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FTR Allocations to Ease Transition to Nodal Pricing: An Application to the German Power System

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Outline

1 Introduction

- Increasingly accepted that nodal pricing is most efficient way of operating a power system
- Major obstacle: implied distributional impacts from a change from uniform to nodal prices
- Generators in low-price and loads in higher-price zones might lose out with new pricing system
- A successful element of implementation of nodal pricing has been the parallel allocation of FTRs
- *Initial* allocation of FTRs: highly disputed element of market liberalization processes

1 Introduction

- Initial provision of FTRs boils down to sharing the pie among various market participants
- NYISO: early implementation of an FTR market to deal with “grandfather” contracts
- New Zealand: nodal prices date back to 1989, FTRs were not immediately implemented
- Australia: zonal pricing system developed that has complicated the initial allocation of FTRs
- Europe: lack of nodal prices makes unlikely that revenue-adequacy for FTR allocations is met

1 Introduction

- Develop model to explore how initial free allocation of FTRs (at the time of transition to nodal pricing) is designed
- Three node network: analyze effects of different modalities to allocate FTRs
- Models for uniform pricing, nodal pricing and for optimal allocation of FTRs
- Simplified FTR allocation methods available in practice. We compare across them
- Application to the German power market

2 Optimization Models

- Three optimization models developed
- **First model**: current German electricity market clearing approach with a uniformly priced national spot market, and subsequently congestion management based on curative power plant redispatch
- **Second model**: follows idea of nodal pricing and combines the economic dispatch of power plants and optimal operation of the physical transmission network

2 Optimization Models

- Models differ in the way congestion in the transmission network is handled
- Uniform pricing model uses curative methods, whereas preventive congestion management is applied in the nodal pricing model
- **Third model**: deals with allocation of FTRs to market participants based on results of the uniform and nodal pricing market models
- Feasibility and the revenue adequacy of the FTR allocation are checked out

2 Optimization Models: Uniform Pricing Model

- Market Clearing

$$\min_{G} \sum_{p,t} mc_p G_{p,t}$$

$$\sum_{n} d_{n,t} - \sum_{p} G_{p,t} - \sum_{n} g_{n,t}^{RES} = 0$$

$$0 \leq G_{p,t} \leq g_p^{max}$$

- Congestion Management

$$\min_{G^{UP}, G^{DOWN}, \Delta} \sum_{p,t} mc_p (G_{p,t}^{UP} - G_{p,t}^{DOWN})$$

$$d_{n,t} - \sum_{p \in A(n)} (g_{p,t} + G_{p,t}^{UP} - G_{p,t}^{DOWN}) - g_{n,t}^{RES} - \sum_{nn} b_{n,nn} \Delta_{n,t} = 0$$

$$0 \leq G_{p,t}^{UP} \leq g_p^{max} - g_{p,t}$$

$$0 \leq G_{p,t}^{DOWN} \leq g_{p,t}$$

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

$$\Delta_{n',t} = 0$$

2 Optimization Models: Nodal Pricing Model

$$\min_{G} \sum_{p,t} mc_p \, G_{p,t}$$

$$d_{n,t} - \sum_{p \in A(n)} G_{p,t} - g_{n,t}^{RES} - \sum_{nn} b_{n,nn} \, \Delta_{n,t} = 0$$

$$0 \leq G_{p,t} \leq g_p^{max}$$

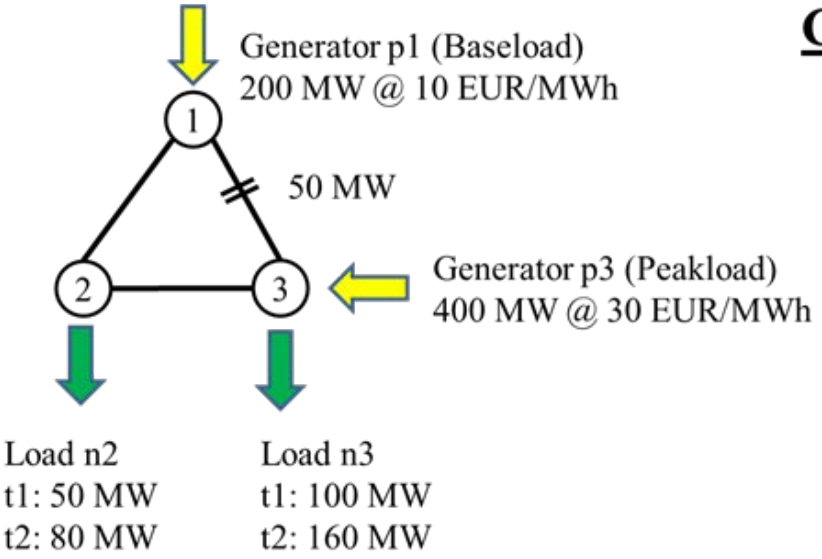
$$\left| \sum_{l} h_{l,n} \Delta_{n,t} \right| \leq p_l^{max}$$

$$\Delta_{n',t} = 0$$

2 Optimization Models: FTR Allocation Approach

- Two approaches for initial allocation FTRs:
  - First approach allocates FTRs to conventional and renewable generators based on historical production
  - Second approach relies on installed generation capacities to determine the amount of FTRs
- On the demand side, FTRs are allocated relative to consumption given the total amount of FTRs allocated to generation
- For both allocation approaches, we explore different levels or amounts of total FTRs

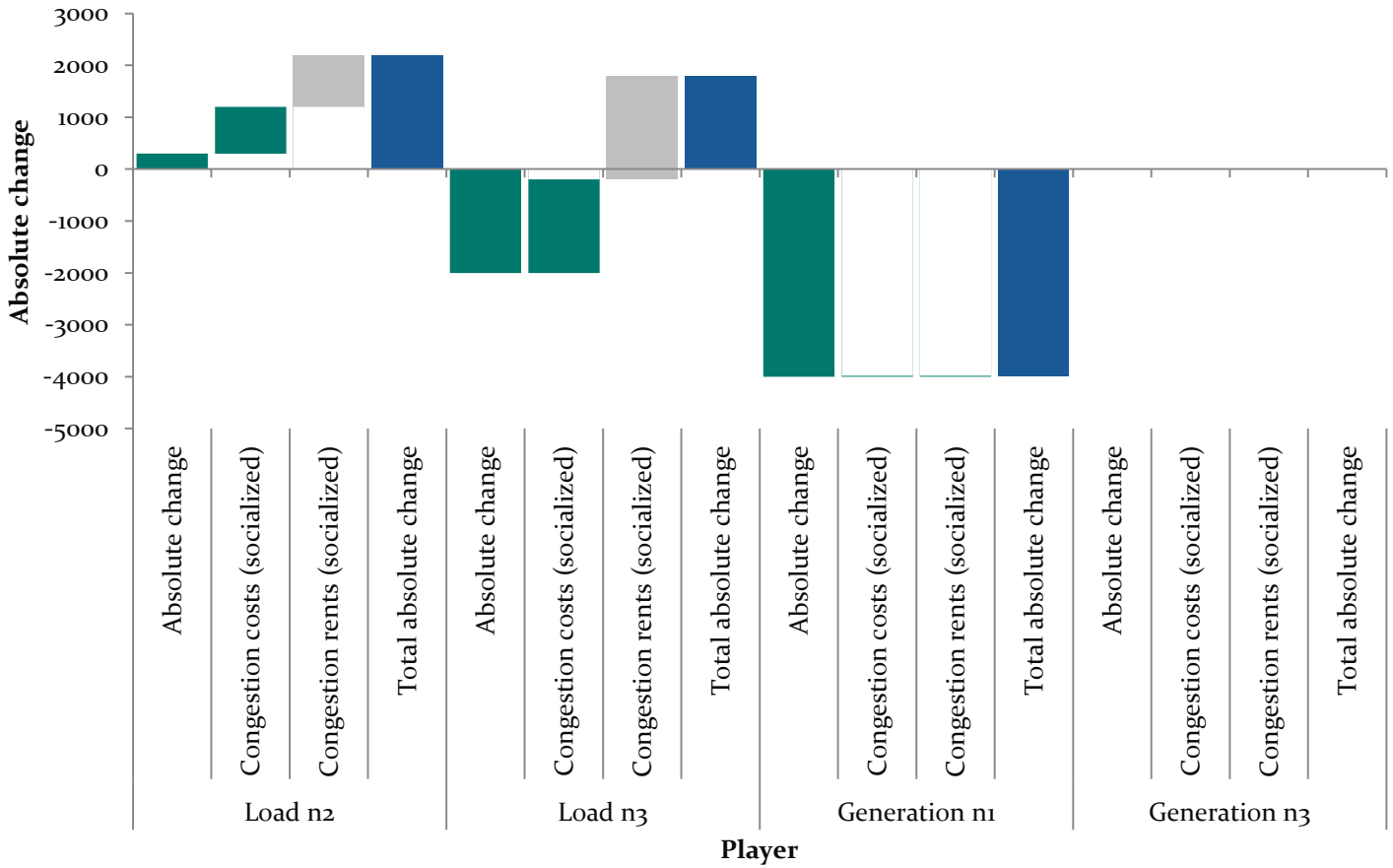
3 FTR Allocation in a Three-Node Network: Setting



Characteristics

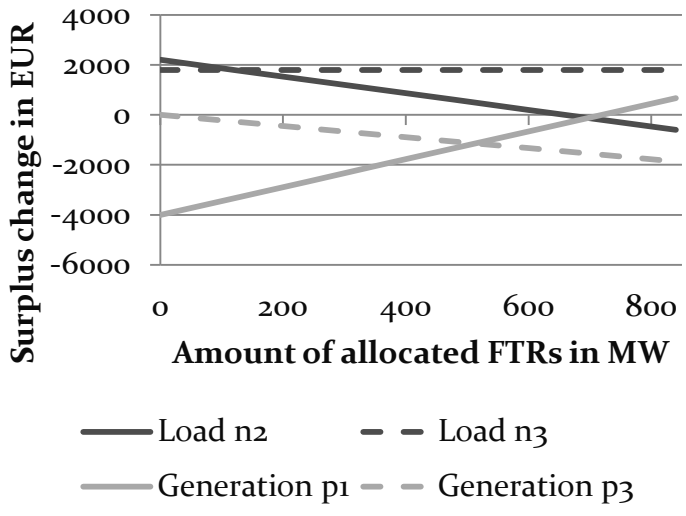
- Time periods: t1, t2
- Generation: p1, p3
- Load: n2, n3
- Equal line characteristics
- Line capacity unlimited except for line n1-n3 = 50 MW

3 FTR Allocation in a Three-Node Network: Surplus Change

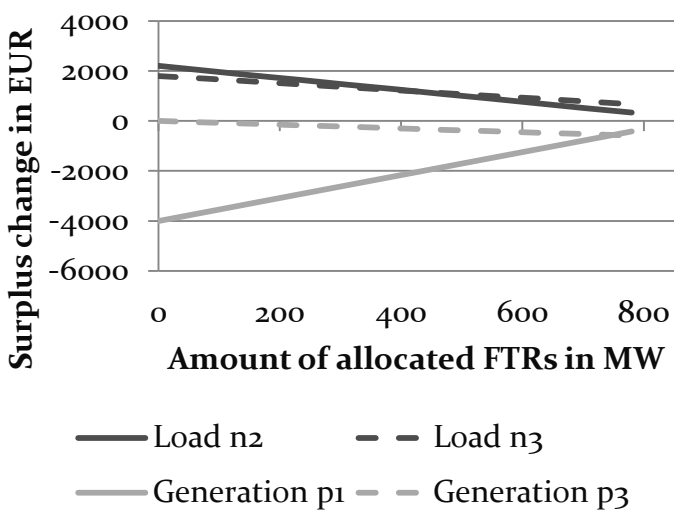


3 FTR Allocation in a Three-Node Network: Surplus Change with FTR Allocation

Capacity-based FTR allocation



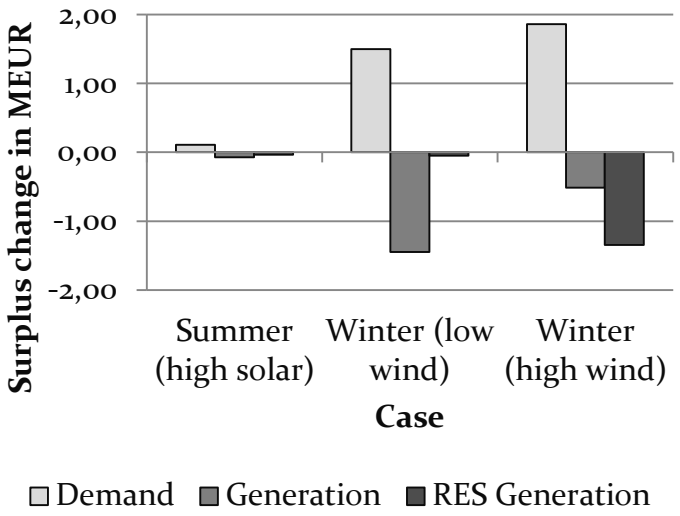
Volume-based FTR allocation



- Both approaches initiate a redistribution of surplus
- Capacity-based approach seems to be less effective as utilization of generation technologies is not taken into account

4 FTR Allocation for the German Power System: Setting

- Detailed representation of the German transmission network, including conventional and renewable generation based Egerer et al. (2014, DIW Data Documentation 72)
- Simulation of three characteristic weeks in 2012
  - Summer week with high solar generation
  - Winter week with low wind generation
  - Winter week with high wind generation



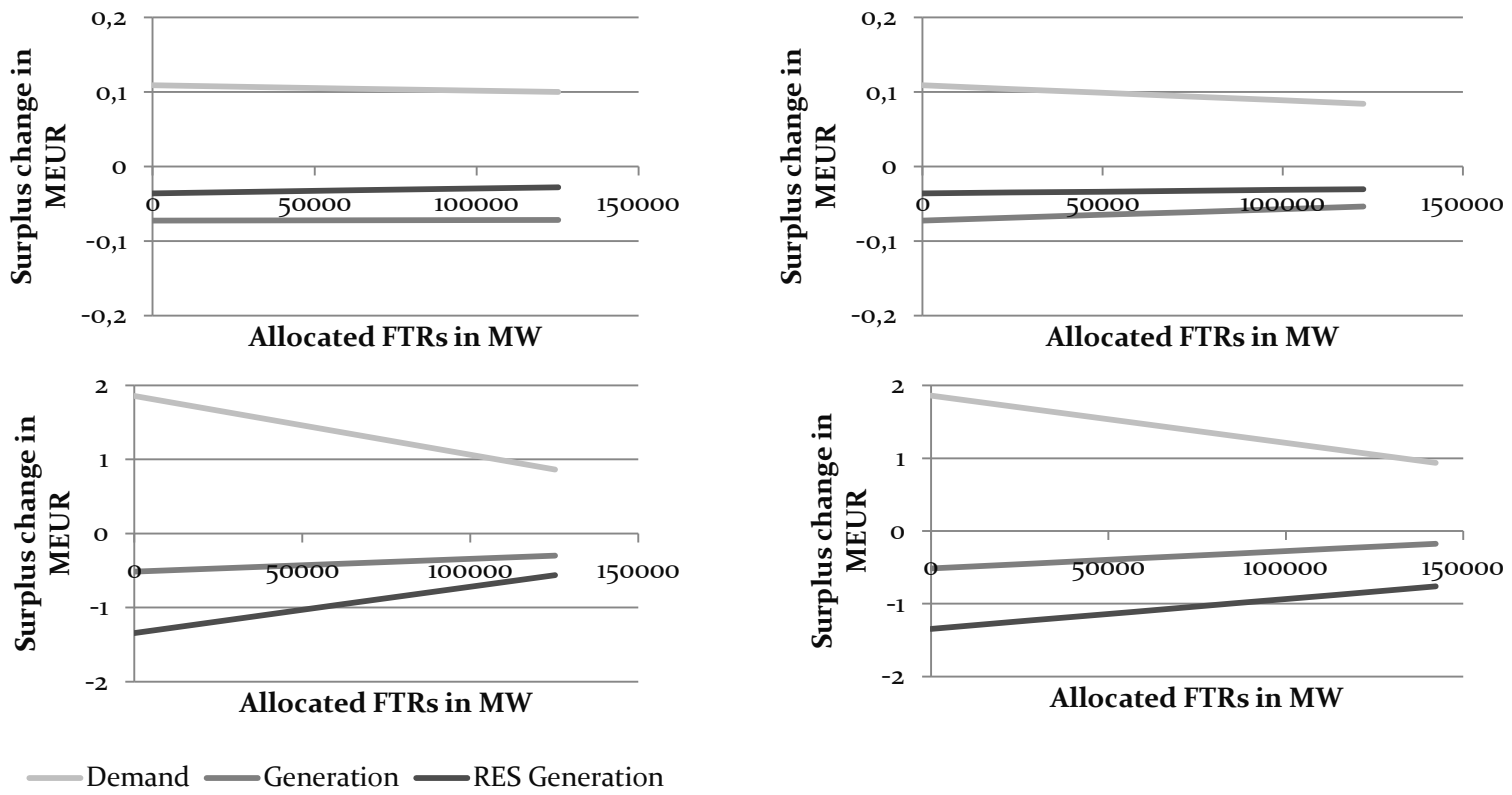
4 FTR Allocation for the German Power System: Change of Surplus

Capacity-based FTR allocation

Volume-based FTR allocation

Summer week

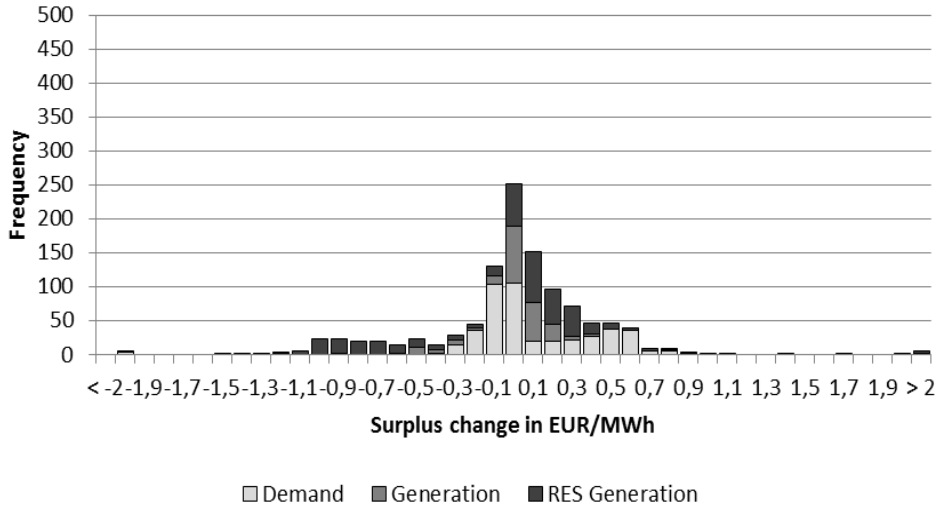
Winter week (high wind)



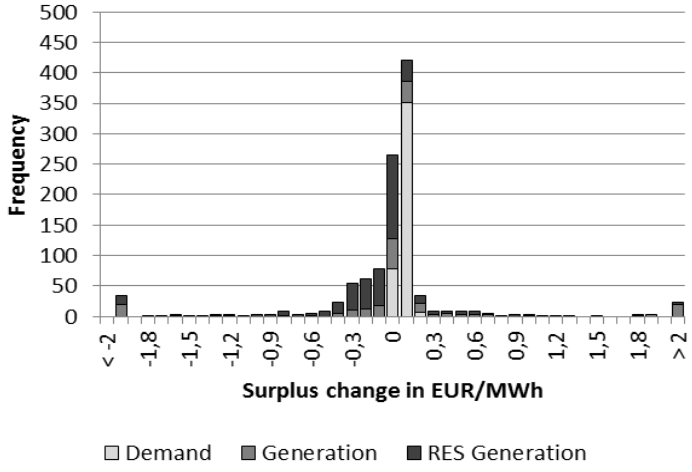
- Volume-based more effective than capacity-based approach

4 FTR Allocation for the German Power System: Surplus change for winter week with high wind

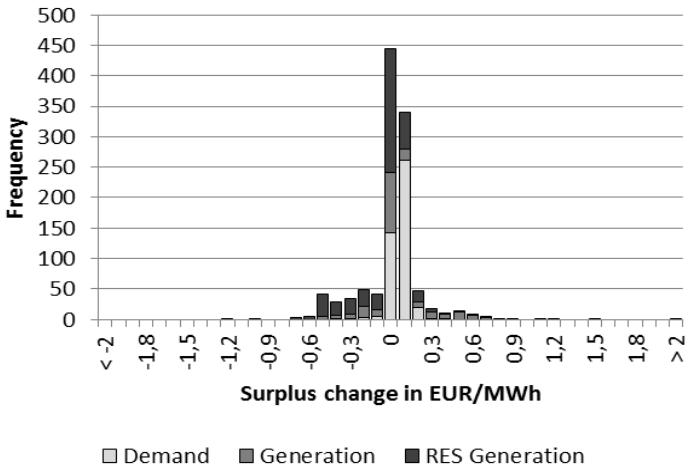
No FTR allocation



Capacity-based FTR allocation

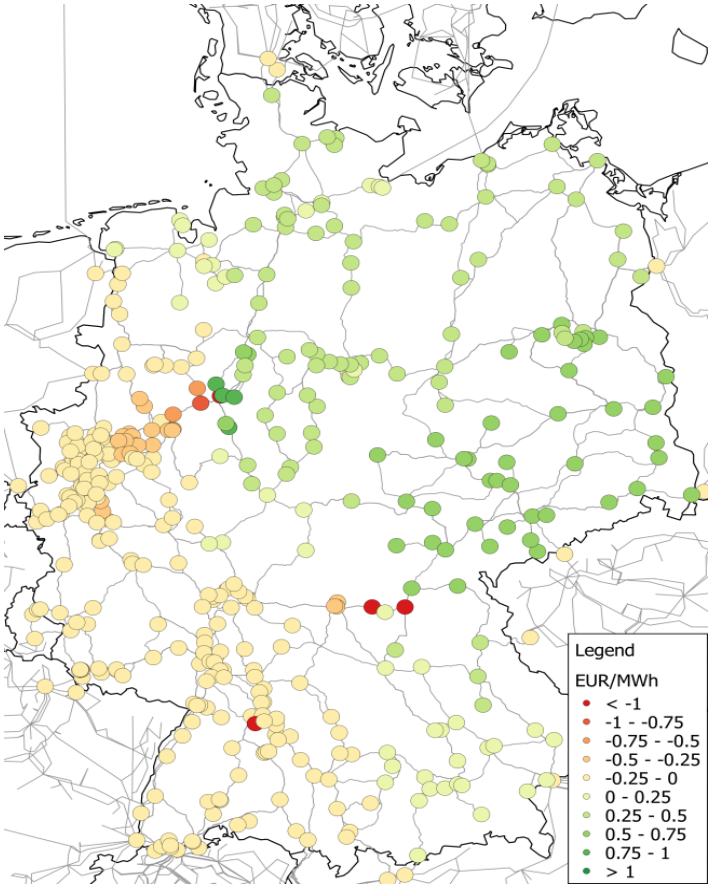


Volume-based FTR allocation

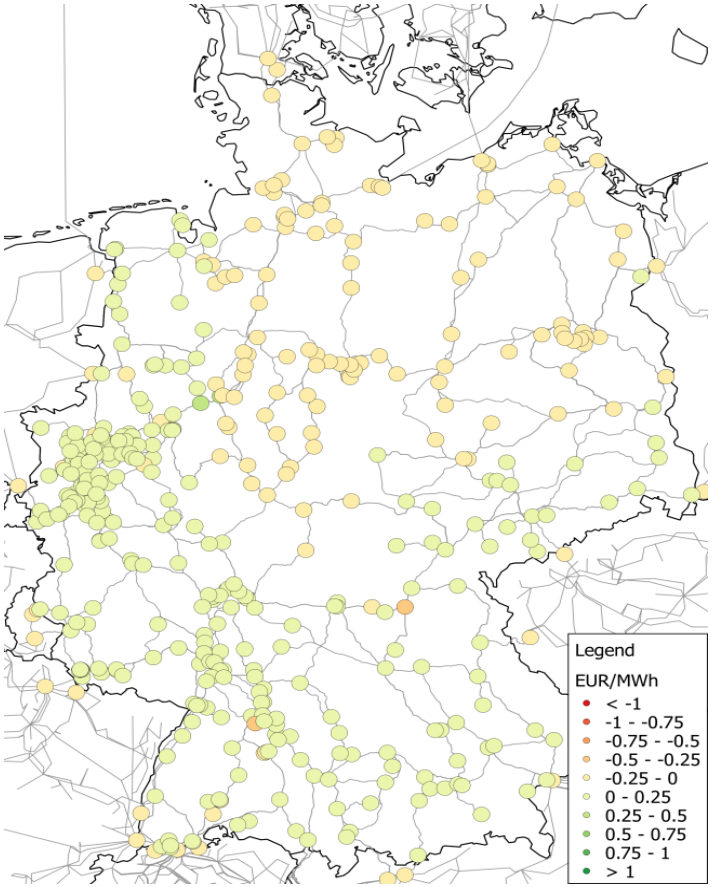


4 FTR Allocation for the German Power System: Regional Change of Consumer Surplus in Volume-based Approach for Winter Week

No FTR allocation



Full FTR allocation



5 Conclusions

- Major challenge for implementation of nodal pricing is the distributional impact of price changes facing generation and load in different locations of the system
- Implementation of nodal pricing accompanied with free allocation of FTRs to market participants to mitigate distributional effects
- In a three node network allocation in proportion to annual production volume allows to better compensate the distributional impact than allocation in proportion to installed capacity

5 Conclusions

- Modeling in the German power system with full nodal representation:
  - FTR allocation can mitigate almost all distributional effects for the demand side, and a large share for conventional generation
  - For intermittent renewables the allocation of FTR obligations can mitigate fewer of the distributional effects
  - This points to the need of more complex FTR designs
- Further assessment of numerical results

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