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Review of wholesale markets and regulations for advanced energy storage services in the United States: Current status and path forward

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ABSTRACT

Today, advanced energy storage technologies, particularly electrochemical batteries, represent an increasingly economic option for supporting the integration of renewable energy resources and providing the grid with greater operational flexibility. Crucially though, the large-scale deployment of these assets, and the development of successful business models to support them is heavily reliant on policy, regulation and market design. In this paper, we present a comprehensive review of the array of federal, ISO/RTO and state-level rules and regulations shaping today's energy storage deployment across the United States. We highlight the fragmented and heterogeneous nature of existing market participation models available for advanced energy storage across restructured power markets and emphasize the need for design changes to power markets at all timescales to allow for the more efficient integration of energy storage. We also reflect on how well FERC's recent Order 841 does in terms of providing a framework for the establishment of more fit-for-purpose market participation models for storage, something that will be key for today's evolving power sector as it becomes more dependent on intermittent renewable resources.

1. Introduction

The structure of the US power system is changing as renewable resources play an increasingly important role in generation, and as consumer adoption of distributed energy solutions grows. Evidence of this dynamic includes the fact that since 2005 the combined annual generation from wind and solar has increased by an order of magnitude, amounting to 307 TWh, or some 7.6% of total US electricity generation in 2017 (EIA, 2018). Realizing a future power system that is much more reliant on intermittent renewables will require a more flexible power system capable of effectively accommodating the uncertainty and variability inherent with resources like wind and solar PV. Some flexibility can and will be provided by resources like fast ramping gas turbines, demand response, and traditional storage options like pumped hydro; however, demand for additional flexible resources is growing and new storage technologies have the potential to meet this need. Battery storage systems are one such new resource, which are now experiencing rapid growth in adoption. In 2015 alone, the global installed capacity of such systems increased by almost 117% from 166 MW to 361 MW, and this base further increased to 568 MW in 2016 (DOE Global Energy Storage Database, 2017a). In the US, grid-connected battery storage deployments increased by 27% in 2017 to 431 MWh, up from 340 MWh in 2016 with the cumulative deployed battery storage capacity exceeding 1GWh (Munsell, 2018). This rapid expansion in storage deployment is happening despite the fact that regulatory and policy mechanisms that properly remunerate energy storage for the services it is able to provide are still under development and evolving.

Emerging regulatory and policy needs in the context of wholesale market participation for energy storage are complex and nuanced. Prominent among them is the need to develop thoughtful regulatory and market design frameworks to support the broad range of system services that advanced storage technologies like batteries can provide to the grid at the wholesale level, which at the moment is comprised primarily by energy storage's provision of ancillary services such as frequency regulation (see Supplementary information). Issues requiring action includes the determination of whether storage be categorized as generation, demand, or as a transmission asset for regulatory purposes, along with the broader requirement for market reform across all timeframes to ensure the technical benefits that storage can provide can be fully monetized in the market. The Federal Energy Regulatory Commission's (FERC's) recent rule (Order 841) to regional grid

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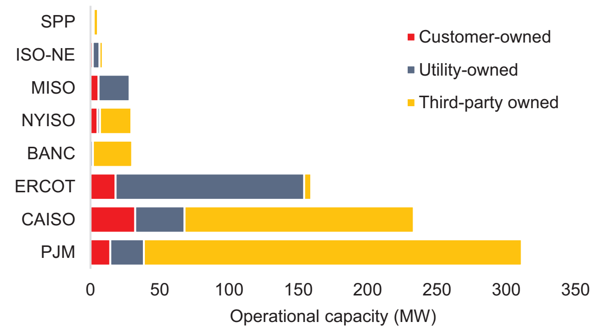

Fig. 1. Operational capacity of energy storage assets and ownership across all applications, not including pumped-hydro across different ISO/RTOs. (data source: DOE Global Energy Storage Database, 2017a).

operators to devise new tariffs that addresses barriers to the participation of storage is triggering further activity to design market rules that accommodate the unique features of energy storage (FERC, 2018a,2018b).

In this review, we compare contemporaneous markets, regulations and policies that are shaping the deployment and adoption of advanced energy storage technologies across the various ISOs/RTOs in the United States. While some work on policy barriers and market trends exist (Bhatnagar et al., 2013; Telaretti and Dusonchet, 2017), such a comprehensive review was found to be non-existent in the recent literature and served as a motivating factor for this work. We discuss ongoing efforts to improve upon today's regulations in order to enhance their efficacy and efficiency in integrating storage into the broader power system and we comment on key considerations to be kept in mind during the process. We start our review with a look at recent developments at the federal level, with a particular focus on the recent FERC order 841. This is followed by a review of the regulatory landscape for energy storage among the regional electricity markets and for individual states. We conclude with synopsis of our findings and recommendations for future policy improvements.

2. Regulatory, market, and policy landscape in the United States

A diverse set of rules and regulations inform the participation of energy storage across the different markets in the U.S., which includes the seven different organized power markets: CAISO, ERCOT, SPP, MISO, PJM, ISO-NE, and NYISO. Of these, PJM, with 61 million customers, has by far the largest customer base, followed by MISO at 48 million (FERC, 2016a, 2016b). However, there are also large swathes of the U.S. that are not part of these seven power markets. In these areas, vertically integrated utilities operate under more traditional utility regulation in addition to cooperatives that serve about 42 million people in 47 states (America's Electric Cooperatives, 2017). The operational capacity of energy storage across the seven U.S. ISO/RTO markets and the Balancing Authority of Northern California (BANC) has been compared in Fig. 1. In this paper, we focus on the organized power markets.[1] These ISOs and RTOs have different rules and regulations governing the participation of energy storage in their wholesale electricity markets. Development of these rules usually involve lengthy stakeholder initiatives, wherein different stakeholders, including the associated states, can play a role in ensuring that there are no inconsistencies between these and their own state-level policies. These rules must be in compliance with applicable overarching regulations from FERC, which regulates the transmission and wholesale sale of electricity in interstate commerce under the Federal Power Act (FPA) (FERC, 2016c). In this section, we first discuss the overarching landscape at the federal level before delving into the individual ISOs/RTOs, which includes a comparison of some attributes of their ancillary services markets, and finally highlighting some initiatives at the state-level.

2.1. Landscape at the FERC-level

Most regulations that apply to energy storage participation in U.S. wholesale electricity markets, were not designed for flexible, fast-responding, two-way resources like batteries and flywheels but rather for traditional supply resources such as power plants with limited flexibility. Energy storage assets provide a host of different services given their ability to supply electricity while discharging, thereby acting as generation, and as demand by consuming electricity while charging. Moreover, energy storage may contribute to defer investments in transmission and distribution infrastructure. Hence, energy storage does not clearly fall into the category of generation, demand, or transmission. Restructuring and unbundling in the electricity market requires that network companies do not own generation assets. As such, defining storage as a generation, demand, or transmission asset is critical to determine which agents can own and operate them and the different business models that will allow this technology to be fully compensated for the range of services it is capable of providing. One could consider categorizing storage as a separate asset, but such a measure may not result in a solution that duly addresses "transparency, completeness and consistency of accounting practices for the cost of assets, the expenses incurred in providing services, along with revenues collected" as required by FERC Order 784 (FERC, 2013). FERC's Order 784 along with other relevant FERC-issued orders have been highlighted in Table 1, which includes highlights of FERC Orders 890, 719, 745, 755, 764, and 825.

FERC Order 890 was released in 2007 and it was aimed at preventing undue discrimination and preference in transmission service (FERC, 2007). The design of the rule required that non-generator resources like demand response be evaluated comparably for services provided by generation resources in the areas of reliability standards, ancillary services, and transmission expansion planning (CAISO, 2015). In 2008, FERC released Order 719 and amended its regulations under the Federal Power Act to improve the operation of wholesale electricity markets which includes demand response and market pricing methods (FERC, 2008). Among its requirements was that minimum prices for energy and ancillary services be calculated every 5 min resulting in improved remuneration mechanisms that accounted for short-term market variability, which directly impacted faster responding energy storage systems. CAISO's non-generator resources (NGR) participation mechanism, discussed later in Section 2.1, resulted largely from FERC's Order 890 and 719 (CAISO, 2015). FERC Order 745, released in 2011, allows demand response (energy storage units can be considered as a type of DR) to participate in the wholesale energy market when cost-effective compared to other generation resources and be compensated accordingly based on the locational marginal price (LMP) (FERC, 2011a). Order 755, also released in 2011, remedied issues so that providers of frequency regulation, including energy storage, receive proper rates that include a capacity payment as well as a payment for performance (FERC, 2011b). Order 764, released in 2012, aimed to remove integration barriers for variable energy resources included the enactment of an intra-hourly scheduling requirement by public utility transmission providers, which was expected to benefit energy storage resources as well (FERC, 2012). When it comes to fostering competition and transparency in the ancillary services market, FERC Order 784, released in 2013, paved the way for public utility transmission providers to account for the speed and accuracy of regulation resources and improved accounting and reporting requirements for energy storage devices (FERC, 2013). Of particular importance was FERC Order 825, released in 2016, which addressed practices that fail to compensate resources at prices that reflect the value of the services they provide

[1] SPP has ~5 MW of operational non-pumped-hydro energy storage resource with no planned projects at the time of writing (DOE Global Energy Storage Database, 2017a). As a result of that, and limited data availability, we do not include SPP in this analysis.