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Balancing Electric Vehicle Adoption with Grid Stability in California: A Time-sensitive Challenge

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Issue

California leads the nation in a shift to electric vehicles (EVs), with ambitious targets for phasing out the sale of new gas-power cars by 2035. However, this transition raises serious concerns about whether the state's electrical grid can handle the surge in charging demand. Without careful planning, grid infrastructure limitations and the associated costly upgrades could become a major bottleneck to widespread EV adoption.

To better understand this challenge, we simulated EV charging profiles (i.e., how, when, and where EVs are charged) across different types of locations across California, including homes, workplaces, and public charging stations. We then evaluated the impact on the state's electrical distribution system. Our findings point to where and when the grid is most vulnerable—and what policies can help balance EV growth with grid stability.

Key Research Findings

More than half of California's electrical feeders will be overloaded by 2035. Due to increased EV charging demand, our projections indicate that 50% of electrical feeders and transformers—local power lines that deliver electricity to homes and businesses—will be overloaded by 2035 (See Figure 1). By 2045, this number is expected to grow to 68%. This impending issue necessitates an urgent reassessment of electrical infrastructure capacities.

Upgrading the grid will require billions in new investment. We estimate that the required infrastructure upgrades will cost anywhere from $7 billion to $22 billion by 2045. These figures underscore the magnitude of investment needed and offer a framework to guide immediate and long-term actions.

Grid stress and upgrades vary by charging type. Feeders with heavy home charging demand face nearly twice the overload risk of those serving public charging. By 2045, feeders supporting home charging will require a 19 GW capacity increase, costing $4.6 to $14.5 billion, while feeders for public charging will need a 10 GW upgrade, with costs ranging from $2.4 to $7.5 billion. Encouraging more charging outside the home—such as at public stations or workplaces—could reduce pressure on local grids. These differences highlight the importance of targeted, location-specific upgrades and interventions depending on the type of charging taking place.

California Resilient and Innovative Mobility Initiative

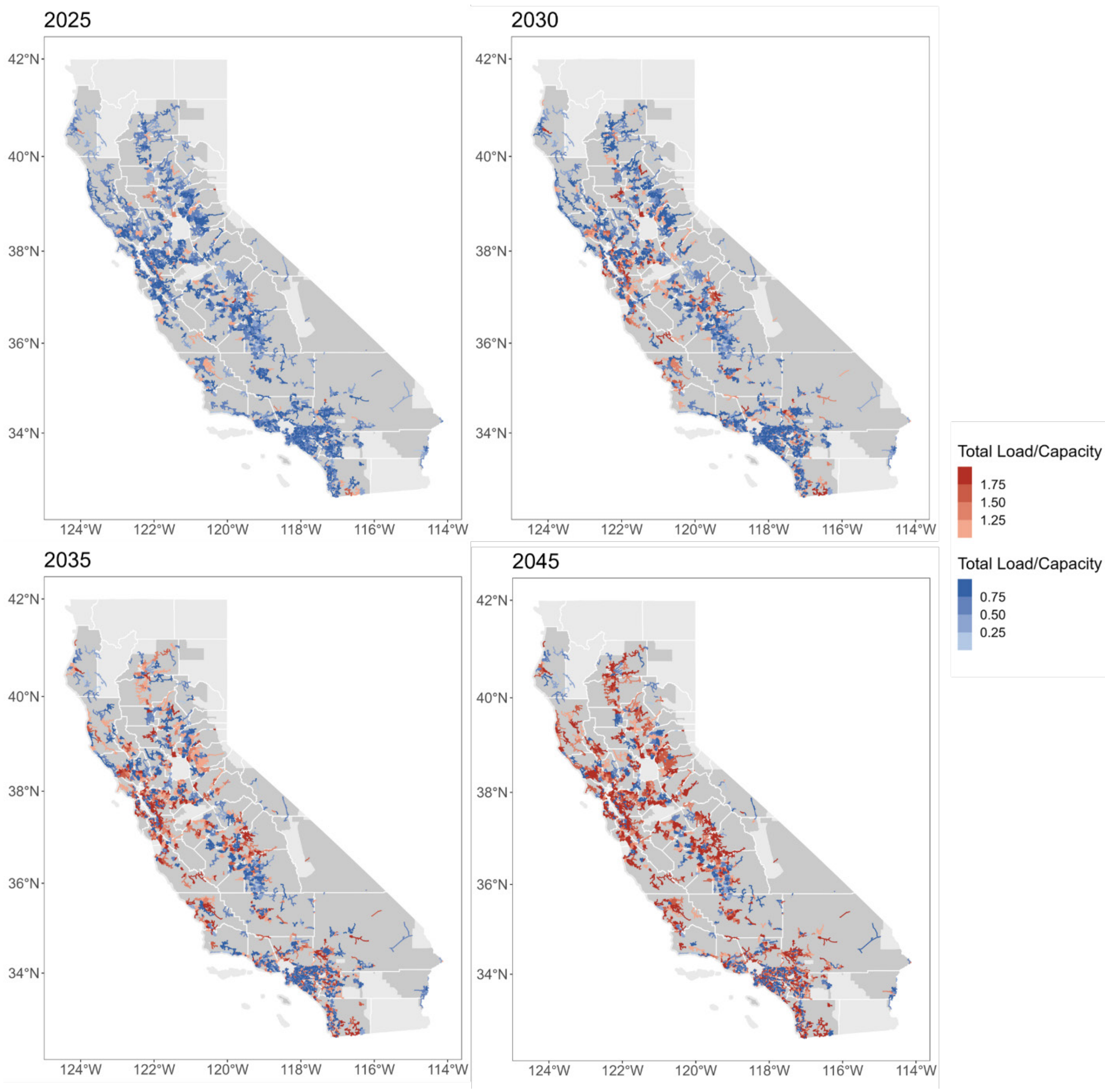

Figure 1 Spatial distribution of peak load intensity of electrical feeders in different years.

The feeders are colored by the ratio of total peak load (baseload and EV charging load) over capacity. Feeders noted in red are overloaded, and those in blue are not overloaded. The darker the color, the more severe the overloading, or the closer to overloading if not already overloaded. Areas in darker grey are the territories of the three major Investor-Owned Utilities in California.

When charging happens matters. Home charging overloads tend to occur at night, while public charging peaks during the day. This timing difference suggests that policies like dynamic pricing—charging lower rates during off-peak hours—could shift demand and ease strain.

Workplace charging could be part of the solution. Feeders serving workplace chargers were found to be less prone to overloading, pointing to an opportunity for policies that encourage workplace charging as a means for alleviating grid stress and distribute demand more evenly throughout the day.

Policy Implications

Prioritize near-term upgrades. With half of electrical feeders projected to overload within a decade, California may want to accelerate targeted grid improvements, focusing first on feeders that are at most risk for frequent overloading.

Adopt dynamic pricing to shift demand. For feeders that are overloaded at specific times of the day, dynamic pricing and other demand-response strategies could incentivize off-peak charging, and avoid or postpone costly infrastructure upgrades.

Promote public and workplace charging. Given that feeders in commercial areas are generally less stressed than residential feeders, grid stress could be reduced by encouraging the shift of EV charging to public and workplace locations, such as through increasing charger availability at these locations and implementing special charging rates based on location.

Consider heavy-duty EVs in future assessments. Our study focused only on light-duty vehicles, however, the adoption of heavy-duty EVs and their higher charging power could add further stress to the grid. Future regulatory frameworks should consider this in the planning process.

More Information

This policy brief is drawn from the report "Impact of Electric Vehicle Charging Demand on Power Distribution Grid Congestion" prepared by Alan Jenn and Yanning Li with the University of California, Davis. The report can be found at http://arb.ca.gov/cc/sb375/policies/policies.htm and the published article can be found at https://doi.org/10.1073/pnas.2317599121. For more information, contact Alan Jenn at ajenn@ucdavis.edu or Yanning Li at yspli@ucdavis.edu.

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