DOCKETED	
Docket Number:	19-AB-2127
Project Title:	Implementation of AB 2127 Electric Vehicle Charging Infrastructure Assessments
TN #:	247323
Document Title:	Hevi-Load and Wired Analysis Workshop
Description:	November 9, 2022 at 10 a.m.
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Submitter Role:	Commission Staff
Submission Date:	11/7/2022 4:44:08 PM
Docketed Date:	11/7/2022

HEVI-LOAD and WIRED Analysis Workshop

California Energy Commission Fuels and Transportation Division

November 9, 2022 | 10:00 a.m.

Agenda

1) Background and motivation for HEVI-LOAD and WIRED analysis including AB 2127 requirements

2) HEVI-LOAD modeling updates including methodology, inputs, assumptions, and scenarios

3) WIRED modeling updates and changes to inputs and assumptions

4) Q&A and Public Comment

Housekeeping

- Workshop is being recorded
- Workshop Event Webpage:

  https://www.energy.ca.gov/event/workshop/2022-09/assembly-bill-ab-2127-assessment-workshop

- Written Comments to Docket # 19-AB-2127:
  https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=19-AB-2127

Deadline for Written Comments: 5:00pm on Wednesday, November 23, 2022

Commitment to Diversity

The CEC adopted a resolution strengthening its commitment to diversity in our funding programs. The CEC continues to encourage disadvantaged and underrepresented businesses and communities to engage in and benefit from our many programs.

To meet this comment, CEC staff conducts outreach efforts and activities to:

- Engage with disadvantaged and underrepresented groups throughout the state;
- Notify potential new applicants about the CEC's funding opportunities;
- Assist applicants in understanding how to apply for funding from the CEC's programs;
- Survey participants to measure progress in diversity outreach efforts

Diversity Survey

One Minute Survey

The information supplied will be used for public reporting purposes to display anonymous overall attendance demographics

Zoom Participants, please use the link in the chat to access the survey or scan the QR code on the left of the screen with a phone or tablet to access the survey

Survey will be closed at the end of the day

Scan the code on a phone or tablet with a QR reader to access the survey.

Survey Link:

https://forms.office.com/Pages/ResponsePage.aspx?id=RBI6rPQT9k6NG7qicUgZTqEU3EeANX9DvlX_on7oPclUNlR
YOFVYTVJIQzlIUTFQSjgyVkhaOVRXQS4u

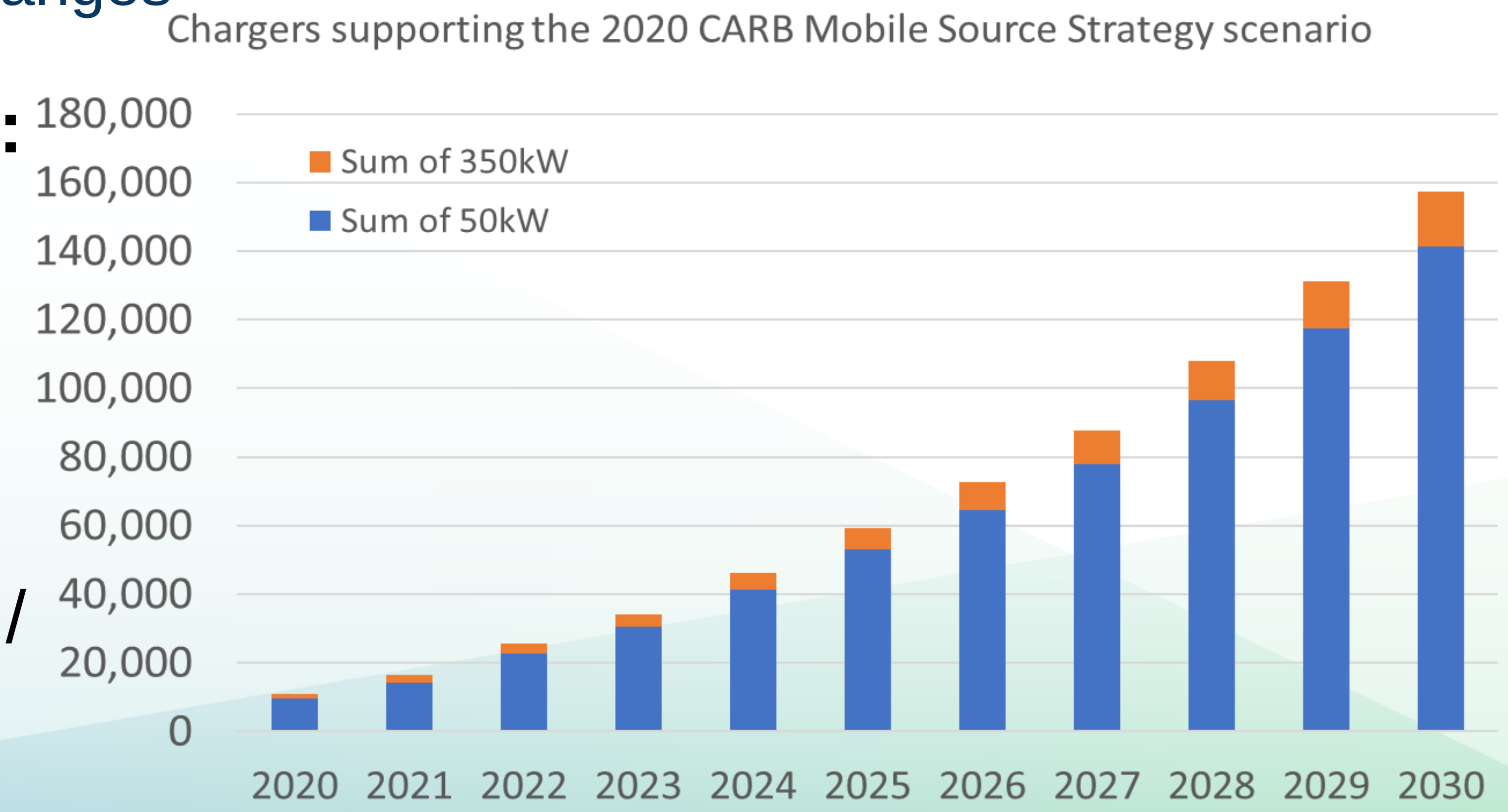
Background and Motivation: HEVI-LOAD and WIRED

HEVI-LOAD: Modeling Objectives

- Estimate charging demand from medium- and heavy-duty BEVs for **inter-regional travel**
- Design supply of overnight and daytime charging infrastructure capable of meeting demand without behavior changes

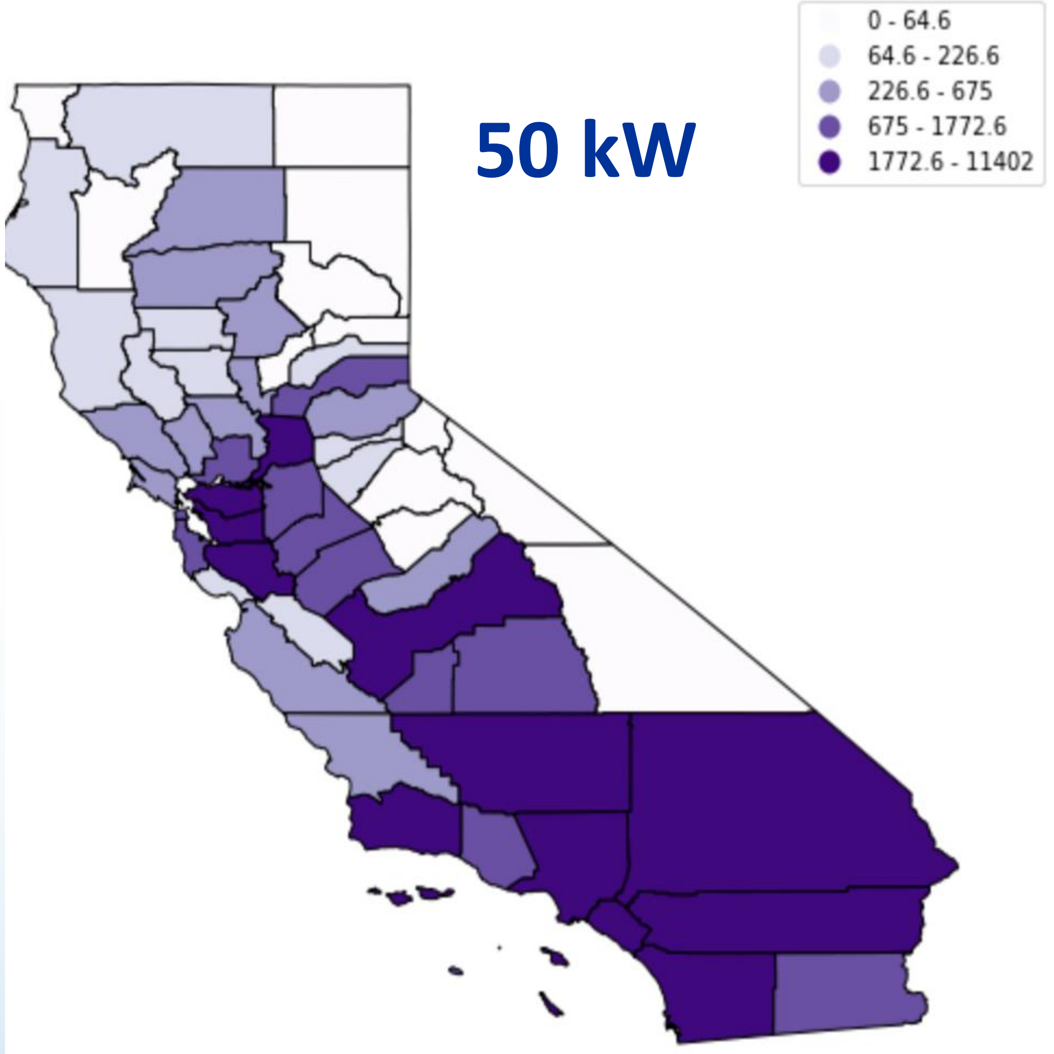
First assessment (2021): 157k chargers needed to support **180,000 BEVs**

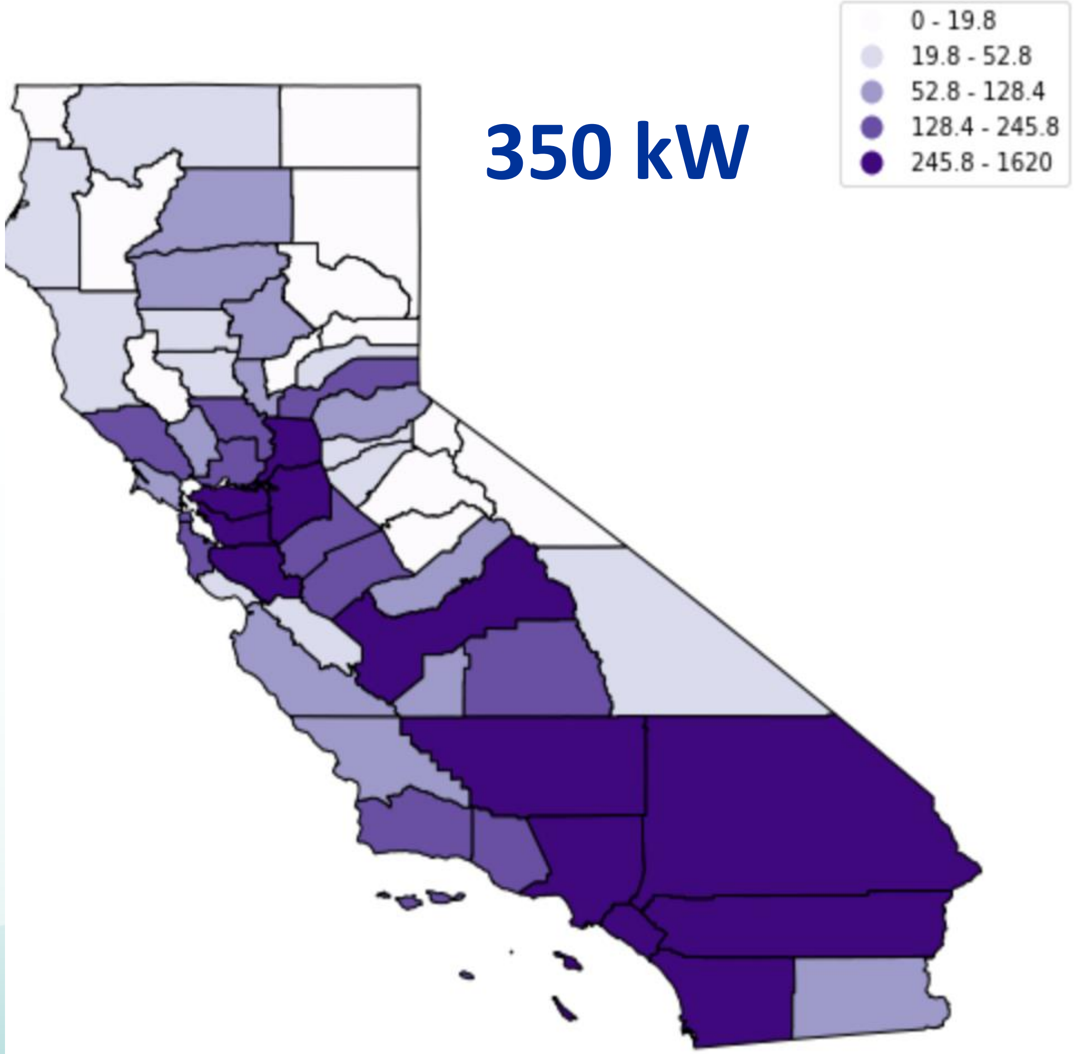
Second assessment: Chargers needed to support BEVs under ACF / ACT regulations



HEVI-LOAD: First Assessment Results

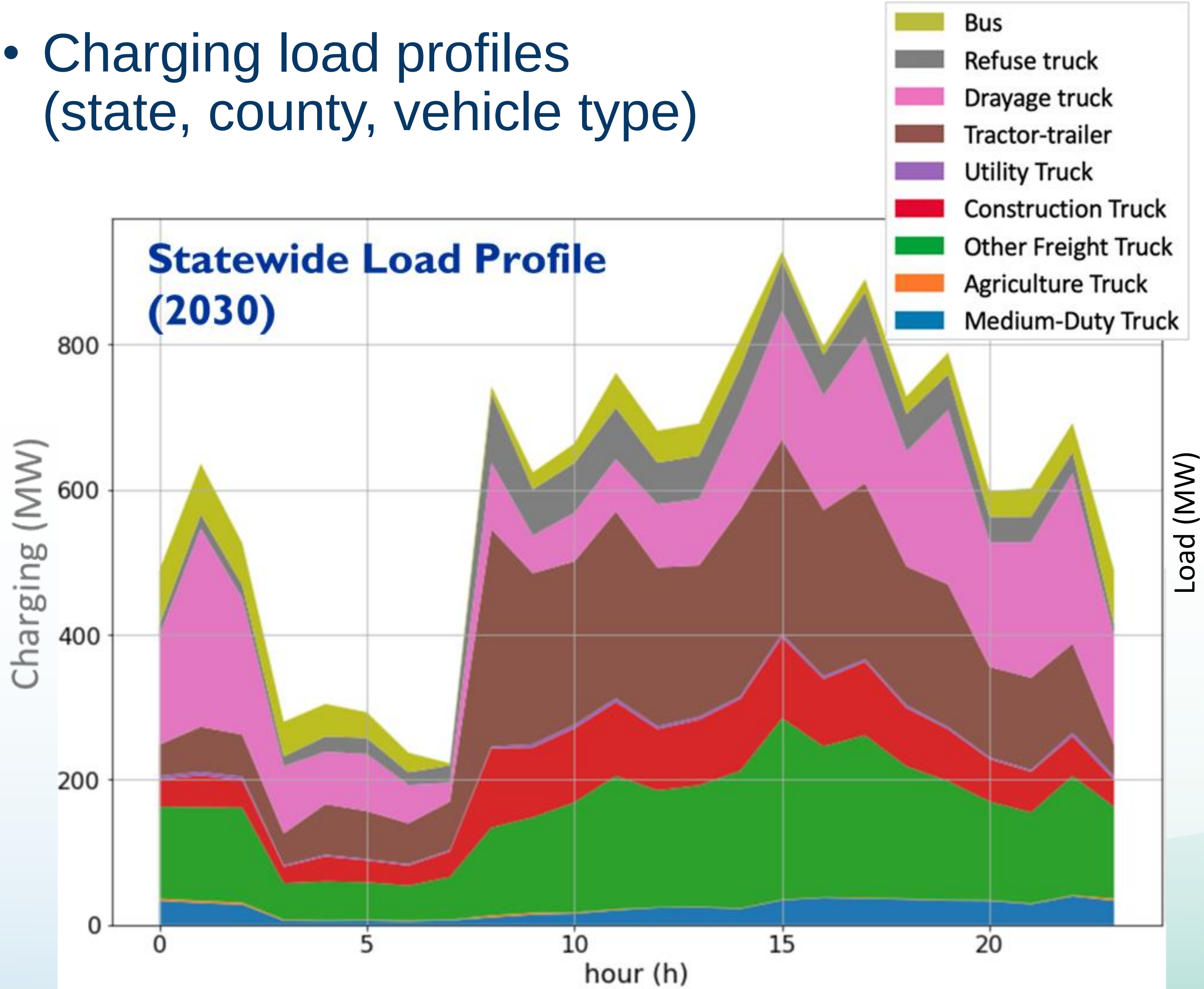
- Number, type, and location of chargers required to meet charging demand

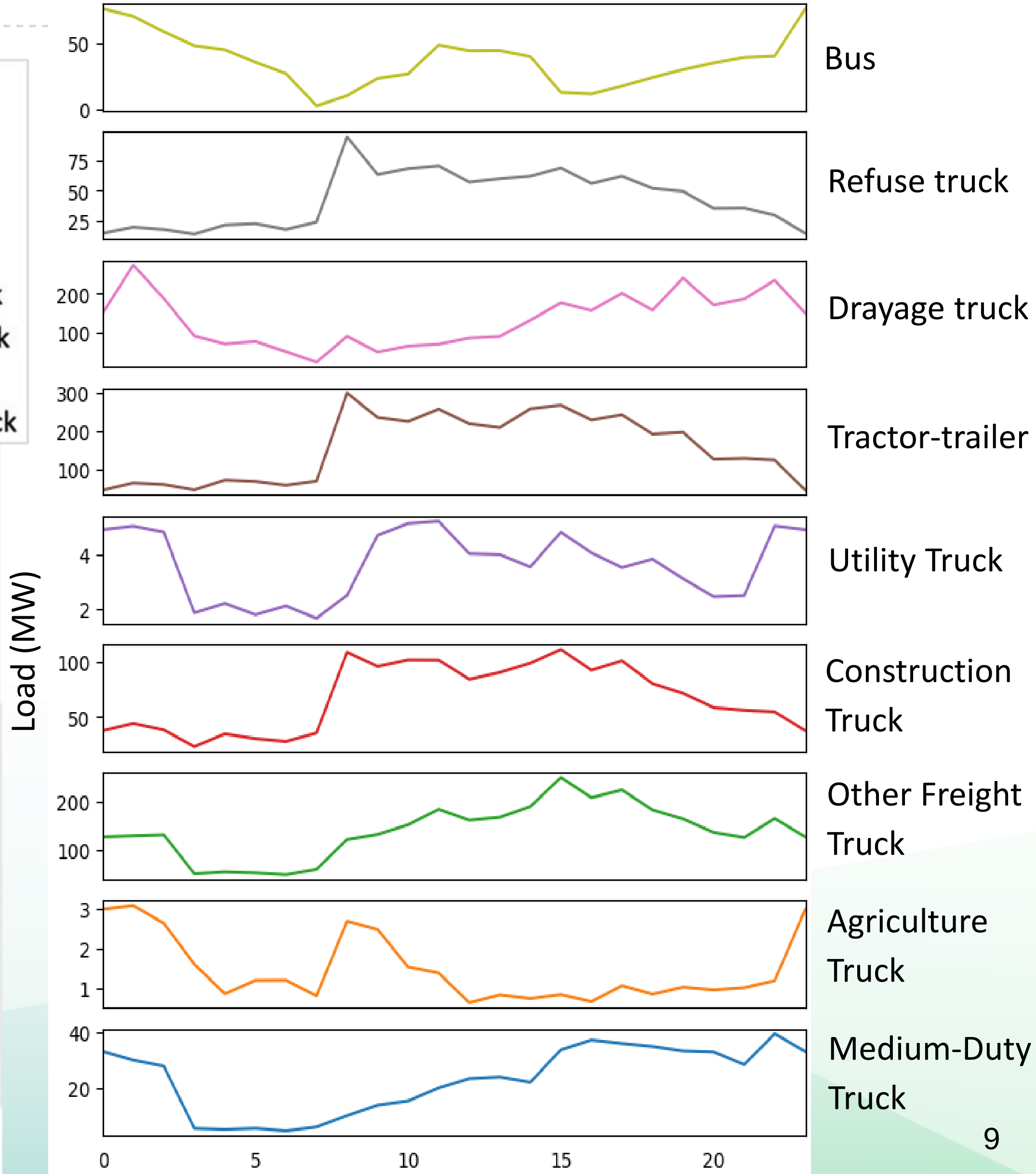




HEVI-LOAD: First Assessment Results

- Charging load profiles (state, county, vehicle type)

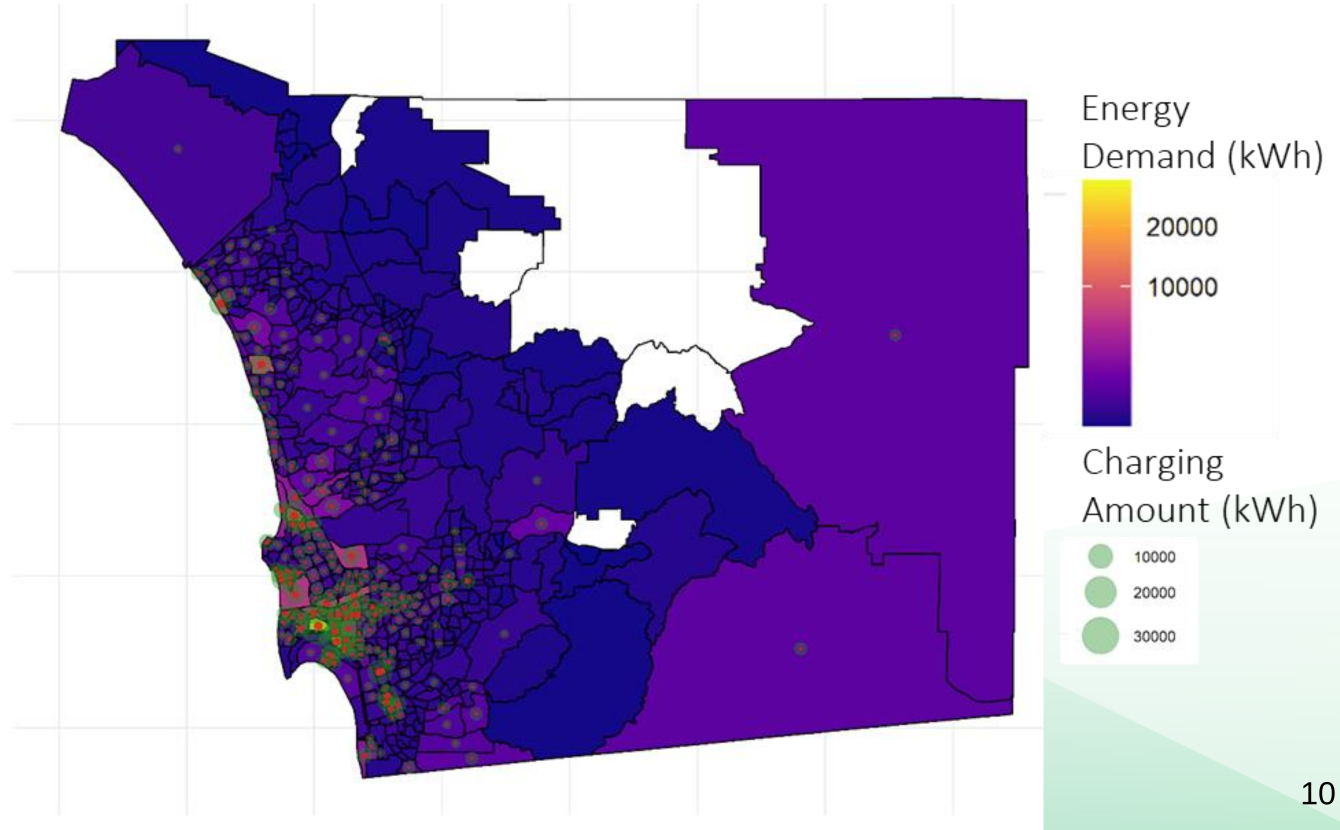




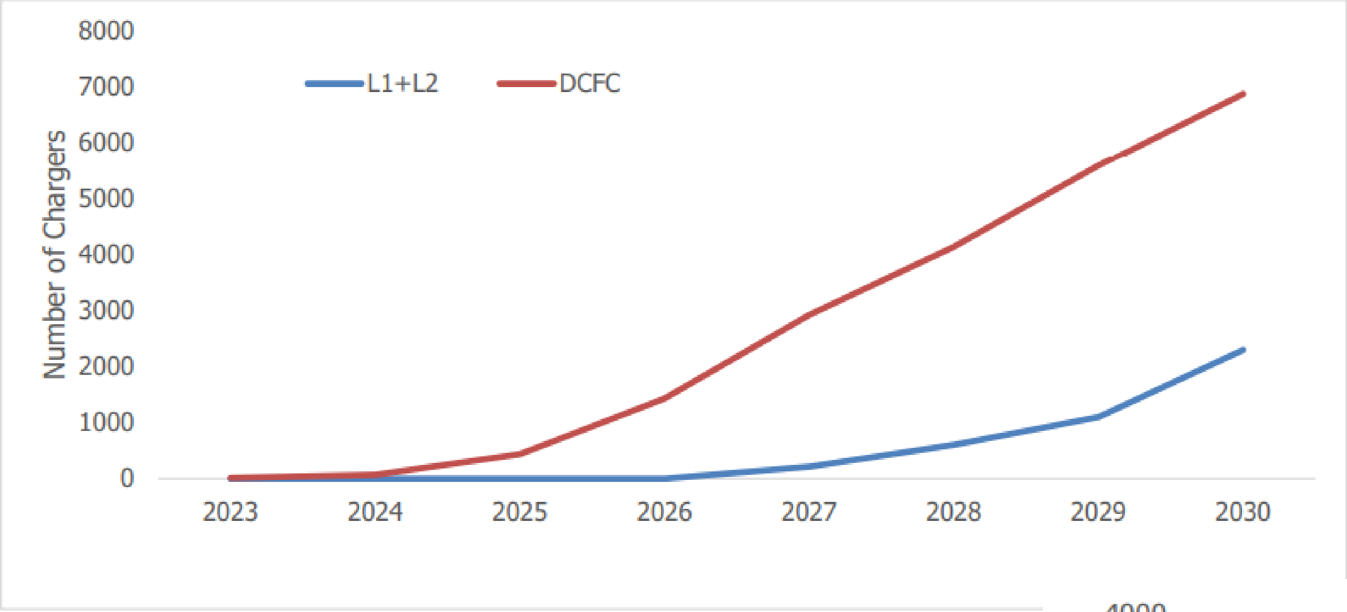
WIRED: Modeling Objectives

- Motivation and Objectives
  - TNC BEV charging needs: San Diego, Los Angeles, San Francisco
  - Clean Miles Standard (CARB, SB 1014)
    - 50% VMT electrified by 2027
    - 90% VMT electrified by 2030
  - 80% of 333k TNC ZEVs assumed to operate in these regions
  - Optimizing charging infrastructure buildout for TNC electrification

- Deployment challenges
  - Higher utilization of DCFCs
  - Fast charging to minimize downtime
  - Coverage to reduce deadheading

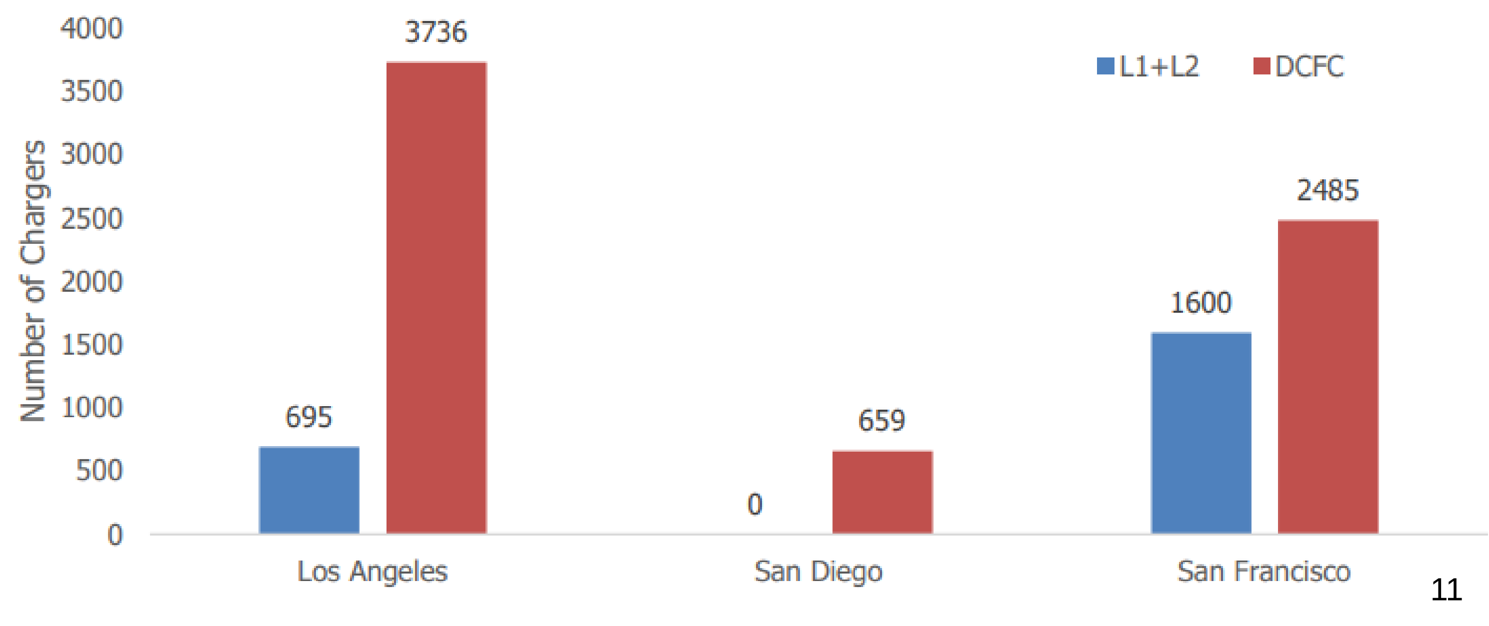


WIRED: First Assessment Results



- Steady increase over time in each region, DCFCs accounting for the most need

- Region-specific infrastructure needs
- Needs across all regions (2030)
  - ~2000 L1+L2
  - ~7000 DCFCs



HEVI-LOAD (LBNL)

ENERGY TECHNOLOGIES AREA

LAWRENCE BERKELEY NATIONAL LABORATORY

Medium and Heavy-Duty Electric Vehicle Infrastructure - Load Operations and Deployment

(HEVI-LOAD)

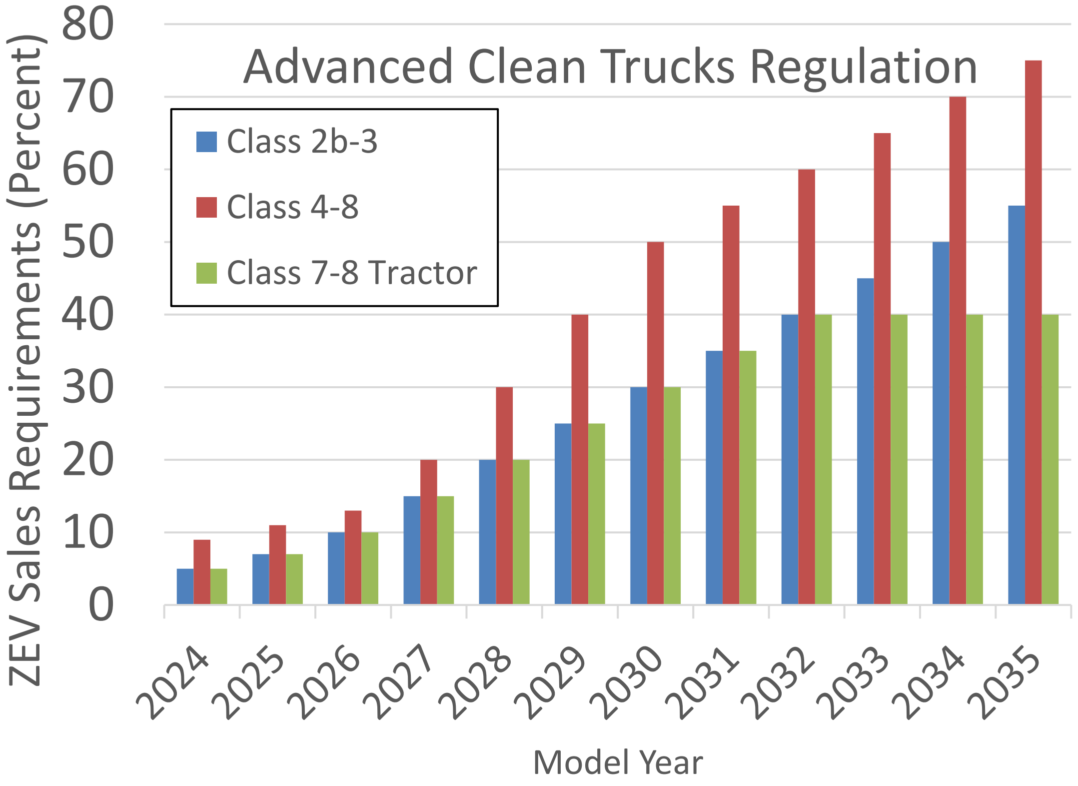
Bin Wang, Ph.D.
Research Scientist, wangbin@lbl.gov
Lawrence Berkeley National Laboratory

Outline

- HEVI-LOAD Overview
- Modeling Approaches and Assumptions
  - Trip and Travel Demand Forecast
  - Energy Consumption/Charging Demand Quantification
  - Circuit Load and Capacity Analysis
  - Drayage Electrification Case Study
  - Smart/Managed Charging Design
- Discussion and Future Work
  - Challenges
  - Next steps
  - Call to action

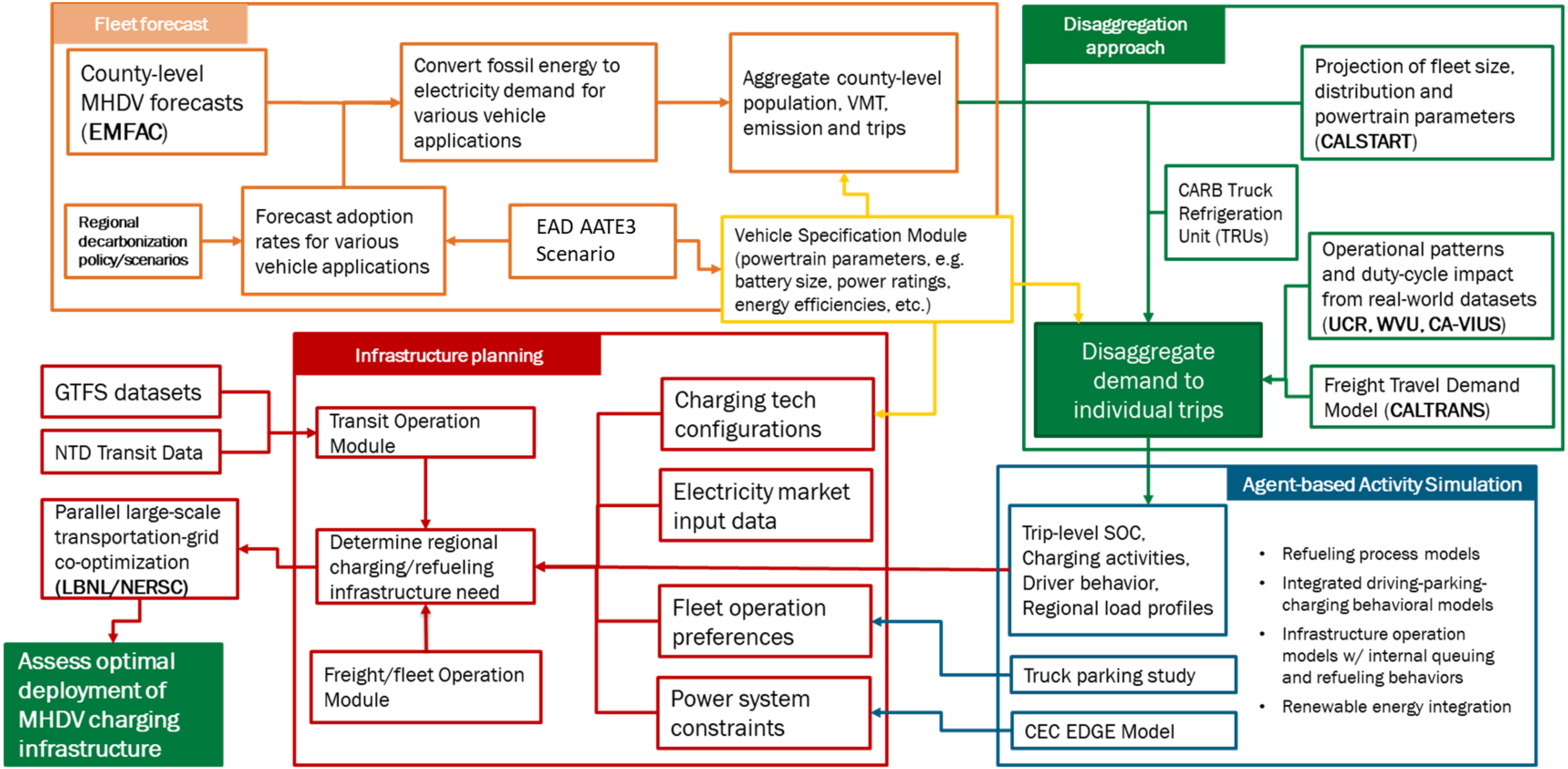
Electrifying Medium and Heavy-Duty Vehicles

- CARB's Advanced Clean Trucks regulation requires an increasing share of trucks sold in California to be zero emission starting in 2024, leading to a full transition to ZEVs by 2045.
- AB 2127 calls for the CEC to project charging infrastructure needed to decarbonize trucking and to reduce the impact of diesel air pollution.
- LBNL is developing HEVI-LOAD in collaboration with the CEC, via applied research funds from the Clean Transportation Program.
- HEVI-LOAD will project infrastructure needs for decarbonizing medium and heavy-duty vehicles (GVWR > 10,000 lbs.).



https://ww2.arb.ca.gov/news/california-takes-bold-step-reduce-truck-pollution
https://ww3.arb.ca.gov/regact/2019/act2019/30dayattb.pdf

HEVI-LOAD Overview



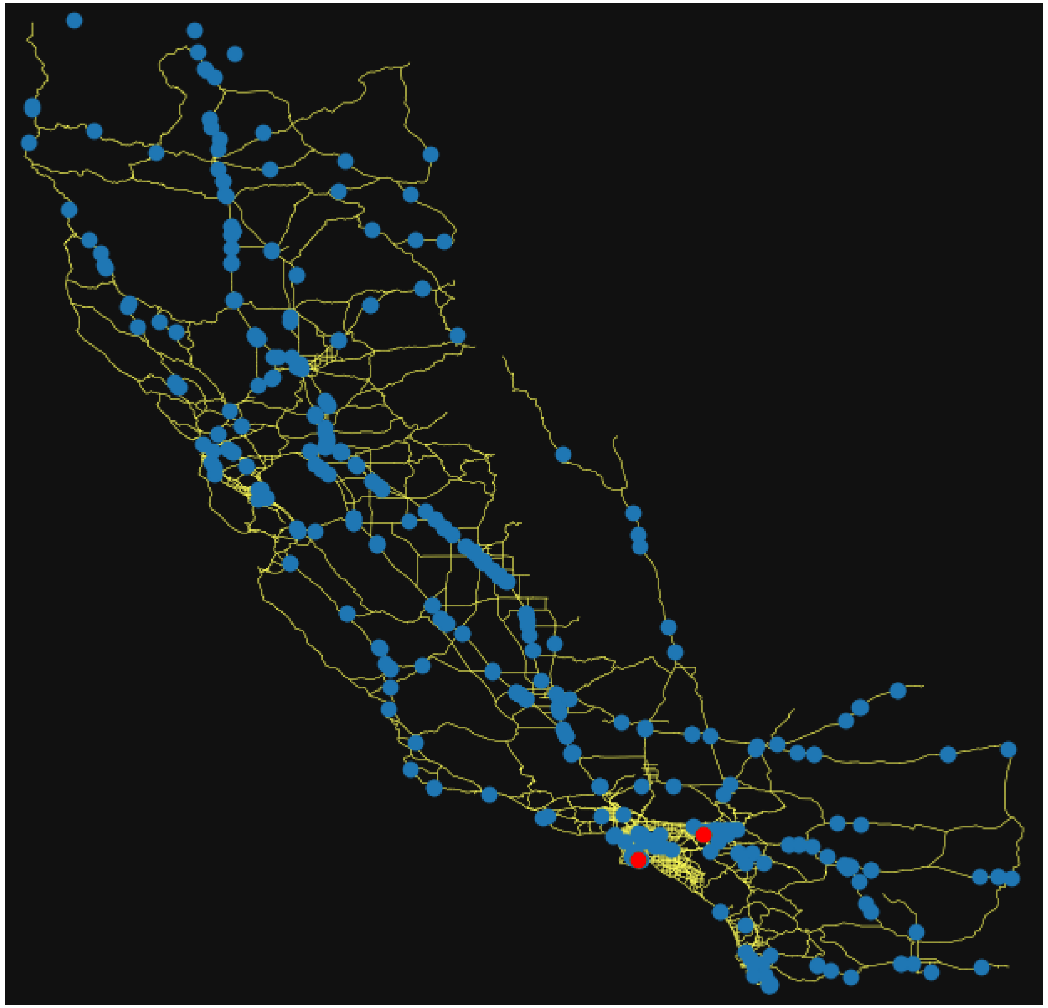
HEVI-LOAD | Metrics

Charging infrastructure need and load profiles for MHDVs

Region	Charging infrastructure		Number of chargers/plugs
	Type of accessibility	Charger type	
Charging infrastructure requirements for **each county**. Aggregate estimates by: **(1) City** **(2) Town** **(3) Rural area** **(4) Interstate/state highway**	**(1) Public (Shared)** **(2) Private (Dedicated)** **(3) Public/Private (Shared / Dedicated)**	Examples include: **(1) 50 kW (DCFC)** **(2) 125 kW** **(3) 250 kW** **(4) 350 kW** **(5) 1 - 4 MW** Charging stations servicing Class 8 heavy-duty trucks should be listed in a separate manner from “normal” charging stations (serving LDVs & MHDVs).	For each type of chargers used for each type of use application, estimates shall be given as **(1) # of plugs** [Alternative metrics could also be given] **(2) # of stations** **(3) # of plugs per station** **(4) # of plugs per 1,000 PEVs**

Site-Level Analysis via Bottom-up Simulations

- Bottom-up vs Top-down approaches
  - Bottom-Up approach has more granular geographical resolution, taking into account road networks, critical locations and travel demand model, while the Top-Down approach takes the aggregated vehicle adoption info to project infrastructure needs and load profiles at county-level
  - Bottom-Up approach has the capability to reveal granular vehicle behaviors – driving, routing, parking and charging, etc.
- Prepare for inputs for the simulation
  - Road network
  - Travel demand – MD/HD trips with origins, destinations, and trip start times
  - Critical/candidate locations: truck stops, rest areas, etc., using the California Statewide Truck Parking Study
  - Calibrate behaviors using real-world GPS & duty-cycle data
- Enable decision-making, routing and decision-making capability for each agent (vehicle)
  - Compute shortest distance/travel time routes
  - Provide flexibility for more customization for future scenarios, e.g., select optimal en-route charging stations

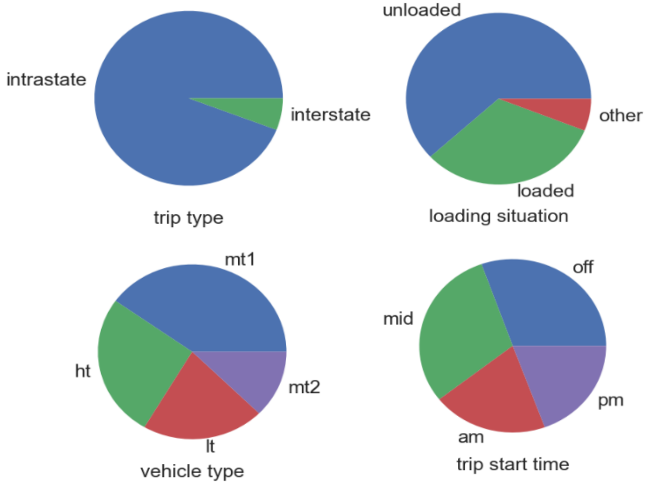


Activity Simulation of selected MDHD vehicle applications: integrated driving-routing-parking-charging scenarios in CA. Red dots: moving MD/HD vehicles being simulated; Blue dots: hwy entry points for the candidate infrastructure deployment locations, such as truck stops, etc.

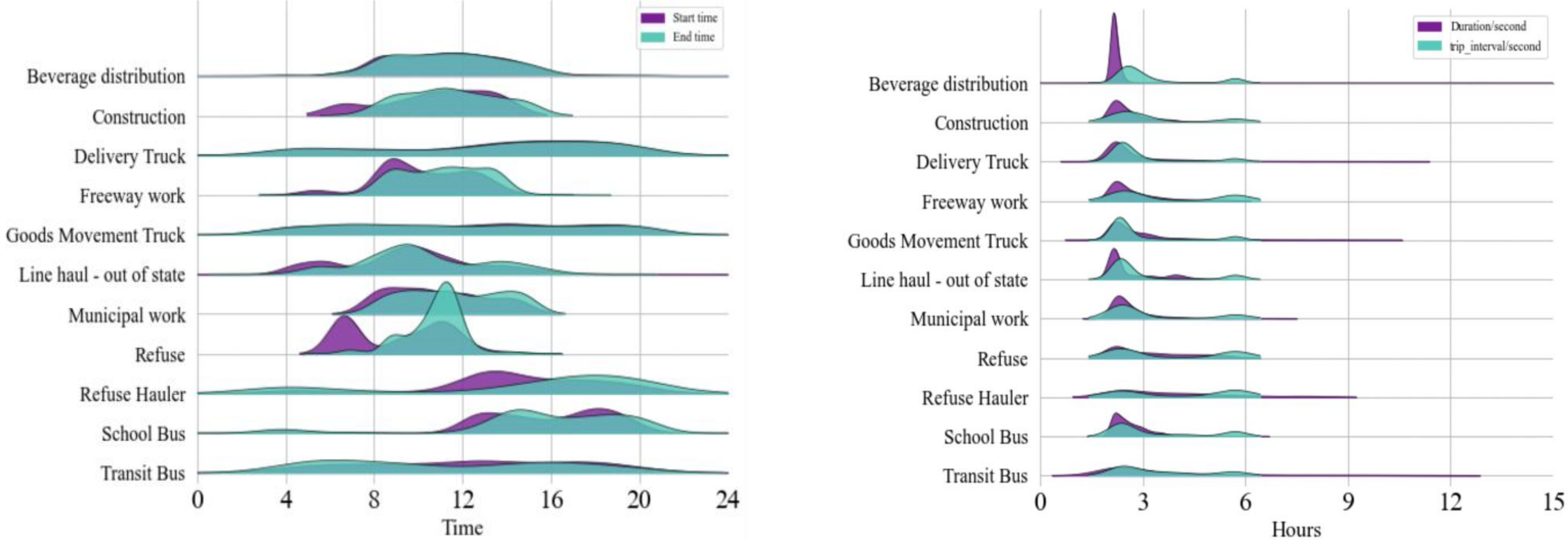
California statewide truck parking study: https://dot.ca.gov/-/media/dot-media/programs/transportation-planning/documents/freight-planning/plan-accordion/catrkpkgstdy-finalreport-a11y.pdf

Trip and Travel Demand Forecast

- Extract MD/HD trips from CSTDM/CSFFM
  - ~ 1.3 million trips (LT, MT, HT)
  - Time periods: AM, Mid-day, PM and OFF
- Calibrate the travel demand models as inputs to HEVI-LOAD Simulation
  - Characterize trip behaviors with real-world GPS location datasets
  - Combined with uniform and other distributions for trip start time, etc.



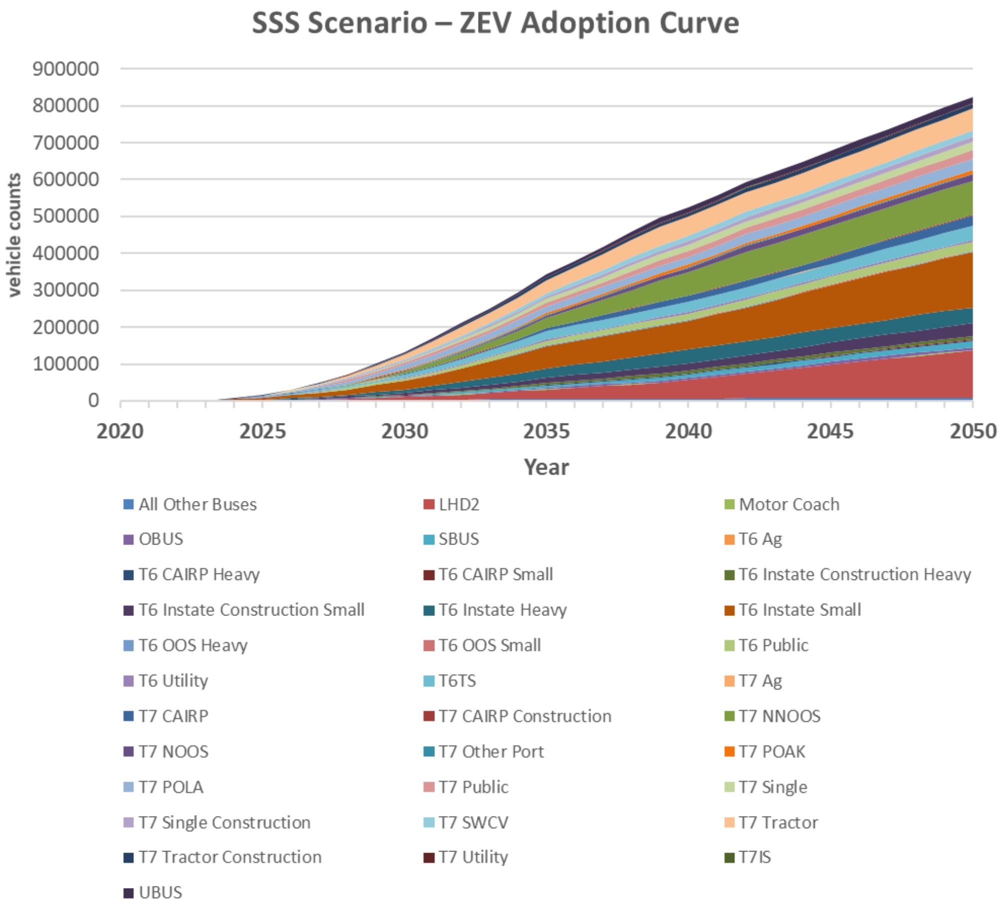
LT, MT, HT, Load/Unload trip percentage in the CSTDM/CSFFM model

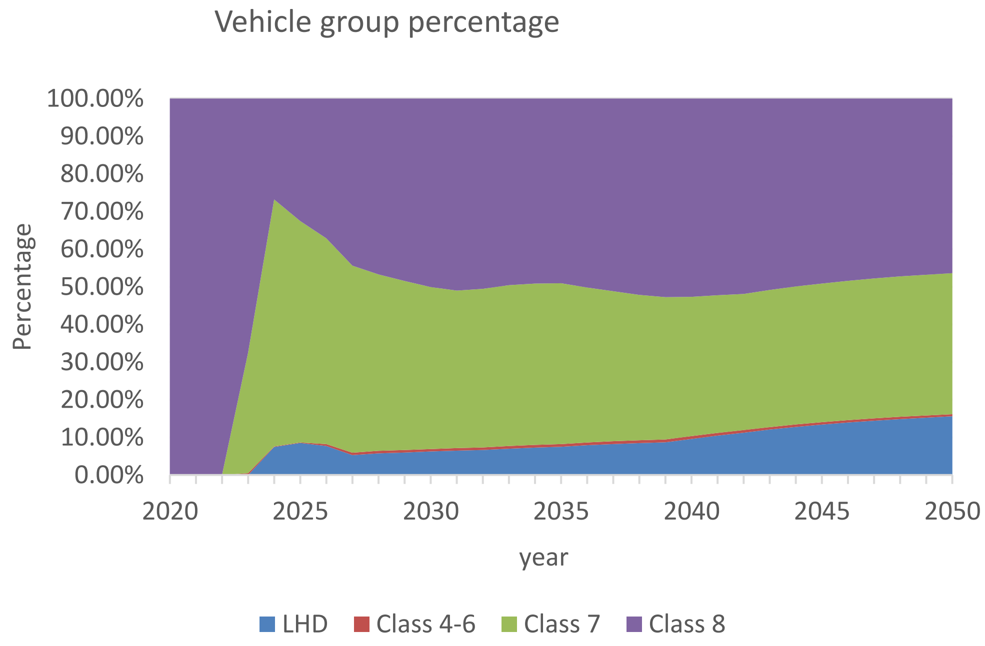


GPS location data (UCR & WVU) to inform the travel demand model, left: statistical distribution of trip start time (purple) and end time (green) for multiple applications, right: statistical distribution of trip duration (purple) and trip interval duration (green)

Integration with Existing Adaption Scenarios

- Harmonize CSTDM/CSFFM trips with EMFAC's vehicle categories and populations
- Re-group CSTDM/CSFFM trips into customized categories





Vehicle group aggregation

- LHD: load, haul, dump trucks
- Class 4-6: T6 Ag, T6 small (instate, OOS, CAIRP), T6 public, T6 utility, T6TS
- Class 7: T6 heavy (instate, OOS, CAIRP)
- Class 8: T7 trucks, buses

Note SSS adoption scenario provides adoption scenarios for 2024 – 2037

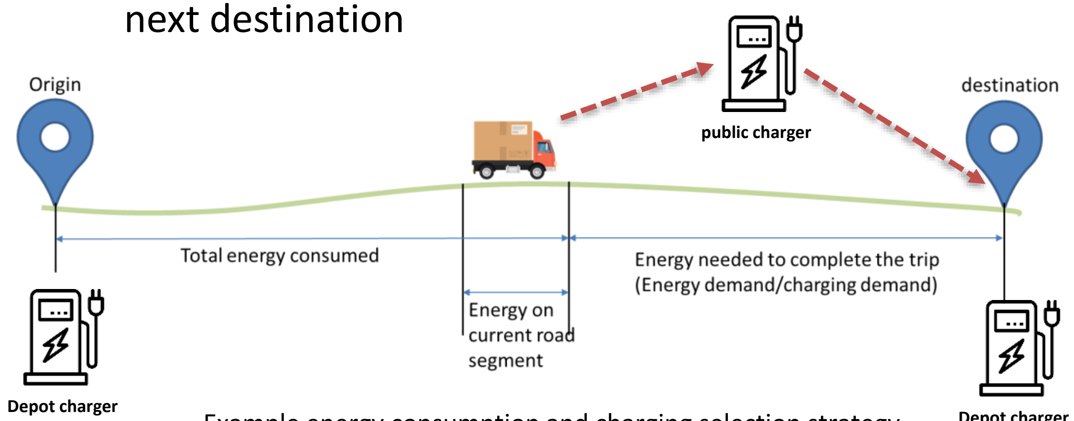
Customized Scenarios for HEVI-LOAD Bottom-up Simulation

	Baseline Scenario	Circuit Capacity Analysis	Smarting Charging Study	Energy Demand Estimation Study	Drayage Trip Study
Battery Capacity Level	B1: low (~200kWh), B2: medium (~400 kWh), B3: high (~600kWh)				
EV Adoption Scenario	SSS[1] 2030	SSS 2025, SSS 2030, SSS 2040, ACT/ACF	SSS 2030, ACT/ACF[2]	SSS 2030, ACT/ACF	SSS 2030, ACT/ACF
Charging Rate	Low (18:00-24:00), Medium (6:00-12:00), High (0:00-6:00 & 12:00-18:00)	C_1 (10kW-150kW), C_2(10kW-350kW), C_3(10kW-1MW)	C_1 (10kW-150kW), C_2(10kW-350kW)	C_1 (10kW-150kW)	C_1 (10kW-150kW)
Charger Placement	Charger level (kW) = [20, 50, 100, 200, 350, 500, 1000] Charger Num: 20 per station	Charger level (kW) = [20, 50, 100, 200, 350, 500, 1000] Charger Num: 20 per station	Charger level (kW) = [20, 50, 100, 200, 350] Charger Num: 20 per station	Charger level (kW) = [20, 50, 100] Charger Num: 20 per station	Charger number: assume no constraints
Charging Mode	Uncontrolled charging (with pre-assigned charging rates)	Uncontrolled charging, Smart charging	Smart charging: reduce peak load, energy cost	Uncontrolled charging	Uncontrolled charging
Energy Pricing	E-19 PG&E	E-19 PG&E	Dynamic pricing, PG&E E-19, PG&E-REV, PG&E-BEV	E-19 PG&E	E-19 PG&E

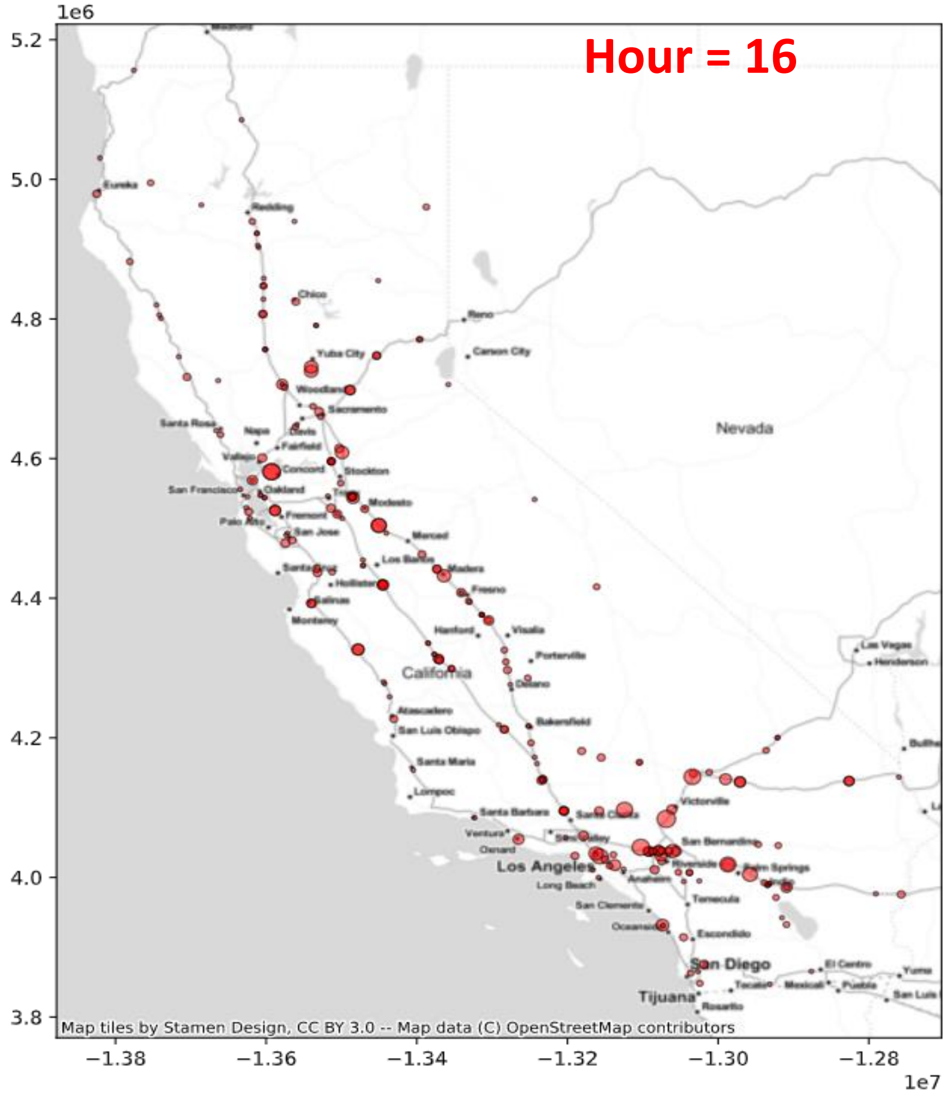
1. **SSS**: CARB State SIP Strategy Scenario, https://ww2.arb.ca.gov/resources/documents/2022-state-strategy-state-implementation-plan-2022-state-sip-strategy
2. **ACT/ACF**: CARB Advanced Clean Truck and Advanced Clean Fleet scenarios, https://ww2.arb.ca.gov/our-work/programs/advanced-clean-trucks, https://ww2.arb.ca.gov/resources/fact-sheets/advanced-clean-fleets-regulation-summary

Quantify Charging Demand and Load Profile over Candidate Locations

- Simulate the entire driving-routing-parking-charging behavior chain within HEVI-LOAD
- Compute routes for each trip using the routingkit[1]
- Solve the charging plans for each trip (depot vs. public chargers)
- Develop algorithms to select the enroute charger(s) with the shortest distance/travel time
- Compute the energy consumption over each road segment and estimate the energy needed to reach next destination



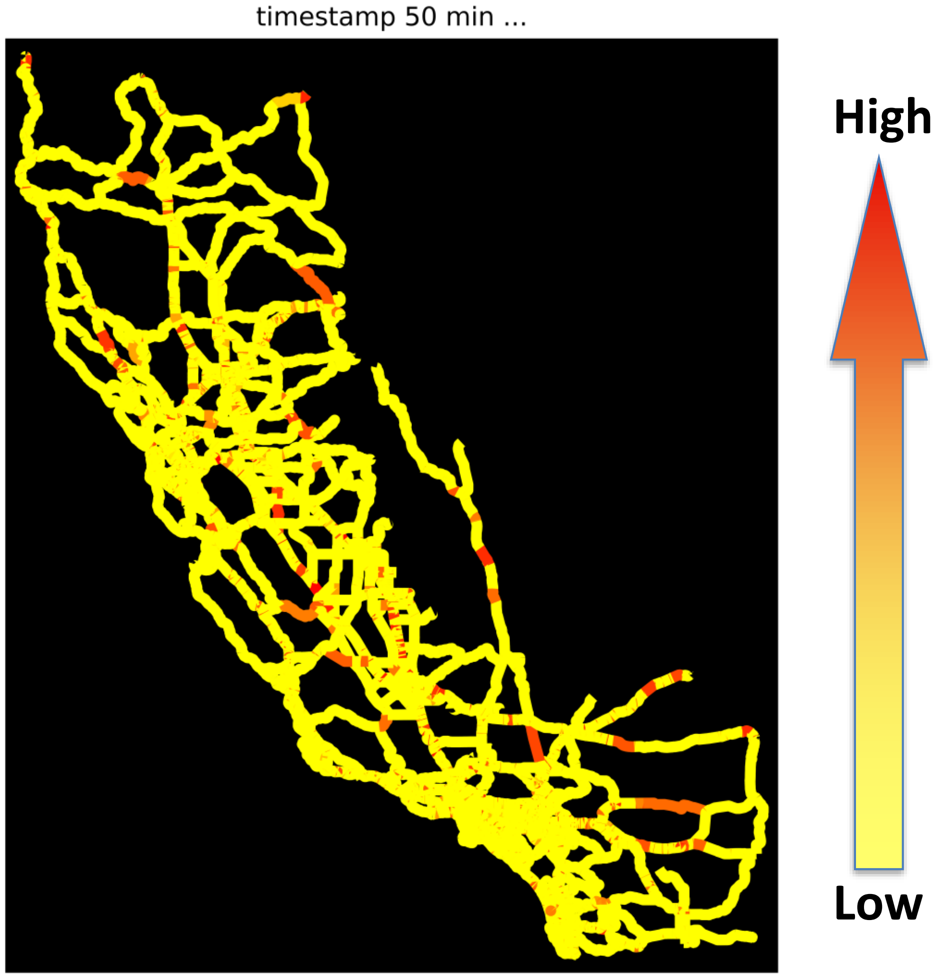
Example energy consumption and charging selection strategy

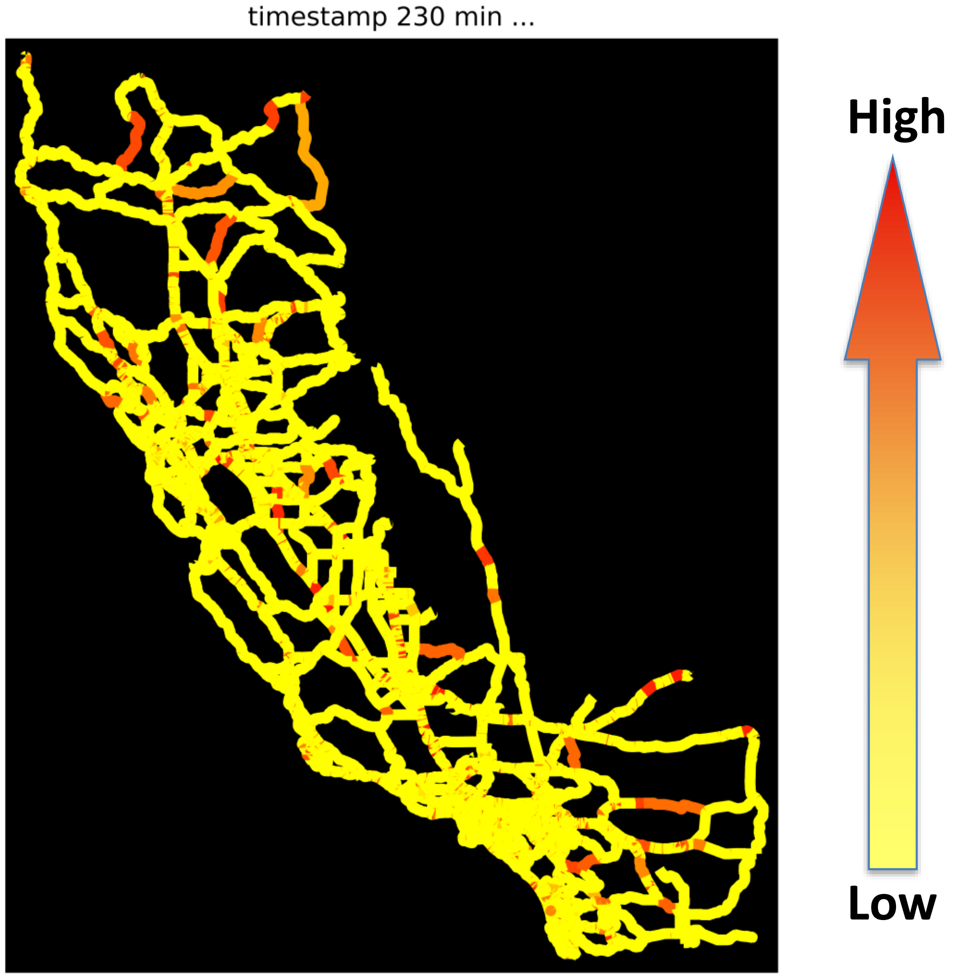


- **Radius of red circles is proportional to the charging demand at each site (truck stops and rest area, etc.)**
- **Aim to assist planning agencies to prioritize infrastructure deployment locations**
- **Can assist to identify freight corridors and critical locations**

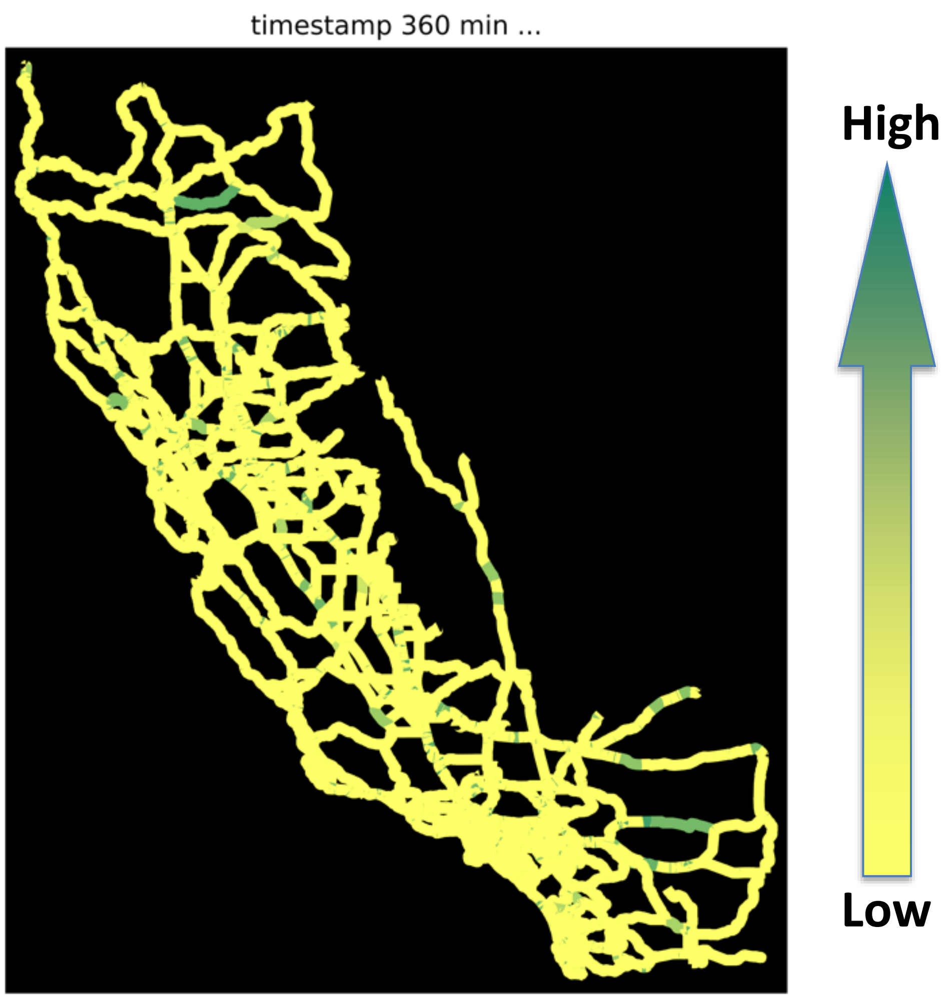
1 - Routingkit:https://github.com/RoutingKit/RoutingKit

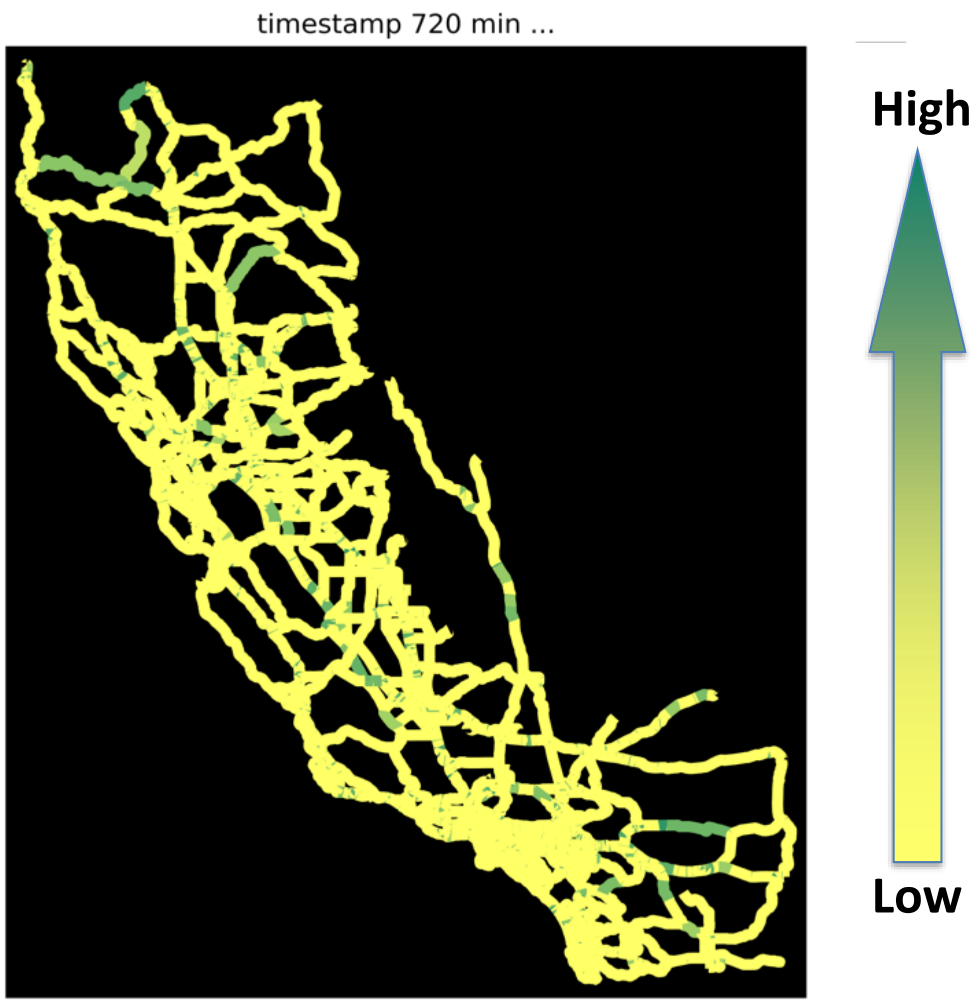
Energy Consumption Estimation by Road Segments





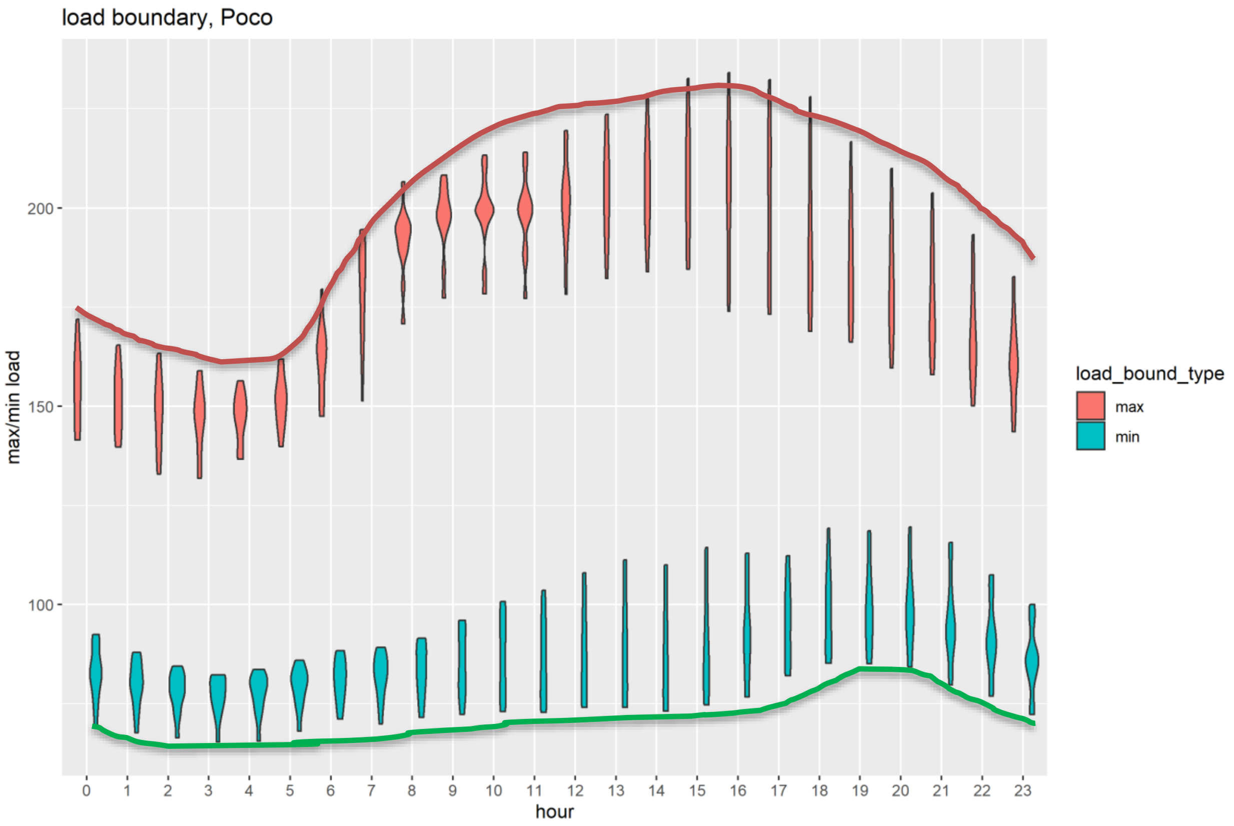
Charging Demand Quantification over Road Segments

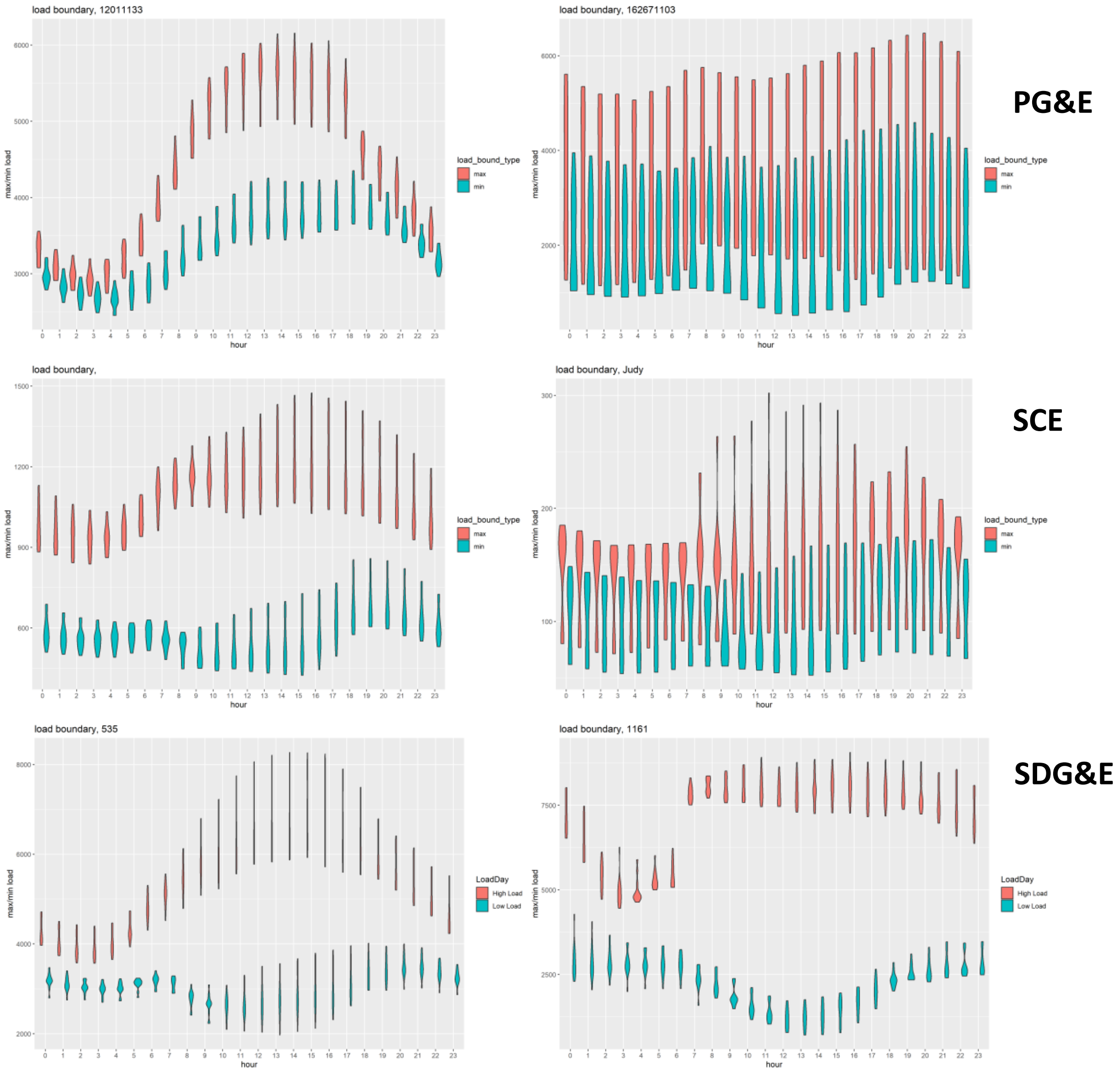




Circuit Load and Capacity Analysis

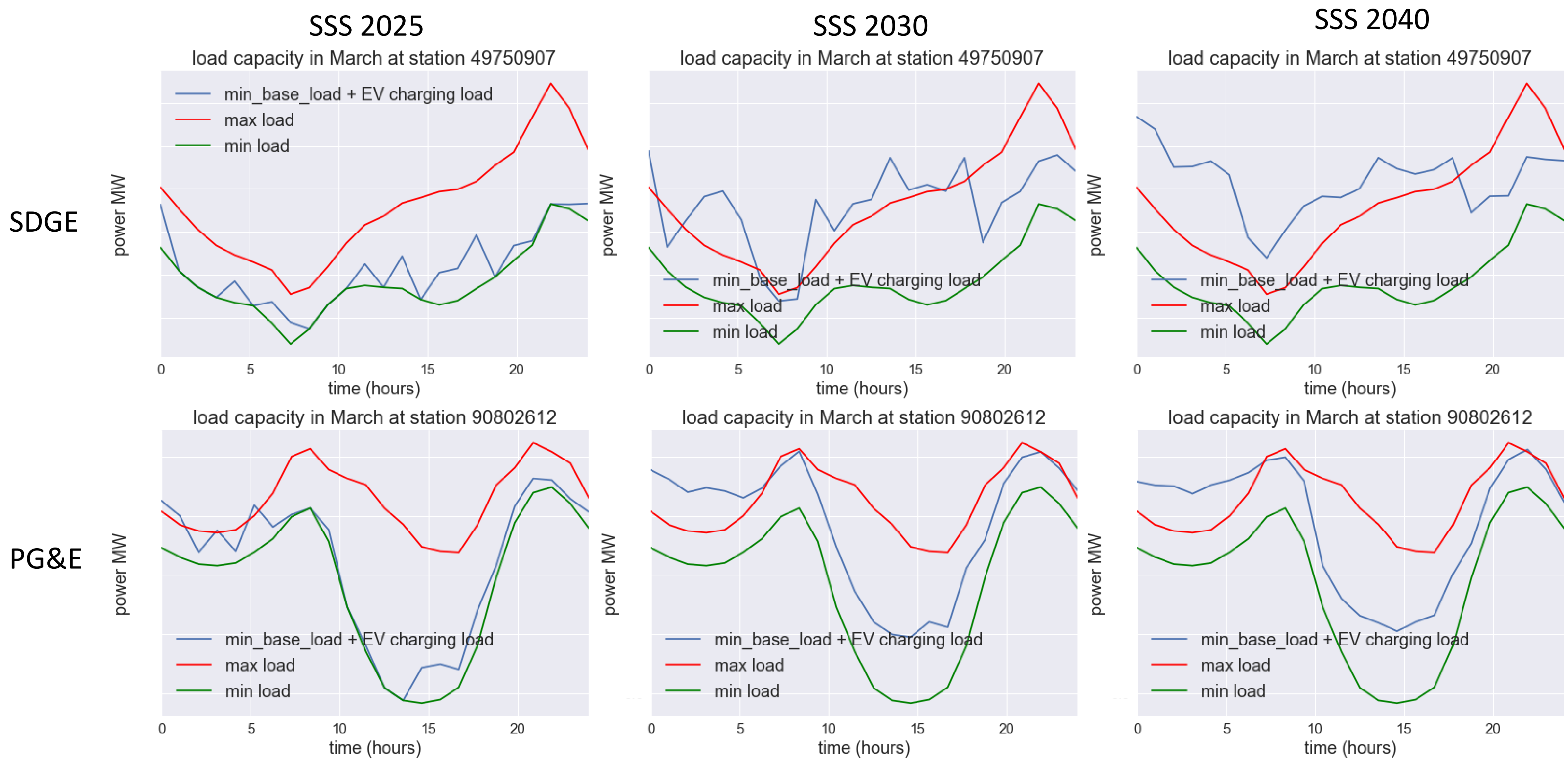
- Quantify the load variation, e.g. the upper and lower boundaries of the circuit baseload
- Prepare the load patterns for circuit capacity analysis with simulated MDHD EV charging load





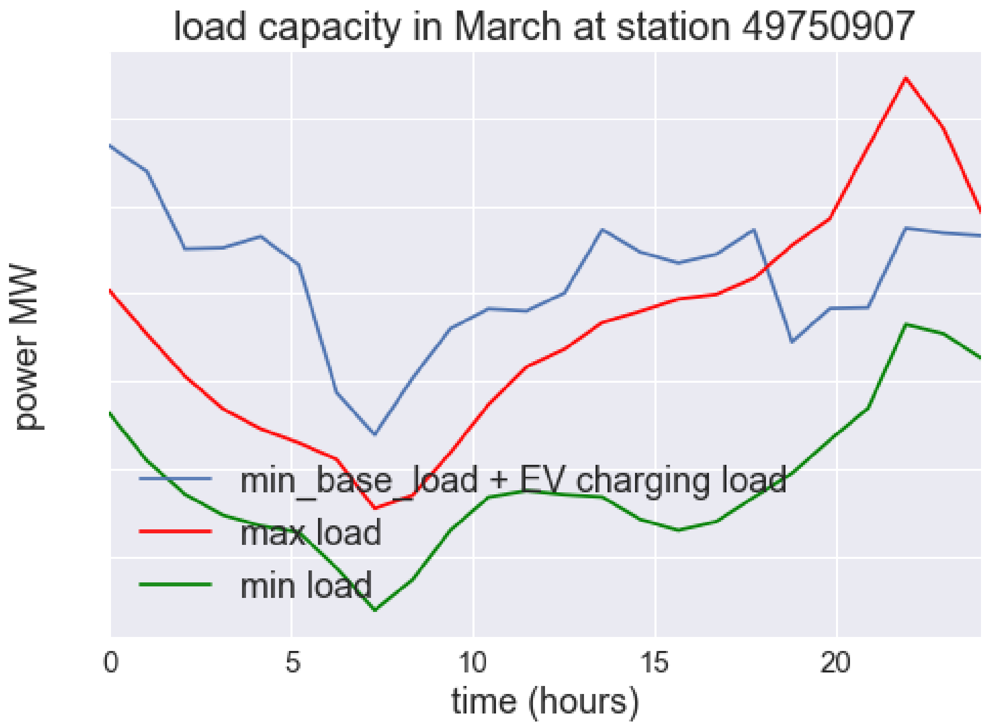
Example Load Patterns

Circuit Capacity Analysis at the Site Level (optimistic)

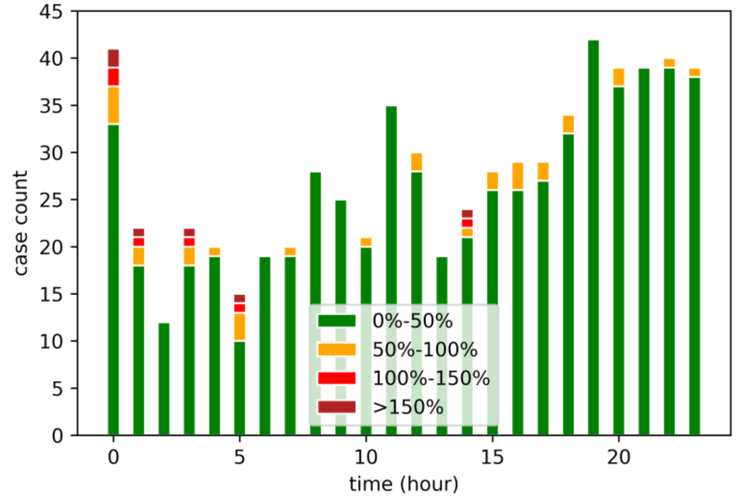


Circuit Capacity Analysis

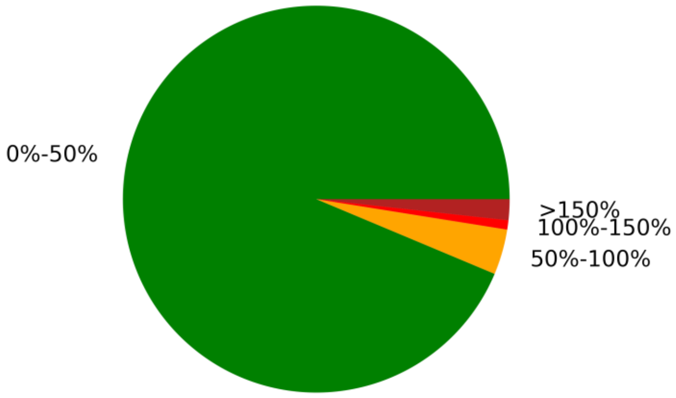
- Summarize the hourly EV charging load, grid capacity and base load statistics
- Identify the number of potential overload cases in the future
- Compare the new load with the circuit capacity limit and dynamic high load boundary



SSS 2025 Scenario

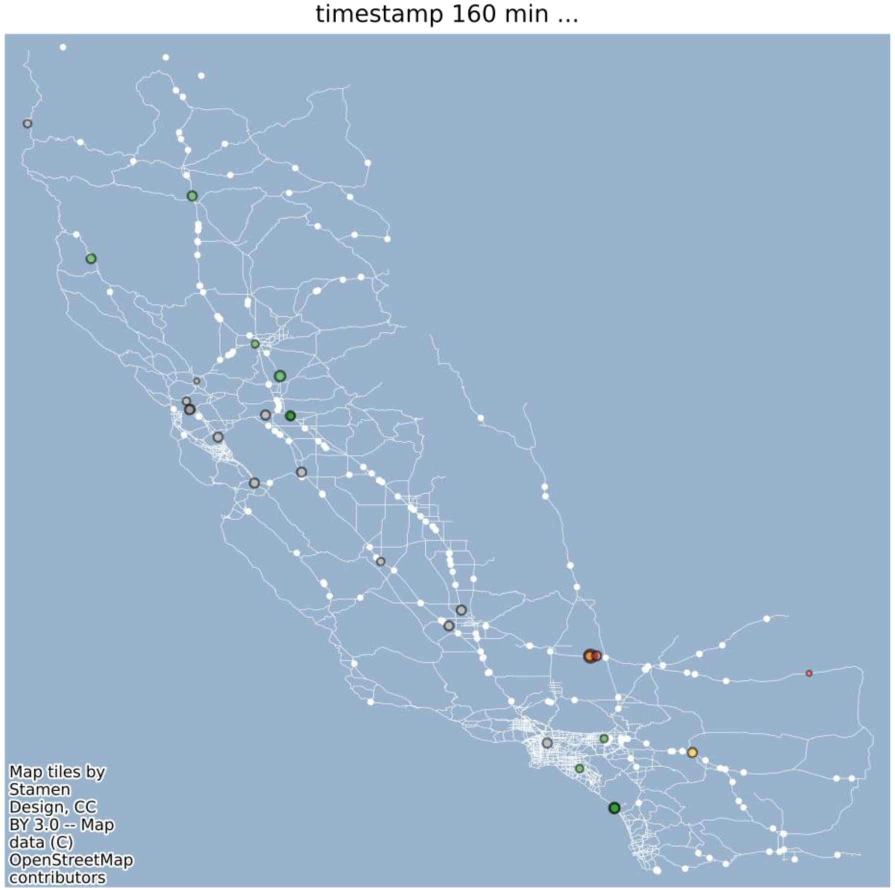


$$exceeding\ \% = \frac{exceeding\ amount}{max\ load\ bound}$$

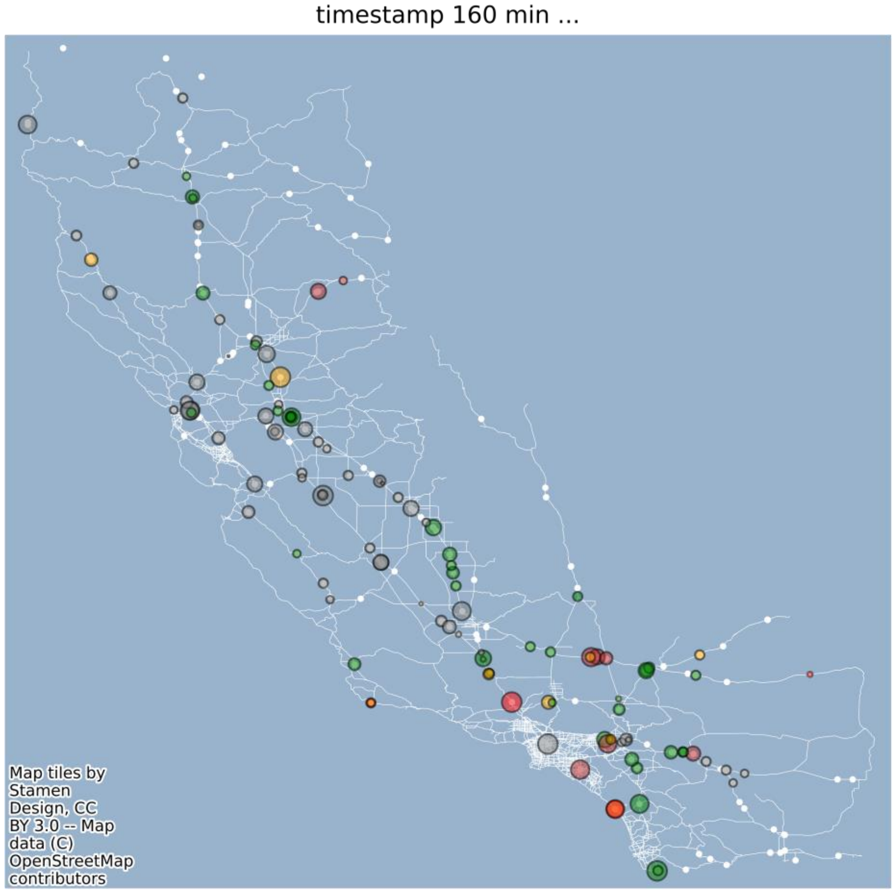


Circuit Capacity Analysis (Preliminary) – SSS 2025 and SSS 2030

- Site-level charging load at same time of a work day, colors show different percentage loading scenarios
  - Percentage loading: K = current load/load capacity
  - green: K = 0% - 50%, yellow: K = 50% - 100%, red: K > 100%, gray: circuit capacity data not available



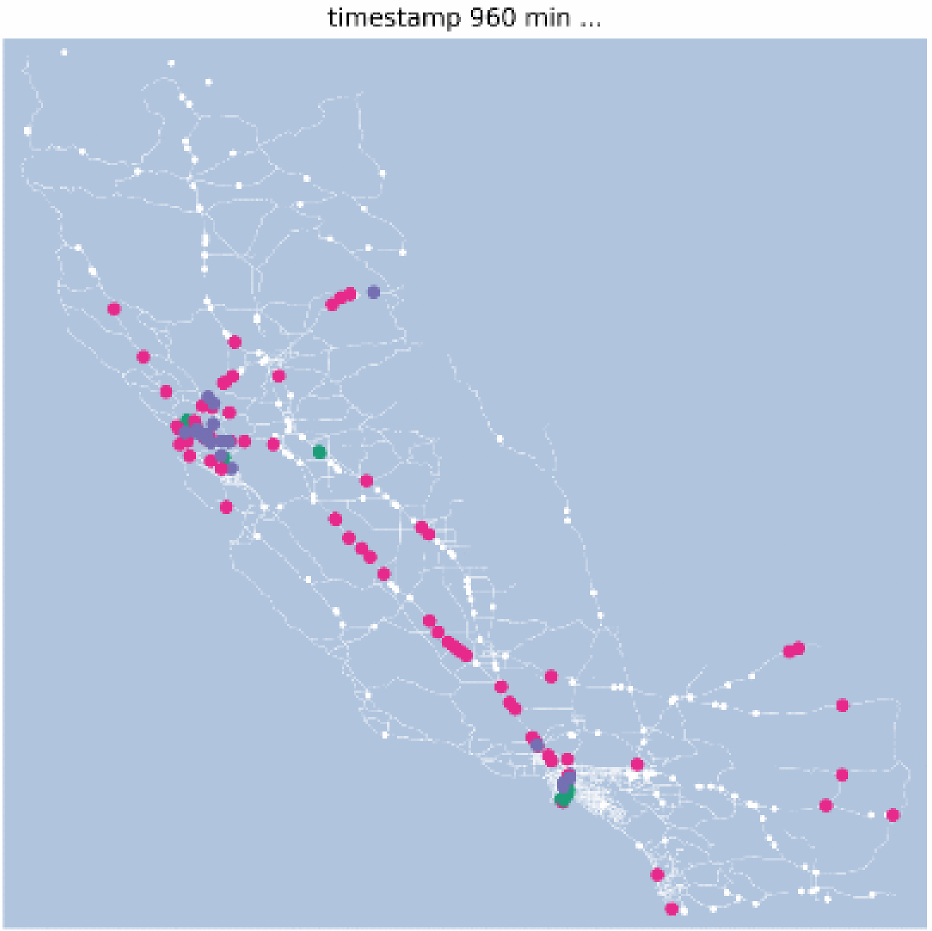
SSS 2025



SSS 2030

Drayage Trip Study - Location and Vehicle Type Specific

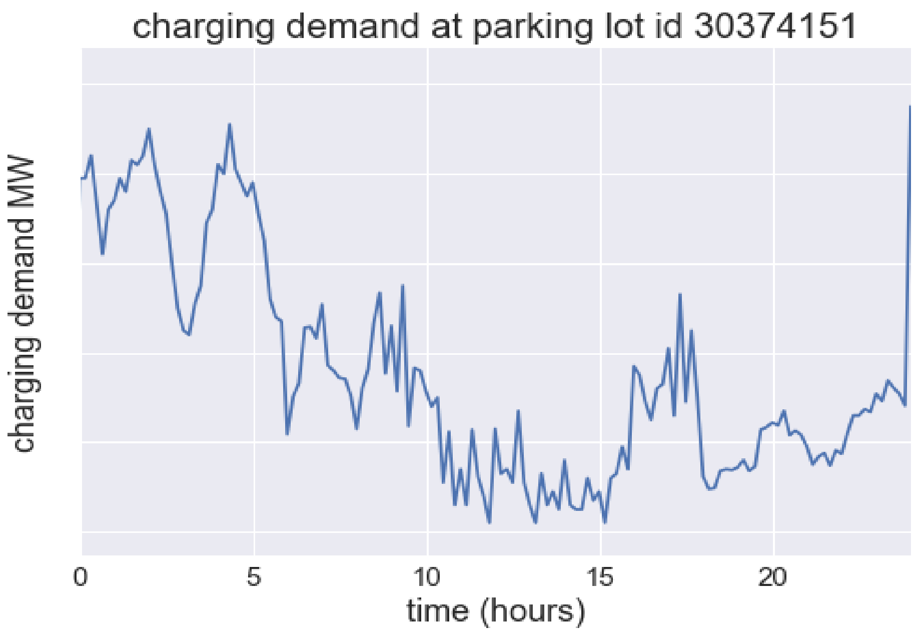
- **Battery capacity level**: [B1: 200kWh, B2: 400kWh, B3: 600kWh]
- **Ports: Port of Oakland, Port of LA, Port of Long Beach**
- **Drayage Trip Scenario**: ACT+ACF 2030 (Approx.: 3900 drayage trips per day, enter/exist above ports)
- **Charging rate**: we define three vehicle charging rate during the day for each level:
  - Cn: [rate1(18:00-24:00), rate2(6:00-12:00), rate3(0:00-6:00, 12:00-18:00)]
  - C1: [10 kW, 20 kW, 50 kW]
  - C2: [20 kW, 50 kW, 100 kW]
  - C3: [50 kW, 100 kW, 150 kW]
- **Vehicle groups**: based on different **battery capacity levels, charging rate levels and vehicle classes from EMFAC**, we divided the 34 vehicle types into 6 vehicle groups:
  - LHD: [B1, C1], Class 4-6: [B2,C1], Class 7: [B2,C2], Class 8: [B2, C3], [B3,C2], Buses: [B3,C3]
- **Charging Scenario:**
  - Overnight charging/parking: Assume of 70% vehicles will charge/park nearby the port to charge overnight before the trip start



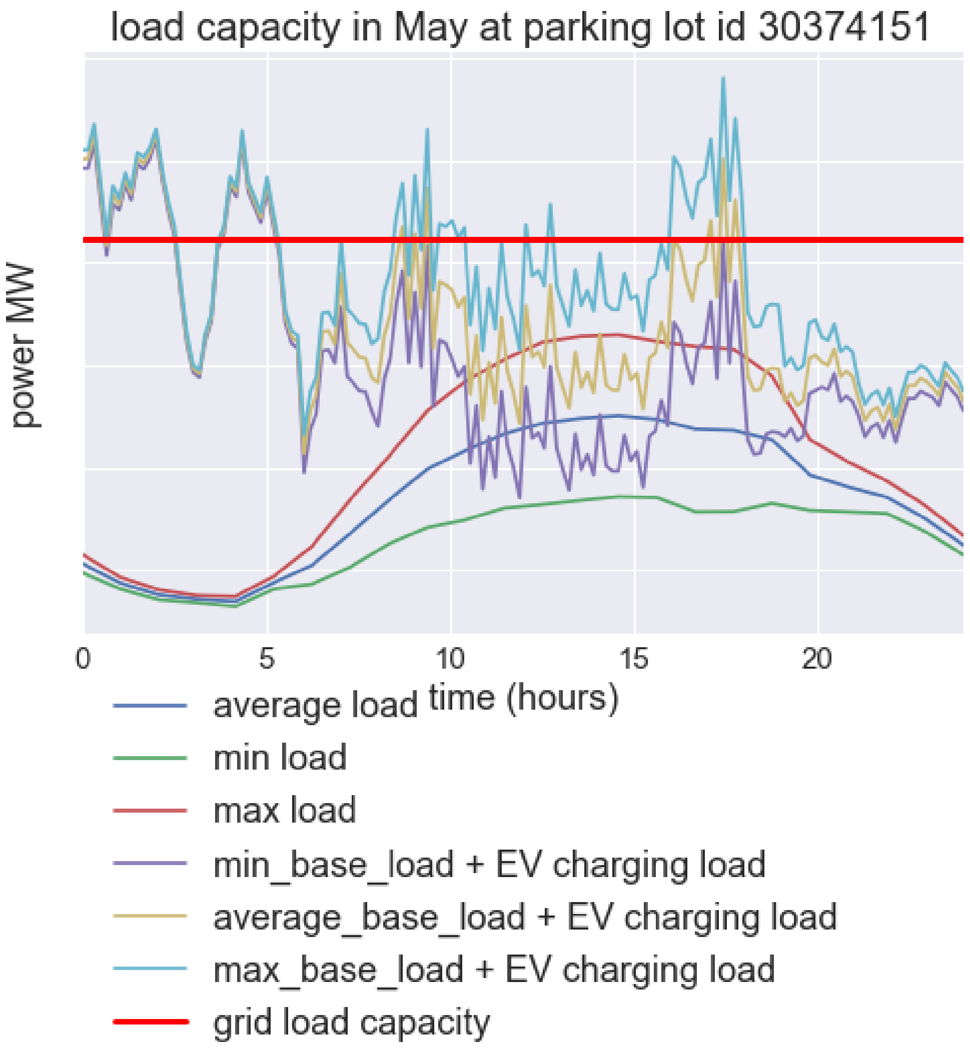
Drayage Charging Load Profile (Preliminary)

PG&E territory, close to Port of Oakland

- Simulate the drayage trips near the port area
- Quantify the charging load throughout the day



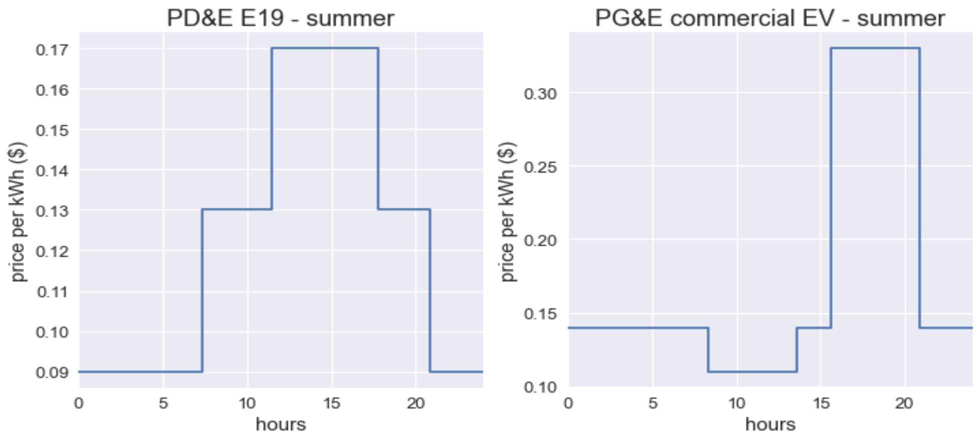
Simulated charging load at site-level



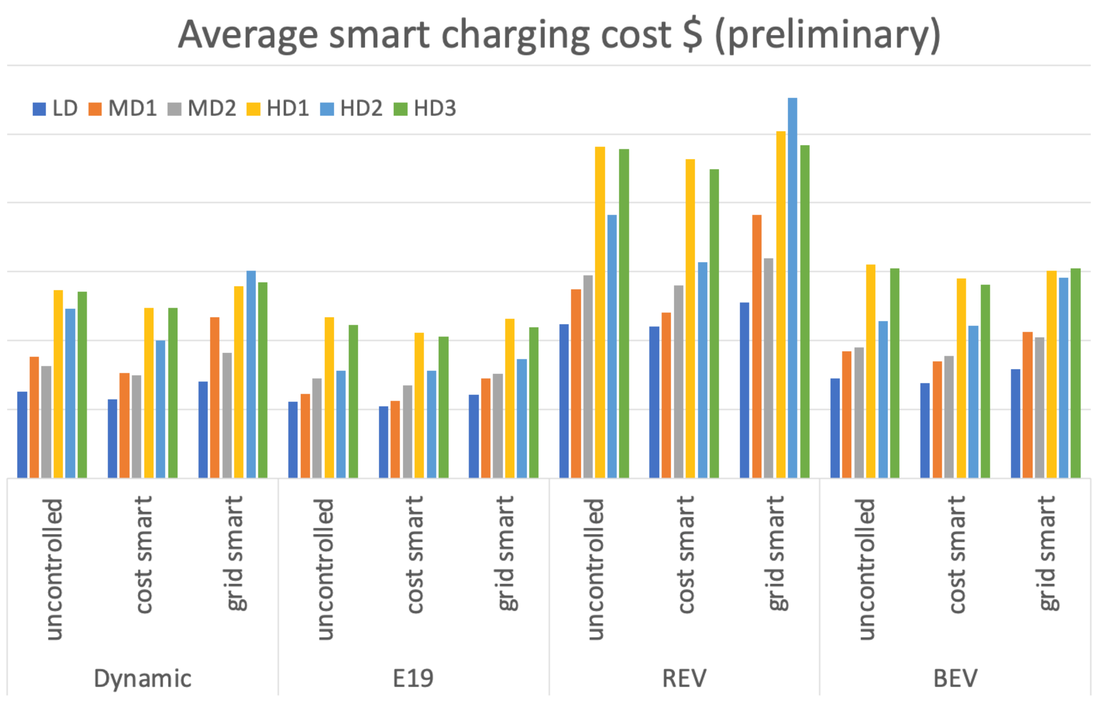
* Note that these are preliminary results needs to be validated with utility

Smart/Managed Charging Design

- Multi-objective design
  - Reduce peak charging load
  - Reduce overall charging cost
- Incorporate time-of-use pricing
  - Energy charges
  - Demand charges
- Will consider the integration of co-located distributed energy resources
  - Energy storages
  - Solar PV generative
- Integration with HEVI-LOAD
  - Assumption about the flexibility of each MD/HD trip, i.e., the extra time when the charging load can be managed
  - Communication about pricing info schedule among operators and drivers in the simulated environment



Example Time-of-Use Pricing Schemes

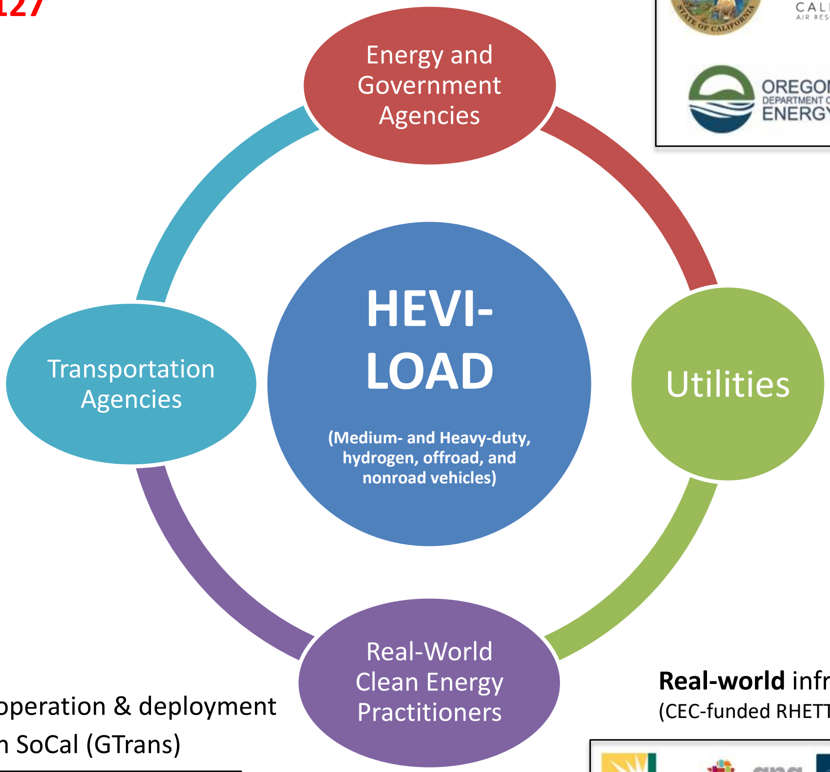


Challenges and Future Work

- Challenges
  - Data needed to
    - Characterize the MD/HD fleets penetration, business-as-usual duty-cycles and tour-based travel demand
    - Candidate locations for future infrastructure deployment, beyond truck stops, rest areas, critical warehouses/distribution centers, and existing refueling stations, etc.
    - Validate the assumptions in the simulation models
  - Model and simulation validation
    - Calibrate the simulated scenario with real-world deployment practices
- Current and future work
  - Fully integrated scenario analysis
  - Work with utility to validate the circuit capacity analysis
  - Incorporate hydrogen refueling infrastructure into the simulation and analysis
  - Finalize the results into AB 2127 reports

Call to Action – Look Forward to Working with You!

- AB 2127



Utility collaboration via WCCTCI

Real-world infrastructure operation & deployment (for electric transit buses in SoCal (GTrans)

Real-world infrastructure planning case (CEC-funded RHETTA for T7 & T8 heavy-duty ZEVs along CA freight corridors)

Thanks!

Bin Wang, LBNL, wangbin@lbl.gov

Micah Wofford, CEC, micah.wofford@energy.ca.gov

WIRED (UC Davis)

WIRED: TNC infrastructure deployment model

California Energy Commission Workshop

Alan Jenn, PhD

Assistant Director & Associate Professional Researcher

Institute of Transportation Studies

University of California, Davis

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WIRED model framework

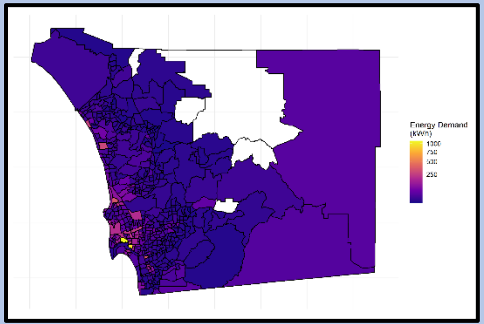
Empirical Trip Data

Uber lyft

Station Attributes

chargepoint EVgo electrify america

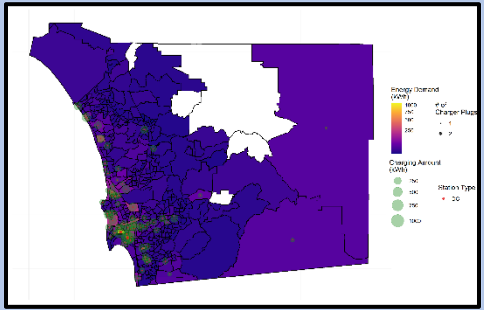
Bootstrap Data to Simulate Demand



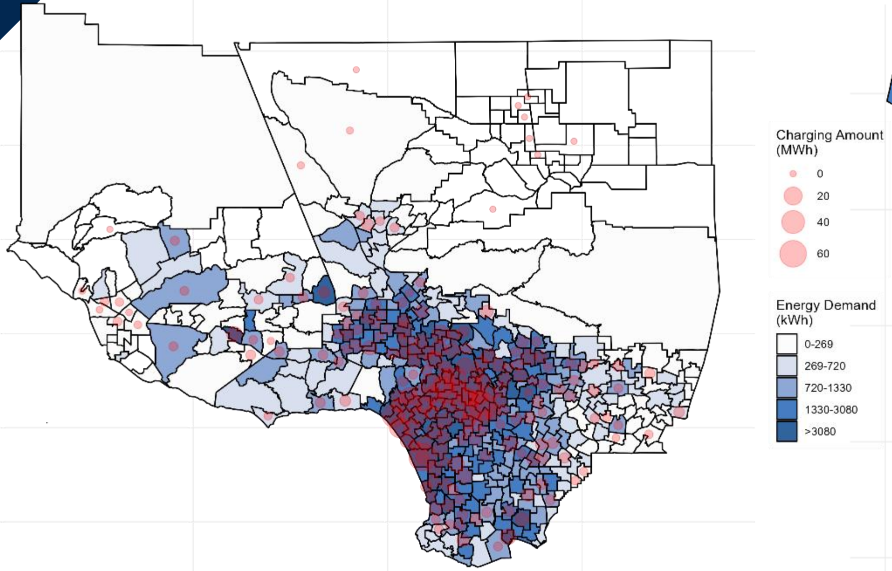
Widespread Infrastructure for Ride-Hailing EV Deployment (WIRED) model

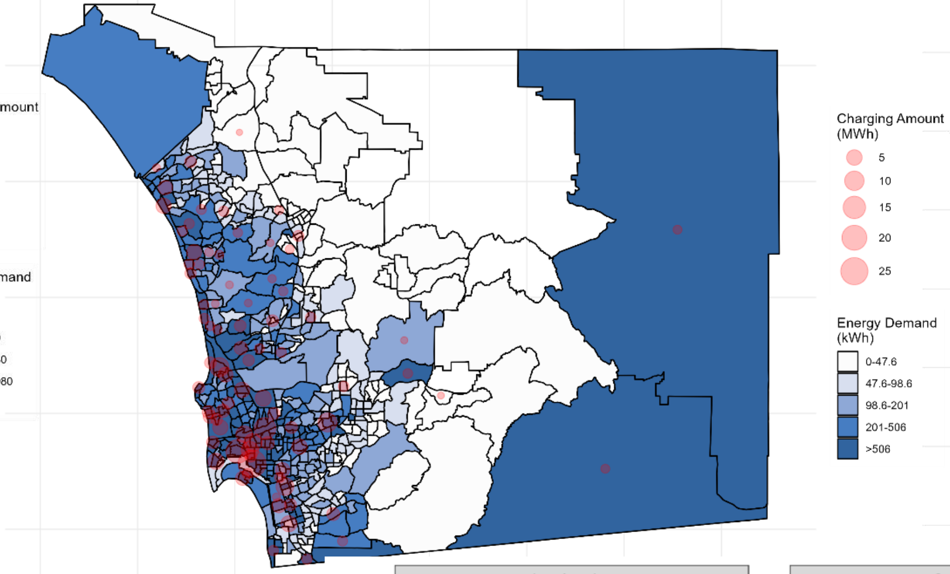
- Reduce costs to charge and downtime (traveling and charging) of drivers
- Meets energy requirements for trips provided throughout the day

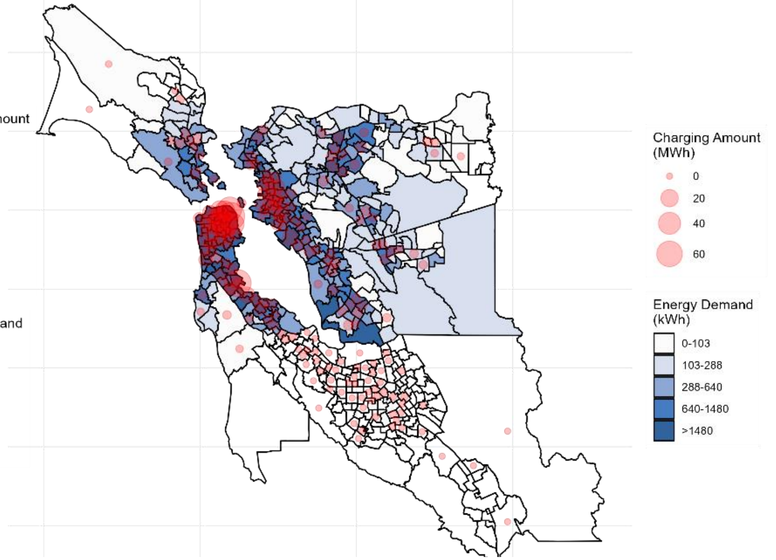
Infrastructure Deployment Results

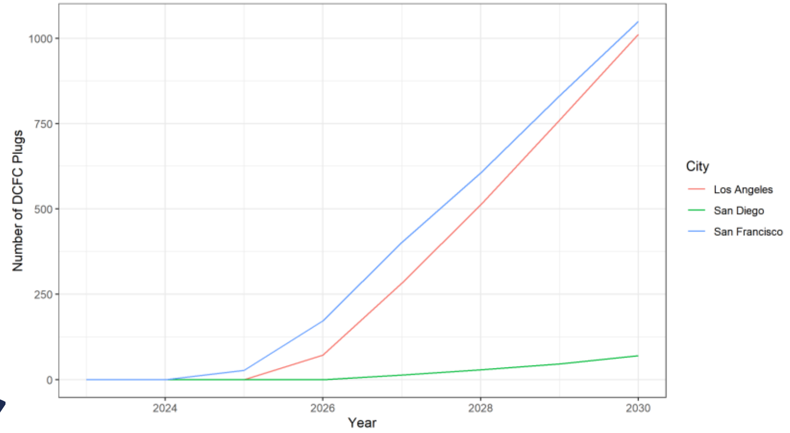


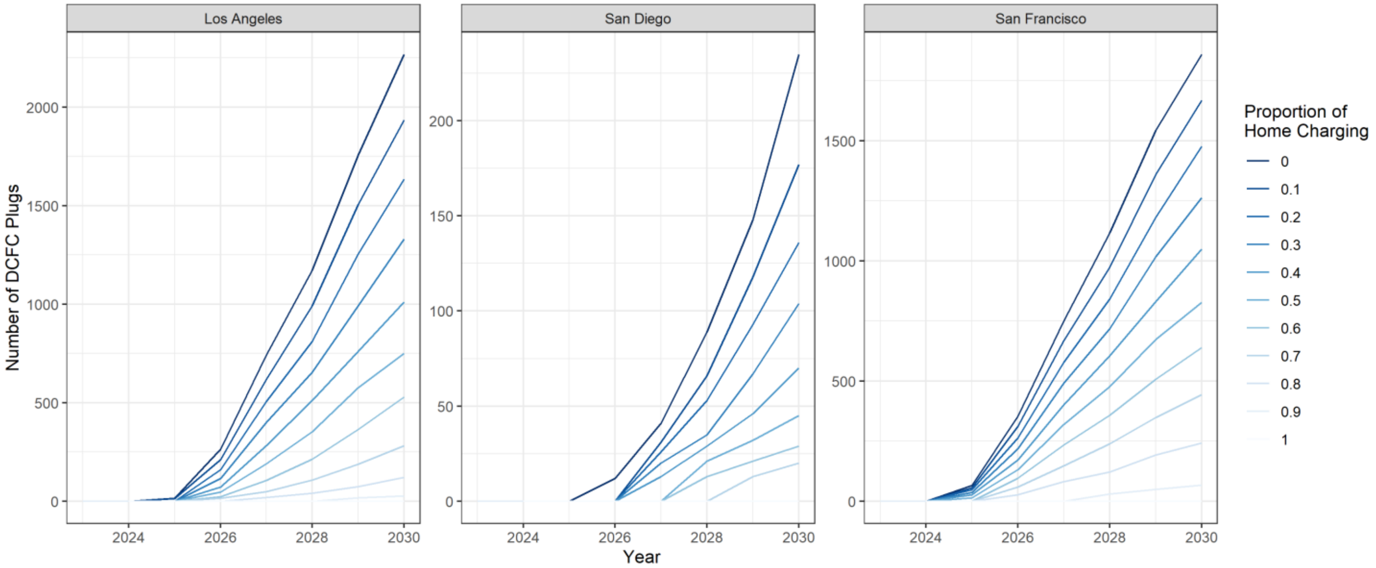
WIRED Infrastructure Deployment











AB 2127 2nd Assessment Updates

- Extend analysis to 2035 from 2030
- Ride-hailing demand and electrification rates are based on pre-pandemic values – we would update these volumes based on updated projections
  - Scaling trip-level data based on volumetric travel data from TNCs
- Provide update infrastructure requirements for the state of California
  - Total infrastructure requirements for CA
  - Infrastructure requirements for San Diego, Los Angeles, and San Francisco

Long-term updates

- Better calibration and sensitivity of home charging availability and work-from-home
- Higher resolution analysis of cities outside of San Diego, Los Angeles, and San Francisco in California
- Update vehicle models to reflect a more representative breakdown of ranges and classes
- Update infrastructure types to reflect higher power charger availabilities
- Introduce pricing elasticities for better representation of responsiveness to pricing plans

Thank you!

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Q&A and Public Comment

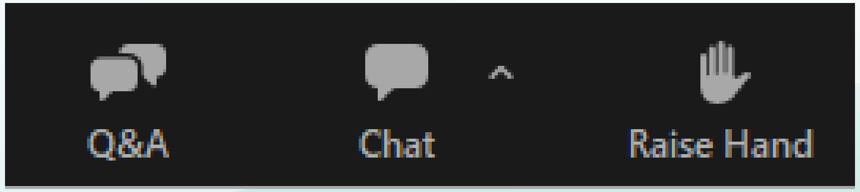
Public Discussion

Zoom Participants:

- Use the “raise hand” feature to make verbal comments
- Use the Q&A feature to type in your question

Telephone Participants:

- Dial *9 to raise your hand
- Dial *6 to mute/unmute your phone line.



Discussion Topics

- HEVI-LOAD inputs, assumptions, and scenarios
- WIRED inputs and assumptions
- Medium- and heavy-duty electric vehicle infrastructure
- EV infrastructure for transportation network companies (TNCs)

Written Comments

Electronic Commenting System

Visit the comment page for this docket at:
https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=19-AB-2127

Comment by E-mail

Email: docket@energy.ca.gov

Subject Line: "Second AB 2127 Assessment"

All comments due by 5:00pm on Wednesday, November 23, 2022

Thank you