Long-term electricity system planning for electric vehicle charging in Germany

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1 Introduction

- Increasing EV adoption will impact the electricity system. EV demand is shaped by behaviours and charging infrastructure [1].
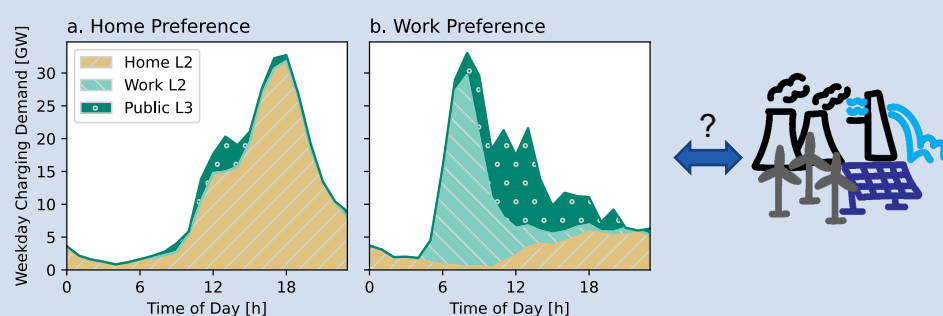

Figure 1. EV demand profiles for Home and Work preference scenarios.

- How can we use these factors to improve impacts on the grid?

- Missing clear policy direction; there is an untapped opportunity to use charging infrastructure to reshape future demand.

2 Methods

- Model Germany from 2025 to 2050

- Agent-based model of charging behaviours [2] using travel survey data from the German Mobility Panel [3]

- MANGOelec optimization of capacity investments and operations in with six 5-year investment, net-zero target in 2045 [4]
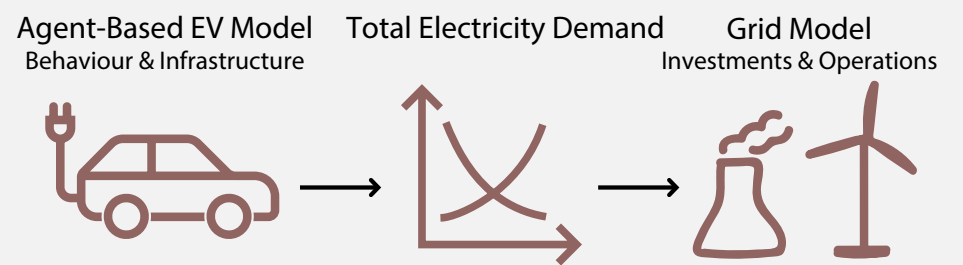

Agent-Based EV Model
Behaviour & Infrastructure

Total Electricity Demand

Grid Model
Investments & Operations

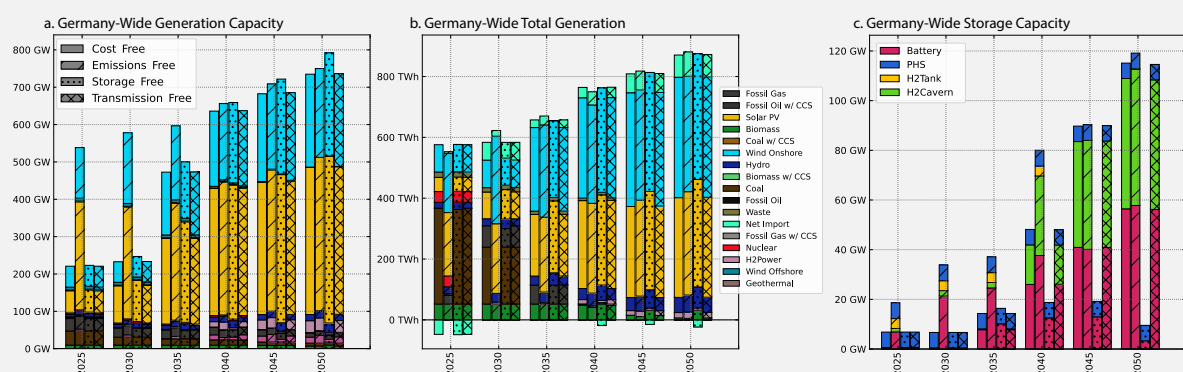**Figure 2.** Overview of modelling framework.

3 Results

Figure 3. Optimal investments depend on the objective; to minimize emissions, renewables are installed from the first period.
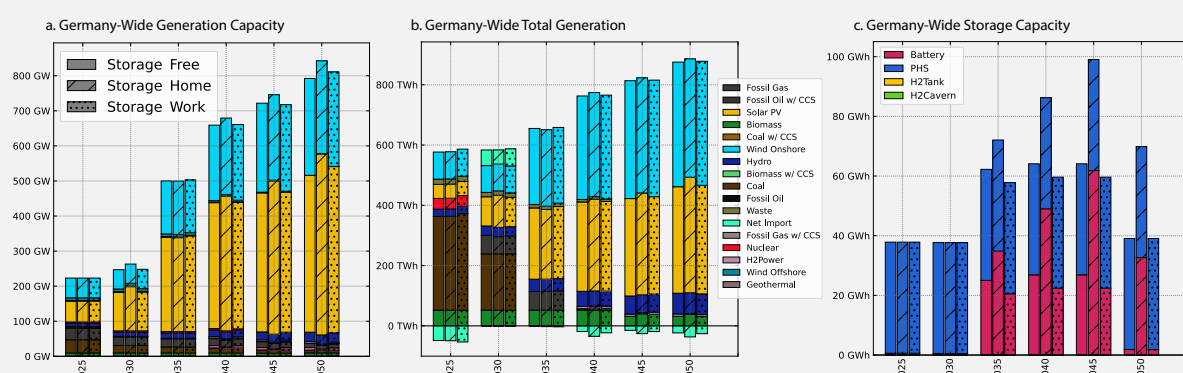

Figure 4. With home charging only, more batteries are needed, more capacity is built, and more generation is curtailed/exported.
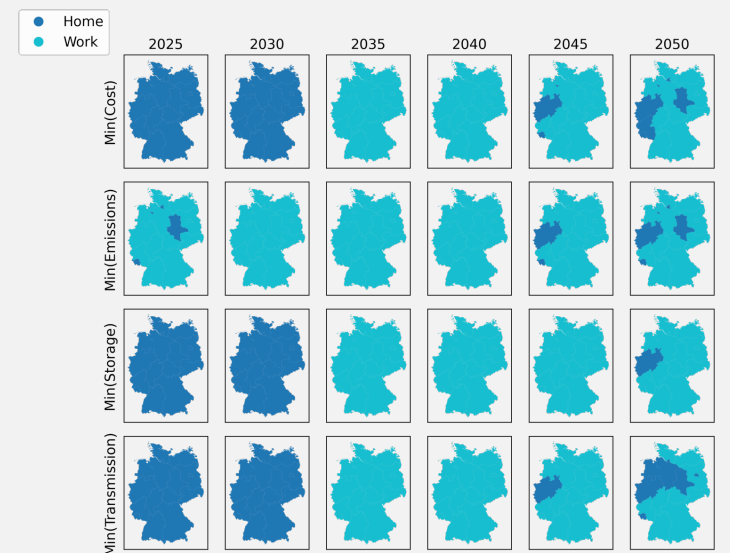

Figure 5. The optimization chooses different charging profiles by region and time.

Table 1. How much is it worth? This freedom has the biggest impact on storage.

Objective Function Values, normalized	Choice	Home	Work
System Cost, Min(Cost)	99.2%	100%	99.5%
CO_2 Emissions, Min(Emissions)	96.7%	100%	-
Storage Capacity, Min(Storage)	55.9%	100%	55.9%
Installed Transmission, Min(Transmission)	99.6%	100%	99.7%

4 Conclusion and expected impact

The best charging policies depend on the optimization objective and vary by region and time. In all cases, more daytime charging will be needed after the phase-out of coal. Policy makers should consider region-specific infrastructure policies to promote system-friendly charging.

Acknowledgements

References

1. Powell et al. Nature Energy 7.10 (2022): 932-945.
2. Gschwendtner et al. Sustainable Cities and Society 88 (2023): 104263.
3. Deutsches Mobilitätspanel (MOP) (2022). https://mobilitaetspanel.ifv.kit.edu/english/
4. Thimet and Mavromatidis. Applied Energy 351 (2023): 121764.

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