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GRID FLEXIBILITY: METHODS FOR MODERNIZING THE POWER GRID

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INTRODUCTION

An abundance of new technologies are now available to produce cleaner, cheaper electricity. Many countries—for example the United States, China, and Germany—are deploying large amounts of solar panels and wind turbines. At the same time, information technology and advanced power electronics are hitting the grid around the world, giving grid operators visibility into and control over power flows and demand variability. Today, more than ever before, there is enormous potential to incorporate a great deal of low-cost, zero-emissions resources extremely efficiently. But in order to take advantage of these new technologies, system operators must develop new tools, market structures, and institutions to balance supply- and demand-side resources against one another dynamically. In short, they must build a *flexible* electricity grid.

The electric grid has always been somewhat flexible in order to meet variable electricity demand in every instant. But increasing variability and ramping requirements introduced by a cleaner, more modern power system means system flexibility is poised to become more and more valuable. Fortunately, there are many options available to increase grid flexibility in the short-term, as well as the long-term.

This paper touches on the growing importance of grid flexibility, reviews the types of resources that can deliver it, describes case studies of how the United States has attempted to foster it, and concludes with options for how to incorporate and enhance grid flexibility.

SHORT-TERM: HANDLING CONTINGENCIES AND BUILDING OPERATIONAL FLEXIBILITY

Operational flexibility ensures that grid operators can meet daily, hourly, or sub-hourly fluctuations in supply and demand. In parts of the world with liberalized electricity markets, this kind of short-term operational flexibility has not traditionally been explicitly valued. Electricity markets have instead focused on ensuring the system has enough generators online at any given moment to meet uncontrollable electricity demand, selecting generators via an energy market based on lowest marginal-cost. Short-term variability has been handled by a relatively small parallel market for “ancillary services,” which typically comprise only around five percent of all the transactions in an electricity market.[1] These ancillary service markets often include products designed to support grid flexibility (such as operational reserves and regulation) and contingencies (such as voltage regulation and frequency response), but the primary concern of overall electricity markets has been to ensure adequate generation *supply* is dispatched in order of least cost to meet overall electricity demand. This gives little or no focus on the value of dynamically matching *demand* to available supply, and only minor attention to selecting supply with adequate *capabilities* to provide grid flexibility.

Part of the reason this kind of advanced operational flexibility has been largely neglected is that it hasn't been much of an issue to date. Traditional approaches to resource acquisition and market operations have typically delivered the necessary flexibility to run the grid reliably.[2] However, as the grid modernizes, technologies become available to cheaply manage electricity demand to meet available supply (rather than simply dispatching available supply to meet uncontrollable electricity demand). Variable clean energy sources will also become a bigger part of the electricity mix, thus operational flexibility will become more important. Indeed, some areas (such as Hawaii[3] and California[4] in the United States) that have high shares (20 percent or more) of electricity from renewable sources are beginning to see operational flexibility issues on the horizon.

LONG-TERM: PLANNING FOR FLEXIBILITY

As the overall resource mix evolves and new, clean technologies become a bigger part of the electric system, grid planners must begin to look several years out to ensure that sufficient flexible capacity is available down the road, either via direct mandates or through the right economic incentives.

In liberalized electricity markets it will be important to consider how to ensure the market delivers adequate flexible capacity in future years. Some liberalized electricity markets have introduced capacity markets alongside their energy and ancillary service markets to address concerns over resource adequacy. But traditional capacity markets have excluded

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[1] Mike Hogan, "What Lies 'Beyond Capacity Markets'?" (Brussels, Belgium: Regulatory Assistance Project, August 14, 2012).

[2] Ibid.

[3] The sunny island state of Hawaii has the highest electricity rates of any state in the US, as well as a net metering program (where customers with solar are paid retail rates for the electricity they export back to the grid), so the financial case for rooftop solar is strong. One in nine Hawaiian homes has solar panels on its roof, which means a great deal of variable generation has entered the distribution system—specifically, the solar generation on the average circuit in Hawaii is equivalent to 120 percent of the circuit's minimum daily load. See this report for further information: http://www.eia.gov/todayinenergy/detail.cfm?id=19731

[4] As California gets closer to 2020, when variable renewables will make up a third of the state's electricity supply, grid operators are beginning to consider new options for flexibility: sharing balancing services with neighboring regions through "energy imbalance markets," aggregating demand-side sources of flexibility and allowing them to participate in the state's wholesale market, exploring additional flexibility from the state's remaining fossil fuel fleet (natural gas), analyzing new ways to operate renewable energy resources more flexibly, and more. See this analysis for further information: http://lowcarbongrid2030.org/

considerations of flexibility, focusing instead on “firm” capacity, eschewing any consideration of the *type* of capacity that is being acquired; in other words, all megawatts are treated the same. As the electric system modernizes, though, the need to plan for adequate *flexible* capacity will grow.

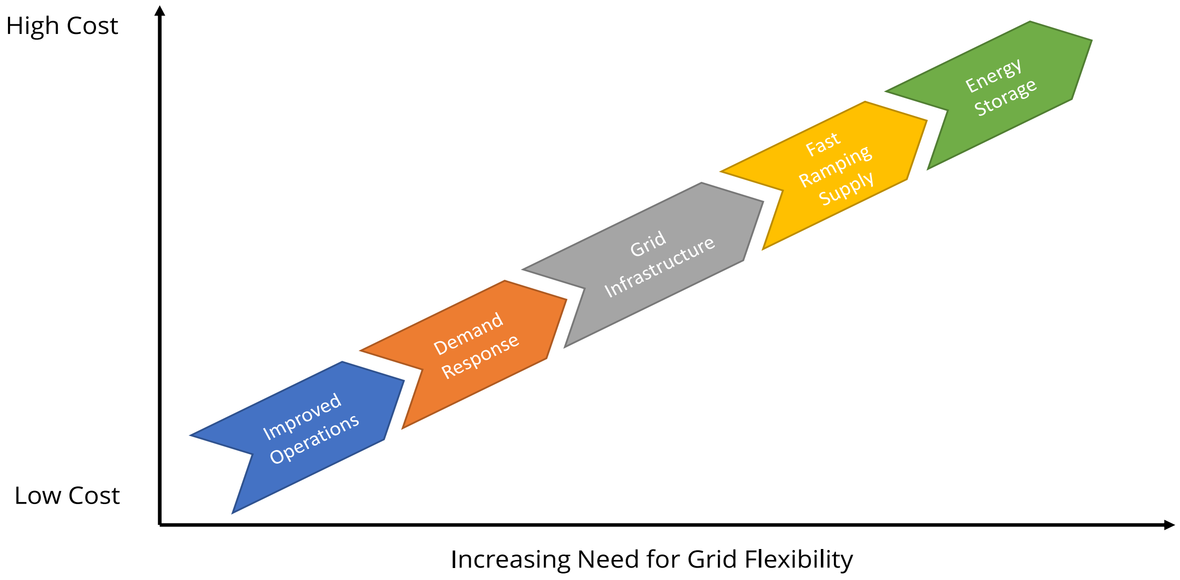
The section below, titled “Case Studies and Options for Improving Grid Flexibility,” highlights ways to incorporate flexibility into near-term operations and long-term planning. But first, we will describe some of the operational changes and physical resources that can be used to provide low-cost flexibility today.

RESOURCES FOR FLEXIBILITY

Many different resources are already available to deliver grid flexibility on both the short-term operational timeframe and the long-term planning timeframe. Flexibility can come from physical assets, such as batteries and fast-ramping natural gas plants, but it can also come from improved operations, such as shorter dispatch intervals and improved weather forecasting. The lowest-cost options fall into the category of improved operations, which can take advantage of existing infrastructure, making relatively small operational changes or introducing advanced information technology to more efficiently match electricity supply and demand. As illustrated in Figure 1, several physical options are available today, but they remain somewhat more expensive than improved operations.

The following sections describe some options for grid flexibility.

Figure 1: Flexibility Resource Supply Curve [5]



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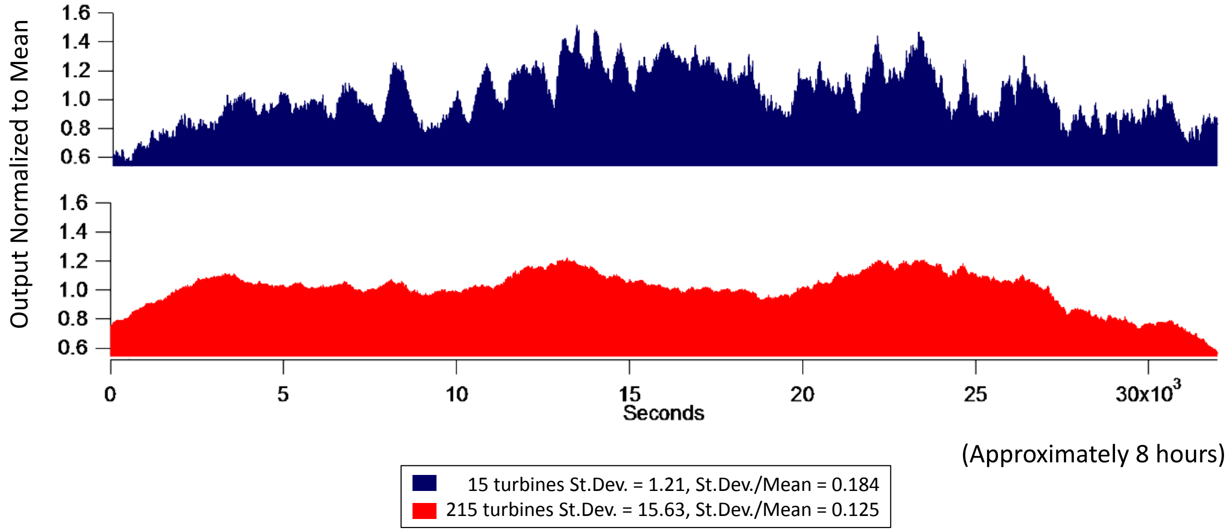
[5] Graphic adapted from: Paul Denholm et al., “The Role of Energy Storage with Renewable Electricity Generation” (National Renewable Energy Laboratory, January 2010).

Improved Operations

Several straightforward operational improvements can increase grid flexibility. First, **shortening dispatch schedules** can allow the grid to respond more rapidly to changes in supply from variable renewables. Historical utility practice in the United States is to schedule the system at one-hour intervals, but many power systems around the world are now beginning to clear the market more frequently. “Sub-hourly dispatch” refers to when grid or market operators schedule or clear the markets more often than once an hour—in some markets as often of every five minutes. This kind of scheduling upgrade allows grid operators to respond more quickly to fluctuations in electricity demand and in supply from variable clean energy sources. Shortening dispatch intervals also creates value for flexible resources that are capable of responding in near-real-time by ramping up or ramping down easily.[6]

Improved weather forecasting can be used to update commitment, dispatch, and transmission schedules more frequently, thereby reducing the need for operating reserves. As higher levels of variable renewables come online, reliable weather forecasting becomes increasingly important. High-quality weather forecasting that can accurately predict output on a two- to six-hour interval can significantly improve system reliability.

Figure 2: Decreased Variability with a Bigger Portfolio of Resources[7]



Another way to increase flexibility is to **consolidate balancing areas**. This can be achieved a number of ways, including merging existing balancing areas or simply allowing for trading of electricity between existing balancing areas. For example, there are special markets developing right now in the western U.S. to trade grid balancing services between regions that have to date been operated independently from one another (“energy imbalance markets”). Without

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[6] Michael Hogan, “Aligning Power Markets to Deliver Value,” The Electricity Journal 26, no. 8 (October 2013): 23–34, doi:10.1016/j.tej.2013.08.010.

[7] Graphic adapted from: Michael Milligan, “Capacity Value of Wind Plants and Overview of U.S. Experience” (Stockholm, Sweeden, August 22, 2011).

needing to build new physical transmission capacity—simply by allowing trades between regions that did not allow them before—these burgeoning markets are expected to save customers $72-208 million every year. In general, when a diverse portfolio of energy resources is balanced over a wide geographical area, variability in the electric grid declines considerably.[8] Variability is minimized because fluctuations in output tend be localized, so larger areas are less prone to as much variability. This effect is demonstrated in Figure 2 above, in which a system with 215 wind turbines experiences significantly less variability in output (measured as the standard deviation divided by the mean) than a system with 15 wind turbines.

Demand Response

An emerging, powerful approach for increasing grid flexibility is to better manage our electricity demand using a resource called **demand response**. Demand response refers to a suite of demand-side options, including using more electricity when there is a surplus and using less when there is a scarcity. For example, switches and radios can turn every building into thermal batteries: by simply pre-cooling or pre-heating buildings and water supplies, thermostats and hot water heaters become amazing sources of grid flexibility, all while delivering the same comfort and service to homeowners.[9] Dynamic electric vehicle charging is another example, in which vehicles charge during times of oversupply and low prices, and either cease charging or return electricity to the grid during times of scarcity and high prices. These powerful resources can be dispatched remotely with no noticeable inconvenience to the consumer.[10]

Market designers should ensure that demand response can participate in all wholesale markets (energy, ancillary service, and the capacity market if one is established). Demand response should be allowed to participate in day-ahead and intra-day energy markets in the same way that supply-side generators bid into those markets. This allows demand to participate in setting the true market value of electricity in daily scheduling intervals. Demand response should also participate via markets for ancillary services, such as regulation and spinning reserves.[11] Some wholesale market operators in the United States have already experienced success with this. For example, PJM (the largest market operator in the United States) has successfully enabled demand response to bid into its ancillary service markets to provide regulation services, while the Electricity Reliability Council of Texas (ERCOT) gets half of its spinning reserves from demand response.[12]

Finally, however long-term capacity needs are evaluated, demand response that meets necessary qualifications should be allowed to compete on equal footing with supply options.

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[8] Ibid.

[9] Sonia Aggarwal, "Clean Energy, Batteries Not Included (Op-Ed)," *LiveScience.com*, accessed July 9, 2015, http://www.livescience.com/46973-clean-energy-storage-without-using-batteries.html.

[10] Hogan, "Aligning Power Markets to Deliver Value."

[11] Ibid.

[12] Katherine Tweed, "Demand Response and Renewables: Too Good to Be True?," *Greentech Media*, March 14, 2011, http://www.greentechmedia.com/articles/read/demand-response-and-renewables-too-good-to-be-true.

The payoff can be enormous; for example, when PJM allowed demand response to participate in its capacity market, it saw overall prices drop by about 85 percent in one year.[13] PJM now procures about 10 percent of its resource needs through demand response at significantly less than the comparable cost for new supply-side resources.[14]

Grid Infrastructure

Improved transmission and distribution infrastructure can also increase grid flexibility. **Increased transmission capacity** allows electricity to be transported more readily within a balancing area, meaning that more of an area's resources can be used to help balance supply and demand. Similarly, increased transmission capacity connecting balancing areas means that operators in different regions can buy and sell electricity from each other. This allows operators to draw on the resources of multiple regions to balance out variability (see Figure 2), and similarly allows operators to import electricity when local prices are high, or export electricity when there is a surplus and prices are low.

Distribution system infrastructure also helps balance out supply and demand, similar to investments on the transmission system. For example, creating a networked distribution grid rather than a radial grid increases the pathways for electrons to flow to any given spot, meaning operators have more options available to meet local demand. Similarly, a network architecture increases the value of distributed renewable energy resources like rooftop solar because electricity produced by these resources can more easily flow to areas where it is needed and better balance variability.

Flexible Generation

Quick-ramping supply-side resources can also add flexibility to the grid. For example, new **combined-cycle fast-ramping natural gas plants** can come online rapidly as needed and are designed to be turned up and down regularly. Research has shown that **coal power plants**, though traditionally thought of as relatively inflexible, can in fact provide flexible output, if they have the necessary technical and operational upgrades.[15] Exposing the value of grid flexibility and offering to pay coal plant owners to operate their plants flexibly can be a huge opportunity for certain markets. Finally, **hydroelectric plants** can also provide a significant degree of flexibility, both in terms of supply (producing electricity as needed) and demand (pumping to refill reservoirs in times of excess supply).

Of course, encouraging power plants to operate as balancing load rather than baseload will require new revenue streams that compensate operators for making these changes, which would otherwise decrease revenue and increase costs. For example, transitioning a coal power

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[13] Sonia Aggarwal and Jeffrey Gu, "Two Kinds of Demand-Response" (Energy Innovation: Policy & Technology, LLC, November 2012).

[14] Hogan, "Aligning Power Markets to Deliver Value."

[15] Jaquelin Cochran, Debra Lew, and Nikhil Kumar, "Flexible Coal: Evolution from Baseload to Peaking Plant" (Golden, CO: National Renewable Energy Laboratory, December 2013).

plant from baseload to balancing load means operators will likely have to invest in new equipment while facing lower annual capacity factors and more frequent forced outages.[16] However, with an adequate compensation mechanism, operators can run plants for balancing while also maintaining a profit.

Energy Storage

Finally, storage in the traditional sense – **grid-scale batteries**, **pumped hydro facilities, compressed air energy storage**, and others – can provide flexibility on the grid. Pumped hydro and compressed air work best on longer timescales, while grid-scale batteries can also support shorter-term contingencies. Pumping water uphill during periods of low demand and using it to generate electricity during periods of high demand has long been used to store energy in regions with the right terrain, though careful consideration must be given to the local environmental impacts that may result from this kind of pumping and releasing of water in fragile habitats. The cost of battery storage has come down nearly 80 percent in the last five years, and continues to drop. Batteries are still very expensive for large-scale storage, but they could become a more cost-effective resource if current learning rates continue.[17]

CASE STUDIES AND OPTIONS FOR IMPROVING GRID FLEXIBILITY

First, it is worth noting that a well-functioning energy market—that clears on short timescales and allows participation from both supply- and demand-side resources—is theoretically adequate to manage contingencies and support grid flexibility. Sufficient differences in the market clearing price at different times of day can support flexible resources, as well as resources that can make themselves available during the most expensive times.

However, in practice, at least two challenges may arise. First, electricity policymakers and regulators often become uncomfortable with the price volatility of energy-only markets. The market clearing price may swing multiple orders of magnitude within a matter of hours, which increases risk for inflexible market participants. But those swings in price are exactly what provide the financial opportunity for flexible resources. Still, policymakers and regulators often react to volatile prices by collaring the market or taking other measures to contain volatility, thereby reducing that financial opportunity for important flexible resources. Second, because of uncertainties associated with sub-hourly (or even day-ahead) markets, as well as uncertainty about the response from policymakers (e.g., collaring the market), the promise of an energy-only market with volatile prices can be insufficient to finance assets that measure their lifetimes in decades.

The first of these concerns could be mitigated via a set of financial instruments that could sit on top of the energy market itself, such as insurance-like products for price volatility, the payments

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[16] Ibid.

[17] Sonia Aggarwal, "Clean Energy, Batteries Not Included (Op-Ed)."

for which could create a pool of funds for flexible resources. Other financial hedging instruments could be created as well. However, this approach has never been tested in real markets.

The following sections describe mechanisms that several energy markets have instituted to try and increase the amount of flexibility on the system. These case studies, as well as other theoretical options, are discussed below.

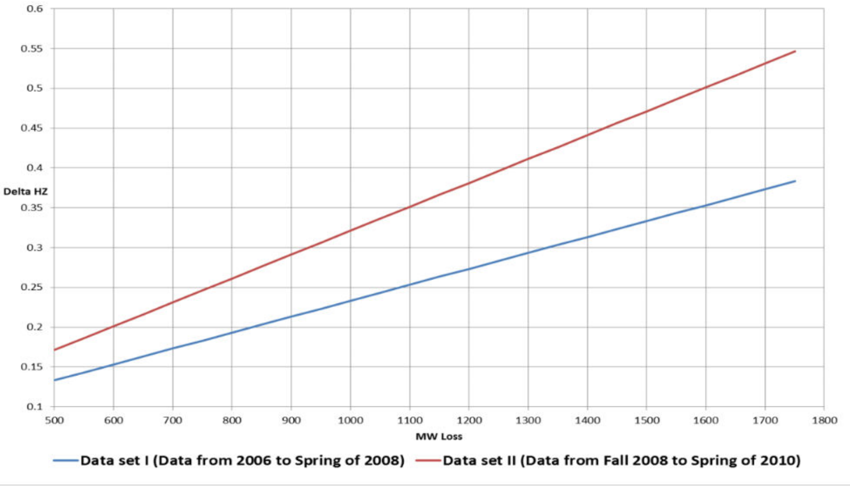
Short-term: Operational Flexibility Programs

This section discusses case studies of market mechanisms that are focused on handling contingencies and improving the operational (short-term) flexibility of the system.

Texas' Fast Frequency Response Program

The Electricity Reliability Council of Texas (ERCOT) recently concluded a pilot program for a new type of ancillary service market product called Fast Frequency Response (FFR). Traditionally, generator fluctuations have been handled through a combination of system inertia and Responsive Reserve Service (RRS), which consists of load shedding (sources can respond in under 0.5 seconds) and automated generator response (sources can respond within 16 seconds).[18] Because system inertia slows drops in frequency, traditional RRSs have been adequate to regulate frequency. However, in recent years Texas' share of renewables has increased significantly, and as of 2014 the state had more than 12 GW of wind installed, generating roughly 10 percent of its electricity.[19] As the share of variable renewables has increased, Texas has seen a decline in the share of synchronized generators (the vast majority of wind turbines are asynchronous). As a result, the grid's ability to respond to changes in frequency—which has traditionally been achieved on very short timescales via system inertia and RRSs—has significantly diminished.[20] For example, Figure 3 shows how the effect of a generator going offline has changed in recent years, showing greater overall grid disturbances as more of Texas' generation has come from wind. This is a special kind of operational flexibility—or contingency support—that increases in value as renewables make up a greater share of the electricity supply.

Figure 3: Change in Frequency with Loss of Generation in Texas [21]



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[18] "ERCOT Concept Paper: Future Ancillary Services in ERCOT," September 27, 2013.

[19] April Lee, "Wind Generates More Than 10% of Texas Electricity in 2014," *Energy Information Administration: Today in Energy*, February 19, 2015, http://www.eia.gov/todayinenergy/detail.cfm?id=20051.

[20] "ERCOT Concept Paper: Future Ancillary Services in ERCOT."

[21] Ibid.

As a result of these changes, ERCOT is experimenting with a new market product, Fast Frequency Response (FFR), to respond immediately to frequency fluctuations. The FFR product includes electricity sources that can respond within a half-second of a signal from the dispatcher and can operate for at least ten minutes. The FFR pilot included 37 MW of battery storage and 100 kW of grid-connected electric vehicles.[22]

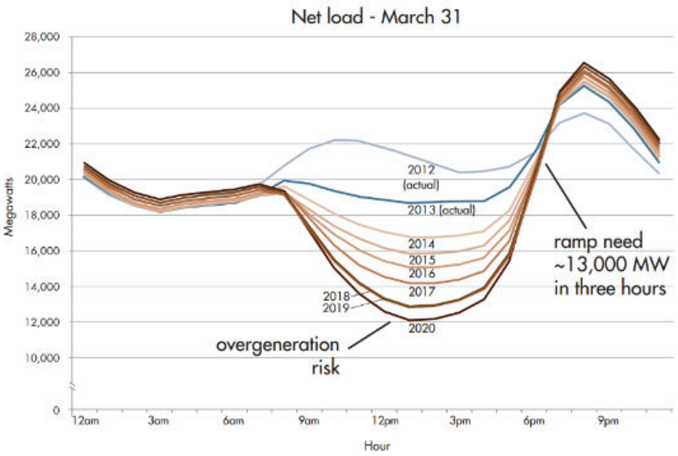
So far, this market product has been very successful. ERCOT has seen a noticeable improvement in its ability to slow and stop frequency drops when generation goes offline. For example, during the pilot program, grid operators saw a 37 percent improvement[23] in the rate of change of frequency during a loss-of-generation event.

The use of the FFR market product is an example of a wholesale market mechanism that can be used to create value for fast responding resources and help improve short-term operational flexibility.

California's Flexible Ramping Product

The California Independent System Operator (CAISO) has proposed a new market product designed to increase the availability of flexible ramping capacity in the real-time market. Like ERCOT, CAISO has seen system needs evolve in recent years as higher penetrations of renewables have been deployed.[24] For example, Figure 4 shows a projection of net electricity demand (after renewable generation is subtracted) on March 31st between 2012 and 2020. By 2020, the decrease in net load from 8:00-12:00 and increase from 17:00-20:00 suggests that large amounts of fast-ramping resources will be needed during these times (e.g. 13 GW will need to come online within three hours).

Figure 4: CAISO projection of net electricity demand, 2012-2020[25]



The Flexible Ramping Product (FRP) is used in both the day-ahead market and the real-time (five minute) market. There is no minimum certification for ramp capability, though CAISO can disqualify a resource if its submitted ramp rate differs significantly from its actual ramp rate. Eligible resources will respond in the real-time dispatch cycle to help balance fluctuations in net demand. The FRP can be further broken down into up-ramping and down-ramping resources, which are procured separately.

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[22] "ERCOT Pilot Project for Fast Responding Regulation Service (FRRS)," April 15, 2014.

[23] Percentage calculated from data on Slide 9 in Ibid.

[24] "Fast Facts: What the Duck Curve Tells Us About Managing A Green Grid," California ISO, October 2013.

[25] Ibid.

The ERCOT and CAISO programs are examples of ways to use market products to help take care of contingencies and improve the short-term operational flexibility of the electric grid. The ERCOT program creates value for *new* kinds of innovative flexible resources, and in particular those resources that can respond instantly, like batteries, by compensating resource owners for providing this instantaneous service. In CAISO, the development of the FRP has focused on better using *existing* resources, creating a separate market product to pay them to operate flexibly. Other grid operators in the United States, such as the Midcontinent Intendent System Operator (MISO), have followed similar approaches to improving operational grid flexibility.

Long-term: Programs to Plan for Flexibility

This section discusses case studies of market mechanisms that are focused on ensuring that adequate flexibility is available in the long-term.

California Storage Mandate

In 2013, California passed a law requiring that 1,325 MW of energy storage be procured by the state's three investor-owned utilities by the end of 2024. This mandate was issued in part as a response to the same evolving conditions on the grid that motivated the creation of the Flexible Ramping Product, discussed earlier. The storage procured under this law can be used for generation, transmission and distribution system reliability, and as customer-sited storage. The law mandates that the most cost-effective storage be procured first to keep costs as low as possible.[26]

Well-designed Capacity Markets

Capacity markets are longer-term (3+ years) markets used in part to ensure sufficient capacity is in place to meet demand in future years. In many cases, resource developers bid into these markets, and the market operator uses a least-cost mechanism to choose which projects are procured. Most capacity markets in the United States do not include flexibility criteria for participation in a capacity market, but a minimum ramp-rate for all capacity eligible to participate in a capacity market, for example, could be a way to build flexibility into a potential new market.

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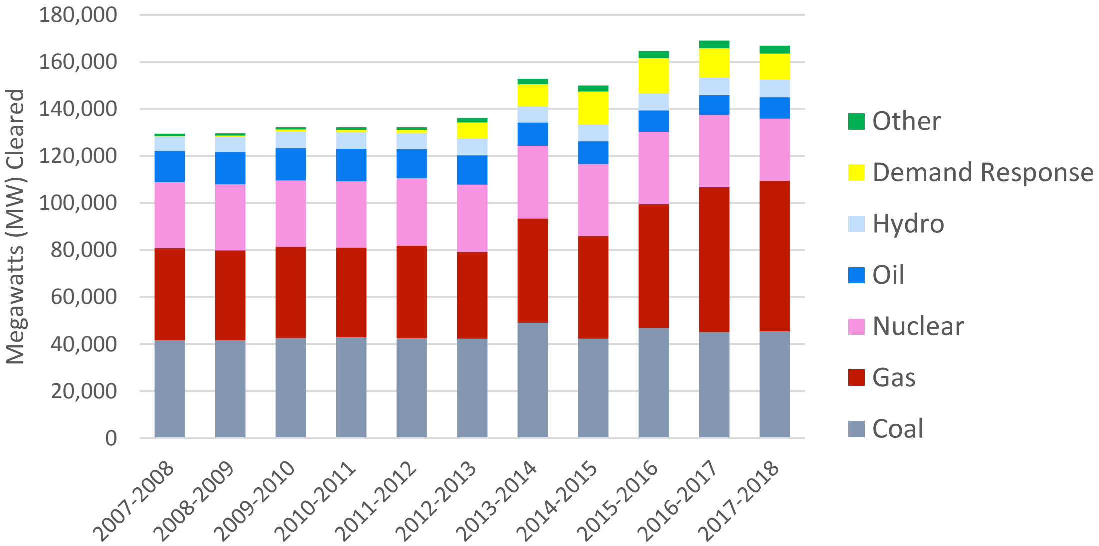
[26] Order Instituting Rulemaking Pursuant to Assembly Bill 2514 to Consider the Adoption of Procurement Targets for Viable and Cost-Effective Energy Storage Systems (2013).

Figure 5: Capacity Cleared in PJM Capacity Market[27]



Another way to promote cost-effective flexibility in the long-term is through including demand response in capacity markets. Demand response has been allowed to participate in these markets in the United States and has played a major role in recent years. For example, Figure 5 shows the mix of resources procured through PJM's capacity markets between 2007 and 2018 (estimated).

Other market operators in the United States, such as the New York Independent System Operator (NYISO) and the New England Independent System Operator (ISO-NE), also allow demand response to participate in capacity markets. By allowing cost-effective and flexible resources to participate in capacity markets, market operators can help create an incentive for market participants to aggregate and use these resources.

Staircase Capabilities Market

A "staircase capabilities" market is a conceptual approach to increase grid flexibility while minimizing overall costs. The idea behind the staircase capabilities market is to use an iterated sequence of long-term, small-volume procurements for new *capabilities* that match anticipated system needs. The staircase capabilities market is an improvement over traditional capacity markets that have treated all capacity identically because it is focused on procuring the particular system *capabilities*, such as flexibility, that are likely to be needed in the future.[28]

The staircase capabilities market would use a long time horizon (e.g., 10 to 20 years) to provide investor certainty. The comparatively small volumes of resources acquired in sequence would

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[27] PJM, "Commitments by Fuel Type & Delivery Year 2007/08 - 2017/19," May 29, 2014, http://www.pjm.com/markets-and-operations/rpm.aspx.

[28] Eric Gimon, Sonia Aggarwal, and Hal Harvey, "A New Approach to Capabilities Markets: Seeding Solutions for the Future," *The Electricity Journal* 26, no. 6 (July 2013): 20–27, doi:10.1016/j.tej.2013.06.002.

allow regulators to experiment with specifying the particular capabilities they need. Reverse auctions could be used to allow the market to find the right price for the resources.[29]

The staircase capabilities market would not replace traditional market mechanisms, but instead work alongside these mechanisms. For example, if market operators know that one GW of fast-ramping capacity and a total of 10 GW overall capacity is needed in the coming years, the staircase capabilities market could be used to procure just the flexible resources, with the traditional capacity market being used to procure the remainder of the capacity. This is just an example of the way that market procurement mechanisms can be used to acquire flexible resources on the planning timescale.[30]

CONCLUSION

As countries continue to deploy large amounts of variable renewable resources, an increasingly flexible electric grid will be required to take full advantage of these zero-emissions resources. As described in this short brief, there are many options to enhance grid flexibility—everything from short-term operational changes, to using advanced information technology, to developing and building flexible physical grid assets. Policymakers and market operators have an opportunity to lead the world into the age of the dynamic, flexible electric grid. As some countries begin to liberalize their markets—for example, China and Mexico—this moment of clean-sheet electricity market design is the perfect time to set the wheels in motion on flexibility.

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[29] Ibid.

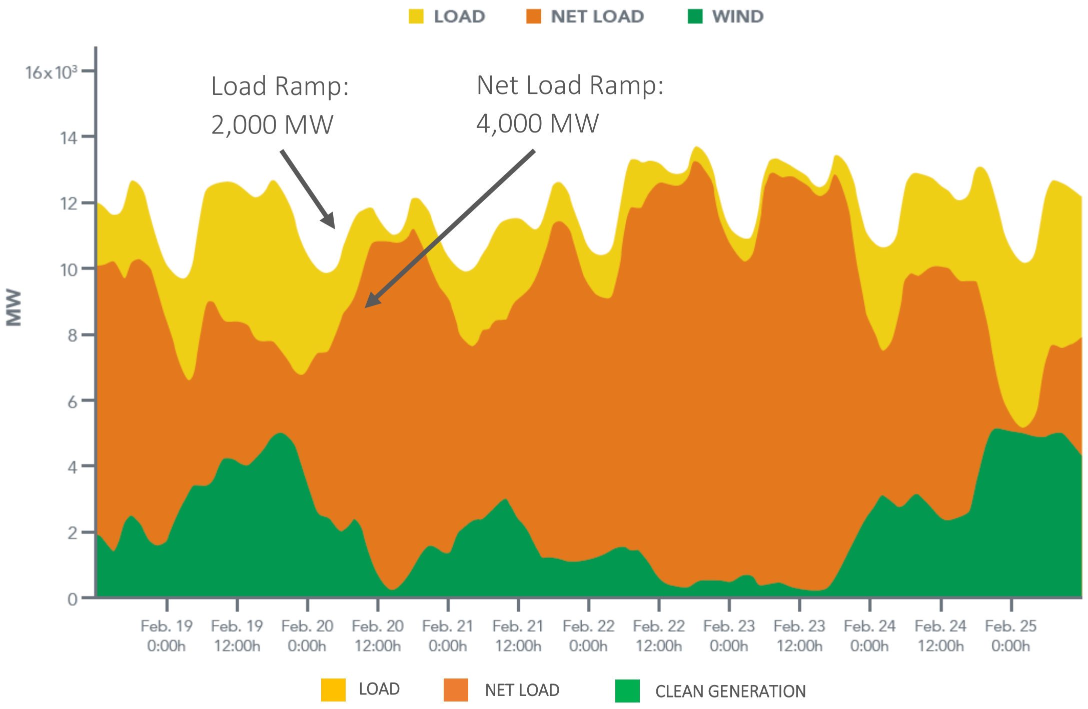
[30] Ibid.

APPENDIX A: NET LOAD AND NEW FLEXIBILITY REQUIREMENTS

An electric system with large amounts of renewables requires grid planners to prioritize system efficiency as the cleanest, cheapest resource, and then turn to the cleanest power generation sources to meet the remaining need. Consider the illustrative electricity demand curve displayed in Figure 6. Overall electricity demand, which is referred to as load, is shown by the top edge of the yellow curve. Grid operators should begin by exploiting cost-effective opportunities to reduce load (while delivering the same electricity services). In Figure 6, this would refer to shifting the whole yellow load curve downward along the y-axis. The next step should be to integrate the very low marginal-cost electricity from solar, wind, and hydro facilities. The generation from these clean, variable facilities is illustrated in green in Figure 6. Finally, only the remaining electricity need should be filled in with electricity from higher-emitting resources. This remaining electricity need is illustrated in orange in Figure 6 below—this orange "net load" is the total demand (yellow) minus the clean, variable generation (green).

There are several important differences between the shape of the overall electricity demand curve and the net electricity demand curve. Overall load, before efficiency and zero-emissions generation, never drops below 10 gigawatts (GW) in this illustration, and the typical ramping requirement is less than two GW. But net load, after efficiency and zero-emissions generation, has very different ramping requirements—the curve is more variable overall, and the maximum ramp is more than double.

Figure 6: Illustrative Load Curve[31]



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[31] Graphic adapted from: Jaquelin Cochran et al., "Flexibility in 21st Century Power Systems" (Golden, CO: National Renewable Energy Laboratory, May 2014).