Future Smart Charging Profiles in Danish Homes

UCDAVIS PROGRAM FOR INTERNATIONAL ENERGY TECHNOLOGIES

UCDAVIS FACILITIES MANAGEMENT

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 university (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 charing profiles are present: Slow Charging (<7kW), Rapid Charging (7<value<22), and Fast Charging (>22kW). 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.

DANISH CLIMATE GOALS

According the Danish Census, Denmark is populated by 5.9 million people. Demographically, Denmark is 96.1% white, 86% of which are ethnic Danes. The median household income is roughly $78,575.72 USD. As a small, homogenous Scandinavian nation, Denmark maintains high levels of trust in governance by the people. This is in part due to its multi-party system and the election of the Socialdemokratiet, or the Social Democratic Party. As a member within the European Union (EU) and the United Nations (UN), Denmark continues to push for policies aligning with the sustainable development goals (SDGs). Enacting the Climate Action Plan allows Denmark to reach such goals.

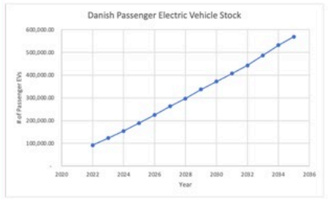
THE DANISH GRID

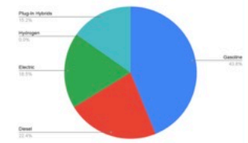
- Denmark has two grid networks. DK1 supports Western Denmark consumption and DK2 supports Eastern Denmark consumption.
- DK1 has more renewables than DK2.
- Peak Loads:
  - Monthly - January (3,597,221 MWh
  - Hourly - 6:00pm (5,073 MWh)

OBJECTIVE

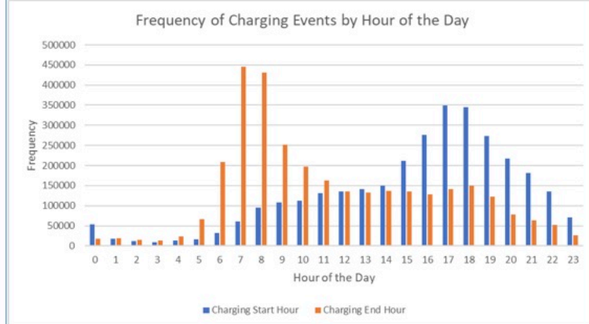
Assuming there will be 580,000 passenger EVs in 2035,

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 & SHIFTING



Month	Profile Share	Day	Profile Share	Hour	Start Profile Share	End Profile Share
Jan	0.08	Sun	0.13	0	0.017	0.005
Feb	0.08	Mon	0.14	1	0.006	0.006
Mar	0.09	Tue	0.15	2	0.004	0.005
Aprl	0.05	Wed	0.15	3	0.003	0.004
May	0.06	Thu	0.15	4	0.004	0.007
Jun	0.06	Fri	0.15	5	0.005	0.021
Jul	0.09	Sat	0.13	6	0.010	0.066

Charging Shifts

- Baseline: No Shift
- Scenario 1: Charging ending at 6:00am-9:00am shifted six hours forward
- Scenario 2: Charging beginning 5:00pm-9:00pm shifted 6 hours later

Boundaries:

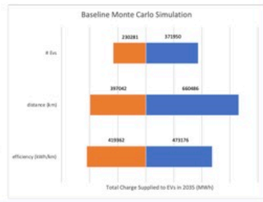
1. Spatial: Denmark, domestic
2. Temporal: 2022-2035
3. Product: Passenger EVs

Tools:

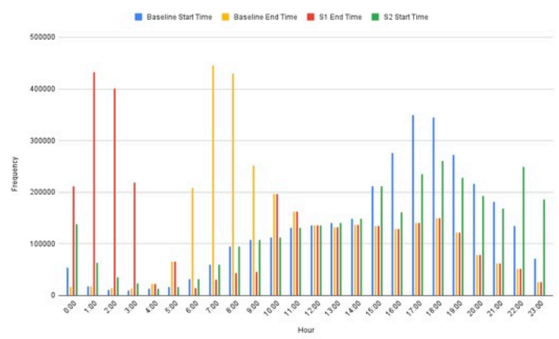
1. R Studio
2. Excel
3. Power BI

SENSITIVITY

- EV Stock: varied +/- 12.5%
- VKT: varied by different EU countries (2022 level)
- Efficiency: varied by different popular EV efficiencies
- VKT had the highest sensitivity

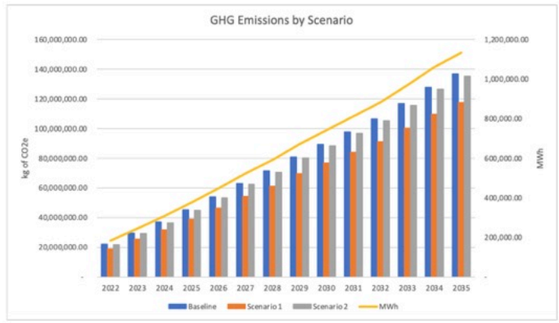


RESULTS



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

GHG EMISSIONS PROJECTIONS



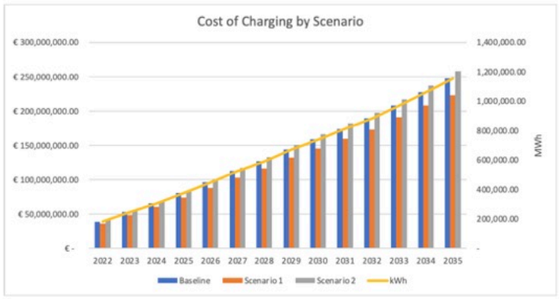
Scenario 1

- Can reduce GHG emissions by up to 14.2%
- Cumulatively reduces **153.4 million** kg of CO2e

Scenario 2

- Can reduce GHG emissions by up to 1.1%
- Cumulatively reduces **11.5 million** kg of CO2e

PRICE PROJECTIONS



Scenario 1

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

Scenario 2

- Can increase price to consumers by up to 4.4%
- Cumulatively costs **€85 million**

EQUITY

Co^{27} Cobalt

Li^{3} Lithium

Mn^{25} Manganese

Ni^{28} Nickel

- **Critical minerals** are a nonrenewable 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 predominately 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.

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