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

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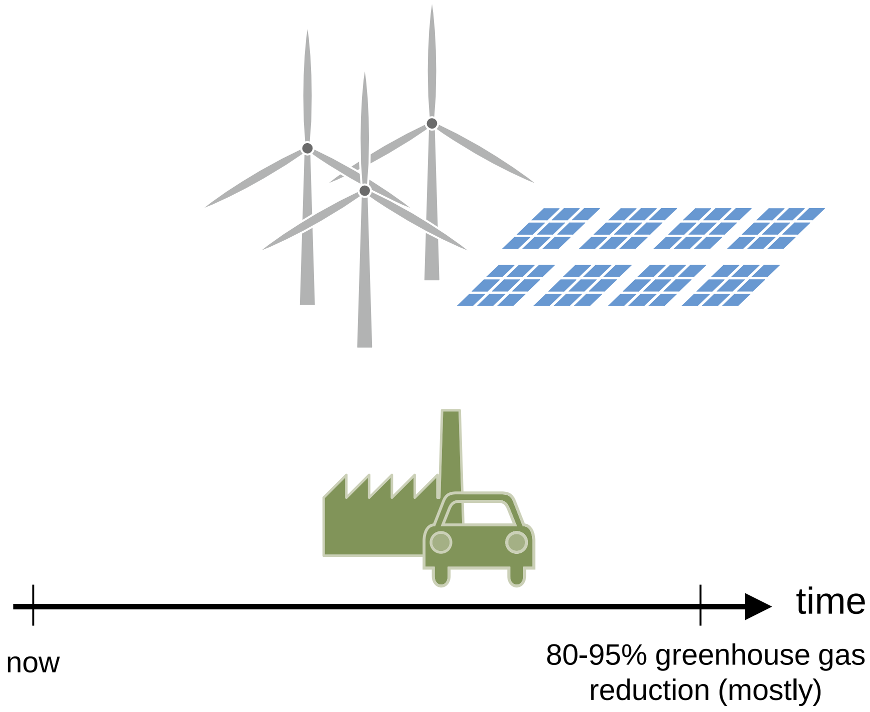
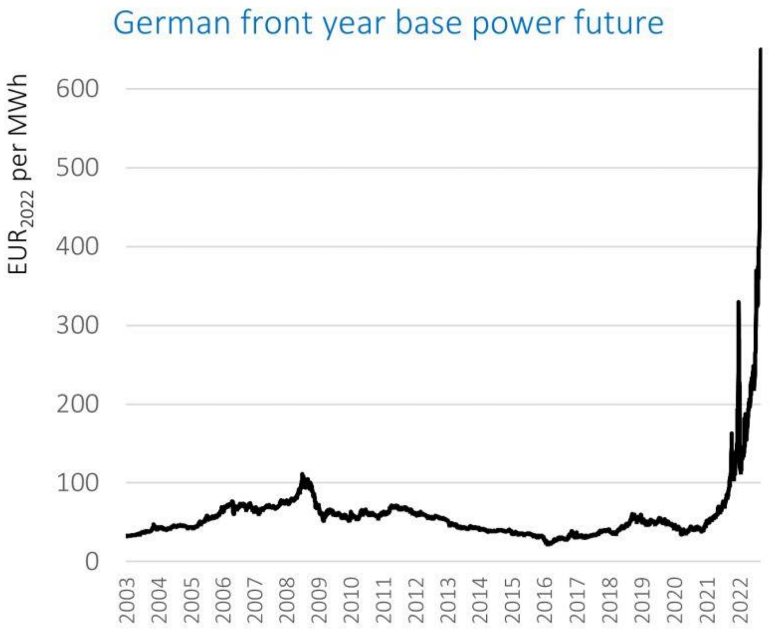
Motivation: Demand response as a flexibility option …

„What we knew“



„What we did not (want to?) know“



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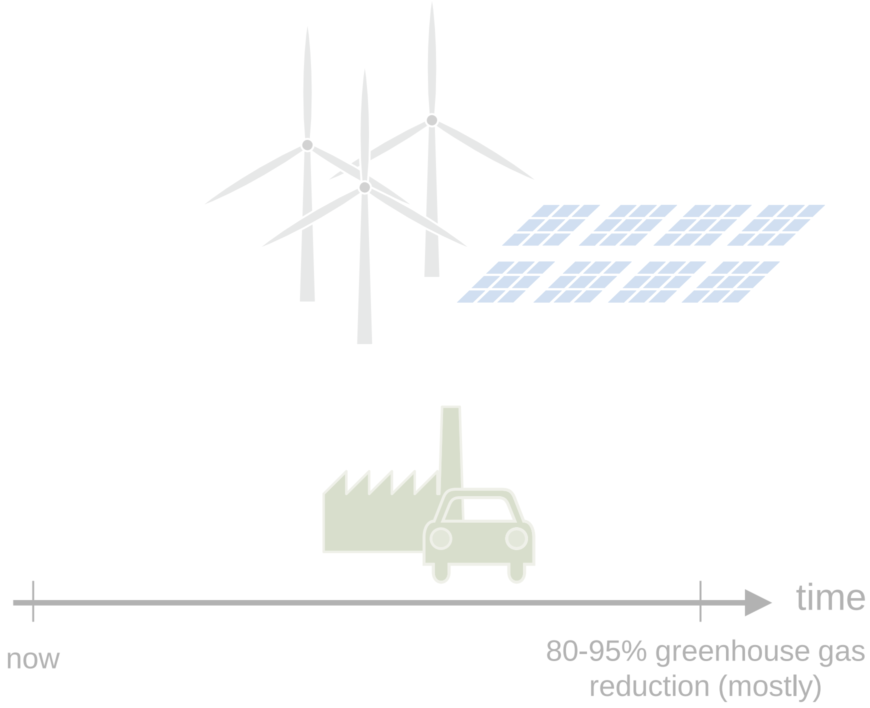

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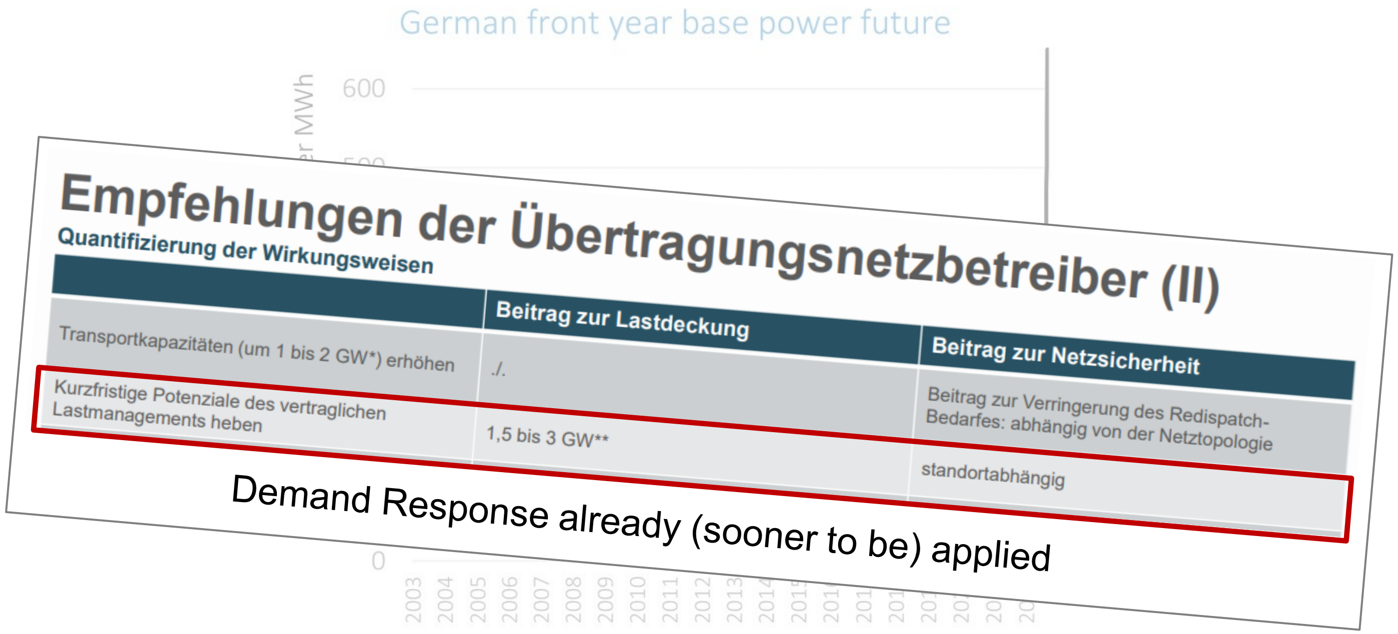


	Beitrag zur Lastdeckung	Beitrag zur Netzsicherheit
Transportkapazitäten (um 1 bis 2 GW*) erhöhen	./.	Beitrag zur Verringerung des Redispatch-Bedarfes: abhängig von der Netztopologie
Kurzfristige Potenziale des vertraglichen Lastmanagements heben	1,5 bis 3 GW**	standortabhängig

*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]

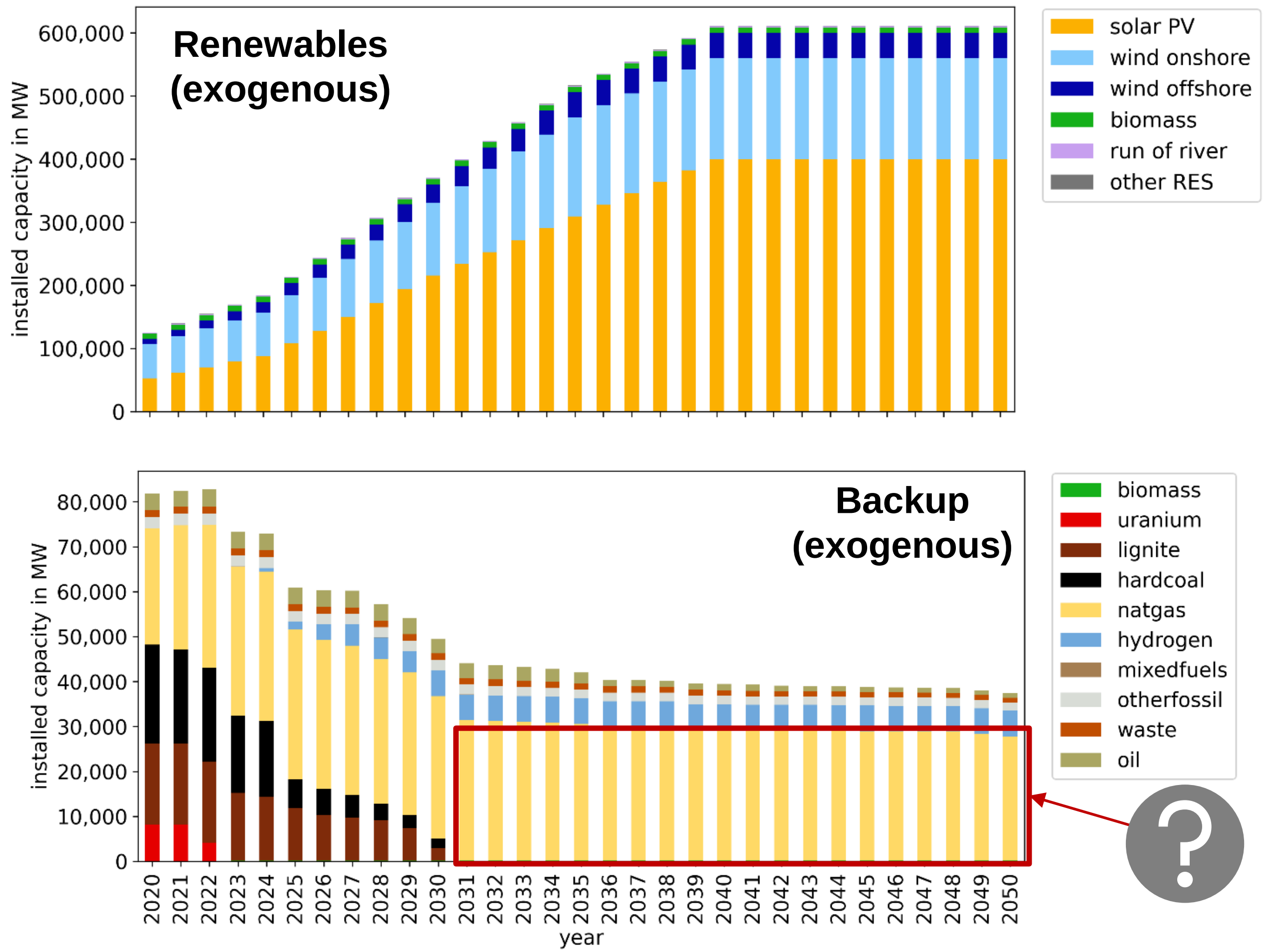
pommesevaluation

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

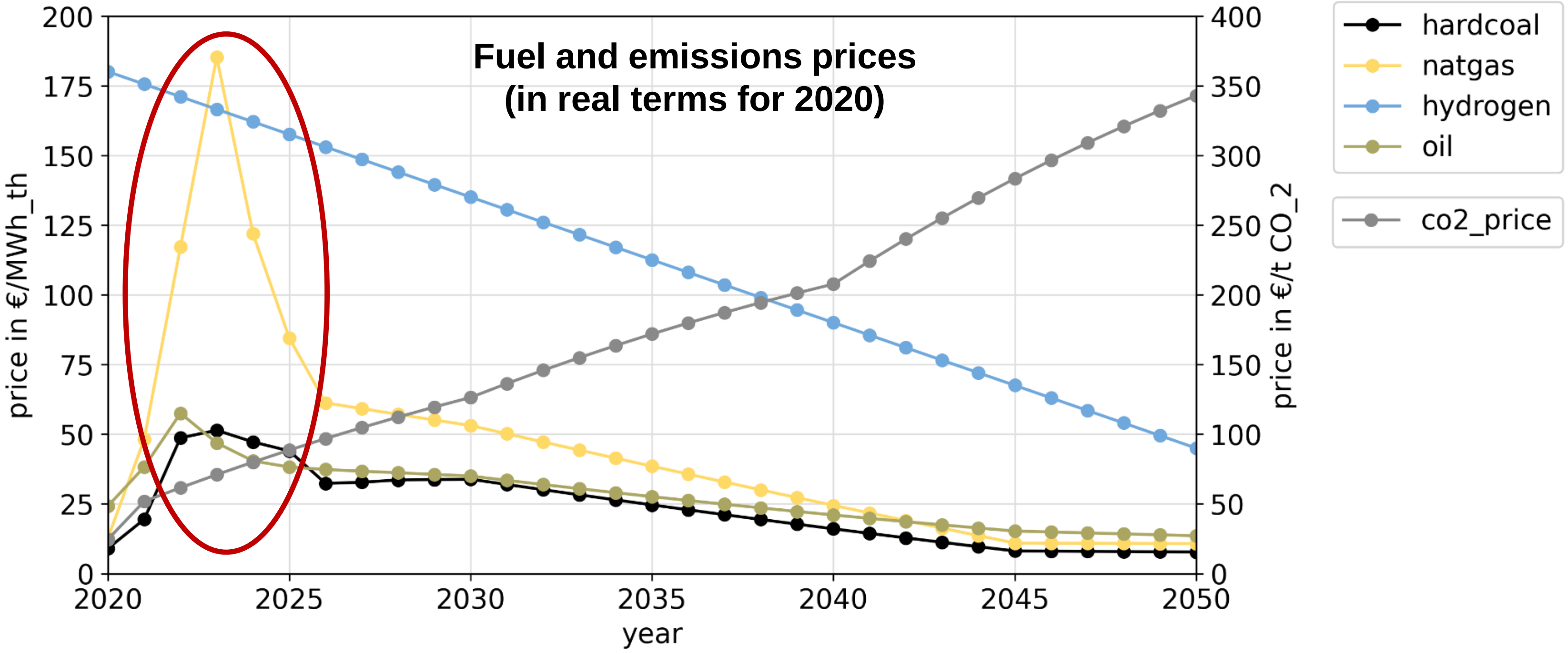


Important premise

brownfield approach considering current planning and state of legislation!

Main assumptions across the scenarios

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



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

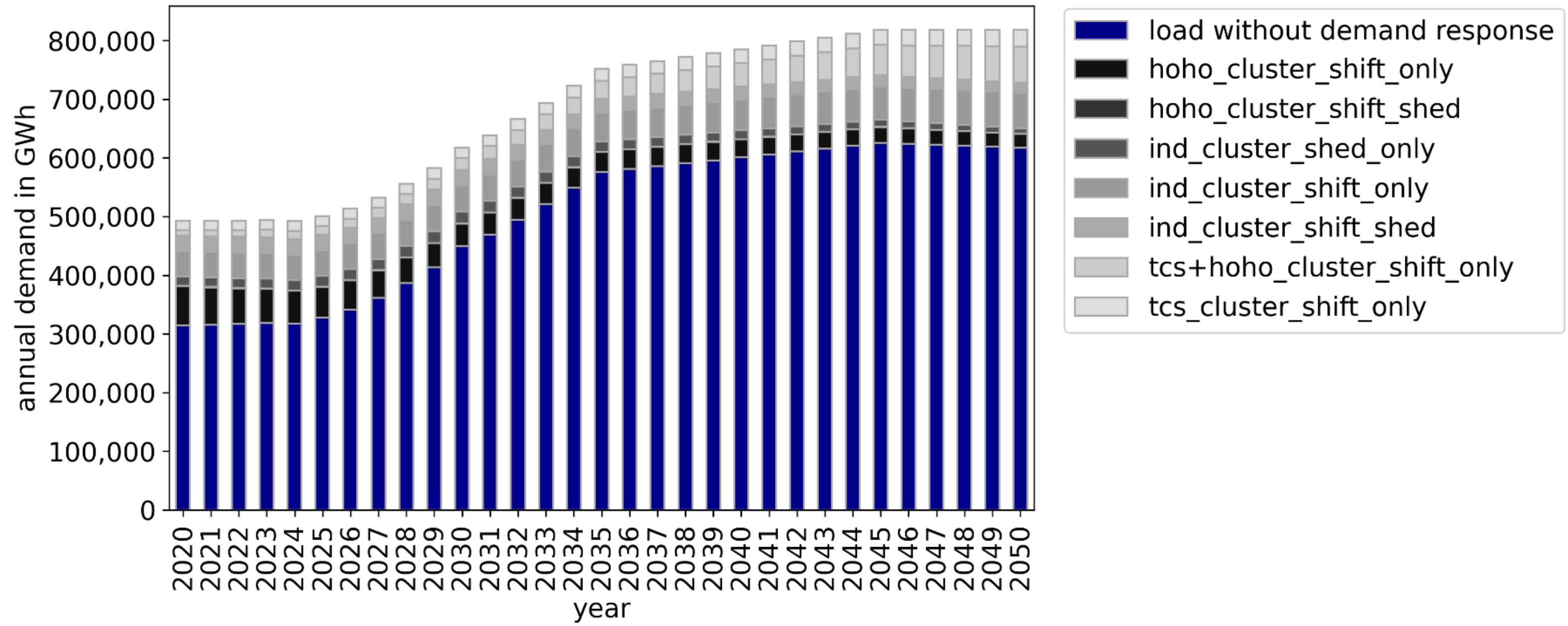
storages
- pumped hydro energy storage
- (lithium-ion) batteries
- electrolyzers

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]

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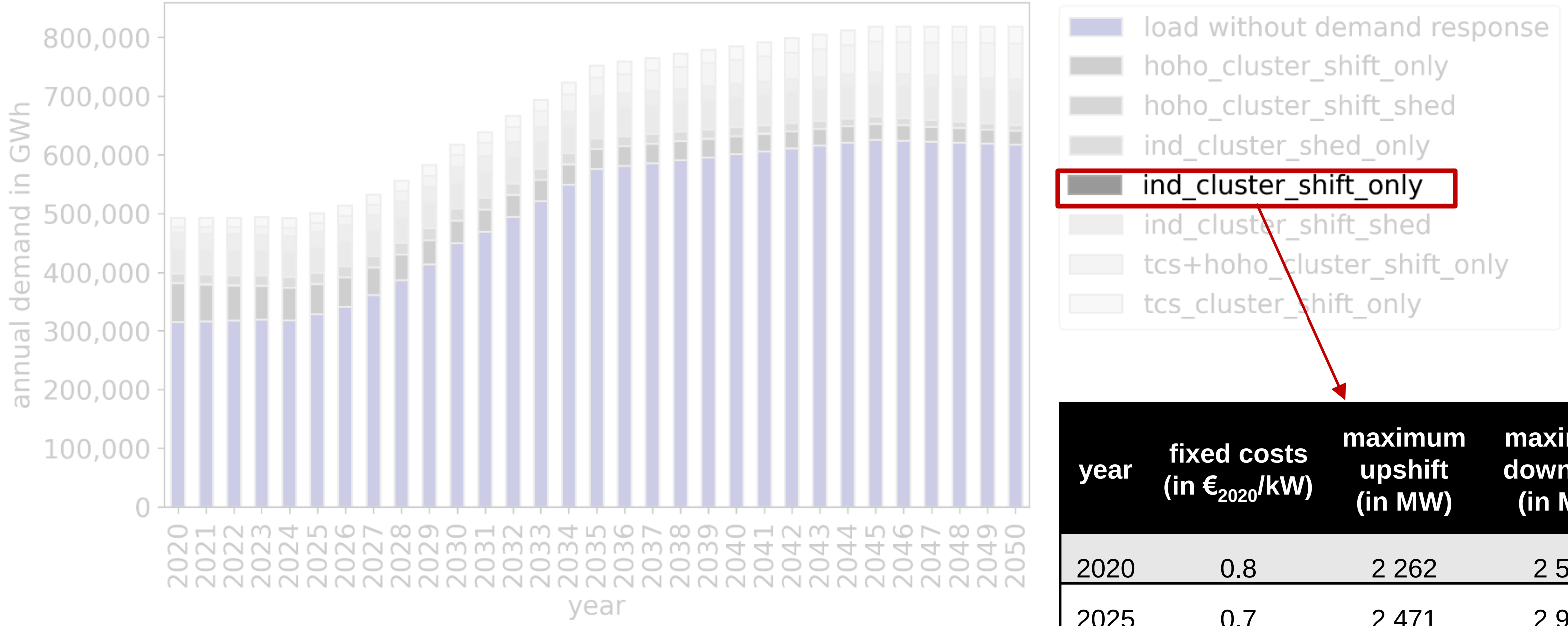
Reaching a climate-neutral power sector by 2035 … and focussing on „classical“ demand response



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

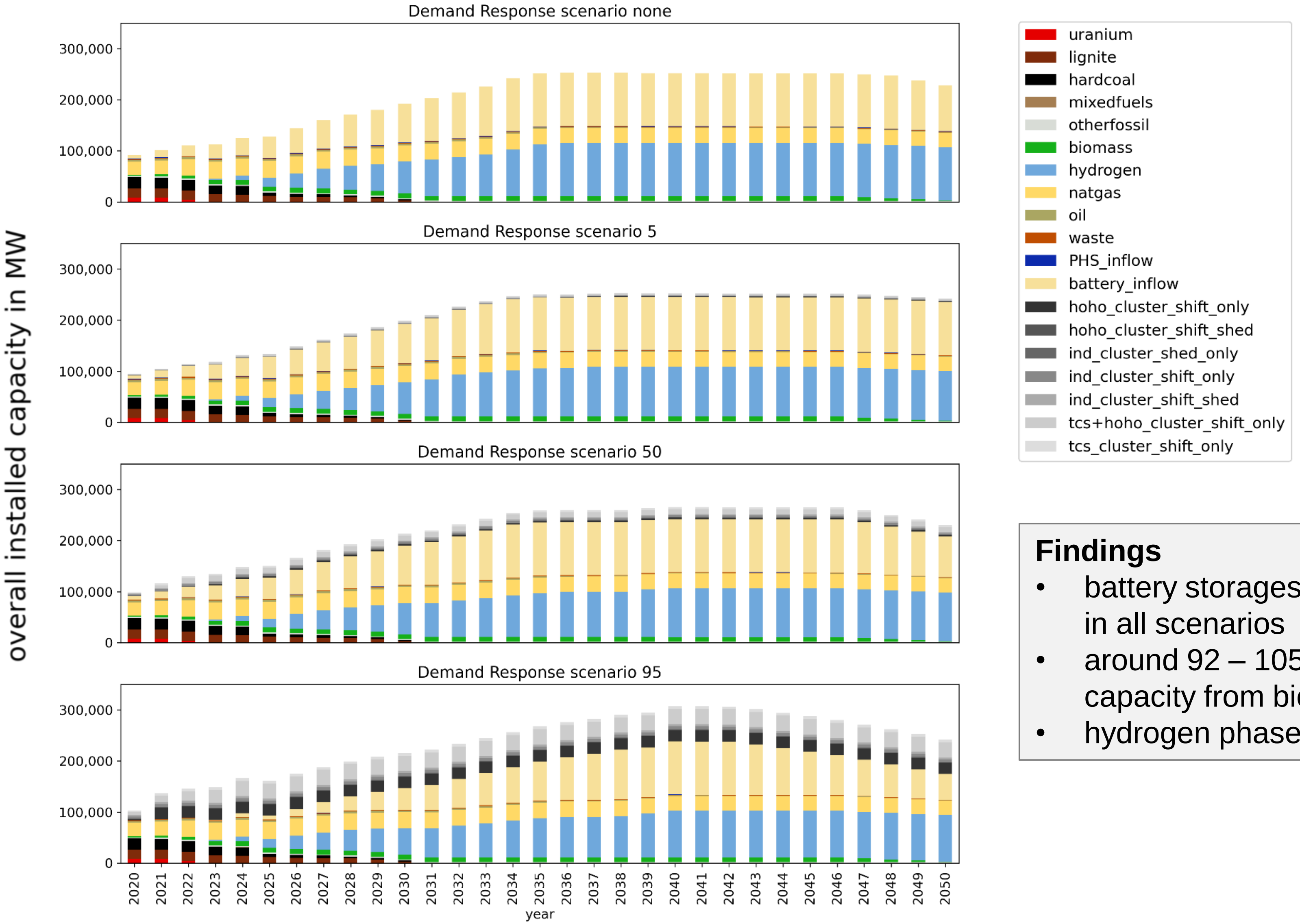
	no DR (DR none)	DR pessimistic (DR 5)	DR neutral (DR 50)	DR optimistic (DR 95)
Demand response (DR) prevalent?	✗	✓	✓	✓
Costs of DR	✗	↑	○	↓
technical potential of DR	✗	↓	○	↑
Costs of other flexibility options	○	↓	○	↑

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

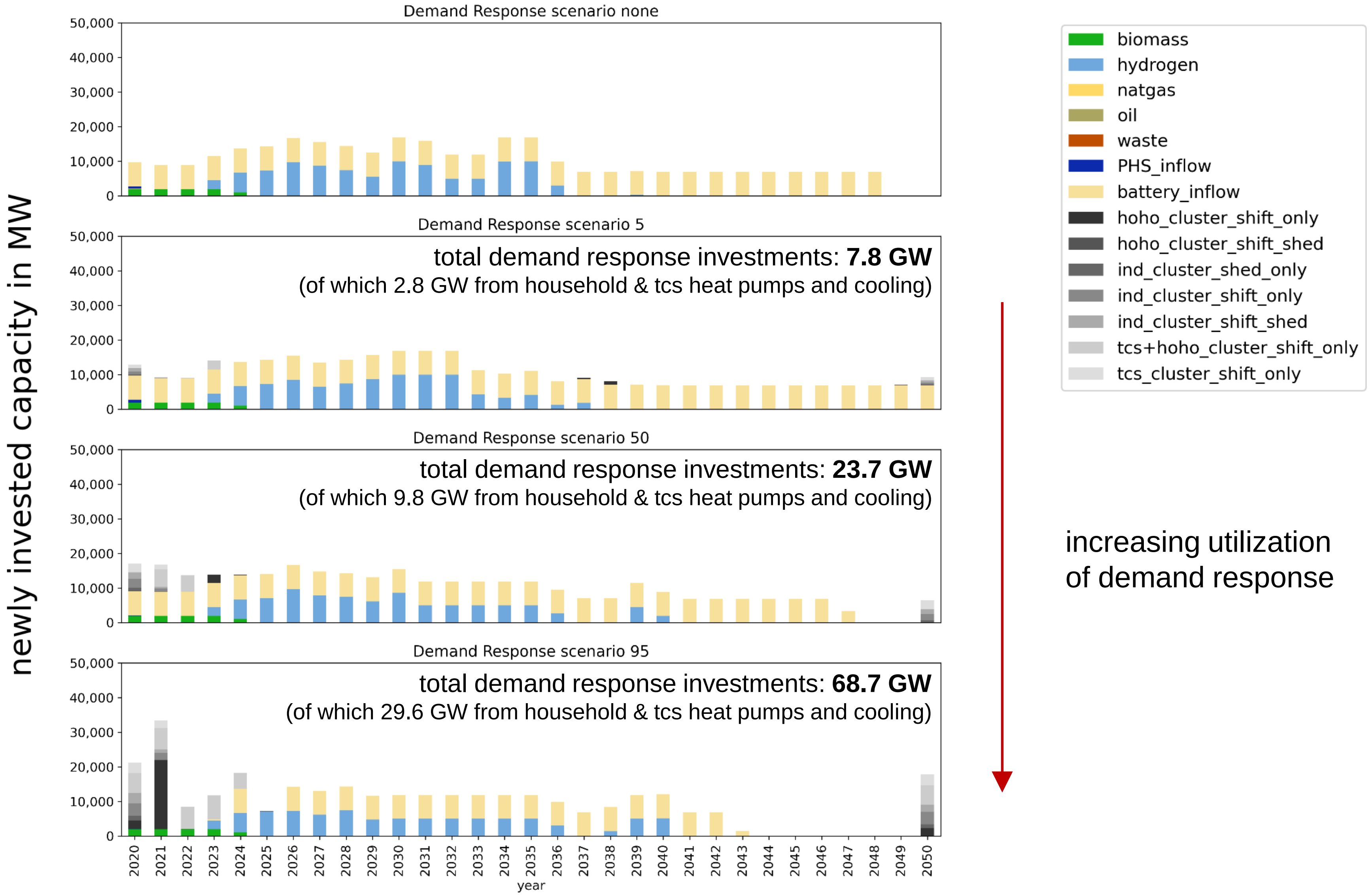
- battery storages massively deployed in all scenarios
- around 92 – 105 GW of usable (!) secured capacity from biomass and hydrogen in 2050
- hydrogen phase in starts in mid-2020s

DLR

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 <u>not available at the same time</u>!

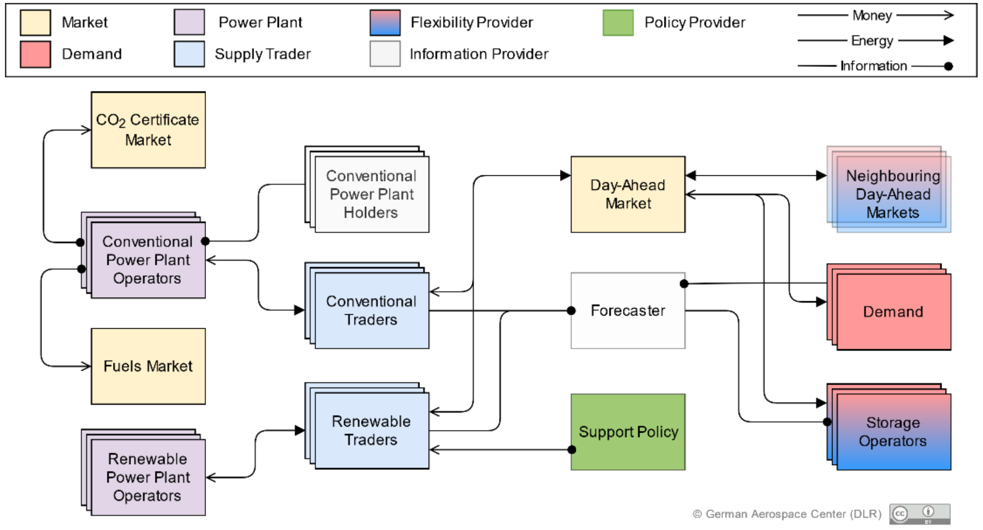
   Note that this is a very preliminary estimate
   and the model seems to overestimate flexibility needs

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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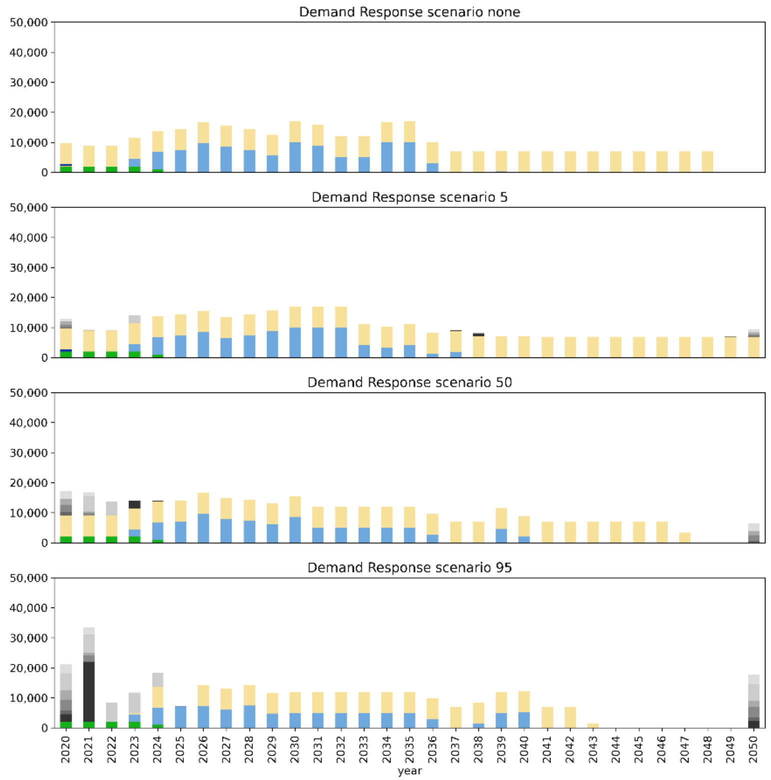

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