Gone with The Wind: Consumer Surplus from Renewable Generation

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Overview

Wind generation in the Midcontinent Independent System Operator's (MISO) foot print is impacting the wholesale market price of electricity. The impact on the market price depends on how market participants change their generation strategy in response to wind. In theory, wind generation might not suppress the price as much if the wind turbines generating electricity are owned by firms that own steam, combustion, or hydrological based resources as well (Acemoglu et al. 2017). This is because these market participants have an incentive to strategically curtail their conventional assets in response to their own wind generation. This allows them to benefit from the lower marginal cost associated with wind generation, but not worry about their wind based assets supressing the market price.

This strategic curtailment of steam and combustion based resources during periods of increased renewable generation has implications for the consumer surplus associated with renewable generation. One argument for supporting renewable generation is the consumer benefits associated with the low marginal cost generation. However, if market participants curtail their steam and combustion resources to exactly offset the increase in renewable generation in each hour, the wholesale price will not decrease as much. To assess how much consumers are benefitting from increased renewable generation, it is necessary to identify how strategic curtailment impacts the market price.

I evaluate if market participants in MISO's wholesale market are strategically curtailing in response to increased renewable generation, and how this impact consumer surplus.

Methods

I use detailed data on MISO's wholesale electricity market from 2014 to 2016 to assess if and how market participants are strategically curtailing their thermal generation in response to increased renewable generation. To do this, I first re-construct the offer curves for every unit within MISO, for every hour, and aggregate this to the market participant level. These offer curves represent the quantity the market participant is willing to produce, ex-ante, for a given market price across all its generation units. These are the supply curves of the market participants.

I evaluate how these hourly, market participant level, offer curves change in response to increased renewable generation. Identification comes from month of year, by hour, owner and price specific **fixed effects**. As a result, I am comparing the quantity offered by a market participant at that given price to the average quantity they offer at that price within the same month-year-hour (e.g. September 4pm, 2014). I also control for other determinants of their offer curve such as temperature, expected congestion, and hourly demand. This identification is similar to Fabra and Reguant (2015). From these regressions, I estimate firm specific curtailment parameters, quantifying the extent to which they are curtailing their steam and combustion offer in response to wind generation

To calculate consumer surplus, I consider how wind generation impacts the equilibrium price as a function of the slope of supply, the slope of demand, and a parameter for firm conduct. With the detailed data on market operations I calculate the expected price change due to renewable generation for every hour. I do this for three different models of firm conduct. One where firms act as price takers, submitting an offer curve equal to marginal cost regardless of their wind generation. Another, where diverse market participants curtail perfectly in response to their own wind generation. And a third, using the curtailment parameters estimated form the observed market participants offer curves.

Results

I find that large market participants, owning both wind turbines and other assets, withhold the steam and gas generation quantity in response to increased renewable generation. For a 1 GWh increase in the quantity of wind generation, I find these diverse market participants each withhold 10 MWh on average. I estimate curtailment rates for every diverse market participant, showing significant heterogeneity in which firms are curtailing. Some firm's do not curtail at all in response to wind generation, while others curtail over 100MWh of their steam and gas generation in response to a 1 GWh increase in wind generation. I also show evidence that these diverse market participants

curtail more in response to their own wind generation than in response to wind generation overall. This is consistent with the theory regarding strategic curtailment.

If firms did not curtail strategically in response to increased renewable generation, total consumer surplus due to renewable generation in MISO from 2014 to 2016 is over 10 billion, or approximately 67 USD per person per year. If firms were to curtail perfectly in line with their incentives, consumer surplus due to renewable generation would be reduce to only 2.7 billion USD, akin to 18 dollars per person per year. Using the curtailment parameter estimates from the observed offer curves, I calculate the change in consumer surplus due to renewable generation over this time is 6.8 billion USD, that is 46 dollars per person per year. This suggest that actual strategic curtailment in MISO reduces total consumer surplus from 2014 to 2016 by 3.2 billion USD.

Conclusions

These results show that it is important to consider how firms might strategically respond to increased renewable generation, as strategic curtailment has the potential to reduce consumer surplus by over 70% in MISO. Current strategic curtailment within MISO reduces the consumer surplus due to increased renewable generation by approximately 20 dollars per person per year.

Overall, this is an important dimension of firm behaviour which market monitors should keep track of. Especially considering the crucial role renewable generation will play in the US electricity grid in the future. If consumer welfare is an objective for the policy maker, they might consider policies that promote wind generation by firms that do not own steam or combustion based resources. Alternatively, the market operator should promote a policy or market mechanism that prevents strategic curtailment by diverse market participants.

References

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Fabra, Natalia and Mar Reguant. 2014. “Pass-through of emissions costs in electricity markets.” The American Economic Review 104 (9):2872–2899.