METHODS FOR PROCURING POWER SYSTEM FLEXIBILITY

GREENING THE GRID

Figure 1: Procuring flexibility becomes increasingly important in systems with significant grid-connected wind and solar energy. *Photo from Iberdrola Renewables, Inc., 15180*

OVERVIEW

Flexibility is a prized characteristic in power systems with significant variable renewable energy (VRE). How this flexibility is procured is strongly shaped by the regulatory context. Vertically integrated utilities typically use contractual or policy mechanisms to extract flexibility from generators. In contrast, in partially or wholly restructured power markets, system operators use market designs—with clear definitions of performance requirements—to incentivize the provision of power system flexibility.

This fact sheet reviews *administrative* and *market-based* mechanisms for procuring a cost-effective mix of flexible resources needed to ensure system reliability and adequacy.

PROCURING FLEXIBILITY THROUGH ADMINISTRATIVE TOOLS

Vertically integrated utilities use administrative tools such as contracts, requests for proposals, and internal acquisitions to procure a variety of grid services that support system flexibility. For example, through power system planning, a utility will determine the cost-effective suite of technologies and services necessary to maintain balance between generation and demand. The utility can then procure these services through its normal contractual process. Contracts can address, for example: natural gas storage to increase the ability of natural gas plants to respond to unexpected wind ramps; new generation capacity that can turn down to low output levels; new transmission lines; and compensation for added maintenance costs due to deeper cycling of coal plants (see related fact sheet, "Sources of Flexibility," for more examples). Two example types of flexibility and administrative options to procure them are reviewed in more detail below.

Governor Response and Automatic Generation Control

Governor response and automatic generation control are critical tools to respond to short-term supply-demand imbalances. The provision of frequency response through governors is typically an uncompensated service provided by large synchronous generators as part of interconnection. Yet the provision of this service has declined in some restructured power markets due to disincentives created by market designs [1]. Moreover, the increase in non-synchronous generation, such as from wind turbines without primary frequency response mechanisms, has added to concerns about sufficient supply of this needed grid service. As a result, governor response may need to be mandated or compensated. For example, the Electricity Reliability Council of Texas, a restructured power market, mandates that wind generators provide uncompensated governor response [2].

Automatic generation control, which can involve significant exchanges of energy, is typically a compensated service. In restructured markets, this service is compensated through reserve markets. Vertically integrated utilities, in contrast, compensate this service contractually, and can also use it as a tool to better integrate wind energy. For example, the vertically integrated Public Service Company of Colorado (also referred to as Xcel Energy) requires new wind generators to respond to automatic generation control.

Demand Response

Increasing the responsiveness of electricity demand, for example, through price signals, contractual agreements to change demand in response to events, and/or remote system operator control, can add significant flexibility to the grid. One option is to contract with large customers—typically in the industrial sector—to provide interruptible load (i.e., automated load control by the system operator), effectively allowing for demand-side flexibility under extreme circumstances. Similar contracts can be established with smaller customers—e.g., in the commercial, agricultural, and residential sectors—to grant the system operator direct load control of energy-intensive devices such as water pumps, refrigerator units, and air conditioners. For large or small customers, such contracts typically specify limits to the frequency, number, duration, and amount of load curtailed.

PROCURING FLEXIBILITY THROUGH WHOLESALE POWER MARKETS

Power systems governed by partially or wholly restructured power markets procure energy and many grid services through transactions in the wholesale market. As an example, Figure 2 illustrates the use of markets to procure energy, and the potential role for a ramp market product to incentivize flexibility. Four other examples of market mechanisms to enhance system flexibility are described below.

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[1] Governor response, also known as primary frequency response, is the autonomous change in power output (or consumption) provided by generating units (or responsive load) to stabilize system frequency when deviations occur. Automatic generation control is a regulatory mechanism and set of equipment that provides for automatically adjusting generation within a balancing area from a centralized location to maintain a specified frequency and/or scheduled interchange.

Intraday Markets and Sub-Hourly Dispatch

Wholesale energy markets can encourage flexibility by employing intraday markets and fast (e.g., five-minute) economic dispatch. Short dispatch intervals improve flexibility by better aligning changes in VRE generation with load, which allows generators to respond to energy price signals close to real-time. Additionally, frequent intraday markets can reduce forecasting errors and the associated reserves needed for balancing [3, 4].

Ancillary Services Markets

Integrating significant VRE to the grid may necessitate changes to market designs and rules for ancillary services.[2] The variability and uncertainty of wind and solar can increase the need for ancillary services such as regulation reserves, with implications for pricing and scheduling of these services [3]. Variable renewable resources can also provide ancillary services, and market rules may need to be revised in order to allow this provision. In addition to the conventional suite of ancillary services, new market products are emerging to directly compensate flexibility, creating a financial incentive for supply- and demand-side resources that can provide this service [4].

Price-Responsive Demand

Incentivizing electricity customers to reduce their demand in response to power system needs is an emerging option for procuring flexibility. Whereas conventional retail electricity pricing mechanisms set rates at constant levels over longer periods (e.g., days, months, year), price responsive demand allows rates to vary dynamically (for instance, on an hourly basis), based on the wholesale electricity price. The wholesale electricity price can reflect flexibility needs, such as low prices when electricity supply is in excess of demand, and high prices when ramping supply is insufficient. Implementing price-responsive demand requires smart grid technologies such as advanced meters capable of recording sub-hourly electricity consumption [5].

Capacity and Capabilities Markets

Capacity markets can enhance flexibility by rewarding generators for committing firm capacity (regardless of type) during times of operational stress [6]. An alternative, emerging concept is that of capabilities markets, which reward the quality as well as the quantity of the capacity [7]. Capabilities markets suggest and apply criteria for rewarding different types of capacity (e.g., contingency reserves, capacity that can ramp quickly, and flexible cycling). For power systems without capacity markets, capabilities markets could take the form of periodic auctions to procure balancing capabilities for new and existing generators. Systems with capacity markets may either restructure them to assign requested capacity according to type (taking into consideration flexibility attributes of that capacity), or complement them with flexibility markets [6].

[2]Ancillary services support the transmission of capacity and energy from generation to load while maintaining reliable operation of the transmission system in accordance with good utility practice.

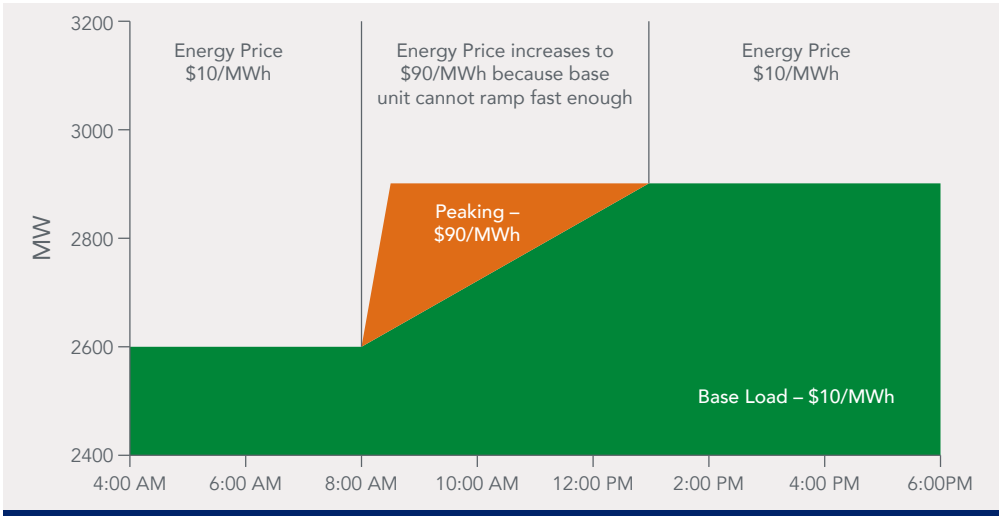

Figure 2: Example of a flexibility-scarce period and resulting spike in the energy clearing price provided to all generators. Alternatively, a ramp market product can be used to incentivize resources that provide flexibility. The ramp product market price is provided only to the resources that provide ramping support, and does not reward the inflexible resources. Source: [8]

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Greening the Grid provides technical assistance to energy system planners, regulators, and grid operators to overcome challenges associated with integrating variable renewable energy into the grid.

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