DRISI
Caltrans Division of Research, Innovation and System Information

Research Results

Effects of Electric Vehicle (EV) Charging at Rest Areas

Investigating effects of placing electric vehicle charging stations at highway rest areas in California on the power grid and renewable energy curtailment

Planning, Policy, and Programming

APRIL 2020

Project Title:
Utilizing Highway Rest Stops for Electric Vehicle Charging: Economics and Impacts on Renewable Energy Penetration in California

Task Number: 3389

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WHAT WAS THE NEED?

California's policy is rapidly incentivizing adoption of electric vehicles (EVs) to comply with the 2040 California Transportation Plan, which aims to increase the number of zero-emission vehicles, and Senate Bill 32, which calls for a 40% reduction in greenhouse gas emissions by 2030. EVs are proving to be a viable solution to mitigate greenhouse gas emissions, but charging infrastructure is currently insufficient.

While many urban areas in California have prioritized construction of charging stations, most rural areas lack charging infrastructure. This deficit hinders EV adoption in rural areas and makes long distance travel with an EV difficult.

WHAT WAS OUR GOAL?

This research seeks to identify the most optimal rest areas to place EV charging stations. At the selected rest areas, the effects on the power grid were investigated. The research team aims to make long-distance and inter-city travel possible while driving an EV.

WHAT DID WE DO?

First, data was collected, including:

- Travel demand data to gauge the number of vehicles that currently could utilize rest areas,
- Transmission and electricity usage data to understand how the grid and transmission systems are currently functioning near by the rest areas, and
- Financial data to estimate costs of adding needed electrical infrastructure to support EV charging
- To develop scenarios for future EV usage, the research team collected estimates for market share and performance of EVs in three periods of 2017, 2030, and 2050.

Next, a California specific energy-dispatch model was developed at the University of California, Davis - Institute of Transportation Studies for this study. Model input data consisted of hourly information about California's grid spanning the entire year of 2018. The model outputs were projected travel and electricity demand through 2050.

The energy-dispatch outputs were used to run a MESSAGE optimization model developed for this project, which selected the best rest area locations to install EV charging stations based on travel demand and cost. The effects on the electric grid were considered at these locations.

Additionally, the model projected the percent of renewable resource penetration that might be expected in California by 2050, if aggressive EV adoption occurs. An overview of the whole modeling framework can be seen in Figure 1.

WHAT WAS THE OUTCOME?

- Charging demand at rest areas increased moderately between 2017 and 2030, and then significantly between 2030 and 2050. The increase in charging demand is mostly due to the assumed large growth in the number of Battery Electric Vehicles (BEVs) over time.
- Peak travel occurs in the middle of the day, suggesting that solar power could be utilized for rest area charging.
- Charging demand and vehicle usage varies widely among California's 86 rest areas. The model predicts that ~10-12% of rest areas (mostly located in low traffic flow rural areas) will have zero charging demand in 2030 and 2050. This is due to the fact that EVs are projected to have increased driving range by 2030 and 2050.
- As the BEV fleet grows from 0.2 million in 2017 to 30 million in 2050, demand for BEV charging increases rapidly and many more charging locations (beyond the 86 rest stops) will be needed.
- The additional electricity generation capacity needed for long distance intercity BEV chargers would be about 7 GW by 2050, and for charging all BEVs, including intracity and intercity travel, additional generation capacity of about 60 GW will be needed. Total electricity generation of 122 GW of solar, 56 GW of wind, and 67 GW of gas power plants would be required for total California electricity demand in 2050, including the charging demand from a 100% battery electric vehicle (BEV) fleet. This mixture gives California up to 72% variable renewable energy penetration in the electricity grid.
- Future research should consider the demographic contexts of zero-demand rest areas, as more affluent cities are likely to have higher EV penetration. Additionally, other possibilities besides rest areas should be considered for charging.

WHAT IS THE BENEFIT?

The research results provide insights to the California Department of Transportation for implementing a state-wide, EV charging station system at highway rest areas in the most optimal way.

This study highlighted the potential for using renewable energy to help meet EV charging needs at rest stops. This strategy could help reducing the amount of greenhouse gases emitted from the transportation sector, a necessity if the state hopes to meet its ambitious climate goals.

LEARN MORE

Final report can be found at
https://doi.org/10.7922/G2N29V6B

To view the evaluations:
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IMAGE

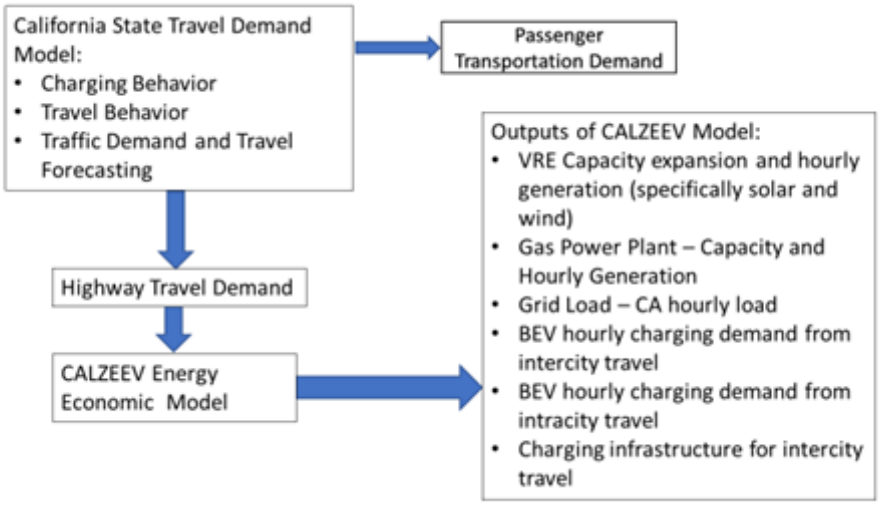

Figure 1: Overview of Modeling Framework