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A TIME-VARIANT WELFARE ECONOMICS ANALYSIS OF A NODAL PRICING MECHANISM IN GERMANY

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Overview

Nodal pricing has emerged from a theoretical approach to a practicable and efficient tool of transmission pricing. Experiences from North America, Australia as well as the UK and Scotland have proven nodal pricing to be workable without serious technical problems. Continental European electricity grids like the German one are still based on a uniform pricing mechanism. This paper models a nodal pricing mechanism in the German high voltage grid to estimate the impacts on electricity prices, generation and consumption. In particular, the impact of varying wind energy is analyzed since none of the existing nodal pricing markets has comparable wind capacities.

Methods

The model is based on the German high voltage grid consisting of 365 nodes and 530 380kV and 220kV lines. The surrounding UCTE-grid is approximated with 60 auxiliary nodes to allow cross border flows. Each node has a reference demand based on per capita consumption and demand curves are based on load curve figures. Using EEX Spot Market Prices, a linear demand function is approximated to simulate demand behavior. Generation capacities of power plants are located at 130 nodes. Wind capacities are disturbed according to the actual allocation in Germany. To estimate the wind energy input for each hour, wind figures from representative wind stations are used. Load flows are calculated within the DC load flow model. The calculation is carried out for 24 hourly sequences to simulate impacts of changing environmental conditions.

The optimization is based on a social welfare approach. Generation costs are constraint to partial load conditions to model the impact of varying wind input on the fossil plant fleet. Also start-up and shut-down conditions are considered. Optimal demand and supply is therefore based on generation availability and line capacities. This leads to different node prices representing the need to extend the grid or the generation facilities. The calculation is carried out in GAMS.

Results and Conclusions

The paper undertakes three thematic scenarios. First of all the existing uniform pricing mechanism is compared to a nodal pricing approach. Reference summer and winter days are analyzed and welfare, price fluctuation and the line congestion situation are compared. Since nodal pricing is supposed to lead to a more efficient electricity distribution, the welfare in a nodal pricing system will be higher, while on the other hand more line congestion will occur.

In a second approach the impact of wind energy in a nodal pricing system is analyzed. Since nodal prices should react strongly to changing generation conditions the question arises how large wind capacities will influence the system. To estimate this effect, different combinations of wind and demand patterns are compared. In particular:

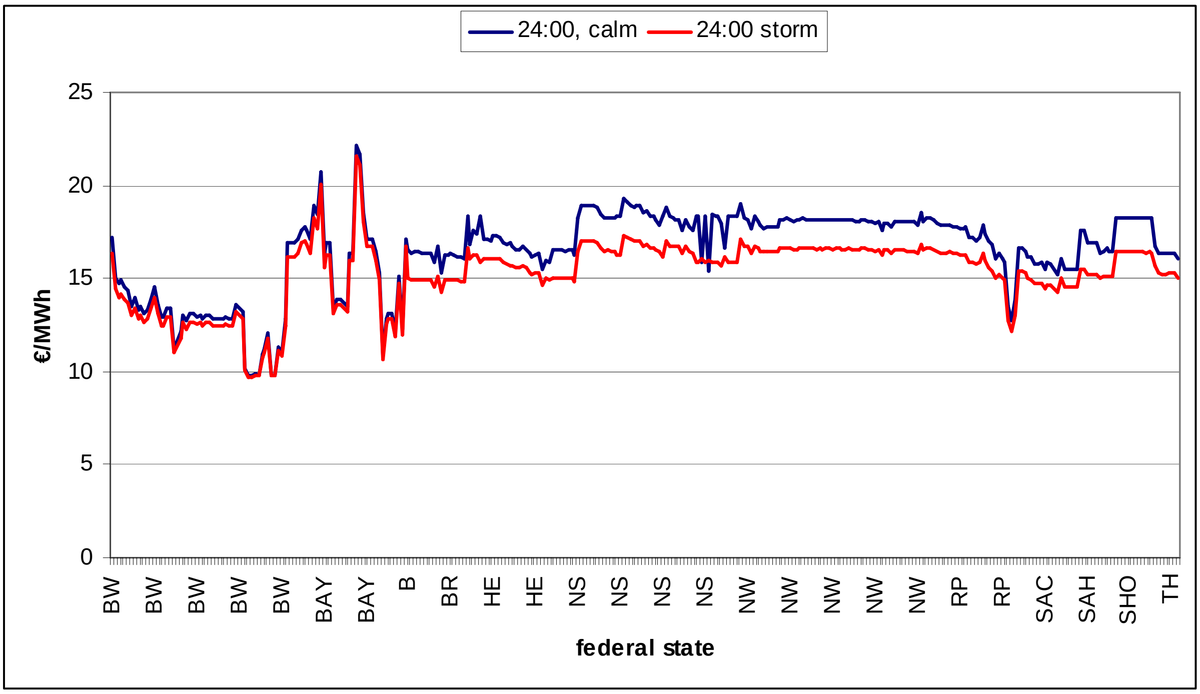

Figure 1 provides preliminary results: price compariosn of low (calm) and high (storm) wind input conditions during the night time

- Low and high wind input in low demand situations like stormy weekend days: The main problem is that in times of low demand high wind input could lead to additional congestion. Since excessive wind energy has to be transported to demand centers while on the other hand large base load plants can not go offline, this may lead to price spikes at certain nodes. First results show that on an average winter day, high wind input during the night time leads to reduced prices in Northern Germany while prices in Southern Germany are nearly uneffected. (see fig. 1)
- Low and high wind input during peak load: The interesting question is how far wind energy can reduce prices in peak load situations. Northern Germany surely will experience lower peak prices but the impact on Southern Germany is not clearly predictable.
- Uprising storm with temporal shut down of wind energy turbines: The final question is how the market will react in cases of storm and the shut down of wind turbines. Based one the obtained wind data, one reference day is calculated in which the wind speed exceeds the allowable range for wind turbines and a temporal shut down will occur. This will mainly affect the coast line while wind input in the inland will still be near a maximum.

In a last analysis, the impact of additional offshore capacities is examined. Based on the exiting grid additional offshore capacities are installed to find weak spots in the grid. Nodal pricing is supposed to display these spots by peak prices. The results are used to estimate necessary grid extensions to implement additional offshore capacities. In a second analysis the extended grid is used to model a future scenario. Beside additional offshore wind the onshore capacities are will increase thus possibly aggravating the congestion situation.

References

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