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# The policy and institutional challenges of grid integration of renewable energy in the western United States☆

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ABSTRACT

Are organized markets necessary in the U.S. Western Interconnection for cost-optimal integration of renewable energy resources that, in accordance with state mandates, must be brought online in the coming decades? We examine the technological components of the western power grid as well as its political, institutional, economic, legal, and cultural attributes to assess the potential and feasibility of organized markets.



## 1. Introduction

Composed of diverse and largely independent organizational units and facing interesting technical challenges, the Western Interconnection power grid of the United States' electricity system must integrate increasing penetrations of variable renewable energy generation as required by various state laws providing for renewable portfolio standards (RPS) and encouraged by federal policies (such as the wind production tax credit) that aim to lower the costs of renewable power generation.[1] Integrating more renewable energy will likely require grid operators to procure increasing amounts of *ancillary services* that keep the grid running smoothly and reliably in the event of a failure on some portion of the system or, increasingly, a sudden, uncontrollable, weather-driven change in the output of renewable energy generators. As penetrations of renewable energy rise on the grid, the need for ancillary services and other grid modifications tends to increase as larger proportions of generation are subject to additional weather-driven uncertainty. Unlike in most of the Eastern Interconnection, where special markets allow both utility and independent generators to submit bids to the system operator for the opportunity to provide ancillary services at competitive market rates, the West continues to exhibit a distinct absence of organized markets, with the notable exceptions of California and Alberta. Western utilities typically procure ancillary services from their own systems, and do not always have access to the cost-savings and efficiency benefits that organized energy markets potentially offer. The result, presumably, is higher costs for system reliability overall as well as for the integration of renewable energy. The latter issue is the focus of this paper, as renewable generators often bear the sizeable financial brunt of integration costs even though they have little control over them (DeCesaro and Porter, 2009). The practical implication is that the current institutional organization of much of the West, including the absence of organized markets, limits the flexibility in the grid needed to integrate variable generation in the most cost-effective manner. As a whole, this tends to increase costs ultimately borne by ratepayers.

*Abbreviations:* WECC, Western Electricity Coordinating Council; NERC, North American Electric Reliability Corporation; FERC, Federal Energy Regulatory Commission; ISO, independent system operator; EIM, energy imbalance market; RTO, regional transmission organization; ITAP, Intra-hour Transaction Accelerator Platform; DSS, the Dynamic Scheduling System; RBC, Balancing Authority Reliability-based Control; ADI, ACE Diversity Interchange; ACE, Area Control Error.

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[1] In 2000, FERC Order 2000 encouraged utilities to join RTOs, independently operated organizations that oversee transmission service and administer energy markets for a given region. RTOs and ISOs are often referred to as organized energy markets and are regulated by the FERC.

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The West's electricity stakeholders, alongside its regional reliability organization, the Western Electricity Coordinating Council (WECC), have designed an array of creative solutions that attempt to address this problem, though they may fall short of integrating the large amounts of state-mandated renewable energy that must be brought online in the coming decades in a cost-optimal manner. Accordingly, we are interested in two questions. First, do rising concerns about the costs of renewable energy integration suggest a pressing need for organized markets in the Western Interconnection? Second, how would such markets arise, and what are the barriers to their creation in the West?

Addressing these questions requires an analysis not only of the technological components of the western grid, but also its political, institutional, economic, legal, and cultural attributes. We undertook a year-long study of the problem, including a literature review at both the technical and policy levels; extensive confidential interviews with electric utilities, state and federal regulators, independent analysts, and energy system and renewables integration experts at the national laboratories; and observations of institutional and political dynamics at relevant meetings of the WECC, utility sub-groups, as well as the multi-state Public Utilities Commission Energy Imbalance Market Group meetings, which have centered attention around the possible creation of one or several regional energy markets for balancing energy. This paper collects our findings and observations (stripped of identifying information) and attempts to construct a coherent narrative of the Western Interconnection's historical relationship with the concept of organized markets and where policy may be headed. Our aim is to explain these issues clearly to legislative and regulatory decision-makers and their staff members so as to translate the concerns and insights of various technical experts, grid modelers, and utilities into a policy-level discussion.

This paper differs from the existing literature in terms of both focus and overall scope. Sovacool (2009) performed interviews with electricity system stakeholders and an extensive literature review on the impact of intermittent renewable generators on system reliability in the United States and posited that the main barriers to renewable integration were social, political, and historical. However, that analysis considered neither ancillary services nor the Western Interconnection specifically. Cappers et al. (2013) reviewed market and policy barriers to allowing demand-response ancillary services in U.S. electricity markets, an oft-suggested means of aiding renewables integration. Interestingly, they identify changes in regional reliability councils' specific reliability definitions as a primary action needed to overcome barriers. However, even with these changes conflicting state policies and the strategic philosophies of individual utilities could still present a persistent barrier to both renewable energy integration and demand response adoption. Bohne (2011) explored the conflicts between different national regulatory cultures and the subsequent conflict within larger international energy regulations. While the work focuses on the EU and three of its member states, the different state paradigms described (enabling, providing, and ensuring) have analogs with the state policies encountered in the Western Interconnection.

We proceed in four parts. We first discuss the current state of the electricity system in the West, with an emphasis on the evolving legal and regulatory landscape. Second, we examine the expected additional requirements on the system with increasing rates of renewable energy penetration. Third, we address barriers, primarily institutional and cultural, to the development of solutions to meet these emerging needs. Finally, we describe a number of potential solutions, both market and non-market based, and explore where alternative paths might lead and projected environmental and economic outcomes.

## 2. Discussion

### 2.1. State of the WECC

WECC is the regional entity responsible for bulk power system reliability in the Western Interconnection. Geographically, it is the largest of the regional entities recognized by the North American Electric Reliability Corporation (NERC) and the Federal Energy Regulatory Commission (FERC), and includes all or part of 14 states, two Canadian provinces, and a portion of Baja California, Mexico. WECC consists of over 363 member institutions and serves compliance monitoring and enforcement, standards development, reliability coordination, and transmission planning functions for these members.

Ancillary services play a vital role in power system reliability and encompass many of the actions necessary to support the transmission of power from generators to consumers while ensuring reliable system operations. The manner in which ancillary services are named and defined varies greatly throughout the electricity industry. Ultimately, there is no uniform standard by which ancillary services are classified. For our purposes, we will adhere to the National Renewable Energy Laboratory's nomenclature when discussing ancillary services (Ela et al., 2011). Some examples of these services include voltage and frequency control, scheduling, load-following, and system protection. Another class of ancillary service, operating reserves, includes generation capacity kept available in case of unexpected deviations from schedules or variability within a scheduling interval. Operating reserves are particularly relevant to the integration of increasing amounts of variable renewable energy onto the system, and are the primary focus here. Operating reserves can be classified according to the circumstance that triggers their deployment, the timescale of the response, and the direction of deployment.

A "following reserve" (often called a load-following reserve in practice) is a particular operating reserve that handles more sustained trends over a timescale of minutes. These reserves allow the power system to "follow" changes in load throughout the day. For example, a hot day will create additional electricity demand due to the need for more cooling in homes and businesses; system load will grow over the course of the afternoon and then recede later that night. Following reserves allow the system operator to match generation to this cycle on a sub-hourly basis. In organized energy markets, load-following is covered through real-time "balancing energy" markets run by the independent system operator (ISO). Some utilities operating in the West have proposed an Energy Imbalance Market (EIM) for the region to achieve the same goal, but deliberations are ongoing and it is unclear how many stakeholders will ultimately participate in a western EIM.[2]

Organized energy markets, that is, those portions of the bulk power system run by an ISO or Regional Transmission Organization (RTO),[1] provide for distinct dynamic markets for some of these ancillary services in addition to markets for energy commodities (see Fig. 1). The FERC recognized a number of ancillary service types in its landmark Order 888 (1996), which was instrumental in the development of both open energy commodity markets and supporting ancillary service markets in the organized regions. Below we detail some of them, along with other commonly recognized ancillary services based on Ela et al. (2012):

[2] The continually-evolving EIM landscape merits further analysis. The CAISO/Pacificorp EIM is just one recent example of a regional EIM that will likely evolve. This dynamic issue requires additional monitoring before any broader conclusions can be drawn.