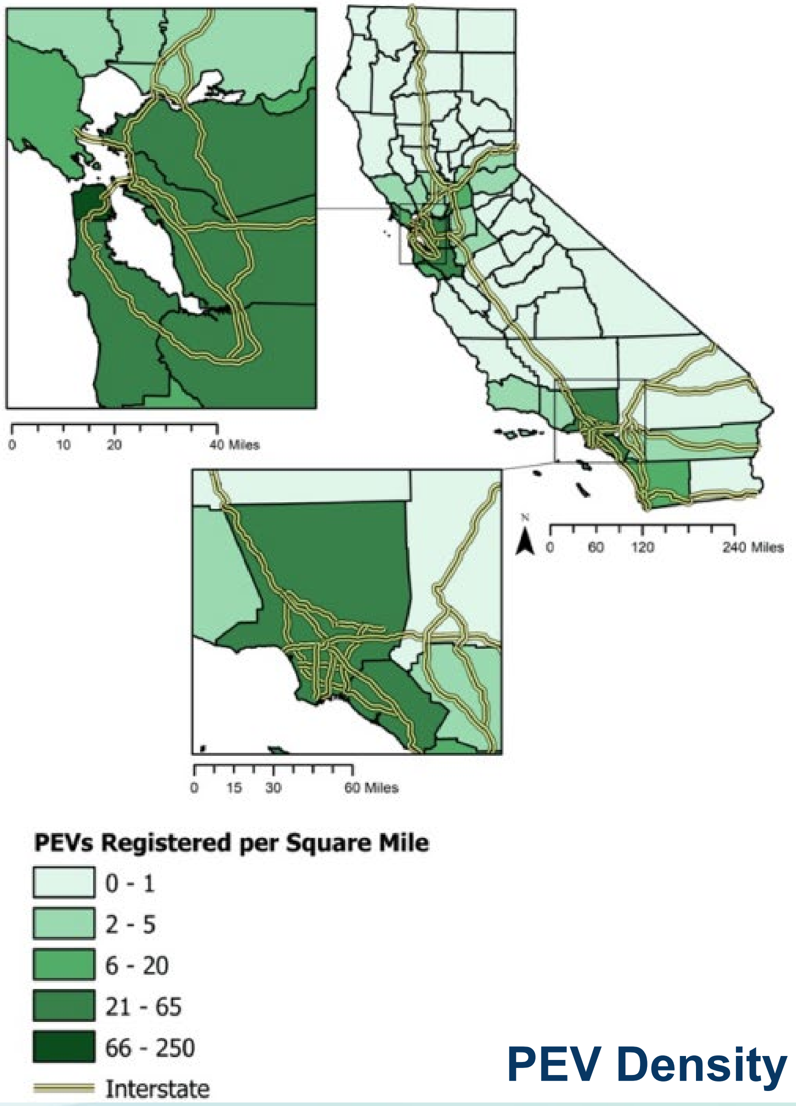
2020 Objectives

- Define income levels, population density, and geographical area
- Evaluate statewide public charger numbers by location and population characteristics
- Begin to investigate factors that influence location of public charging

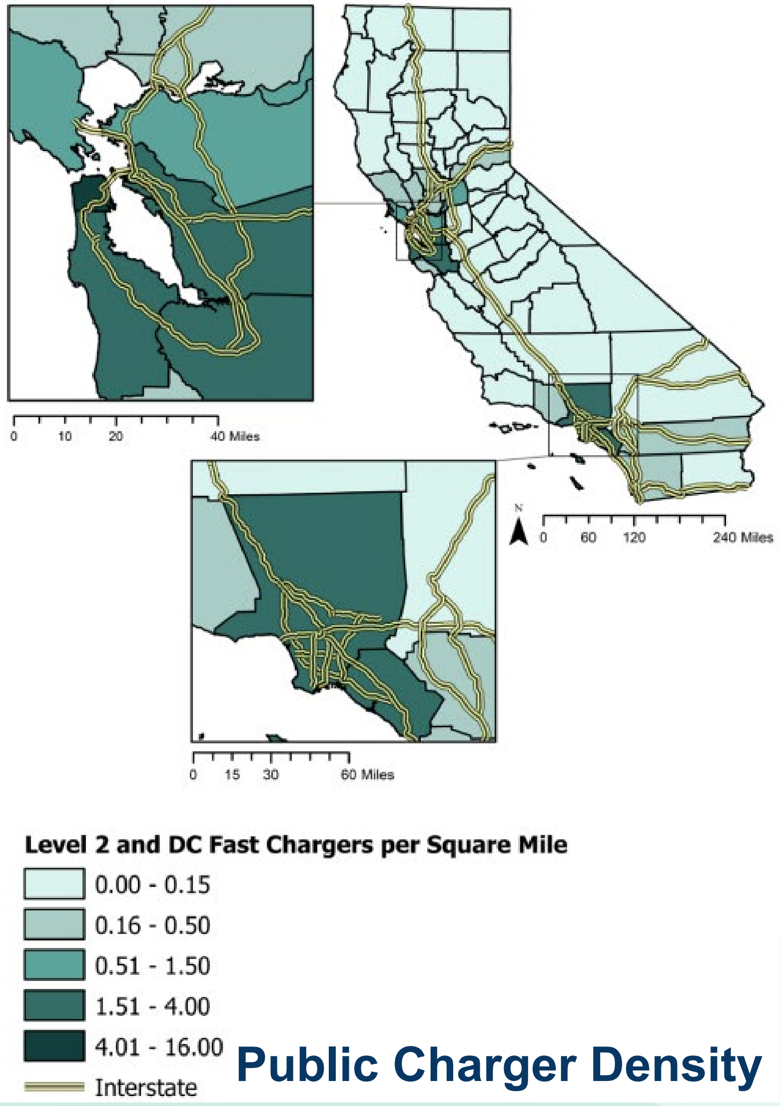
Geographic Distribution Results



Population Density



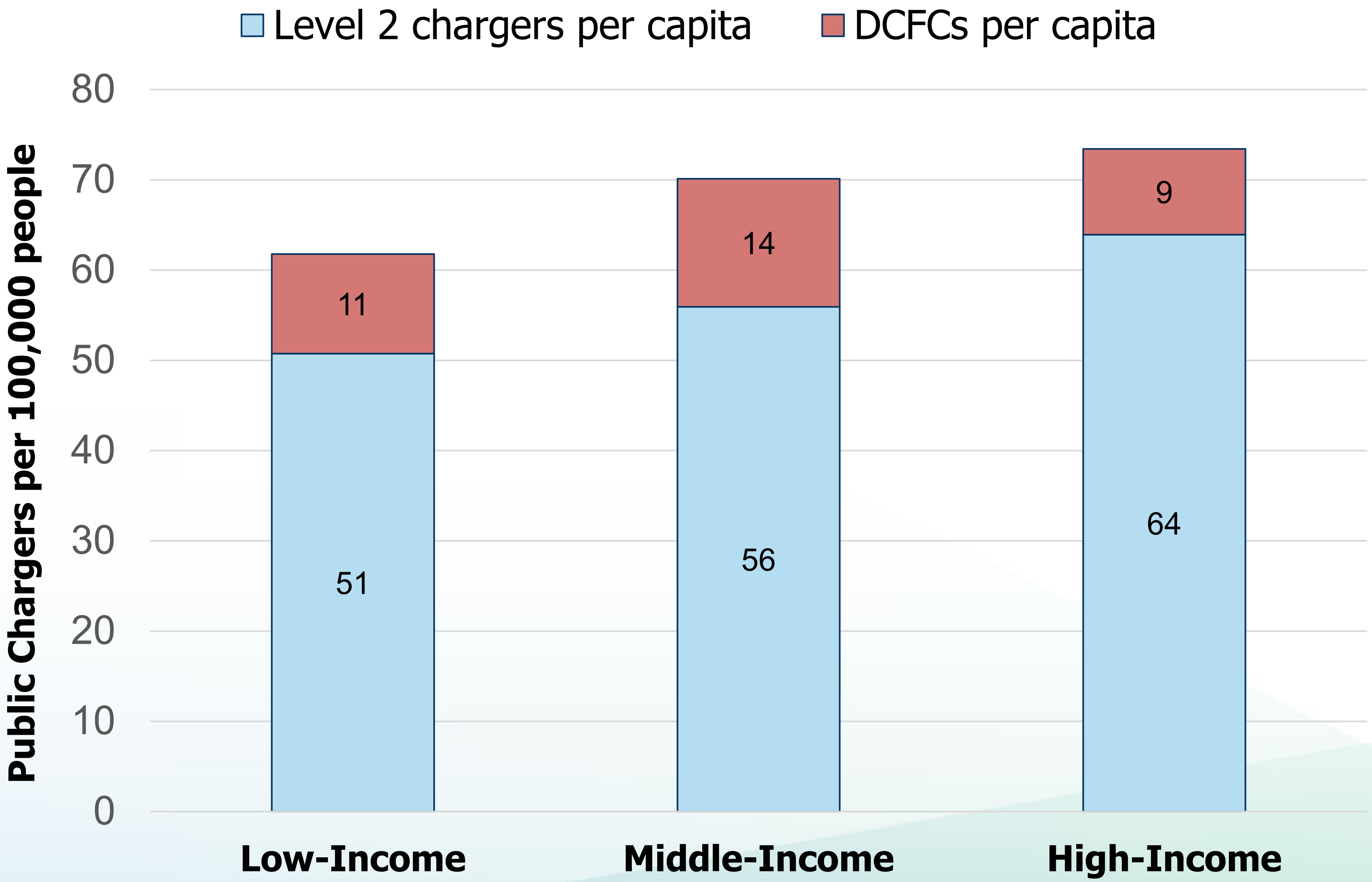
PEV Density



Public Charger Density

Sources: U.S. Census Bureau 2014 – 2018 American Community Survey Total Population 5-Year Estimates, California Department of Motor Vehicles registration statistics as of October 2018, and U.S. Department of Energy's Alternative Fuels Data Center Station Locator data as of July 23,2020.

Income Distribution Results



Sources: U.S. Census Bureau 2014 – 2018 American Community Survey Median Household Income 5-Year Estimates and U.S. Department of Energy's Alternative Fuels Data Center Station Locator data as of July 23,2020.

Identification of Low-, Middle-, and High-Income Communities

Low-Income Communities:

- 120% State Median Income
- State Median Income
- 80% State Median Income

OR

- HCD Moderate-Income Limit
- HCD Low-Income Limit

Middle-Income Communities:

- 120% State Median Income
- State Median Income
- 80% State Median Income

OR

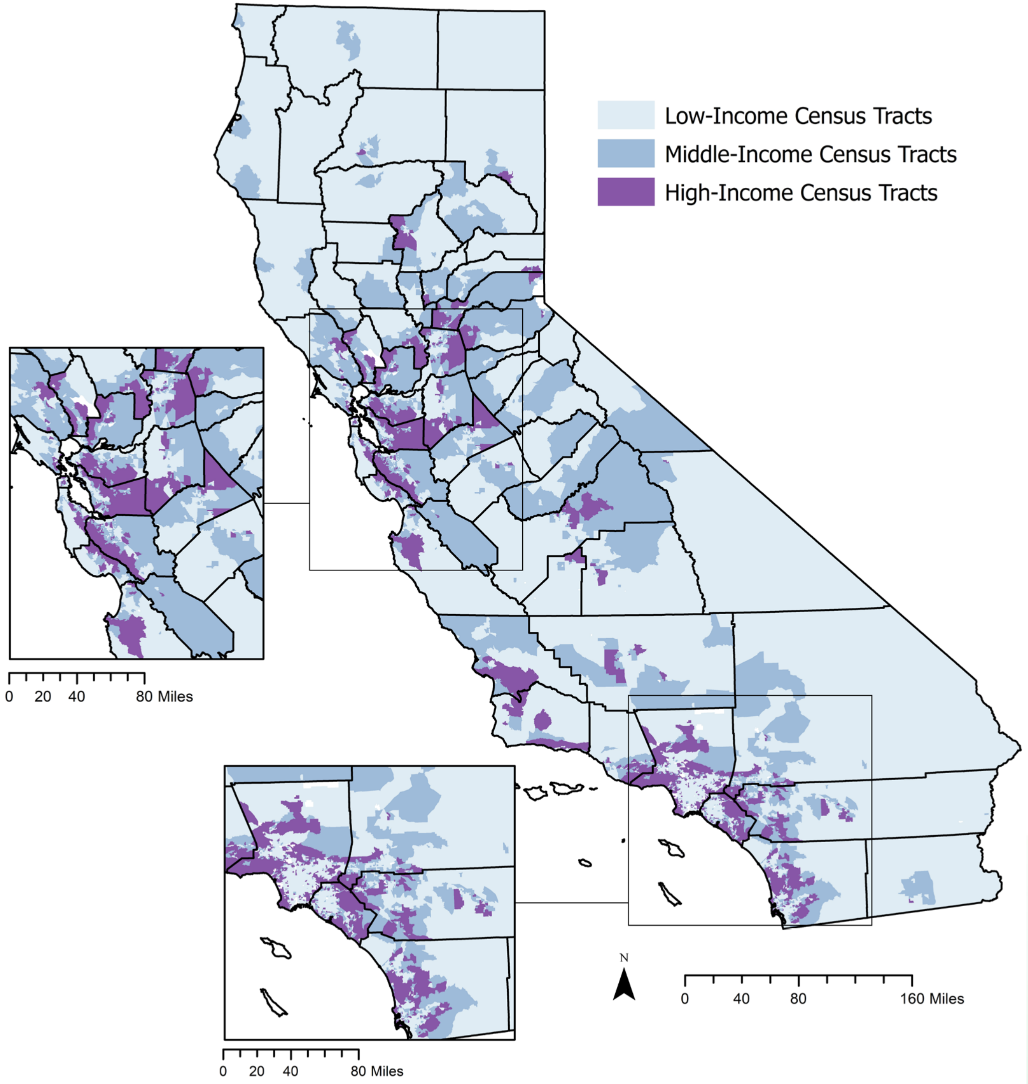
- HCD Moderate-Income Limit
- HCD Low-Income Limit

High-Income Communities:

- 120% State Median Income
- State Median Income
- 80% State Median Income

OR

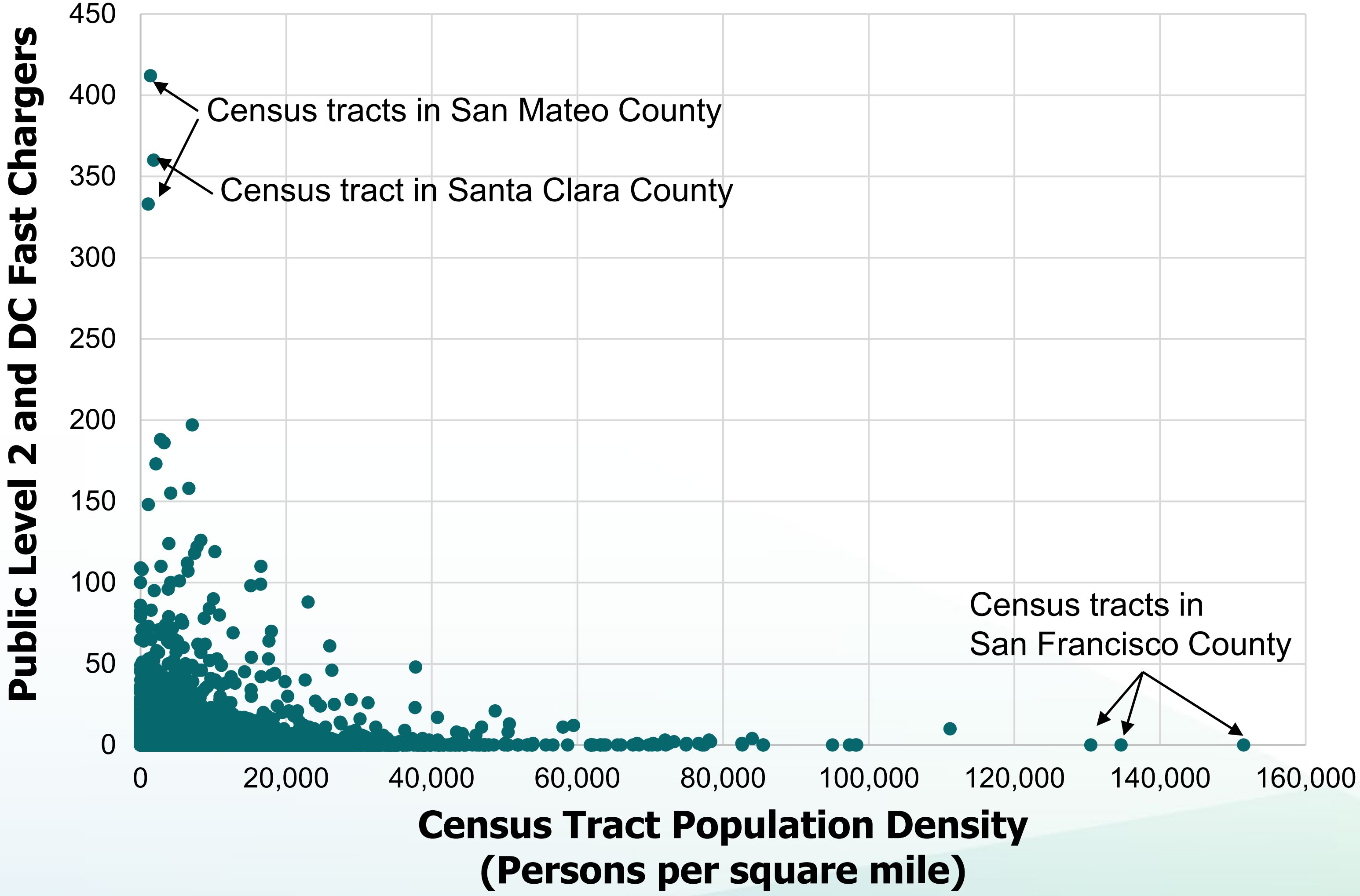
- HCD Moderate-Income Limit
- HCD Low-Income Limit



The California Department of Housing and Community Development (HCD) establishes state income limits for each county by household size

Sources: U.S. Census Bureau 2014 – 2018 American Community Survey Median Household Income 5-Year Estimates and HCD 2020 State Income Limits

Population Distribution Results



Sources: U.S. Census Bureau 2014 – 2018 American Community Survey Total Population 5-Year Estimates and U.S. Department of Energy's Alternative Fuels Data Center Station Locator data as of July 23,2020.

Next Steps

- Expand analysis to urban and rural areas, dwelling types, and combinations of these
- Evaluate public charging access beyond charger numbers and location
- Identify communities with low public charging access and provide information on opportunities for deployment

Break

Return at 2:05

EVI-Pro 2

Matt Alexander
Air Pollution Specialist

What is EVI-Pro?

Simulation model to:

1) Estimate charging demand from light-duty PEVs (GVWM < 10,000 lbs) for **intra-regional travel**
2) Design supply of residential, workplace, and public charging infrastructure capable of meeting demand

Key outputs:

1) Number, type, and location of chargers required to meet charging demand
2) Load profiles associated with charging demand

EVI-Pro 2 Updates

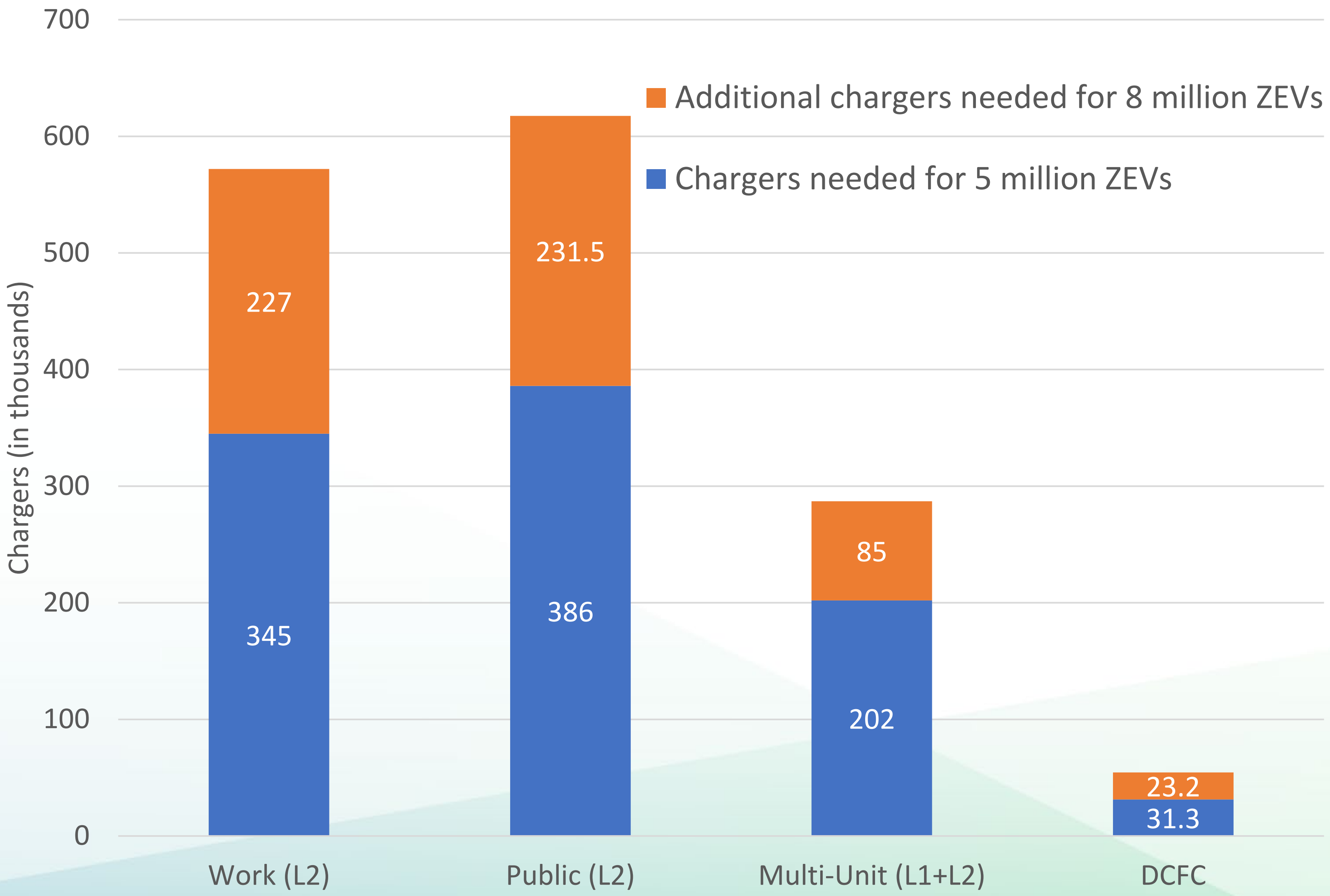
	EVI-Pro 1 (in 2025)	EVI-Pro 2 (in 2030)
ZEV Population	1.5 million in 2025	2M, 5M, and 8M scenarios
PEV / Hydrogen Fuel Cell Electric Vehicle Split	87/13% in 2025	Shift towards more PEVs
Within PEVs, PHEV / BEV Split	45/55% in 2025	Shift towards more BEVs
Charging Behavior Objective	Maximize electric miles traveled	Mirror observed behavior
PEVs w/ Home Charging	92%	Decrease with larger fleet size based on survey data
Time-of-Use Rate Participation	Not included	Included
Infrastructure Utilization	Assumed	Observed
Travel Data	2012 CHTS	2012 CHTS + 2017 NHTS

EVI-Pro 2 Scenarios

	Core Forecast Scenarios		
Values for Year 2030	**Low**	**Baseline**	**High**
ZEV Population	1.9 million	5.0 million	7.9 million
PEV / Hydrogen Fuel Cell Electric Vehicle Split	95/5%	96/4%	95/5%
Within PEVs, PHEV / BEV Split	38/62%	30/70%	30/70%
PEVs w/ Home Charging	81%	72%	67%
Time-of-Use Rate Participation	67%	67%	67%

2030 Network Results

- About **1 million** chargers needed to support **5 million ZEVs**
- Over **1.5 million chargers** needed to support **8 million ZEVs**
- Does not include residential chargers at single-family homes

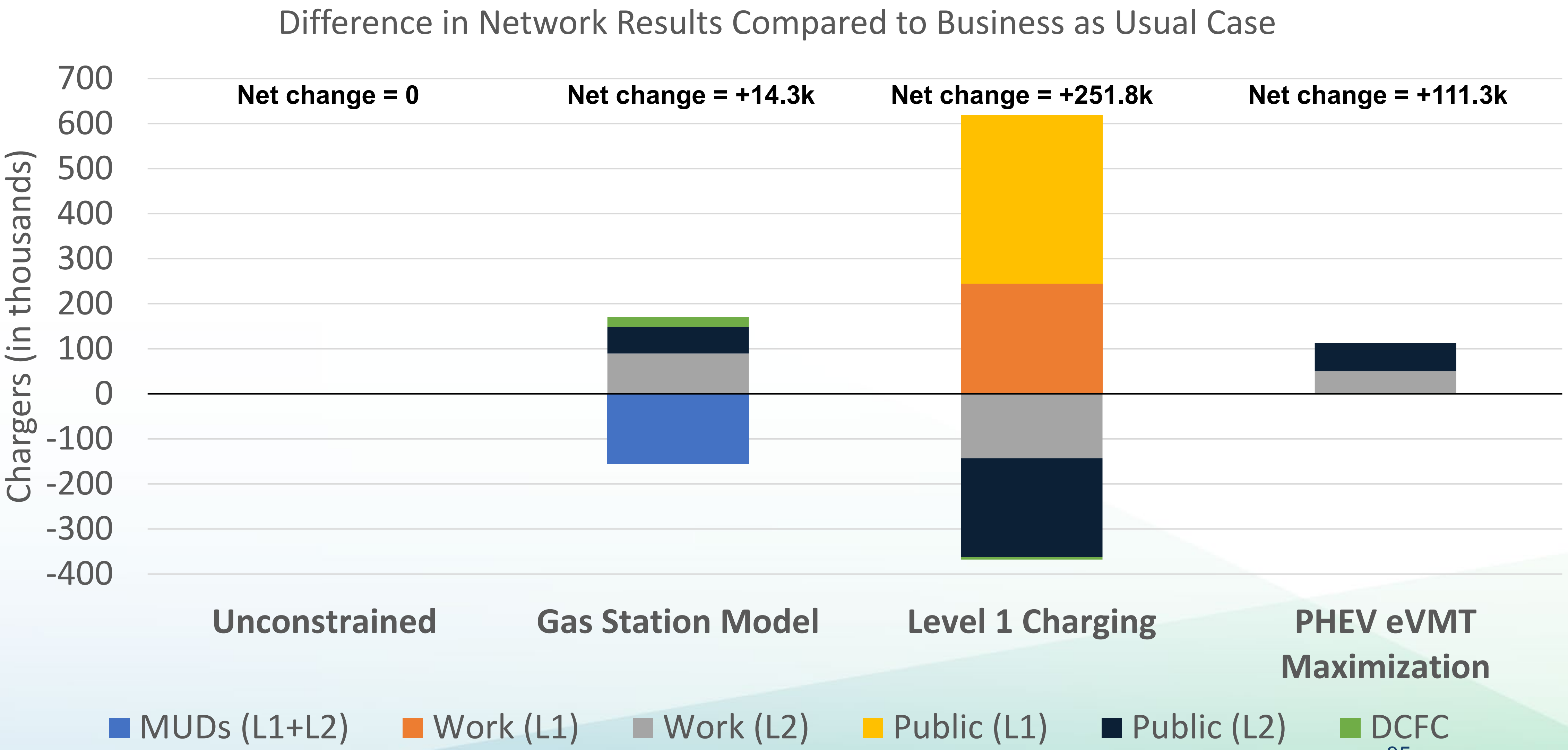


Alternative Futures Scenarios

Illustrate potential futures given the uncertainty of how the electric transportation landscape may evolve in the next decade.

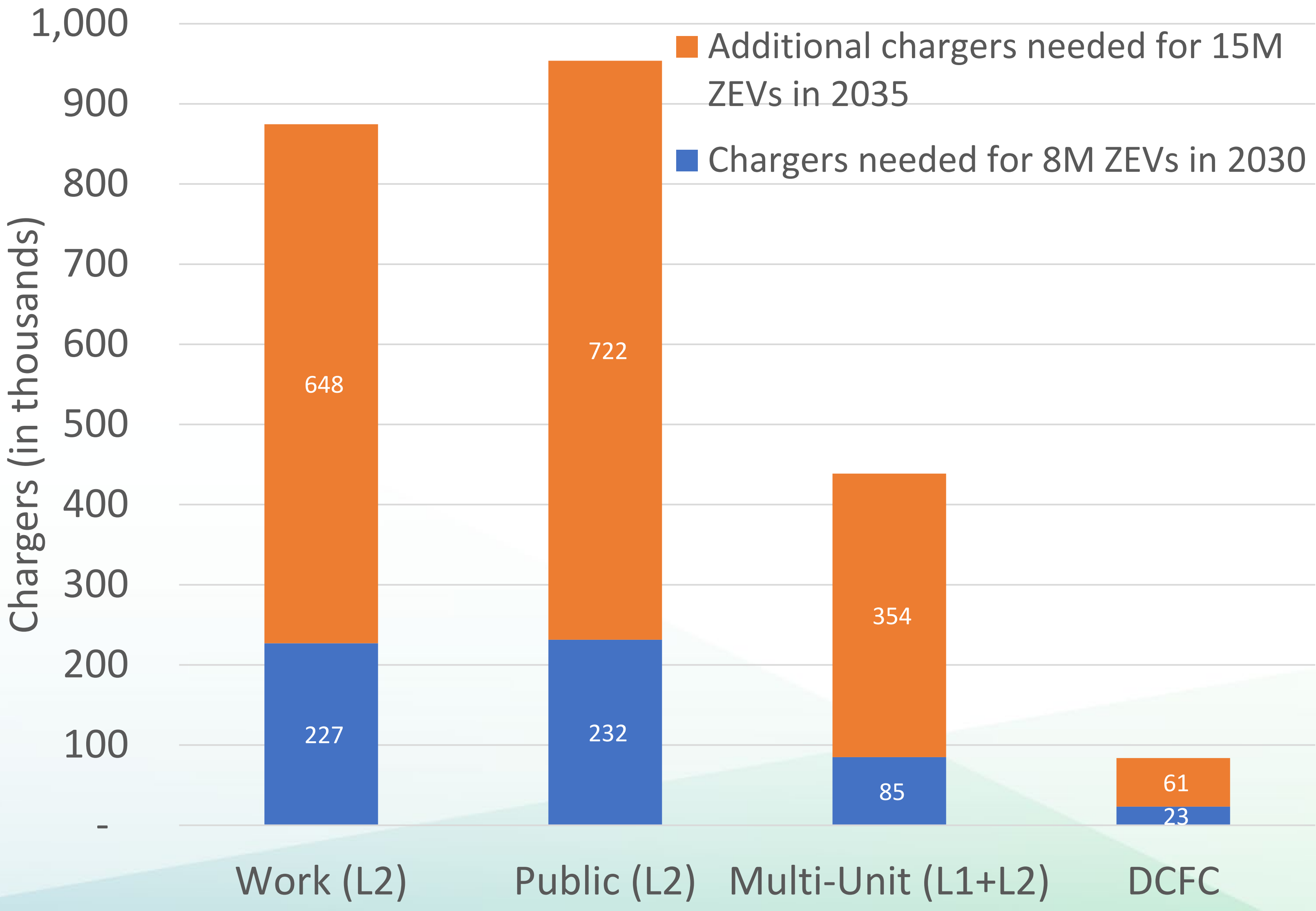
	Core Forecast Scenarios		
Values for Year 2030	**Low (1.9M ZEVs)**	**Baseline (5M ZEVs)**	**High (7.9M ZEVs)**
Business as Usual	~375k chargers	~1M chargers	~1.5M chargers
Unconstrained *No TOU Participation*	N/A	~1M chargers	N/A
Gas Station Model *40% w/ residential access*	N/A	~1M + **14.3k chargers**	N/A
Level 1 Charging *Enabled at work & public*	N/A	~1M + **251.8k chargers**	N/A
PHEV eVMT Maximization *Charge at every stop*	N/A	~1M + **111.3k chargers**	N/A

Alternative Future Network Results



Preliminary 2035 Network Results

- **1.5M** chargers needed to support **8M ZEVs in 2030**
- **2.3M** chargers needed to support **15M ZEVs in 2035**
- Does not include residential chargers at single-family homes



Implications

- For intra-regional light-duty travel demand:
  - 5 million ZEVs in 2030 require about 1 million chargers
  - 8 million ZEVs in 2030 require over 1.5 million chargers
  - 15 million ZEVs in 2035 require over 2.3 million chargers

- Gap of more than 750,000 chargers to meet 5M ZEV infrastructure needs

- Charger counts are one metric, but do not tell the whole story. We need to continually evaluate infrastructure needs as the market evolves.

Next Steps and Future Work

- Continued refinement of EVI-Pro 2 and results for final AB 2127 publication
  - Tweaking inputs, assumptions, and methodologies
  - Results broken down to at least the county level
  - Results for all years from 2020-2030, and preliminary 2035 results
- Standalone EVI-Pro 2 report
  - Detailed methodology, analysis, and results including sensitivities
- EVI-Pro 3!

EVI-RoadTrip

Matt Alexander

Air Pollution Specialist

What is EVI-RoadTrip?

Simulation model to:

1) Estimate charging demand from light-duty BEVs (GVWR < 10,000 lbs) for long-distance **inter-regional travel** over 100 miles
2) Design supply of DC fast charging infrastructure capable of meeting this demand

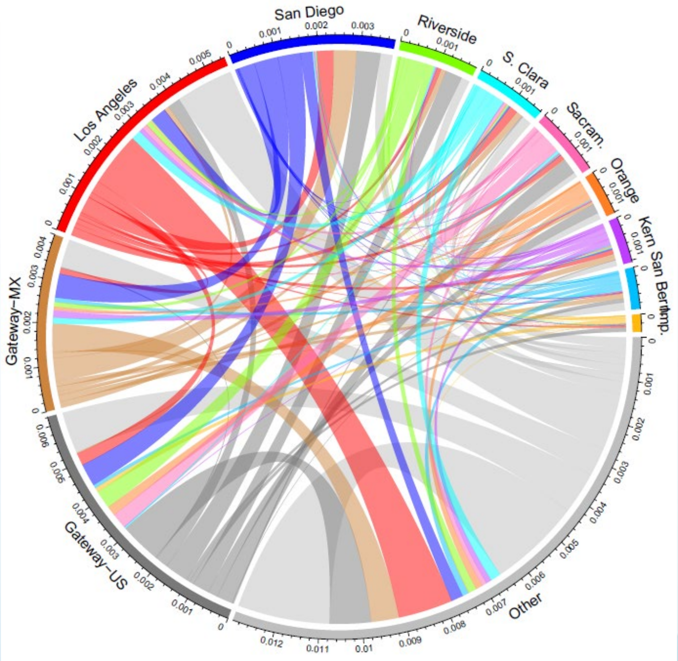
Key outputs:

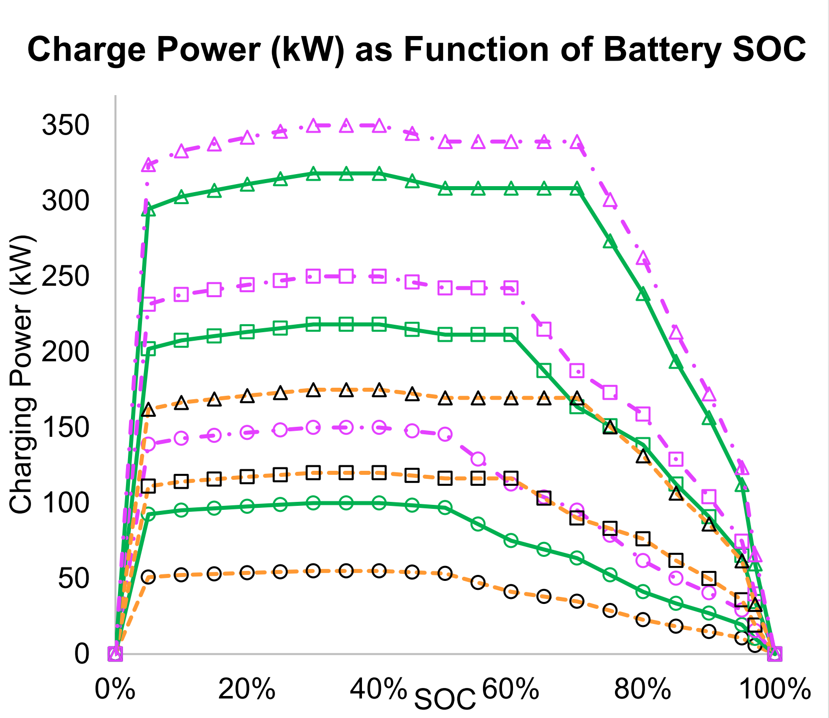
1) Number, type, and location of DCFC chargers and stations required to meet demand
2) Load profiles associated with charging demand
3) Potential grid impacts (case study)

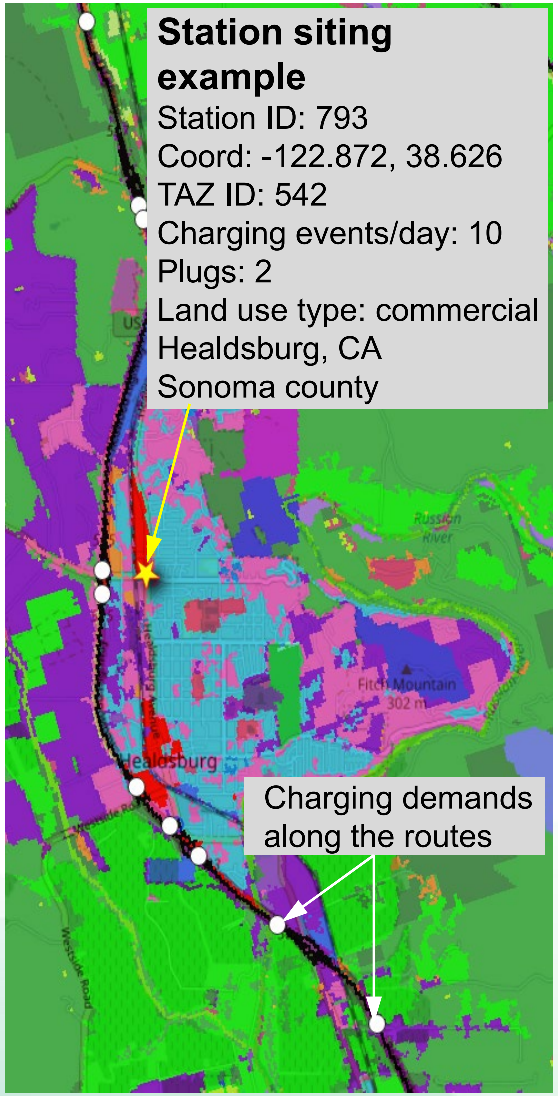
Methodology and Key Inputs

4 Step Model:

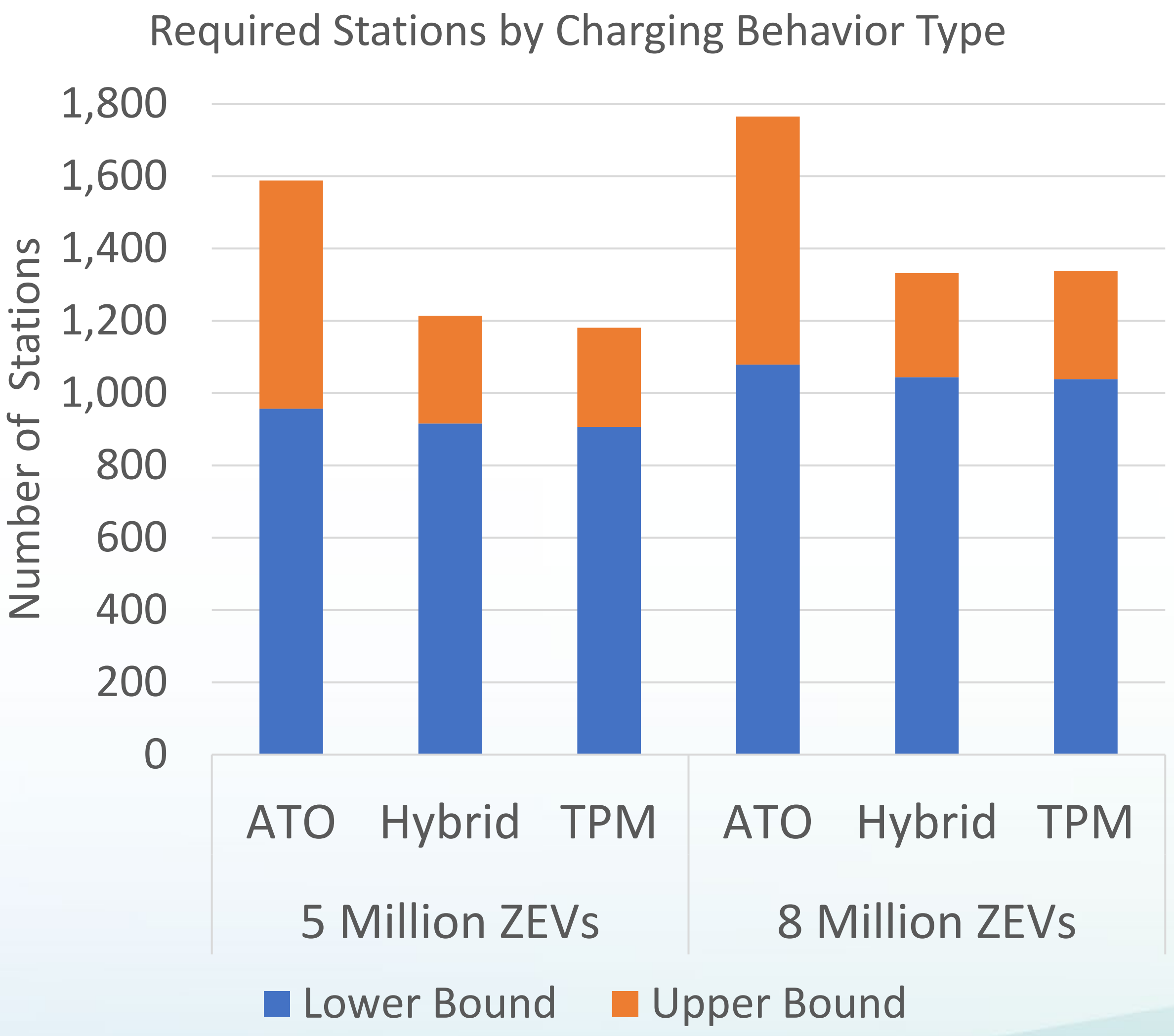
1) Road Trip Volume and Pattern
2) BEV Energy Use and Charging Simulation
3) Station Design (siting and sizing)
4) Capacity Analysis

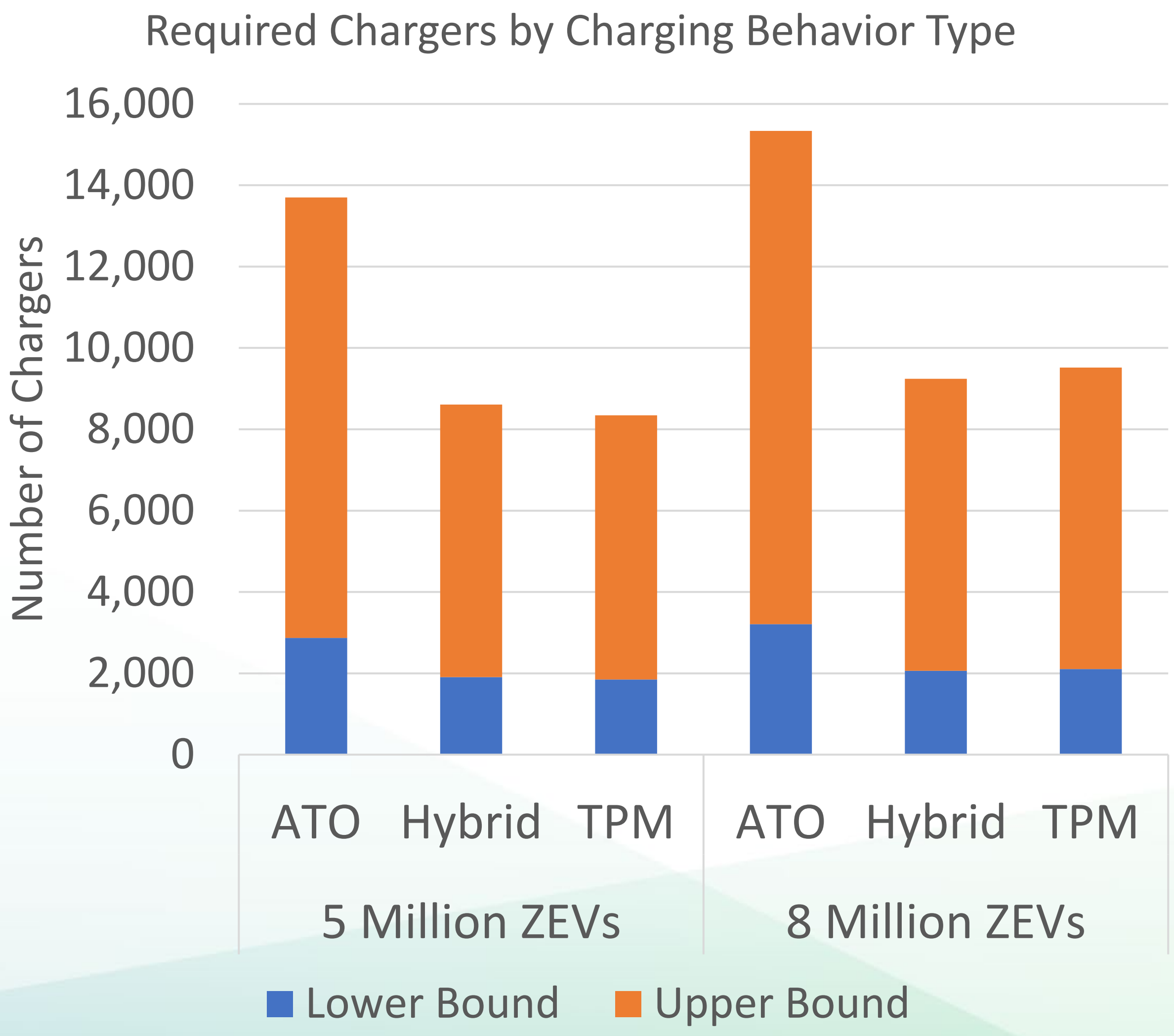






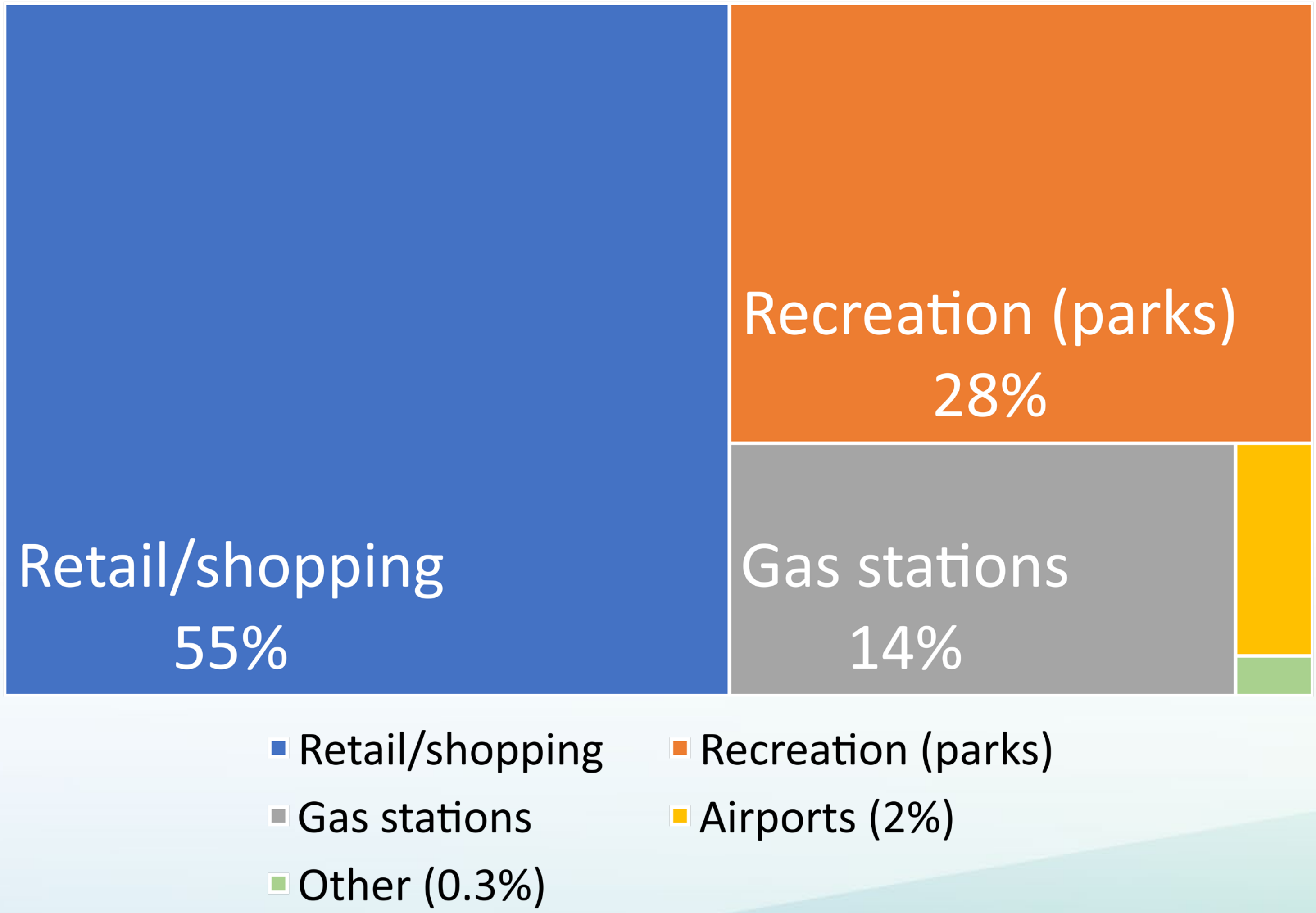
2030 Network Results



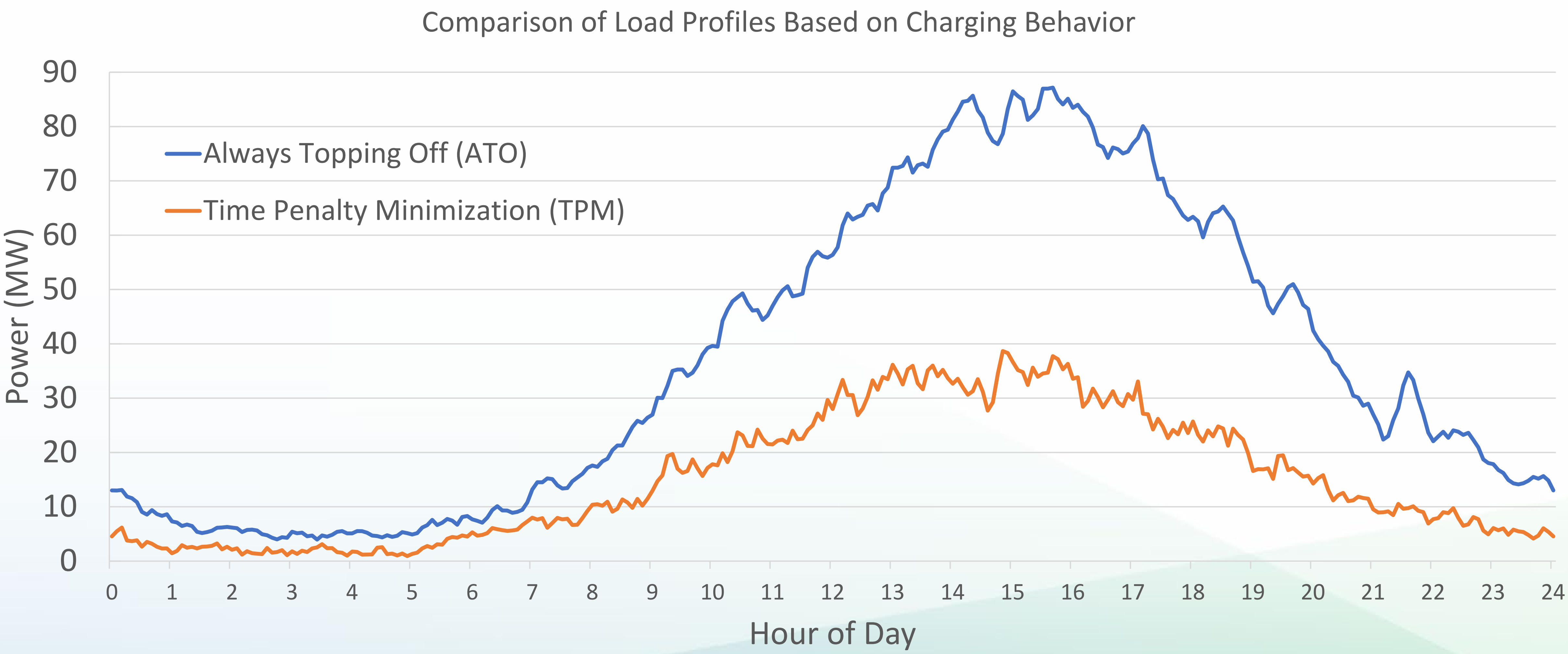


Station Locations

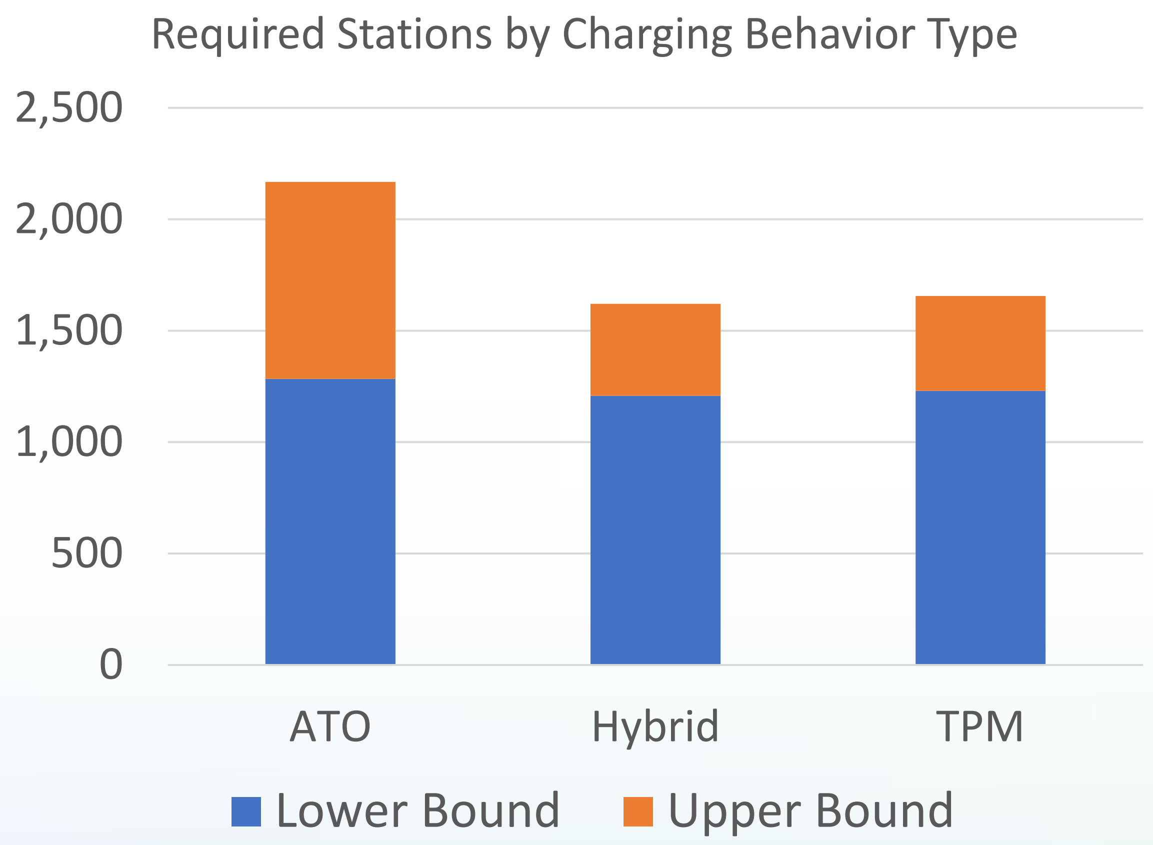
DCFC Stations by Land Use Type

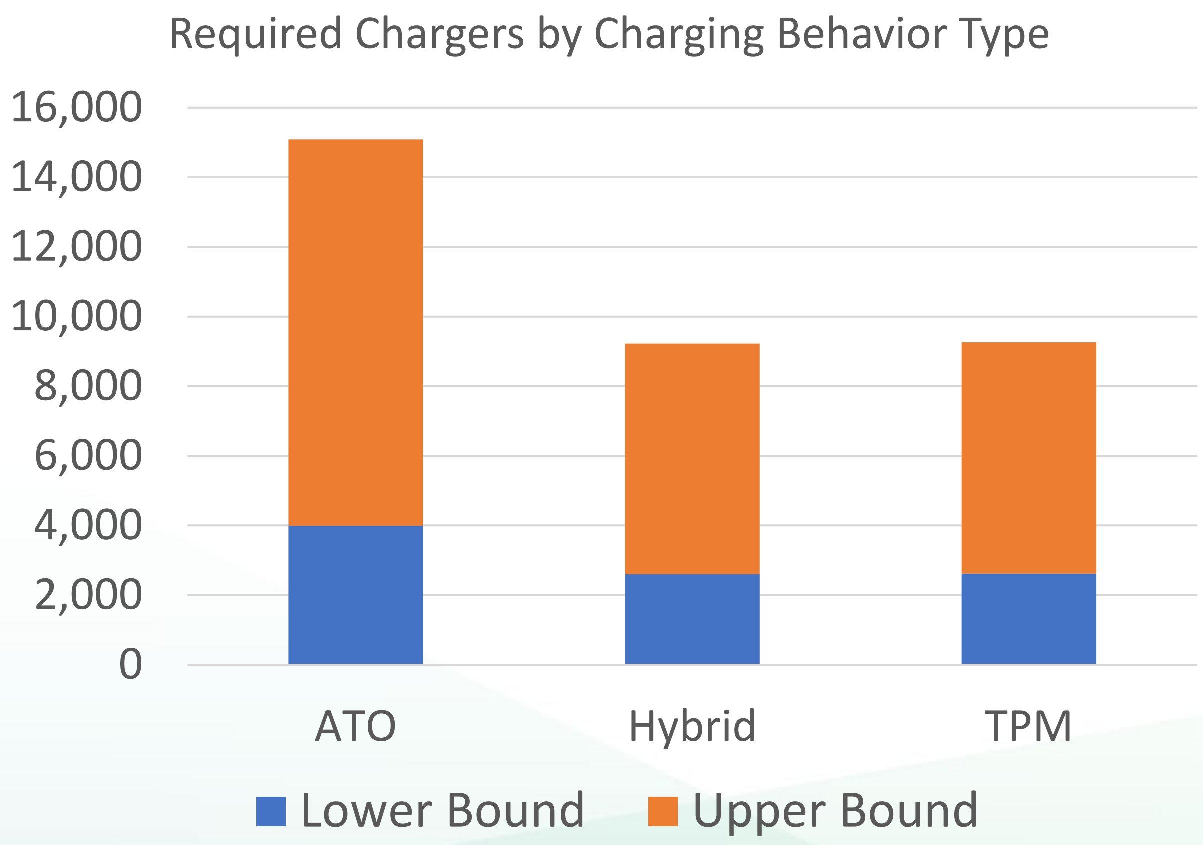


2030 Load Profiles

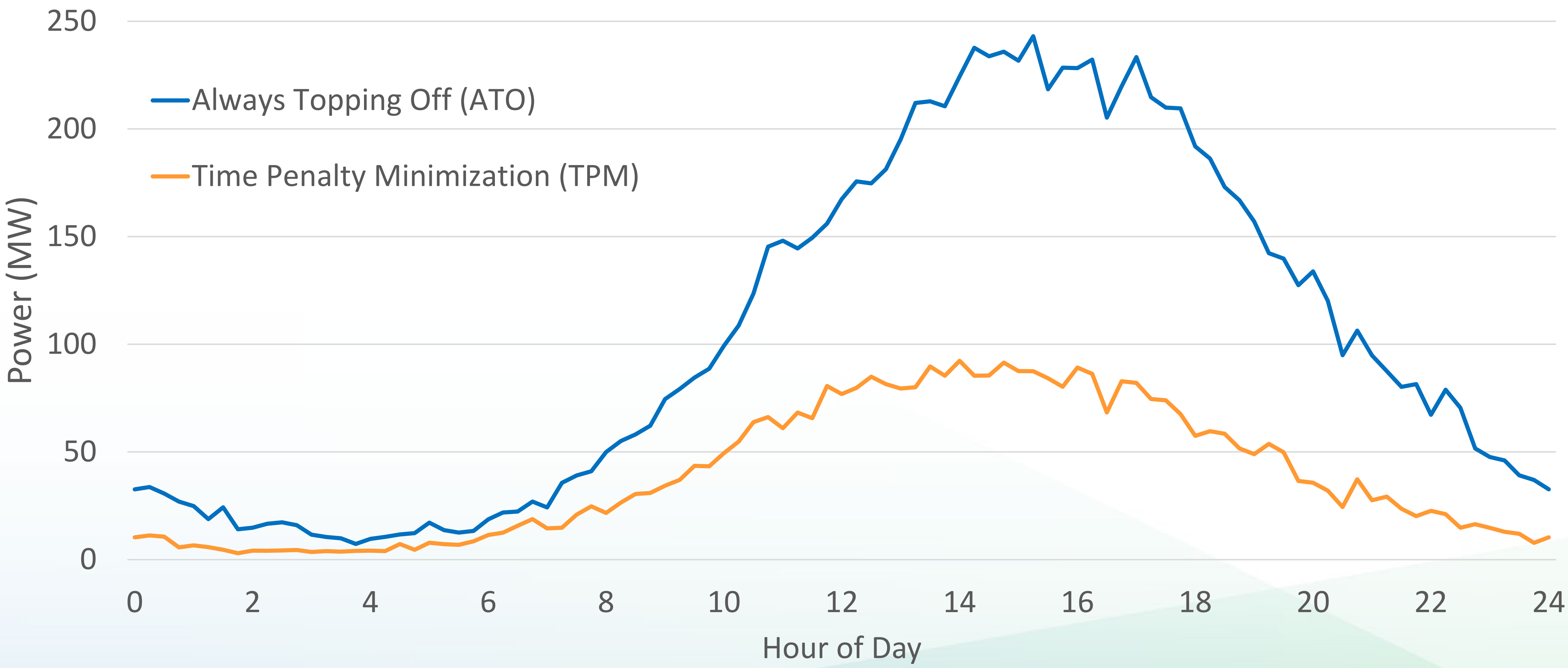


Preliminary 2035 Network Results

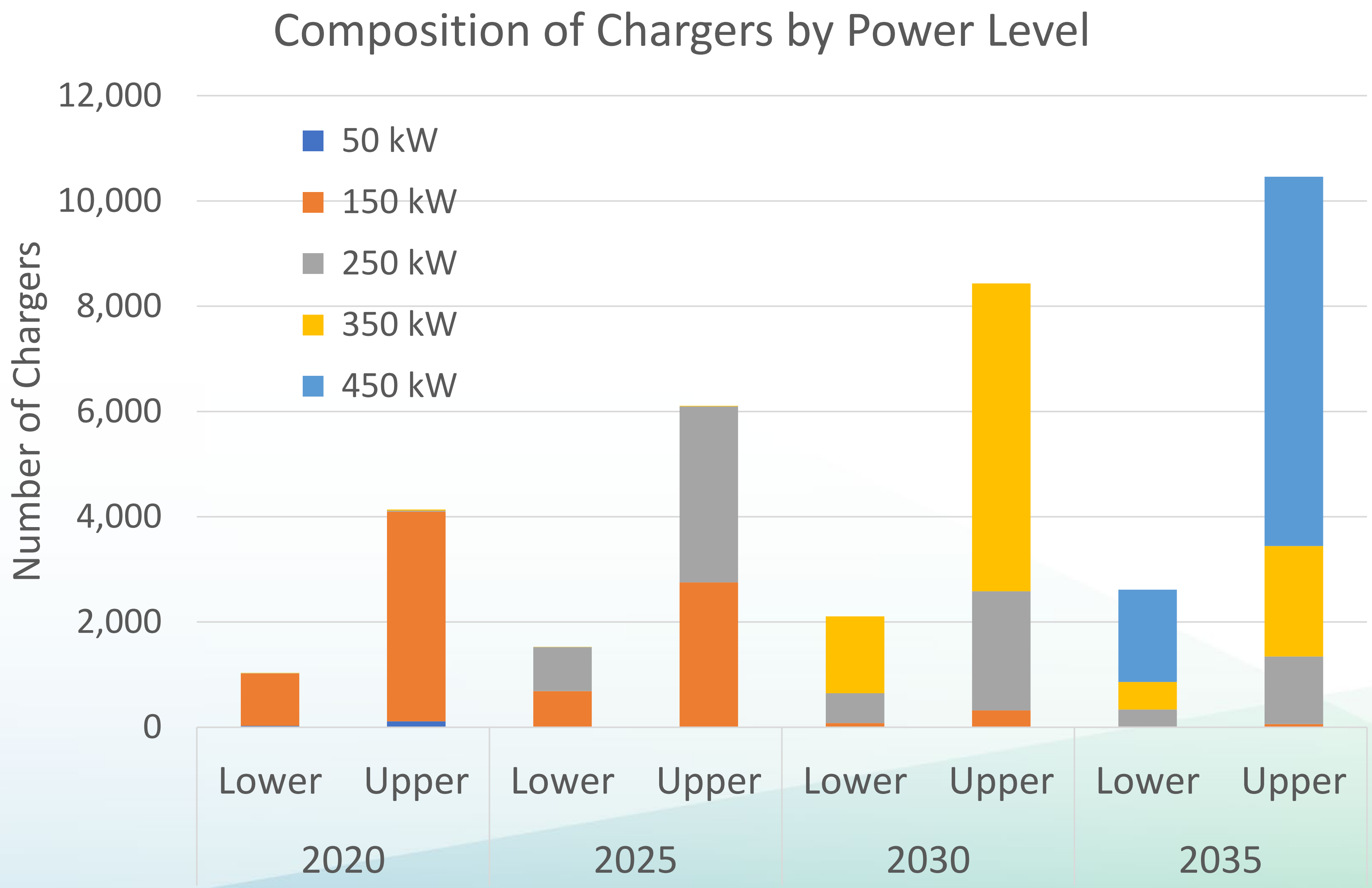




Preliminary 2035 Load Profile



Moderation of Chargers over Time



Implications

- For BEV inter-regional travel demand (100+ miles):
  - 5 million ZEVs in 2030 require average of 1,044 DCFC stations and 4,173 chargers
  - 8 million ZEVs in 2030 require average of 1,189 DCFC stations and 4,758 chargers
  - 15 million ZEVs in 2035 require average of 1,443 DCFC stations and 5,939 chargers

- Technology improvements will moderate growth in number of stations and plugs in the future, highlighting the importance of future proofing and connector interoperability today

- Inter-state collaboration is needed

Next Steps and Future Work

- Standalone EVI-RoadTrip report
  - Detailed methodology, analysis, and results including sensitivities

- EVI-Pro 3!

Questions & Answers

Please raise your hand and the moderator will unmute you.

Optimizing Charging Infrastructure Buildout For TNC Electrification

Alan Jenn, PhD
Assistant Director, Assistant Professional Researcher
Institute of Transportation Studies
University of California Davis

Chargers for EVs in TNCs

- EVs driving for TNCs pose several interesting challenges for the deployment of future infrastructure:
  - Significantly higher utilization at public DC fast charging, 2-3 times a day (compared to once every 2-3 weeks for the average EV driver)
  - Need for high-speed charging to minimize driving/service downtime
  - Spatial coverage to reduce travel/deadheading for TNC service vehicles

Framework for Infrastructure Buildout

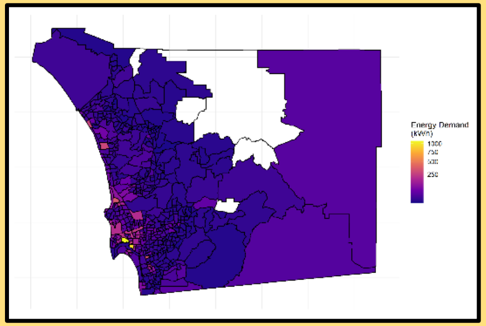
Empirical Trip Data

Uber lyft

Station Attributes

chargepoint EVgo electrify america

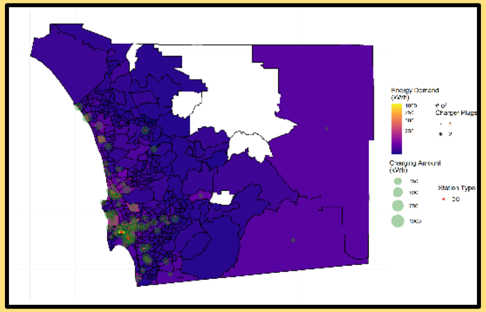
Bootstrap Data to Simulate Demand



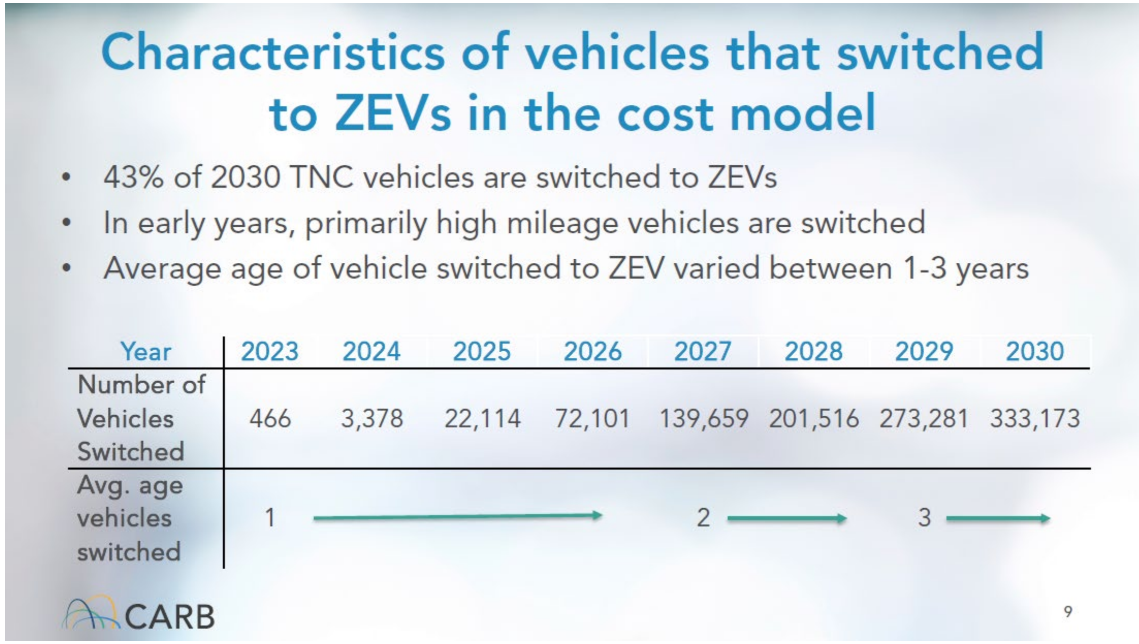
Widespread Infrastructure for Ride-Hailing EV Deployment (WIRED) model

- Reduce costs to charge and downtime (traveling and charging) of drivers
- Meets energy requirements for trips provided throughout the day

Infrastructure Deployment Results



Projecting EVs in TNCs through 2030



Characteristics of vehicles that switched to ZEVs in the cost model

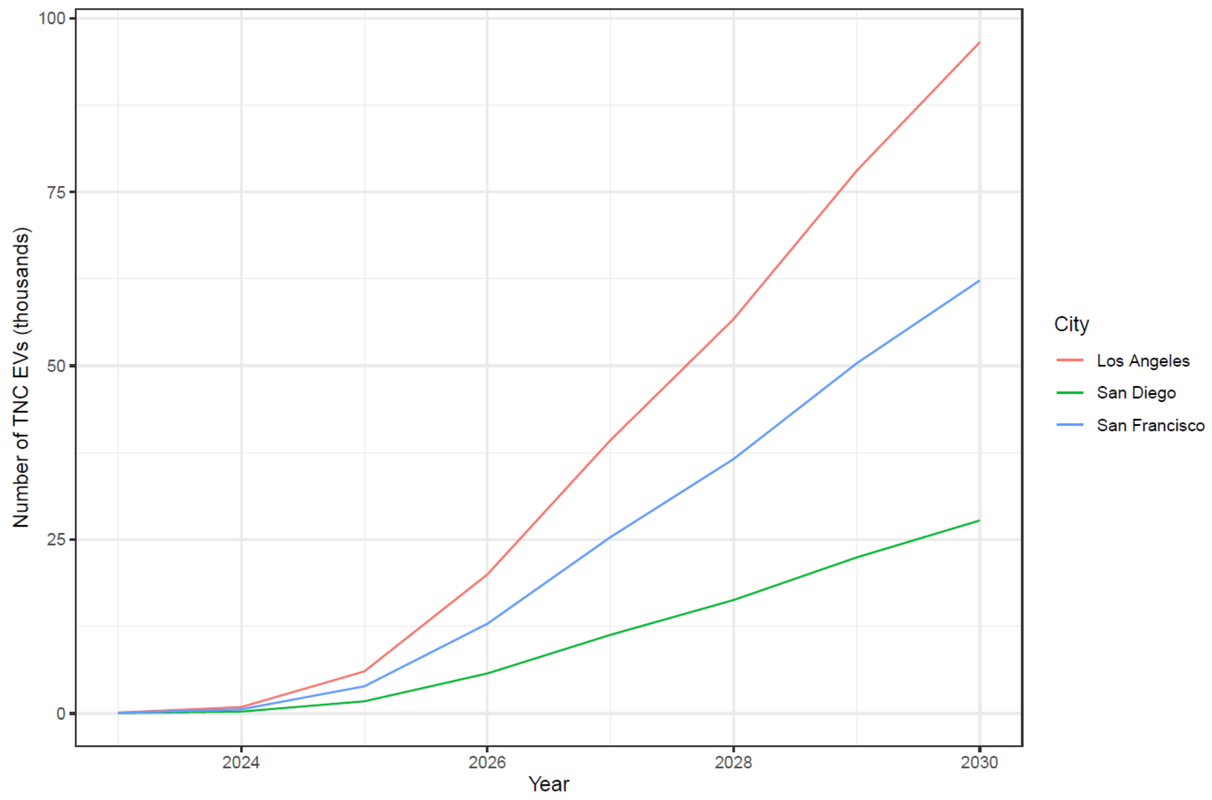
- 43% of 2030 TNC vehicles are switched to ZEVs
- In early years, primarily high mileage vehicles are switched
- Average age of vehicle switched to ZEV varied between 1-3 years

Year	2023	2024	2025	2026	2027	2028	2029	2030
Number of Vehicles Switched	466	3,378	22,114	72,101	139,659	201,516	273,281	333,173
Avg. age vehicles switched	1 →				2 →		3 →	

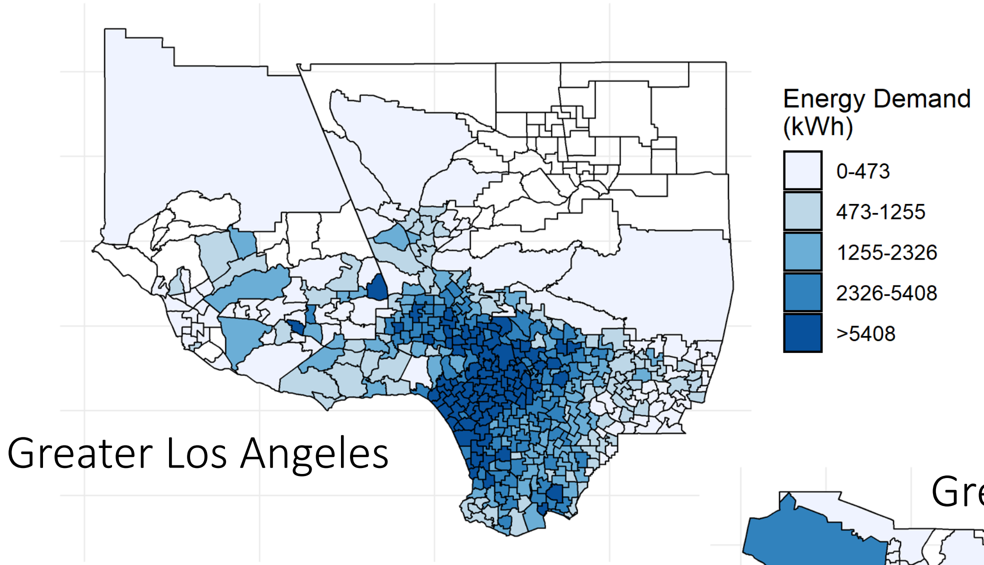
CARB

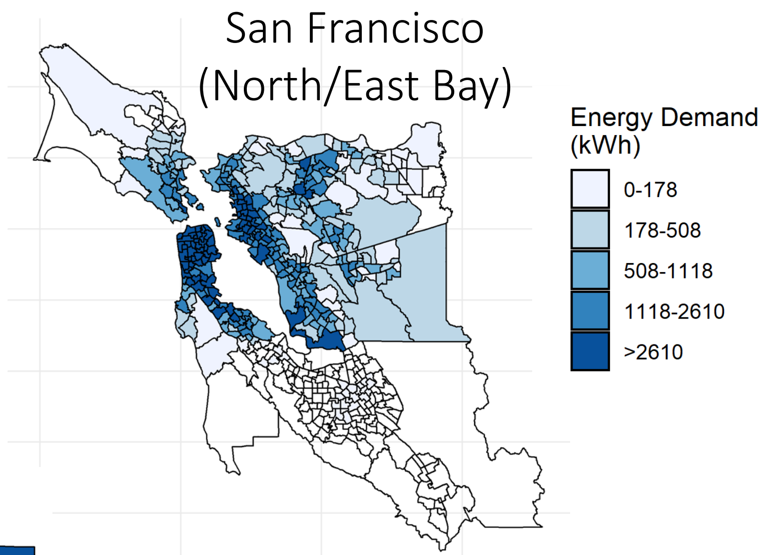
9

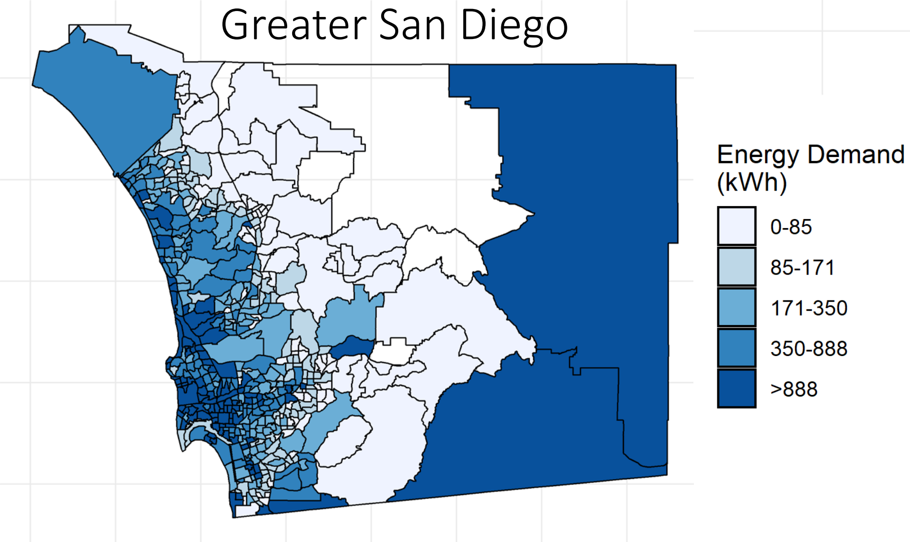
- In the summer of 2020, the California Air Resources Board revealed some of the forecasts for EVs in TNCs to comply with the new Clean Miles Standard in California.
- We take these estimates to forecast vehicle adoption in three major cities in California (right figure).



Simulated Daily Energy Demand in 2030



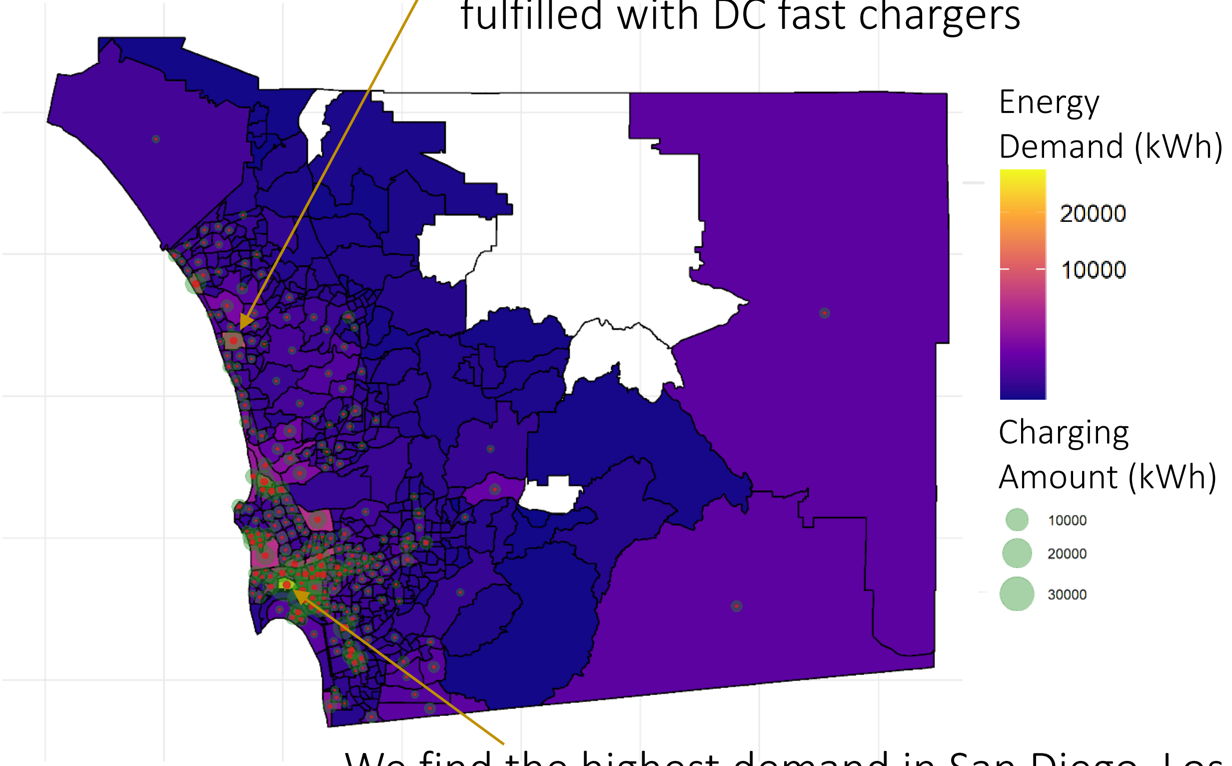




Daily demand profiles are taken as the average day across simulated bootstrap trips over a 3-month period using empirical trip data from Uber and Lyft.

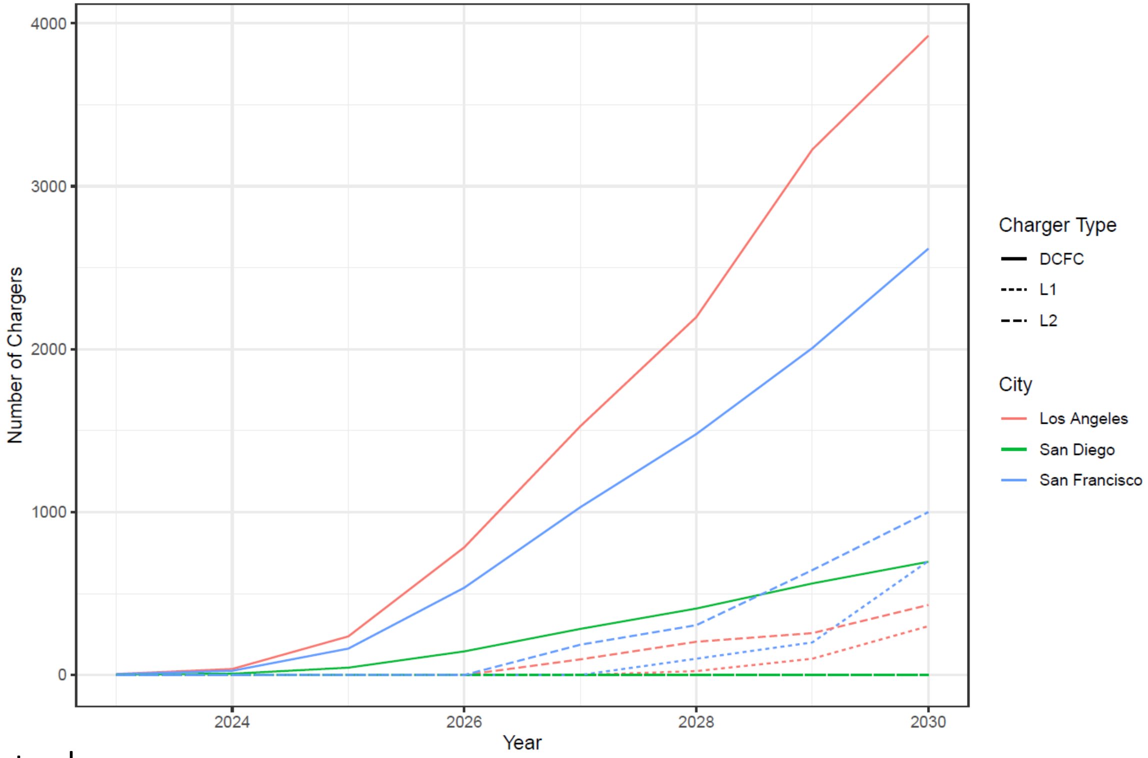
WIRED Infrastructure Deployment

The vast majority of demand in scenarios with day-time charging is fulfilled with DC fast chargers



We find the highest demand in San Diego, Los Angeles, and San Francisco to be consistently located near major airports and around downtown areas.

The volume of DC fast chargers to meet demand is several times larger than exist today, despite fewer vehicles due to the high demand intensity of drivers for Uber and Lyft.



Conclusions

- High travel intensity of EVs driven for Uber and Lyft ride-hailing services is leading to a requirement for public fast charging several times than what exists today
- Infrastructure requirements are highly dependent on the amount of overnight charging—higher access to home/nighttime chargers will reduce dependency on DCFCs
- Currently working to integrate existing/projected public chargers from EVI-Pro2

Acknowledgements

Special thanks to Peter Day at Lyft and Michiko Namazu and Adam Gromis at Uber for providing data used for this analysis. Funding for this work was provided by the Pacific Southwest Region UTC of the National Center for Sustainable Transportation, the California Energy Commission, and the 3 Revolutions Mobility Program.

Research Supported by:

ITS UCDAVIS University of California
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Appendix: Infrastructure Development Model

$$\min Downtime = \sum_{jitr} x_{jitr}^{occupied} + \sum_{jrot} x_{jrot}^{locDiff} c_{ro}^{travelTime} + w \sum_{ir} x_{ir}^{installed} c_i^{station\,\mathrm{Cost}}$$

$$\sum_r x_{jrt}^{loc} - 1 = 0, \forall jt$$

$$x_{jrt}^{loc} - c_{jrt}^{travelIndicator} \geq 0, \forall jrt$$

$$x_{jrt}^{loc} - \sum_i x_{jitr}^{occupied} \geq 0; \forall jrt$$

$$\sum_i x_{jitr}^{occupied} + c_{jrt}^{travelIndicator} - 1 \leq 0, \forall jrt$$

$$\sum_{ir} x_{jitr}^{occupied} - 1 \leq 0; \forall jt$$

$$\sum_j x_{jitr}^{occupied} - x_{ir}^{installed} + c_{ir}^{existingStations} \leq 0; \forall itr$$

$$\sum_{itr} x_{jitr}^{occupied} c_i^{chrgRate} - c_j^{energyDemand} \geq 0; \forall j$$

Questions & Answers

Please raise your hand and the moderator will unmute you.

Break

Return at 3:40

HEVI-LOAD

Noel Crisostomo
Air Pollution Specialist

What is HEVI-LOAD?

Simulation model to:

1) Estimate charging demand from medium- and heavy-duty BEVs (weighing greater than 10,000 GVWR) for **intra-regional travel**
2) Design supply of overnight and daytime charging infrastructure capable of meeting demand without behavior changes

Key outputs:

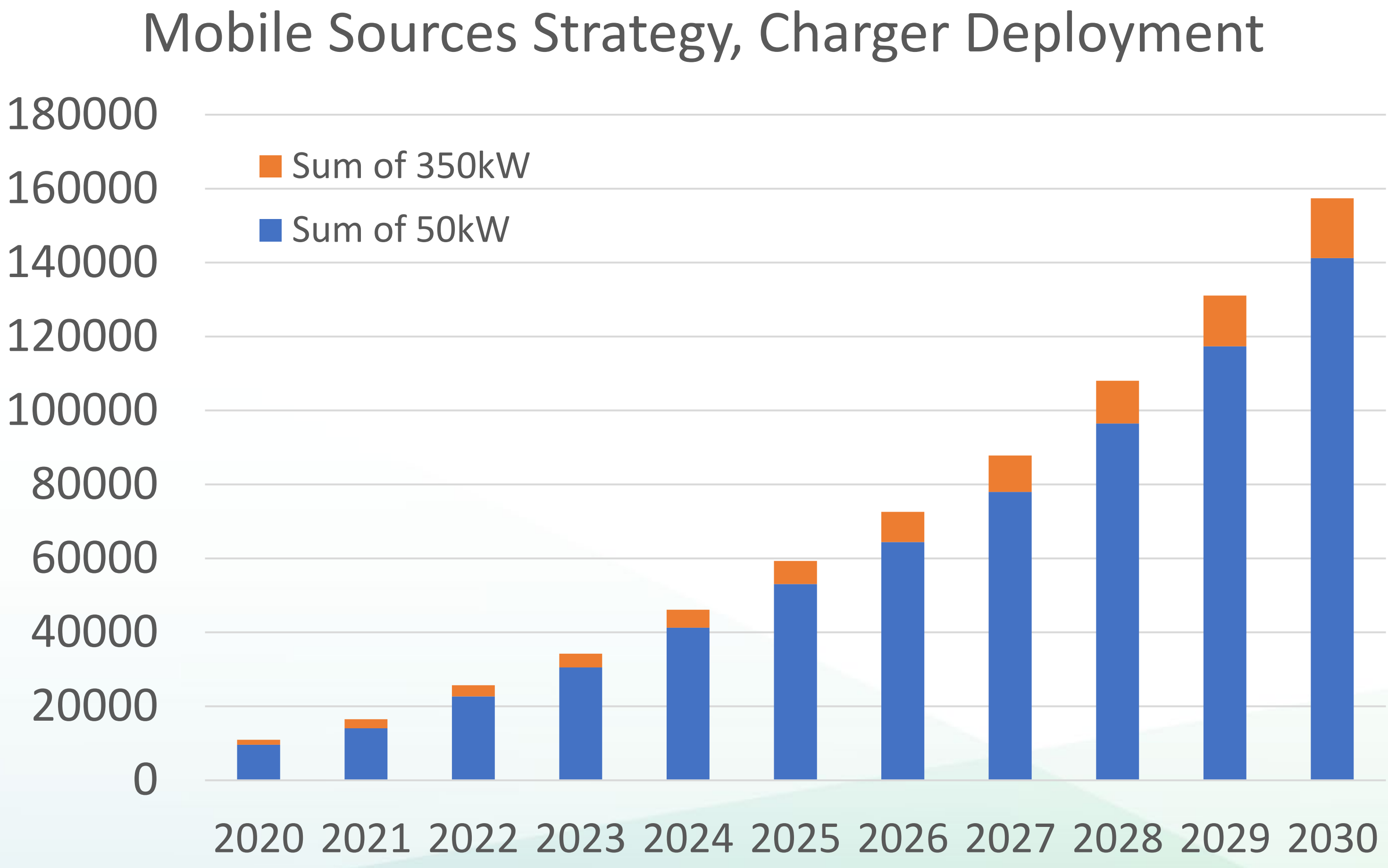
1) Number, type, and location of chargers required to meet charging demand
2) Load profiles associated with charging demand

HEVI-LOAD Updates

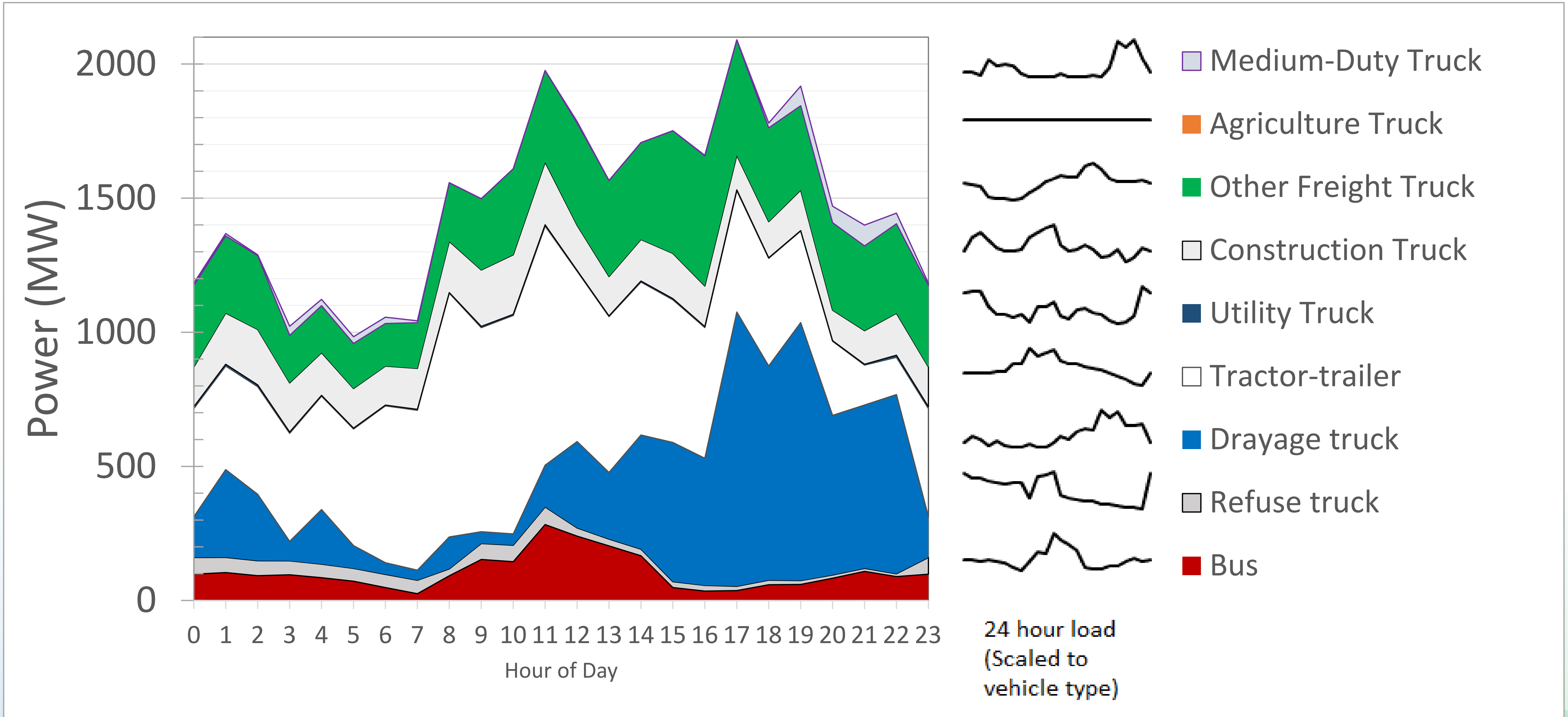
Scenario	Preliminary (August 2020)	Medium Charging Demand	High Charging Demand	Mobile Source Strategy
BEV Population	130,000 in 2030	75,000 in 2030	81,000 in 2030	180,000 in 2030
Regional Populations Enhanced for Attainment	South Coast Air Quality Management District Counties	Not Specified	Not Specified	Not Specified
Payload Associated with Vehicle Type	N/A (Assumed Electricity Consumption Rates)	3 choices, based on the relevant Weight Classes	Maximum GVWR for the relevant Weight Classes	Maximum GVWR for the relevant Weight Classes
Battery Energy Density Improvement (%/year)	None	7.2%	5.2%	5.2%

2030 Network Results

- **157k** chargers needed to support **180,000 BEVs**
- **141,000 50 kW chargers** used overnight
- **16,000 350 kW chargers** used in the daytime



2030 MSS Scenario Load Profile



Implications

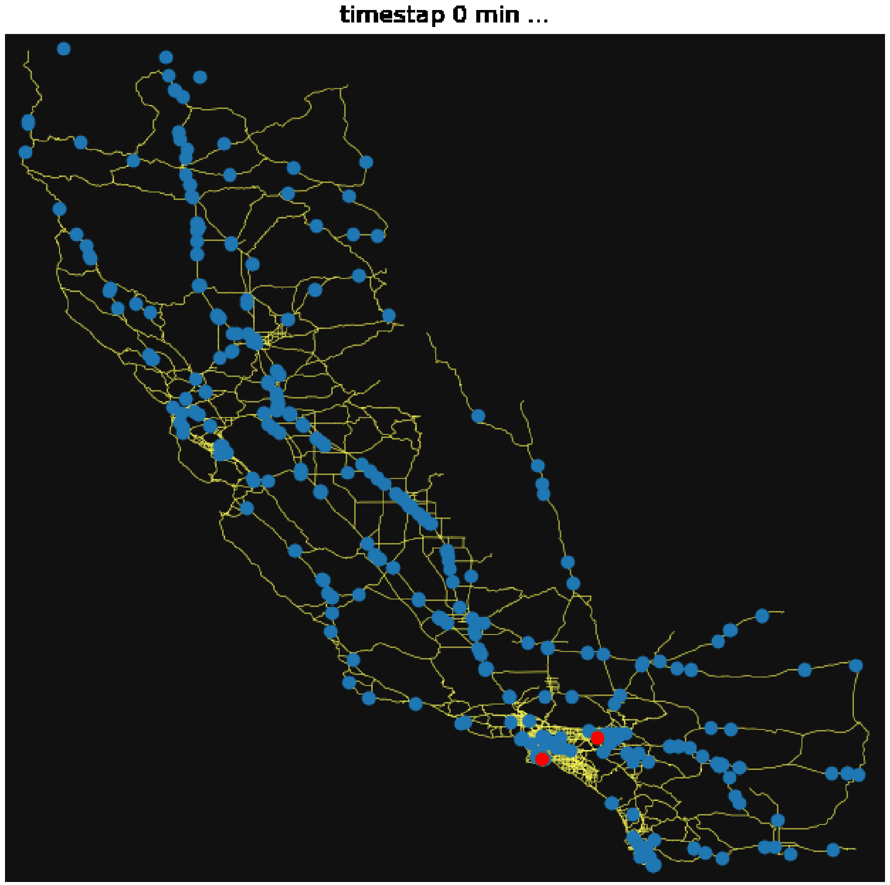
- For BEV intra-regional travel demand:
  - Dependent on portfolio of vehicle classes complying with regulatory deadlines
  - County-level infrastructures are unique and signify importance of local planning
- Additional behavioral data (or economic activity assumptions) are necessary to more robustly profile diversity in energy needs
- Rapid changes in vehicle and charging technologies require ongoing market analysis
- Top-down estimates should be complemented with bottom-up modeling

Next Steps and Future Work

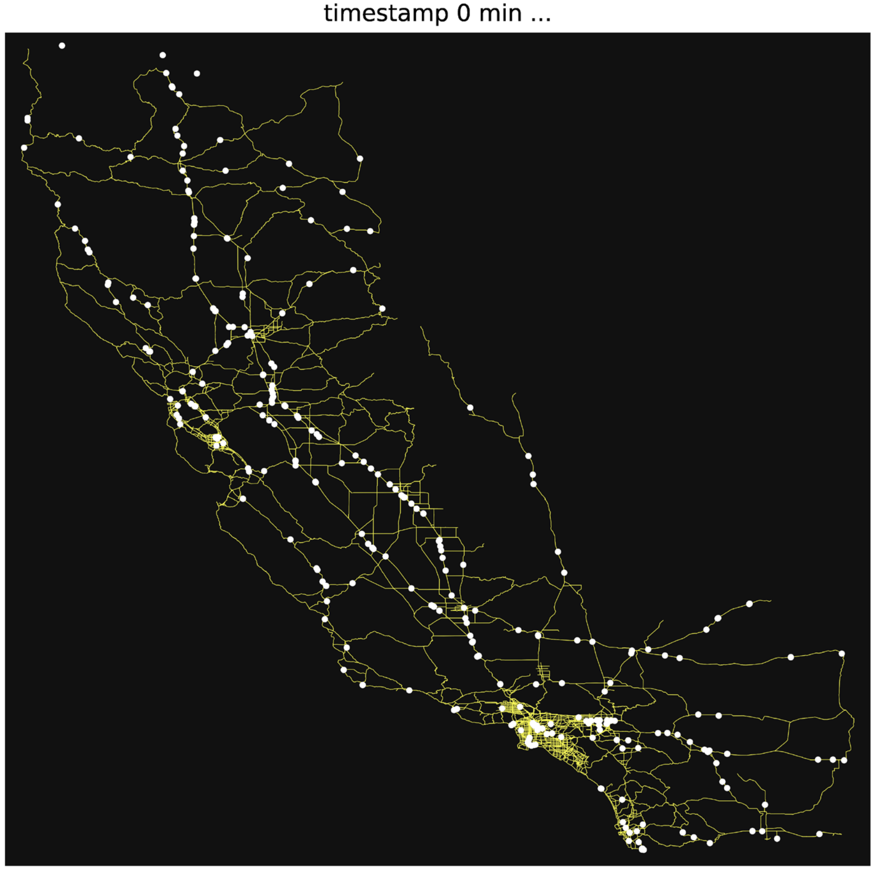
- HEVI-LOAD Model Features In-Progress
  - Scenario alignment among econometric choice and state and regional air quality attainment targets, including EMFAC 2021, META, TEDF
  - Higher resolution load profiling: hour to minute
  - Agent-Based Modeling to reflect truck operations within the road network
    - Economic activity model
    - Trip chaining and recharging stops
    - Truck parking and fueling stations
  - Charger power selection (up to MW) → Station siting and sizing
  - Utility tariff, smart charging, and integration with EDGE

- Standalone HEVI-LOAD report
  - Detailed methodology, county-level analysis, and results to 2035

LBNL Agent-Based Model In-Progress



Preliminary truck simulation results using UCR/WVU data



Single trip visualization w/ smart charging optimization

We seek input on the 2035 analysis:

- **Scenarios for 100% Drayage and toward 100% ZEV operations by 2045**
  - Aligning the Mobile Source Strategy and state & local regulatory measures with the Transportation Energy Demand Forecast to profile load
- **Travel origins-destinations and schedules and driver preferences**
- **Vehicle & charging technology configurations**
  - Make-model availability, especially to 2024-2025
  - Energy density growth rate, especially from 2030-2035
  - CalEPA and UC ITS Carbon Neutrality Study 1 regarding ZEV powertrains
  - Battery charge curves at the megawatt scale
- **Grid Impacts**
  - Identifying fleets (and vehicle composition) to utility customer locations and to public fueling stations to assist with distribution service planning

Survey and Additional Resources

Some complimentary stakeholder efforts supporting medium- and heavy-duty vehicle electrification:

- West Coast Clean Transit Corridor Initiative Study on preparing the Interstate 5 corridor (California, Oregon, Washington) for freight electrification
- Medium and Heavy-Duty Alternative Fuel Infrastructure Strategic Development Plan developed by the West Coast Collaborative Medium & Heavy-Duty Alternative Fuel Infrastructure Corridor Coalition (WCC AFICC)
- Survey to further support WCC AFICC efforts, **open until March 31, 2021**

Off-Road Charging

Jeffrey Lu

Air Pollution Specialist

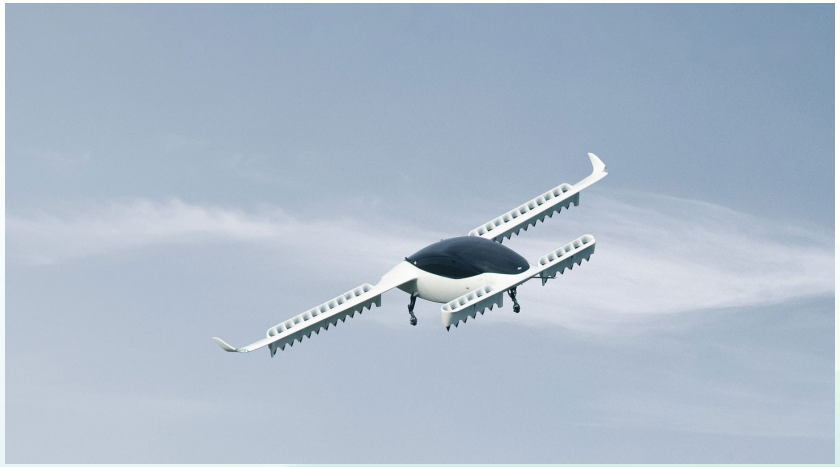
Context: New Executive Order Will Accelerate Off-Road Electrification

100% zero-emission off-road operations by 2035 where feasible

Previously, electrification primarily driven by air quality goals:

- **CARB**
  - Transportation refrigeration units (bifurcated due to EO)
  - Cargo handling equipment (ports, railyards) + forklifts
  - Airport ground support
- **Local clean air action plans** (for example, ports and airports)

Growing Commercial Options Across Many Sectors



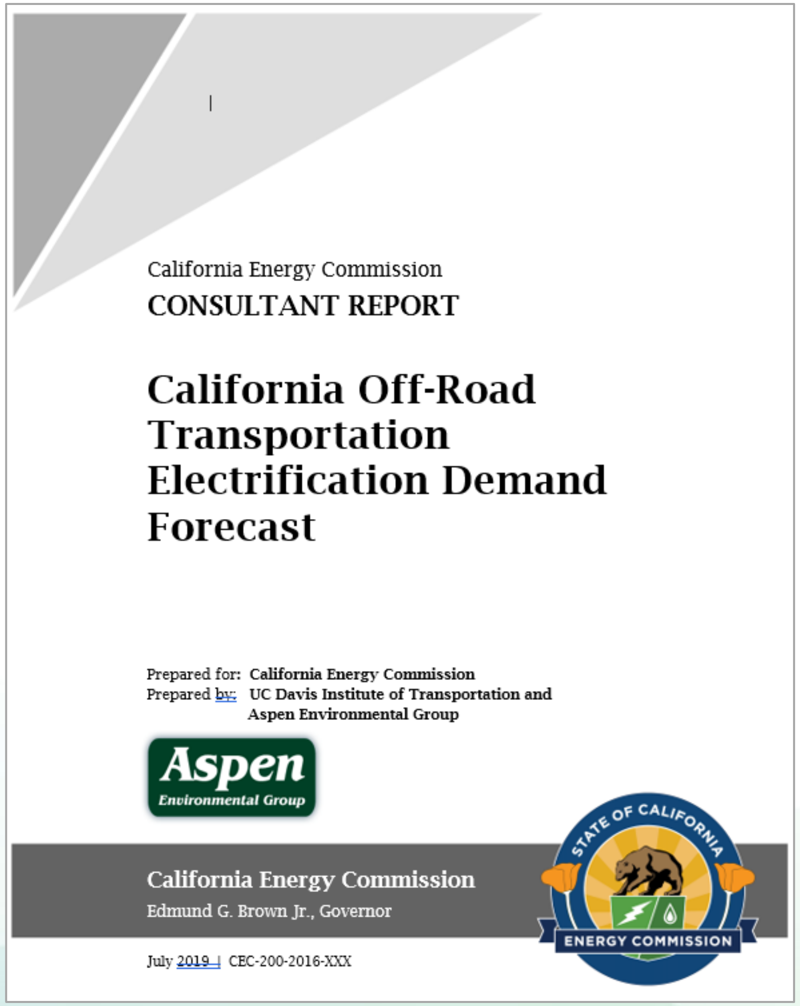
Clockwise from left: CASE, Dannar, JCB, Monarch, Lillium

Challenges Similar to On-Road MD/HD

- Many applications **extremely energy intensive**
  - Taylor-BYD top handler: **931 kWh**, 200 kW charging
  - Megawatt-level connectors under development
  - Distributed energy resources to mitigate grid constraints
  - Agriculture and construction may have no grid access at all
- Operators dismayed by **lack of charger interoperability**, standardization
- **Landlord-tenant relationships**: Who is responsible for infrastructure?
- Rigid operating **demands and rules**

Detailed Report on Off-Road Charging

- Based on prior off-road electricity demand forecast (2019)
- Align with CARB regulatory actions and projected populations
- Broader range of analysis, including discussion of agriculture, eVTOL, construction
- Publication later this year



California Energy Commission
CONSULTANT REPORT

California Off-Road Transportation Electrification Demand Forecast

Prepared for: California Energy Commission
Prepared by: UC Davis Institute of Transportation and Aspen Environmental Group

Aspen Environmental Group

California Energy Commission
Edmund G. Brown Jr., Governor

July 2019 | CEC-200-2016-XXX

ENERGY COMMISSION

Questions & Answers

Please raise your hand and the moderator will unmute you.

Submit Comments to Docket 19-AB-2127

Electronic Commenting System

Visit: https://efiling.energy.ca.gov/EComment/EComment.aspx?docketnumber=19-AB-2127

Comment by E-mail

E-mail: docket@energy.ca.gov

Subject Line: "Workshop on Assembly Bill 2127 Electric Vehicle Charging Infrastructure Assessment"

All comments due by 5:00 pm on February 26, 2021

* If answering or providing comments on a specific matter included in this presentation, please reference the workshop session (date) and slide number.