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Price vs. risk – the effect of wind generation on modern electricity systems[1]

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Renewable generation, such as wind or solar generation, has expanded rapidly in modern electricity systems. This is due largely to government-mandated targets. These targets are justified under the rationale that renewable generation reduces costs, decreases carbon emissions and mitigates against a dependency on imports of fossil fuels, such as oil, natural gas and coal. However, much of the analysis undertaken regarding the effects of renewable generation on electricity systems is severely limited. This is because the complex interactions of renewable generation with fossil fuel generation is difficult to model, and must take account of fuel prices, electricity demand and the weather, none of which can be known with certainty. Analyses of the effect of renewable generation are therefore often performed for a limited number of scenarios (e.g. a high, medium and low fuel price scenario, or high, medium and low demand). The results are heavily dependent on the inputs chosen and usually do not provide any insight into the impact of extreme events. For example, what would be the impact of an unusually cold winter, leading to high electricity demand, along with low levels of wind generation and high gas prices? Furthermore, models that only run two or three demand or fuel price scenarios cannot provide any information on the likelihood of each of the scenarios and their associated outcomes.

This study addresses this shortcoming in the literature by using a novel computer model of a modern electricity system allowing a wide range of inputs and their corresponding outputs to be examined. In this case, we performed a study based on the Irish electricity market using 5,000 different scenarios for hourly electricity demand, hourly wind generation and annual gas, coal, oil and carbon prices. The analysis was repeated for seven different levels of wind generation, ranging from no wind at all to 6GW of installed wind, which is roughly equal to the installed wind capacity anticipated in Ireland in 2020.

The results show that increased wind generation reduces the average cost of electricity production incurred by electricity generators. The average electricity price paid by consumers does not see a corresponding decrease. However, the costs and prices arising during extreme years, rather than average years, sees a

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decrease in both generator costs and final consumer electricity prices as wind increases.

Increased wind capacity also reduces the variability of both costs and prices. This means that producers are less likely to be faced with very high production costs, and consumers are less likely to be faced with very high electricity prices, as wind generation increases. This effect is actually stronger in relation to consumer prices than to producer costs. Thus, as wind generation increases, producers see a small decrease in the chances of facing unusually high production costs, while consumers see a much greater decrease in the chances of facing unusually high electricity prices.

The results also indicate a break in the link between fuel costs and corresponding electricity prices. With low levels of wind installed (3GW or less), the lowest fuel price years correspond to the lowest electricity price years. With 4GW of wind installed or higher, the lowest prices are not seen in the years with the lowest fuel costs. This weakening of the link between input fuel prices and output electricity prices is undesirable for electricity generation companies, as there is less of a link between their costs and their revenues. However it is desirable for consumers, who are therefore less exposed to unusually high electricity bills when fuel prices are unusually high.

This result is relevant in determining the optimal level of installed wind for producers and consumers, considering not just average outcomes but also extreme outcomes. If we assume that consumers and producers care primarily about their average electricity payments or generation costs respectively, and do not place much store on extreme events, then consumers will opt for low levels of installed wind, while producers would rather high levels of wind. If, however, consumers and producers care very much about extreme events, and would like to minimise their exposure to very high electricity payments or very low profits respectively, this result reverses, and consumers would rather higher levels of installed wind, while producers (incl. thermal generators) would prefer low levels of wind.

There is no optimal level of wind production taking both consumers and producers into account. It is up to policy makers to determine the level of wind generation that best balances the costs faced by producers, the prices faced by consumers, and the level to which both consumers and producers wish to be shielded from extreme events.