Distribution Grid Impacts of Electric Vehicles: A California Case Study

EVS35 OSL2022

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Abstract

California has adopted a substantial number of electric vehicles over the last decade but there are many challenges associated with the electrification of vehicles, including how they interact with the electricity grid. We employ real-world feeder circuit level data in California from PG&E to measure the capacity of local feeders. We model the adoption of electric vehicles down to the census block and take advantage of real-world vehicle charging data to simulate the future loading on circuits throughout Northern California. In our highest adoption scenario of 6 million electric vehicles in California, we find that across PG&E's service territory, 443 circuits will require upgrades (nearly 20% of all circuits) and merely 88 of these feeders have planned upgrades in the future. The costs of these feeders are an essential part of a utility's planning process, and this work speaks to the importance of electric vehicles on local distribution networks.

Data and Methods

1. Characterizing transformer and feeder circuits — we employ the Grid Needs Assessment capacity data and Integration Capacity Analysis maps to determine feeder infrastructure characteristics and locations.
2. EV adoption and load simulation — we employ an EV adoption forecasting tool called EV Toolbox which allocates future EVs at the census block group level. We then employ real-world travel and charging data to bootstrap future localized EV charging loads.
3. Spatially connecting distribution infrastructure to EVs — EVs are re-allocated to blocks based on proportion of populations. Blocks are then allocated to specific feeder lines in the distribution network.
4. Determination of feeder threshold exceedance — EV charging loads are added on top of base load electricity data and compared against threshold capacities of all feeder lines in the PG&E network.

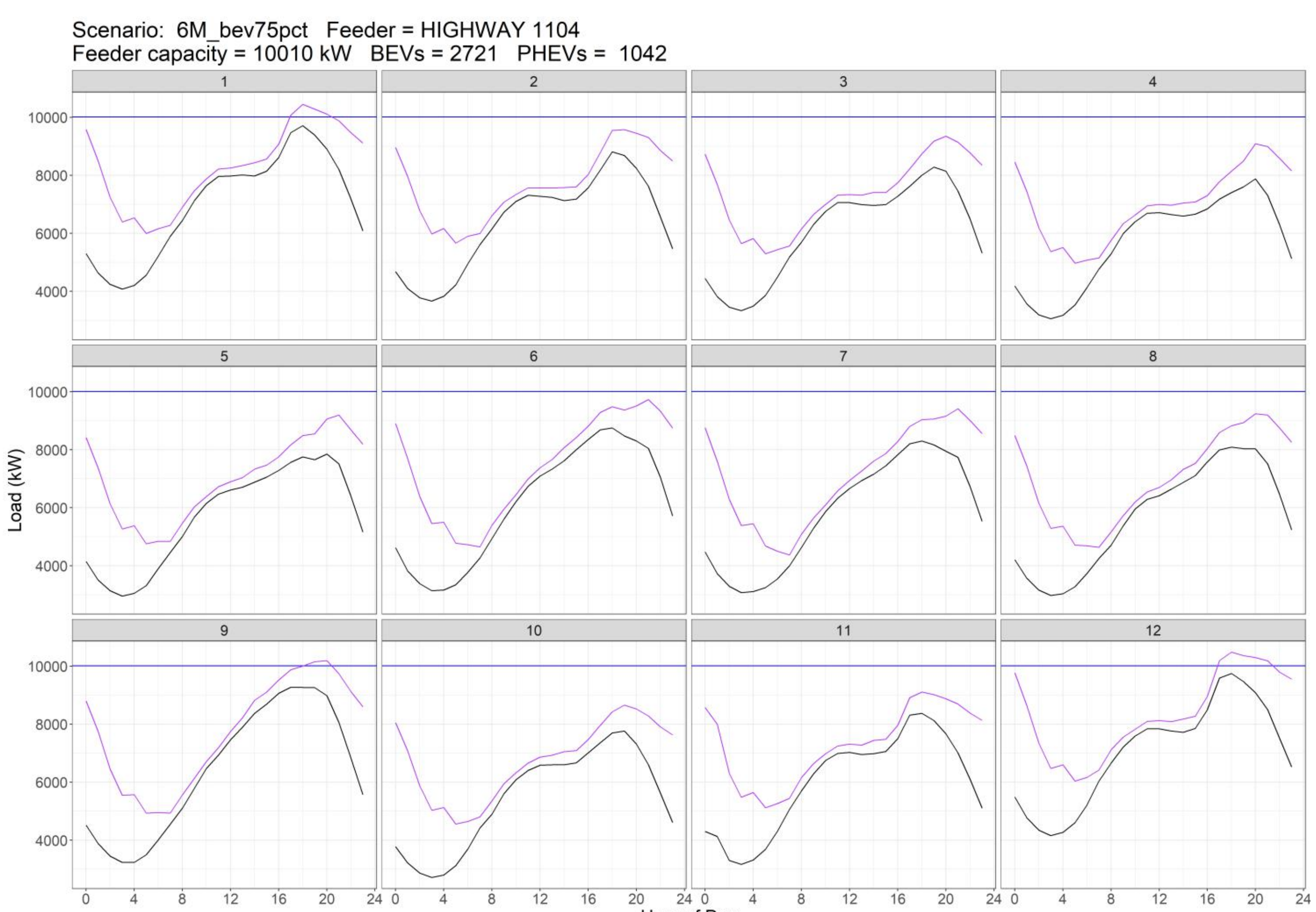

Figure 1: Example of the peak load day event in each month of the year for a single feeder circuit with a capacity of about 10 MW. In a scenario of 6 million electric vehicles, we forecast 3,763 vehicles adding charging load to the feeder. The threshold capacity of this feeder is exceeded in three months of the year (January, September, and December) and is dependent on the peaking of baseload.

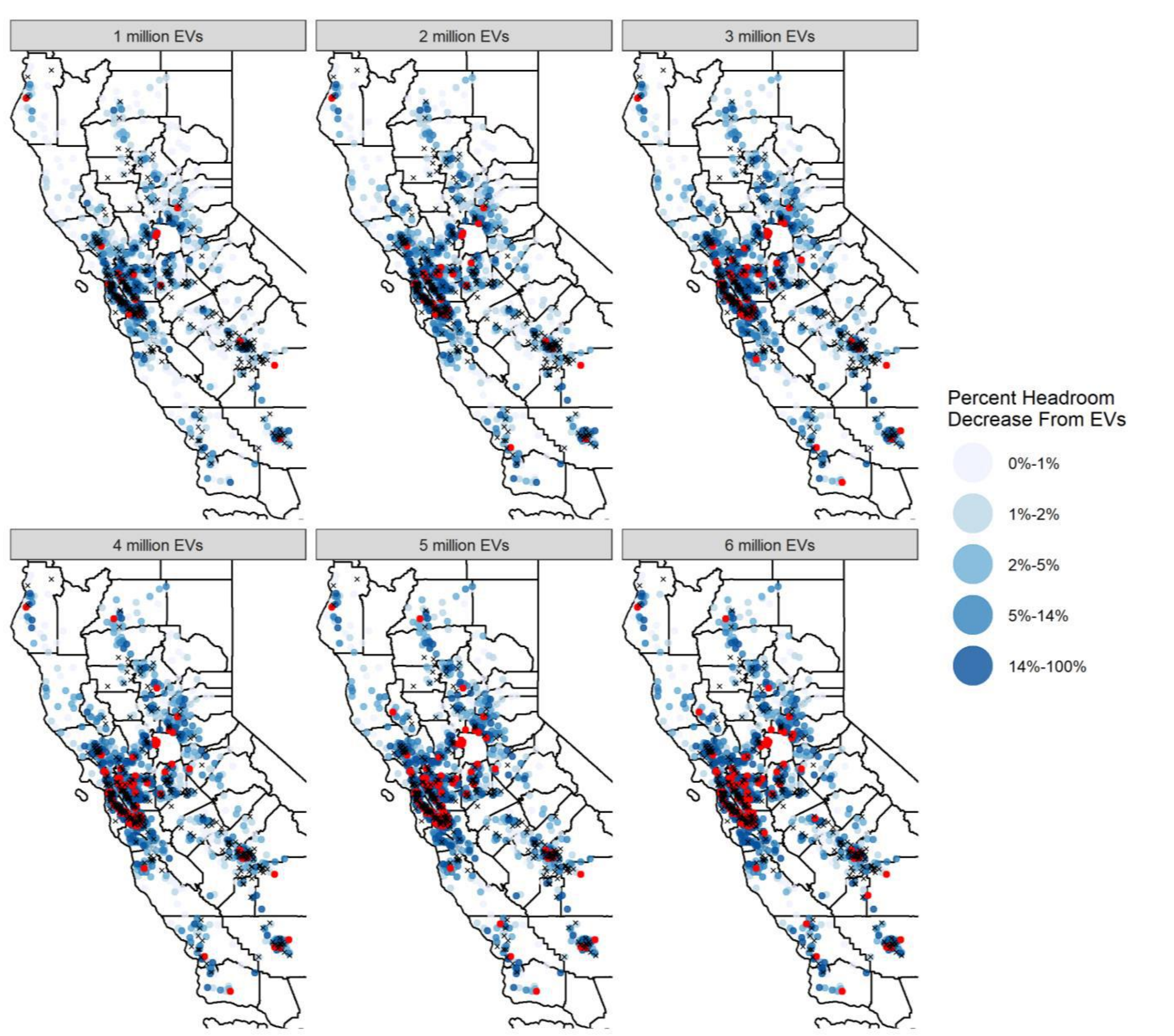

Figure 2: Decrease in headroom (spare capacity) of feeder circuits (represented as points at the centroid of the network) during peak load events due to electric vehicle charging. Red dots indicate feeder circuits that would exceed their rated capacities due to vehicle charging and black X's indicate feeders whose capacities are exceeded during peak load regardless of EV charging.