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Merit-Order Effects of Day-Ahead Wind Generation Forecast in the Hydro-Rich Pacific Northwest

An assessment of the performance of the day-ahead wind generation forecast published by Bonneville Power Administration in the hydro-rich Pacific Northwest region finds BPA's daytime forecast unbiased, but not the nighttime forecast. Using market-price regressions to estimate the day-ahead merit-order effects of BPA's forecast finds that the merit-order effect estimates do not materially depend on whether the forecast or actual MW are used, as the forecast and actual wind MW data are highly correlated. Finally, the merit-order effect estimates are small, implying small short-term price-related benefits to end users from wind generation development.

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I. Introduction

Two transformative events have taken place in the electricity industry around the turn of the century. The first is the electricity market reforms that have resulted in competitive wholesale markets in various parts of the world (Sioshansi, 2013). In the U.S., electricity trading may occur in the centralized markets operated by

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an independent system operator (ISO) (e.g., ERCOT in Texas) (Zarnikau et al., 2014). These systems have day-ahead and real-time markets based on the concept of locational marginal pricing rooted in Bohn et al. (1984). Wholesale electricity market prices are inherently volatile (Milstein and Tishler, 2012), leading to extensive research on electricity price behavior, derivatives, and risk management (Woo et al., 2015 and references thereof).

Electricity trading in the U.S. also occurs in a bilateral market such as the Mid-Columbia (Mid-C) hub in the Pacific Northwest. The Western Systems Power Pool (WSPP) Agreement defines standard contracts for day-ahead trading at Mid-C and other bilateral markets in the Western Electricity Coordinating Council (WECC) (e.g., the NP15 and SP15 hubs in California and the Palo Verde hub in Arizona). The WSPP's on-peak period is 06:00–22:00, Monday through Saturday, excluding holidays; the off-peak period consists of the remaining hours.

The second transformative event is the development of wind generation in many parts of the world (Alagappan et al., 2011; Barroso et al., 2010; Hoogwijk et al., 2004; Lu et al., 2009). Wind generation displaces thermal generation and reduces wholesale market prices through the merit-order effect (EWEA, 2010), as demonstrated by model simulations (Morales and Conejo, 2011; Traber and Kemfert, 2011) and market-price regression analyses (Gil and Lin, 2013; Ketterer, 2014; Paraschiv et al., 2014; Woo et al., 2011, 2013, 2014). While benefiting end users (Gil and Lin, 2013; Woo et al., 2014), the merit-order effect weakens the investment incentive for new generation that may be necessary for reliable grid operation (Traber and Kemfert, 2011; Woo et al., 2012, 2015).

This article estimates a day-ahead wind generation forecast's merit-order effects, thereby complementing the regression analyses of (Ketterer, 2014; Paraschiv et al., 2014). Our analysis's focus is the Pacific Northwest, chosen because of the region's data availability, active day-ahead bilateral trading, and hydro-dominated generation mix. A detailed description of the region can be found in Woo et al. (2013).

One transformative event is the development of wind generation in many parts of the world.

Our article highlights the thorny issue of data matching in a day-ahead price regression analysis: at the time of day-ahead trading, only the day-ahead forecast, not the actual, wind MW data are available.[1] There are three ways to address this issue. First, one can estimate a real-time price regression because the real-time price data properly match the actual wind MW data (Woo et al., 2011, 2014). Second, one can use published wind forecast MW data, if available, in the day-ahead price regression analysis (Ketterer, 2014; Paraschiv et al., 2014). Finally, if such data are unavailable, one may assume: (a) the forecast and actual wind MW data are highly correlated so that the actual wind MW can proxy the forecast wind MW in the day-ahead price regression's estimation; or (b) the day-ahead trading is done under perfect foresight, which obviates the need for the forecast wind MW data (Woo et al., 2013). At least for the Mid-C hub, neither (a) nor (b) has been formally tested.

Our article aims to assess the performance of the day-ahead wind generation forecast of Bonneville Power Administration (BPA), determine how the day-ahead Mid-C prices vary with BPA's wind generation forecast, and test if the day-ahead Mid-C prices move with BPA's latest forecast performance information available at the time of day-ahead trading. It statistically analyzes a sample of over 1,000 daily observations from the period of 06/01/2012, when BPA first published its day-ahead wind generation forecast, through 03/31/2015, the latest quarter of complete data available at the time of our writing.

The article makes two main contributions. First, to the best of

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