Till Jeske, Hannes Weigt and Florian Leuthold

WHEN THE WIND BLOWS OVER EUROPE – A SIMULATION ANALYSIS AND THE IMPACT OF GRID EXTENSIONS

Till Jeske: Dresden University of Technology, Dept. of Business and Economics, Chair of Energy Economics and Public Sector Management, D-01062 Dresden, Germany, T: +49-(0)351-463-39764, F: +49-(0)351-463-39763, e-mail: till.jeske@mailbox.tu-dresden.de

Overview

Wind power is the fastest growing renewable energy generation source in the European Union. In the past, wind power generation was decentralized and thus impacts on the grid in terms of congestion problems played only a minor role. However, considering a further expansion of onshore and, more importantly, projected construction of considerable offshore capacities, questions arise which impact growing wind capacities have on the grid and whether the existing grid is still capable of reliably securing energy supply in the integrated network (UCTE grid) of the European Union.

Existing literature show that due to power distribution through the entire UCTE grid according to relative line impedances, North West Europe, namely Benelux countries, was affected by unintended but inevitable cross-border flows congesting the grid. With the intended expansion of off shore wind capacities in the German North Sea this problem is bound to aggravate. Similar developments are expected in Denmark, the Netherlands, and Spain. Based on different scenarios of wind power expansion in the European Union within the next decades, we assess the impact of the integration of additional wind power capacities on the existing UCTE grid in the European Union.

Scientific analysis so far is scarce: DENA (2005) provide an assessment of the impact of wind power expansion to the year 2015 on the German grid, but taking into account the domestic situation only. Leuthold et al. (2005) analyse the impact of a nodal pricing system on electricity flows from wind power within the German grid. Freund et al. (2006) extend the latter analysis beyond the German borders and carry out economic simulations of relevant parts of the UCTE high voltage grid (Denmark, Benelux, France, Austria and Switzerland).

Methodology

Our paper analyses the UCTE grid of the entire European Union (EU25). The physical model is based on a GAMS code. By providing grid topology data (including line transmission capacities and line impedances) as well as demand and supply data, power flows within the grid are determined. Power flow simulation is based on a simplified model of a fixed UCTE grid topology, which includes all lines and nodes, but ignores topology variation through switching. Load flows are calculated according to the DC load flow model (Schweppe et al., 1988, Stigler and Todem, 2005), i.e. neglecting reactive power flows. Reference demand is based on annual power demand per country which is assigned to provinces relative to provincial GDP. Demand curves are defined by reference demand and an assumed demand elasticity of -0.25. Supply is constrained by generating capacities of power plants which charge constant marginal production costs for their energy output.

We model different regulatory systems (uniform pricing, nodal and zonal pricing) as a welfare maximizing approach, assuming perfect markets without exercise of market power by players. In a first step, the feasibility of the model is evaluated by estimating the current grid situation within the UCTE grid. In a second step, the extension of wind capacity in the EU (offshore and onshore) according to accepted forecasts for the years 2010, 2015 and 2020 is simulated. Several scenarios with different grid extension and wind input states are modelled to estimate the impact of the planned extensions. Additional to the analysis of impacts on the grid we analyse economic aspects, e.g. price differences as a result of wind energy generation.

Expected Results

It is expected, that congestion increases with additional wind energy generation capacities. It is also expected, that especially in areas with high wind energy penetration such as Germany, Denmark, Spain and in future Italy, prices will increase significantly under a nodal pricing model.

Conclusion

The necessity of grid extension measures cannot be ignored in the future planning process for the European UCTE-grid. Additional measures such as e.g. demand management and the restructuring of the existing grid-design have to be implemented. The paper draws some policy conclusions regarding these issues.

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