VALUE OF FLEXIBILITY FOR BALANCING WIND POWER GENERATION

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Overview

The future European electricity markets will include higher shares of intermittent renewables generation (I-RES), which is less predictable in nature, resulting in increasing deviations between predicted and realized electricity production. This will increase the need for balancing wind in real time. In addition, a considerable amount of back up capacity is needed for those periods in which renewables production is low. System operators are already calling for flexibility from conventional generation to cope with the uncertainty and variability of increasing wind and solar production. Simultaneously, low operating costs and subsidies for renewables are decreasing electricity prices, reducing the income for conventional power production. There is an ongoing debate on the need of capacity mechanisms in Europe to secure sufficient amount of generation capacity with increasing shares of I-RES in future.

Increasing shares of I-RES therefore poses challenges for the performance of the current electricity market and for the business model of conventional generation. However, it may also raise new opportunities in competitive markets where all participants are responsible for balancing their programs. Balancing responsible parties (BRP) will look for flexibility to balance their programs, given differences in their realized wind production compared to their submitted programs. The need to accommodate forecast errors with steeper ramps could create new revenue streams for flexible resources in the form of flexibility markets or bilateral contracts with BRPs. In order to investigate the potential of these new market opportunities and business cases of different flexibility options, we address how demand and value of flexibility for balancing wind will develop in the future with significant increases in wind generation and forecast errors.

For the analysis of flexibility, we extended the European electricity market model COMPETES[1][1] with a unit commitment formulation. A unit commitment formulation accounts for the flexibility capabilities of different technologies and the lumpiness in generator start-up decisions, a feature not considered in most continent-wide electricity market models. By using COMPETES, we simulate the expected future developments on the electricity market in the Netherlands and the rest of Europe for the years 2017 and 2023 based on the Energy Agreement [2] and Scenario A of ENTSO-E [3], where I-RES generation increases substantially in the Northwest European countries.

Methods

For this study, we developed unit commitment formulation of COMPETES. Flexibility capabilities of resources are implemented in the model via constraints for ramping, minimum up and down times, and provision of balancing power. Lumpiness in generator start-up decisions, start-up and minimum load costs are also taken into account. The incorporation of start-up and shut-down costs and ramping rates allows for the analysis of price volatility and flexibility requirements to accommodate the variability and forecast errors of wind. The long-term planning decisions in the form of adequate generation capacity and cross-border import capacity is part of the scenario and thus exogenous to the model.

In the analysis for flexibility, we make a distinction between the variability from wind energy based on the expected wind power generation on the day ahead market and the increasing demand for balancing on the balancing markets because of the forecast error of wind power generation. The model is utilized in two steps. First, the unit commitment model for the entire EU market simulates the day-ahead market in Europe with *predictions* of intermittent generation at an hourly resolution for each day of the year. This results in a schedule of imports between countries and the commitment of slow generating units. Second, by fixing the day ahead import/export schedules to/from the Netherlands, we in particular simulate the balancing market in the Netherlands with *actual*

[1] COMPETES is developed by ECN in corporation with B.F. Hobbs, who is a professor with the Department of Geography and Environmental Engineering of the Johns Hopkins University, Baltimore, USA. COMPETES includes 27 EU countries, Norway, Switzerland, and Balkan countries. Every country is represented by a single node, except Luxembourg which is included in Germany, and Denmark that is split in two nodes due to its participation in two nonsynchronous networks.

wind power generation by dispatching the Netherlands generation against realised net load, subject to the fixed slow generator commitment and net imports from day-ahead market. The generation and price differences between the day-ahead and the balancing markets are used to calculate the demand and value of flexibility for wind generators to accommodate their forecast errors.

Results

With increasing levels of IRES generation, the total demand for flexibility on the day-ahead market[2] in the Netherlands increase by 46% in 2023 compared to 2012. While the total demand for flexibility in 2012 is fully supplied by domestic generation in the Netherlands, interconnection capacity is becoming more important in future years since net imports are contributing to the supply of flexibility. Developments that are likely to increase the importance of interconnection capacity for flexibility are the increasing scarcity of generation capacity, stronger links between the Netherlands and surrounding countries, and the increasing variability due to wind, not only in the Netherlands, but in the whole of Europe. From the supply-side, especially Gas CCGT units are becoming important to accommodate wind variability on the future day-ahead market.

Increase in wind power generation also increases demand for flexibility on the balancing market[3] in order to accommodate wind forecast errors (see Table 1). Flexibility to balance wind forecast errors is mainly supplied by gas units (i.e., CCGT and gas turbines), which are the most flexible units available to supply flexibility in our scenarios. Some flexibility is supplied by new coal fired power plants that are more flexible than the old coal units. Given a national Dutch balancing scheme where cross-border capacity do not contribute in real time balancing, part of demand for flexibility in 2023 cannot be met by domestic production, resulting in significant demand curtailment. This can be seen as potential demand for new flexibility providers such as demand response and storage. In case of fully integrated real-time balancing markets, part of this demand might also be provided by redispatch via import/exports..

Table 1 Demand for flexibility to accommodate forcast errors on the Dutch balancing market

GWh	2012	2017	2023
Curtailment			2231
Demand for flexibility ramp up	1191	2288	4275
Demand for flexibility ramp down	-734	-1383	-3991

To calculate the value of flexibility, we assume that both upward and downward supplied flexibility for balancing forecast errors are compansated at the actual market price of the specific hour in which the flexibility is supplied. On such a balancing scheme, the net revenues of existing and new generators on the balancing market, especially for Gas CCGT and gas turbines, increase by an order of magnitute in 2023 compared to 2012, improving the business cases for these generators. In addition to the increase in the volume of demand for flexibility, there is also an increase in price volatility on the day-ahead and balancing markets, indicating better business cases for investments in storage and demand side management.

Conclusions

Higher shares of wind power generation does not only increase the need for flexibility to accommodate wind variability, it also leads to an increased demand for flexibility to accommodate wind forecast errors. We assume that BRPs having responsibility for wind production need to compensate these forecast errors. This results in significant increase in revenues for flexible generators (i.e., GAS CCGT and GTs) providing flexibility for real time balancing. Hence, investment incentives for flexible generation capacity are likely to increase in future with higher I-RES shares.

References

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[3] ENTSO-E (2013): Scenario Outlook and Adequacy Forecast 2013-2030, Available at https://www.entsoe.eu/about-entso-e/system-development/system-adequacy-and-market-modeling/soaf-2013-2030/

[2] Demand for flexibility in day-ahead is defined as the sum of the change in generation from one hour to the next over a year plus the total curtailment of demand in a year.

[3] The generation difference between day-ahead and the balancing markets indicate the demand for flexibility to accommodate wind forecast errors.