COST OF WIND POWER IN SOUTH-WESTERN AUSTRALIA

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Overview

With substantial support from subsidies and mandates, the south-west interconnected electricity supply system (SWIS) in Western Australia, like many electricity networks around the world, has witnessed strong penetration of wind power. The real cost of such power depends not only on the construction and operating costs for wind farms and associated transmission infrastructure but also the costs or benefits of the impacts that wind generation has on the rest of the system.

The costs of traditional thermal-generation technologies are commonly measured using the levelized cost of electricity (LCOE). Two important implicit assumptions underlie such calculations. The first is that electricity produced using one technology is a perfect substitute for electricity produced using a different technology. The second is that the electricity can be produced whenever it is wanted and is not produced when it is not wanted – that is, the capacity is "dispatchable."

The generation of electricity from renewables technologies violate these assumptions in important ways with the result that renewable power imposes costs on the system that are not captured in LCOE estimates. We extend the framework of Hirth (2013) and rehated papers to develop a concept of the "systemic cost" of wind power. Systemic cost adds profile, utilization and variability costs to the traditional LCOE measure. We apply this framework to the SWIS in order to better understand the full cost of wind and solar PV power within the existing electricity network.

Approach

Starting with the LCOE for wind power we use market data to calculate possible profile, utilization, balancing and grid costs associated with the wind generation.

Profile costs typically are measured as the difference between the wind-power-weighted average electricity price and either the (i) time-weighted average electricity price or (ii) system-load-weighted average electricity price. Using the former compares the market value of wind power with that of a dispatchable generator, such as a baseload plant, that has a flat generation profile, whereas the latter compares it with a dispatchable generator that has a generation profile that follows system load. To estimate the profile cost we first estimate the generation-weighted average system price. We then estimate the wind-weighted average price using 30-minute wind generation data. The profile cost is then defined as the difference.

Wind power generators are non-dispatchable, and output from them fluctuates substantially over short periods of time. As a result, they must be fully backed-up by conventional thermal-generating capacity, which then is idle when wind power is being produced. The lower utilization rate for the thermal plants is unlikely to much affect either plant life or required maintenance, and the wind power saves fuel costs (as is reflected in the different LCOE for wind and thermal power). However, wind power raises the cost of capital per unit of generated output from the thermal power plants. The latter effect is called an under-utilization cost that additional wind imposes on the system.

To estimate utilization costs for the SWIS, we first calculate the average hourly amount of wind generation. Next, we calculate what would happen to dispatchable thermal generation if all wind power generation were removed from the network. We then calculate adjusted LCOEs based on these new capacity factors.

The intermittent nature of wind power generation, which is dependent upon stochastic wind speeds that are only partly forecastable, increases the need for balancing power. This imposes additional costs on the system by lessening the amount of power that can be delivered under long-term contract. In contrast to profile costs, which reflect expected variability in wind generation, balancing costs reflect unexpected variability in wind generation between the day-ahead market and the actual real-time system operation. We calculate the balancing costs of wind power in the SWIS by examining to what extent the unexpected variability in wind power generation at the 30-minute frequency affects the balancing market price.

Within the SWIS, high frequency stability is achieved through the load-following ancillary services (LFAS) market. This runs in parallel with the balancing market. Increased unpredictable variability of wind power output also raises the demand for these load-following services. We are using data from the LFAS market to calculate these costs.

The final component, grid costs, arises as wind generation alters the pattern of flow on the network and may change transmission losses and required investments in new transmission capacity. This can only be adequately estimated using a dispatch model of the network.

Preliminary research

We currently have estimated the costs apart from the grid costs. We cannot estimate the final component without a full dispatcg model of the SWIS.

Potential implications

Our intention instead was to provide an approximate lower bound on the system-wide costs using readily available market data. We believe this is a useful alternative to the commonly used LCOE approach to compare generation technologies, but gives a more realistic view of the full costs of the non-disptachable generation. At a more practical level, we believe we are the first to attempt to calculate the systemic cost of wind generation in the SWIS network in Western Australia. Our results should be of relevance to industry players and regulators in the state of Western Australia.

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