Strommarkttreffen

Coordinating Cross-Country Congestion Management

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Changing electricity generations patterns

Low-carbon transformation entails changing spatial generation pattern

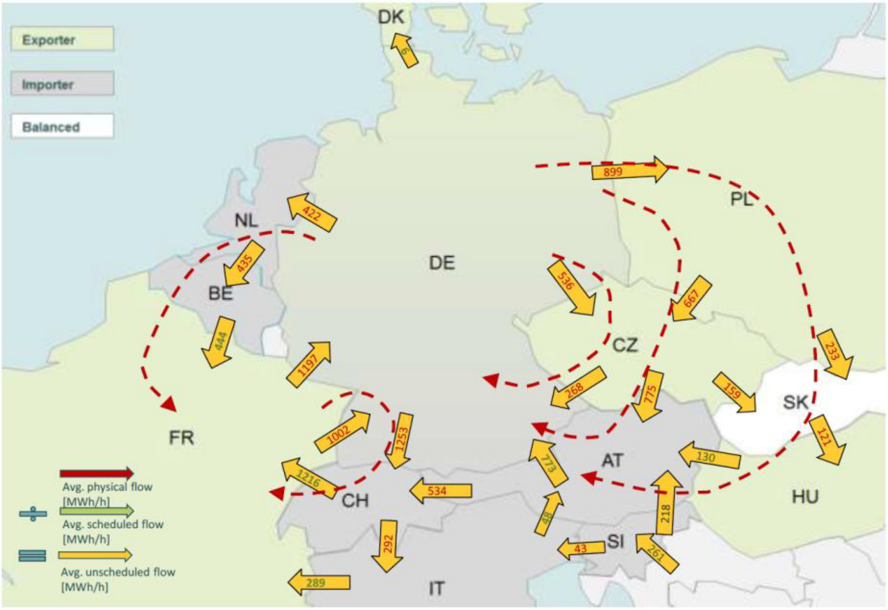
- Transmission system suits centralized large-scale generation and national self-sufficiency
- Many hours with insufficient line capacities in high-voltage grid
- Increasing costs for congestion management (BNetzA 2012, 2013, 2014, HB 2016)

Redispatch as short-run relief

- TSO arranges changes in dispatch until network flows feasible
- Costs socialized

Electricity flows not bounded by national borders

- Pressure on adjacent systems (ČEPS et al 2013; BNetzA and BKartA 2015)



Source: Thema Consulting (2013)

Relevance of international cooperation (EC 2009)

- Network Codes to harmonize cross-border operation of electricity systems (EC 2009)
- CACM (EC, 2015b, p L197/53): TSOs should

  “abstain from unilateral or uncoordinated redispatching and countertrading measures of cross-border relevance. Each TSO shall coordinate the use of redispatching and countertrading resources taking into account their impact on operational security and economic efficiency.“

This paper

- Analyzes different cases of cross-border coordination in congestion management
- Highlights benefits of closer cooperation

Contributions

- Academic evidence on coordination of cross-border congestion management
- State-of-the art model and detailed dataset

2 Two model stages

First stage: stELMOD (Abrell and Kunz 2015) creates hourly spot market dispatch

- Cost-minimal dispatch for Europe
- Market clearing subject to national energy balances and international NTCs

Second stage: congestion management model

- Cost-minimal redispatch, renewables and load curtailment as last resort measures
- Subject to physical network constraints

$$\min_{G_{p,t}^{CM}, CUR_{n,t}^{res}, CUR_{n,t}^{load}} \sum_{p,t} mc_p G_{p,t}^{CM} + \sum_{n,t} c^{C,res} CUR_{n,t}^{res} + c^{C,load} CUR_{n,t}^{load}$$

$$q_{n,t} - g_{n,t}^{RES} = \sum_{p \in n} (g_{p,t}^{DA} + G_{p,t}^{CM}) + \sum_{s \in n} (v_{s,t}^{DA} - w_{s,t}^{DA}) - CUR_{n,t}^{res} + CUR_{n,t}^{load} + NI_{n,t}$$

$$on_{p,t}^{DA} g_p^{min} \leq g_{p,t}^{DA} + G_p^{CM} \leq on_{p,t}^{DA} g_p^{max}$$

$$\left| \sum_{l} ptdf_{l,n} NI_{n,t} \right| \leq p_l^{max}$$

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Four cases of cross-country coordination

Case 1 – uncoordinated congestion management

- Separate objective function and constraint set for each TSO
- National energy balance
- Formally: generalized Nash Equilibrium framework

$$\sum_{p \in c} G_{p,t}^{CM} = 0$$

Case 2 – coordinated congestion management with information sharing

- Impact of own actions on adjacent systems known
- Formally: one objective function for entire study region, national energy balances

Case 3 – coordinated congestion management with counter-trading

- Redispatch across countries possible, bounded by NTCs
- Formally: augmented energy balance, NTC restrictions

$$\sum_{p \in c} G_{p,t}^{CM} = \sum_{cc} \left(TF_{c,cc,t}^{CM} - TF_{cc,c,t}^{CM} \right)$$

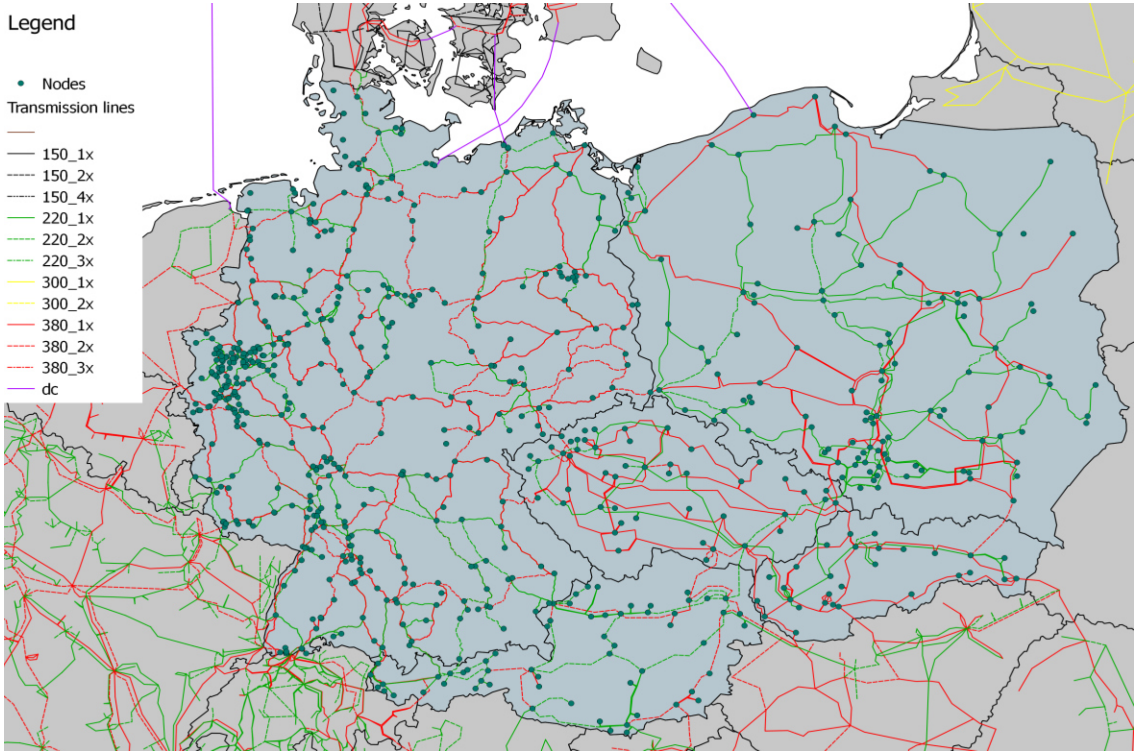
$$0 \leq tf_{c,cc,t}^{DA} + TF_{c,cc,t}^{CM} \leq ntc_{c,cc}$$

Case 4 – coordinated flow-based congestion management

- Integrated optimization, physical capacities for all lines

Detailed representation of the European electricity market in 2013

- Study region (AT, CZ, DE, PL, SK) with detailed representation
- 8760h simulation horizon
- Spatial distribution of load based on regional economic indicators
- Spatial distribution of renewables based on EEG installation register
- Representation of the high-voltage transmission grid based ENTSO-E and TSO maps

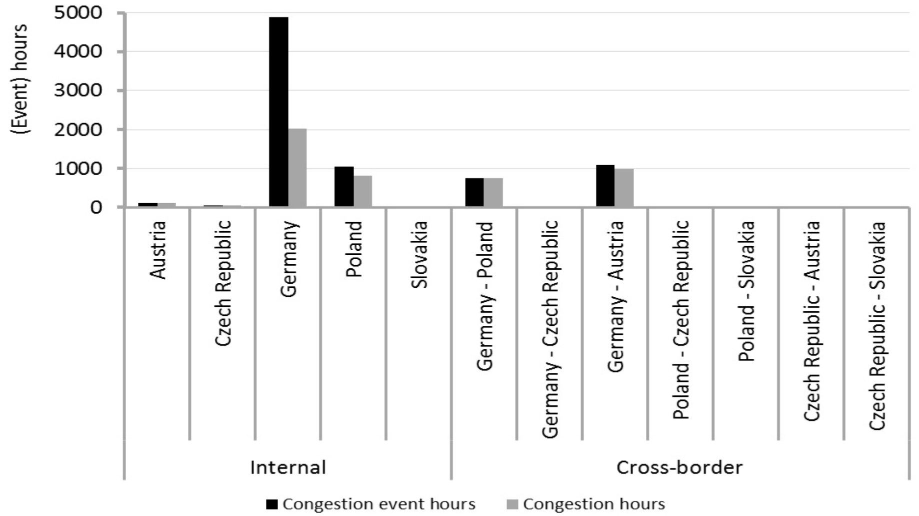


Source: own illustration

4 Congestion pattern and loop flows

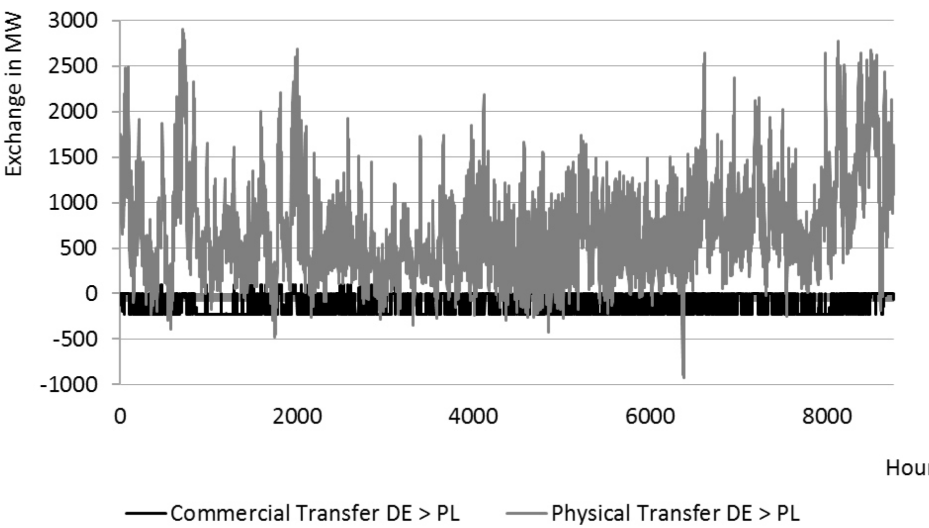
Main fraction of congestion events affecting Germany

- Spatial pattern close to reported numbers (BNetzA 2014)



German generation impacts physical cross-border flows Germany-Poland

- Energy flows not equally reflected in spot market transactions
- National generation patterns influence adjacent systems in meshed networks



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4 Total redispatch costs influenced by volume and specific costs effects

Case	Total cost	Negative redispatch volume	Total redispatch volume	Specific cost
Case 1: Uncoordinated CM	357.5	5.6	11.2	55.4
Case 2: Coordinated CM with information sharing	137.8	3.1	6.2	43.1
Case 3: Coordinated CM with counter-trading	80.8	2.8	5.5	29.1
Case 4: Coordinated CM with MRAs	70.0	3.8	7.5	18.6

Cases 1 and 2 – Volume effect

- Congestion can be removed by resources in another country, creation of new congestion prevented
- Common IT infrastructure, information exchange (Coreso, TSC), shared responsibility

Cases 2 and 3 – Specific costs effect

- Counter-trading enables to set off congestion across countries
- Liquid intraday markets

Cases 3 and 4 – Full use of cross-border capacities

- Flow-based congestion management
- Caveat: re-optimization possible but restricted in the model: lower-bound interpretation

Efficiency gains entail distributional effects

	AT	CZ	DE	PL	SK	Total (absolute)
Congestion management costs						
Case 2: Coordinated CM with information sharing	13.0%	2.8%	76.6%	7.5%	0.0%	134.7 million Euro
Case 3: Coordinated CM with counter-trading	39.7%	11.1%	35.9%	13.2%	0.1%	80.3 million Euro
Case 4: Coordinated CM with MRAs	40.0%	12.9%	42.1%	5.0%	0.1%	69.9 million Euro
Congestion volume	4.0%	0.1%	86.7%	9.2%	0.0%	1221.5 GWh

- Total savings accompanied by absolute and relative shift of costs toward “cheaper countries“
- Prudent allocation policies to maintain incentives for cooperation

5 Some conclusions

Congestion management

- relevant to ensure secure network operation as long as network expansion is not in place

Coordination of TSOs

- is key to enable an efficient integration of RES
- decreases congestion management costs through lower redispatch volumes and specific redispatch costs

→ Extension of TSO cooperations to perform multilateral actions

Distribution of congestion management costs

- differs among cases and might impede national incentives

→ Development and evaluation of cost sharing approaches

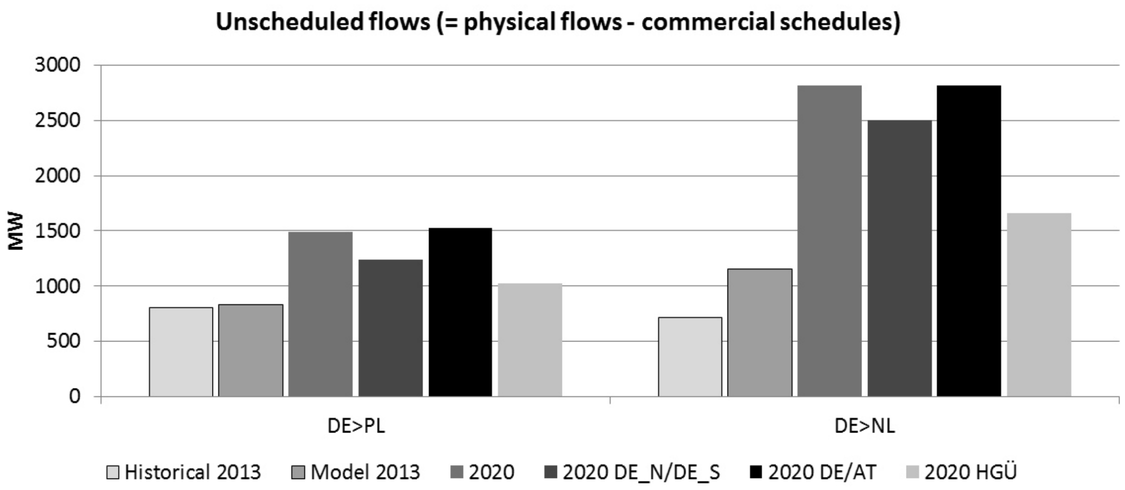
Nomenclature of electricity flows (ACER Market Monitoring Report)

- Physical flows can be decomposed into planned and unscheduled flows
- Unscheduled flows are composed of loop and unallocated flows

Loop and unallocated flows impact power systems not involved in a market transaction

- Unallocated flows can be addressed by a flow-based market allocation
- Loop flows are affected by market zone delineation or network extension

Quantitative analysis for 2013 and 2020 reveals increasing interactions between national systems



→ Analysis of national policies should account for impacts in neighboring / European countries

Thank you very much for your attention.

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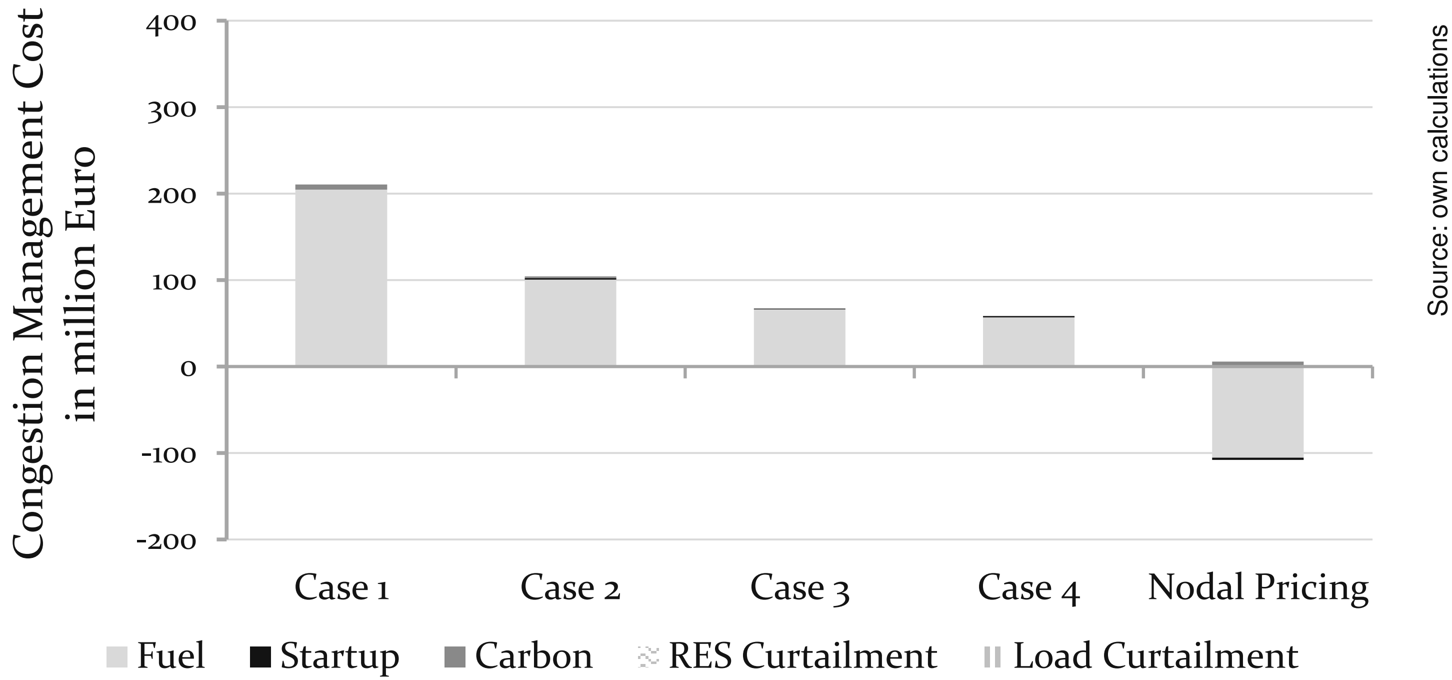
Total congestion management costs decrease with higher cross-country coordination



- Congestion pattern identical throughout cases
- Redispatch accounts for biggest share, curtailment qualitatively does not change results
- More coordination enables access to cheaper plants

Appendix: Data

Detailed representation of the European electricity market in 2013

- Study region Austria, Czech Republic, Germany, Poland, Slovakia
- Other European countries considered with lower level of detail
- 8760h simulation horizon
- Detailed representation of power plants in study region; vintage classes for other countries (BNetzA; PLATTS WEPP)
- Hourly load and renewables generation based on ENTSO-E, ECMWF
- Spatial distribution of load based on regional economic indicators
- Spatial distribution of renewables based on EEG installation register
- Representation of the high-voltage transmission grid based ENTSO-E and TSO maps
- CHP mustrun based on regional temperature profile
- Technical power plant data based on DIW Data Documentation