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Refining competitive electricity market rules to unlock flexibility

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ABSTRACT

Competitive electricity markets are undergoing a rapid transformation from systems with large, inflexible baseload resources to ones with smaller, modular, variable resources. Making the grid more flexible is critical to enabling a smooth transition. A significant amount of unused flexibility exists in the system today, but harnessing it requires changes to market rules.

1. Introduction

Competitive markets for electricity, or regional transmission organizations (RTOs), are at an inflection point. When RTOs were first created in the United States during the 1990 s, founders designed operations and practices around the technical elements of the grid of that time. Grid operators dispatched large central station generators to follow inflexible load, with power flowing in one direction from these central generators out to customers. RTOs managed the scheduling and dispatch of these generators, ensuring they met relatively predictable demand. While this system and its concomitant rules, procedures, and definitions has worked well for the last 20 years, it is becoming increasingly strained as the grid modernizes.

2. Flexibility for an evolving electricity grid

Today's grid is evolving in at least four ways due to new innovation and cost breakthroughs in technologies like wind, solar, batteries, and information technology (IT). First, RTOs have to plan for predictable variations in supply in new ways. While managing a predictable decrease in supply is nothing new for RTOs (think of a nuclear unit refueling, for example), RTOs now have to do this on a daily basis with an increasingly large pool of resources whose output varies on shorter and more frequent timescales. For example, in a region with plentiful solar power, grid operators have to manage the decrease in output from solar in the evenings and ensure sufficient alternative resources are available to dispatch.

Second, RTOs also have to manage the unpredictable variations in supply associated with higher penetrations of variable resources. As with managing predictable variations, managing unpredictable variations is not new to grid operators. RTOs have managed the grid around contingency events, such as the loss of a generator or transmission line, for decades. However, with growing levels of variable renewables, the sources and degrees of variability have increased. Some of this increase is offset, however, by the fact that historically, unpredictable variations were often the result of large generator failures. The unpredictable variation in output from renewables, on the other hand, tends be much more modular and not highly correlated across resource types, meaning the unpredictable variations will be smaller in magnitude and tend to balance each other out when compared to the historical paradigm of large generator failures.

Third, grid operators must manage the bulk electricity system (i.e. the transmission system, the domain over which they have control) with increased output coming onto the grid from distributed energy resources (DERs), like rooftop solar. With little visibility into and little control over the types and amounts of resources on the distributed system, RTOs are facing new challenges in accurately forecasting net demand.

Fourth, innovations in load resources are creating vast new opportunities for RTOs or load suppliers to harness the flexibility of load as a valuable resource. From advanced vehicle charging to electric water heaters that together can act as a giant distributed battery, RTOs increasingly are able to dispatch load resources to balance supply and demand.

Successfully managing a modern grid comes down to ensuring the grid is flexible enough to handle the characteristics of new resources and capitalize on their capabilities to the benefit of customers. Flexibility comes in many forms, but broadly, it means the ability to respond over various time frames – from seconds to seasons – to changes in supply, demand, and net load. The more flexible the power

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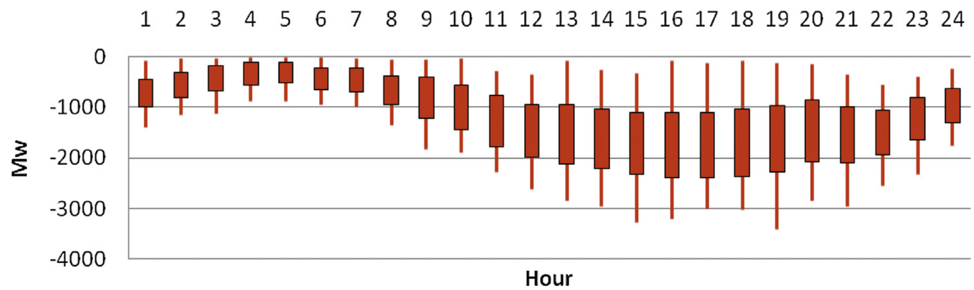

Fig. 1. CAISO summer downward 5-minute capability, limited by self- schedules, 2009 and June 2010. "Integration of Renewable Resources: Operational Requirements and Generation Fleet Capability at 20% RPS" (Folsom, CA: California ISO, August 31, 2010), Fig. 4-2.

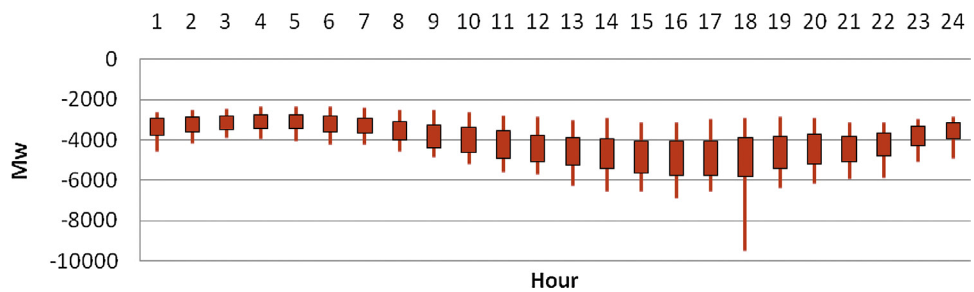

Fig. 2. Summer downward 5-minute capability of thermal units, not limited by self-schedules, 2009 and June 2010. "Integration of Renewable Resources: Operational Requirements and Generation Fleet Capability at 20% RPS" (Folsom, CA: California ISO, August 31, 2010), Fig. 4-3.

system, the easier it is for grid operators to manage the system around variable supply and demand. As the system becomes increasingly modular and renewables-based, ensuring sufficient grid flexibility is key to operating the grid reliably and minimizing costs.

3. Refining market rules to unlock the flexibility of existing resources

Fortunately, significant amounts of latent flexibility exist in the grid today. Tapping into unused flexibility available on the grid requires updates to market rules – restrictions, exceptions, definitions of resources, and technology requirements – around which the system was originally designed. Many of the RTOs in the U.S. are already tackling some of these changes, with a noticeable increase in the amount of flexibility on the grid and improved ability to integrate renewables. However, RTOs can tap the tremendous wealth of additional flexibility potential by increasing the share of resources that participate in economic dispatch, improving price signals, removing barriers to resources participating in markets, and better aligning natural gas markets with electricity markets.

3.1. Require all generators and imports to participate in economic dispatch

Most RTOs allow resources to choose between being dispatched based on the market price of energy, or to schedule resources to dispatch regardless of price as "self-scheduled" price-takers. Resources might choose to self-schedule for several reasons.

First, resources with very low or zero marginal costs may choose to self-schedule because the market clearing price will never fall below their marginal production costs. For example, a merchant wind plant built in 2016 receives a $23 per megawatt-hour (MWh) production tax credit and has zero operational costs, meaning it will make money so long as the energy market price is above -$23/MWh. Because the energy market-clearing price will usually be more than this price, the wind plant can just self-schedule rather than respond to price signals.

Second, resources may choose to self-schedule if the penalties for generating during times of congestion are not sufficiently high. In other words, if the market price floor is too high, generators will not have an incentive to reduce production. Consider a market with a minimum bid price of $0. In this case, even if the same wind generator described above submitted an offer curve, it would never ramp down production; at $0 and with the production tax credit, the generator is still profitable. All U.S. markets currently allow negative prices, though some are reconsidering whether or not to restrict minimum bids to $0. Of course, lowering the price floor can simply penalize resources without improving market efficiency. If resources are physically unable to respond and change output in response to prices, then further lowering the floor will simply fine them for inflexibility. RTOs should therefore conduct careful analysis before deciding to lower the price floor.

Third, a resource may choose to self-schedule if its contract terms are inflexible and require guaranteed delivery. For example, roughly half of the California Independent System Operator's (CAISO) power imports are on fixed schedules and do not participate in economic dispatch.[1] As another example, natural gas generators sometimes have to secure gas supply ahead of when they need it, and may schedule themselves (or may be forced to by the gas company) into the market to ensure generation to match their supply (this is discussed in more detail in Section 3.3).

Finally, generators might have physical reasons for self-scheduling. For example, hydro plants may choose to self-schedule due to water management and environmental functions other than providing electricity. In other instances, for example with some nuclear plants, a resource may be physically incapable of responding to dispatch signals and therefore choose to self-schedule.[2]

Self-scheduling removes some resources from the economic dispatch that could provide flexibility if those resources relied on price signals from the market to decide when to run, regardless of price signals and conditions on the grid (barring emergency conditions). For example, a hydro plant responding to price signals could provide a significant amount of flexibility, but if it is self-scheduled, it is unable to do so

[1] "Integration of Renewable Resources: Operational Requirements and Generation Fleet Capability at 20% RPS" (Folsom, CA: California ISO, August 31, 2010), 84.

[2] E. Ela et al., "Evolution of Wholesale Electricity Market Design with Increasing Levels of Renewable Generation."