Friedrich-Alexander-Universität
Rechts- und Wirtschafts-
wissenschaftliche Fakultät

The cost of missing regional investments incentives in zonal electricity markets

Case study for the Germany electricity system in a European context

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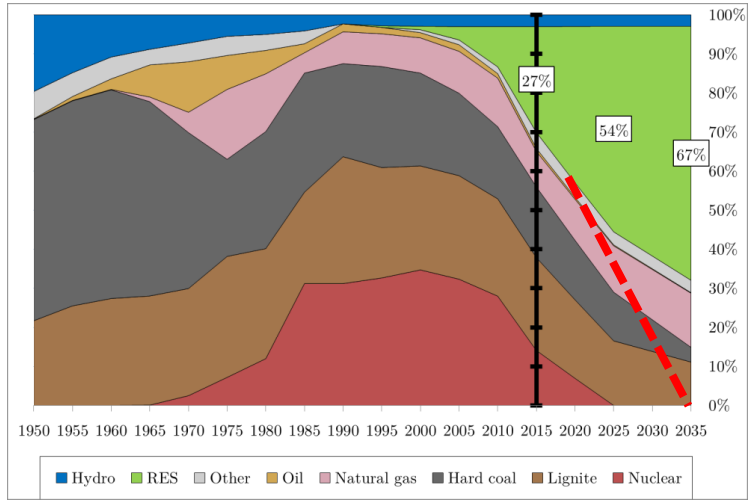
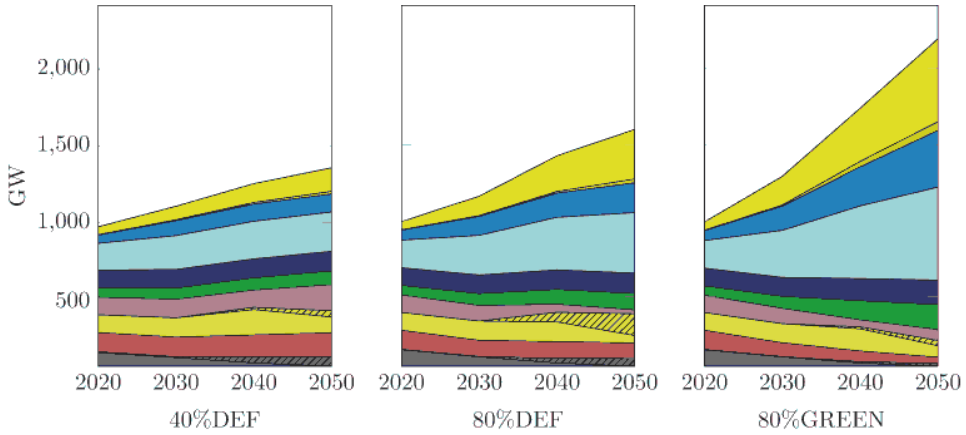
Jonas Egerer, Veronika Grimm, Lukas M. Lang, Ulrike Pfefferer

Running out fossil fuels…

- **Old world:**
  - Fossil gas as bridge well into the 2040s
  - Coal exit in 2037 or earlier with more fossil gas in a carbon constraint world
  - Gradual addition of renewable electricity generation
- **New world:**
  - Green deal: Climate targets for contribution to +2°C
  - Decarbonization of the energy sector by 2040 (EU-ETS)
  - RePowerEU or lessons learnt on the price of gas
  - 69% renewable target for 2030 + electrification / PtX
- **Question:**
  - (Regional) (dis-)incentives for (in-)flexible assets (?) in a zonal electricity market

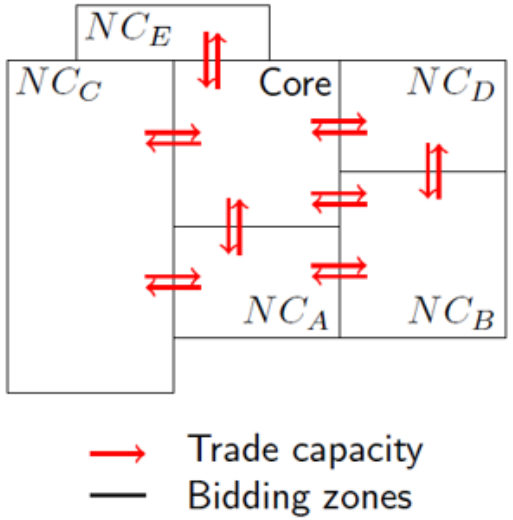
T-10 years





Methodology

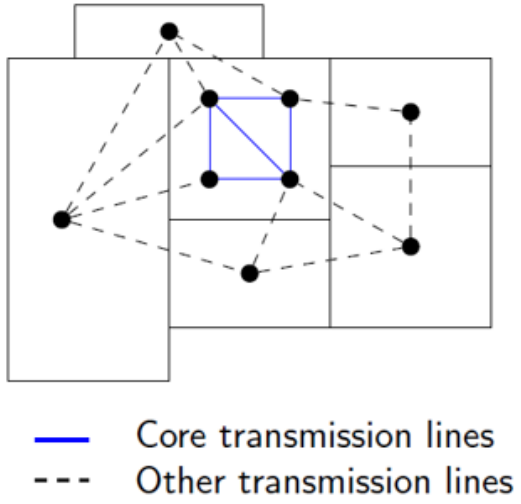
Level 1: Spot market and (dis)investment decisions



Private companies decide on their profit-maximizing production volumes and their long-term (dis)investments in conventional generation capacities.

Cross-zone trading capacities between the zones are taken into account accordingly.

Level 2: Congestion management in core market (German bidding zone)



The TSO in the core zone optimizes cost-based congestion management to make spot market results technically feasible according to the flows in the extra-high voltage grid.

If existing generation capacity is not sufficient, the TSO can invest in reserve power plants.

Scenario framework for 2030

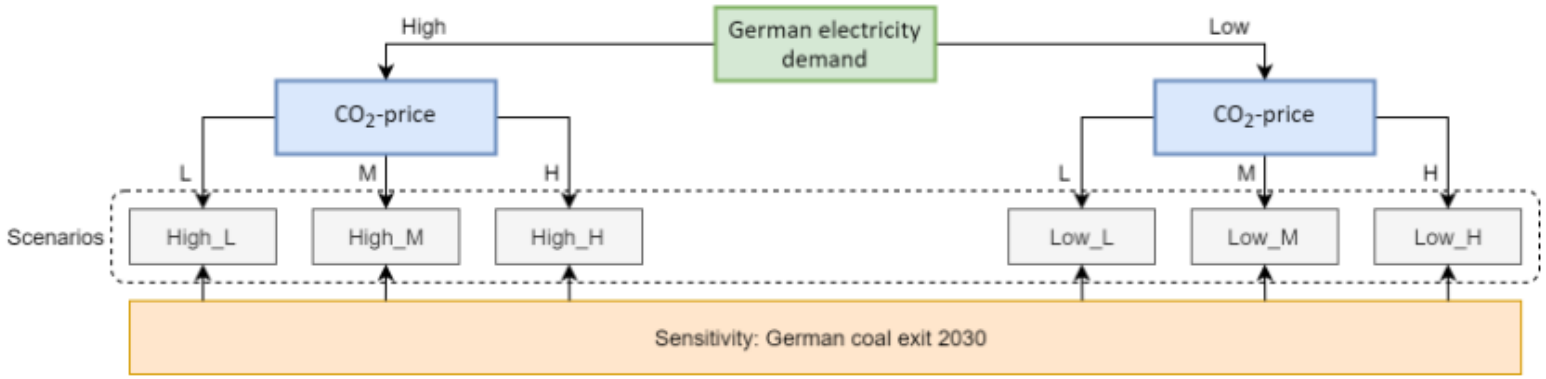


FIGURE 4. Formulation of scenarios from the main sources of uncertainty: The development of German electricity demand and the CO_2 price.

German perspective in European context:

- **Development of CO2 price (55/105/155 EUR/t)**
- **Electricity demand DE (TYNDP vs. NCEP)**

Scenario framework for 2030

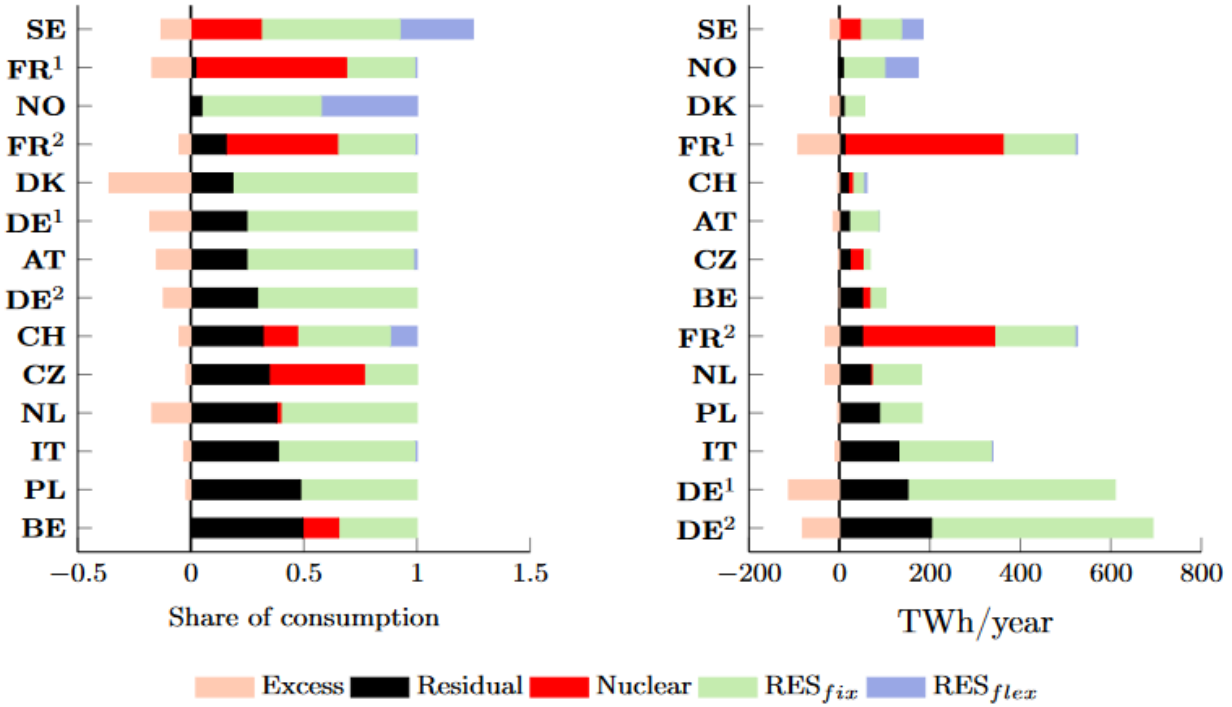


FIGURE 5. Hourly RES and nuclear supply, remaining residual demand and excess RES and nuclear generation aggregated at national level over one year, left: relative to demand and right: absolute, with [1]Low nuclear/demand and [2]High nuclear/demand in FR/DE

German perspective in European context:

- Development of CO2 price (55/105/155 EUR/t)
- Electricity demand DE (TYNDP vs. NCEP)
- **NCEP renewable targets (35% - 100%) and national nuclear**

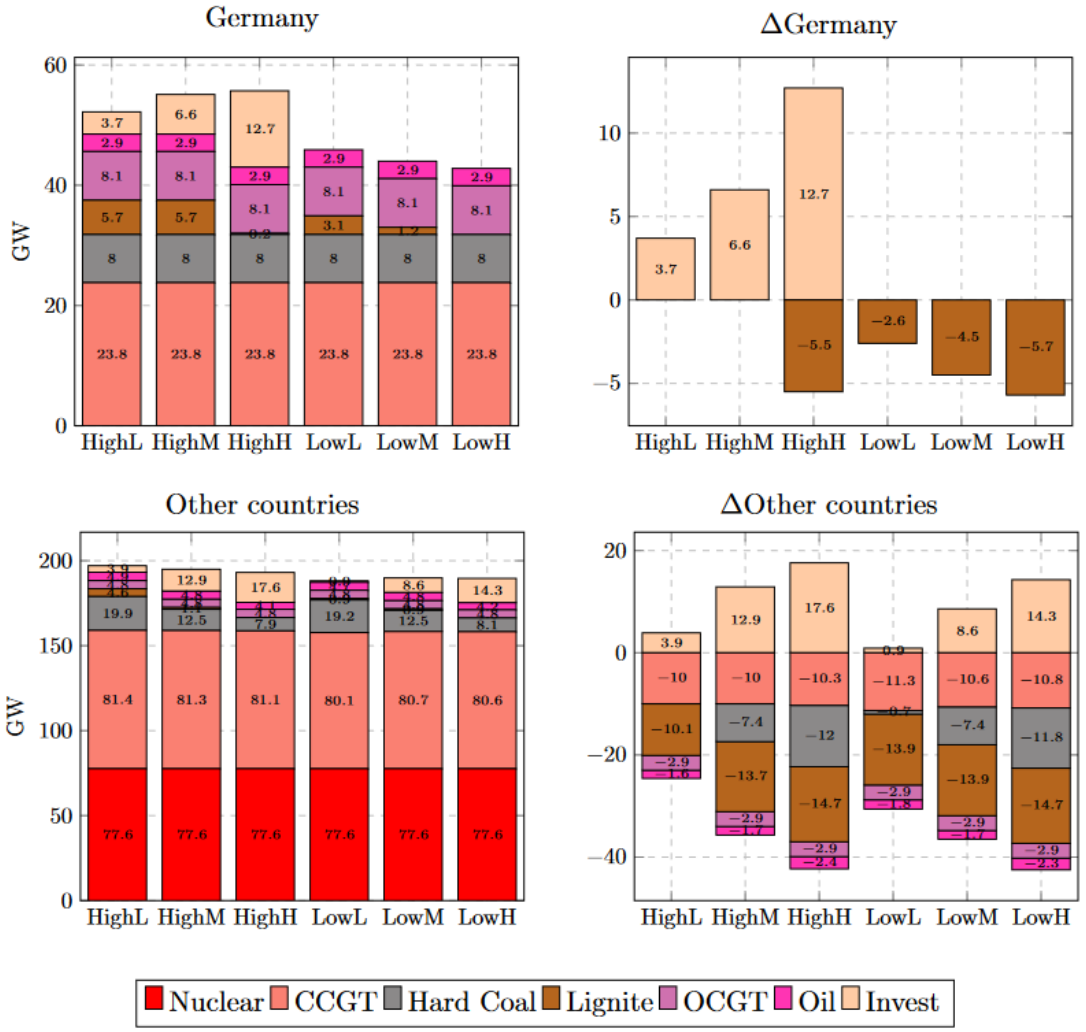


FIGURE 6. Generation capacity (left) and (dis-)investments in Germany (top) and other countries (bottom) in 2030

- No market-driven shut-down of all coal
- **BUT:** de-facto slow coal phase-out in generation
- Limited investment in gas capacity to mitigate uncertainty in demand growth

TABLE 2. Generation (in TWh/y) and emission (in Mt CO_2/y) in Germany

		High			Low		
		L	M	H	L	M	H
RES	TWh/y		571.1			560.5	
CCGT	TWh/y	118.8	124.1	140.3	80.6	77.8	75.1
Coal	TWh/y	19.8	12.6	4.6	11.2	7.5	4.1
Lignite	TWh/y	6.2	2.6	0.0	1.3	0.4	–
OCGT	TWh/y	6.8	6.8	5.1	3.7	4.9	4.4
Oil	TWh/y	0.4	0.4	0.3	0.3	0.3	0.3
Total	TWh/y	723.1	717.6	721.4	657.6	651.4	644.4
Electrolyser	TWh/y	14.4	13.0	13.0	21.7	20.4	20.4
Emission	Mt CO_2/y	64.8	57.4	53.1	39.1	34.9	30.7

Implications of neighboring bidding zones

- Price spreads at borders vary by region (higher variation at hourly level)
- Likely internal network congestion in DE
  → Discussion on e.g. bidding zones

TABLE 4. Average (hourly demand weighted) electricity spot market price by country in 2030 (in EUR/MWh)

	High			Low		
	L	M	H	L	M	H
NO	57.1	57.1	57.2	56.5	56.5	56.5
SE	56.0	56.0	56.0	55.2	55.2	55.2
DKE	74.4	80.3	89.5	68.8	75.2	84.8
DKW	73.9	79.2	88.3	65.2	72.1	81.7
PL	87.6	97.0	112.5	87.4	96.8	112.3
CZ	85.5	94.0	108.5	83.6	93.7	107.8
DE	80.4	88.1	101.0	69.1	78.1	91.0
NL	77.0	84.6	97.7	70.4	79.7	93.2
BE	83.6	91.9	105.5	80.3	89.5	103.0
FR	79.1	87.9	102.3	77.6	85.6	99.5
AT	80.4	88.9	102.3	71.7	81.7	96.1
CH	77.0	87.0	101.7	72.7	81.9	97.0
IT	70.7	79.1	93.2	69.9	78.2	92.2

Implications of neighboring bidding zones

- Price spreads at borders vary by region (higher variation at hourly level)
- Likely internal network congestion in DE
  → Discussion on e.g. bidding zones

Alternative route:

- No clear regional investment incentives within bidding zone in DE
- Comparison of "even" vs. "optimal" distribution
  - Electrolysis capacity
  - (Dis-)investment decisions

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PL	87.6	97.0	112.5	87.4	96.8	112.3
CZ	85.5	94.0	108.5	83.6	93.7	107.8
DE	80.4	88.1	101.0	69.1	78.1	91.0
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IT	70.7	79.1	93.2	69.9	78.2	92.2

Regional implications

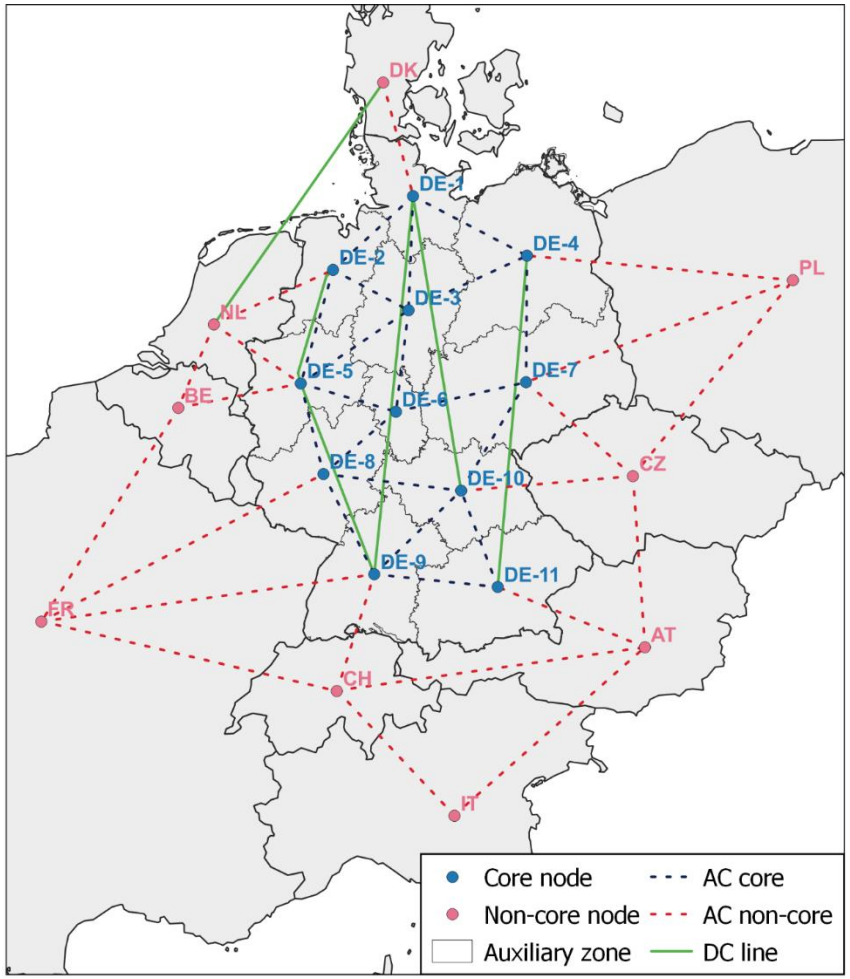
- Congestion management in Germany
- Market results with inter-zonal trade
- DCLF flow with 11 zones in Germany and aggregated lines for neighboring countries

Input:

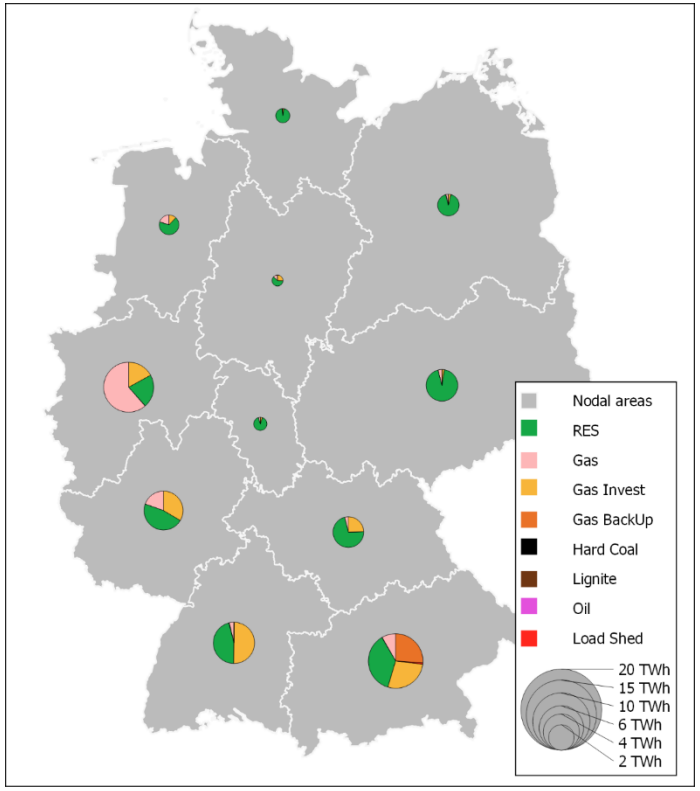
- Market results with fixed zonal net balances
- Tie-breaking of operation decisions for Germany

Output:

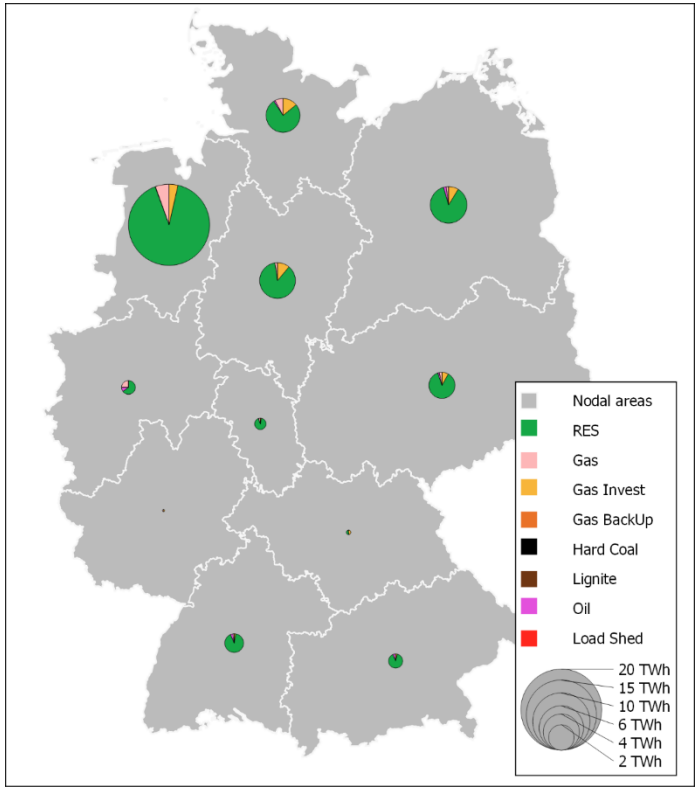
- Cost-optimal feasible operation with congestion management in Germany
- "Even" vs. "optimal" location of installations



Congestion management



Positive redispatch



Negative redispatch

Traditional redispatch: RES + CON

Assumptions:

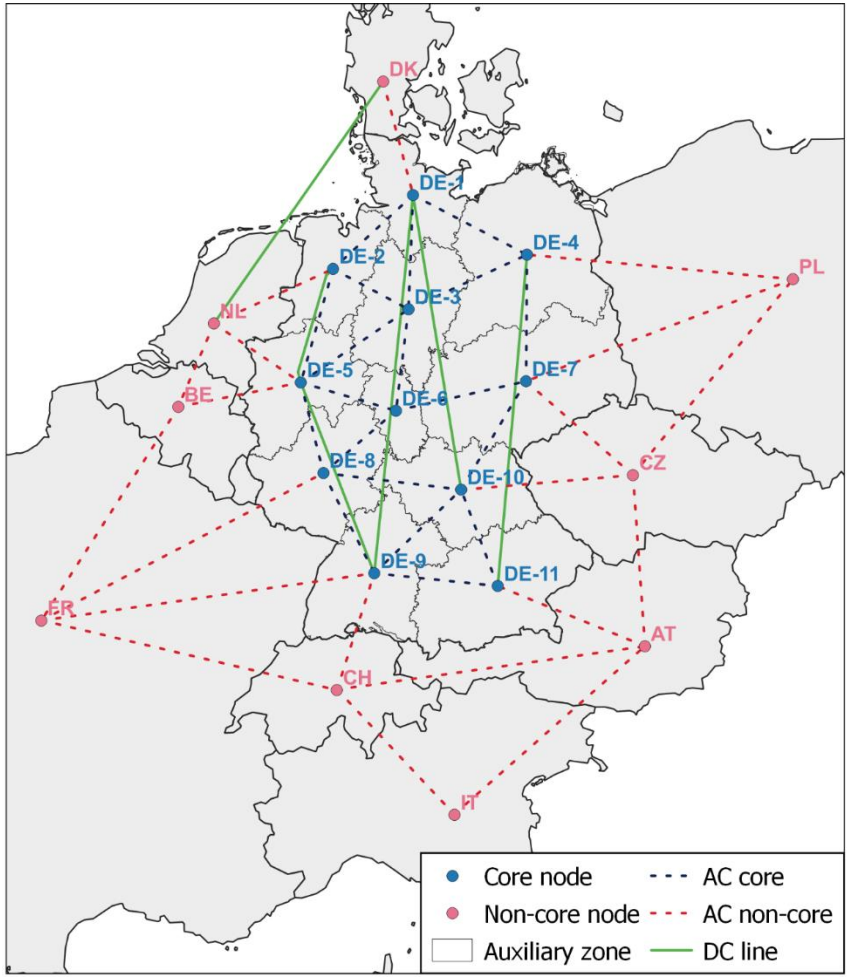
- Hours with RES >100% load
- Positive and negative redispatch of conventional power plants
- Negative redispatch of load (electrolysis)
- No optimization of flexible demand in redisptach

Regional implications

- Congestion management in Germany
- Market results with inter-zonal trade
- DCLF flow with 11 zones in Germany and aggregated lines for neighboring countries

Locational decisions within bidding zone:

- Backup capacity TSO
- Disinvestment of conventional capacity
- Investment in new capacity (gas, biomethane)
- Electrolysis capacity (with control?)
- Battery storage (with control?)



Work in progress

The spatial value of:

"Even distribution" versus "optimization"

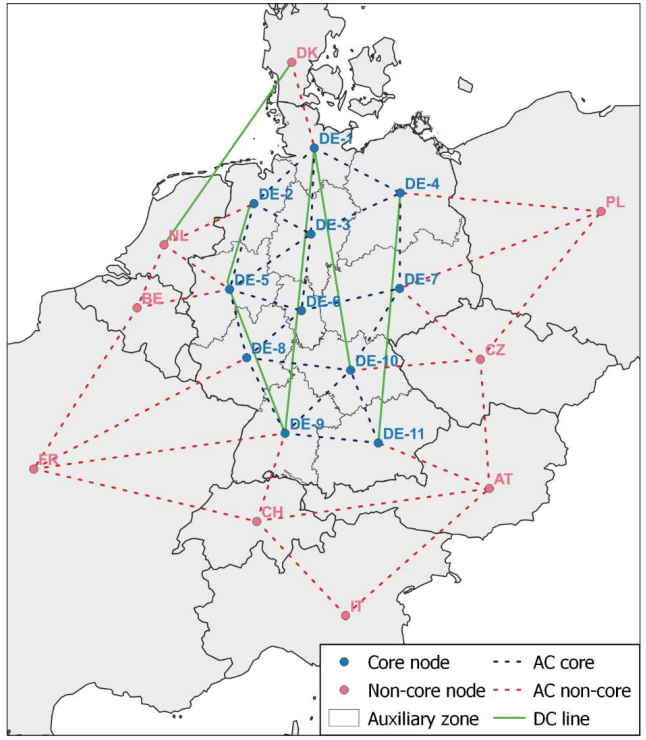
- Disinvestment of conventional capacity
- Investment in new capacity (gas, biomethane)

"Location" and "active" utilization in congestion management

- Electrolysis capacity (neg)
- Large battery storage (?)

"Optimization" TSO Backup

- Gas turbines, battery (?)



Discussion

- Implementation and evaluation of different redispatch scenarios for sensitivities
- Interplay market (dis-)investments and setting for congestion management?
- **Remain in current zonal electricity setting**
- **Implications of interaction with European transition**
- **Impact on system operation costs for different scenarios (market) with subsequent congestion management in 2030**

Level 2: Congestion management in core market (German bidding zone)