SMART CHARGE

Charging Electric Vehicles to Support a Low Carbon Grid

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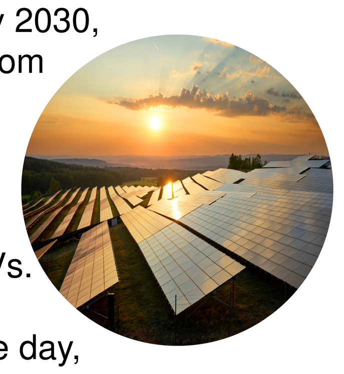
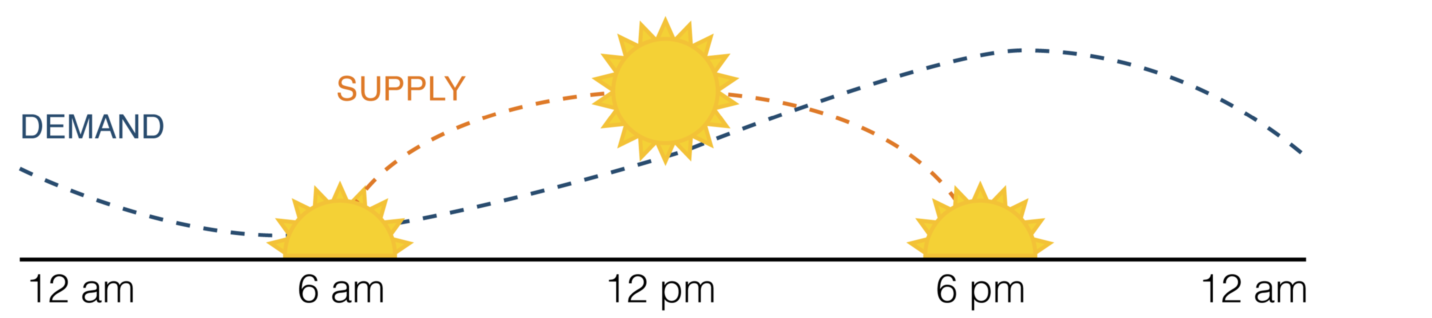
1 PROJECT BACKGROUND



Electric Vehicle (EV) sales are expected to increase dramatically in California by 2030, as the state seeks to expand the number of zero emission vehicles on the road from 570,000 to 5 million. The integration of EV charging onto the electrical grid could create an increase in evening peak electricity demand that has to be met by carbon-intensive fossil fuel resources, such as natural gas. If EV charging is left unmanaged, the potential increase in peak demand may stress electrical grid infrastructure and limit the greenhouse gas (GHG) and air pollution benefits of EVs.

However, if managed effectively, EV charging could be shifted to the middle of the day, when California has an ***excess of solar energy***, as shown by the orange line in the figure below. Midday demand is currently lower than supply, as indicated by the blue line. When this occurs, solar power must either be shut off or sold for a loss – a process known as 'grid curtailment.'



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Managing Charging by shifting EV charging to the middle of the day will take advantage of California's excess solar energy and reduce the demand for evening peak electricity to support statewide climate and air pollution goals. Southern California Edison (SCE), the largest electricity provider in Southern California, is investigating ways to manage charging. Our project develops models to estimate the extent to which various interventions can encourage drivers to shift to midday charging at 4 long-dwell locations: workplaces, destination centers, fleets, and multi-unit dwellings.

2 OUR APPROACH

RESEARCH QUESTIONS

In order to evaluate how EV charging could benefit the electrical grid and support climate and air pollution goals by using the excess supply of midday solar energy, we examine 3 research questions:

- What interventions shift charging demand to midday?
- How much demand can be shifted by these interventions?
- What are the greenhouse gas and air pollution implications of shifting charging demand?

To answer these questions, our project produces 3 deliverables: an economic model that is accessible through an online application, a hypothetical analysis of how much demand can be provided by charging infrastructure and load shifting, and an evaluation of a SCE pilot charging program.

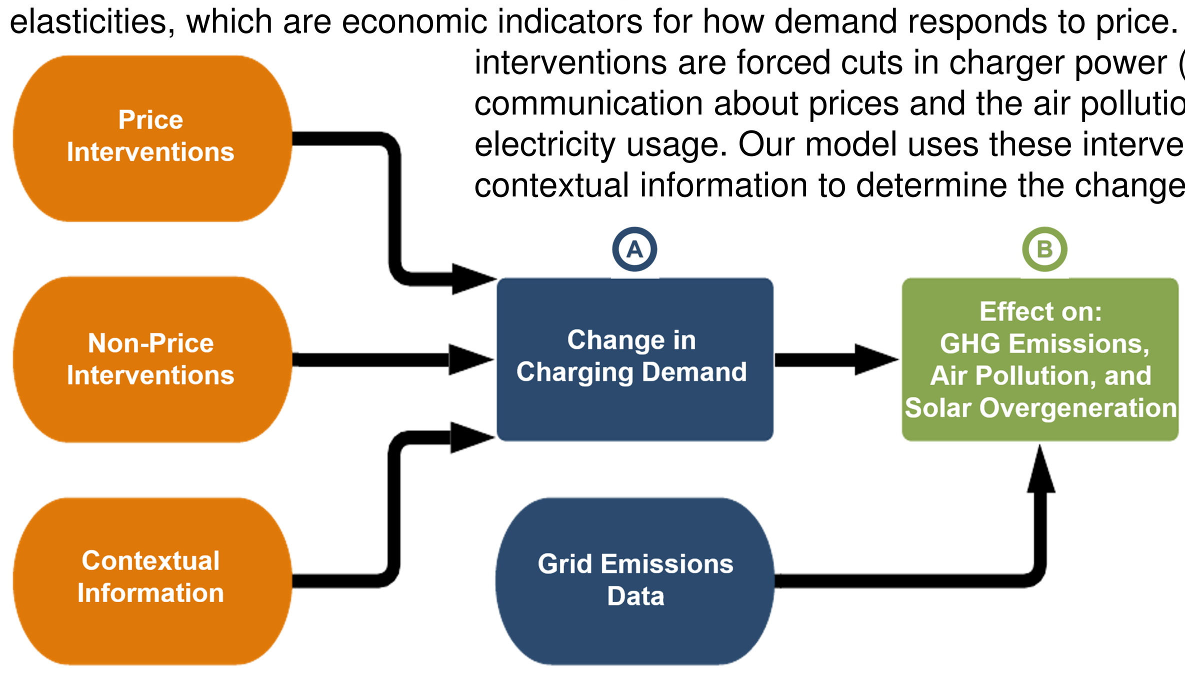
MODEL DEVELOPMENT

Our economic model simulates 2 outputs:

Ⓐ **Change in charging demand over the course of a day compared to baseline demand**

Ⓑ **Effect on greenhouse gas emissions (CO_2), air pollution (NOx), and solar overgeneration**

Our model considers how ***economic, technical, and communication interventions*** shift EV charging to different periods of the day, and how this impacts the environment, human health, and the electrical grid. Price interventions include discounts, rebates, and completely new price schedules (Time-of-Use Rates). A discount is typically a midday price reduction intended to increase load, while a rebate is a payment to a consumer for reducing load when demand is high. Price is factored in by using elasticities, which are economic indicators for how demand responds to price. Our 2 non-price interventions are forced cuts in charger power (throttling), and communication about prices and the air pollution impacts of electricity usage. Our model uses these interventions and contextual information to determine the change in demand.

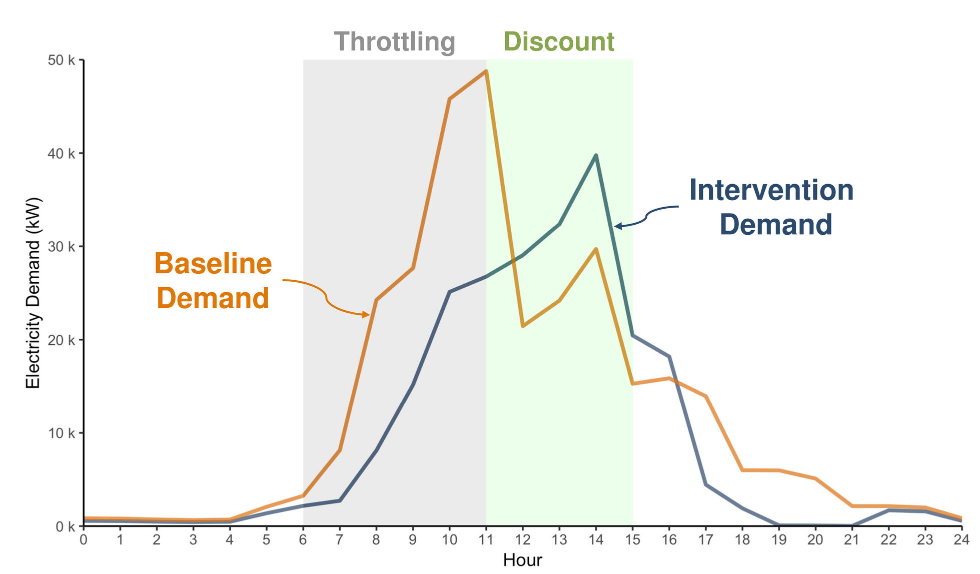


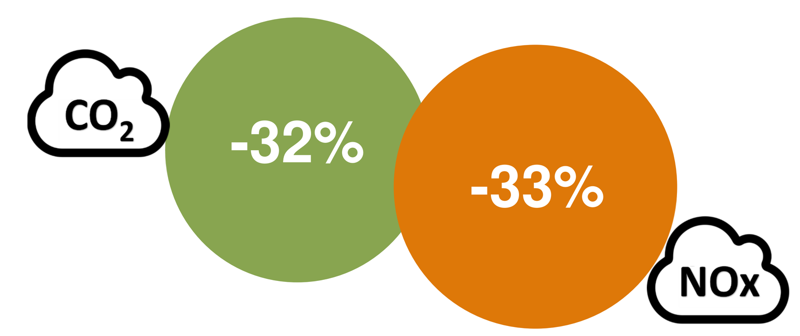
3 RESULTS

MODEL OUTPUTS

WORKPLACE

Interventions
31,435 Chargers
2019 Time-of-Use Rate
Charger Power Reduction (Throttling) 6 - 11 a.m.
Communication on Price and Air Pollution
$0.05 Discount 11 a.m. - 3 p.m.

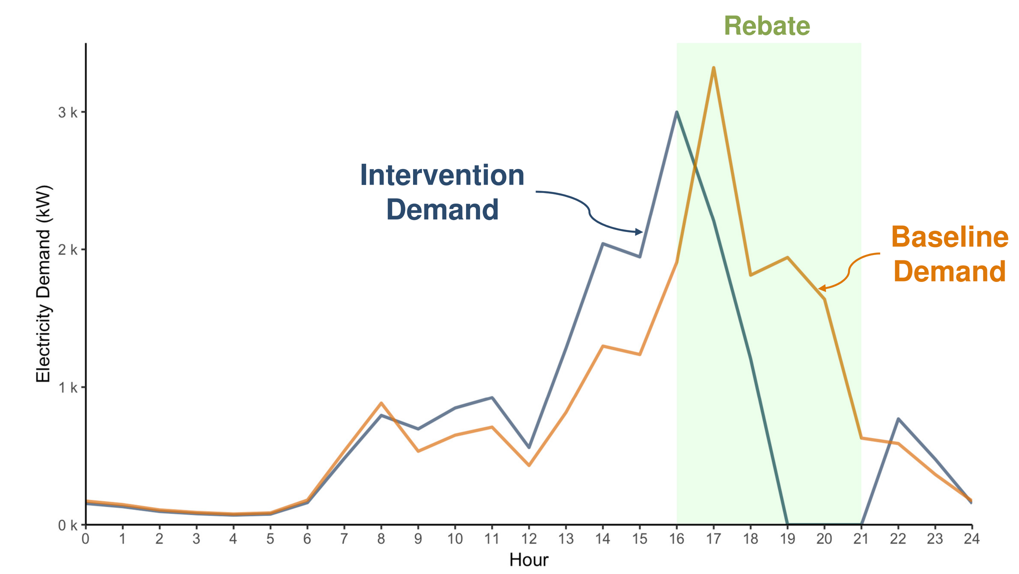




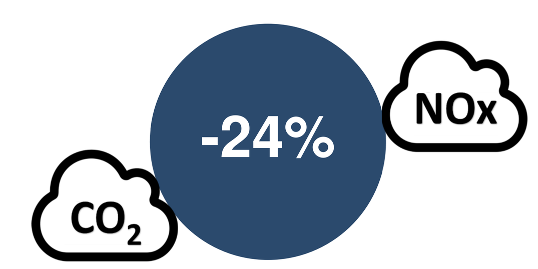
Evening ***peak demand falls by 80%.*** Midday charging increases by 34%. This decreases greenhouse gas and air pollution emissions by 32% and 33%, respectively.

FLEET

Interventions
4,378 Chargers
2019 Time-of-Use Rate
Communication on Price
$0.10 Rebate 4 - 9 p.m.



Evening ***peak demand falls by 63%.*** This decreases both greenhouse gas and air pollution emissions by 24%.



Displayed above are the most impactful interventions for two long-dwell locations. Workplaces and fleets have similar characteristics to destination centers and multi-unit dwellings, respectively.

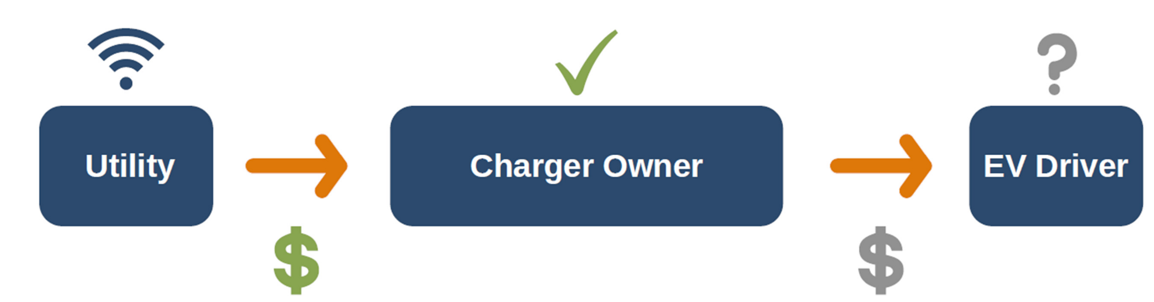
HYPOTHETICAL ANALYSIS

In 2030, if there were 50,000 chargers in SCE's territory – all at our long-dwell locations – and they only worked from 11:00 a.m. to 3:00 p.m., could we meet all daily EV charging demand? We find that this would only meet 13% of all daily demand for EV charging, and the daily emission reductions would be minimal:

This highlights that the ***demand analyzed in our modeled scenarios represents a fraction of the possible demand that could be shifted.*** Therefore, we need to expand load shifting to other charger locations to maximize EVs' greenhouse gas and air pollution reduction potential.

PILOT ANALYSIS

We analyze the impact of 8 real-world events that applied price and throttling interventions and compared them to our modeled scenarios. Our ***modeled response is higher than that of EV drivers during these SCE pilot events***, revealing a communication challenge: SCE can communicate to the owners of the chargers, but cannot directly influence the price charged to EV drivers. Due to this, these demand response events had a limited impact on shifting charging demand.



4 KEY FINDINGS

I LOAD REDUCTION IS MORE SIGNIFICANT THAN LOAD SHIFTING

Modeled interventions successfully *reduce* demand in the evening peak period by up to 93%, while up to 37% of load is *shifted* to the middle of the day to take advantage of solar energy.

II LOAD SHIFTING AND REDUCTION REDUCE DAILY EMISSIONS

Daily greenhouse gas and air pollution emissions fall by up to 37% in our modeled interventions. Daily reductions are limited because we see more load reduction than shifting and we make conservative assumptions regarding renewable electricity availability.

III COMMUNICATION IS ESSENTIAL TO BEHAVIOR CHANGE

Under the SCE pilot, EV drivers often do not know the initial price of electricity or receive notifications about the price changes analyzed in our model. This makes it challenging to induce EV drivers to change their charging behavior.

IV LOAD SHIFTING IN 4 LONG-DWELL LOCATIONS WILL NOT SUPPORT CHARGING DEMAND IN 2030

We consider load shifting at workplaces, destination centers, fleets, and multi-unit dwellings, but most people charge at single-family homes. Thus, the load analyzed here represents a fraction of the possible demand that could be shifted.

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5 RECOMMENDATIONS

TEST OTHER STRATEGIES

Alternative strategies, such as subscription charging, graduated pricing, and limited morning throttling, should be explored.

CLOSE THE COMMUNICATION GAP

Strategies and incentives to help charger owners pass along interventions to EV drivers will reduce the communication barrier.

RESEARCH DRIVER BEHAVIOR

Conducting an economic study on EV drivers in non-residential charging locations can improve our model and better inform energy providers.

EXPAND THE PROGRAM

Including single-family homes or other charging locations in load shifting programs will increase the benefits of managing charging.

MORE INFORMATION

Interested in learning more about our research?
Visit our **WEBSITE** to access our **FINAL REPORT** or to use our **APPLICATION** to simulate EV charging demand.

ACKNOWLEDGMENTS

We would like to thank the numerous people who supported this project, including our faculty advisor, Chris Costello, our external advisors, and the entire team at SCE. We are grateful for the community of staff, faculty, and students at the Bren School and our funders at Yardi Systems.