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The effect of Demand Response and wind generation on electricity investment and operation[1]

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Concerns over climate change have led to an increase in renewable energy usage, particularly in the electricity sector. Given that the output from many renewable sources of energy, such as wind and solar, increases and decreases throughout the course of a day or week, there is a greater requirement for the rest of the electricity system to behave flexibly as renewable energy increases. Traditionally, electricity demand was considered fixed and power generation units, such as coal, gas and oil units, varied their supply to match supply and demand in realtime. However in recent years, there has been a new focus on the potential for electricity demand itself to become flexible or responsive by means of households and businesses increasing their electricity usage at times of high availability, and decreasing their usage at times of low availability.

Electricity generators generally sell the electricity they expect to produce the day before they produce it; in other words they sell their electricity "day ahead" in a day ahead market. On the actual day, if their electricity output is less than they expected, they buy the difference from a reserve market. Similarly, if they produce more electricity than they expected, they sell the surplus in the reserve market. This ensures that demand and supply are balanced in realtime. Currently, some electricity markets allow demand response to participate in day ahead markets, but very few allow demand response to participate in reserve markets.

This research examines the impact of demand response participation in both energy and reserve markets simultaneously, under high levels of wind generation, by simulating a competitive electricity market at hourly resolution. The demand response potential considered in the research is based on the potential flexibility from electricity demand for hot water. The electricity required to heat the water is considered flexible (with the caveat that the water must remain hot enough to meet the end user's requirements) and is based on real electricity usage for water heating in Irish homes. The total electricity demand and the wind generation

[1] This Bulletin summaries the findings from: Devine, M., Nolan, S., Lynch, M.A. and O'Malley, M., "The effect of Demand Response and wind generation on electricity investment and operation", *Sustainable Energy, Grids and Networks*, Available online: https://doi.org/10.1016/j.segan.2019.100190

considered are also based on the Irish system. The research considers whether demand response has an impact both on how many of each type of conventional electricity generation units are built and how they are operated. The market simulation considers the actions of several competing electricity firms, who attempt to maximise their profits, which are determined by the revenues they earn from selling electricity to the market and the costs they incur when generating the electricity.

The results find that demand response decreases the final costs to electricity consumers, and that this effect is stronger as wind generation increases. In this sense wind and demand response can be seen as complementary. The savings come about primarily by reducing electricity prices in the day ahead market, but also by decreasing the amount of electricity generation units that are built on the system. There is no significant decrease seen in reserve market prices in general, although the specific case of high levels of wind and a high requirement for reserve does see demand response having an impact on reserve prices.

Even though electricity consumers see their bills reducing as a result of demand response, there is no corresponding decrease in generator profits. This is because the generation companies save money by having a lower generation investment requirement. Thus, electricity consumers are better off while electricity producers are no worse off, which means that there is an overall improvement for electricity market participants as a result of demand response.

Demand response also reduces the variability of electricity prices, by reducing price spikes and increasing off-peak prices. This reduction in electricity price variance is good for both consumers and producers. The operator of the demand response resource also benefits from participation in the electricity market. As wind generation increases, the demand response resource has increased opportunity to participate in the market, but the wind itself reduces electricity prices. These two effects cancel out, which means the incentive for demand response to participate in the electricity market is constant under different levels of wind generation.

Our paper suggests that there is potential for demand response to play an increased role in electricity markets. The benefits of demand response depend on the level of wind generation on the system.

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