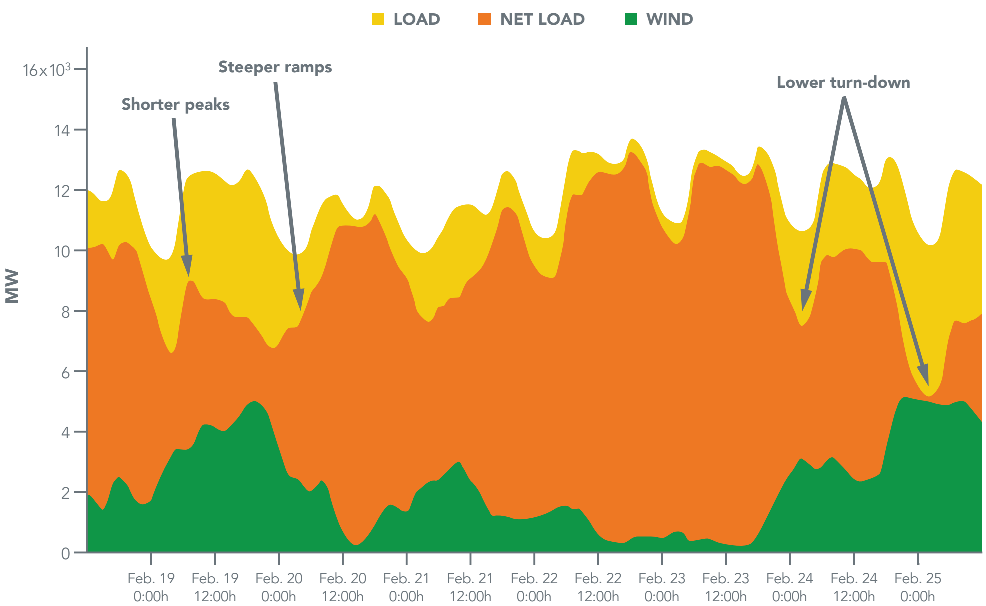
SOURCES OF OPERATIONAL FLEXIBILITY



High levels of wind and solar generation can increase the need for flexibility in a power system. In this figure, net load (i.e., total load minus wind energy) must be supplied by generation sources other than wind. Flexible generators are able to rapidly increase and decrease output, and operate efficiently at a lower level, in response to variable wind energy generation. Source: [1]

WHAT IS OPERATIONAL FLEXIBILITY?

Changes in electricity demand and generation must be constantly balanced to maintain power system stability and reliability. Operational flexibility refers to the ability of a power system to respond to these changes.

Power systems are designed and operated to efficiently manage variability and uncertainty in electricity demand and resource availability. Variable renewable energy (VRE) increases this inherent variability and uncertainty, and thus increases the need for flexibility. Systems with significant variability and uncertainty require flexible generators that can rapidly change output, operate efficiently at lower outputs, and operate for short durations. This flexibility in turn can reduce the need to curtail (decrease the output of) solar and wind generation; improve investor confidence in VRE and revenue streams; decrease the risk of negative market pricing (which results when conventional generators cannot turn down to low outputs during times of high VRE output); and reduce environmental impacts by increasing system efficiency and maximizing the utilization of VRE.

SOURCES OF FLEXIBILITY

Sources of flexibility exist—and can be enhanced—across all of the physical and institutional elements of the power system, including system operations and markets, demand-side resources and storage; generation; and transmission networks. Accessing flexibility requires significant planning to optimize investments and ensure that both short- and long-time power system requirements are met.

System operations and markets. Changes to system operation practices and markets can unlock significant flexibility, often at lower economic costs than options that require changes to the physical power system.

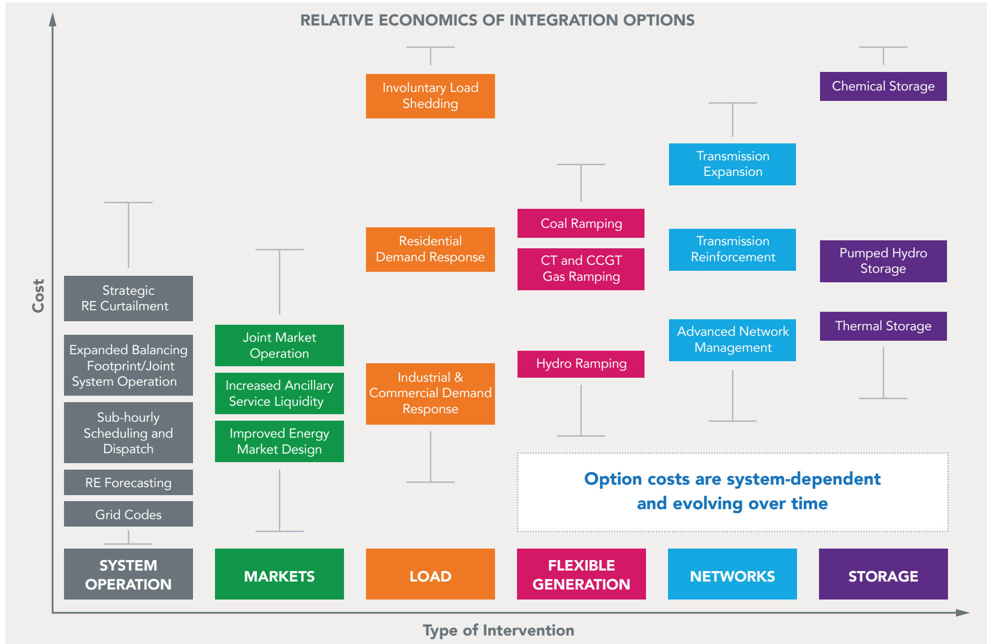
VARIABLE RENEWABLE ENERGY INCREASES THE NEED FOR FLEXIBILITY

Operational flexibility refers to the ability of a power system to respond to changes in electricity demand and generation. Flexibility is particularly important for power systems that integrate high levels of solar and wind, whose power outputs can be variable and uncertain, creating a fluctuating supply.

Variability refers to the changes in power demand and/or generation. Figure 1 demonstrates how the increased variability from renewables due to underlying resource fluctuations can impact power system operations. This figure introduces the concept of ***net load***—i.e., the demand that must be met by other generation sources if all wind and solar power is consumed. Variability in wind and solar resources has several implications for the remaining generators, which experience steeper ramps, deeper turn downs, and shorter peaks in system operations. ***Ramps*** are the increase or decrease in rate of output to follow changes in net load. If, for example, wind generation is decreasing at the same time that demand rises, ramps can be steep, leading to less efficient generator operation and possibly a need for additional maintenance.

Other challenges occur during periods when power demand and wind and solar output are poorly correlated. For instance, high wind and solar output during periods of low demand creates a need for generators that can ***turn down*** output to low levels but remain available to ramp up again quickly. In contrast, well-correlated VRE generation and demand can lead to shorter ***peaks*** for dispatchable power plants, resulting in fewer operating hours and affecting cost recovery for these generators.

Uncertainty refers to the inability to accurately predict the power demand and/or generator output, which can be affected either by unexpected outages or by the unpredictability of the resource. Uncertainty in forecasting wind and solar generation has implications for ***scheduling*** generation assets ahead of time.



Example options for increasing flexibility in power systems characterized by high levels of variable renewable energy. Relative costs are illustrative, as actual costs are system dependent. Source: [2]

Adjusting day-ahead generation scheduling practices to allow changes closer to real time allows dispatch decisions to be made based on improved forecasts of both VRE output and demand. This decreases the need for expensive reserves and allows more accurate and efficient market operation.

Other examples of institutional and operational sources of flexibility include expanding a power system's balancing area to provide access to geographically diverse wind and solar resources and diverse demand; improving wind and solar forecasting; and increasing thermal plant cycling capability.

Flexible demand and storage. Demand-side management and demand response enable consumers to participate in load control based on price signals. Demand response mechanisms include automated load control by the system operator; smart grid and smart metering; real-time pricing; and time-of-use tariffs. Demand response can be relatively inexpensive but requires strict regulations related to response time, minimum magnitude, reliability, and verifiability of demand-side resources.

Storage technologies—including pumped hydro and thermal storage and batteries—hold energy produced during periods of excess VRE generation and then discharge this energy when it is needed. Relative to demand response and other options for flexibility, storage generally has a higher capital cost [3].

Flexible generation. Conventional power plants and dispatchable renewable generators such as biomass or geothermal plants provide flexibility if they have the ability to rapidly ramp up and ramp down output to follow net load; quickly shut down and start up; and operate efficiently at a lower minimum level during high VRE output periods. New and retrofitted large-scale power plants, as well as smaller-scale distributed generation (e.g., micro combined heat and power units), can supply flexible generation.

Flexible transmission networks. Extending transmission lines and interconnecting with neighboring networks provides the power system greater access to a range of balancing resources. The aggregation of generation assets through interconnection improves flexibility and reduces net variability across the power system. Other sources of flexibility include smart network technologies and advanced network management practices that minimize bottlenecks and optimize transmission usage [4].

REFERENCES

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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.

FOR MORE INFORMATION

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