

Flexibilities in a sector coupled, net zero energy system

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Motivation

Challenges in the energy transition

1

Renewable energy sources

Wind and PV fluctuating

2

End Use Sectors

Electrification increases sector coupling

3

Flexibility

Demand and Supply need to be balanced

The energy system model REMod

Modeling approach and scope

Geographical scope

- Germany as one node

Conversion and consumption sectors

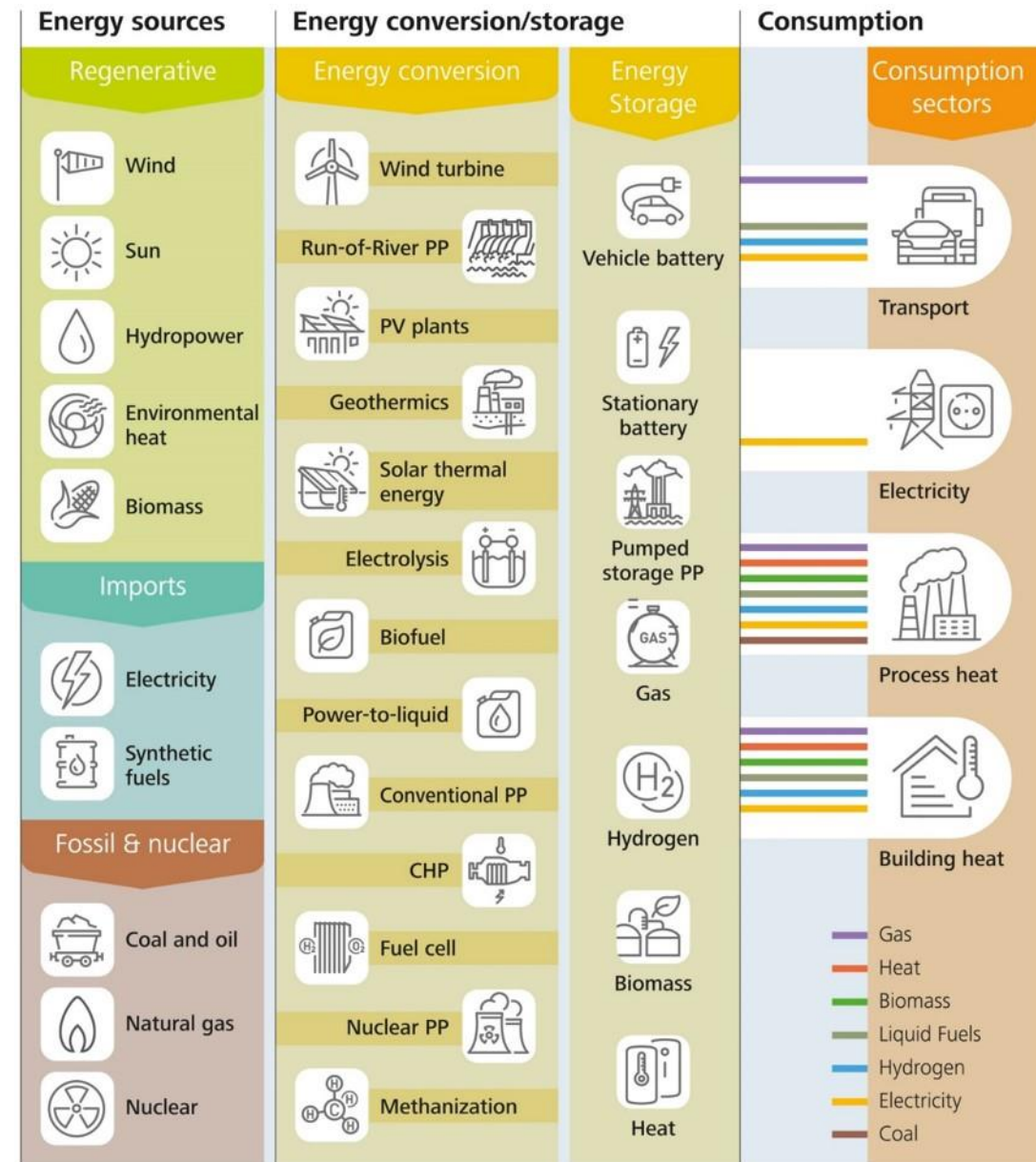
- Inclusion of all consumption sectors
- Multiple technologies are optimized separately
- Detailed integration of sector coupling effects

Optimization

- Minimization of transformation costs
- Non-linear „Black box“ optimization of transformation path on yearly basis

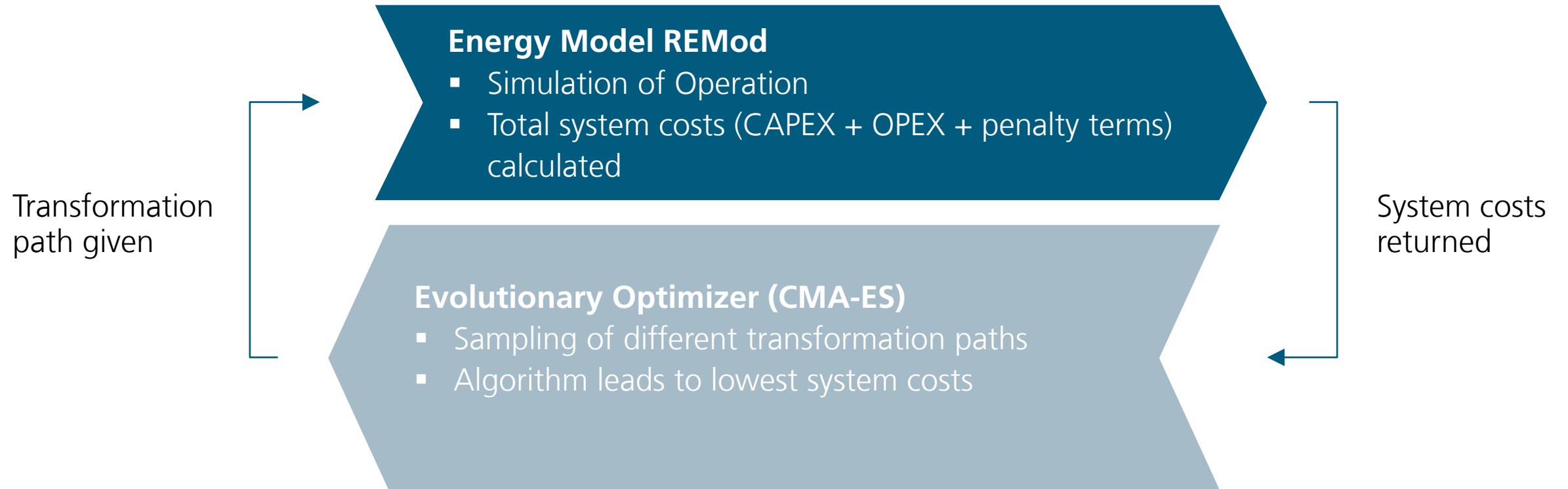
Simulation

- Simulation of operation on hourly basis
- Including historic timeseries (demand, weather) of five years



The energy system model REMod

Simulation and Optimization



Simulation

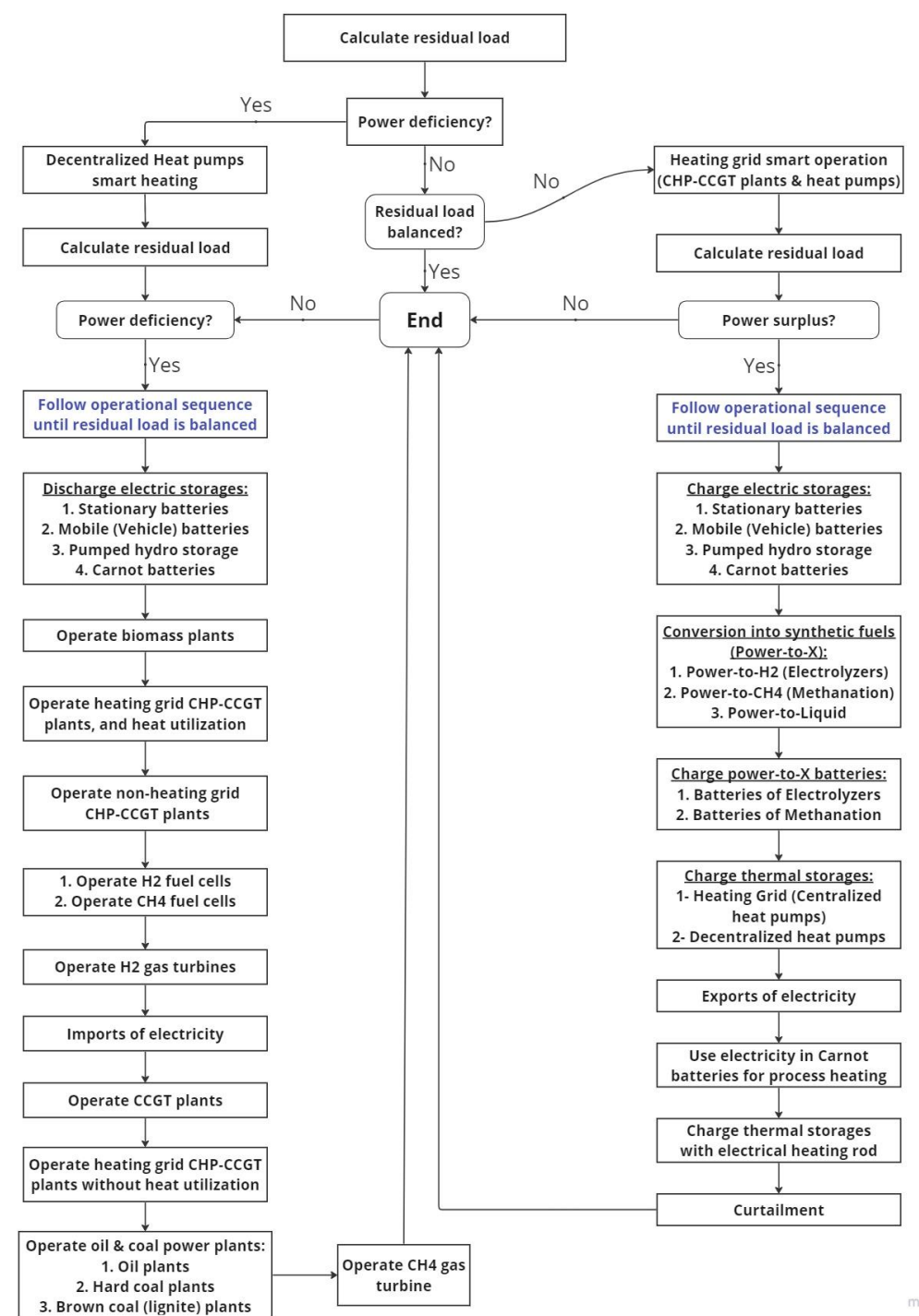
Based on a merit order

Operational sequence

Similar to merit order

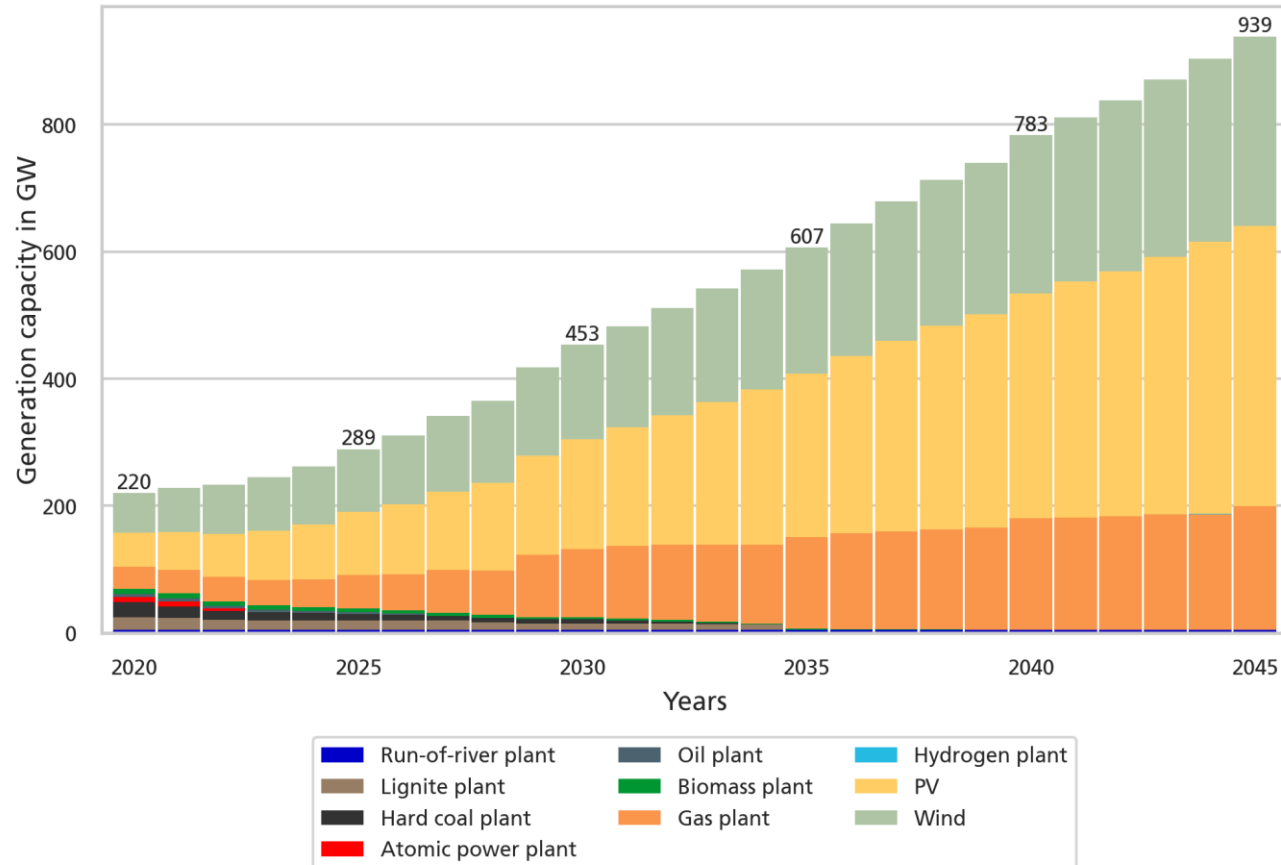
Minimises costs and emissions, maximises efficiency

→ Not optimized, but fixed during optimization!

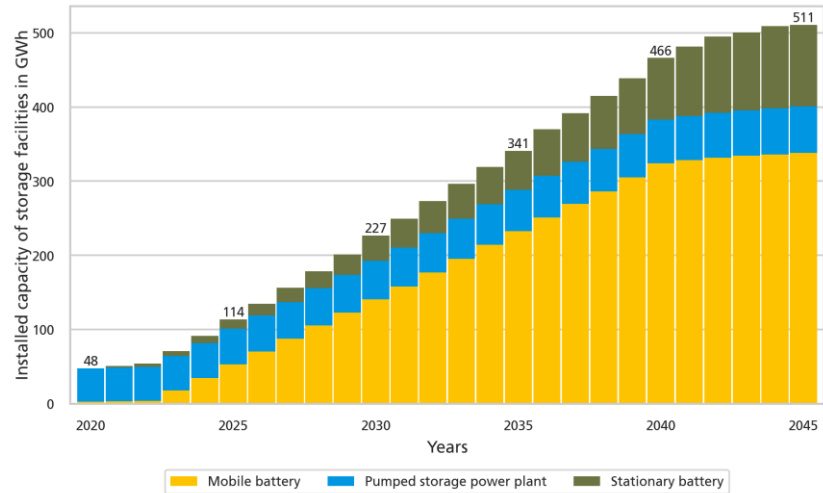


Transformation of the German energy system

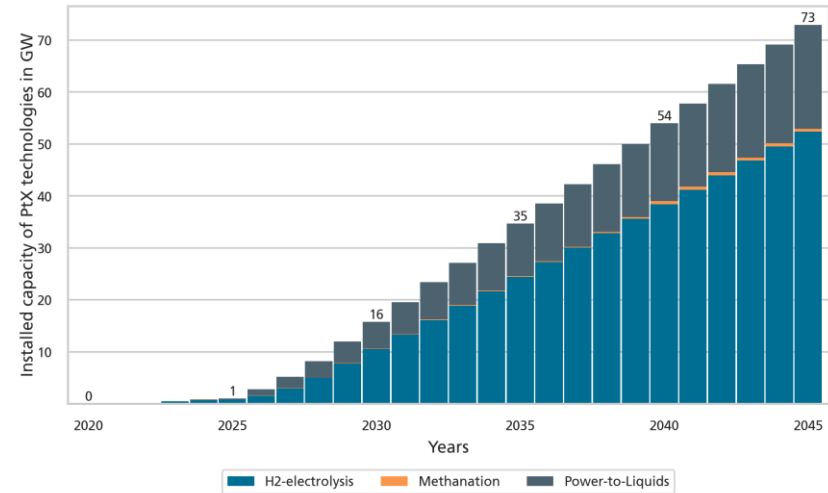
Installed generation capacity of electricity



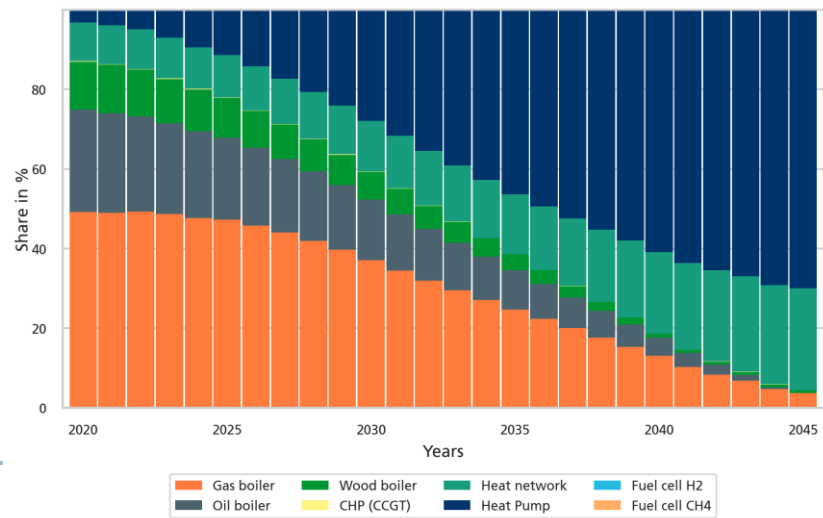
Transformation of the German energy system



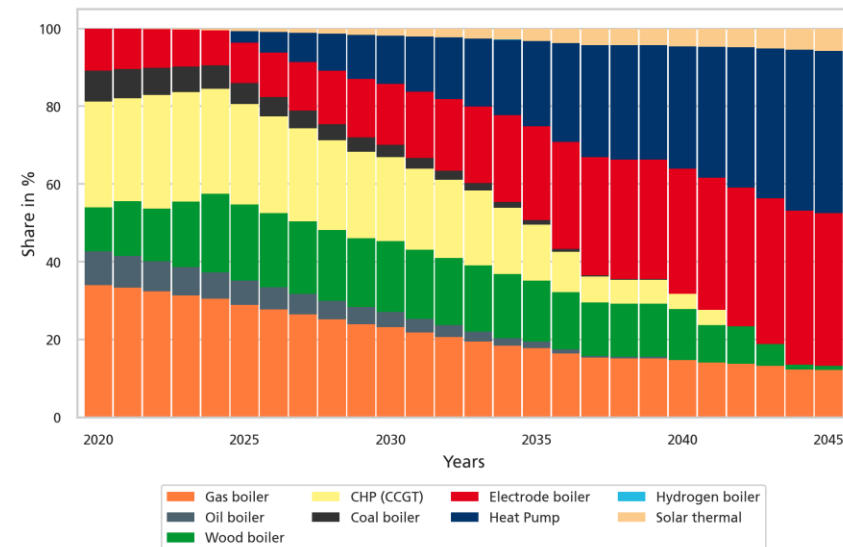
(a) Installed capacity of storage reservoirs.



(b) Installed capacity of power-to-X technologies.



(c) Technology mix in the buildings sector.



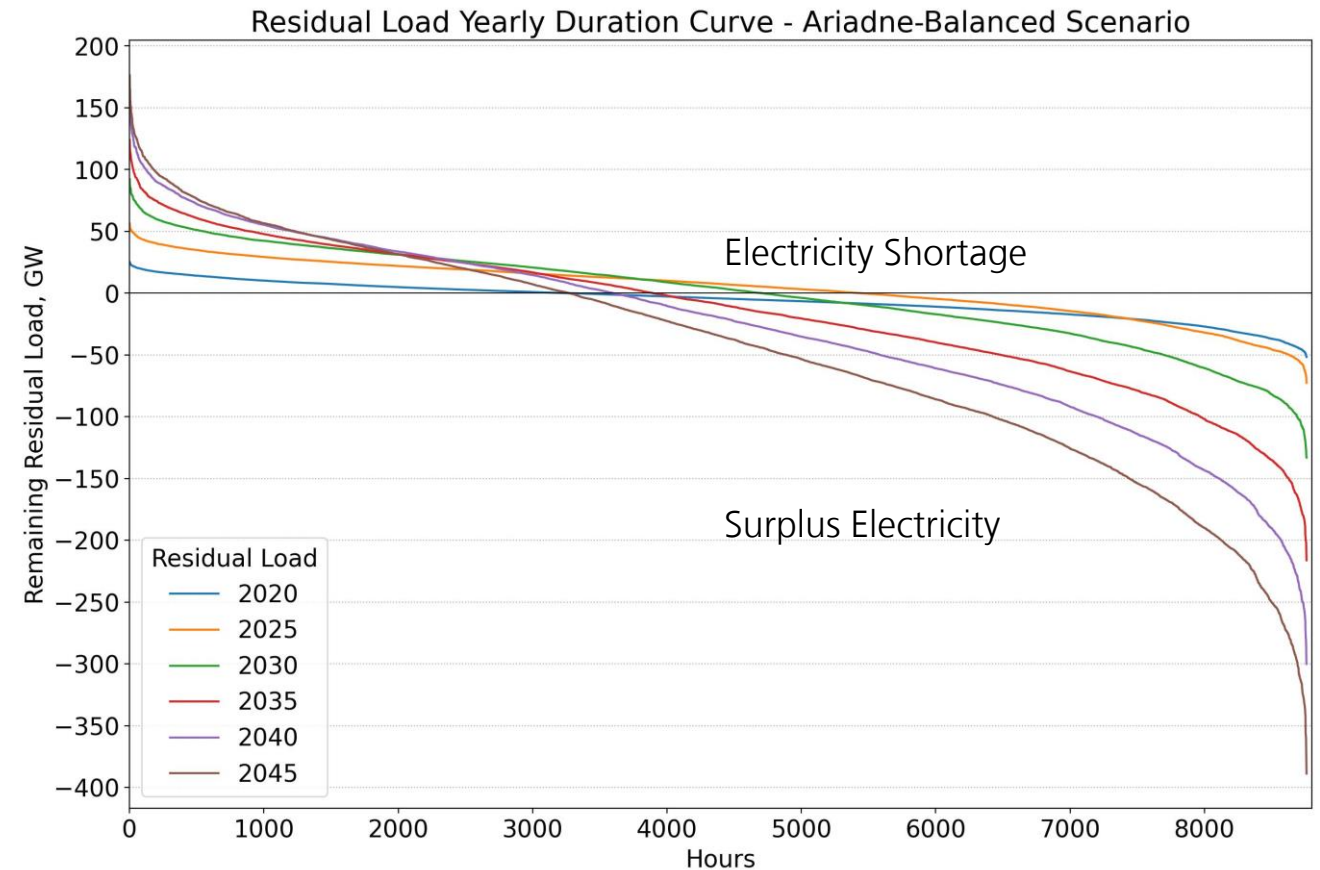
(d) Technology mix in the industrial sector.

Residual load

Times of electricity surplus increase

→ Surplus dominates in 2045

Extrema (both positive and negative) increase



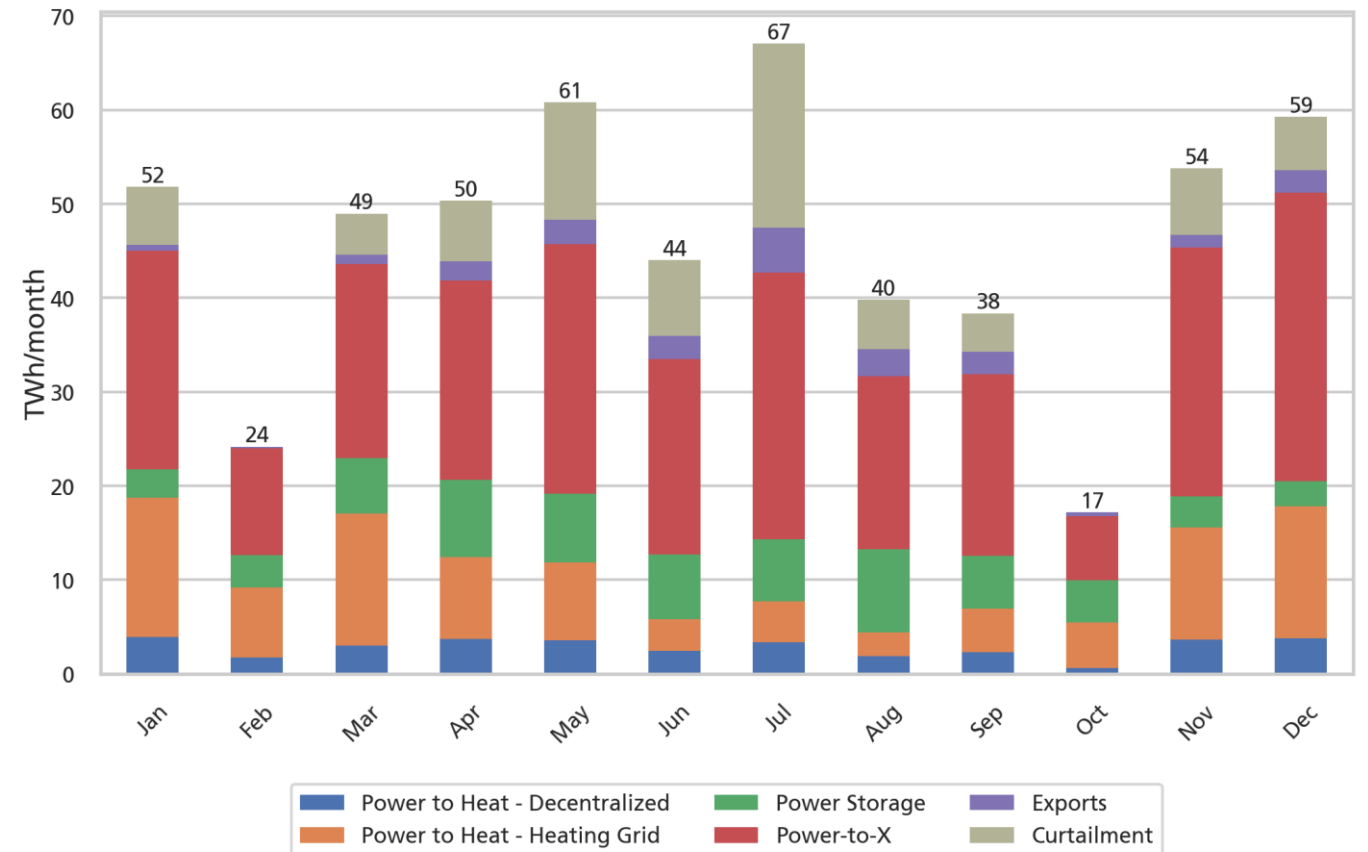
Flexibility provision

In times of excess electricity

Power-to-X (hydrogen, methane, liquids)
dominant

Power-to-Heat stronger in winter

Storages, Exports & Curtailment stronger in
summer

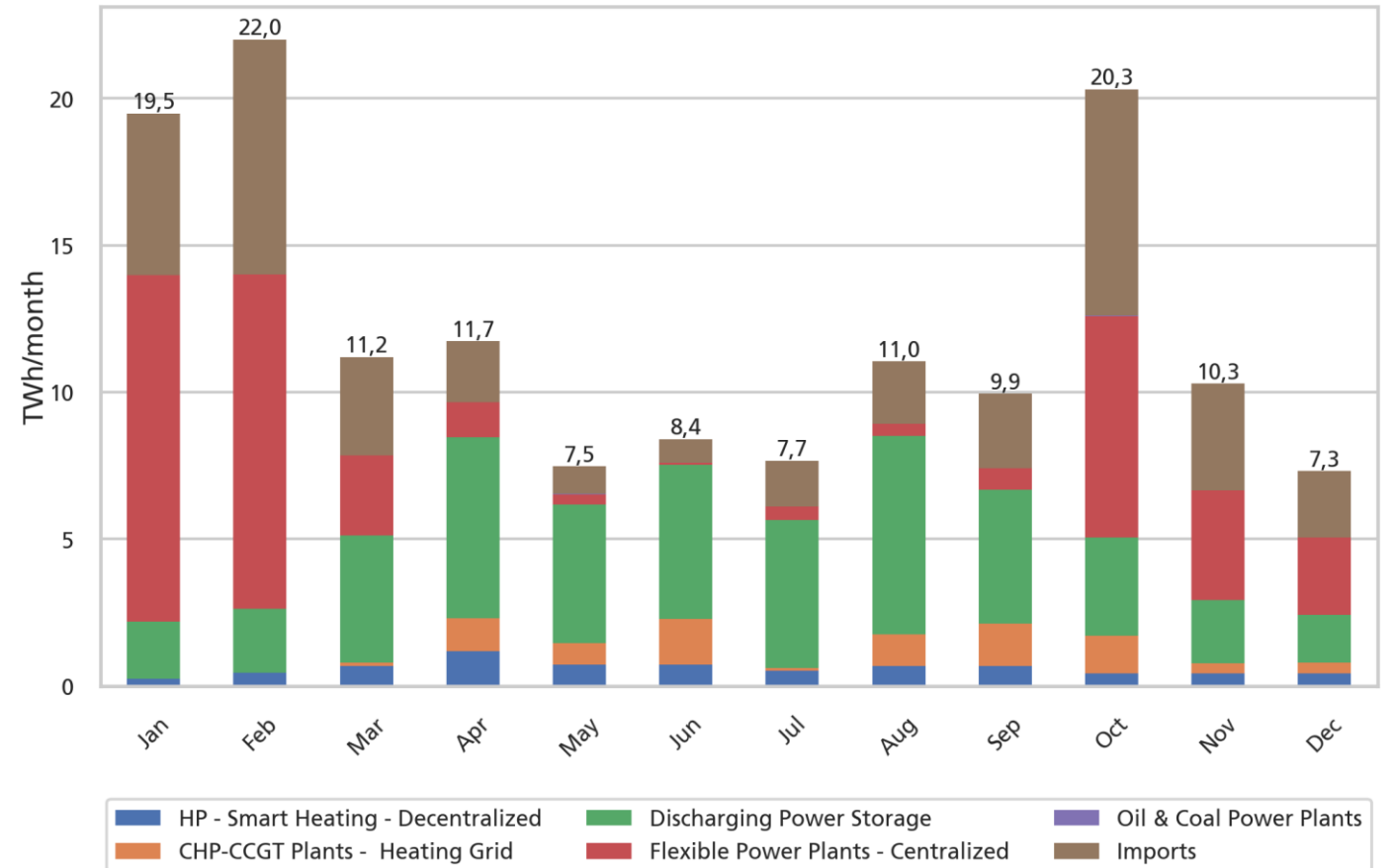


Flexibility provision

In times of electricity shortage

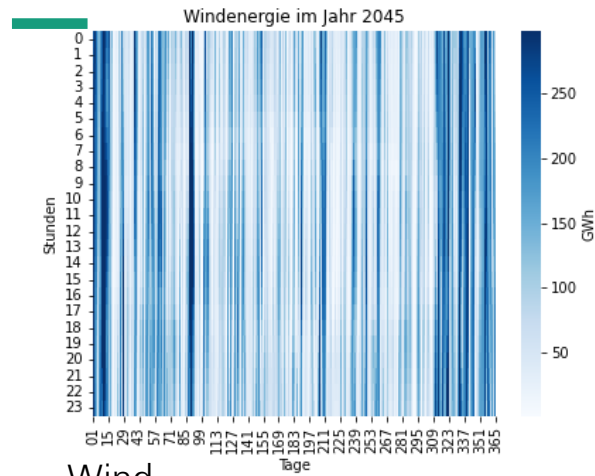
Storages in summer

Flexible power plants & imports in winter

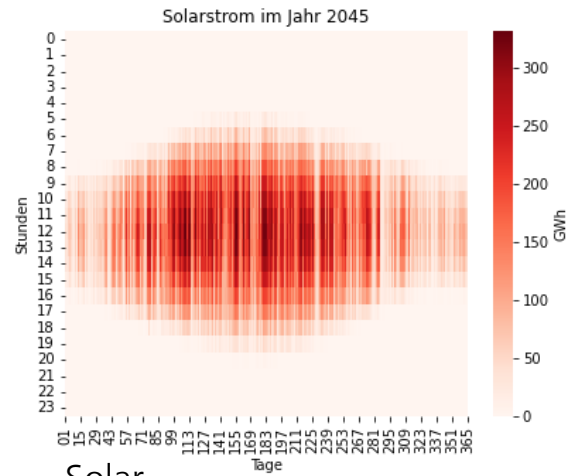


Hourly profiles of selected inflexible and flexible system components

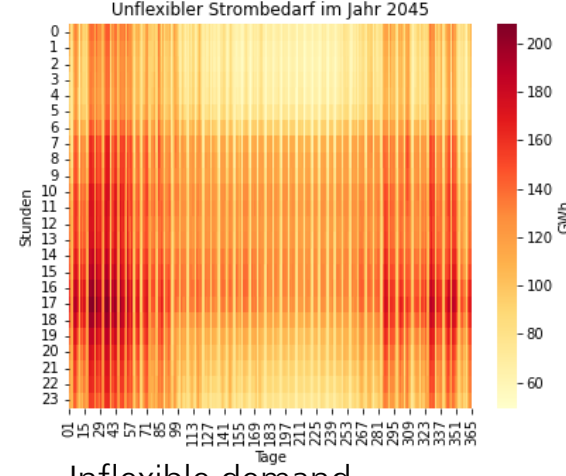
inflexible



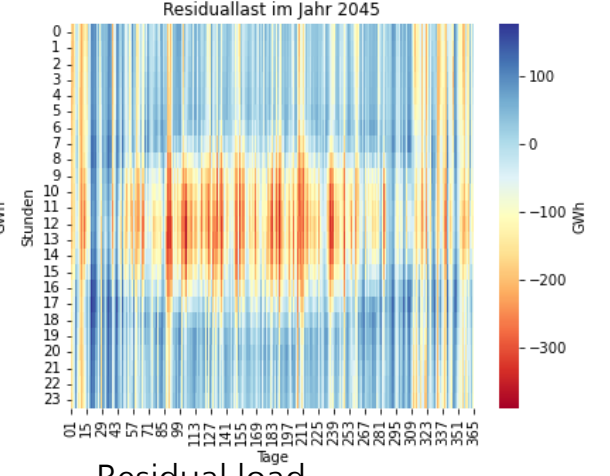
Wind



Solar

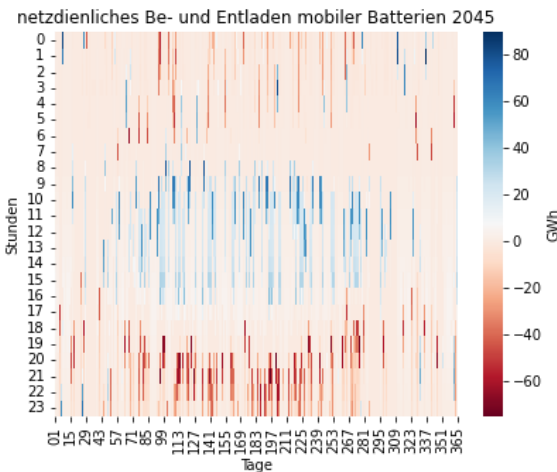


Inflexible demand

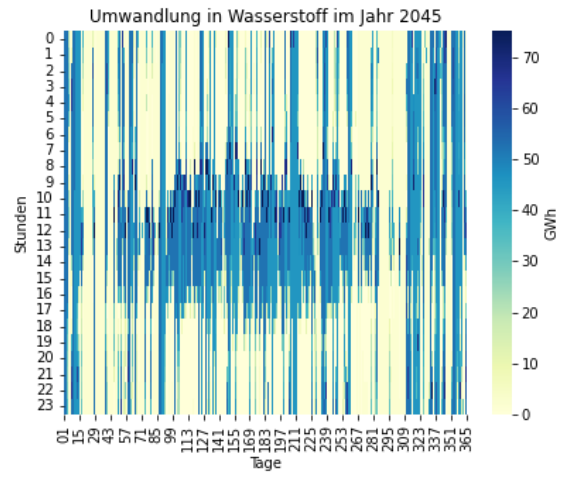


Residual load

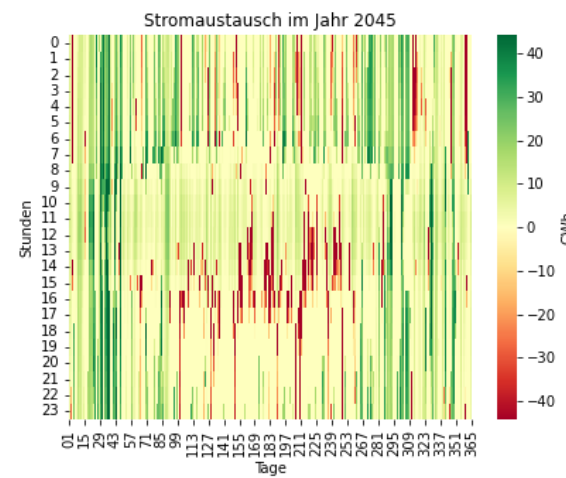
flexible



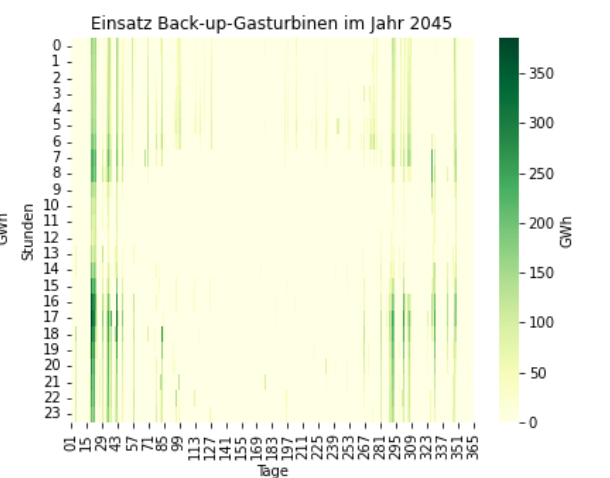
Vehicles (V2G & G2V)



Electrolysers



Im-/Exports



Gas turbines (backup)

Drivers of Flexibility

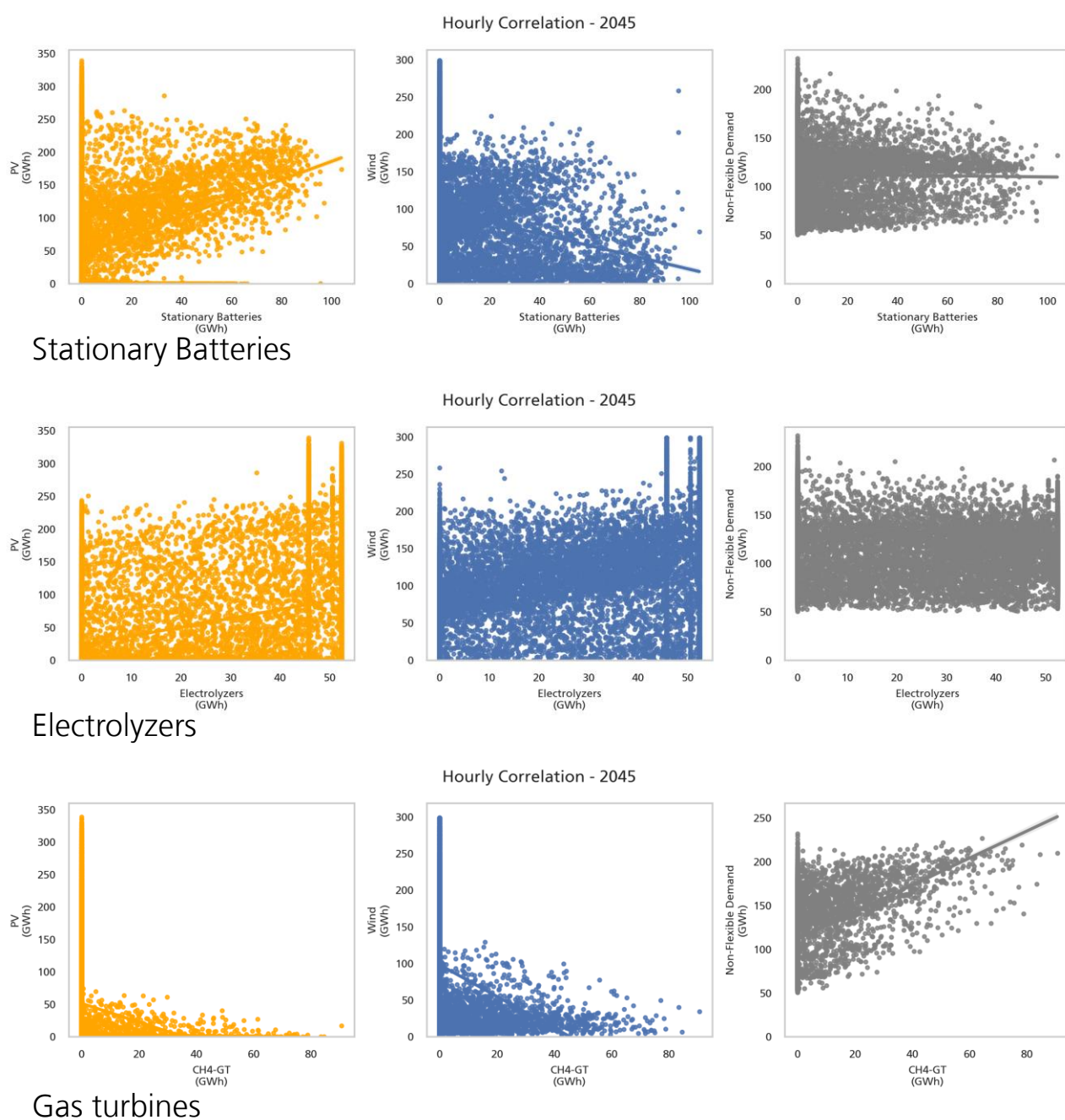
Correlation analysis

What are the drivers for specific flexibility options?

Interplay between

- Solar production
- Wind production
- Inflexible demand

Further analysis to investigate share of these drivers (multi-variate correlation analysis?)



Conclusion

Flexibilities in a sector coupled, net-zero energy system

1



Interaction between different flexibility options

2



Electrolyzers central for flexibility and sector coupling

3



Different options for different use-cases

Short-term / summer: storages, smart heating

Long-term / winter: Power-to-X, back-up turbines

Thank You for Your Attention!

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