ABSTRACT
Passing the Climate Action Plan, Denmark seeks to reach ambitious decarbonization goals by 2030. Similar to California, this includes banning the sale of new gasoline, hybrid, and diesel light-duty vehicles. Consequently, the anticipated demand for Electric Vehicles (EV) heightens rapidly in the coming decade. Partnering with the Danish Technological Institute (DTU), creating charging profiles to characterize when and where Danes are charging EVs allows for governmental and private entities to pinpoint potential regions for grid improvements and expansion. Analyzing available charging data from a climate similar to Denmark, the United Kingdom, three categories of charging profiles are present: Slow Charging (<7kW), Rapid Charging (7–115kW), and Fast Charging (>150kW). Additionally, two scenarios were created: Scenario 1, reducing idle time, and Scenario 2, reducing grid intensity. Projecting to 2035, smart charging was shown to be beneficial. On a hourly basis, shifting 24% of charging instances results in 14% reduction in greenhouse gas (GHG) emissions, and 8% of saved costs to consumers. Further research could be done utilizing Danish charging data if available. Recommendations include shifting consumer charging times outside of 7:00am-10:00am, and 5:00pm to 9:00pm, in order to reduce grid use during peak demand hours.

OBJECTIVE
Assuming there will be 580,000 passenger EVs in 2035, 1. When is the cheapest time to charge your EV? 2. When is the lowest-emitting time to charge your EV? 3. Find the overall between lowest costs and emissions for charging EVs in Denmark.

SCOPE & SHIFING
Frequency of Charging Events by Hour of the Day

GHG EMISSIONS PROJECTIONS

RESULTS

Smart charging reduces GHG and costs, along with lowering electricity demand during peak hours, shown in the figure above.

The DANISH GRID

- Denmark has two grid networks. DK1 supports Western Denmark consumption and DK2 supports Eastern Denmark consumption.
- DK1 has more renewables than DK2.
- Peak loads:
  - Monthly - January (3,597,221 MWh)
  - Hourly - 6:00pm (5,073 MWh)

SENSITIVITY

- EV Stock: varied +/- 12.5%
- VKE: varied by different EU countries (2018 level)
- Efficiency: varied by different popular EV efficiencies
- VKT had the highest sensitivity

PRICE PROJECTIONS

Scenario 1
- Can save consumers up to 8.3%
- Cumulatively saves €164 million

Scenario 2
- Can increase price to consumers up to 4.4%
- Cumulatively costs €85 million

ACKNOWLEDGMENTS
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EQUITY
- Critical minerals are a non-renewable resources necessary in car battery production
- Mining corporations are more often than not flagrant with corrupt labor practices, violating human rights.
- Such elements needed are predominantly mined in the global south, providing insignificant to no benefits to the nations or workers utilized than the international mining companies.

CONCLUSIONS
- Smart charging is an effective way to reduce ghg emissions, price and peak load
- On a hourly basis, shifting 24% of charging instances results in 14% less GHG emissions and 8% savings.
- 2030 grid consumption and production are estimated to be 61 and 65 TWh respectively. 2030 EV energy demand is 85 TWh, not exceeding grid capacity.

RECOMMENDATION
- Delay the charging instance to avoid the peak period of the grid, reducing GHG emissions and saving costs.
- Reduce the distance travel per vehicle (VKT)
- Reduce demand for private passenger EVs.
- Analyze commercial and workplace charging stations.
- Include a predictive measure for grid mix and pricing.
- Include a scenario for DK reaching 2050 neutrality goals instead of business as usual.
- Incentives to expand cycling and public transportation infrastructure, and public sharing programs for EVs.