Renewable Technology Ownership: Theory and Applications

Talat Genc, University of Guelph, Guelph, Ontario, Canada, 1.519.8244120, tgenc@uoguelph.ca]
Stanley Reynolds, University of Arizona, Tucson, Arizona, USA, 1.520. 6218450, reynolds@eller.arizona.edu

Overview

We investigate the market implications of ownership of a new low-cost production technology. We relate our theoretical findings to measuring the impact of renewable energy penetration into electricity markets and examine how the ownership of renewable capacity changes market outcomes (prices, outputs, emissions). As the current public policies infuence the renewable energy ownership, this research provides useful insights for policy makers. We show that ownership of renewable capacity will matter when there is market power in energy market. We apply our findings to the Ontario wholesale electricity market to analyze the impact of different ownership structures for wind capacity expansions. We show that consumers enjoy better air quality under the largest firm's ownership, but at the expense of higher prices. We find that market structure and the shape of generation cost functions are the key drivers explaining the impact of renewable ownership on market outcomes.

Methods

Ownership of renewable capacity will matter when there is market power in the energy market. We explore the role of renewable ownership in the simplest possible model with market power. For simplicity we consider market demand and fringe supply functions for a representative period (e.g., an hour) in the wholesale market. We assume that demand is strictly decreasing, fringe supply is strictly increasing, and cost function is increasing and (weakly) convex. We assume renewable output is equal to renewable capacity times its capacity factor, where capacity factor is defined by average renewable output per unit of capacity. Additionally, we assume that the marginal cost of renewable energy generation is zero. The dominant firm sets price to maximize its profit, taking into account the competitive fringe supply response to its pricing decision.

Results

Proposition 1: An increase in renewable capacity owned by competitive fringe firms has larger price-reducing and output-increasing effects than an identical increase in renewable capacity owned by the dominant firm.

Proposition 2: Marginal profit associated with an increase in renewable capacity is greater for competitive fringe firms than for a dominant firm.

Proposition 2 implies that competitive fringe firms would have a greater incentive to invest in renewables than a dominant firm with market power. Absent regulatory intervention regarding renewable investment, we would expect competitive fringe firms to invest in and own renewables rather than a dominant firm with market power. However, in practice it is common for regulatory policies to be important drivers of renewable investment.

Proposition 3: Welfare increases more if competitive fringe firms invest in renewable capacity than if the dominant firm does.

Application to the Ontario Electricity Market
We aim to quantify the impact of renewable capacity ownership on market performance. For this reason we study the Ontario wholesale electricity market and run several wind ownership scenarios to show how different firm ownerships of new wind farms impact the Ontario market prices and emissions. In particular, we employ a model of Ontario wholesale electricity market in which we construct marginal cost curves using financial data (amount spent on fuel and permit prices) and technical characteristics of generators (heat rates, emission rates), and hourly availability and production capabilities of all generators for each hour of the day in a year. We also estimate the hourly market demand curve.

Several key results emerge from the model simulations. We find that extra wind generation improves efficiency (lower prices and higher consumption) and reduces emissions of all gasses for all firms irrespective of ownership. However, the rates of emissions reductions are nonlinear. That is, the impact of each MWh wind generation has different effects on prices and outputs (and therefore emissions) depending on the wind scenario (level of wind capacity) as well as on the ownership. For instance, when the wind capacity investment doubles the average market price goes down by 1.1% (drops from $49.68 to $49.15) under Brookfield ownership, and falls by almost the same amount under OPG ownership (although equilibrium prices under Brookfield ownership are different than the prices under OPG ownership for every hour).

Conclusions

An important finding of this paper is that the ownership of wind turbines impacts firm and market performance as well as air quality. Even though it is the zero marginal cost technology, the market outcomes under OPG ownership of wind farms are different than those under the Brookfield ownership. It is clear that emissions and market prices nonlinearly decrease in wind generation. However, the amount of emissions is affected not only by who operates the new wind turbines but also how much electricity is produced by the wind generators.

A policy implication of our results is that regulators and policy makers should be careful about allocating green certificates (i.e., the rights to operate green technologies). From the Ontario power market analysis we learn that a) because the market prices are lower, the wholesale electricity buyers benefit if the smaller firm, Brookfield, operates the new wind farms; b) however, because emissions of all gasses are lower for all wind scenarios, society enjoys better air quality under the OPG ownership; c) total emissions (CO2, NOx, S02) reduce in wind generation relative to no wind production, but the rate of change of emissions reductions differ depending on the ownership and the wind generation capabilities; d) the impact of each MWh wind power production has different effect on the emissions. However, in aggregate the wind generation improves the air quality over the course of periods.

References

Baker, E., Fowlie, M., Lemoine, D., and Reynolds, S., (2013) \The Economics of SolarElectricity", Annual Review of Resource Economics, 5: 387-426.

Cullen, J. (2013). \Measuring the Environmental Benefits of Wind-Generated Electricity", American Economic Journal: Economic Policy, 5(4): 107-33.

Demsetz, H., (1983). \The Structure of Ownership and the Theory of the Firm", Journal of Law and Economics, 26(2):375-390.

Denny, E. O'Malley, M., (2006). \Wind generation, power system operation and emissions reduction", IEEE Transactions on Power Systems, 21(1): 341-347.

Genc, T.S. (2016). \Measuring Demand Responses to Wholesale Electricity Prices Using Market Power Indices", Energy Economics, 56: 247-260.

Traber, T. and Kemfert, C., (2011). \Gone with the Wind?: Electricity Market Prices and Incentives to Invest in Thermal Power Plants under Increasing Wind Energy Supply", Energy Economics, 33(2): 249-256.