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Smart Charging of Electric Vehicles Will Reduce Emissions and Costs in a 100% Renewable Energy Future in California

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Issue

California has goals of achieving 100% renewable energy by 2045 and 100% zero-emission vehicle sales by 2035. Electric vehicles will introduce significant new demand for electricity at the same time the state's electricity grid is incorporating more intermittent energy sources, raising concerns about grid reliability. However, the flexibility of electric vehicle charging provides a potentially powerful asset in mitigating the challenges of a renewable energy-based electricity grid. *Smart charging*—adapting electric vehicle charging based on the conditions of the power system and the needs of the vehicle user—can take advantage of this flexibility by charging vehicles when renewable energy is readily available.

Researchers at UC Davis simulated 100% electric vehicle adoption and a 100% renewable energy-powered electricity grid by 2045 in California. They then compared a scenario of regular electric vehicle charging behavior with a scenario of advanced, flexible, smart charging under which charging is aligned with renewable energy availability, to understand how smart vehicle charging could benefit the electricity grid.

Key Research Findings

Smart electric vehicle charging can maximize emissions reductions. A shift to electric vehicles would lead to a substantial decrease in emissions even without changes to California's electricity grid, because of electric vehicles' advantages over gasoline vehicles. Coupling electric vehicle deployment with a transition to a fully renewable electricity system by 2045 results in further emissions reductions of nearly 130 million tons of carbon dioxide (CO_2) over the next 25 years. Policies that enable smart charging could reduce emissions by another 31% below the regular charging scenario by maximizing renewable energy use (Figure 1).

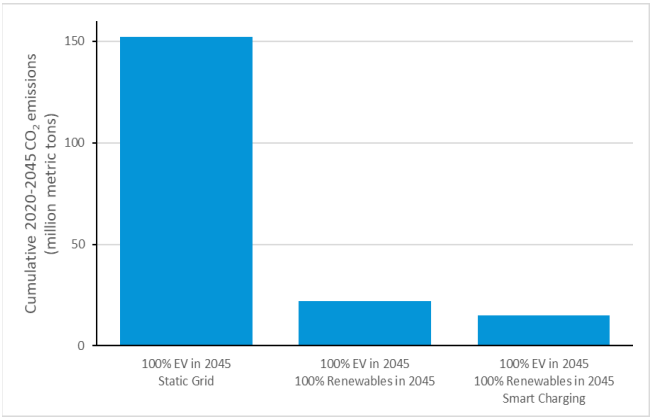

Figure 1: Cumulative upstream greenhouse gas emissions from passenger electric vehicles (EVs) in California from 2020 through 2045 across three different scenarios: 1) 100% EVs in 2045 but with the current electricity grid mix, 2) 100% EVs and a 100% renewable electricity grid in 2045 with a regular charging scenario, and 3) 100% EVs and a 100% renewable electricity grid in 2045, plus smart charging behavior

Smart charging can reduce curtailment of renewable energy. If electricity produced from solar and wind resources exceeds demand, much of this resource is wasted, a situation known as curtailment. Shifting electric vehicle charging demand to times when excess renewable energy is available decreases curtailment and improves operational efficiency of renewable resources. It also reduces the need

for excess renewable energy and energy storage capacity to compensate for the intermittency of solar and wind.

Smart charging can reduce the costs of transitioning to a 100% renewable electricity grid. With flexible electric vehicle charging, demand can be aligned with availability of cheap solar energy, reducing the need for more expensive wind energy and installed storage capacity. Over the course of 25 years from 2020 to 2045, nearly $30 billion can be saved (Table 1).

	Regular Charging Scenario	Smart Charging Scenario
Generation Costs	$65.3 billion	$67.2 billion
Solar Capacity Costs	$154 billion	$172 billion
Wind Capacity Costs	$264 billion	$227 billion
Storage Capacity Costs	$79.5 billion	$67.7 billion
Total Costs	**$563 billion**	**$535 billion**

Table 1: Cumulative cost breakdown of grid infrastructure and operation between two vehicle charging scenarios from 2020 through 2045.

Policy Considerations

A suite of policy actions could facilitate flexible electric vehicle charging to benefit California's electricity grid.

Strategically deploy charging infrastructure. Providing access to chargers at workplaces can encourage charging during midday solar energy peaks when excess renewable energy is available.

Create pricing signals to incentivize strategic charging. Strategically pricing charging based on the time of day can encourage charging at desirable times (i.e., midday for solar power and during the evening for wind power). In addition, integrating an emissions or renewable energy uptake goal into commercial electric vehicle charging rate setting would allow utilities and charging service providers the ability to recoup their investment costs while simultaneously aligning with sustainability outcomes.

Develop and standardize smart charging and vehicle-to-grid protocols. Regulations that standardize protocols for communication between grid operators and/or utilities with vehicles and drivers would ensure that all vehicle models, regardless of the automaker, would be able to participate in a vehicle-to-grid system.

Deploy public awareness campaigns to guide consumer charging behavior. A program like "Flex Your Power" in California could be designed to shift electric vehicle charging behavior as the vehicles start to reach a critical mass. Flex Your Power has led to a more than 90% decrease in energy use during peak hours and a more than 10% decrease in overall energy consumption in several California regions.

Support grid infrastructure requirements. Widespread charging infrastructure can lead to challenges for the electricity grid, particularly within the localized distribution infrastructure. Concurrent with the increased popularity of electric vehicles, utilities must accelerate upgrades and rollout of distribution infrastructure. The California Public Utilities Commission must carefully consider the costs to utilities of additional infrastructure due to electric vehicles, as well as how these costs can be recovered.

More Information

This policy brief is drawn from the report, "Green Charging of Electric Vehicles Under a Net-Zero Emissions Policy Transition in California," prepared by Alan Jenn and Austin Brown of the University of California, Davis. The report can be found at www.ucits.org/research-project/2020-08. For more information about the findings presented in this brief, contact Alan Jenn at ajenn@ucdavis.edu.

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