POWER MARKETS
aligning markets with clean energy policy

Flexibility Policies

By Bentham Paulos
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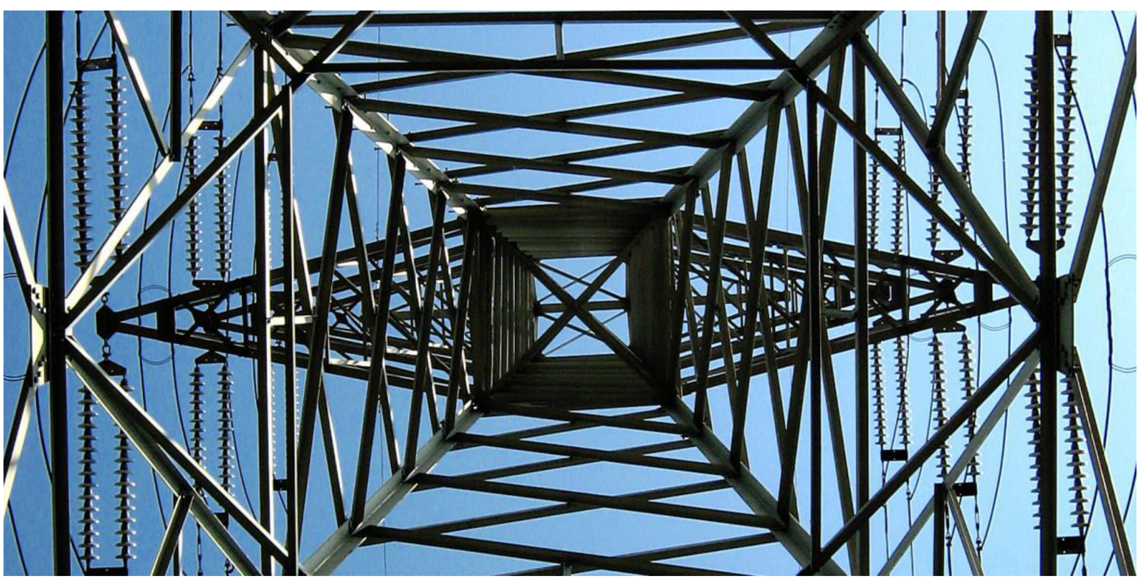
A power system with large amounts of wind and solar power requires flexibility to maintain reliability. While the flexibility toolbox is well-known to grid operators, policies and financial incentives to apply them to integrating renewables are sometimes lacking.

The world is heading into the next phase of a global *Energiewende*, the transition from fossil energy to a highly-efficient, renewable, and low carbon future. As renewable energy technologies become more mature and cost-competitive, policies to promote their use need to adapt.

Mandates and subsidies have been critical in moving renewable technologies down the learning curve and pushing them into the marketplace. Now that they are in the market, the fundamental design of the market will be the decisive factor in their future growth.

Markets need to be redesigned to accommodate and nurture renewable energy, taking into account their unique needs and benefits. Variable renewables – wind and solar power – need to be integrated into the mix.

While variability is nothing new to grid operators – demand varies widely and constantly – large amounts of wind and solar add an additional dimension of variability. Grid operators need a larger set of



options to maintain reliability, with a premium on flexible resources. A precedent is the development of very large, highly inflexible nuclear power plants from the 1960s to the 1980s. Integrating these rigid generators into a system with variable demand required extensive integration measures, including large pumped storage hydroelectric facilities and, in France, a distributed thermal energy storage system.

Under the old way of thinking, demand was given, and supply was composed of dispatchable baseload, intermediate (or mid-merit), and peaking power plants. Regulators made forecasts of demand and made sure enough plants were built to meet the maximum, with a fair margin added for security. And grid operators dispatched power plants to meet the total demand every day.

But wind and solar are square pegs in the round hole of traditional utility planning. Neither baseload, intermediate, nor peaking, they are not dispatchable, yet their low operating costs make them first in line for use whenever the are producing. As they scale up, they are increasingly pushing aside conventional generators, in a "merit order effect."

And wind and solar are changing the shape of what grid operators need to track every day. Because wind and solar are driven by weather, they must be worked into the daily routine: rather than meeting total demand, grid operators are thinking of "net demand," the power needs that aren't met by wind and solar. Figure 1 shows the difference between gross and net demand in Denmark, a system dominated by wind at times.

These disruptions are undermining the business model of utilities that are slow to adapt to changing conditions. While the transition to renewable energy will necessarily involve some "disruptive challenges," it can also be done efficiently and cost-effectively.

Figure 1: The shape of things to come. "Net demand" reflects the load needing to be met after accounting for variable renewables.

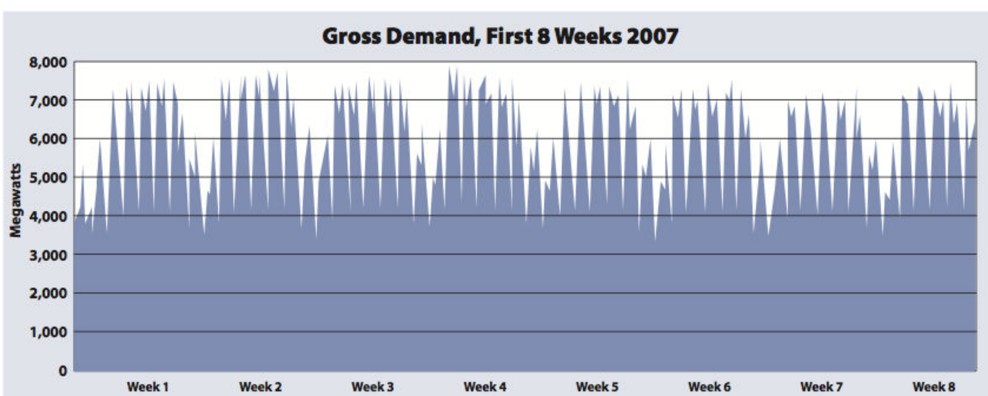
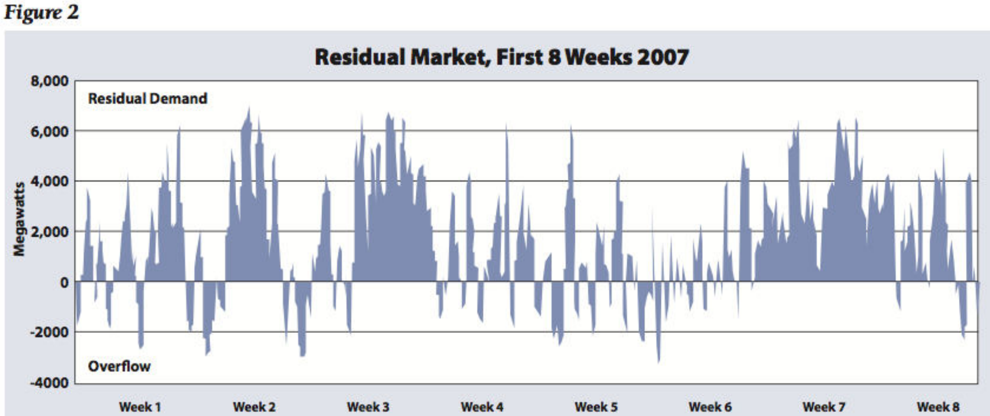


Figure 2



Source: Energinet.

Flexibility tools

The most important step to take in integrating wind and solar into the marketplace is to put a premium on flexibility. Grid operators can rely on a wide set of tools to balance supply and demand, as shown in figure 2. Many of these are simply refinements of existing tactics: rather than schedule operations an hour at a time, for example, 15-minute or 5-minute scheduling improves reliability and lowers costs.

Likewise, greater connections between regions allows the variation in wind and solar output (as well as variation in demand) to be absorbed by a larger pool, reducing the speed of changes up or down. Figure 3 shows the difference between a 200-turbine wind farm and a 15-turbine farm. Because the machines are spread more widely, their variations are blended and their total output is smoother.

Sometimes integrating neighboring regions requires new transmission lines, but often it simply requires an agreement between grid operators to coordinate their systems. Solving these “seams” issues is the most cost-effective first step.

Electricity demand is increasingly flexible too. Wireless communications and the internet are enabling smart grid controls to manage demand in factories, buildings, and homes. During shortages or periods of high prices, customers can

2. The Integration Toolbox

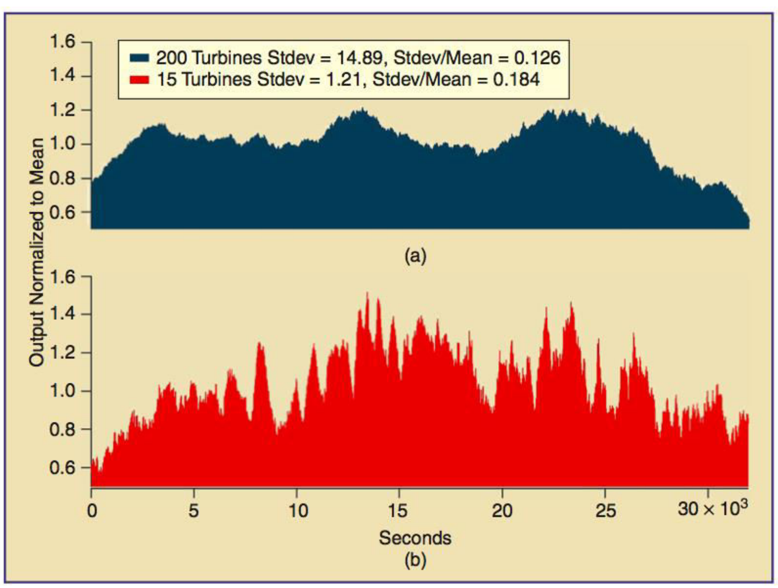
Prepared by RAP for the Western Governors Association

- Subhourly Dispatch and Intra-Hour Scheduling (non-standard, voluntary – not West-wide, 30-minute interval)
- Subhourly Dispatch and Intra-Hour Scheduling (standard, voluntary – not West-wide)[2]
- Subhourly Dispatch and Intra-Hour Scheduling (standard, required, West-wide)
- Dynamic Transfers (improved tools and operating procedures)
- Dynamic Transfers (equipment upgrades, including new transmission lines)
- Energy Imbalance Market (subregion only)
- Energy Imbalance Market (West-wide)
- Improve Weather, Wind & Solar Forecasting
- Geographic Diversity (if using existing transmission)
- Geographic Diversity (if new transmission needed)
- Reserves Management: Reserves Sharing
- Reserves Management: Dynamic Calculation
- Reserves Management: Using Contingency Reserves for Wind Events
- Reserves Management: Controlling Variable Generation (assuming requirements are prospective)
- Demand Response: Discretionary Demand
- Demand Response: Interruptible Demand
- Demand Response: Distributed Energy Storage Appliances
- Flexibility of Existing Plants—Minor Retrofits
- Flexibility of Existing Plants—Major Retrofits
- Flexibility for New Generating Plants

Source: RAP, 2012.

3: Variability is reduced through larger numbers

A wind farm of 200 wind turbines (top) has less variability than one of 15 wind turbines (bottom).



Source: Milligan, et al.

ratchet back demand to avoid costs, often using automated programs that don't require an active response on their part. As renewable energy grows, these same tools can be used to respond to variation in wind and solar output. Electric cars can be set to charge during the day, for example, when solar output is highest. The debate about California's famous "duck curve" has shown that there are many ways to integrate solar power. (Lazar, 2014)

Electricity storage, such as batteries, pumped hydro, and compressed air, often touted as a necessary companion of wind and solar, is in fact only one option, and often the most expensive.

How to Pay for Flexibility

While the many technical approaches are well-known to grid operators, and are being increasingly applied and refined, what is less evolved is how best to pay for these flexibility services.

A number of options are emerging. Like the technical fixes, many are refinements of existing financial policies and tools.

1) Wholesale prices: Locational marginal prices (LMPs) identify where and when flexible resources would be most valued. While these are typically applied only at the wholesale level, they could also be used to identify congested areas of the distribution grid ("load pockets") and offer extra incentives for distributed resources.

2) New wholesale products: It may be necessary to introduce new wholesale market products to pay for what the system needs. The California ISO has proposed a "flexible ramping product" to pay for fast-acting resources that can follow rapid changes in net demand, both up and down.

3) Customer rates: Demand-side flexibility can be improved by exposing a portion of the customer base to "dynamic pricing," rates that change to reflect the cost of production. This can encourage energy efficiency, distributed generation, and demand response, and maximize the value of flexible resources when they are most needed.

4) Demand response: DR has primarily been used in the past to reduce peak demand in emergency or high-price periods. But it can also be used to respond to rapid changes in "net demand" – that is, total demand after wind and solar are subtracted out. PJM allows demand response to participate in ancillary service markets, for example, providing reserves and balancing. Smart rate design can encourage demand response by residential and small commercial customers.

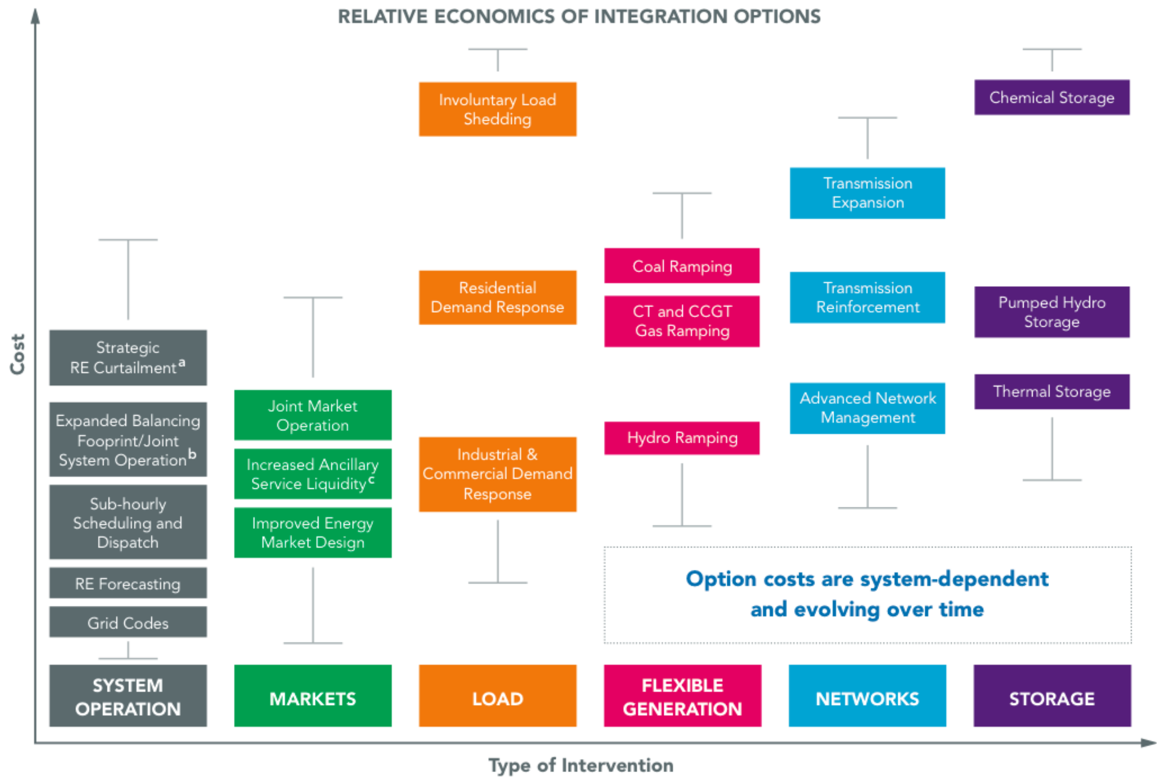
5) Customer demand charges: Currently, customers pay a demand charge whenever their own usage hits a peak, regardless of system conditions. Charging them during periods of system peak demand would give them greater incentive to reduce overall system peaks.

6) Grid planning: While "integrated resource planning" is common for guiding actions by regulated utilities in the US, transmission planning often fails to take all issues into account, including energy efficiency alternatives and public policy. "Integrated transmission planning" would account for the full value of an expanded grid. This would include counting the benefits of integrating low-carbon energy sources into the cost-benefit calculation for new transmission.

A number of flexibility improvements cost little or nothing. Making decisions closer to real time and more frequently, improved use of wind and solar forecasting, and better collaboration with neighbors can all reduce integration costs and conflicts. A "supply curve" of integration options is shown in figure 3, showing that operational changes are usually more cost effective than technical fixes.

These are just a few options for promoting flexibility in electricity markets. More refinements are continuing to emerge as regulators, grid operators, and market participants gain more experience. The bottom line is to ensure that markets align with long-term clean energy policies.

4. A "supply curve" of integration options



Source: 21st Century Power Partnership, 2014.

Further reading

Meeting Renewable Energy Integration Targets in the West at Least Cost: The Integration Challenges, Regulatory Assistance Project, for the Western Governors Association, 2012.

Wind Power Myths Debunked, by Milligan, et al., IEEE Power & Energy Magazine, Nov-Dec 2009.

Teaching the "Duck" to Fly, Jim Lazar, Regulatory Assistance Project, January 2014.

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What Lies "Beyond Capacity Markets"?: Delivering Least-Cost Reliability Under the New Resource Paradigm, Regulatory Assistance Project, August 14, 2012.

Flexibility in 21st Century Power Systems, 21st Century Power Partnership, a project of the Clean Energy Ministerial, May 2014.

The Power Markets Project studies and promotes market policies that align with clean energy goals. It is a project of PaulosAnalysis, with financial support from the Heinrich Böll Foundation, the Cynthia and George Mitchell Foundation, and the Rockefeller Brothers Fund.

For more information on the project and on power market issues, see www.powermarkets.org.