Electric Vehicle Green Charging: Marginal or Average Emission Control?

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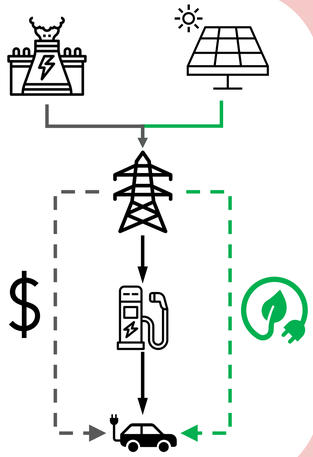
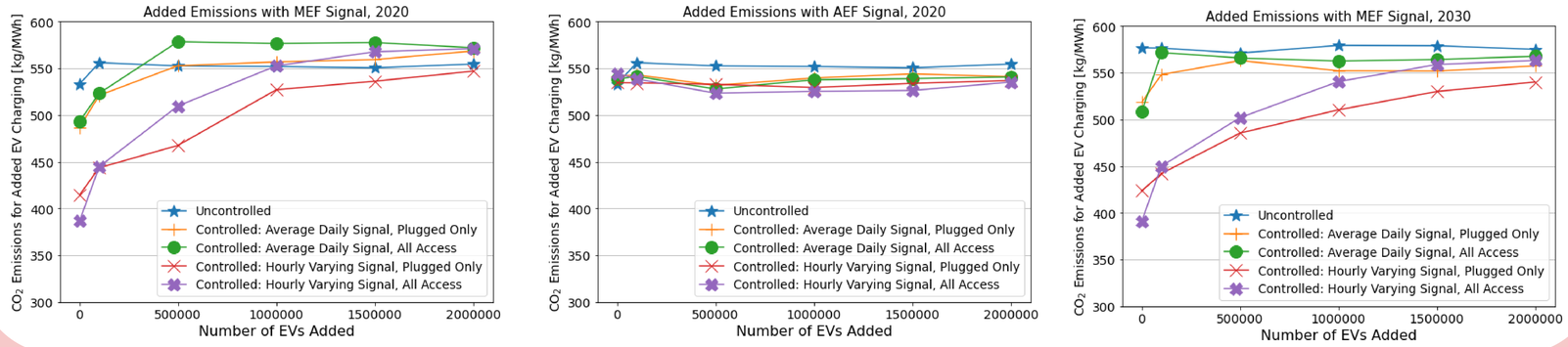
Introduction

- Electric vehicles (EVs) are a promising clean transportation option, but they still release CO_2 emissions when charging from the electricity grid
- Often, drivers charge when it is cheap or convenient. Green charging instead optimizes to reduce emissions by shifting electricity demand in between and across charging sessions [1]

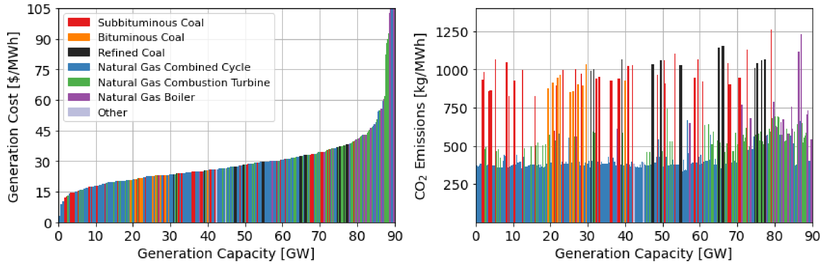


Added Emissions from EVs

CO_2 emissions from added EVs simulated in the month of January. The simulations include a range of added EVs and charging access scenarios, while minimizing the marginal emissions factor (MEF) in 2020 (left), the average emissions factor (AEF) in 2020 (middle), and the MEF in the future 2030 grid (right).

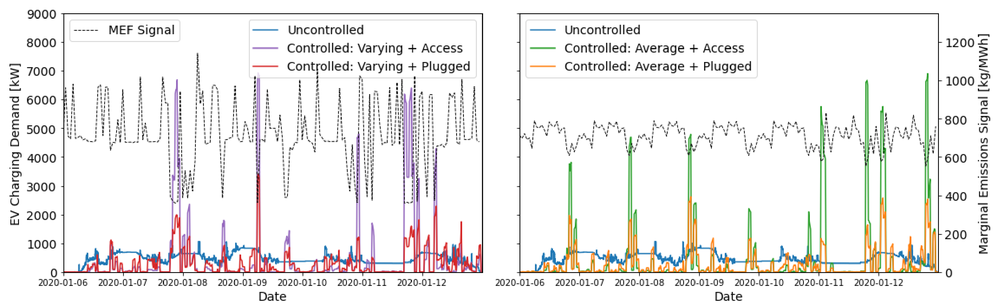


Marginal Emissions Factor



Generator merit order from the first week of 2020, ordered by cost (left) and corresponding, or marginal, emissions (right). As generators are dispatched by cost, this leads to a noisy marginal emissions factor [2].

EV Grid Demand Analysis



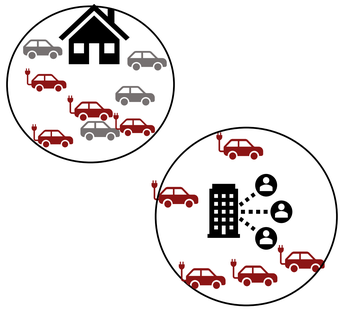
Additional charging demand from 1000 EVs added to the grid, for both an hourly varying MEF signal (left) and average daily MEF signal (right). Demand peaks occur when the MEF is low.

Discussion

- In 2020, controlled charging with the MEF objective reduces emissions from the uncontrolled case by about 20% for less than 1 million added EVs, while the AEF objective reduces emissions by only 5%
- In 2030, controlled charging using the MEF objective performs better than in 2020, relative to the uncontrolled case
- Ultimately, MEF is a useful signal for reducing emissions in 2030 as well as when adding small numbers of EVs to specific grid nodes
- Future work includes calculating added emissions while adding a generator carbon price

Methods: Clustering

- Agglomerative clustering creates groups of individual driver charging locations that are within 50m of each other
- In the “All Access” controlled charging scenario, charging is an option when the driver is at a cluster where charging has occurred before



Parked cars (gray) located in clusters with previous charging sessions (red) can charge in the “All Access” charging scenario.

Methods: Optimization

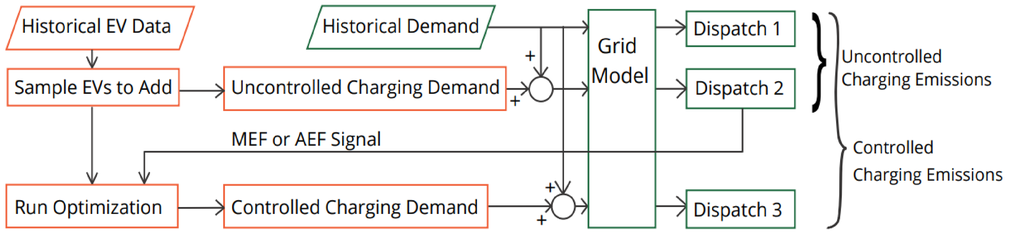


Diagram showing the controlled charging algorithm. The grid dispatch model is run three times: once with historical demand, once with added uncontrolled charging demand, and once with added controlled charging demand.

References

[1] J. S. G. Zivin, et al., “Spatial and temporal heterogeneity of marginal emissions: Implications for electric cars and other electricity-shifting policies“, *Journal of Economic Behavior & Organization*, 2014.
[2] T . Deetjen and I Azevedo, “Reduced-order dispatch model for simulating marginal emissions factors for the United States power sector”, *Environmental science & technology,* 2019.

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