NEGATIVE ELECTRICITY PRICES IN CENTRAL-WESTERN EUROPE: MARKET DISTORTION OR INCENTIVE FOR FLEXIBILITY

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Overview

Recent observations show that European electricity market prices turn negative when high shares of inflexible generation hit a low demand. The increasing share of Renewable Energy Sources for Electricity (RES-E), such as wind and solar Photovoltaic power (PV), is an important driver due to the variability of its energy source. This issue is referred to as the "incompressibility of power systems" and is recently observed in Central Western European electricity markets such as Germany, France and Belgium, with hours showing negative electricity prices on *day-ahead*, *intra-day* and *real-time markets*. Economic theory imposes that a low demand together with a large supply at nearly-zero marginal cost results in lower market prices. However, events with negative prices are less straightforward as these price levels translate into generating units which are willing to pay for the consumption of electric energy.

Methods

In first instance, economic theory together with the current market design is used to explain the occurrence of negative prices. A graphical representation of demand and supply is given, and it is shown how high shares of renewable energy, and technical constraints of the power system, result in negative prices. Furthermore, it is discussed how the current market design substantially impacts the occurrence of negative prices. A clear distinction is kept between the day-ahead, intra-day and real-time balancing market.

In second instance, a data analysis of Central Western European electricity prices (BE, FR, DE) is conducted. The frequency, and level of negative price is analyzed, comparing the results over different markets and countries. The results are thereafter linked to market design in place, showing how the market design interacts with the occurrence of negative prices. The collected time series of electricity is used to build an illustrative example of the impact of negative prices on a potential provider of flexibility, in this case a wind power plant. The wind farm is modeled to react on market prices, showing the revenues which can be obtained under different market designs.

Results

The results of the data analysis show how negative prices occur on Belgian, German and French wholesale markets in periods with low expected demand, and high renewable production. It is also shown that there is a high simultaneity in the different countries. On the other hand, results show that negative prices occur more frequently on the balancing market, when facing large positive forecast errors during low demand periods. However, it is found that negative prices in the balancing market are strongly dependent on national balancing market design.

Results for the wind farm model reacting on power prices under different market designs will show the revenues originating from electricity sales and production support mechanism. This allows to quantify the benefits of different market designs for the wind farm operator, as well to trace back the revenue stream to the stakeholders, i.e. the conventional power plants, and the electricity consumer.

Conclusions

The variability of renewable energy translates into volatile market prices as well as negative prices during periods where high renewable injections hit a low demand. In the day-ahead market, this is driven by expected injections, while in real-time markets, this is driven by unexpected injections due to prediction errors. There are three major reasons why one can end up with negative prices on these markets.

First of all, high production subsidies result in a distorted price responsiveness of RES-E technologies, i.e. renewable generating units are willing to pay to inject power. Furthermore, a large part of the RES-E currently connected to the distribution system lacks control capabilities and right market incentives to react upon negative market prices. Therefore, measures are needed to improve the active market participation of renewable generation and achieve a cost-efficiency and reliable operation of the system.

Second, the negative prices result from the limited flexibility of the conventional power plants. This may result from technological limitations such as start-up, shut-down and output ramping constraints. Negative prices induce flexibility on the short- and long-term by means of incentivizing the output control of must-run conventional generation sources, e.g. nuclear power, or the reduction of minimum run levels of power plants, e.g. CCGT.

Furthermore, these negative prices may facilitate the implementation of new sources of flexibility such as demand-response or storage technologies.

Finally, negative prices occur from must-run conditions of conventional power plants in order to meet system security standards. A major challenge is the increasing need of reserve capacity to balance the prediction errors of RES-E. It is therefore important to counter this need with improving forecast tools, or optimal sizing and allocation methodologies. Furthermore, it should be investigated how an increasing share of the reserve services can be provided with alternative technologies such as storage, demand response, or RES.

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