When Will California's Electric Distribution System Need to be Upgraded to Meet Electric Vehicle Charging Demand?

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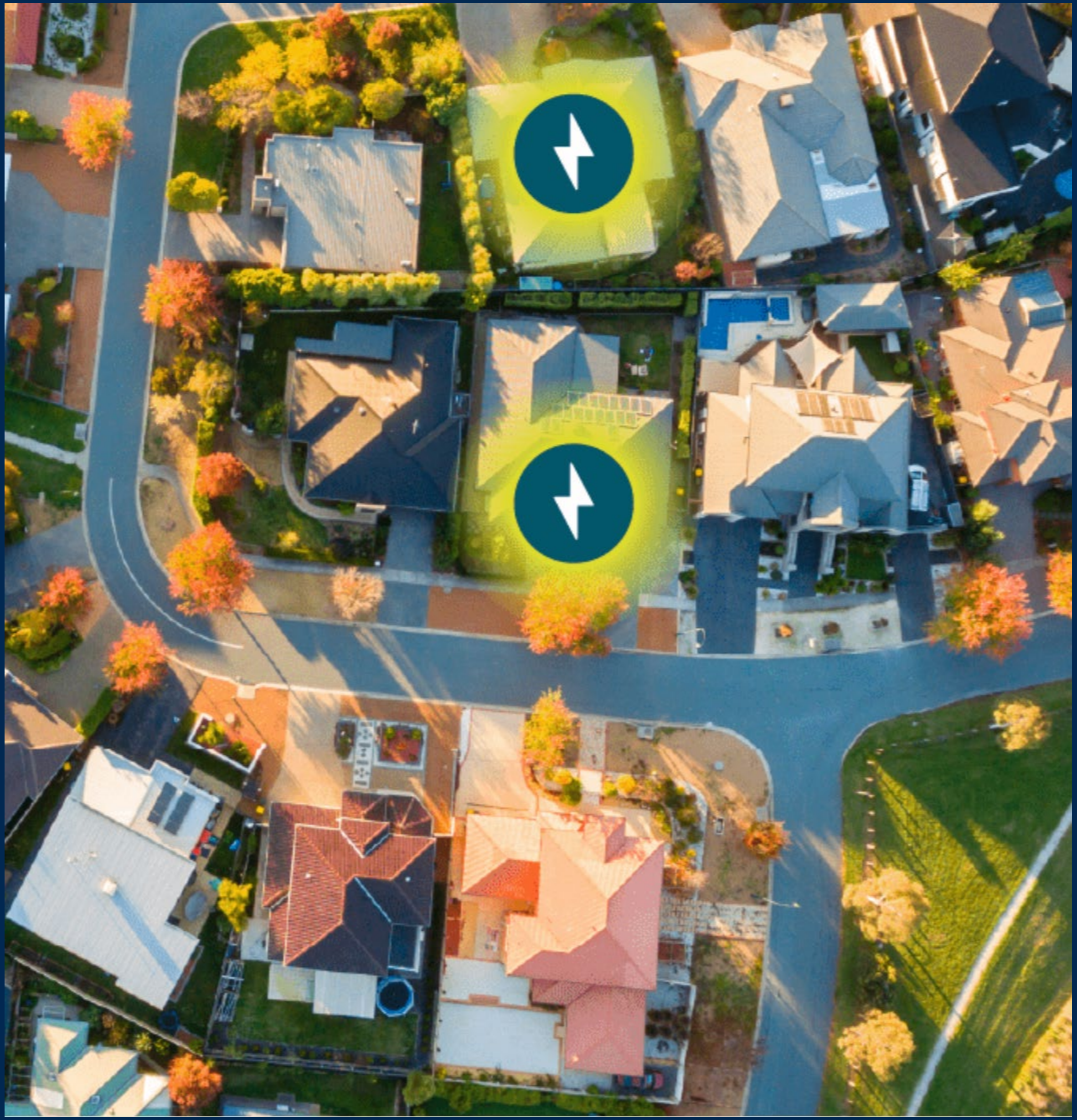


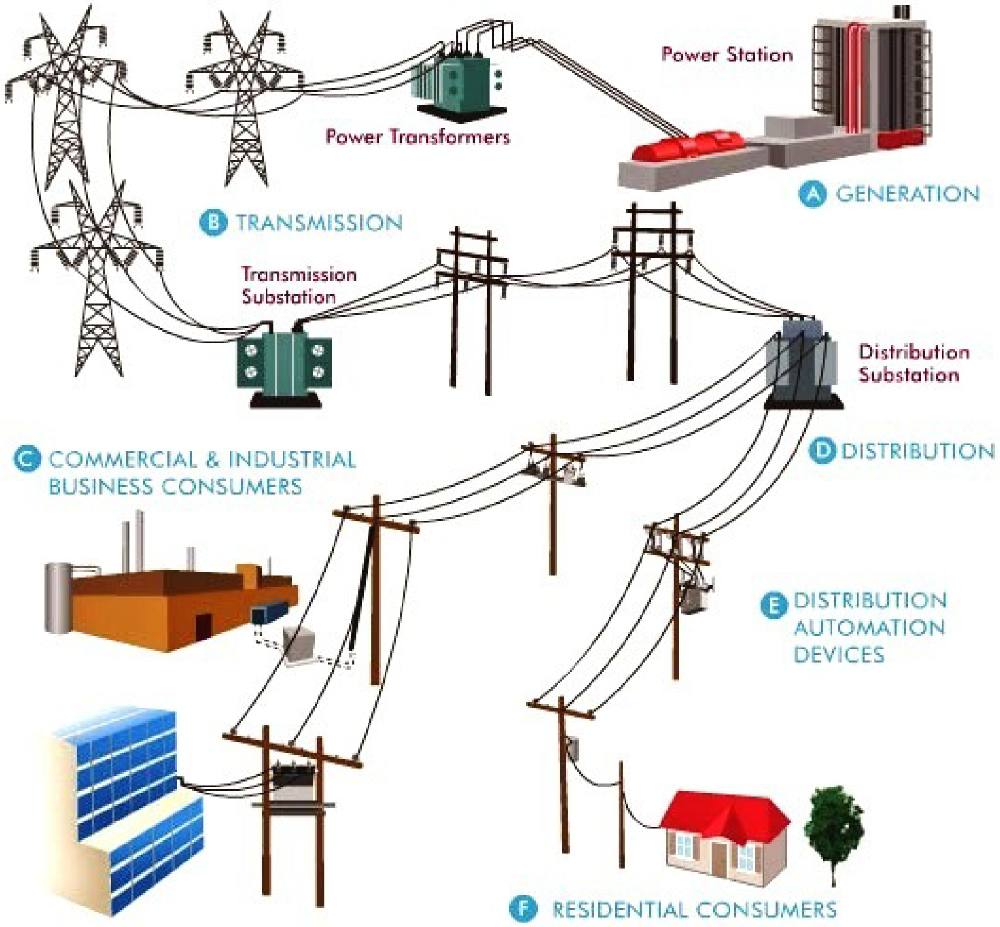
INTRODUCTION

Background

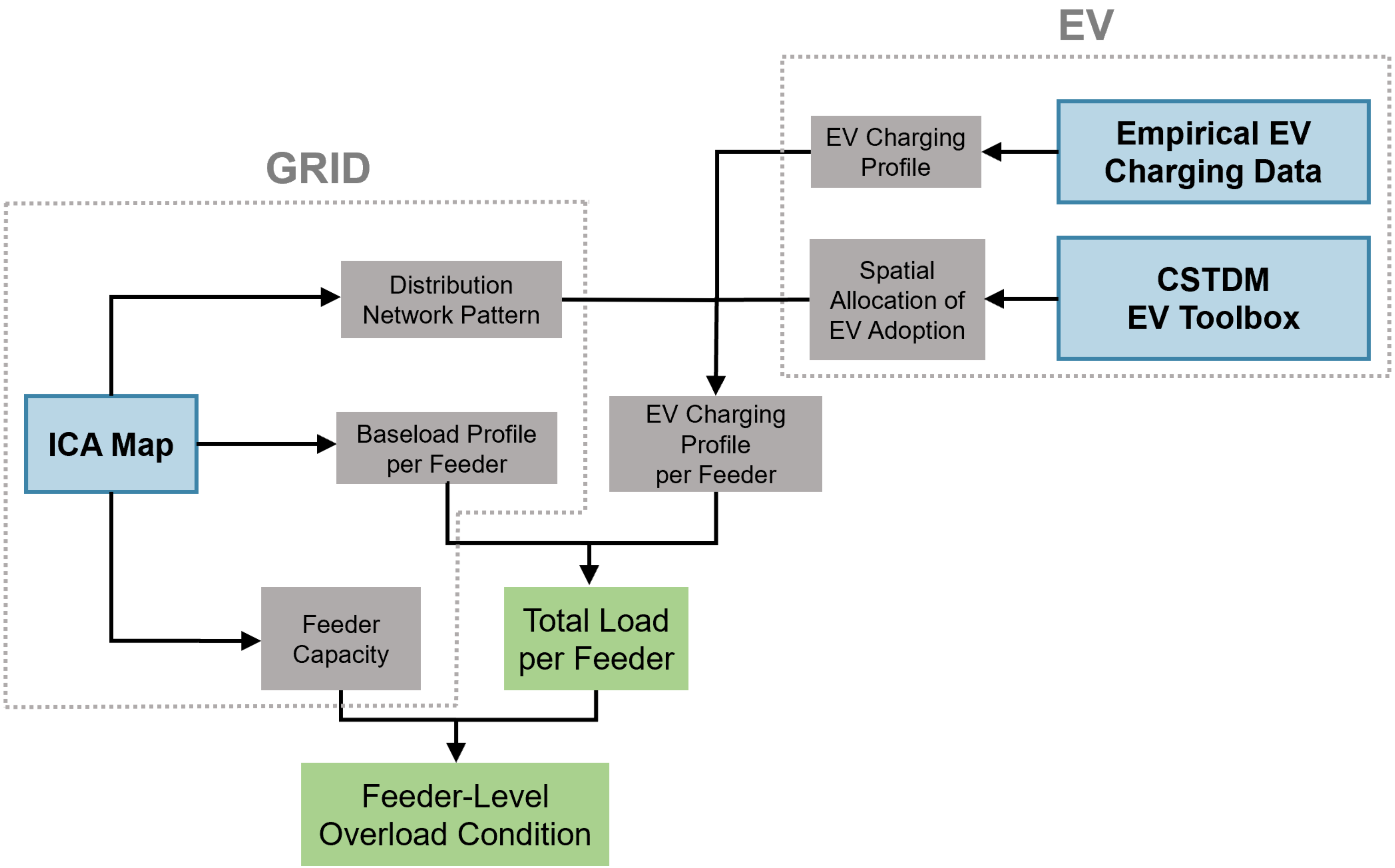
- California's ambitious EV policies may generate a large burden of EV charging load on the power system.
- The distribution grid will encounter challenges before the generation and transmission levels.
- It is essential to understand:
    - How constrained the distribution grid will be
    - How much upgrade should be in place for future EV charging demand

In this study

- We use spatial and temporal data from the utilities that address distribution network capacity limits at feeder level;
- We employ EV adoption model, travel demand model, and empirical EV charging data for future EV charging load projection;
- We examine overload condition in the distribution system from 2022 to 2045 in the 3 major IOU territories.

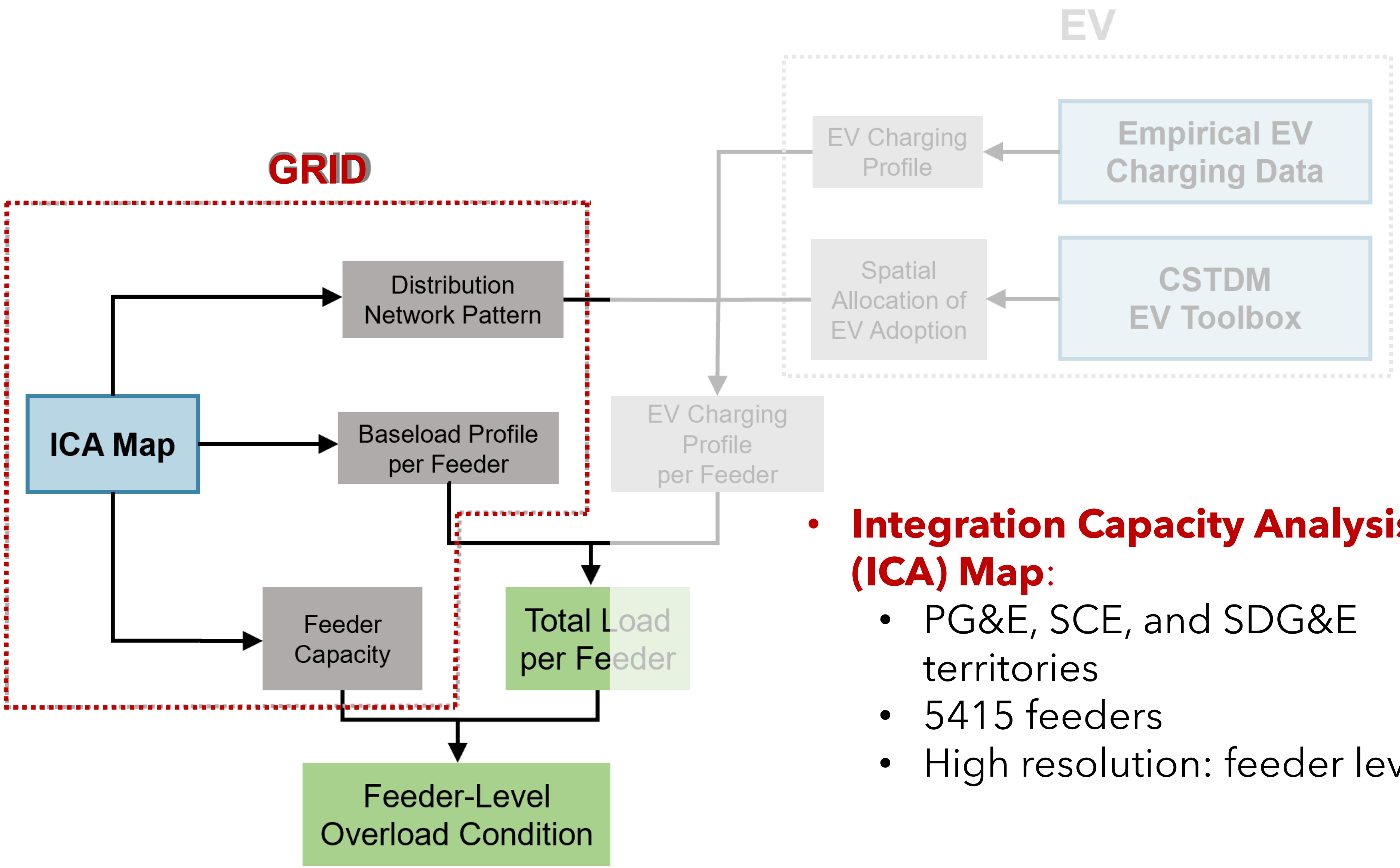


METHODS



EV
GRID
EV Charging Profile
Empirical EV Charging Data
Spatial Allocation of EV Adoption
CSTDM EV Toolbox
Distribution Network Pattern
ICA Map
Baseload Profile per Feeder
EV Charging Profile per Feeder
Feeder Capacity
Total Load per Feeder
Feeder-Level Overload Condition

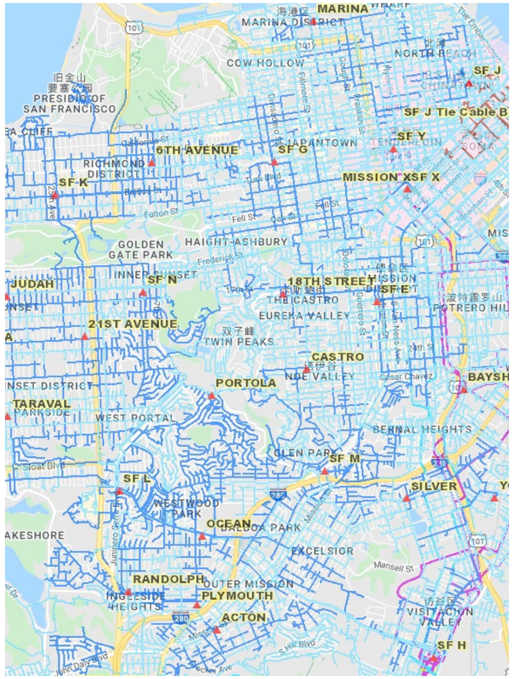
METHODS | Spatial and Temporal Data from Utilities



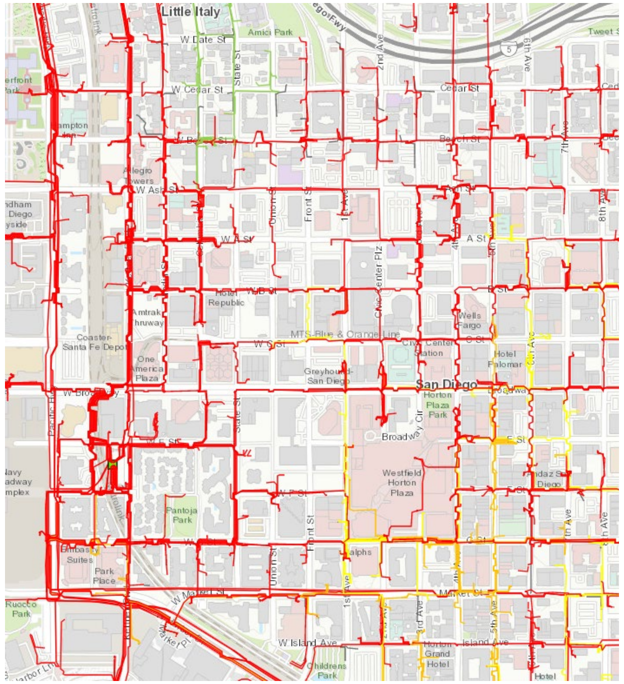
- **Integration Capacity Analysis (ICA) Map**:
  - PG&E, SCE, and SDG&E territories
  - 5415 feeders
  - High resolution: feeder level

METHODS | ICA Map

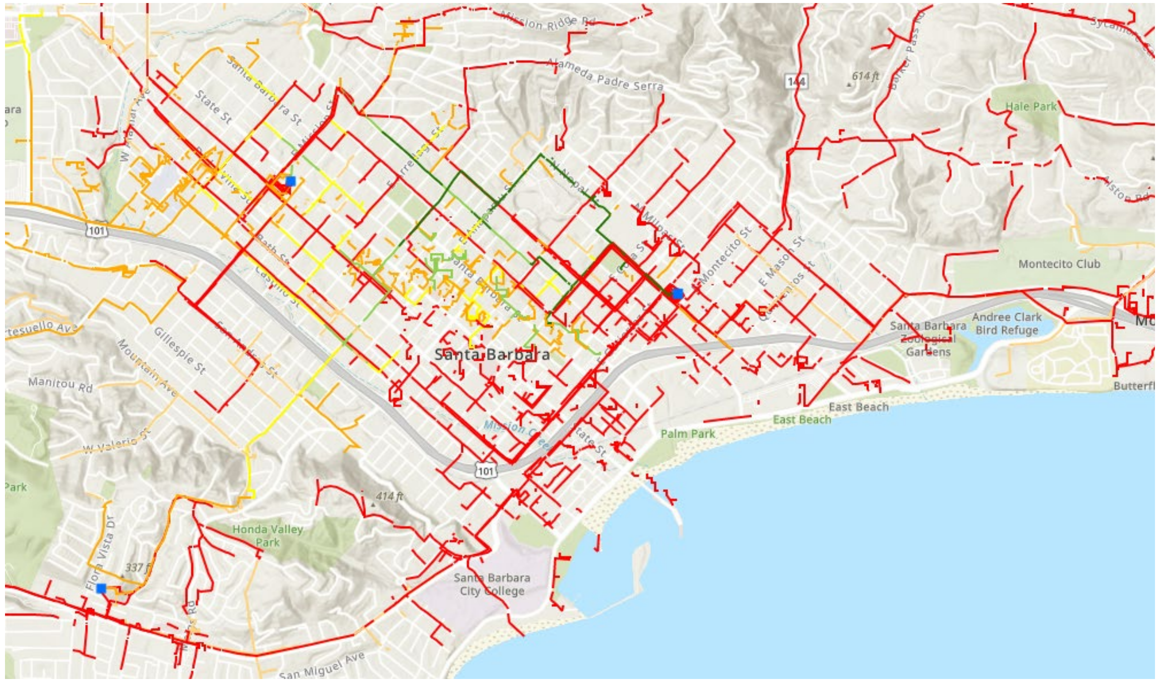
PG&E



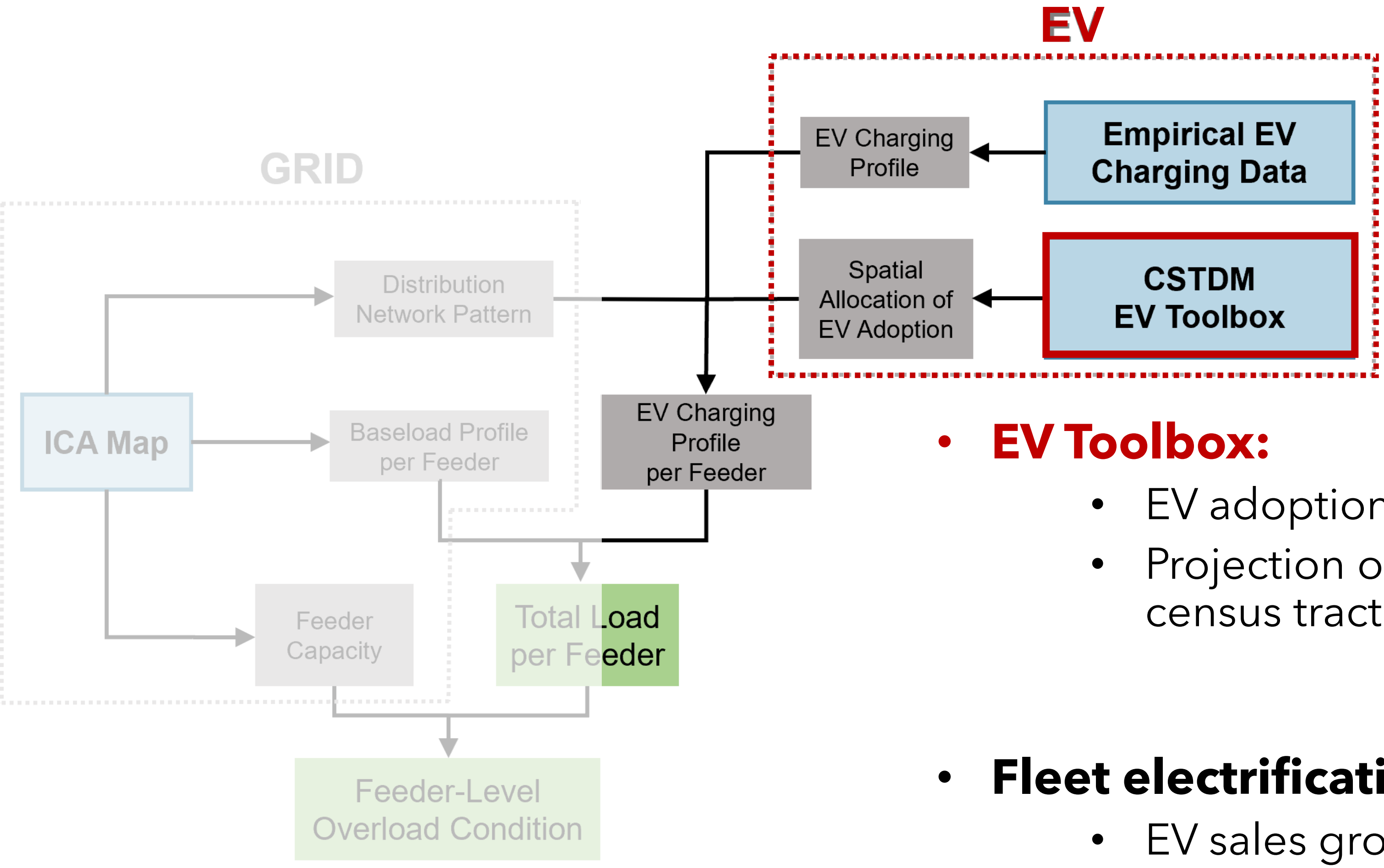
SDG&E



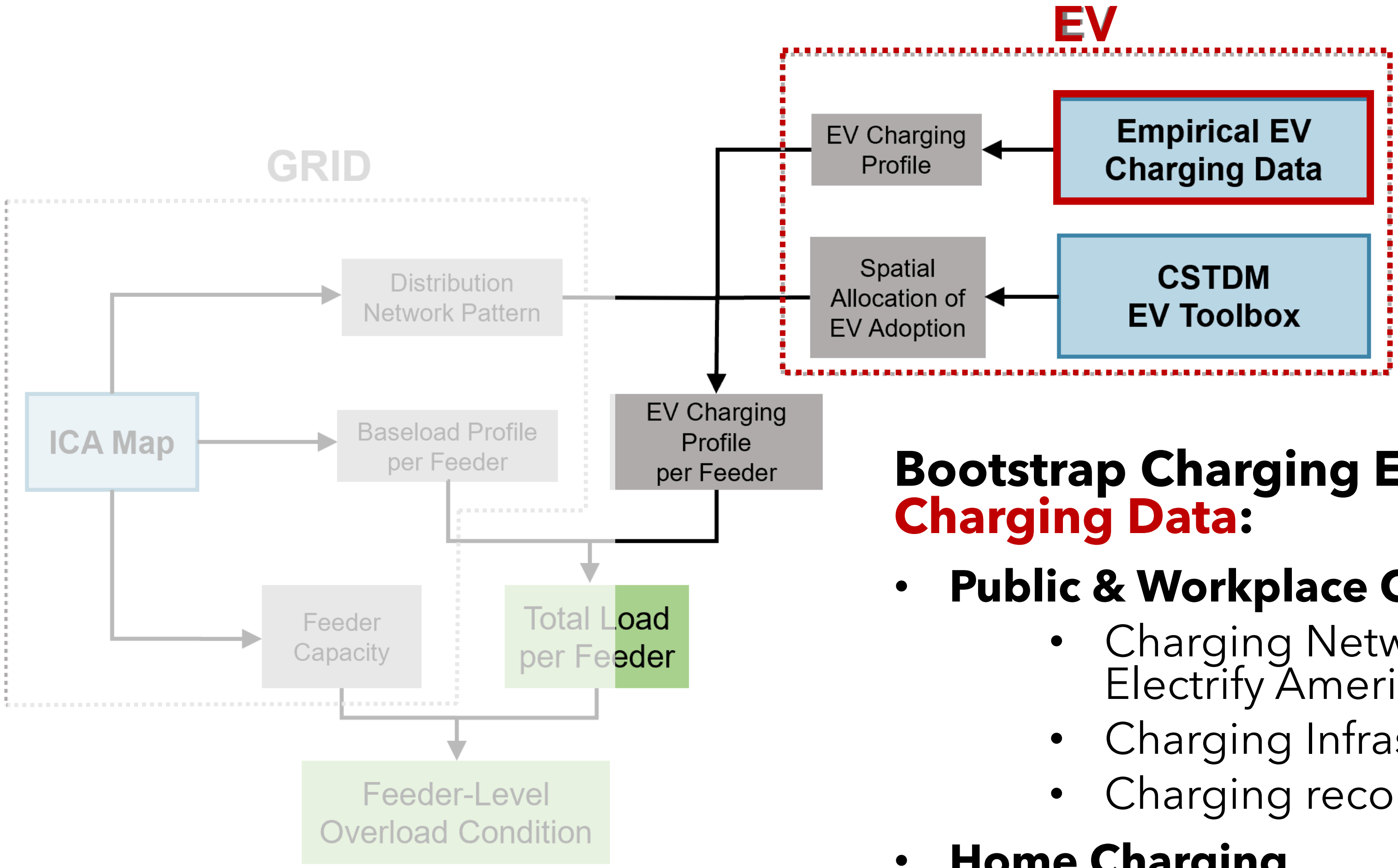
SCE

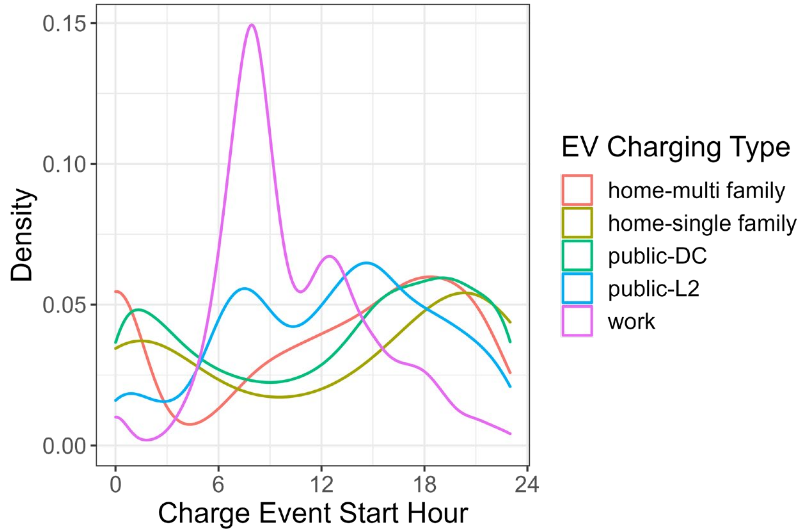


METHODS | Number of EV Trips in each Region



- **California Statewide Travel Demand Model (CSTDM)**:
  - Light duty vehicles (LDV) trips from and to each Traffic Analysis Zone (TAZ)
  - Trip purposes
- **EV Toolbox:**
  - EV adoption model
  - Projection on the number of household with EV at census tract level
- **Fleet electrification**:
  - EV sales growth: up to 100% EV within LDV sales by 2035
  - EV on the road: 6.6 million by 2030
    24 million by 2045

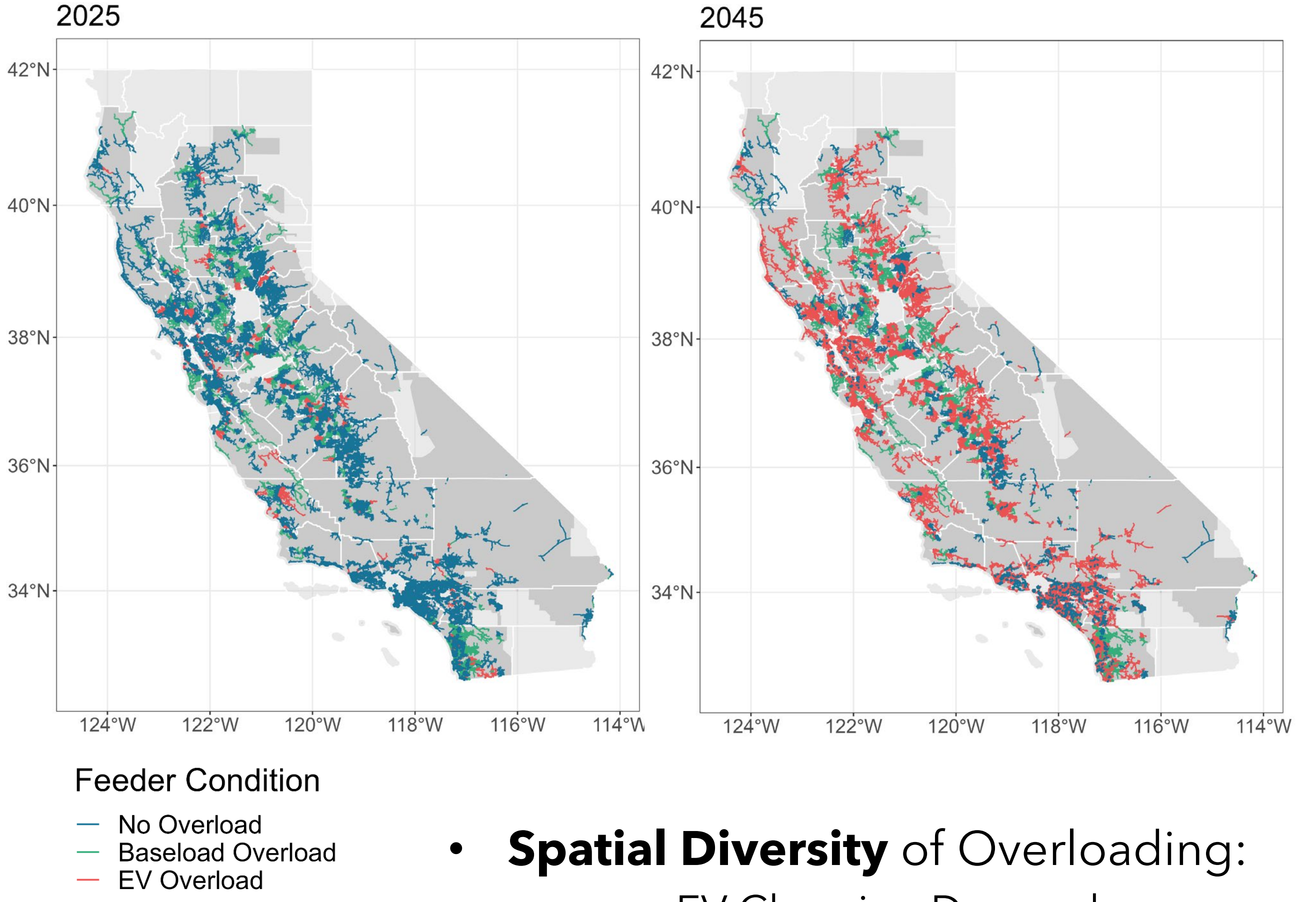


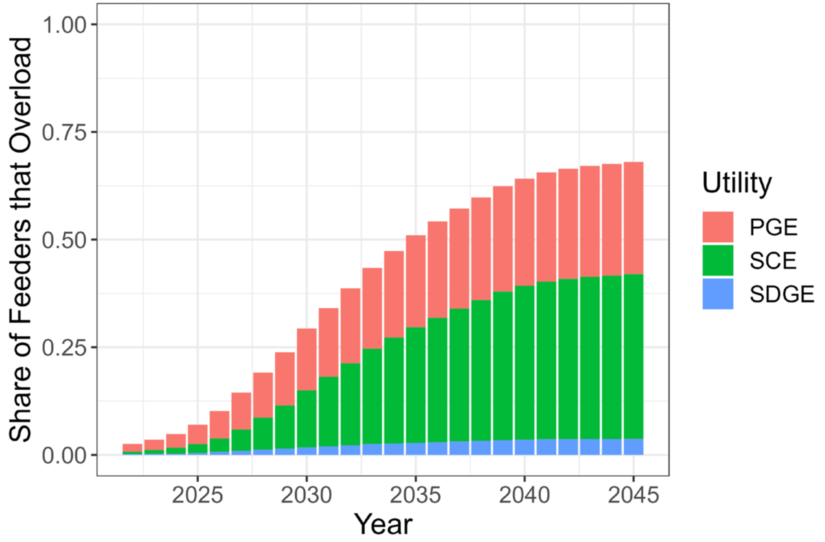


Bootstrap Charging Events from Empirical EV Charging Data:

- **Public & Workplace Charging**
  - Charging Network Providers: EVgo, Chargepoint, Electrify America, BTC POWER, etc.
  - Charging Infrastructure installed by Utilities
  - Charging records 2014 - 2023
- **Home Charging**
  - eVMT project
  - Data loggers on 300 EVs, track for 1 year

RESULTS | **When & Where** will Overload Happen?

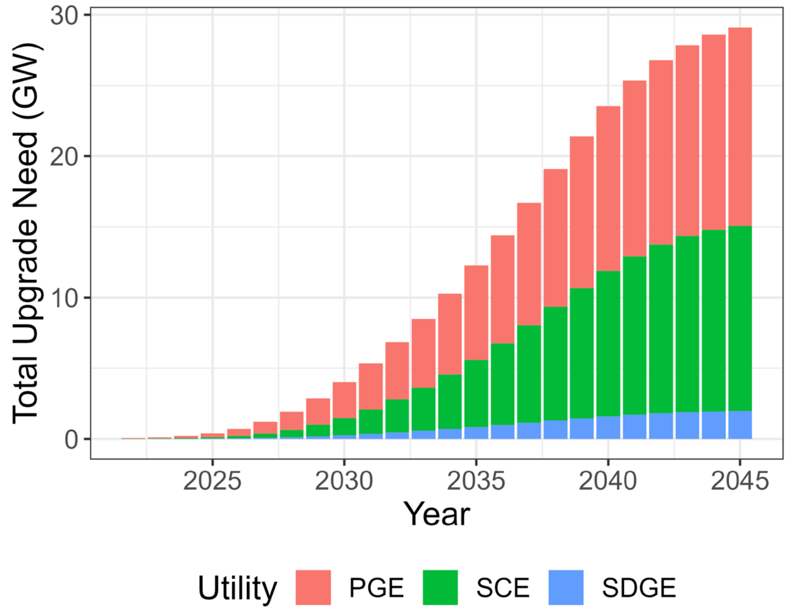


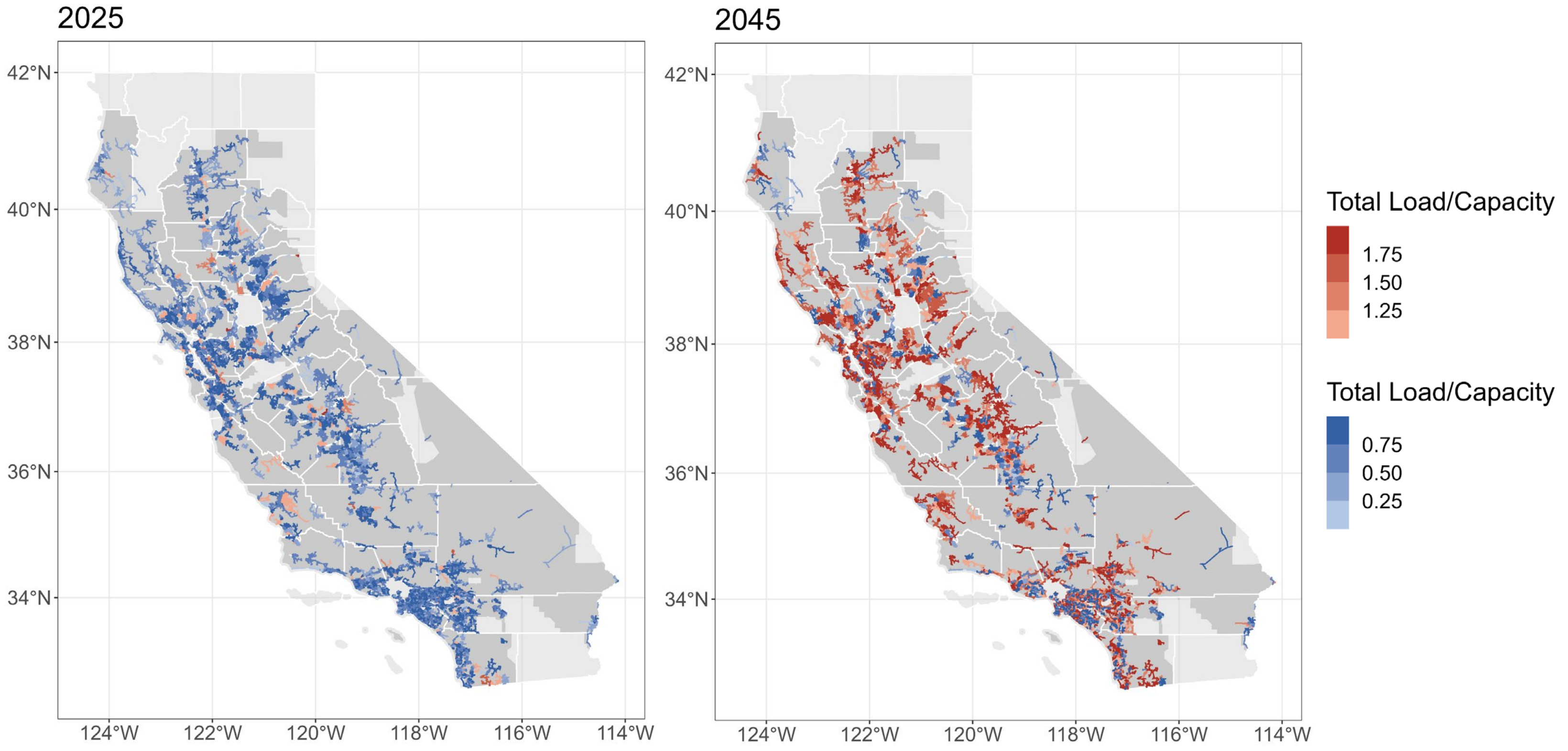


- More than **50%** of the feeders will overload by **2035**.
- Up to **68%** of the feeders will overload by EV charging demand by **2045**.

- **Spatial Diversity** of Overloading:
  - EV Charging Demand
  - Existing Infrastructure Capacity

RESULTS | How **Intense** will Overload Be?



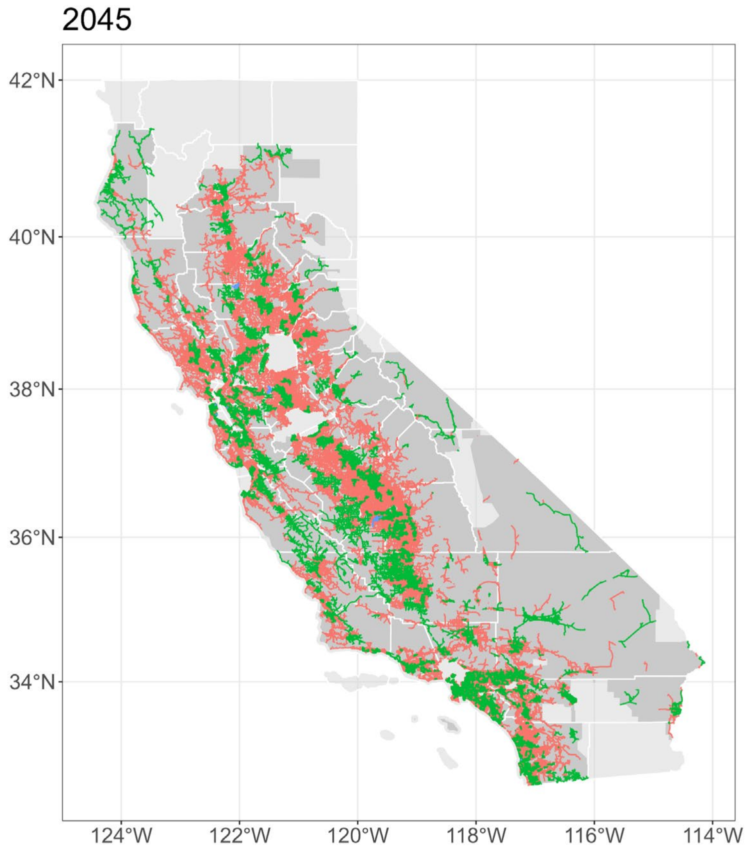


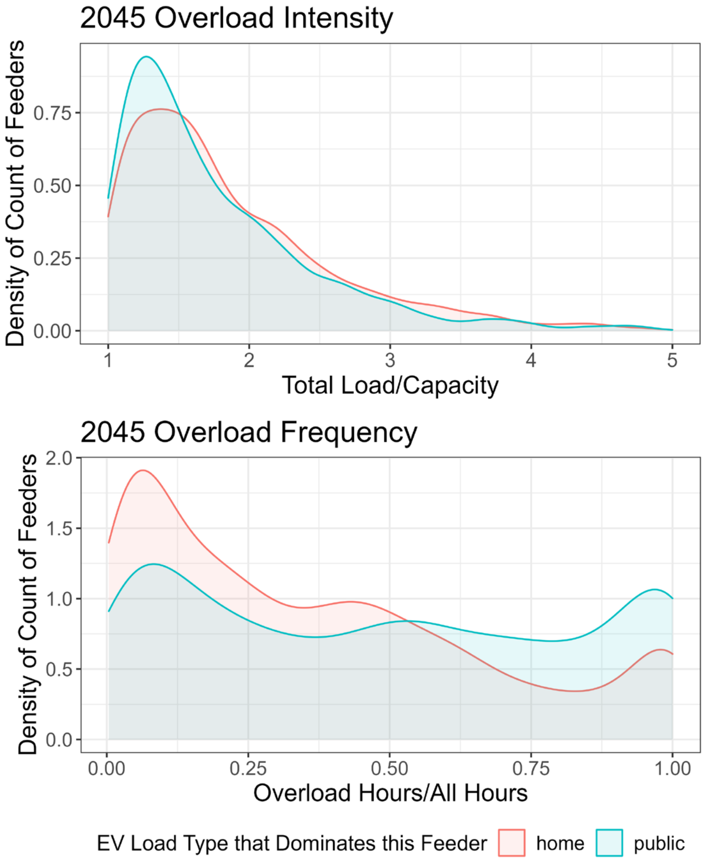
- By **2045**, more than **29 GW** capacity upgrade will be needed in the distribution grid.
- Corresponding cost range between $7 and $22 billion.

- Though overload already start in some areas in early 2020s, they are generally less intense – below 25% of existing feeder capacity.

- In 2045, most feeders around those that have severe overloading will be very close to overloading, if they are not already overloaded.

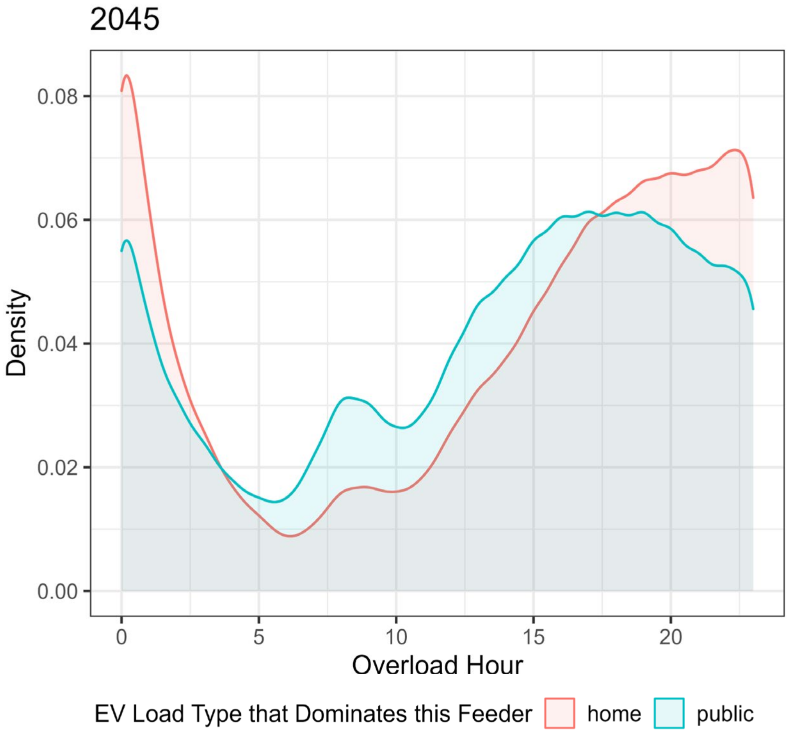
RESULTS | How does Different **Types** of Charging Affect Overload?

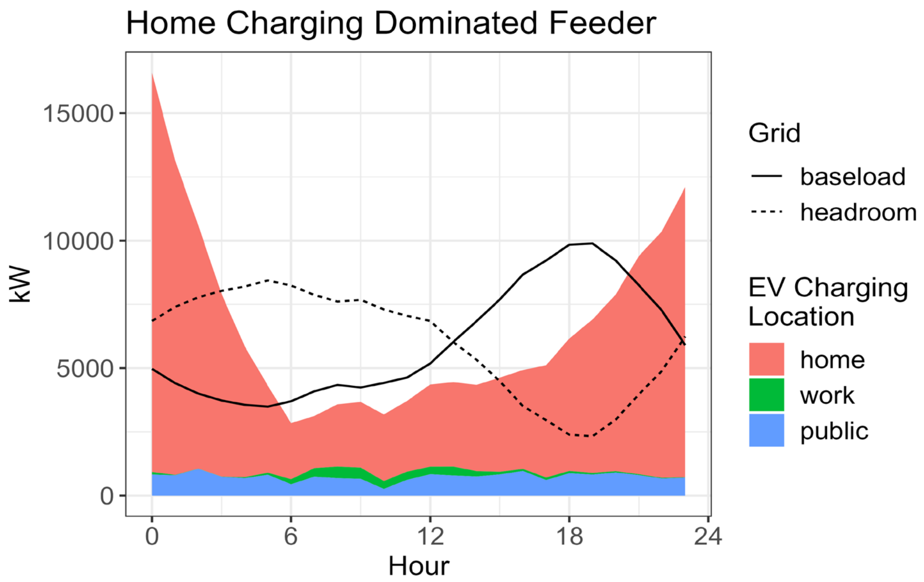


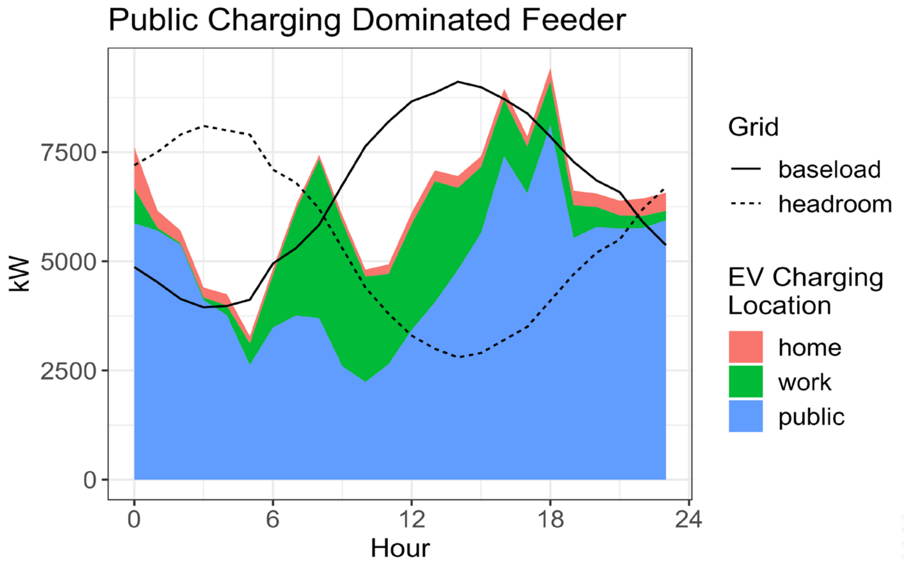


- Feeders dominated by **home charging**:
  - less frequent
  - more intense
- Feeders dominated by **public charging**:
  - more frequent
  - less intense

RESULTS | Overload Time: **Synergy** of Baseload vs EV Load Patterns







Feeder dominated by **Home Charging** (Residential Area)

- Only one peak charging load during the night
- Baseload peaks around 18:00
- Overload take place **mostly at night**

Feeder dominated by **Public Charging** (Commercial Area)

- Two charging load peaks: night and day
- Baseload peak starts earlier, usually from around noon
- Overload tends to happen **more in the day**

CONCLUSION

- Our findings indicate a need for infrastructure upgrade in **68%** of the distribution feeders in California by **2045**, with a total upgrade need of **29 GW**.
- Overloading intensity, frequency, and time are **highly diverse spatially**, which are related to **the mix of different types of EV charging demand**.

OUTLOOK

- Projections on the demand side development of the grid, such as rooftop solar generation and energy efficiency.
- Include heavy duty EV charging demand.

THANK YOU!

QUESTIONS?

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