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MODEL-BASED EVALUATION OF DECENTRALISED ELECTRICITY MARKETS AT DIFFERENT PHASES OF THE GERMAN ENERGY TRANSITION

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Supported by:

Federal Ministry
for Economic Affairs
and Energy

on the basis of a decision
by the German Bundestag

Agenda

1 Motivation and research question

2 Methodology

3 Results

4 Conclusion and discussion

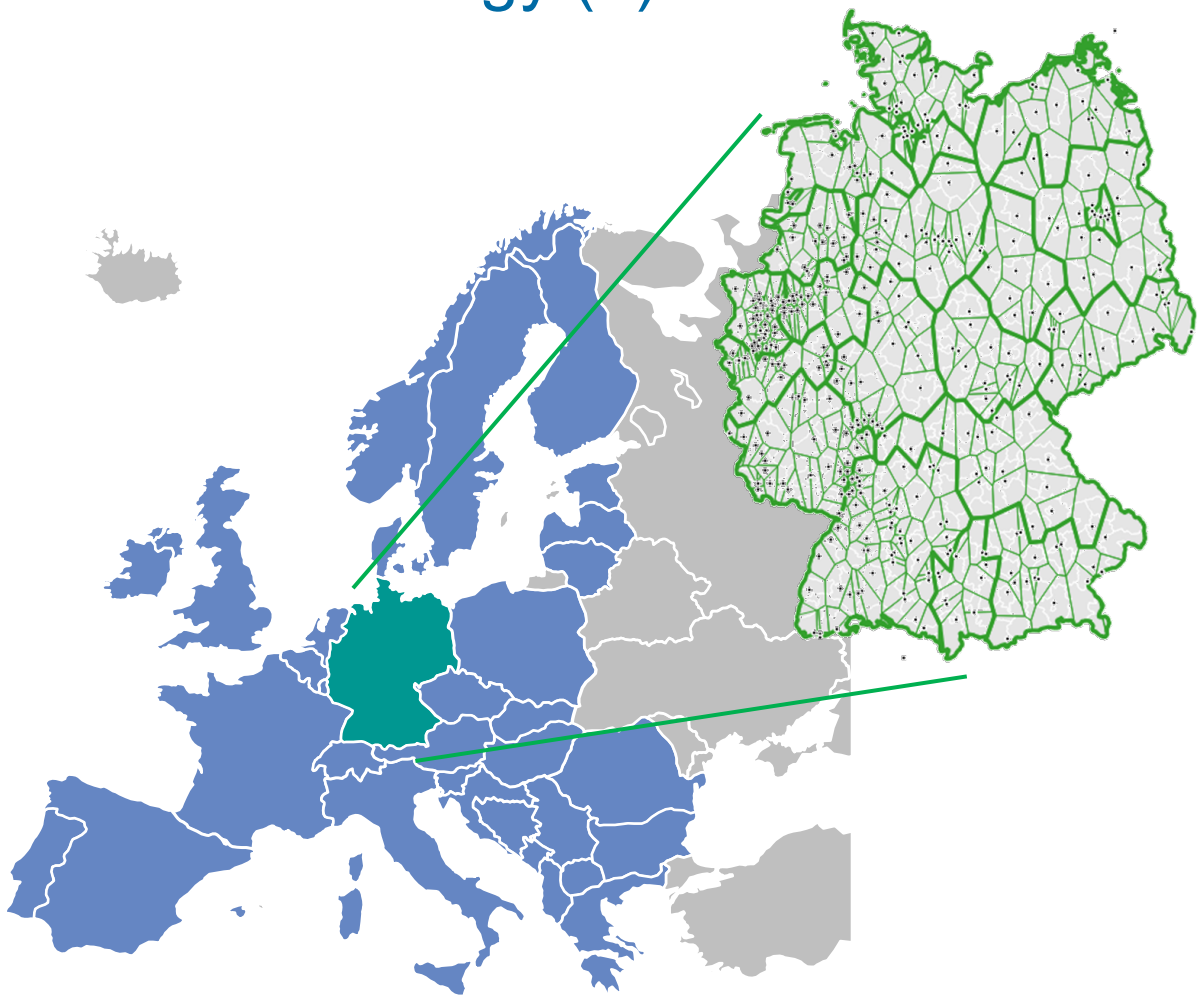
Motivation and research question

- Energy transition in Germany leads to a new structure of the electricity production
  - Small-scale technologies (like PV and batteries), new distributed and localised closer to the consumers
- Are decentralised markets a consequential and beneficial concept to support the transformation of the electricity system towards a generation structure based on decentralised and renewable energy in Germany?
  - How does the size of decentralised markets influence the effects?
  - What is the impact if only power plants of a certain size or technology are allowed to take part in the decentralised markets?
- Main indicators:
  - CO2 emissions, variable costs, regional self-supply, price differences between regions and transmission grid extension

Methodology (1)

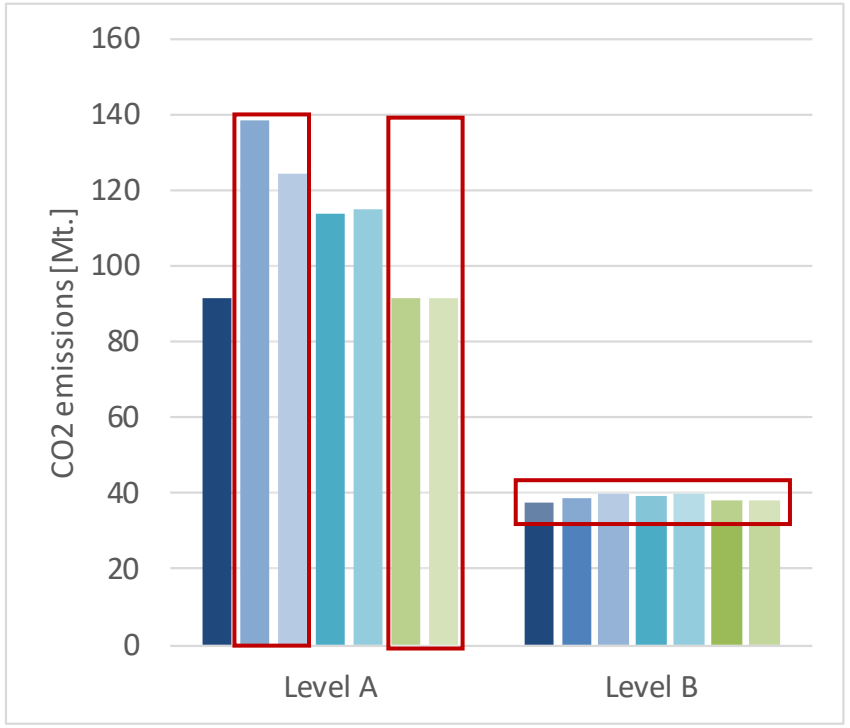
- Decentralised markets defined as markets for a defined spatial region
- Market participants: power plants, storage and other flexibility options such as demand side management.
- Electricity market and grid expansion model PowerFlex Grid EU
- Decentralised markets modelled with a two-step subsidiarity approach
  - First step: matching regional demand by regional generation using flexibility options
  - Second step: remaining demand and available generation capacities are matched via the European internal market
- To achieve ideal result from a market perspective, no grid constraints are considered in the market modelling.
- Based on the market modelling results, congestion and need for expansion of the German transmission grid are calculated

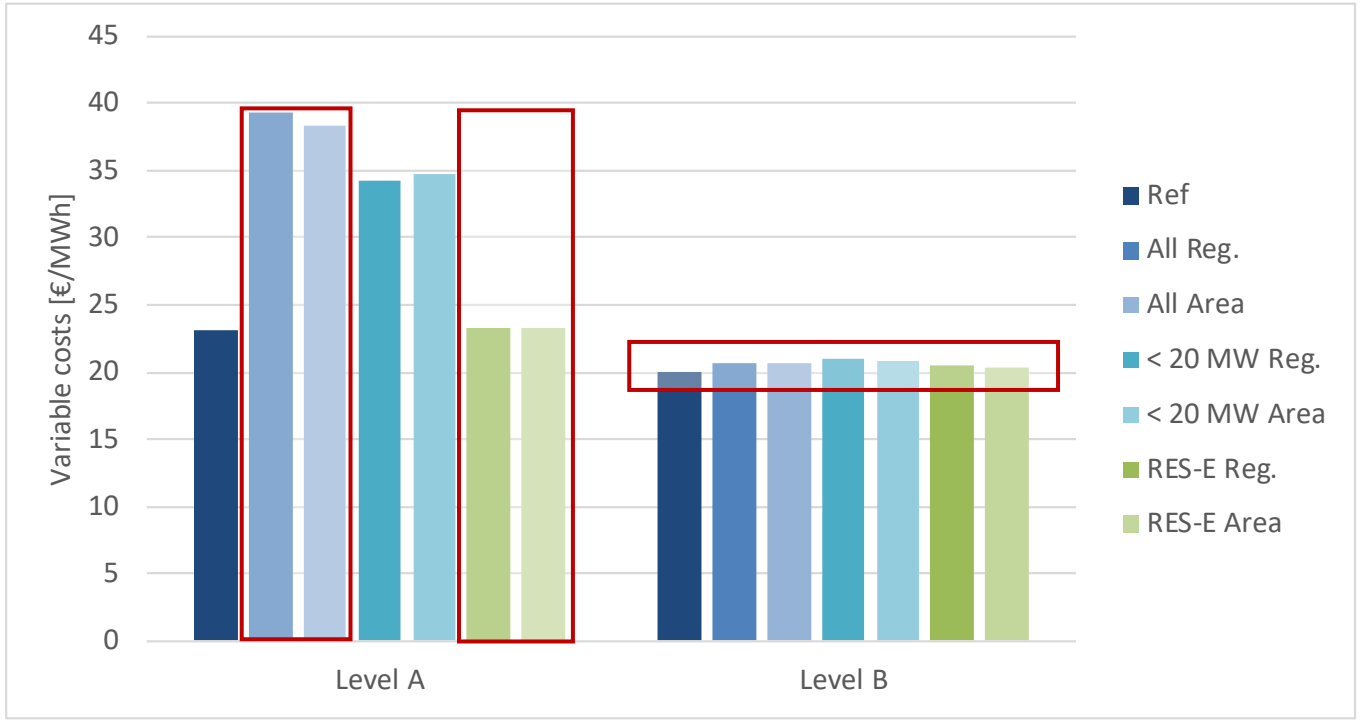
Methodology (2)



- 2 energy transition phases:
  - Level A (≈70% RES-E share)
  - Level B (≈97% RES-E share)
- 2 sizes of decentralised markets:
  - 20 regions (Reg.)
  - 457 areas (Area)
- 3 configuration of authorised participants
  - All producers (All)
  - Only small producers (< 20 MW)
  - Only renewable producers (RES-E)
- Reference case (Ref):
  - load coverage in a central market, according to current regulation

Results
CO_2 emissions and variable electricity generation costs



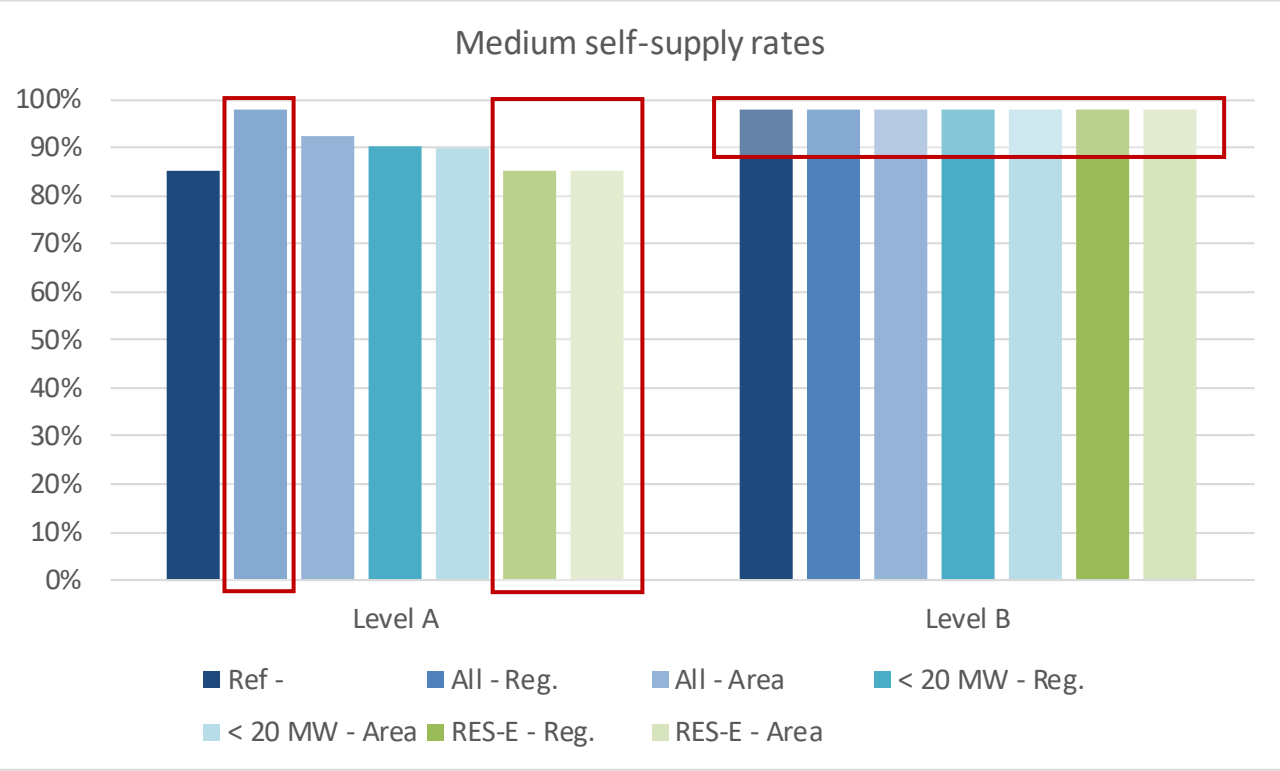


Level A (≈70% RES-E share)

- Higher emissions and variable costs compared to a central market (*Ref*); except *RES-E*
- Biggest effects if all power plants participate

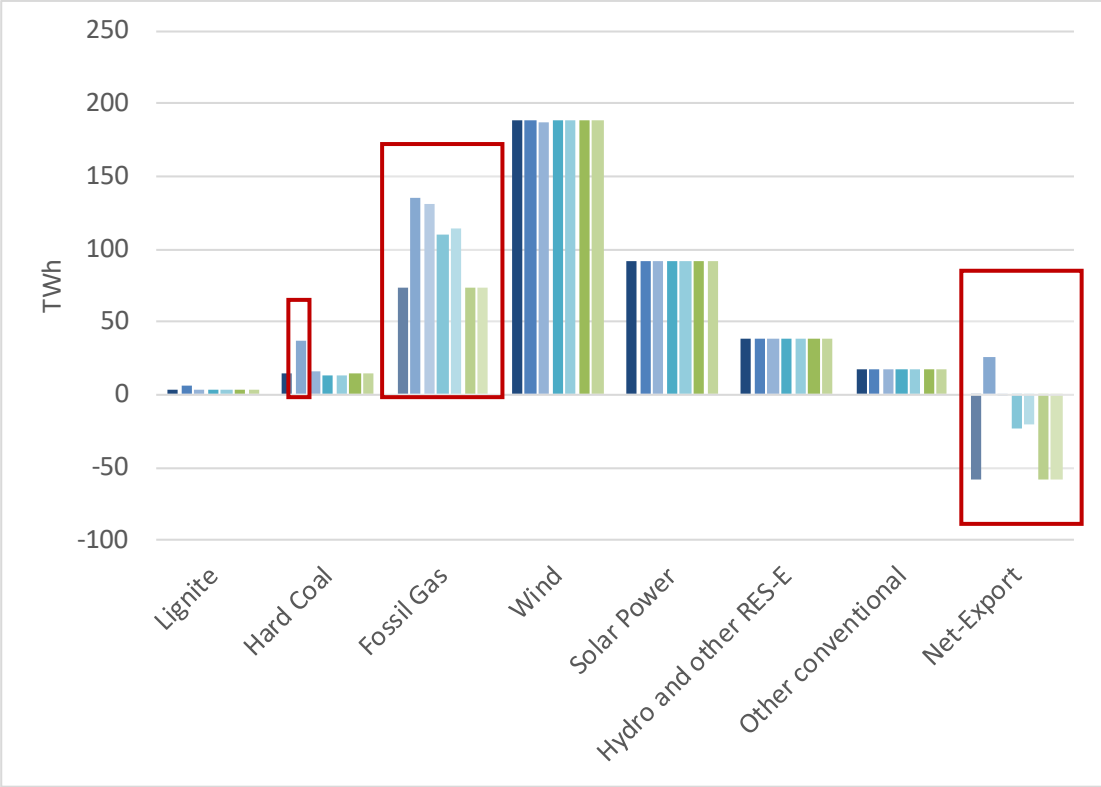
Level B (≈97% RES-E share) only minor differences

Results
Regional self-supply

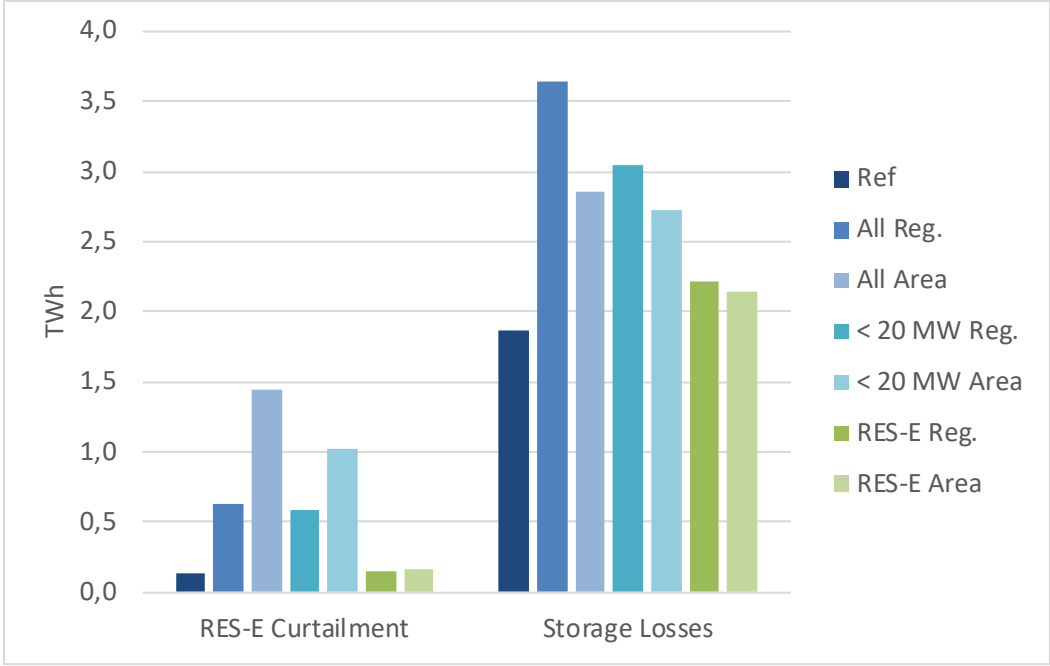


- Method:
  - Share of load covered by regional generation determined for each regional market area on an hourly basis
- Level A | All | Reg.: significant increase by 13% points
- No increase if only RES-E participates in regional markets
  - RES generation is at the beginning of the merit order and cannot be further optimised compared to a central market optimisation
- Level B: high level of self-supply (approx. 98%) in all variants
  - High RES-E expansion leads to broad regional distribution of generation plants

Results – Zoom into Level A
Electricity generation, RES-E curtailment and storage losses



- Main differences for fossil gas
- All | Reg: also hard coal
- Significant change of net export

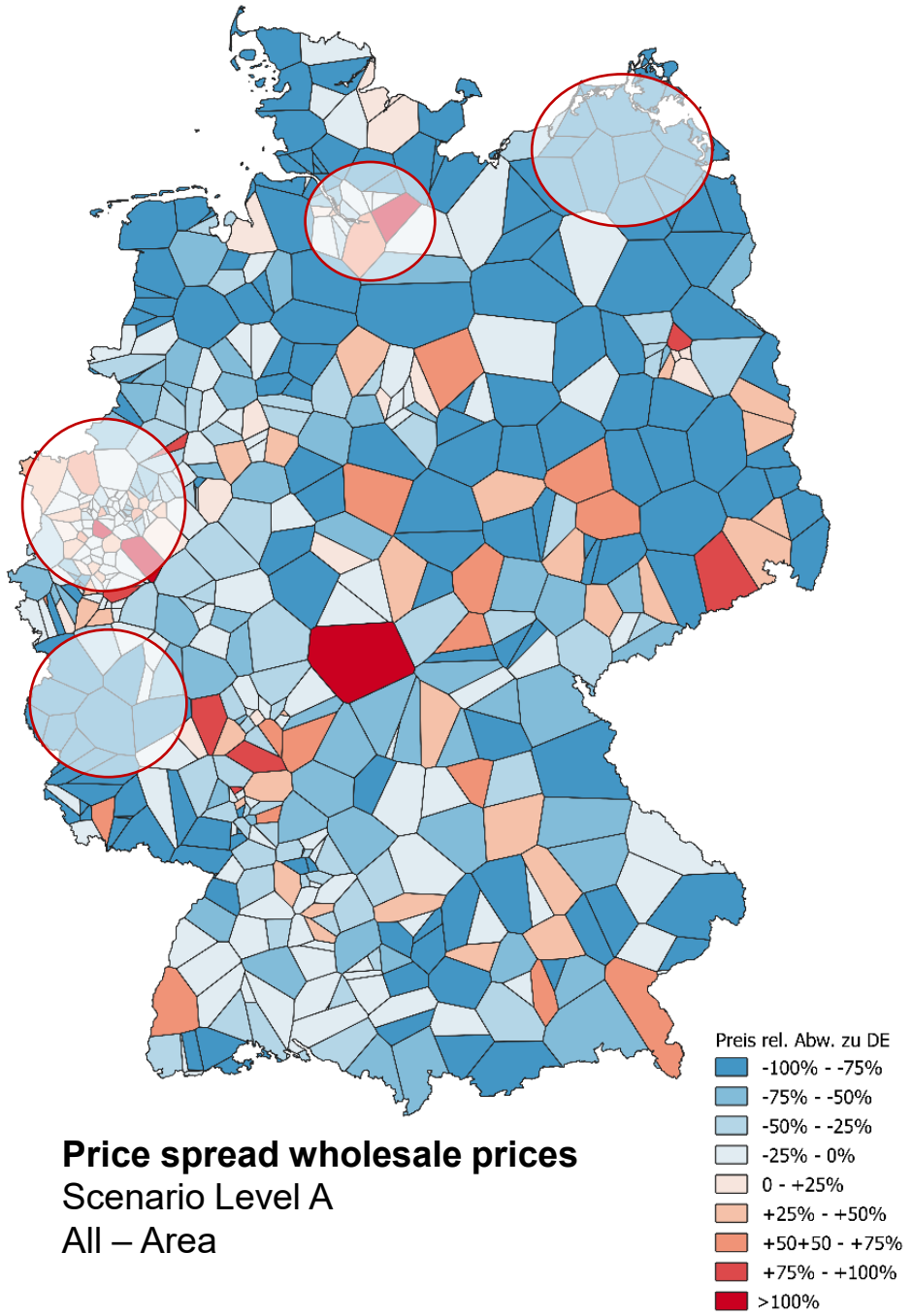


- RES curtailment and storage losses are at a low level in the scenario
- Are increased by decentralised markets
  - Decentralised markets shift RES-E in the merit order to a later position
  - Storages are used more often to increase regional self-supply

Results – Zoom into Level A

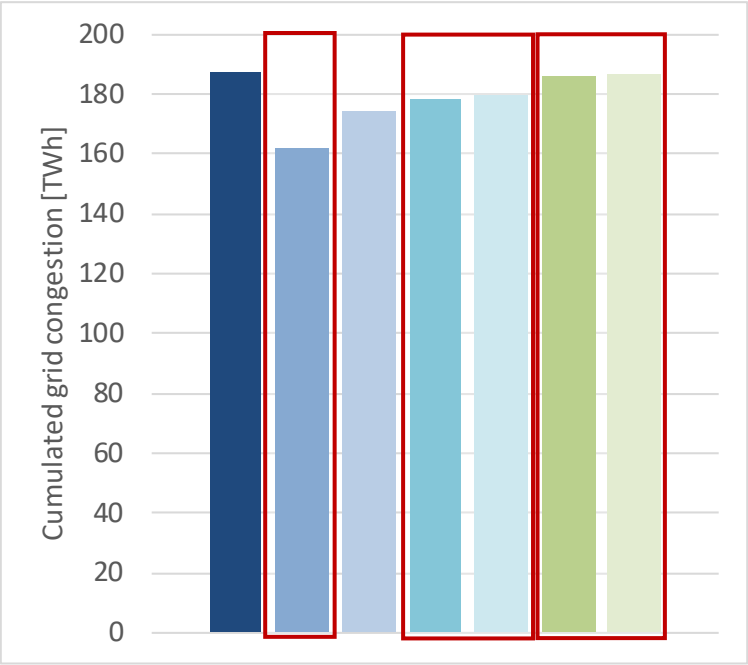
Price spread

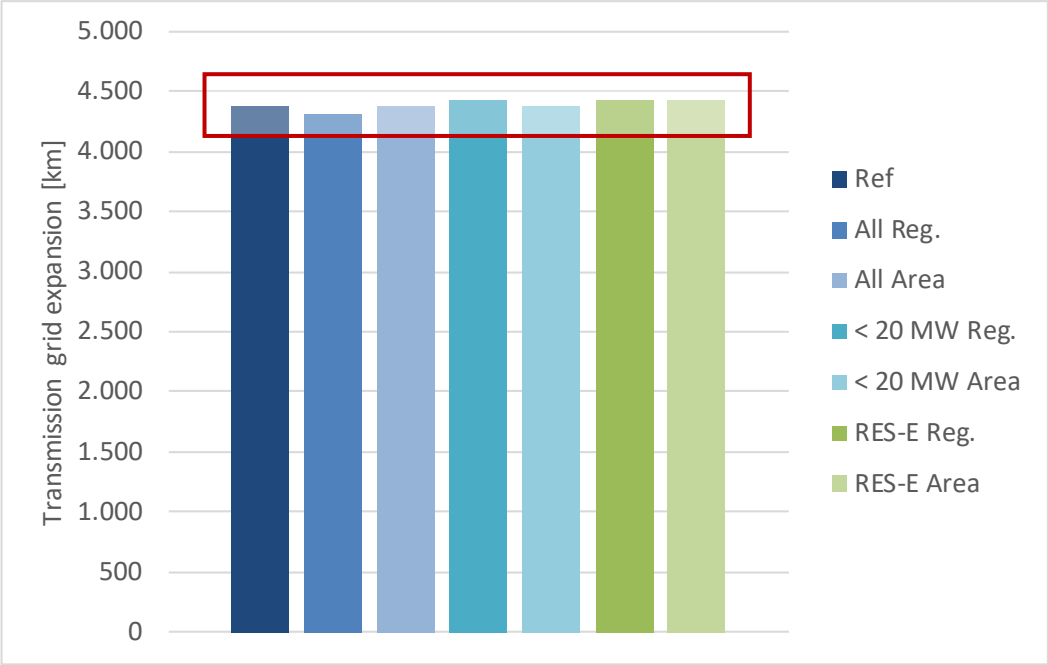
- Considerable price differences between the regions
- As a result of RES-E distribution and electricity demand
- Low electricity prices in regions with high RES potentials or low electricity demand
- Very high prices in urban areas and areas with electricity-intensive industries



Price spread wholesale prices
Scenario Level A
All – Area

Results – Zoom into Level A
Grid congestion before expansion and transmission grid expansion





- Grid congestion can be reduced by about max. 15 %
- Permitting only small power plants reduces the effect significantly
- If only RES-E allowed grid congestion is roughly at reference level

- Grid expansion needs roughly at the same level in all cases
- A reduction in annual grid overload does not necessarily lead to a reduction in peak load and the grid expansion required as a result.

Conclusion and discussion

Conclusion

- In the configuration studied, **negative effects** (higher CO2 emissions, variable costs and price spreads) of small scale markets compared to status quo predominate
- They can be mitigated if **fossil power plants** are excluded from those markets; then only very small effects (pos. and neg.) can be observed
- Decentralised markets can temporarily increase the degree of **regional self-supply**
- No significant reductions of **transmission grid needs** observed

Discussion

- The differences of **wholesale prices** between regions might be reduced if additional RES-E capacities are deployed in high price regions, but only if potentials are available
- The analysis focusses on a **system perspective** and does not include effects for **market players**.
- **Dynamic effects** such as a possible effect of decentralised markets on the overall deployment of RES-E technologies or storage systems is therefore not part of the analysis.
- The results are valid for the **German electricity system** with a relatively strong electricity grid and high interconnection to neighbouring countries

Thank you for your attention!

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