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Transforming the Power Grid with Clean Energy—Reliably—Every Day

America's energy mix continues to evolve, with cleaner, renewable energy providing an increasing amount of dependable electricity flowing to U.S. homes and businesses. Using existing regional planning frameworks, those in charge of the high-power electric grid are keeping pace with these changes. They are retiring scores of expensive and polluting coal-fired power plants that are no longer needed and integrating significant amounts of clean and zero-fuel-cost wind and solar power into the electricity system. The result: lower electricity costs and higher reliability.

To date, more than 75,000 megawatts of wind and solar power have been integrated into the nation's electric grid.[1] However, this is only a small fraction of the total energy supply of nearly 1 terawatt (1,000,000 megawatts) of power plant capacity across the nation.[2] Real-world experience, coupled with forward-looking studies, shows that the grid can handle much higher levels of renewable energy while maintaining and even strengthening reliability.

GRID BASICS

The nation's high-power transmission system is made up of three largely separate grids: one on either side of the Continental Divide (roughly) and the third in Texas. The two largest grids are subdivided into regions. In much of the eastern United States, grid operators known as regional transmission organizations (RTOs) are responsible for managing the flow of electricity in each region, even though the lines, substations, and other equipment are owned by utilities and other commercial entities. In the Southeast and much of the western part of the country, the utilities that own the transmission lines operate their sections of the grid.[3]

Under the Federal Power Act, maintaining a reliable electric grid is a coordinated effort among federal and state authorities.[4] The Federal Energy Regulatory Commission (FERC) has the ultimate responsibility of ensuring the reliable operation of the bulk-power system, which includes the interconnected transmission network and the electric energy needed to maintain transmission reliability. (FERC does not, however, regulate the power grid in Texas.)

Many states have the authority to ensure a sufficient power supply (also called resource adequacy), which directly affects grid reliability. States that exercise traditional regulation over electric companies are responsible for ensuring that those utilities have sufficient resources available to meet projected load and reserve requirements.

Grid planners have extensive experience preparing for the future

Grid operators are the air traffic controllers of the power system, managing the flow of electrons from power plants to customers across thousands of miles of transmission lines. Regulated by FERC, they operate the grid under extremely detailed rules and procedures.

To ensure a reliable transmission system, grid operators think in several time frames. In the immediate seconds to hours, they run the grid according to a detailed set of economic and electrical engineering rules embedded in

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sophisticated computer programs. These programs dispatch power plants with the lowest operating costs first, subject to important constraints to preserve the grid's stability and avoid blackouts. Operators give priority to lower-cost plants, then move up the "dispatch stack" to more expensive plants. Many expensive power plants run only a few hours each year when peak demand is highest—for instance, on a hot summer day when air-conditioners are running full blast.

Grid operators also plan years into the future to ensure reliability. In the same way that one would not set out to drive across the desert on a half-tank of gas, they want to ensure enough power exists and can be delivered to meet consumer demand years ahead. To do so, they identify factors that could either increase or decrease the need for more power and power lines, and then plan accordingly.

Grid planners have extensive experience managing power plant retirements

Planners also look carefully at whether power plant retirements will affect grid reliability and then incorporate changes to avoid such problems. PJM, the RTO that controls the most electric power of any grid operator in a footprint extending from New Jersey to Illinois, has extensive experience dealing with plant retirements. Since 2002 it has approved the retirement of more than 70 power plants with a total capacity of just over 20,000 megawatts (MW).[5] Where reliability was at issue, PJM upgraded the transmission system to bring more power into the affected area or, in a few instances, paid a power plant to stay on line for a limited time.

WIND AND SOLAR POWER

Growing, Reliably

There is more renewable energy flowing through the power grid today than ever before. At times, wind has supplied more than 60 percent of the electricity on some utility systems, without reliability problems. Solar power now routinely contributes 10–15 percent of midday electricity demand in California.[6]

Due to more precise weather forecasts and sophisticated technologies, grid operators increasingly can predict and control wind and solar generation levels.[7] Using advanced and often automatic control systems, grid operators can both increase and decrease the power output into the grid, which helps to stabilize its electrical frequency and maintain reliability.[8]

Needs less backup power than coal, gas, and nuclear

Every electricity resource on the grid needs backup power in case something happens to prevent it from generating as much electricity as planned. The loss of a large power plant can happen at any time, so grid operators have at least 1,000 MW (enough to power a large city) of reserve generation standing by 24/7, ready to activate at a moment's

notice. Wind and solar power, however, need less backup than coal, wind, and nuclear. Why?

In contrast to the large, abrupt, and often unpredictable changes in electricity output from coal and nuclear power plants, wind output changes tend to be gradual and predictable, especially when wind turbines are spread over larger areas.[9] The fact that a wind farm is a collection of many smaller turbines also helps, since the failure of one will have little impact on the farm's total output.

For these reasons, the nation's major grid operators have found that wind and solar energy need very little backup power:

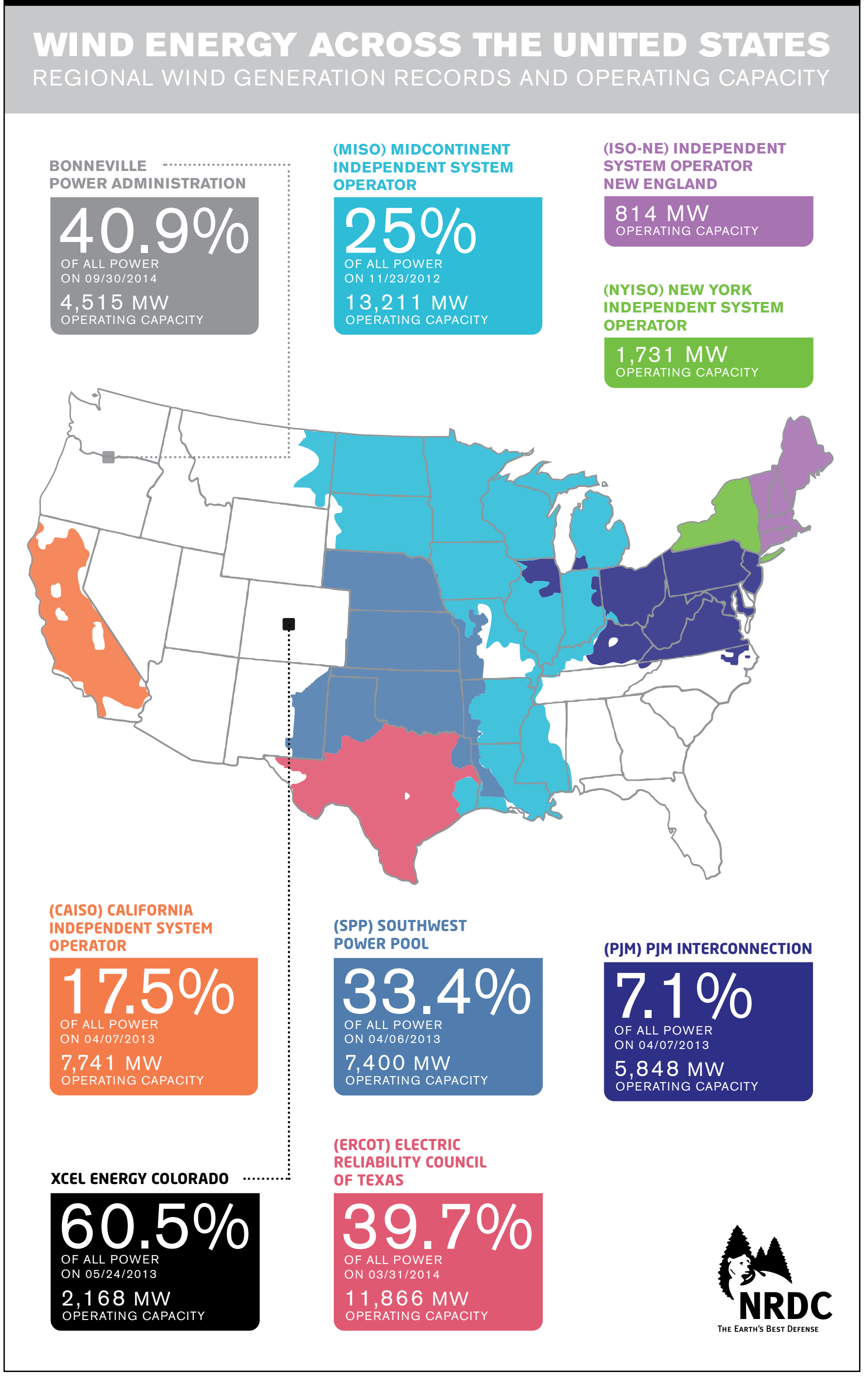
- MISO, the grid operator for the middle part of the country, needs almost no additional fast-acting power reserves to back up its 10,000-plus MW of wind power on the system.[10]
- ERCOT, the grid operator for most of Texas, needs only about 50 MW on average of fast-acting stand-by reserves to reliably integrate 10,000 MW of wind into the grid.[11]
- Increasing PJM's renewable energy output sevenfold by adding 35,000 MW of renewable energy would increase the need for fast-acting reserves by only 340 MW. For comparison, PJM currently holds 3,350 MW of expensive, fast-acting reserves 24/7 to ensure that it can keep the lights on in case a large fossil-fuel or nuclear power plant unexpectedly breaks down.[12]

Our highly adaptable grid is successfully integrating reliable, cleaner energy now and will continue to do so

The power grid has always adapted to changing state and national energy trends and needs, thanks to regular operations and planning frameworks. Forty years ago grid operators learned to plan and prepare for large nuclear or coal plants tripping off line. Now, as utility-scale wind and solar power rapidly expand, grid operators are successfully integrating these new resources into the grid while retiring many outdated coal plants.

The U.S. Environmental Protection Agency's plan to limit pollution from existing power plants will motivate states to use more of these cleaner resources to reduce their emissions.[13] Whatever solutions states choose in order to meet their targets, the grid can easily handle the renewable energy and energy efficiency needed to achieve the relatively modest carbon emission reductions in the EPA's plan.

Figure 1: Record Wind Output Levels to Date[14]



ENDNOTES

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11 David Maggio, "Methodology for Calculating Reserves in the ERCOT Market" (presentation, UVIG Spring Technical Conference, San Diego, April 24–26, 2012), at 6, variablegen.org/wp-content/uploads/2012/12/Maggio-Reserve_Calculation_Methodology_Discussion.pdf (accessed November 25, 2014). Charts show the average difference between wind and no-wind reserve requirements.

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13 U.S. Environmental Protection Agency, "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units," *Federal Register* 79, no. 117 (June 18, 2014): 34830, www.gpo.gov/fdsys/pkg/FR-2014-06-18/pdf/2014-13726.pdf.

14 Source: American Wind Energy Association, independent analysis based on real-time data made publicly available by ISOs and utilities.