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The impacts of demand response participation in capacity markets[1]

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BACKGROUND AND MOTIVATION

Electricity demand varies over the course of a day or a year, with very high levels of electricity demand being seen for only a few hours per year. However, there must be sufficient electricity generation installed on the system to meet the total demand at these few hours per year, in order to avoid blackouts or brownouts, where electricity supply is disconnected for all or some customers, respectively. As electricity generation from variable renewable sources, such as wind and solar, increases, electricity market revenues decrease, which renders conventional generators less profitable. In order to ensure that there is sufficient conventional generation available to meet demand at the hours of highest demand per year, a separate market payment is made to generators, called a capacity payment.

The objective of capacity payments is to ensure there is sufficient generation capacity available to maintain a supply-demand balance at all times. Traditionally, the supply side adjusted to meet the demand. However, in modern electricity markets, the demand side itself is increasingly adjusting to market conditions to ensure a supply-demand balance. For example, industrial electricity consumers might curtail their operations when energy demand and prices are high, and might increase their operation when renewable generation is abundant, demand is low and prices are low. For smaller commercial and domestic consumers, a demand side aggregator often contracts with many end users and then manages their aggregated demand and participates in electricity markets in a manner similar to a conventional generator. This means that the demand side is contributing to system adequacy, and so should arguably be compensated for this through a capacity payment. Establishing the potential for the demand side to contribute to system

[1] This Bulletin summaries the findings from: Lynch, M. Á., Nolan, S., Devine, M. T., and O'Malley, M., "The impacts of demand response participation in capacity markets", *Applied Energy*, Vol. 250, pp. 444-451. Available online: https://doi.org/10.1016/j.apenergy.2019.05.063

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adequacy, and the knock-on implications for the rest of the system, is the focus of this work.

RESULTS AND INSIGHTS

We calculate the extent to which demand response contributes to system adequacy by calculating the reduction in conventional generation capacity that results from flexibility on the demand side. We consider demand flexibility potential from space and water heating, whereby the electricity used for heating can be increased or reduced as necessary as long as the consumer's demand for heat is met. The capacity value of this demand response resource is found to be about a quarter of the total level of flexible demand. In other words, if there is 400MW of flexible demand on the system, that is the equivalent of installing a 100MW generator.

We then simulate an electricity market with and without participation in the capacity market from the demand response resource described above, and compare the market outcomes for both. We find that demand response participation in the capacity market has several effects. There is no reduction in capacity prices at low levels of renewable generation. However, when variable renewable generation reaches high levels (in Ireland, this is primarily wind generation), there is a significant reduction in capacity prices when demand response participates in the capacity market. This is because high wind generation reduces electricity prices, causing capacity prices to rise significantly as firms seek to earn higher capacity revenues to compensate for reduced energy revenues. However, demand response participation in the capacity markets acts as a competitor, reducing the capacity price. This in turn leads to a reduction in consumer costs of between 2% and 7%. The exact reduction in costs varies depending on the particular characteristics of the system. In particular, when there is initial over-capacity on the system (when there is more than enough conventional generation installed to meet peak demand), and when variable renewable generation levels are low, flexible demand reduces consumer costs by only 2%. In contrast, when there is initial under-capacity on the system, and when there is a large amount of renewable generation, the reduction is just over 7%. The interaction between flexible demand and renewable generation play a strong role in driving the results.

The results of this paper suggest that demand response and renewable generation complement each other in an electricity generation portfolio. Flexible demand mitigates some of the challenges of renewable integration, such as depressed electricity prices and reduced generation profits. However, the extent to which demand response reduces consumer costs is very much dependant on the particular characteristics of the system. Furthermore, the capacity contribution of the demand response resource, as measured by the extent to which flexible demand helps maintain a demand-supply balance, is difficult to calculate, but it is far lower than the total amount of flexible demand that was considered here. Specifically, in this particular case, the contribution to system adequacy was 25% of the total amount of flexible demand available. Therefore, market operators should be careful to neither over- nor under-compensate flexible demand from the capacity market. Capacity markets should be designed such that flexible demand can participate in the market, but there should be appropriate penalties in place to ensure that the contribution of demand response to system adequacy is not overstated.

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