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When ancillary services decrease with more wind in ERCOT

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ABSTRACT

The extant literature predicts that increasing penetration of variable generation resources should have a profound effect on ancillary services for maintaining system frequency and reliability. However, a study of the ERCOT market found that between 2014 and 2017, the procured quantities of ancillary services continuously declined, while annual wind generation output increased by 26 million MWh. This article discusses potential reasons for the phenomenon of declining need for ancillary services and its implications.

1. Introduction

With the prospect of transitioning to a low-carbon-intensity power system and owing to various policy incentives or subsidies, zero-emission intermittent renewable resources have rapidly penetrated into the bulk electric grid, which traditionally has relied heavily on fossil fuels such as coal and natural gas. Nonetheless, increasing penetration of renewable energy also brings impacts to bulk power system assets, pricing, and costs. Extant studies argue that one of the physical impacts brought by the growing intermittent renewable resources, all else being equal, is an increase in the total amount of ancillary services (regulation, spinning, and non-spinning reserves) and ramping to maintain operating reliability (NREL 2012; U.S. DOE 2015; U.S. DOE 2017). Based on simulation models, these studies also predict that the trend of increasing demand for ancillary services may continue as the penetration of intermittent renewable resources do not slow down.

Nonetheless, in the Electric Reliability Council of Texas (ERCOT) market, the need for ancillary services has been steadily declining even as wind generation deepens its penetration of the Texas grid. Between 2014 and 2017, total annual ERCOT wind generation output increased 72% from 36 million MWh to 62 million MWh. During the same period, the procured quantity (MW) of ancillary services continuously declined. In particular, the need of regulation services at a 15-minute real-time security constrained economic dispatch (SCED) interval, including Regulation-Up and Regulation-Down services, dropped 53% from 1022 MW in 2014 to 541 MW in 2017. The observed decreasing trend in the ancillary services requirement seems counter-intuitive, and may potentially result from various operational improvements implemented by ERCOT. Furthermore, the decrease in the need for ancillary services in ERCOT also has interesting implications to policymakers and market participants, particularly for energy storage. Harmonizing intermittent renewable resources with energy storage is a concept garnering much attention lately. To date, most energy storage providers are participating in ancillary services in competitive markets, unless such energy storage is mandated by state public utility commission and procured by regulated utilities to serve multiple applications, without necessarily being directly compensated through market mechanisms.[1] Our investigation shows that the current ERCOT market operation practice with sufficient flexible thermal generation capacity have been capable accommodating rapid penetration of intermittent wind generation between 2014 and 2017, even without an assist from energy storage. Not surprisingly, the majority of ancillary services requirement in ERCOT was provided by natural gas generation resources during our study period, while coal plants also fulfilled a noticeable amount of ancillary services requirement.

This study contributes to a strand of literature that investigates the impact of intermittent renewable resources penetration.[2] First, this research covers a period (2014 to 2017) with aggressive development of wind capacity and increase in wind generation in ERCOT. Installed wind capacity within ERCOT footprint increased from 11.1 GW in the

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[1] See, U.S. EIA, The design and application of utility-scale battery storage varies by region, Feb. 28, 2018, accessed at https://www.eia.gov/todayinenergy/detail.php?id=35132; The Brattle Group, Stacked Benefits: Comprehensively Valuing Battery Storage in California, September 2017, accessed at http://files.brattle.com/files/7208_stacked_benefits_-_final_report.pdf.

[2] See, e.g. Andrade et al. (2017), and Baldick (2012).

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beginning of 2014 to 21.1 GW at the end of 2017, and wind generation output fulfilled 17.4% of ERCOT average load year-round in the year of 2017. These installed capacity and production numbers for wind power lead all organized ISO/RTO markets in the U.S. during our sample period. Second, this study utilizes 15-minutes real-time SCED data in ERCOT. The high granular nature of RT market data allows us to investigate the sub-hourly temporal pattern of wind generation and its relationship with the requirement of ancillary services. Our study also adds contribution by assessing ancillary services based on generation resource fuel type.

The remainder of the paper is organized as follows. In Section 2 we provide background information on ERCOT market and its ancillary services products, then take an extensive look into the trend of ancillary services during our study period and discuss potential factors contributing to the declining requirement of ancillary services. In Section 3 we discuss market or policy implications, and conclude the paper.

2. The ERCOT market and ancillary services

ERCOT provides a unique setting for investigating the relationship between integrating intermittent renewable energy into the bulk power system and the need for ancillary services. The foremost reason is that among all organized wholesale electricity markets in the U.S., ERCOT experienced the most aggressive addition of wind power between 2014 and 2017. On an annual basis, wind generation output increased from 36 million MWh in 2014 to 62 million MWh in 2017. It should be noted that the explosive increases in installed capacity and aggregate production numbers for wind during our study period benefit from the state's Competitive Renewable Energy Zone (CREZ) initiative, which induced the investment of $6.9 billion in nearly 3600 miles of new transmission lines to increase transmission capacity to accommodate a total of roughly 18,500 MW of wind resources in West Texas. CREZ was completed in early 2014, and has greatly unlocked the wind potential in West Texas and the Panhandle.

Currently there are four major types of ancillary services capacity products per ERCOT nodal protocol, namely Responsive Reserve, Non-Spinning Reserve, Regulation-Up, and Regulation-Down services. Responsive reserve service (RRS) is a service used to restore or maintain the frequency of the ERCOT System, which can be provided by either generation resource or load resources. It is important to note that RRS procured from load resources cannot exceed 50% of the total RRS requirement. Non-spinning reserve service (NSRS or non-spin) can also be procured from either generation resource or load resources, which is being synchronized and ramped to an ERCOT-instructed level within 30 min. Lastly, both regulation-up (reg-up) and regulation-down (reg-down) are services that provide capacity that can respond to signals from ERCOT within five seconds to respond to changes from scheduled system frequency. Similarly, regulation services can be provided by either generation resource or load resources. A generation resource providing reg-up service must be able to increase energy output when deployed and decrease energy output when recalled, while a load resource providing reg-up service must be able to decrease load when deployed and increase load when recalled; or vice versa for providing reg-down service.[3] ERCOT maintains methodologies for determining minimum ancillary services quantities, with periodical reviews or proposing changes to such methodologies when necessary. Operation-wise, ERCOT utilizes the SCED and non-spin as soon as practicable to minimize the prolonged use of RRS, and also to minimize reg-up and reg-down as much as practicable in each SCED cycle.[4] In the following sections, we introduce our data and present an in-depth look into how the procured quantities of ancillary services have changed during our study period.

[3] Please refer to ERCOT Nodal Protocol 3.16 "Standards for Determining Ancillary Service Quantities" and 3.17 "Ancillary Service Capacity Products" for more details.

[4] Per ERCOT Nodal Protocol 6.5.7.6.2.2 (7) and 6.5.7.6.2.1 (4) (b).

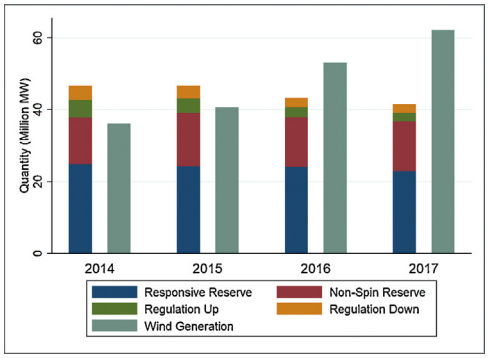

Fig. 1. Annual wind generation and ancillary services in ERCOT.

2.1. Data

Our dataset consists of real-time security constrained economic dispatch (SCED) for every 15-minute interval at each generation resource and load resource, from 2014 to 2017.[5] For generation resource, we identify the name of its resource node, resource type, operation status, telemetered energy output and procured ancillary services quantity (both in MW).[6] For load resource, we similarly identify its resource name, telemetered resource status, and ancillary services responsibilities. We also aggregate the telemetered generation output at all wind resource nodes to get 15-minutes ERCOT-wide wind generation output; and sum telemetered generation output at all generation resource nodes as proxy to 15-minutes ERCOT-wide load.

2.2. Wind generation and procured quantities of ancillary services: by year and month

In Fig. 1 we illustrate the annual quantity of wind generation and procured ancillary services. As mentioned earlier, there was an explosive increase in annual wind energy production between 2014 (36 million MWh and accounts for 10.6% of ERCOT load) and 2017 (62 million MWh and accounts for 17.4% of ERCOT load). During this timeframe, however, the total procured quantity of ancillary services declined. In terms of procured quantities for responsive reserve (RRS) and non-spin reserve (NSRS), not only they did not significantly increase along with growing wind generation, there were also incremental decreases. The procured quantity of RRS slightly declined from 24.8 million MW in 2014 to 22.9 million MW in 2017, while the NSRS quantity fluctuated between 12.9 and 14.9 million MW. It was also worth noting that 49% of the RRS requirement was provided by load resources while the NSRS was mostly procured from generation resources. The most notable decrease came from regulation services: procured reg-up quantity decreased from 4.94 million MW in 2014 to 2.41 million MW in 2017, or a 51% decline; reg-down quantity also decreased from 4.02 million MW in 2014 to 2.33 million MW in 2017.[7] Per ERCOT's Methodology for Determining the Minimum Ancillary Service Requirements, it is ERCOT's practice "to use historical rates of Regulation Service usage to perform evaluation and determine the required quantities for this service."[8] Hence it is interesting to see the procured quantities for regulation services dropped by 50% during our study period.

To better understand how procured ancillary services quantities have changed temporally at monthly level, through Figs. 2–5 we plot

[5] We obtained 60-Day SCED Disclosure Reports (NP3-966-ER) from ERCOT for constructing our main dataset.

[6] The telemetered output and ancillary services data in SCED are in MW, since it's a single snapshot during the first SCED execution in each settlement interval.

[7] Regulation services were also primarily provided by generation resources.

[8] Accessed at http://www.ercot.com/content/wcm/key_documents_lists/104002/9.2_2018_Methodology_for_Determining_Minimum_Ancillary_Service_Requirements.pdf.