Why wind is not coal:

on the economics of electricity generation

Executive Summary

In several parts of the world, it is cheaper to generate electricity from wind than from conventional power sources such as coal-fired plants, and many observers expect wind turbine prices to continue to fall. It is sometimes believed that this cost advantage alone implies that wind power is profitable (as a private investment option) or efficient (for society). However, this is not the case.

Inferring competitiveness from a cost advantage would only be correct if electricity was a homogenous (undifferentiated) economic good. If that was the case, one megawatt-hour of electricity generated by wind turbines would be a perfect substitute for one MWh of electricity generated by coal plants, and their output could be compared purely on cost. However, electricity prices vary over time, which makes electricity a heterogeneous (differentiated) good.

Consequently, electricity produced by one technology has, in general, a different economic value in terms of $/MWh than electricity produced by another. While power system economics accounts for such differences, metrics and tools that are used in practice for policy advice sometimes ignore them. This is the case for simplistic, yet influential metrics, such as “levelized costs of electricity” (LCOE) and “grid parity”, as well as tools such as large numerical economical models.

LCOE are the discounted lifetime average generation costs per unit of energy ($/MWh). Electricity generation technologies, such as coal-fired power plants and wind turbines, are often compared in terms of LCOE. Many readers interpret a cost advantage as a signal of competitiveness. Such reasoning implicitly assumes that the electricity generated by all plant types has the same economic value, i.e. that it is homogenous. While there is nothing wrong with the cost metric itself, this conclusion is flawed. The same caveat applies to “grid parity”, the point where generation costs drop below the retail electricity price.

Many macroeconomic models also implicitly assume homogeneity. Calibrated macroeconomic multi-sector models such as integrated assessment models and computable general equilibrium models are heavily used for research and policy advice, including energy and climate policy. Simple versions of such models assume the output of different power technologies to be perfect substitutes, which can bias findings.

We show how ignoring these value differences introduces two biases. First, it favors conventional base-load generators relative to peak-load generators, and second, at high penetration rates, it favors variable renewable energy sources, such as wind and solar power, relative to dispatchable generators.

This paper applies standard microeconomic methods to the power sector, and shows how these methods have to be adopted to accommodate the peculiar characteristics of electricity as an economic good. It offers a rigorous and general discussion of heterogeneity, arguing that electricity prices vary not only over time, but also across space, and with respect to lead-time between contract and delivery. This three-dimensional heterogeneity implies that the economic value of electricity generated differs across power plant technologies. In other words, different power plant types produce different economic goods. The paper shows that value differences can be interpreted as system-level costs; a new cost metric, System LCOE, is proposed as the sum of LCOE and system-level costs of a technology which allows for economically meaningful cost comparisons. Finally, the paper applies this theoretical framework to the "variable" generation technologies of wind and solar power. We conclude that the difference between variable and dispatchable generators is quantitative, rather than qualitative. We also conclude, however, that at high market shares, the $/MWh value of wind and solar power is lower than that of any other technology.