



Impact of demand-responsive industrial sector on the energy system in Germany

Anas Abuzayed, Mario Liebensteiner, Niklas Hartmann

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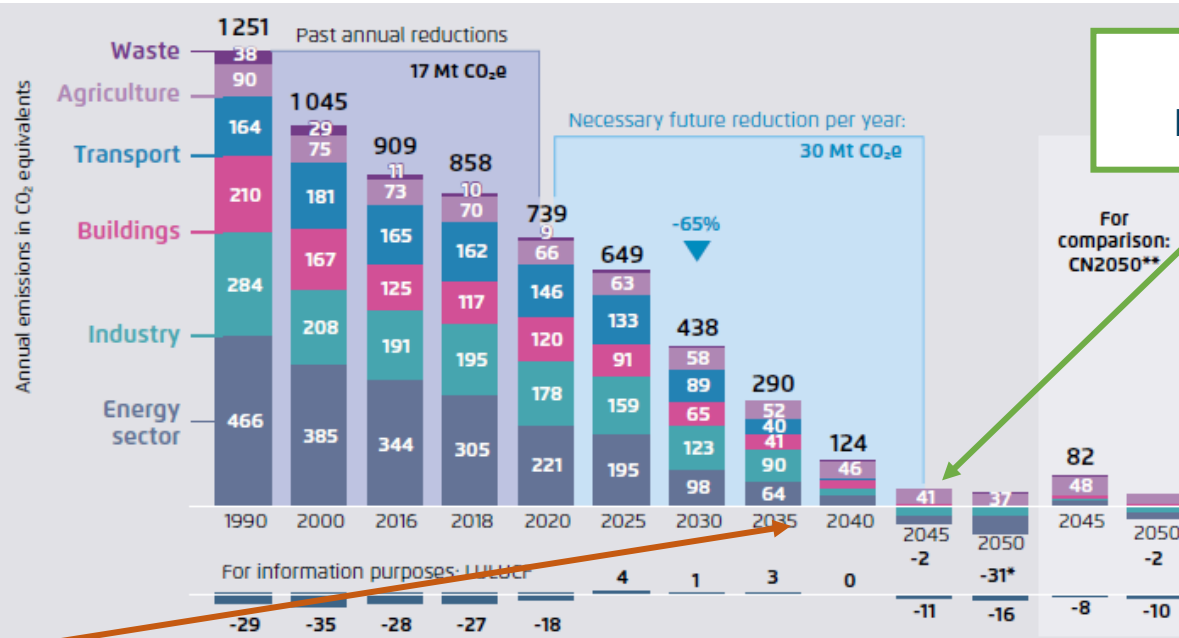
Bundesministerium
für Wirtschaft
und Klimaschutz

aufgrund eines Beschlusses
des Deutschen Bundestages

Presentation Content

- **Work Motivation**
- Methodology and Model Development
- Results and Discussion

Emissions and goals of Germany up to 2050



Climate Neutrality

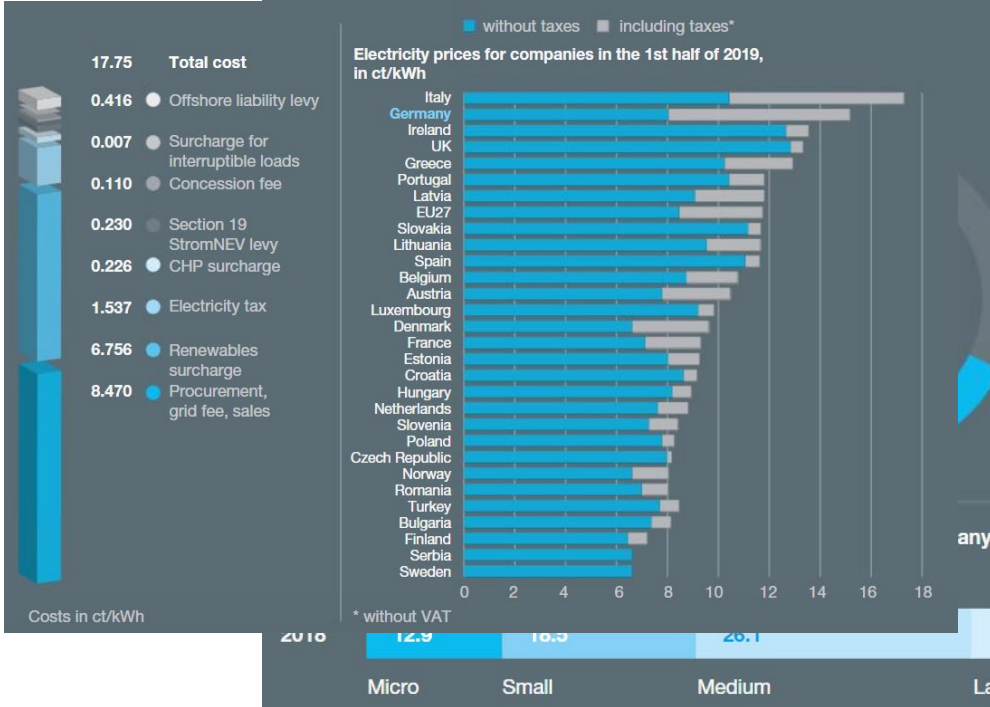
Coal Phase-out

Prognos, Öko-Institut, Wuppertal Institut (2021)

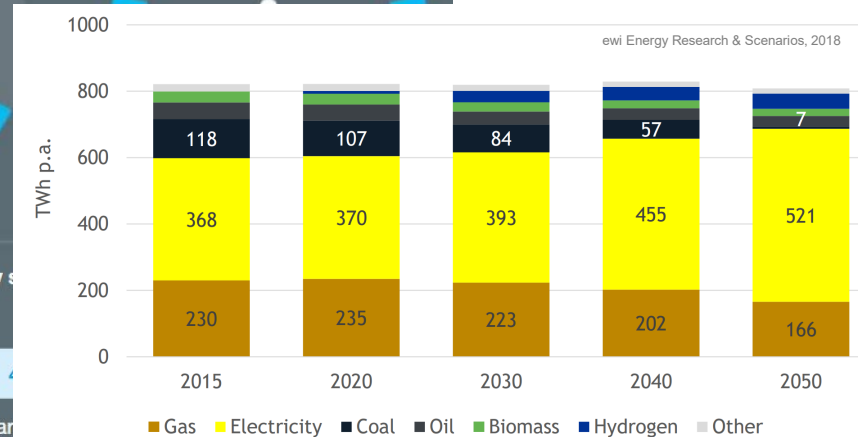
Negative emissions are considered in the sectors directly.
 * This figure merely extrapolates the trend after 2045; further emissions reductions are possible.
 ** Climate-Neutral Germany 2050

SME's Electricity Future

BDI, The German Mittelstand, April 2021



- Huge electrification process
Employees subject to social security contributions
- Demand-Flexibility Potential in SME industrial sector



Motivation for Work

- **What is the impact of SME's flexibility**
 - On the national energy system transformation goals
 - On other flexibility measures
- **What is the participation of SME's flexibility in the network congestion management**
- **What is the way forward to analyse and quantify flexibility measures**



Presentation Content

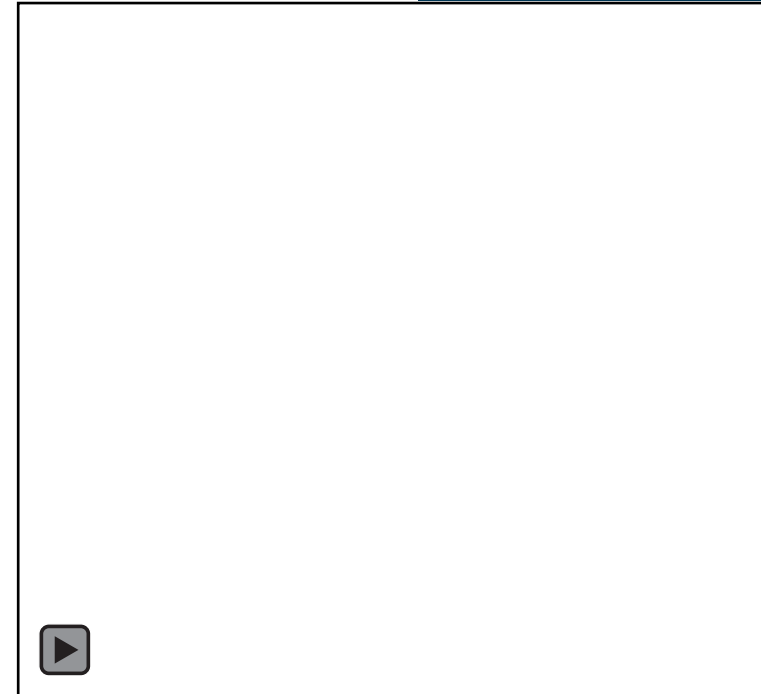
- Work Motivation
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Our Energy System Model: MyPyPSA-Ger

MyPyPSA-Ger enables new opportunities for action in the context of energy system transformation



- Optimal path to a climate-neutral energy system
- High spatial-temporal resolution
- Help decision makers to work towards a climate neutral energy system



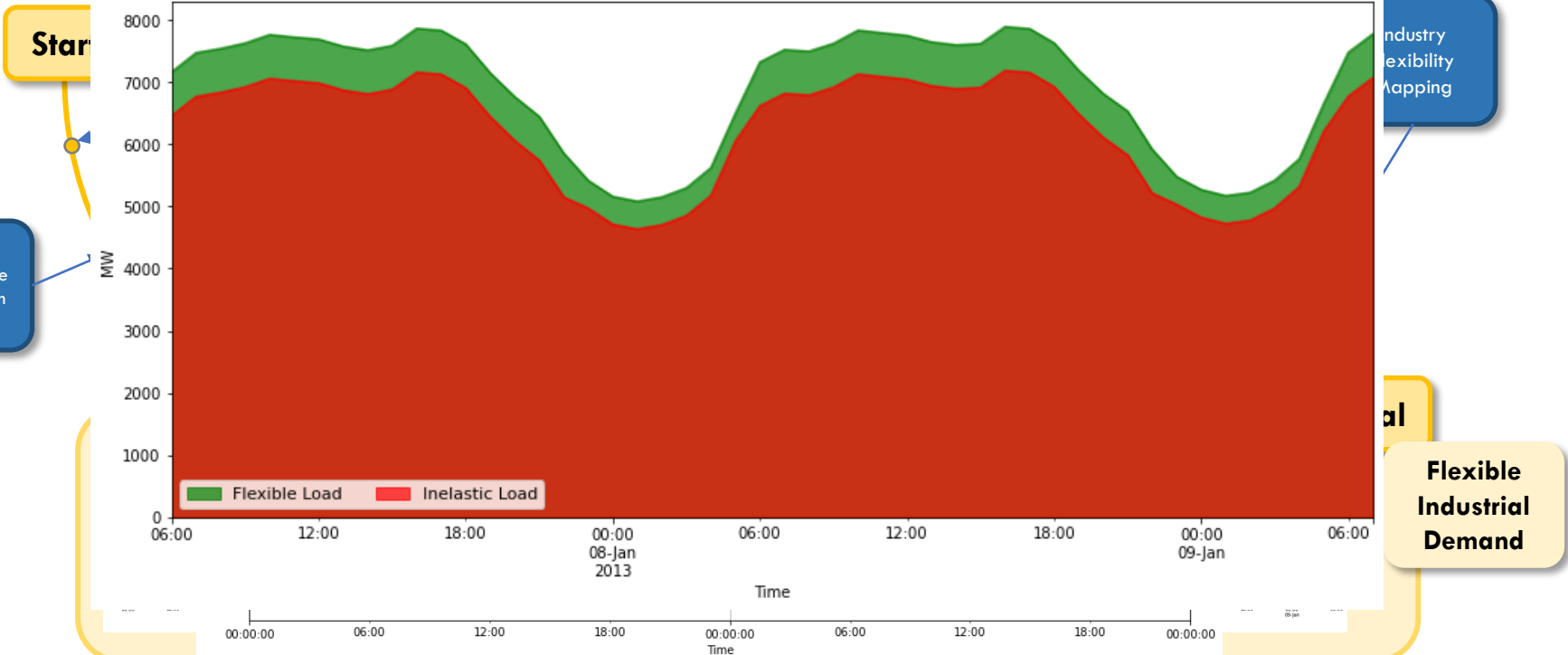
Abuzayed, A. & Hartmann, N., MyPyPSA-Ger: Introducing CO2 taxes on a multi-regional myopic roadmap of the German energy system towards achieving the 1.5 °C target by 2050. Applied Energy, Vol. 310, 2022.

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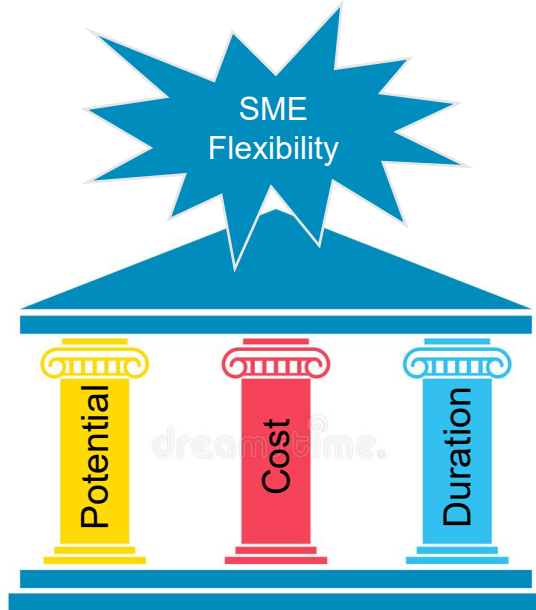


Industrial Sectors Classification

Load DE0 0 with 10% Flexibility from All sectors



Scenarios Settings



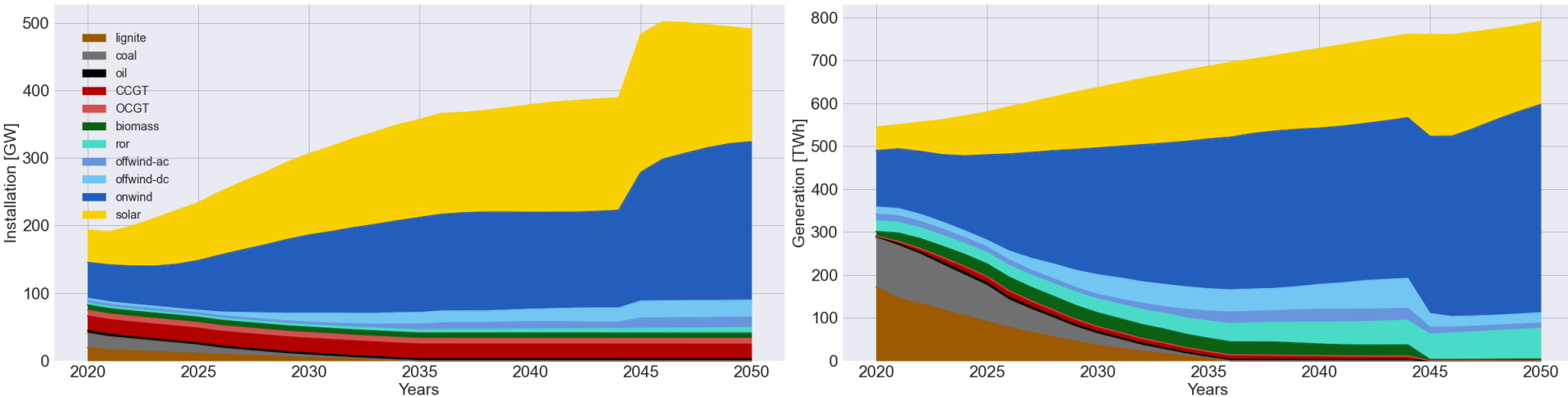
- Different flexibility potentials (% of full load): 5% to 20%
- Different cost assumptions: 0.01 to 0.1 Euro/kWh
- Different temporal settings: 1 to 8 hours
- Flexibility potential increase of 1% annually → electrification of industry
- Sensitivity Analysis → **129** Scenarios (+1 REF)

Presentation Content

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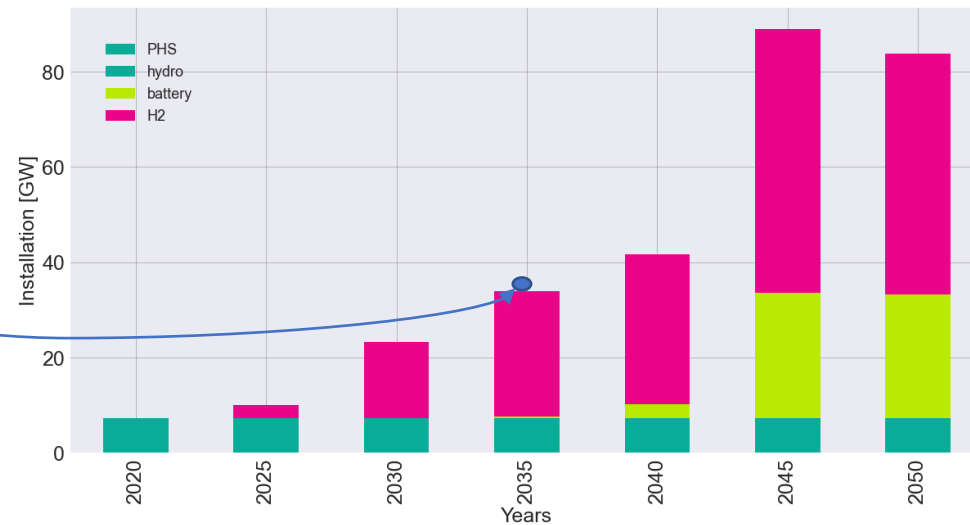
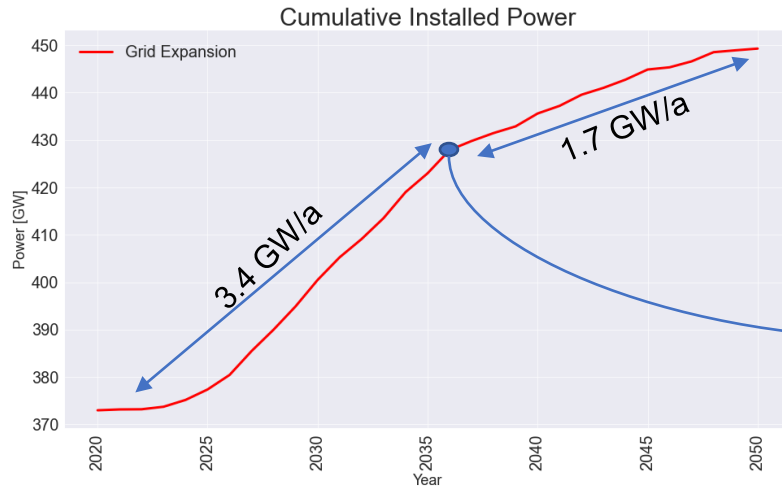
Preliminary Results

Renewable Energy Expansion



Preliminary Results

System Expansion



- Huge grid expansion is needed to realize the energy transition

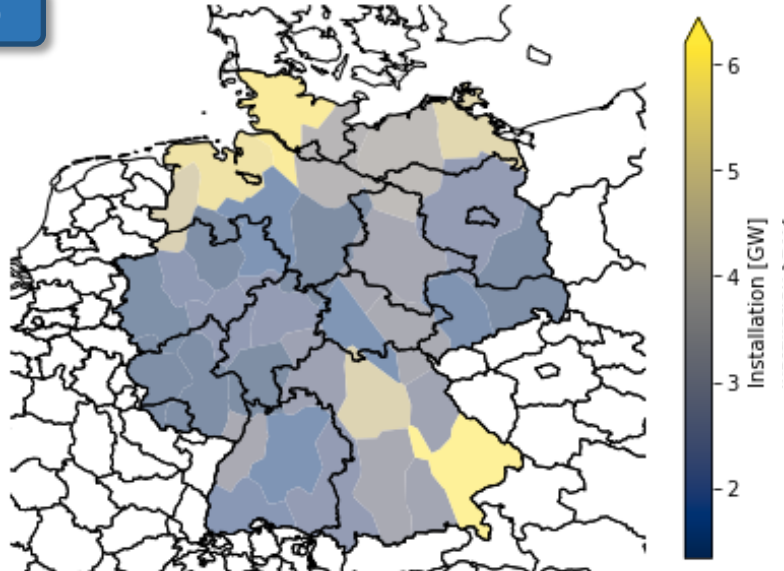
- High flexibility deployment (especially batteries) slows grid expansion

Preliminary Results

System Expansion - Regionality

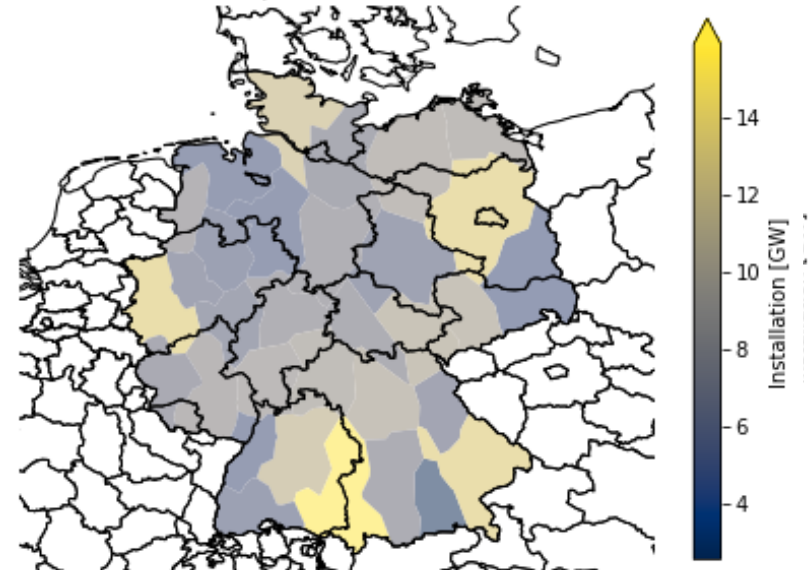
2050

Battery Expansion w.r.t 2020



- High regional-correlation between Onshore wind and long-term storage (Hydrogen facilities)

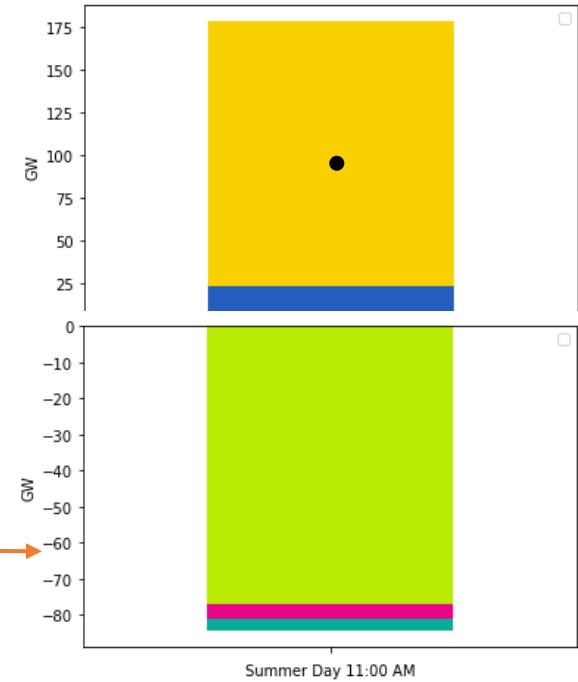
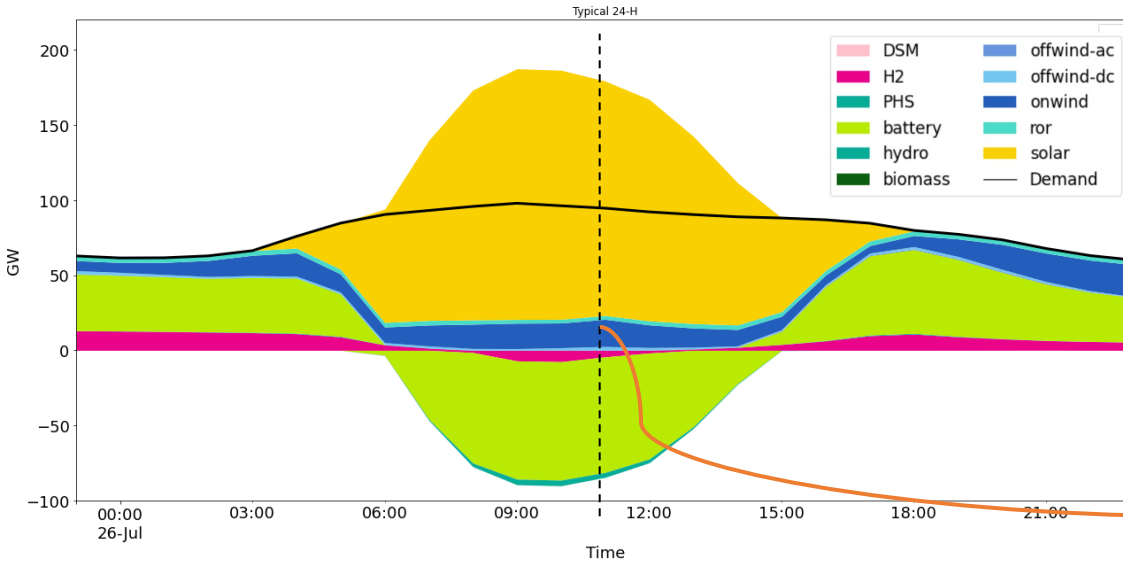
Solar Expansion w.r.t 2020



- High regional-correlation between Solar and short-term storage (BESS)

Preliminary Results

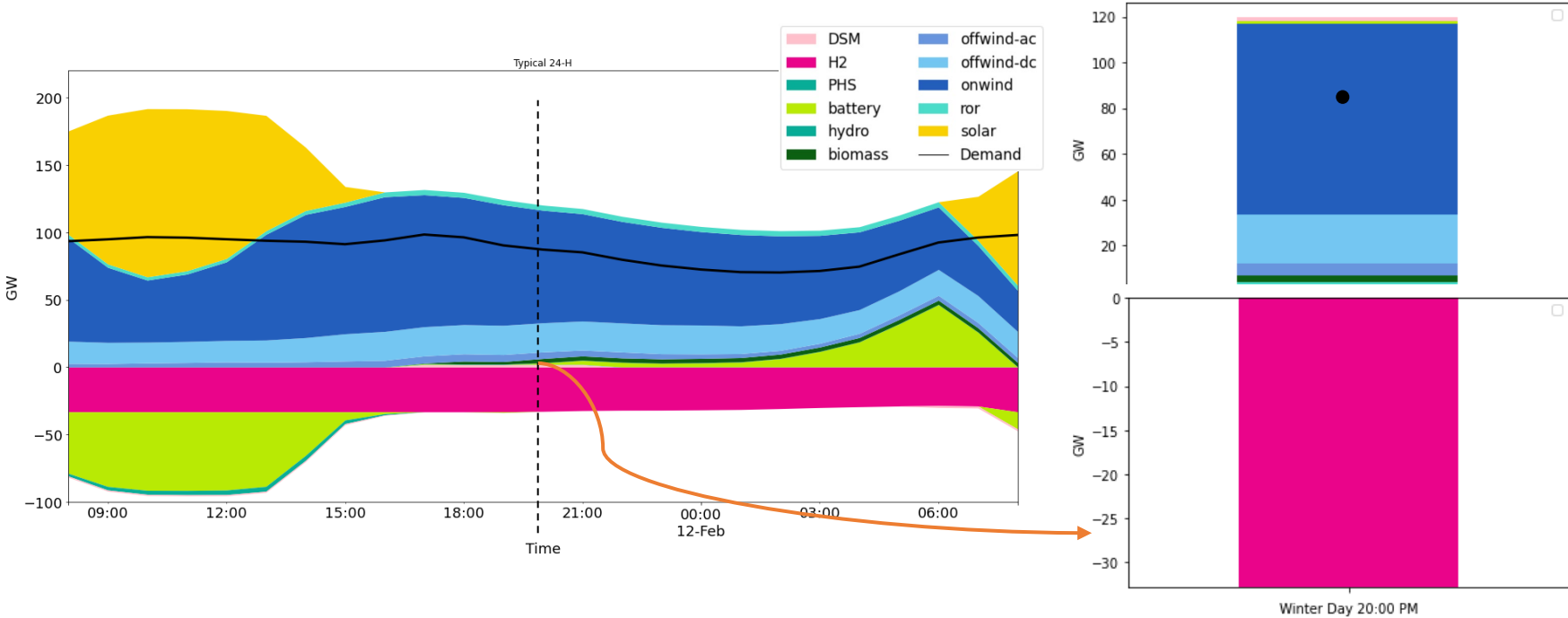
Summer Day - 2045



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Preliminary Results

Winter Day - 2045



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Preliminary Results

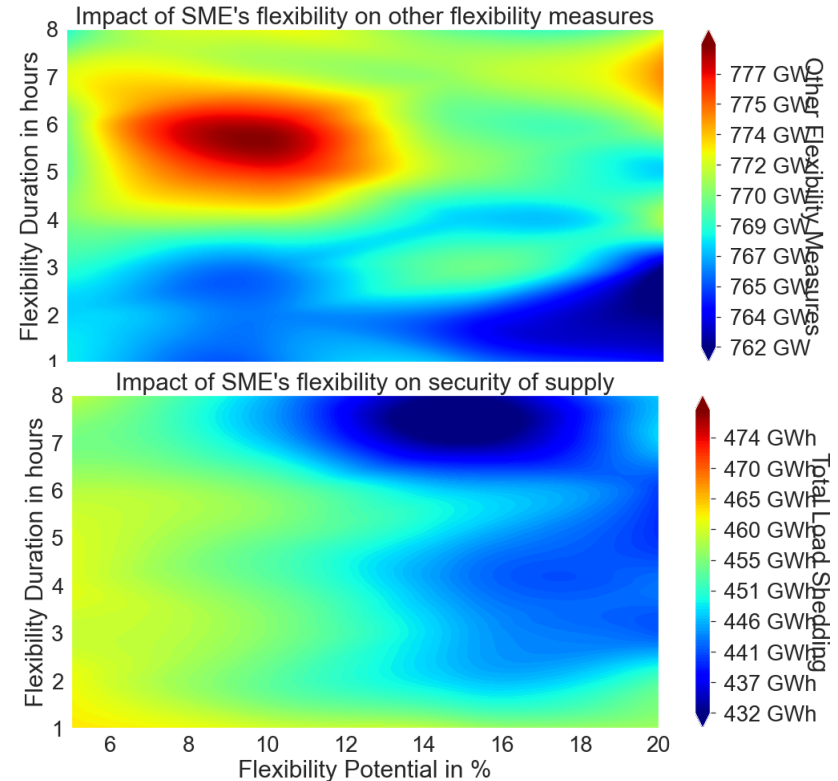
SME's Impact

Flexibility potential

- Reduces the system dependence on other flexibility technologies (Storage, Grid, DER)
- Lowers the overall investments in RES generation, yet enhances their utilization (FLH)

Flexibility duration

- Strongly utilized to enhance the congestion management (Load Shedding)
- Lower imbalance (energy shortages)



Summary

- SMEs flexibility **contribute** to the network congestion management, but will **not** be enough
- Less favoured **DSM** settings (cost/potential/duration) **increase** dependence on other flexibility measures
- Electrification **implies** an enormous potential form Demand-Side-Management

Thank you for your Attention

Questions?



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More on this:

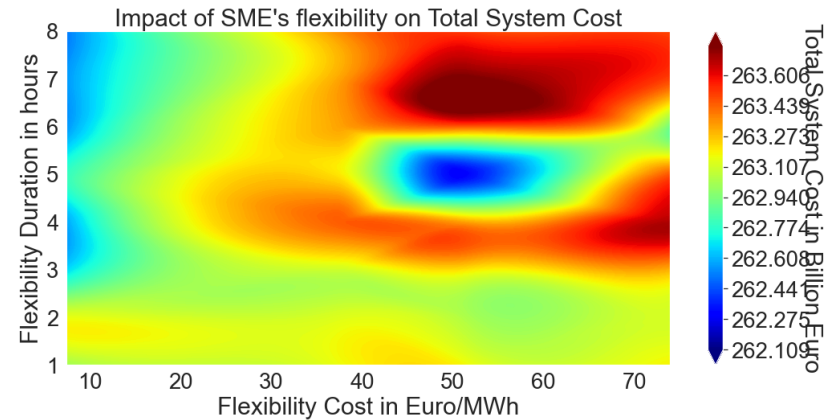
- Abuzayed, A. & Hartmann, N., MyPyPSA-Ger: Introducing CO2 taxes on a multi-regional myopic roadmap of the German energy system towards achieving the 1.5 °C target by 2050. Applied Energy, Vol. 310, 2022.
- Abuzayed, A. & Hartmann, N., Triggering Germany's ambitious dream of a completely renewable electricity sector by 2035. International Conference on Renewable Energies and Smart Technologies, Tirana, Albania, 2022.
- Abuzayed, A. & Hartmann, N., Achieving 100% renewable power system in Germany. Energy Proceedings, Vol. 21, 2021.

Back-up Slides

Flexibility Measures

Flexibility cost

- Nearly negligible in terms of national energy system analysis
- 212 Million Euro STD (0.08%) and 933 Million Euro Range (0.4%)
- Correlation with other flexibility measures (Hydrogen & Batteries) → Higher Flexibility cost → in favour of H2 & BESS



COP27 – Sharm El-Sheikh 2022

- Secure global net zero by mid-century and keep 1.5 ° C within reach.
- Robust and ambitious climate plans and stronger policies to cut emissions are a must
- Further investments remains crucial to meet the scale and speed of the challenge
- A lot more needs to be done by governments to fully deliver on their announced pledges.

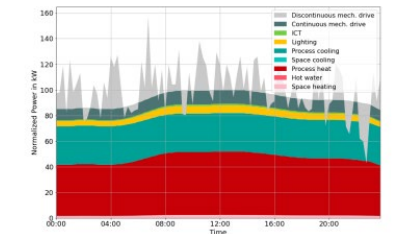
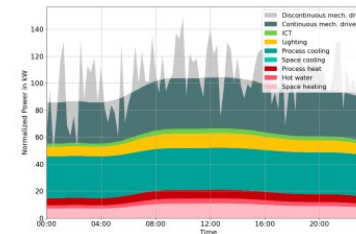
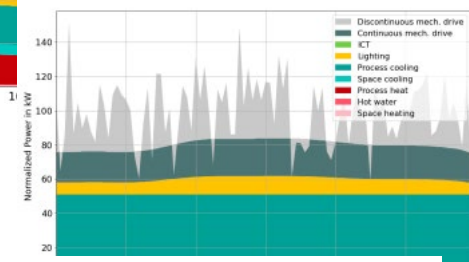
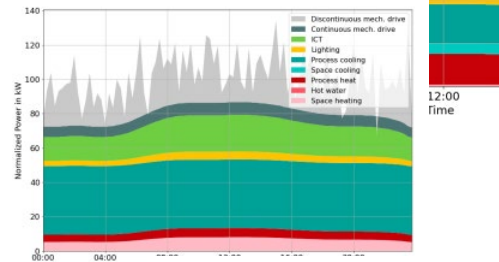
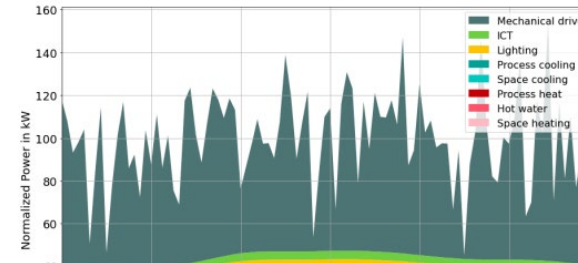


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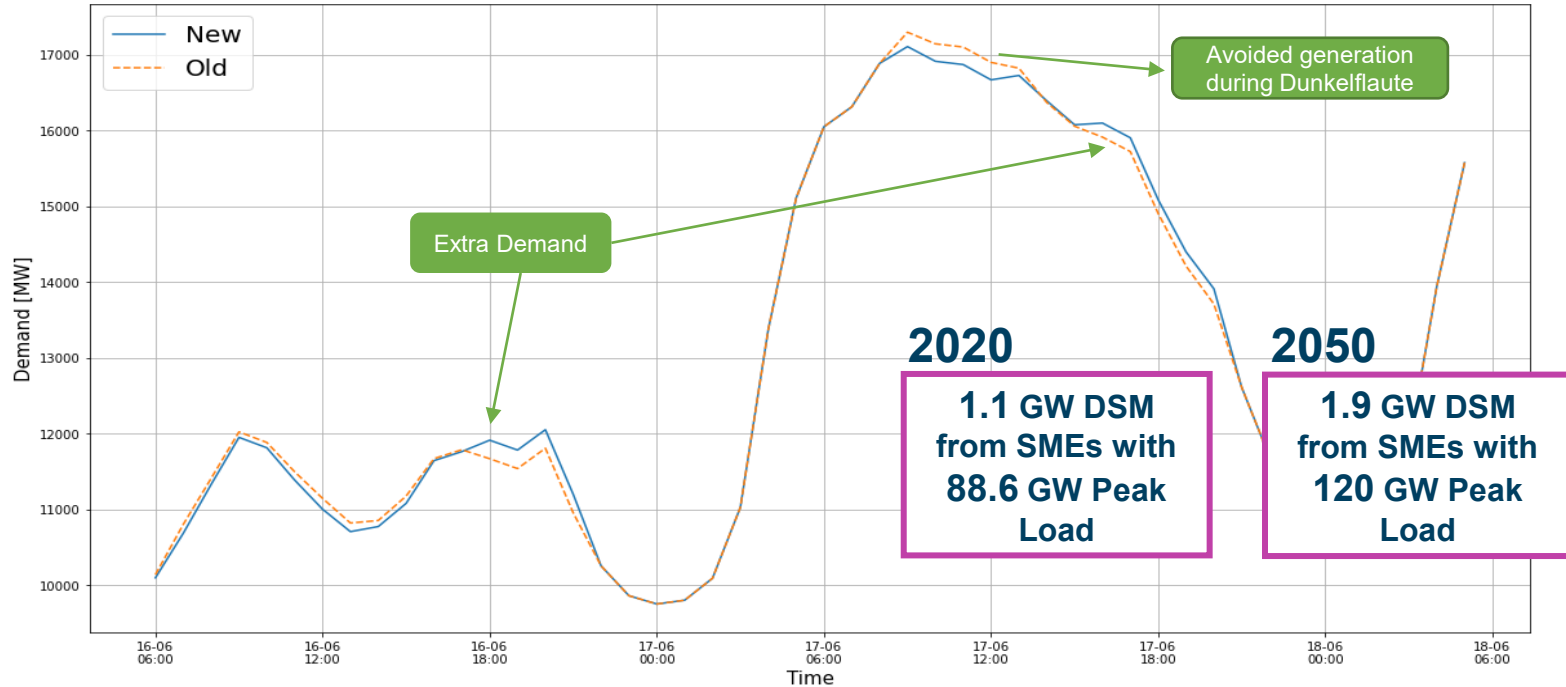
Actual SME's Electrical Demand

- Industrial enterprises have heterogenous demand
- Demand is usually neglected in energy system analysis
- Spatial and temporal characteristics of demand make a huge difference in energy models
- The need to temporally shift energy can supplement the flexibility options within the energy system
- Mapping the diverse and different characteristics adequately of the medium-sized industrial sector in the energy system models is very challenging

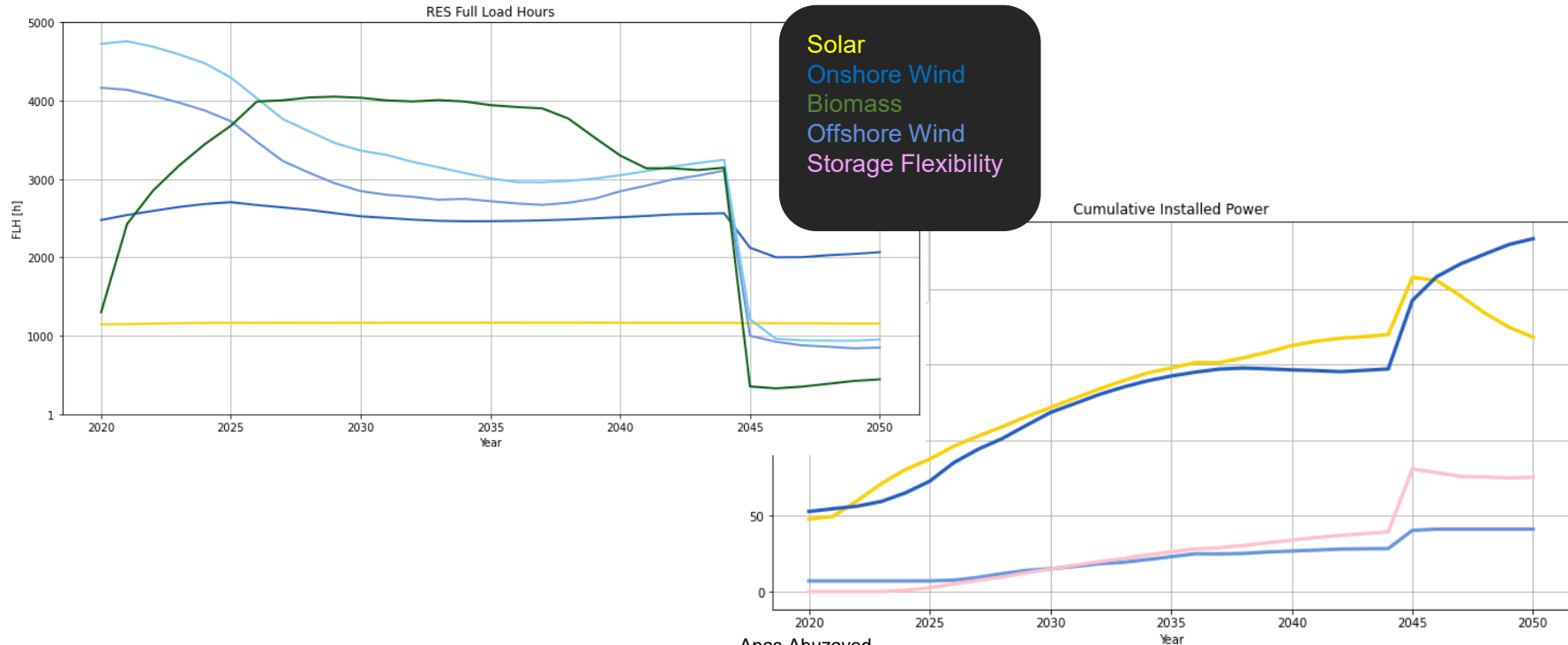


Sandhaas, A.; Kim, H.; Hartmann, N. Methodology for Generating Synthetic Load Profiles for Different Industry Types. Energies 2022, 15, 3683.

Demand-Side-Management Use Case

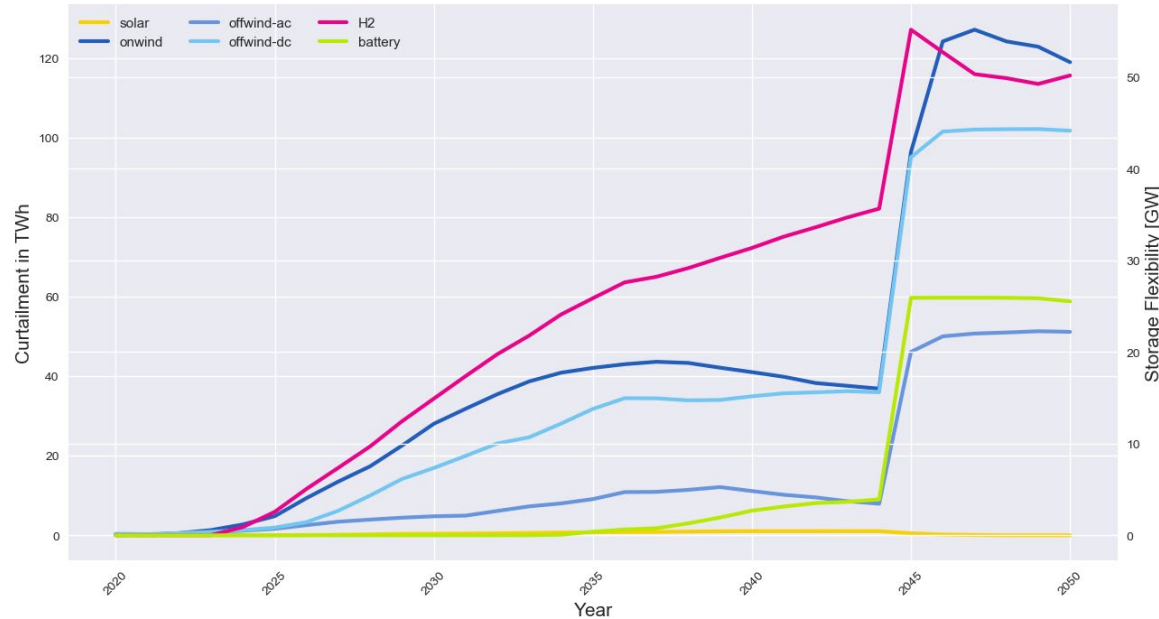


Model Optimality Vs Economic Reality



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Model Optimality Vs Economic Reality

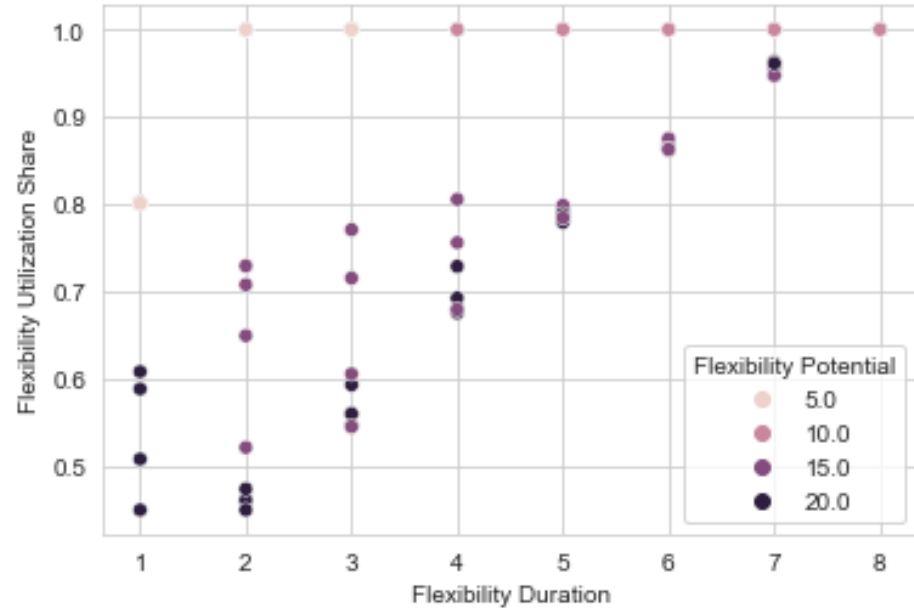


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Flexibility Measures

Flexibility duration

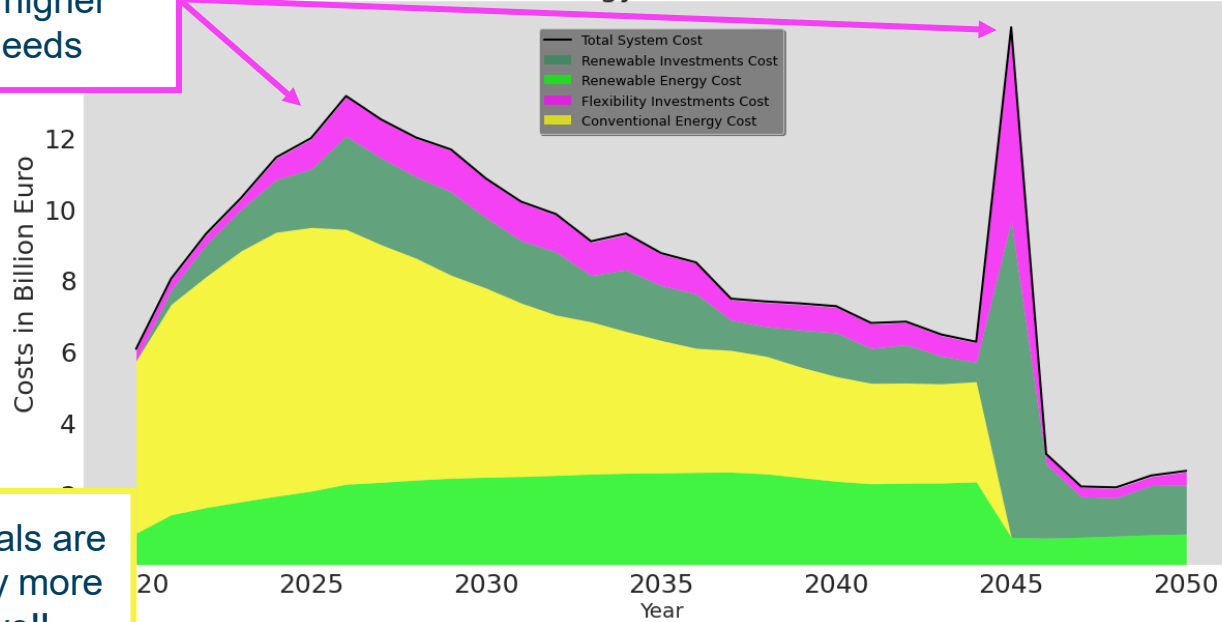
- Longer duration are more preferred to provide flexibility
- Less duration with higher potential can be less preferred than longer duration with lower potential



Total Annual Energy Transition Cost

Sustainable energy system has higher flexibility needs

Total Energy Transition Cost



Conventionals are dramatically more expensive!!

Generation costs in a sustainable energy system are much cheaper

Total Annual Energy System Cost

