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Two Price Zones for the German Electricity Market: Market Implications and Distributional Effects

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Agenda

1. Introduction
2. Methodology
3. Data and Scenarios
4. Results
5. Conclusion

1 Introduction: Bidding Areas

Bidding Areas in Europe

- Internal Energy Market: Implicit market coupling with NTC capacity
- Today only in markets with clear geographic borders (exception: Nordpool/Italy)
- Discussion on bidding zones on European level (regulation on CACM)
- Implications of bidding zones: Effects on prices and rent distribution
  - Re-shaping of zones
  - NTC capacity

The Case of Germany

- Regional imbalances increasing (RES and coal plants in the north)
- Internal congestion: redispatch up from EUR 26mn (‘09) to EUR 165mn (‘12)
- Neighbors: transit flows and loop flows (north-south)
- No support for regional pricing in Germany
  - Other current issues (capacity markets/feed-in tariffs/network, etc.)
  - Perception that split in prices zones is a “defeat” (for the “Energiewende”)
  - Grünbuch (BMWi): bidding zones only if no network investment
- Plan: network investment (takes time to realize)

1 Introduction: Research Question

What are the benefits/issues of two bidding zones in Germany?

- System implications
- Zonal electricity prices
- Regional changes in stakeholder rents

Quantitative analysis for Germany (isolated):

- Dispatch
- Redispatch model

2 Methodology: Dispatch Model

Objective: minimizing generation costs

$$\min_{\substack{g_{pt}, r_{nst}, ps_{bt} \\ pslevel_{bt}}} costs^{sp} = \sum_{pt} \left(C_{pt} * g_{pt} \right)$$

subject to: maximum generation by power plant block and renewable technology

$$s.t. \qquad g_{pt} \leq \bar{G}_{pt} \qquad \forall p, t$$

$$r_{nst} \leq \bar{R}_{nst} \qquad \forall n, s, t$$

and the representation of pumped storage plants

$$pslevel_{bt} = 0.75 \overleftarrow{ps}_{bt} - \overrightarrow{ps}_{bt} + pslevel_{b(t-1)} \qquad \forall b, t$$

$$\overrightarrow{ps}_{bt} + \overleftarrow{ps}_{bt} \leq \overline{PS}_b \qquad \forall b, t$$

$$pslevel_{bt} \leq \overline{LS}_b \qquad \forall b, t$$

2 Methodology: (Zonal) Balance and Trade

Uniform pricing energy balance

$$\sum_p g_{pt} + \sum_n \left(\sum_s r_{nst} - Q_{nt} + PT_{nt}\right) + \sum_b \left(\overrightarrow{ps}_{bt} - \overleftarrow{ps}_{bt}\right) = 0 \qquad \forall t$$

Zonal pricing energy balance

$$\sum_{p \in z} g_{pt} + \sum_{n \in z} \left(\sum_s r_{nst} - Q_{nt} + PT_{nt}\right) + \sum_{b \in z} \left(\overrightarrow{ps}_{bt} - \overleftarrow{ps}_{bt}\right) + \sum_y \left(zf_{zyt} - zf_{yzt}\right) = 0 \qquad \forall z, t$$

Constraint on the trade capacity between the two zones

$$zf_{zyt} < \overline{NTC}_{zyt} \qquad \forall z, y, t$$

2 Methodology: Nodal Pricing Constraints

Nodal pricing energy balance

$$\sum_{p \in n} g_{pt} + \sum_{s} r_{nst} - Q_{nt} + PT_{nt} + \sum_{b \in n} (\overrightarrow{ps}_{bt} - \overleftarrow{ps}_{bt}) + ni_{nt} = 0 \qquad \forall n, t$$

DC load flow constraints

$$|pf_{lt}| \leq \bar{P}_l \qquad \forall l, t$$

$$ni_{nt} = \sum_{k} (\theta_{kt} * B_{nk}) \qquad \forall n, t$$

$$pf_{lt} = \sum_{n} (\theta_{nt} * H_{ln}) \qquad \forall l, t$$

$$\theta_{'n_slack't} = 0 \qquad \forall n, t$$

2 Methodology: Redispatch Model

Objective: minimizing re-dispatch costs

$$\min_{\substack{g^+, g^-, \\ r^-}} costs^{rd} = \sum_{pt} \left(g^+{}_{pt} * C_{pt} \right) - \sum_{pt} \left(g^-{}_{pt} * C_{pt} \right)$$

subject to re-dispatch constraints

$$s.t. \qquad g^+{}_{pt} \leq \bar{G}_{pt} - g^0{}_{pt}$$

$$\forall p, t$$

$$g^-{}_{pt} \leq g^0{}_{pt} \qquad \forall p, t$$

$$r^-{}_{nst} \leq r^0{}_{nst} \qquad \forall n, s, t$$

and the re-dispatch energy balance

$$\sum_{p \in n} \left(g^0{}_{pt} + g^+{}_{pt} - g^-{}_{pt} \right) + \sum_{s} \left(r^0{}_{nst} - r^-{}_{nst} \right) - Q_{nt}$$

$$+ PT_{nt} + \sum_{b \in n} \left(\overrightarrow{ps^0}{}_{bt} - \overleftarrow{ps^0}{}_{bt} \right) + ni_{nt} = 0 \qquad \forall n, t$$

3 Data and Scenarios

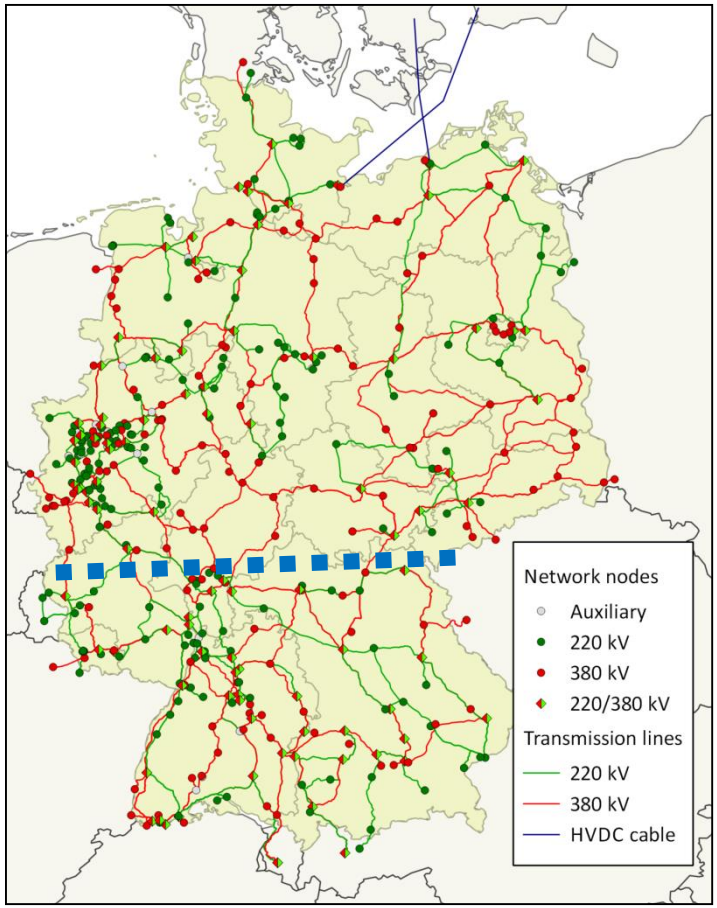
Network data:

- 438 network nodes with supply and demand
- 709 individual transmission lines (220/380 kV)

Hourly data (8784 hours):

- Demand
- Renewable availability
- Fixed imports and exports to neighboring countries

Transmission network 2012



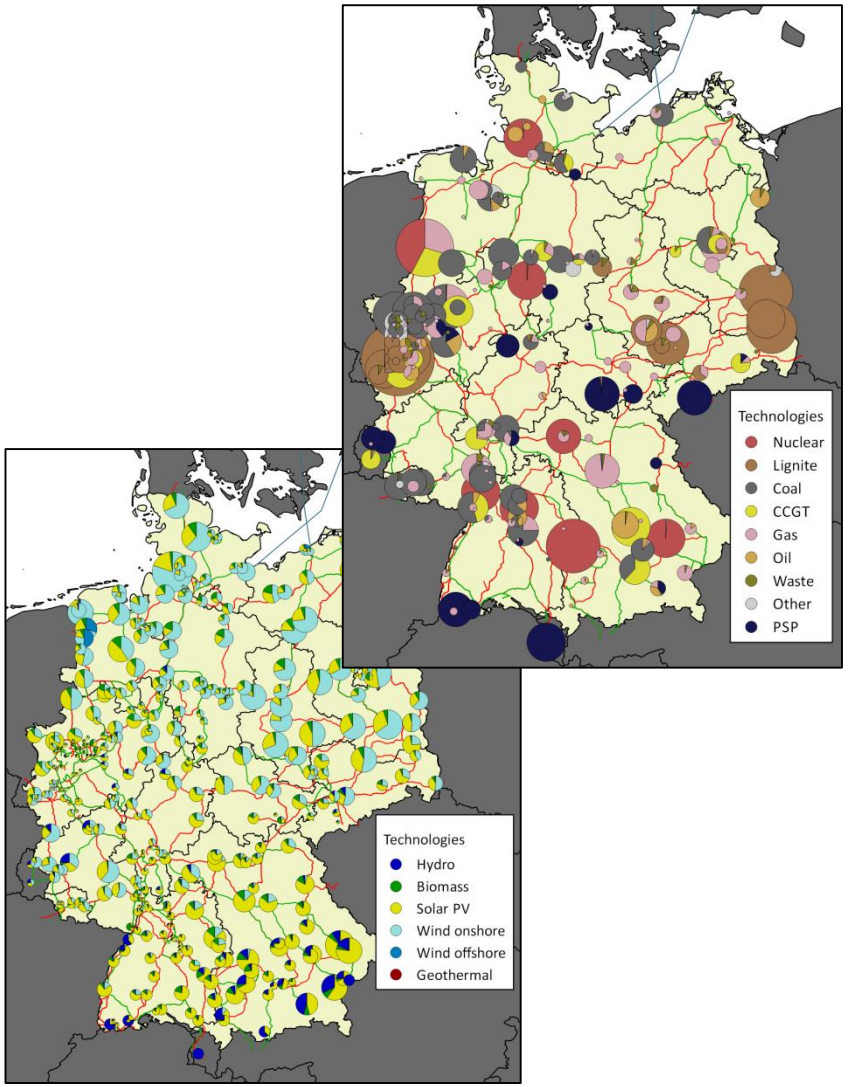
3 Data and Scenarios

Conventional capacity:

- About 600 power plant blocks
- Fuel
- Technology
- Efficiency
- Regional transport costs for hard coal

Renewable capacity (TSO data):

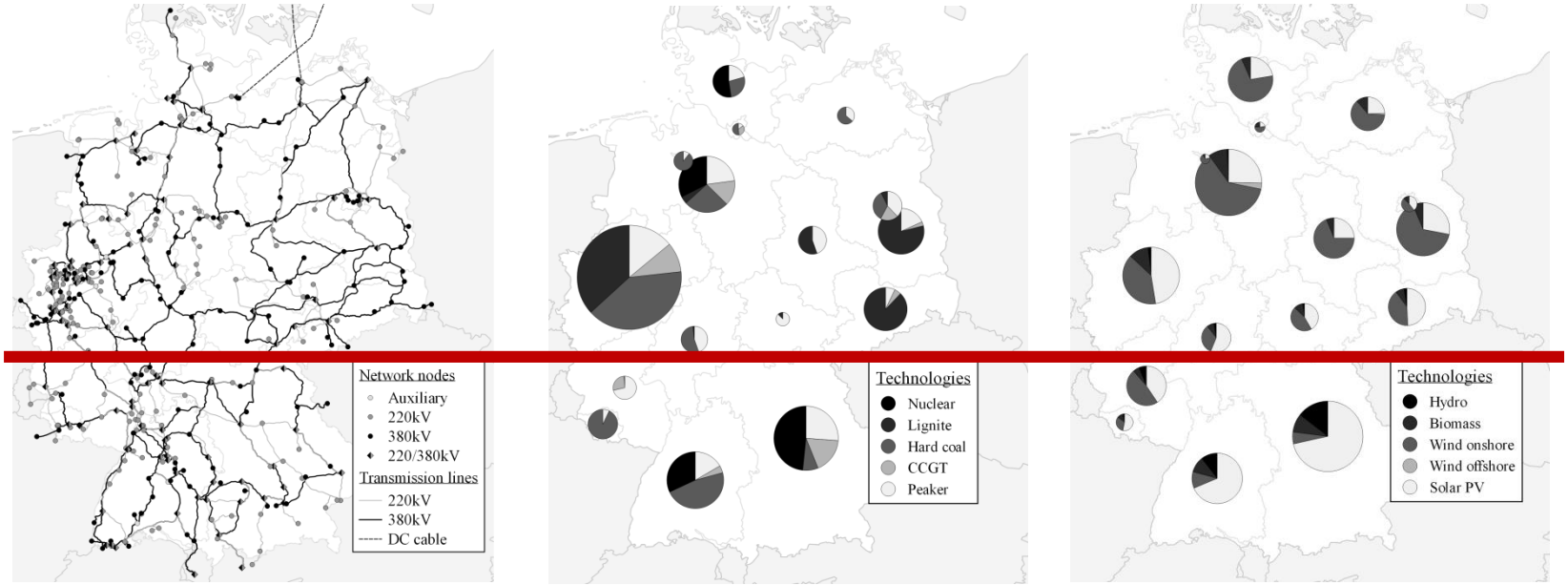
- Capacity aggregated by node
- Zero marginal generation costs



3 Data and Scenarios

Definition of two bidding zones is arbitrary!

- Alternative of defining one high wind zone in the north
- There could be also more than two zones
- Zonal setting in this analysis sets the focus on scarcity in the south



3 Data and Scenarios

Capacities in 2012 and scenario for 2015:

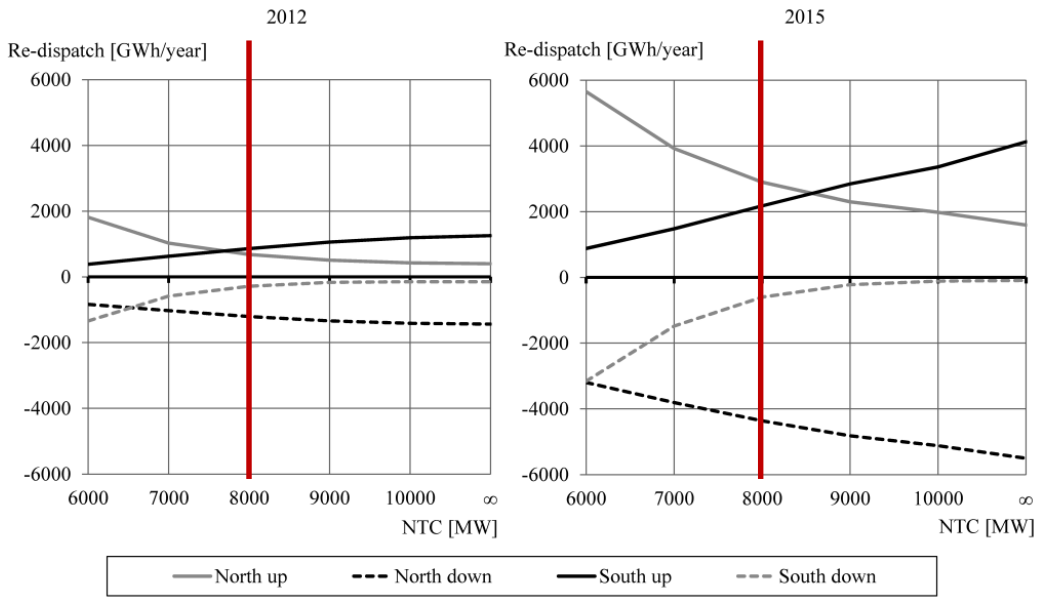
- North: + share of capacity with low variable costs (conventional and RES)
- South: - conventional capacity

[MW]	2012		2015	
Technology	North	South	North	South
Nuclear	4099	7969		-1275
Lignite	20350	–	+580	
Hard coal	17580	7090	+1205	+640
CCGT	5228	3231	+1005	
Gas	8406	3939	-1181	-155
Oil	2145	1687	-206	-1196
Waste	1059	411		
Other	2327	147	-110	
Pumped-hydro storage[13]	3927	4862		
Sum conventional	65121	29336	+1293	-1986
Hydropower	588	3124	+16	+84
Biomass	4326	2052	+355	+168
Solar PV	16800	15551	+4687	+4339
Wind onshore	28520	2964	+5561	+578
Wind offshore	388	–	+2612	
Sum renewable	50622	23691	+13231	+5169
Peak load in zones	54640	31390		

4 Results

Results according to level of „Net Transfer Capacity“ (NTC):

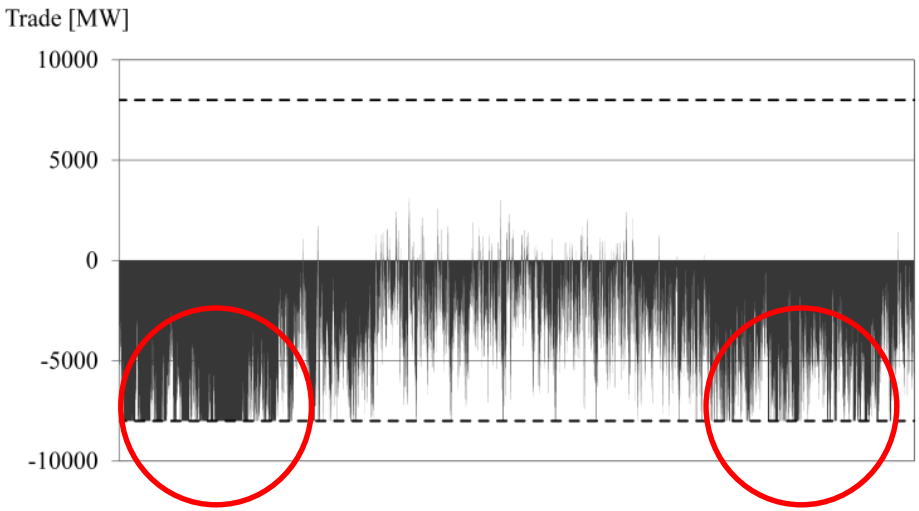
- With lower NTCs increasing intra- and counter-zonal re-dispatch
- Reduction stronger in 2015
- How to choose/calculate the NTC level: lowest overall redispatch at 8GW
- Price zones able to decrease north-south redispatch (35%)



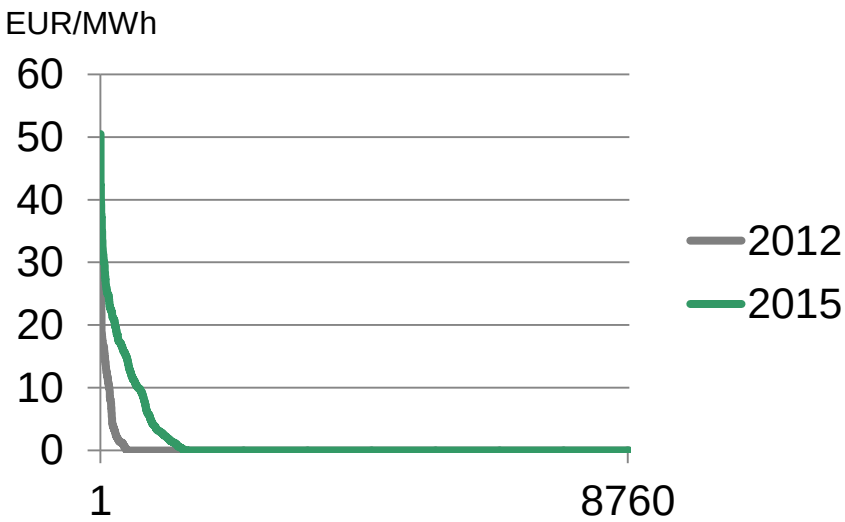
4 Results

Hourly trade flows (2015):

→ 2 TWh from north to south

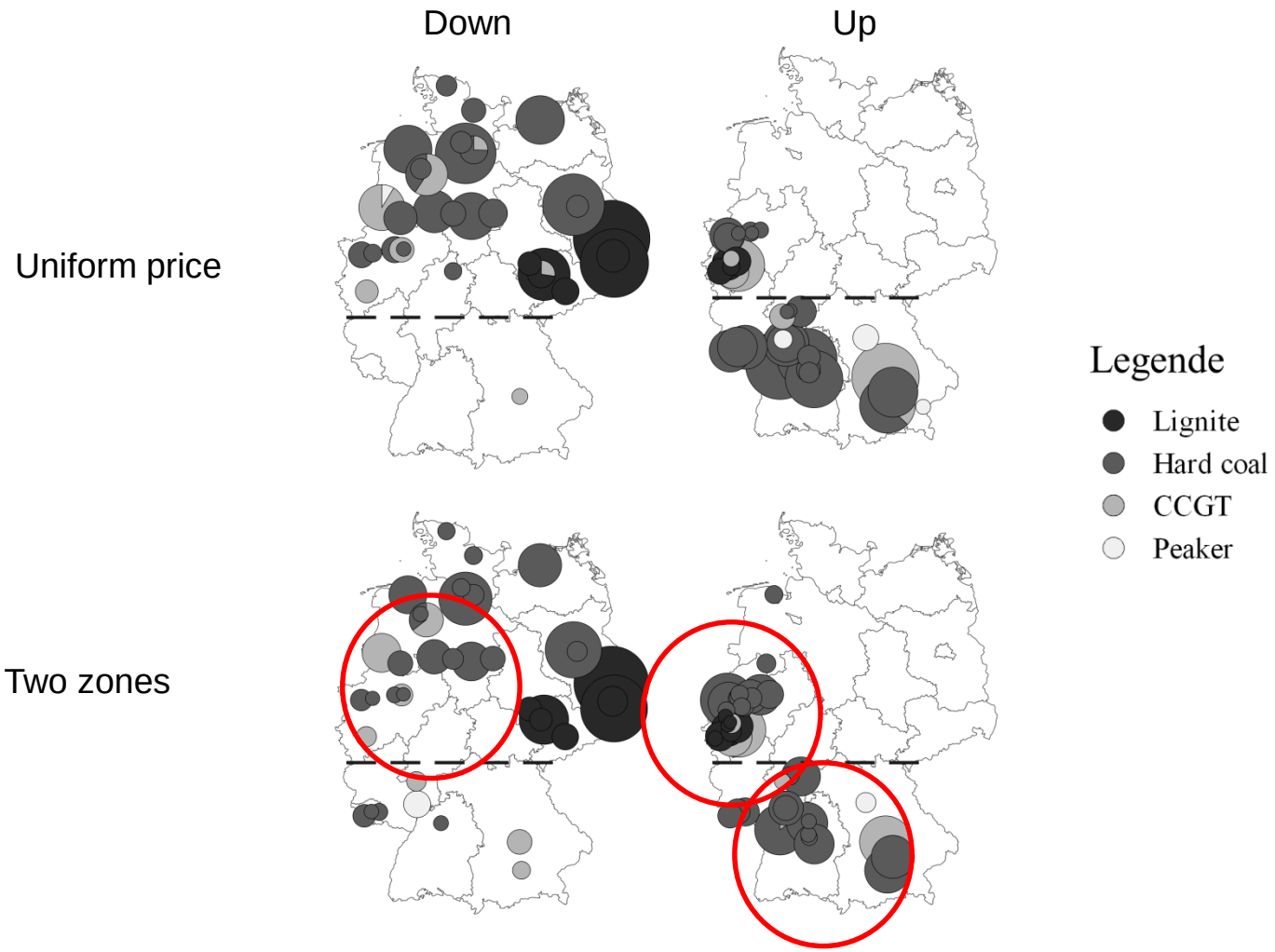


Price differences (south-north)



4 Results

Redispatch by network node and technology (2015):



4 Results

Changes in electricity prices and rents/costs/profits by stakeholder:

[EUR/MWh]		Price	Consumer	Producer				
				Nuclear	Lignite	Coal	Gas	RES
2012	North	-0.10	-0.10	-0.10	-0.10	-0.10	-0.04	-0.18
	South	+0.26	+0.30	+0.29	-	+0.33	+0.28	+0.22
2015	North	-0.46	-0.46	-0.47	-0.45	-0.40	-0.30	-0.72
	South	+1.22	+1.41	+1.40	-	+1.47	+2.20	+1.02

- Consumers in south pay higher than average price markup (correlation load)
- Renewable output highest losses (north) / lowest gains (south)
- Highest gains per MWh for peak generation technologies

[mn EUR per year]		Consumer rents	Producer profits		Costs im-/exports	Congestion rents
			Conventional	Renewables		
2012	North	+35.2	-30.4	-16.2	+2.0	+25.0
	South	-58.4	+36.0	+10.9	-8.3	
2015	North	+163.4	-127.0	-78.9	+8.3	+118.5
	South	-274.6	+149.3	+57.0	-32.7	

5 Conclusion

Prices

- Low average price difference/higher spread in certain hours
- Price increase in south higher than decrease in the north
- Regional signal for dispatch but sufficient for investments?

Rents

- Distributional effects:
  - Generation levels in the southern dispatch (coal 2-4%/gas 3-10%)
  - Stakeholders exposed to redistribution to different extend
  - Generators with high variable costs do better (than RES)
  - Total levels in redistribution: ↑ for lignite, hard coal, and nuclear
  - Collected congestion rent free for allocation (?)

System

- Two zones might be useful for increasing regional imbalance (2015)
- Challenge: Multiple regions with congestions / + network investment
- Question how to define stable bidding zones

Thank You for your attention!

Egerer, J., Weibezahn, J., Hermann, H. (2015): Two Price Zones for the German Electricity Market – Market Implications and Distributional Effects. Berlin, DIW Berlin Discussion Paper 1451

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