Renewable Generation Capacity and Wholesale Electricity Price Variance

Erik Paul Johnson[1]*and Matthew E. Oliver*[2]

Executive summary

It is widely accepted that the share of electric power generated from renewable energy sources such as wind and solar PV must increase dramatically in the coming decades if greenhouse gas emissions are to be reduced to sustainable levels. We explore an under-researched implication of such a transition in deregulated electricity markets. Using an instrumental variables identification strategy to control for endogeneity, we find evidence that greater combined wind and solar generation capacity increases wholesale price variance.

We motivate our empirical analysis with intermediate-level microeconomic intuition for why greater wind and solar PV penetration might be expected either to reduce or to increase short-run electricity expenditure risk using a simple supply-demand model of an electricity market with stochastic demand conditions. We identify two countervailing effects. First, the *stochastic merit-order effect* suggests that because renewable energy enters at the base of the total generation supply curve, this shifts the supply curve outward, causing the stochastic demand curve to intersect it at a flatter portion thus reducing the variation in the electricity price. Conversely, we expect that the intermittency of these technologies introduces stochasticity of supply, thereby increasing the variation in electricity prices, given demand. We refer to this as the *intermittency effect* of wind and solar penetration.

We have compiled an unbalanced panel of policy, price, and wind and solar capacity data for 19 countries over the period 2000-2011. We estimate the effect of the share of wind and solar in total generation capacity on the quarterly variance of daily wholesale electricity prices. One complication is that wind and solar generation capacity is likely to be endogenous because greater price risk would likely provide a disincentive to investment; consequently, standard OLS would produce biased coefficient estimates. We therefore utilize an instrumental variables (IV) specification in which the share of wind and solar in total generation capacity is endogenously predicted by a country's policy support for these technologies.

Our IV estimates reveal the effect to be positive and significant—greater wind and solar penetration results in a statistically significant increase in quarterly price variance. This result supports the hypotheses that, within our sample, the intermittency effect dominates the stochastic merit-order effect. Relative to the sample mean standard deviation of around $18 USD/MWh (2010 constant USD), our IV estimates suggest that a one percentage-point increase in the share of wind and solar PV in total generation capacity is associated with an increase in the quarterly standard deviation of wholesale electricity prices of roughly $1 USD/MWh. Several IV diagnostic tests confirm the validity of our IV strategy. Our main result is also robust to a number of different IV specifications.

1 Corresponding author: Dept. of Economics, Carthage College, Kenosha, WI, USA; ejohnson11@carthage.edu

2 School of Economics, Georgia Institute of Technology, Atlanta, GA, USA; matthew.oliver@econ.gatech.edu

Our results suggest a mostly overlooked consequence of greater wind and solar penetration: wholesale electricity prices are more volatile in the short run the greater is wind and solar penetration, thus increasing price risk in competitive electricity markets. This implies electric utility providers must devote more resources to risk management strategies such as hedging and futures trading. The costs of such activity, and of the pure risk itself, must ultimately be borne by electricity consumers by way of higher risk premiums embedded in retail power rates.

As countries around the world seek to increase the shares of various forms of renewable power generation in their overall energy portfolios, it will be of interest to ascertain whether wholesale price variation increases as a result. Our study suggests it will. Such a shift would thus carry latent costs from increased price risk in deregulated electricity markets. A subtler implication is that commercial-scale electricity storage may ultimately be more important than previously thought for wind and solar PV to be harnessed to their full potential. Without storage to ameliorate supply intermittency (and absent costly market interventions designed to boost penetration) the increased price risk resulting from wind and solar PV may ultimately lead to under-investment relative to what would be required to reduce CO2 emissions to sustainable levels.

Keywords: wind power; solar PV; renewable energy generation capacity; electricity price risk; merit order; intermittency.

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