Wind up with continuous intraday electricity markets? The integration of large-share wind power generation in Denmark

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Executive Summary

In some European countries, electricity trading can be realized through several sequential markets, where a typical electricity generator can choose freely between two ways of functioning: he can sell its production one day before the day of operation (i.e. in a day-ahead market) and/or he can continue to trade close to the time of physical delivery after the closure of day-ahead markets (i.e. in an intraday market). Therefore, given the fact that wind power is intermittent and poorly predictable, it has been suggested that the use of intraday trading is especially important for wind generators, as it provides the possibility to modify their day-ahead production schedules taking into account updated and improved forecasts close to real time. Although intraday markets are regarded as an important tool to handle intermittent wind, and to stimulate its integration into the electricity system, low liquidity has been observed across several European intraday markets, and this has been recognized as a signal for the ineffectiveness of the intraday scheme. Among a very limited number of works on intraday electricity markets, none of them have tested the causal relationships between forecast errors and intraday market elements. Motivated by this context, we depart from

the liquidity criterion and suggest instead an innovative idea to examine the functionality of an intraday electricity market by testing for causality among its fundamentals. Accordingly, an intraday market can be considered effective if causality between price signals and market fundamentals can be established. Towards this end, we aim at: first, explaining how intraday prices deviate from day-ahead prices; second, investigating the fundamental drivers that cause this deviation; and third, showing how wind forecast errors are dissolved in the system.

Using Danish data, we explore causal links and interactions among the price differences between the intraday and day-ahead markets, and the deviations or forecast errors in wind and conventional generations, and in total consumption from their committed day-ahead amounts, as well as the cross-border electricity trades in the Nordic electricity market. Time series techniques are applied to these data for two different trading zones in Denmark, namely Denmark West and Denmark East. First, we test for unit root in the series, and our results suggest that all series are stationary. Then, Granger causality tests are conducted after the estimation of a Vector Autoregressive (VAR) model. Finally, based on the estimation results of this model, we provide impulse response functions in order to analyze the persistence and duration of the price and quantity divergences resulted from a shock in one of the variables.

The principal findings of this paper are as follows. The wind and conventional generation forecast errors are the fundamental factors that drive the intraday price apart from the day-ahead price both in Denmark West and East, and that the relative intraday price decreases with the level of wind forecast errors. The wind forecast errors are absorbed by joint responses from the cross-border intraday power exchanges and adjustments of conventional generation and consumption. Through simulations of impulse response functions, the results also indicate some zonal differences concerning

causality from wind forecast errors to price differences, and the response paths of market fundamentals. Concerning the persistence of the impact of wind forecast errors on the intraday market, the departed price signals tend to fade away after 12 hours in DK1 and DK2, implying that despite generators' continuous adjustments using improved prognoses on real wind generation, the intraday adjustment resulted from a shock does not disappear quickly.

All in all, this paper provides the first evidence on the effective functioning of the intraday market in the case of Denmark, in which intermittent production deviations are explicitly reduced by intraday transactions, and in addition, wind forecast errors are jointly handled through the responses from consumption, conventional generation, and intraday cross-border trade. Meanwhile acknowledging that this work focuses mainly on the practicality of an intraday market, and that it does not lead us to conclude on its optimality, we note that future research would benefit from cost and price comparisons between intraday trading and real-time balancing as well as an investigation on wind generators' strategic behavior.