Perspective

Bringing Wind Energy Up to 'Code'

Grid reliability is one giant step in mainstreaming the technology.

BY RANDALL S. SWISHER

RANDALL S. SWISHER

Wind power is coming of age in the United States. During the past five years, installations have grown by an average 28 percent yearly. Gleaming, high-tech wind turbines now are interconnected to the bulk power grid in some 30 states. The membership of the American Wind Energy Association (AWEA) has tripled in recent years and now includes such manufacturing and energy giants as General Electric, FPL Energy, ScottishPower, and American Electric Power.

As wind power expands, increasingly energy company CEOs are facing the question of whether to invest. Some, like Terry Hudgens, CEO of PPM Energy, or the senior management team at FPL Energy, already have propelled their companies ahead of the wind power curve. Still, misconceptions linger about wind energy's potential (can wind ever be more than a niche market?), its feasibility (won't a variable resource like wind wreak havoc on the grid?), and its cost (doesn't every megawatt of wind need to be backed up with a megawatt of firm power?). This update will dispel some of those misconceptions and spotlight the real challenges and opportunities in bringing more of this new product to the wires.

Can It Be Done?

According to Deputy Secretary of Energy Kyle McSlarrow, the goal of installing 100,000 MW of wind power by 2020 (generating approximately 6 percent of U.S. electricity supply, or about what hydropower provides today) is realistic.[1] McSlarrow, speaking earlier this year, emphasized the importance of technology diversity in power generation. The Energy department estimates that approximately 600 GW of wind capacity (enough to easily provide 20 percent of U.S. power supply, or about what nuclear power or natural gas provides today) is cost-effective at the wind plant busbar when natural gas is at $4 per million BTU. In fact, gas prices that had been hovering at $5 spiked to $20 on the spot market earlier this year. The real issue, then, is the cost of reliably getting wind power from the plant busbar to market—not wind energy technology or the scale of the resource.

On Denmark's Jutland peninsula,

wind generates 28 percent of the electricity supply. Several regions in Germany and Spain operate with more than 20 percent wind penetration. In the United States, regulators, utility managers, and transmission system operators in Texas "just did it" (see sidebar) and put in place more than 1,000 MW of wind power while keeping the system as reliable as any in the nation. The question facing decision-makers today is not, "Can it be done?" but "How? And at what cost?"

Texas 'Just Did It'

1999: Texas passes electricity restructuring legislation including a Renewables Portfolio Standard (RPS) requiring 2,000 MW of new renewable generating capacity by 2009. Windy West Texas is its own little control area, with little load, and is isolated within ERCOT.

2001: Following extremely competitive bids from wind power (at 3 cents/kWh or less, taking into account the federal wind production tax credit, or PTC), more than 900 MW of wind are installed in West Texas in one year—propelling Texas two years ahead of the minimum 400 MW of new renewables required by 2003 under its RPS. At the same time, Texas becomes one single control area and enacts transmission reforms to maximize efficient use of the grid and accommodate new technologies, including allowing variable sources like wind to deliver power in real time without incurring standard schedule deviation penalties.

2003: Having maximized efficient use of existing lines through tariff reform, Texas upgrades some of the lines and builds new ones to eliminate curtailment and fully serve existing wind generation. The state is also exploring ways to further expand transmission capability.

What About Reliability?

If wind is to contribute ever-larger amounts of electricity to the nation's wires, wind power plants need to be good citizens on the grid.

In Denmark and other regions with high wind power use in Europe, wind turbines now operate with a variety of features that actually enhance grid reliability. At the offshore Horns Rev wind farm in Denmark, for example, turbines can stay connected in the event of a short-circuit and help maintain the system's power quality. Cutting-edge software allows grid operators to monitor and manage the output from large numbers of wind turbines in different locations. The sophisticated electronic controls and capabilities of modern wind turbines have changed the energy equation and made it possible for wind power to actively contribute to grid reliability.

Modern wind turbines can and should be designed to:

- Ride through system faults and continue to supply energy to the system when those faults clear;
- Contribute reactive power and active voltage control for stability of the common grid; and
- Communicate with grid operators and be instructed to limit output or rate of change in output if necessary for grid reliability.

AWEA has proposed a "Wind Grid Code" to quantify these performance requirements (and others) in a cost-effective, non-discriminatory way, and is working with engineers and regulators to ensure that wind indeed contributes its fair share to grid reliability.

What About Transmission?

A wind energy grid code is not sufficient, however. If market rules are inefficient and continue to stifle new competition, being a good citizen will be of little use. Changes are needed in those rules—changes that would benefit consumers, irrespective of wind.

Today, the nation's power markets are governed by more than 200 different tariffs that set the rules and conditions for access to, and use of, the grid. Most of these tariffs assign fixed costs to incremental transactions and impose non-cost-based penalties on generators that deviate from precise advance schedules—causing newer and non-standard resources like wind to bear a disproportionate share of the costs of building and operating the common grid. Meanwhile, some major markets, such as the Pennsylvania-New Jersey-Maryland Interconnection (PJM), operate under a totally different, more efficient tariff that coincidentally happens to be very wind-friendly.

The challenge will be to extract those features from these newer tariffs and apply them to wind generation in more traditional tariffs while enhancing reliability but not shifting costs onto other generators and loads. Several jurisdictions or utility systems have successfully accomplished this, including California, ERCOT, PacifiCorp, and the Bonneville Power Administration (BPA). Where such changes are taking place, the results are dramatic.

In California, where the California Independent System Operator (Cal-ISO) replaced discriminatory, non-cost-based penalties with a requirement that wind generators provide forecasts for their energy deliveries that can be used to assign transmission capacity, the costs for wind to use the common grid are about $2/MWh. By contrast, on the Western Area Power Administration (WAPA) system, which operates under an older tariff, the cost of bringing wind to market is about 10 times more, or $20/MWh, at equivalent penetration levels.

What Does It Cost to Integrate Wind?

So what are the real costs, if any, of utility integration of wind? How can they be defined and measured?

In the United States, a first generation of studies offers some preliminary conclusions. These studies—from Xcel Energy, PacifiCorp, BPA, We Energies, and consultant Eric Hirst—are summarized in a report by the Utility Wind Interest Group (UWIG),[2] an organization of some 55 utilities that have wind power on their systems.

The UWIG survey concludes that the studies "lay to rest one of the major concerns often expressed about wind power: that a wind plant would need to be backed up with an equal amount of dispatchable generation. It is now clear that, even at moderate wind penetrations, the need for additional generation to compensate for wind variations is substantially less than one-for-one and is often closer to zero."

Nonetheless some costs do exist, and more detailed studies are needed to quantify them. A second generation of studies, currently under way, should provide much more quantification to the tentative conclusions that can be drawn from the previous studies and international experience:

- The limits to integration of wind on a utility grid are economic, not technical (the technical limits, based on European experience, are reached at approximately 40 percent penetration on an annual average energy basis);
- Costs are minimal (say, <$2/MWh) at low penetration, modest (say, ~$5/mwh) at medium penetration, and mitigatable at high penetration levels with a hockey-stick shape;
- The value of low, medium, and high principally depends on:
  - –size of region
  - –type of tariff
  - –stiffness of grid[3]
  - –flexibility of other generation;
- The order of mitigation actions is generally: software/IT (wind forecasting being a principal tool); curtailment of wind output during extreme minimum load hours; (as medium penetrations are reached) transmission investment; (at high penetrations only) new other generation to back up wind; and finally, storage. It is almost never cost-effective to "firm the wind." The grid itself, with all its diversity, is the best storage;
- The economic limit is reached when wind curtailment is too high and the next reasonable transmission investment is not justifiable.

As an example, New York is average to above-average on this scale. The region is relatively large, and flexible hydropower and natural gas make up an important part of the generation mix. Some special transmission and operating rules will need to be put in place—just as special rules exist to this day to accommodate the specific characteristics of New York's nuclear power plants. But New York should have no difficulty reaching 15 to 25 percent wind penetration without major capital investment to deal with variability. As the first phase of a study funded by the New York Independent System Operator and New York State Energy Research and Development Authority recently concluded, meeting its renewables portfolio standard requirement of increasing the percentage of electricity supplied by renewables to 25 percent by 2012, up from about 17 percent today, is clearly feasible. Phase II of that study, to detail required measures, is due out by the end of 2004. Similar studies are under way in California and Minnesota.

More generally, tariffs that impute a high percentage of the fixed costs of building and operating the transmission system to only the last generator on line or that impose significant non-cost-based penalties for deviations from standard generator behavior tend to impute high wind-penetration costs. More modern tariffs that conform to well-founded economic principles of only charging variable costs to individual transactions while sharing fixed costs over all loads and resources, and that use incentives instead of penalties to encourage good behavior, will, for the same set of facts, impute significantly lower costs. As with transmission access, it is the accounting, not the physics, that determines wind integration costs.

Wind energy's growing success in the marketplace is a good indicator of its attractiveness. As more and more managers and decision-makers become familiar with wind power's characteristics and what it takes (or does not necessarily take) to integrate wind, they will enjoy the icing on the cake that comes with the power supplied by wind: a stable price over time (not subject to volatility in the cost of fuel); savings in resource use (of fuels, water for cooling systems or steam, land for waste disposal); no emissions and, as a result, insurance against environmental risk; and, perhaps most importantly, in spite of the occasional and inevitable not-in-my-backyard outcries of some local residents, support from the vast majority of the public and electric consumers.

Randall S. Swisher has served as executive director of the American Wind Energy Association since 1989. Contact him at rswisher@awea.org.

Endnotes

1. Presentation at Global WINDPOWER 2004, Chicago, March 29, 2004.
2. The report is available online at: *http://www.uwig.org/UWIGOpImpFinal11-03.pdf.*
3. Stiffness of the grid means sufficient transmission capacity to spread the wind and load variability over a relatively large region. Flexibility of other generation means the ability to cost-effectively and quickly change output in response to control signals from the grid operator or changes in spot prices.