Assessing Demand Response Potentials in the climate-neutral German Power System

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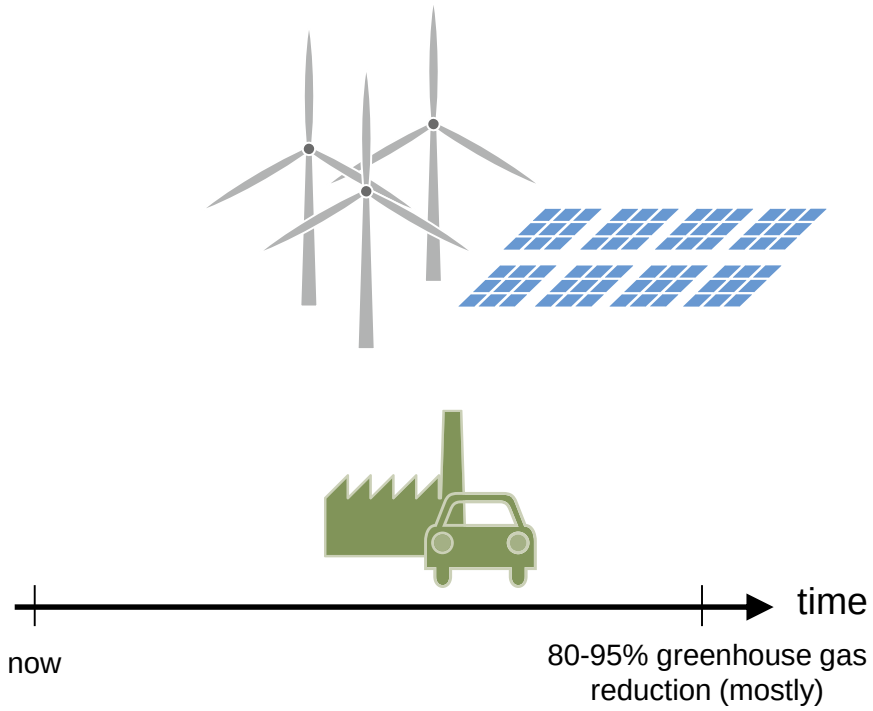
Motivation: Demand response as a flexibility option …

„What we knew“

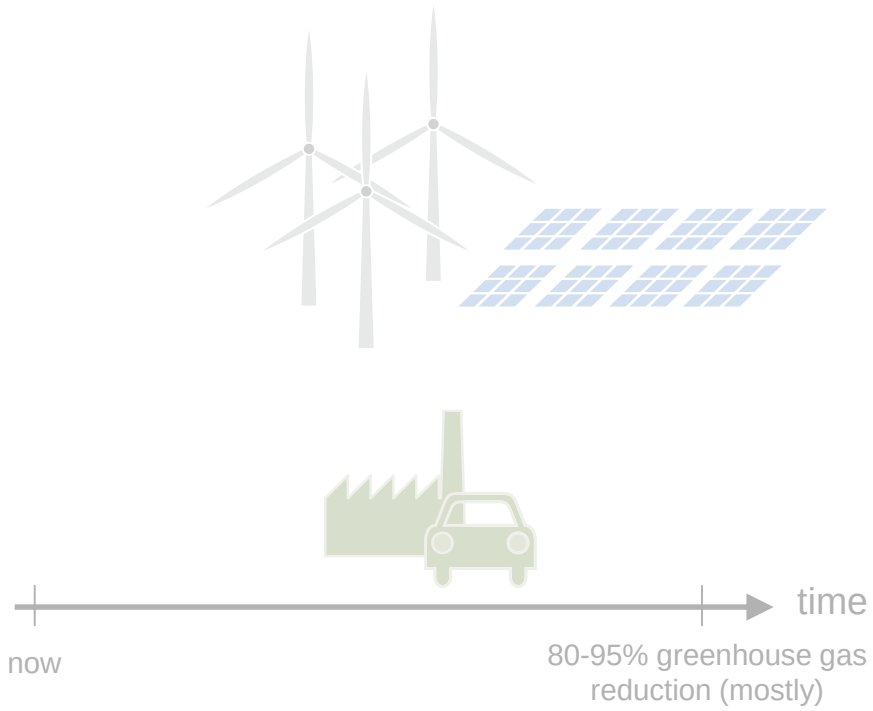


„What we did not (want to?) know“

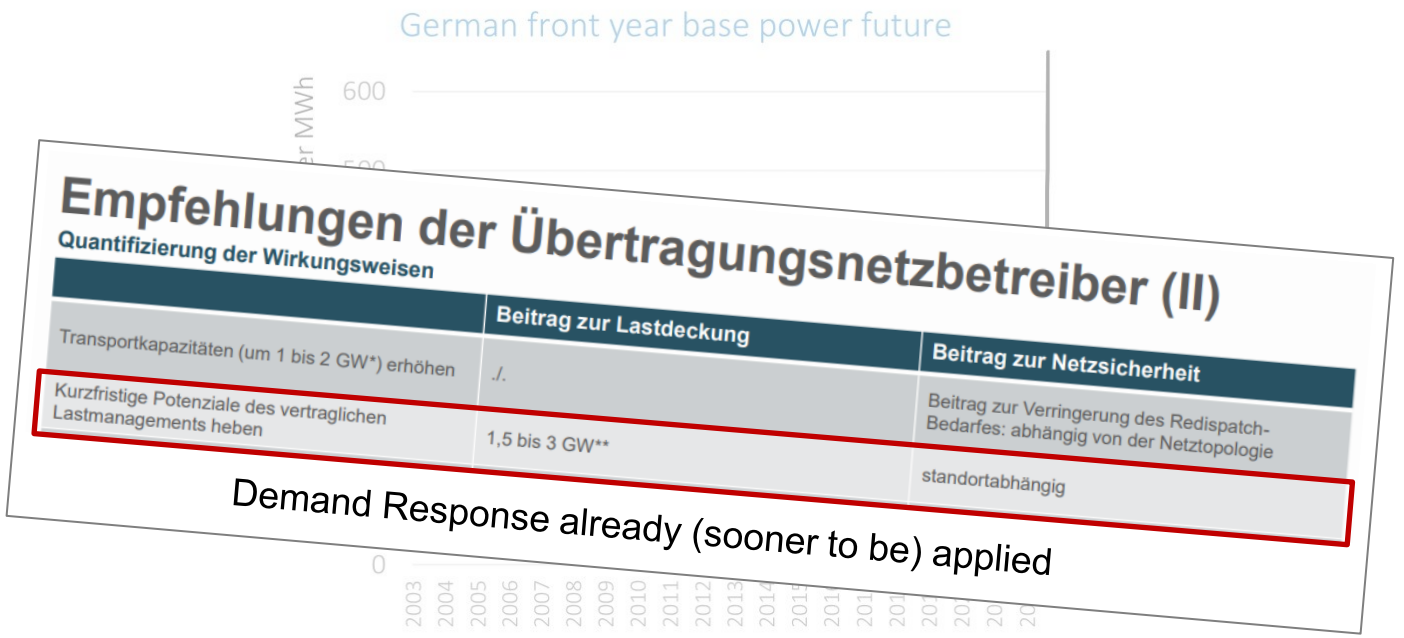
Sources: [1]; [2]

Motivation: Demand response as a flexibility option …

„What we knew“



„What we did not (want to?) know“



*What are the **demand response potentials** in the climate neutral power sector?*

Sources: [1]; [2]

Method: Potential study using a fundamental power market model

Utilizing the power market modelling cosmos POMMES

1. **Data preparation & scenario generation**
2. **Investment model run**
3. **Analysis of model results**

pommesdata

https://github.com/pommes-public/pommesdata

- data for power plants, RES, storage, costs data & technology assumptions
- deriving scenarios based on latest literature, e.g. “big 5” studies [3-7]
- technical demand response potentials based on [8-9]

pommesinvest

https://github.com/pommes-public/pommesinvest

- multi-period capacity expansion and dispatch from 2020 to 2050
- implemented using / extending oemof.solph
- demand response implementation based on Gils (2015) [10]

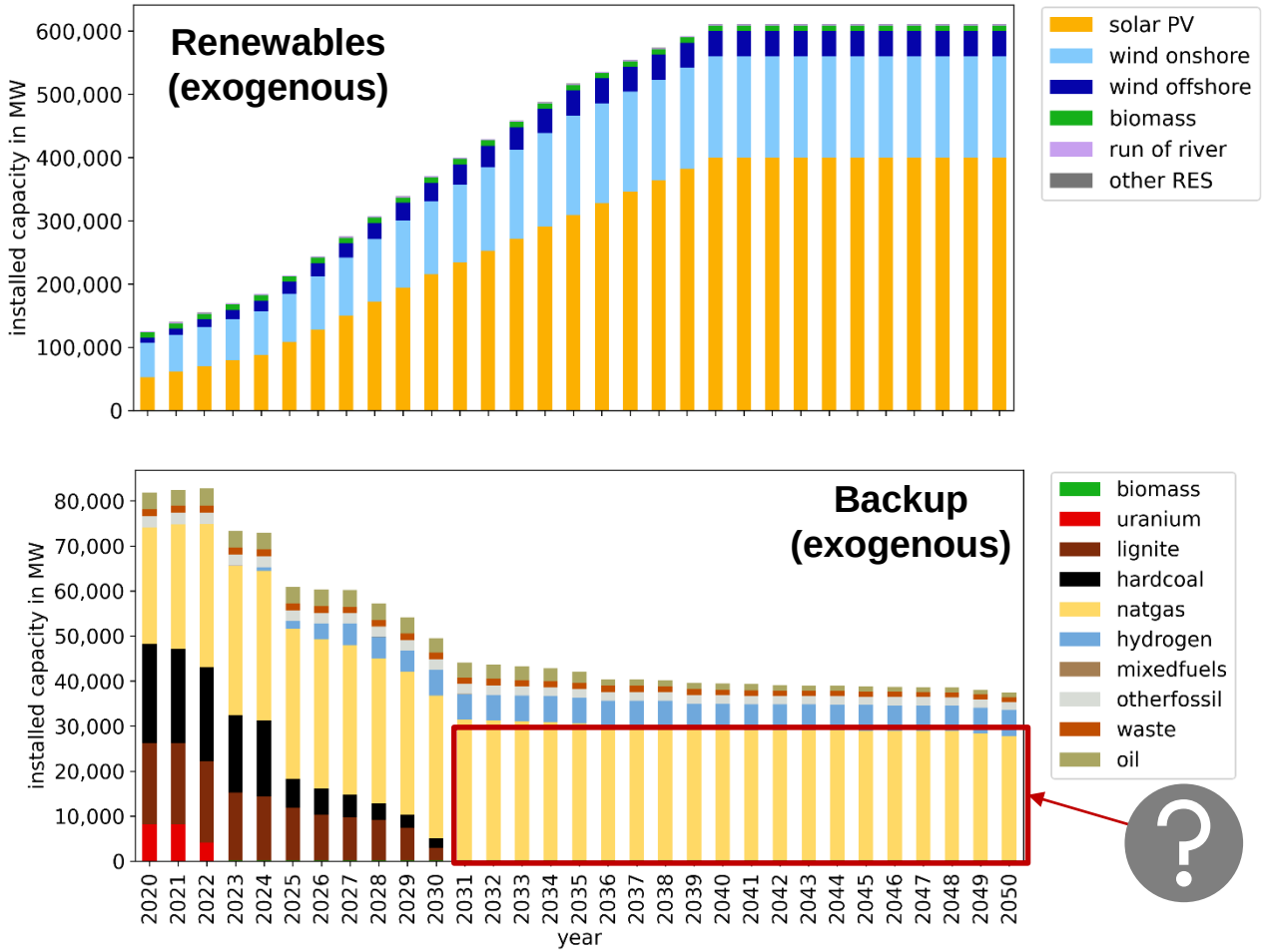
pommesevaluation

https://github.com/pommes-public/pommesevaluation

- ex post analyses: plotting, statistics / metrics etc.

Main assumptions across the scenarios

Reaching a climate-neutral power sector by 2035 … with current expansion & decommissioning plans



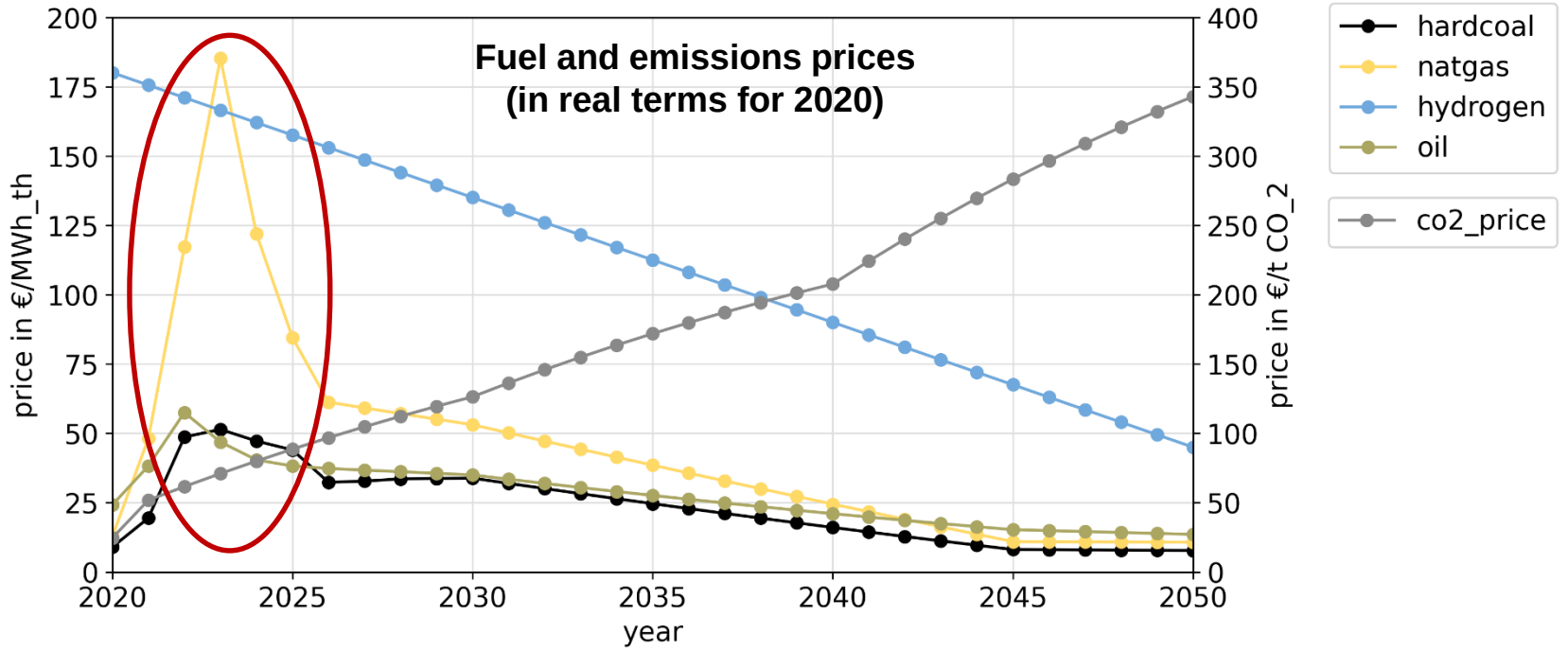
Important premise

brownfield approach considering current planning and state of legislation!

Data sources: [11-24]

Main assumptions across the scenarios

Reaching a climate-neutral power sector by 2035 … considering a short-term fuel price shock



Data sources: [17]; [25-35]

Main assumptions across the scenarios

Reaching a climate-neutral power sector by 2035 … studying investments in the remaining options (not including CCS)

Investment options

backup plants
- natural gas
- hydrogen
- biomass
- oil peakers

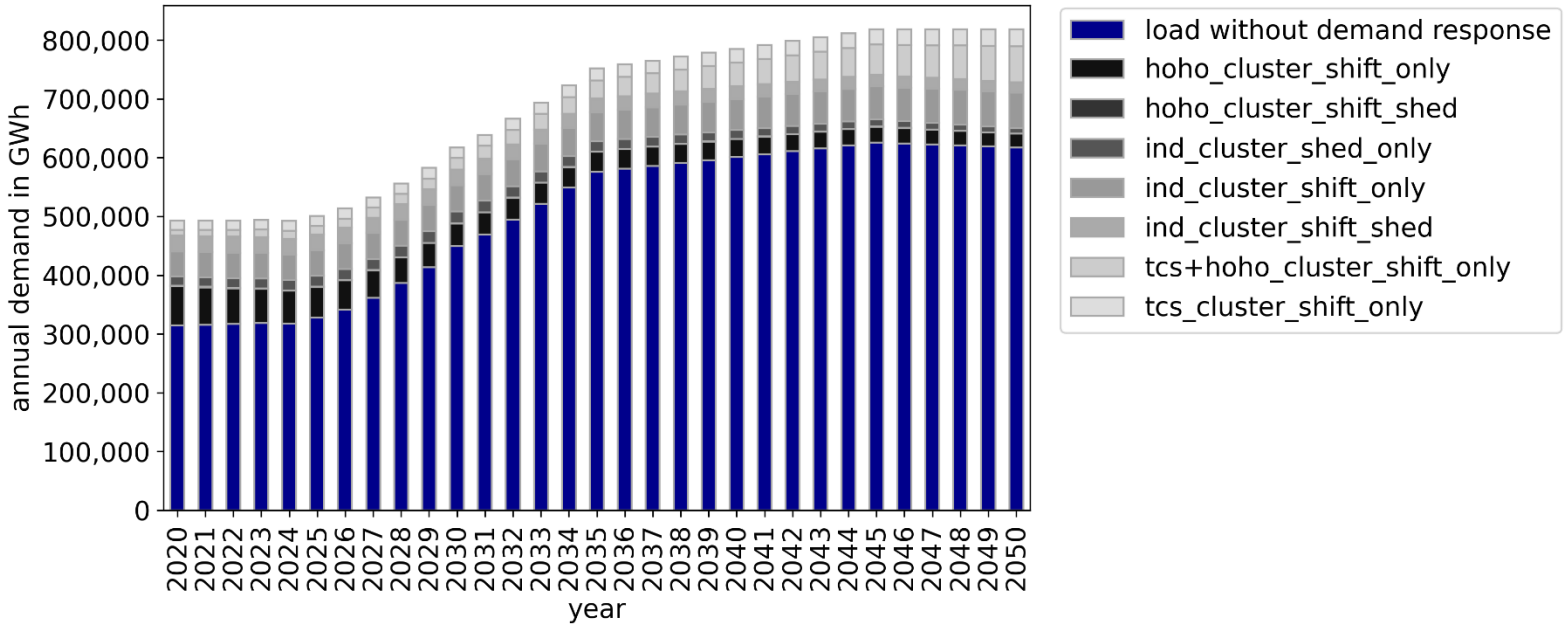
storages
- pumped hydro energy storage
- (lithium-ion) batteries
- electrolyzers

demand response
- for households
- industrial
- commercial

Parameterization
- 30 primary sources from [8] for demand response
- [35-39] for remaining options

Main assumptions across the scenarios

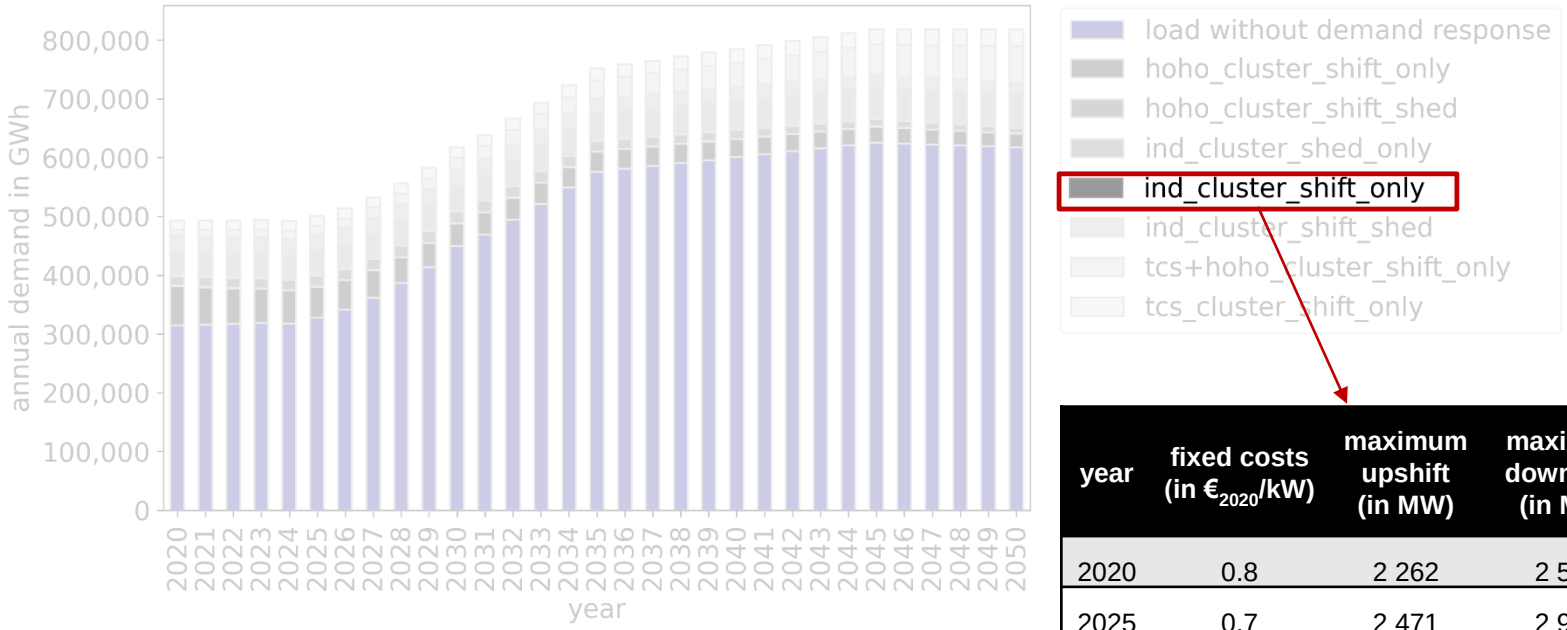
Reaching a climate-neutral power sector by 2035 … and focussing on „classical“ demand response



Data sources: primary sources from [8]; [41]

Main assumptions across the scenarios

Reaching a climate-neutral power sector by 2035 … and focussing on „classical“ demand response



Paper industry	mechanical and chemical wood pulp, paper machines, paper recycling
Processes	air separation units
Cross-cutting technologies	ventilation, process cold, climate cold, compressed air

year	fixed costs (in €$_{2020}$/kW)	maximum upshift (in MW)	maximum downshift (in MW)	shifting duration (in hours)	specific investment expenses (in €$_{2020}$/kW)	variable costs (in €$_{2020}$/MWh)	maximum simulta-neous load (in MW)
2020	0.8	2 262	2 529	6	2.8	137.5	5 987
2025	0.7	2 471	2 978	6	2.4	114.6	6 125
2030	0.6	2 679	3 427	6	1.9	91.6	6 264
2035	0.4	2 466	3 001	6	1.4	68.7	6 823
2040	0.3	2 252	2 575	6	0.9	45.8	7 383
2045	0.2	2 038	2 149	6	0.5	22.9	7 943
2050	0.01	1 825	1 723	6	0.01	0.01	8 503

Limitation

No electric vehicle flexibility (yet)

Data sources: primary sources from [8]; [41]

Scenario design

… Considering one scenario without and three scenarios with demand response

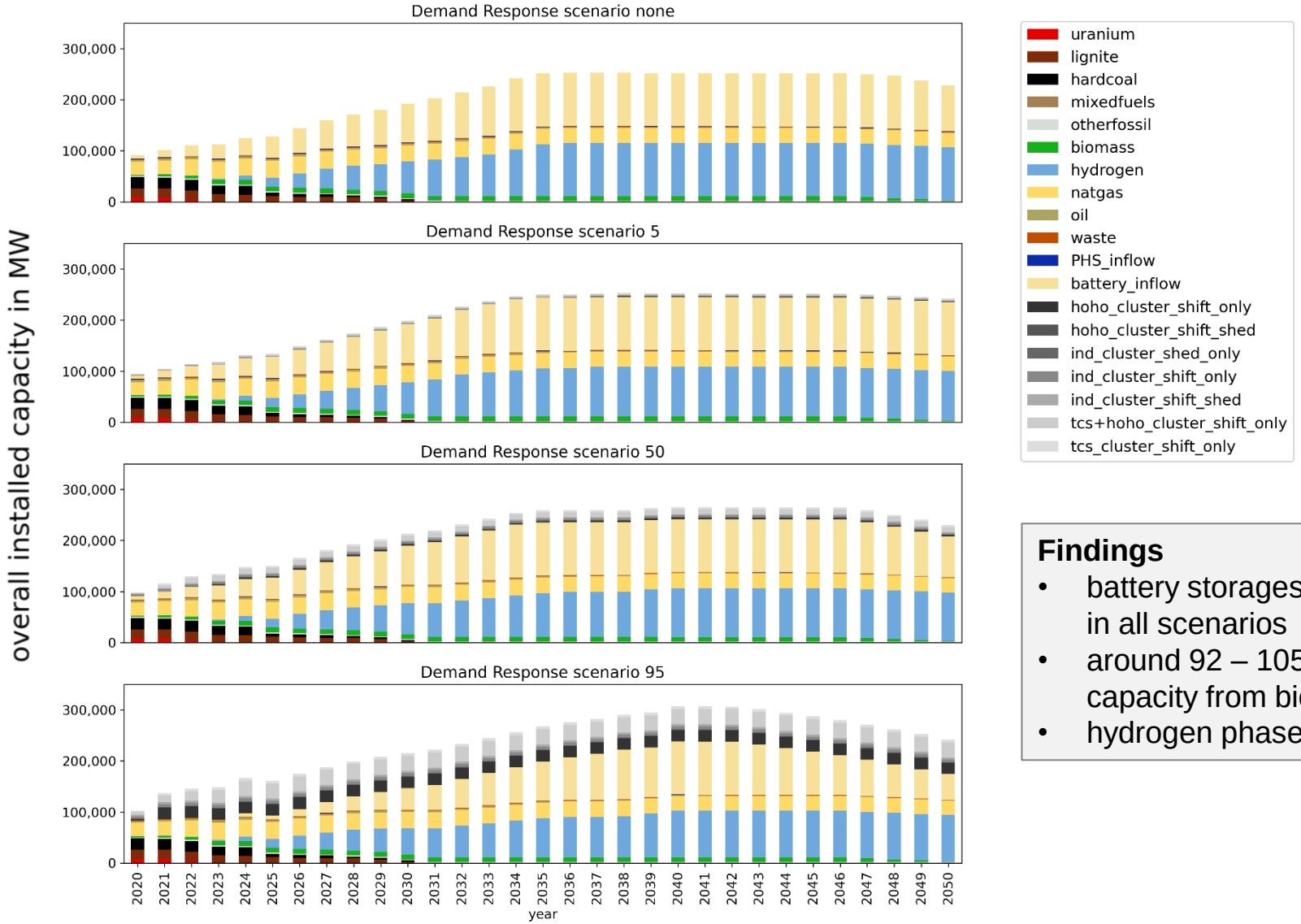
	no DR (DR none)	DR pessimistic (DR 5)	DR neutral (DR 50)	DR optimistic (DR 95)
Demand response (DR) prevalent?	✗	✓	✓	✓
Costs of DR	✗	↑	○	↓
technical potential of DR	✗	↓	○	↑
Costs of other flexibility options	○	↓	○	↑

DR: Demand Response

Very preliminary results!
Only indicating trends

Results: Total installed capacities

Large amount of supply & demand-side flexibility resources with hydrogen and storages dominating



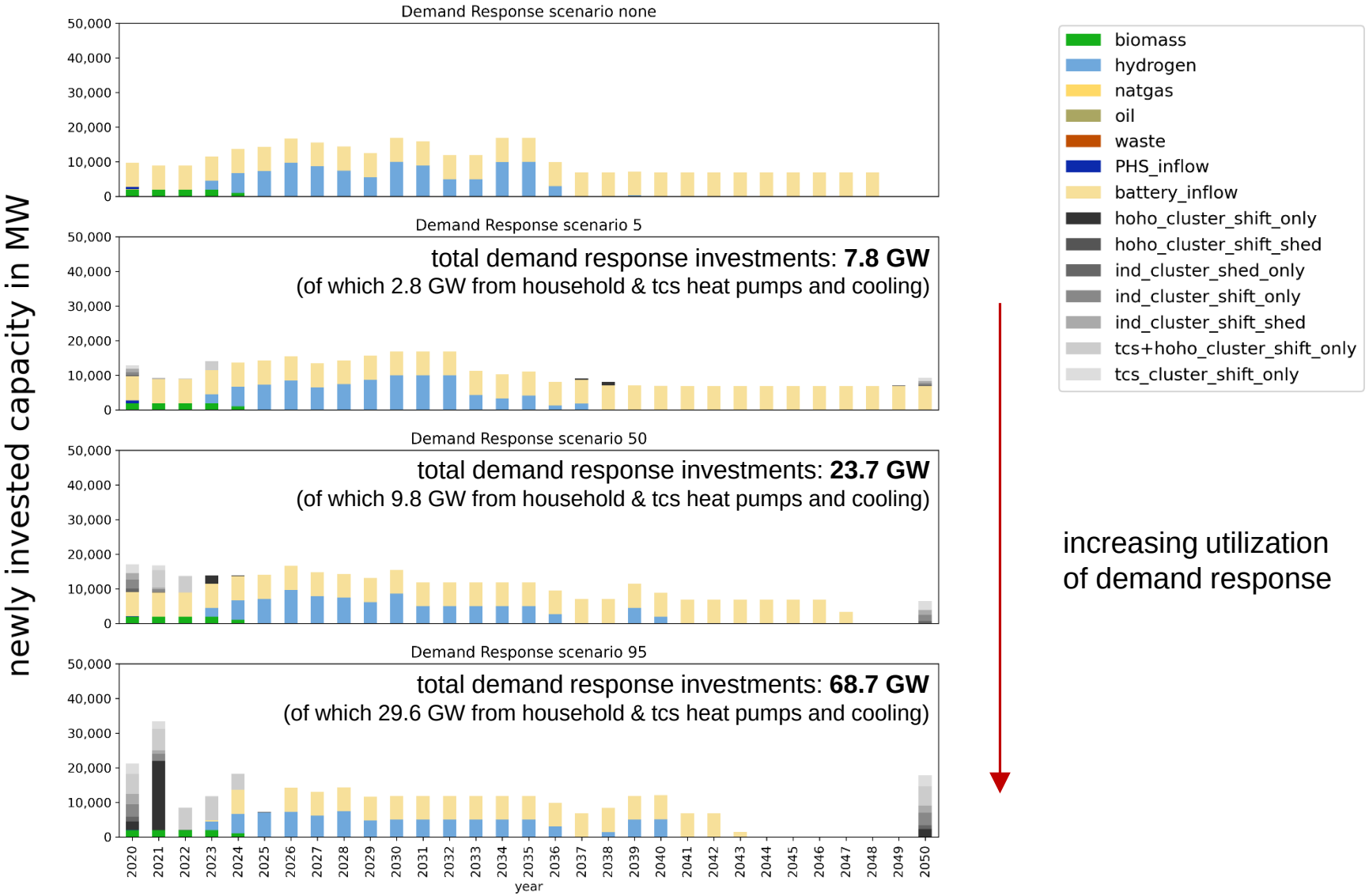
Findings

- battery storages massively deployed in all scenarios
- around 92 – 105 GW of usable (!) secured capacity from biomass and hydrogen in 2050
- hydrogen phase in starts in mid-2020s

Very preliminary results!
Only indicating trends

Results: Investments in demand response

Strong deviation between the scenarios, but large investments when demand response is allowed



Conclusion & Outlook

High uncertainty on demand response potential; values found are comparatively high

Conclusion

1. The demand reponse potential found is 8 - 68 GW.

Note that this capacity is not available at the same time!

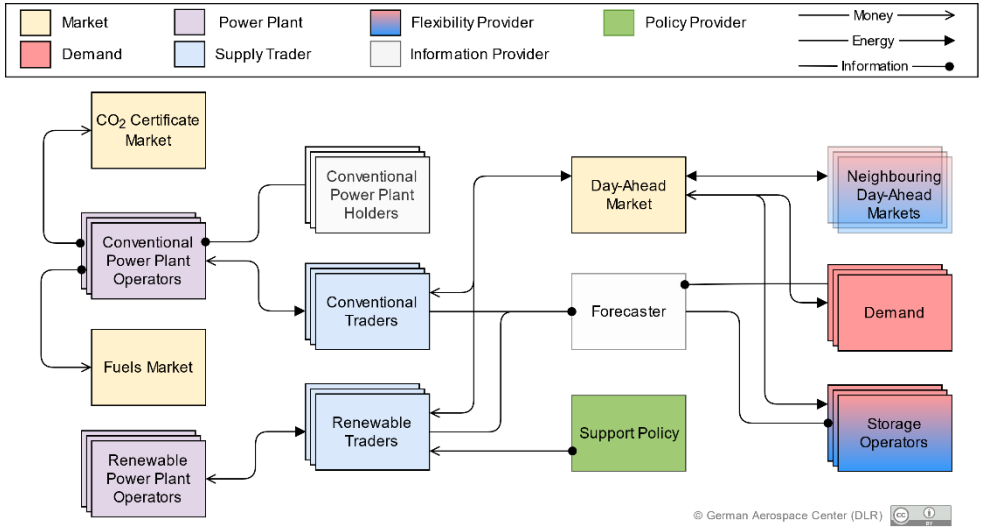
Note that this is a very preliminary estimate and the model seems to overestimate flexibility needs

2. Demand response behaves very sensitive to the technical potential and cost estimates imposed.

3. The largest potentials are obtained from heat pumps and cooling.

Outlook

- Refine model and data
- Assess microeconomic profitability using the agent-based model **AMIRIS**



https://gitlab.com/dlr-ve/esy/amiris/amiris

Thank you!

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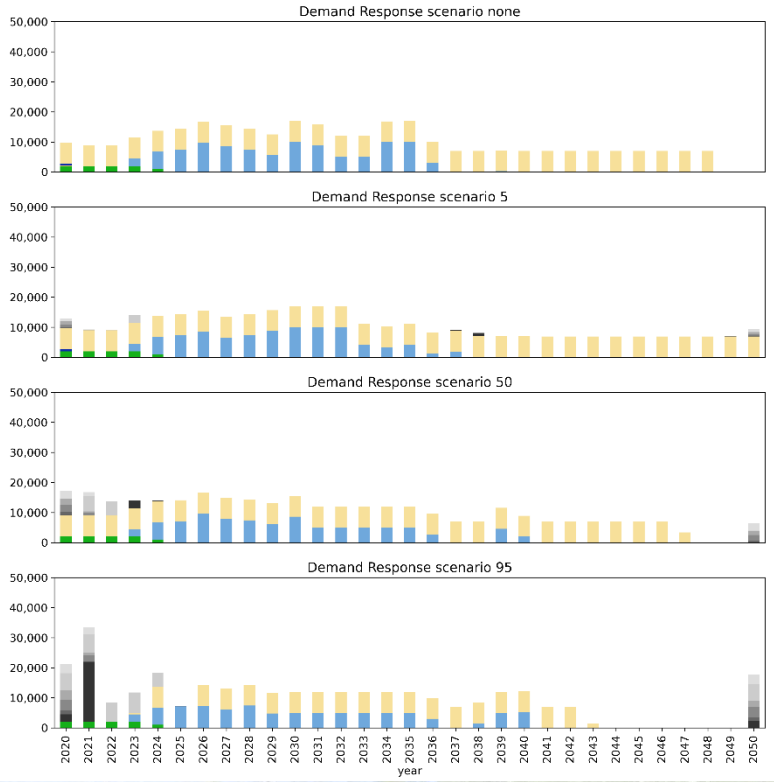

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