AUGUST 2017
FS-17-07-A

FACT SHEET

POWERING INTO THE FUTURE:
RENEWABLE ENERGY, RELIABILITY, AND RESHAPING THE GRID

Wind and solar are America's fastest-growing fuel sources and are making our nation's power system cleaner and more reliable than ever. *Powering into the Future*, a new report by M.J. Bradley & Associates, explains the basics of the electric grid and shows how grid operators reliably integrate renewable energy into the system.

THE KEYS TO MAINTAINING GRID RELIABILITY

The U.S. power grid consists of three separately operated and largely unconnected systems—a complex web of power plants, consumers, and the transmission and distribution systems that link them. Adding to the complexity, each network is managed by a host of entities, including utilities, power producers, grid managers, and federal and state regulators, that work together to precisely balance supply and demand every second of every day.

This supply and demand balancing act is constantly challenged by real-time events, including fluctuating consumer demand and extreme weather. Grid operators must account for every disturbance—even the unpredictable.

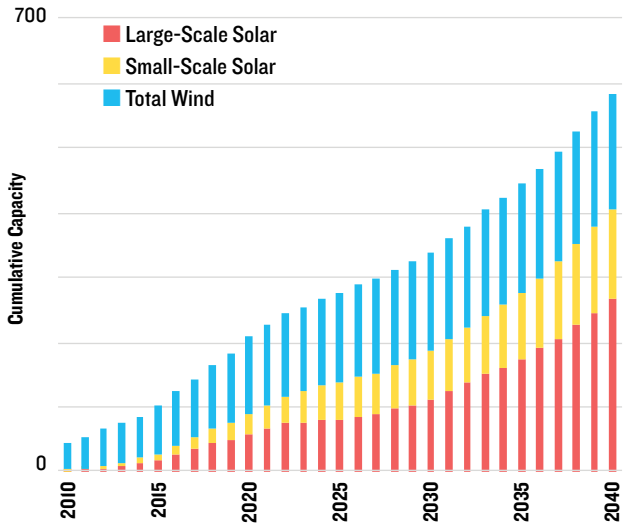
Broadly speaking, maintaining grid reliability comes down to three basic factors:

- Sufficient and flexible resources: Grid operators need enough energy resources to meet consumer demand and be flexible enough to rapidly adjust electric output in response to changes in demand.
- Frequency control: The supply of power generated on the system must perfectly match the demand from customers. Any mismatch in supply and demand will disrupt the frequency of the electrical current, which can cause short circuits, brownouts, and even blackouts.
- Voltage support: Voltage is the "pressure" in the grid that establishes the movement of electricity throughout the grid. To maintain the correct voltage levels on different parts of the grid, operators deploy a variety of devices that can absorb or generate power closer to the point of use.

INTEGRATING RENEWABLE ENERGY INTO THE GRID

Electricity generation from wind grew more than three-fold between 2008 and 2016, and solar energy generation grew more than 20-fold.[1] Projections are for strong future growth:[2]

WIND & SOLAR: PAST AND FUTURE GROWTH



Grid managers are using a suite of tools and strategies to incorporate these new, and sometimes variable, sources of energy onto the grid while ensuring reliability. These include:

- Telemetry, forecasting, and other information tools: These allow planners to "see" what generators are capable of producing in real-time and predict what they can produce in the coming minutes and hours.

WHAT IS A "FLEXIBLE" GRID? A flexible grid reliably and nimbly manages fast-changing customer needs and variable output from wind and solar power. Sources of flexibility may include distributed energy resources, fast-ramping natural gas plants, energy storage, and demand response. Other factors also contribute to flexibility, such as power market designs, grid planning, and local and regional grid coordination.

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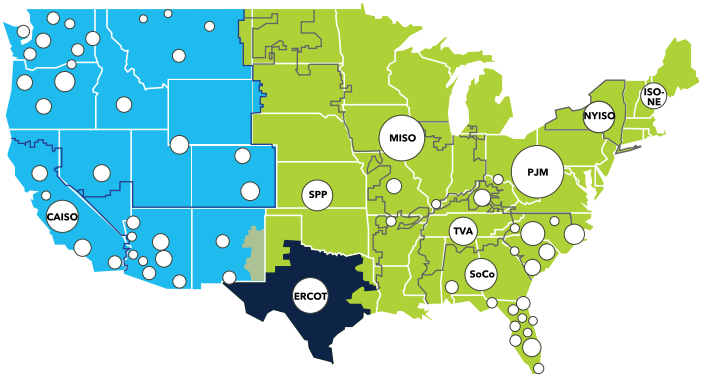
- **Transmission and distribution planning:** This can help link areas of high renewable generation—such as the windy rural Great Plains or sunny Western deserts—with areas of high demand, such as large urban centers.



74 balancing authorities—1 in Texas, 38 in the Western Interconnect, and 36 in the Eastern Interconnect—are responsible both for real-time balancing of load and supply within their boundaries and for long-term planning.

- **Broader regional market coordination:** Providing access to a larger pool of resources boosts flexibility. On a day that's sunny in Arizona and windless in Wyoming, for example, excess solar energy from Arizona could make up for less wind energy in Wyoming.
- **Advanced energy storage:** Next-generation batteries, for instance, can aid reliability by reducing grid congestion and providing reserves.[3]
- **Smart inverters and converters:** Devices that transform renewable energy output into electricity to be transmitted over the grid can quickly adjust output to provide frequency response and other controls.

USING RENEWABLE ENERGY TO ENHANCE RELIABILITY

Modern wind and solar technologies provide a wide range of reliability services—in some cases more flexibly and quickly than conventional resources. Large coal plants, for example, can take minutes or even hours to increase or decrease supply in order to match demand, whereas newer resources can respond more quickly.

Wind and solar resources can help boost reliability several ways, including:

- **Frequency control:** Many new wind and solar facilities have active power controls that enable managers to quickly and automatically adjust output in response to a disruption in frequency. This not only allows these resources to provide important grid-balancing services, it also enables many wind turbines to remain generating during grid disturbances instead of disconnecting (like some conventional resources).
- **Balancing supply and demand in real-time:** Active power controls at wind and solar plants can also follow five-minute schedules, meaning the grid dispatcher can rely on a certain level of output on a short-term basis and adjust it as necessary.
- **Voltage control:** Advanced wind control systems can manage the power output from a large array of turbines, ensuring an entire plant maintains the correct voltage at the point of connection to the grid. Rooftop solar and large solar power plants can also help control voltage by adding or absorbing power as needed at points along the grid.
- **Improving Performance:** Grid managers need to balance energy supply and demand. Wind and solar technology performance has been improving in recent years and will continue to improve over the next few decades. Improvements are increasing the capacity factor—a measure of how often a plant is actually generating power—of renewable power plants.
  - **Wind:** The average capacity factor for wind projects in 2015 reached 41 percent, compared with 26 percent from projects built between 1998 and 2003.[4] And NREL estimates that best-in-class projects could achieve capacity factors of 58 percent by 2025 and 61 percent by 2030.[5]
  - **Solar:** Large-scale solar capacity factors have seen similar gains. In 2016, the average annual capacity factor hit 27 percent for the first time, with solar farms achieving average monthly capacity factors of up to 35 percent in summer months.[6] In addition, with the dramatic decline in solar + storage costs, there are new, potentially cost-effective options that would allow solar to provide useable power day or night.[7]
- **Diversity:** Increasing fuel diversity with cheap fuels such as wind and solar helps protect consumers from price spikes and supply shortages. Renewable generation is also geographically diverse, which expands and strengthens the grid.

Integrating high levels of wind and solar energy is the next evolutionary change for the grid. New tools and technologies are helping grid managers take advantage of these new energy resources while maintaining and even enhancing reliability. Increasing the integration of renewables into our energy mix and improving grid reliability can and should go hand-in-hand.

ENDNOTES

1 U.S. Department of Energy, *Quadrennial Energy Review: Energy Transmission, Storage, and Distribution Infrastructure*, at S-1, April 2015, https://energy.gov/sites/prod/files/2015/04/f22/QER-ALL%20FINAL_0.pdf/.

2 NRDC analysis of U.S. energy forecasts. Historical Data from EIA. "Annual Capacity by State", last revised November 2016. https://www.eia.gov/electricity/data.php" \l "gencapacity" https://www.eia.gov/electricity/data.php#gencapacity. Historic small-scale and near-term solar estimates drawn from *Solar Market Insight Report 2016 Year in Review*. March 2017. http://www.seia.org/research-resources/us-solar-market-insight. Long-term energy forecasts drawn from Bloomberg New Energy Finance, New Energy Outlook 2017, June 2017.

3 Green Tech Media Research, *U.S. Energy Storage Monitor: Q4 2016*, http://www.greentechmedia.com/research/subscription/u.s.-energy-storage-monitor2. [broken link]

4 Wiser, R.H. and Bolinger, M., *2015 Wind Technologies Market Report*. Berkeley Lab, August 2016, https://emp.lbl.gov/publications/2015-wind-technologies-market-report.

5 NREL (National Renewable Energy Laboratory), *2016 Annual Technology Baseline*. Golden, CO: National Renewable Energy Laboratory, September 2016. http://www.nrel.gov/analysis/data_tech_baseline.html.

6 U.S. EIA, "Table 6.7.B. Capacity Factors for Utility Scale Generators Not Primarily Using Fossil Fuels, January 2013-April 2017", *Electric Power Monthly*, Last Accessed July 24, 2017, https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_6_07_b.

7 Tucson Electric Power, "TEP to Power 21,000 Homes with New Solar Array for Historically Low Price", Press Release, May 22, 2017, http://www.businesswire.com/news/home/20170522005290/en/TEP-Power-21000-Homes-Solar-Array-Historically.