May 21, 2013

Please find below responses from Dr. Robert Michaels to questions submitted for the record.

1. It was recently announced that wind was the largest source of newly installed electricity capacity during 2012, and the wind industry regularly touts this growth as a sign of the technology's growing competitiveness and maturity level. However, in the 'Fiscal Cliff' deal, the Production Tax Credit (PTC, the primary tax subsidy for wind), was extended for another year at a cost of $12 billion.

a. Is wind cost-competitive without the PTC? If not, when – if ever - is it expected to be?

Without the PTC, wind is generally not competitive, even if we disregard the added grid operation costs that its intermittency imposes. The U.S. Energy Information Administration expects this situation to continue. Exhibit 2 to my filed testimony shows EIA's 2018 forecast of total levelized [i.e. annualized capital and operating] costs per megawatt-hour (MWh) of gas-fired and onshore wind generation. All-in costs [i.e. inclusive of fuel] per MWh for gas are approximately 24 percent lower than those for wind. Without the PTC subsidy, power from the wind unit will not be cost-competitive. The comparison worsens after we account for the added costs imposed by wind's intermittency. They include those of fuel that extra reserve generators must burn, investments in transmission (which generally operates at less than capacity) whose only use is to reach isolated windy sites, and losses of power associated with that transmission. Even if turbine technology somehow improves to eliminate the 24 percent premium discussed above, there are no substitutes for transmission and little prospect that its costs will fall. The improbability of massive improvements in turbine efficiency, and the unavoidability of extra reserve and transmission costs all strongly suggest that wind will never be competitive with conventional power.

b. How have sustained low natural gas prices impacted the competitiveness of alternative energy sources, specifically wind?

As the likelihood of low gas prices over the forthcoming decades increases (See, e.g. recent EIA forecasts), wind can only become less competitive. Further, the security, accessibility and growth of America's gas reserves are rendering irrelevant any arguments that wind power will be of value for maintaining fuel diversity or national security.

2. Which has a greater impact on wind capacity growth – subsidies, such as the Production Tax Credit, or mandates, such as state renewable portfolio standards (RPS)?

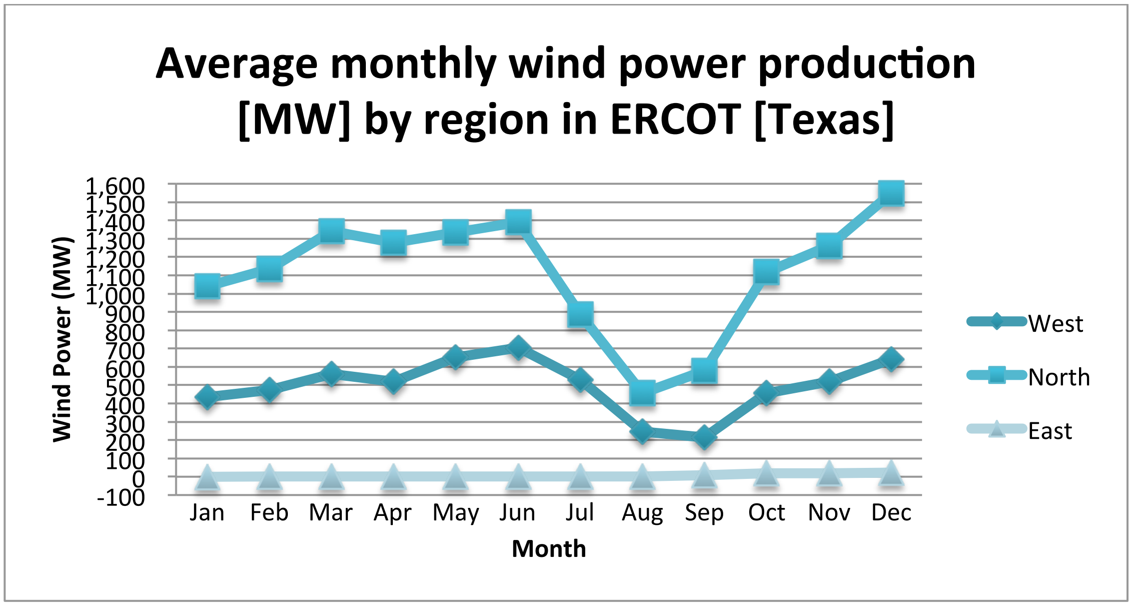
Economists are still attempting to untangle the influences of these two factors and have yet to arrive at a consensus. In many areas wind power is the least-cost way to meet a RPS (In a few others geothermal and biomass are competitive). The problem is that wind-poor states appear less likely to enact RPS, for example most states in the southeast are without one. Thus wind power often thrives in areas that are best suited for it, in which investors build more plants that qualify for the PTC.

Whatever the actual influence of the PTC, we should note that if a state RPS effectively compels investment in wind the federal PTC becomes redundant. To induce RPS compliance state regulators must set rates that are high enough to ensure the returns of wind developers. A PTC in effect compels residents of non-RPS states to subsidize the wind investment in RPS states. These tax payments by residents of non-RPS states provide them with no discernible benefits. These comments expand on those that I made at the hearing in an exchange with Chairman Broun. (Tr. 40)

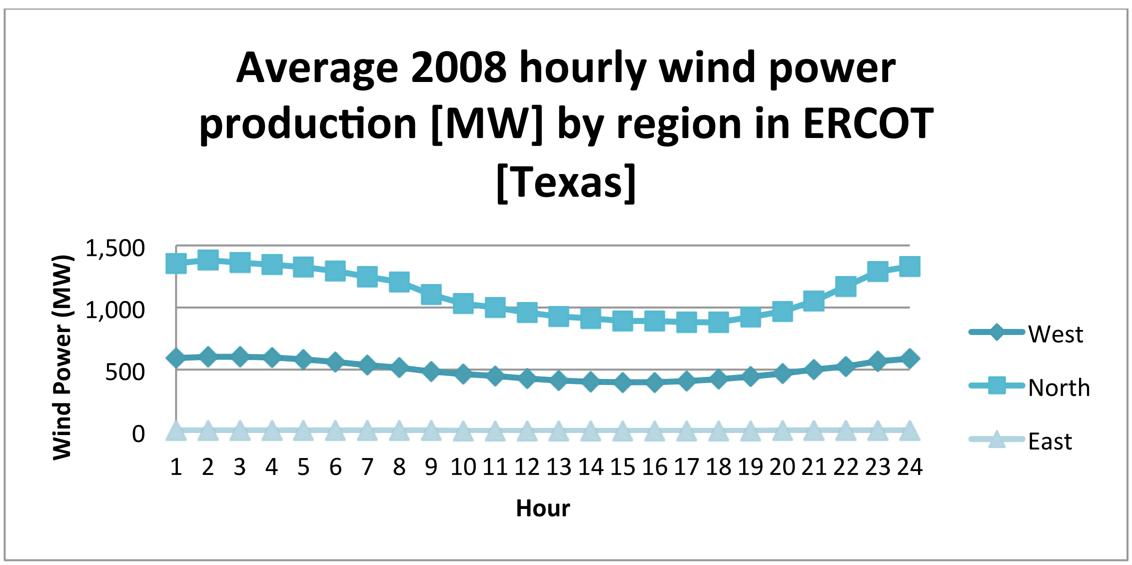
3. Your written testimony notes that data on installed wind capacity are of little or no value in predicting the actual power the system can get at peak times. Please explain the source of the discrepancy between the data and reality.

The following three graphics may be helpful supplements to those in my filed testimony. All use hourly and daily data from the Electricity Reliability Council of Texas [ERCOT], which operates the grid that serves 80 percent of the state's households and businesses.

The first shows how average wind power output per hour varies over the year for turbines in western, northern and eastern Texas. (The very low "eastern" line reflects that area's small generation capacity.) High air conditioning loads drive the demand for power to its peak between July and September, precisely the period at which the average output of wind power falls to its minimum. Conversely, average wind power production is highest during the winter and spring when the need for supplemental power is least.

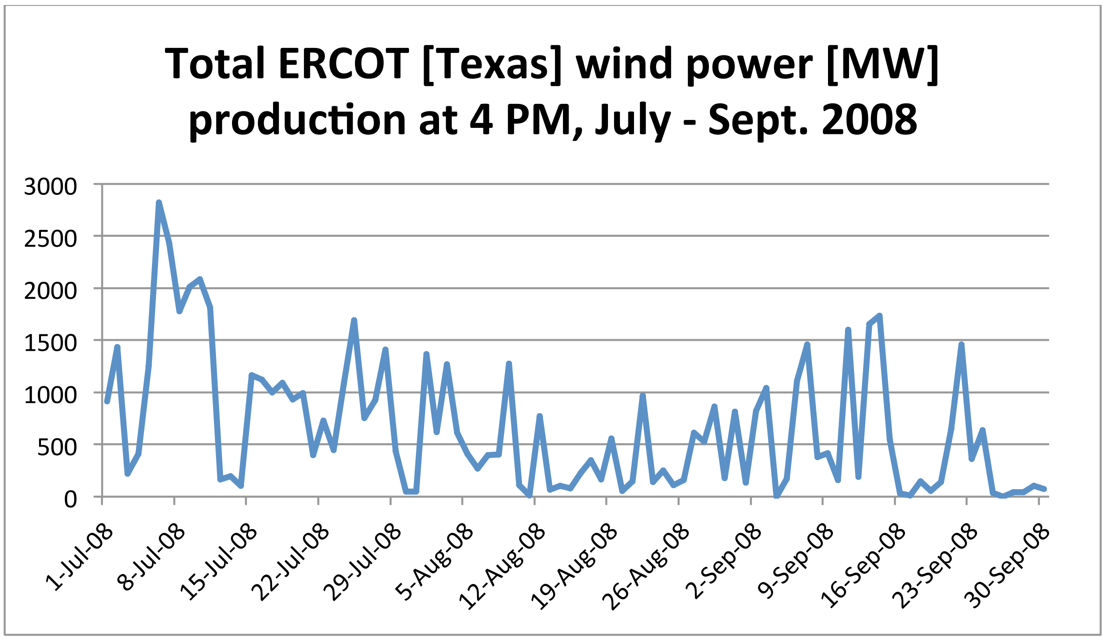


The next chart shows average hourly production of wind power in ERCOT regions over the course of 2008, e.g. the figure above "15" corresponds to the average between 2 and 3 PM (15:00) over 365 days. Again, average wind power output is at its lowest during the hours when it is most valuable. Power consumption by households and businesses typically peaks in afternoon and early evening, when average wind power output is at its lowest.



The next figure uses the same data to illustrate the peak-hour forecasting problem. It plots daily ERCOT wind power output at 4 PM for July, August and September 2008. The fluctuations are *not* reflective of hourly movements.

Rather (e.g.) three consecutive points show 4 PM wind power outputs on three consecutive days. The degree of correlation between nearby points is minimal – a high-wind day is as likely as not to be followed by a high, low or average day. Thus not only does 4 PM wind power output vary dramatically (on one day it reached zero). It varies in ways that make near-term predictions very difficult. The randomness has an important cost consequence: unpredictability requires the commitment of larger reserves of gas-fired generation. If the wind suddenly stops blowing and reserves are not instantly available, even a momentary gap between supply and demand will bring blackouts in its wake.



4. Your testimony discusses how the unpredictable nature of wind power makes it difficult for customers to make decisions about power consumption.

A. How has this challenge affected customers in states already utilizing significant amounts of wind energy?

The issue is not currently relevant for most power consumers, but promises to become so as intermittent power sources grow and as "smart grid" innovations and changes in state-regulated rates come to affect more users. In the growing number of states with competitive power markets energy prices fluctuate, sometimes over five minute intervals, with changing supplies and demands. In a market without intermittent power sources, competitive generators are likely to improve price stability – e.g. an expectation of high prices at the peak will induce some higher-cost generators to operate, and their added production will reduce the severity of possible price spikes. Unpredictable wind generation must also be bid into the market. Unpredictability means that unexpected changes in wind velocity will ultimately bring greater randomness in power prices, and this can have consequences for operating efficiency. A sudden wind upswing may bring prices lower than were expected by generators that had previously committed themselves to operate. The randomness of wind means that prices become less predictable, both for generators and for those customers who receive power at real-time prices. The number of customers who face time-varying prices will soon only increase as "smart grids" encourage the use of "home area networks" that allow users to time-shift their consumption.

Beyond making prices more random, federal wind policy is already affecting longer-term investments in new generation resources. Donna Nelson, Chairman of the Public Utility Commission of Texas, recently testified on the causes of a looming generation shortage in her state:

> "Federal incentives for renewable energy… have distorted the competitive wholesale market in ERCOT. Wind has been supported by a federal production tax credit that provides $22 per MWh of energy generated by a wind resource. With this substantial incentive, wind resources can actually bid negative prices into the market and still make a profit. We've seen a number of days with a negative clearing price in the west zone of ERCOT where most of the wind resources are installed…. The market distortions caused by renewable energy incentives are one of the primary causes I believe of our current resource adequacy issue… [T]his distortion makes it difficult for other generation types to recover their cost and discourages investment in new generation." (Testimony before Texas Senate Natural Resources Committee, Sept. 6, 2012)

B. How have the energy market and the economy in those states been affected?

As noted in my response to (A), these problems are already affecting investment in conventional generation. Forthcoming developments in real-time pricing will add to the difficulties in decision-making that wind poses for consumers. Any continuing growth in wind power can only make adaptation to these changes more difficult.

5. In the White House memo on the "Shepherds Flat" loan guarantee project in Oregon, the President's top economic and climate advisors – Larry Summers and Carol Browner – warned the President that the Shepherds Flat project was double dipping to the tune of $1.2 billion in subsidies for a project that (a) would generate an estimated return on equity of 30%; and (b) would likely move forward even without a Federal loan guarantee.

What can be learned from this example, and what is the best way to ensure federal spending on wind – if it is to proceed at all – is only directed to projects that would otherwise not go forward?

My testimony noted that despite GAO's allusions to the contrary the economic rationales for federal subsidies (as well as loan guarantees) reduce to just one. Specifically, allocations to develop wind technology might be theoretically justified if in fact markets do not give inventors rewards that suffice to induce innovative activity. This reasoning could in principle justify subsidization of those attempting to devise new basic technologies, but it cannot rationalize subsidies like the PTC that encourage deployment of already-existing technologies. Over 98 percent of the funds studied by GAO, however, support deployment rather than invention. The subsidies for both Shepherds Flat and Cape Wind as described by Ms. Parker (April 16 Testimony, 6) appear to be entirely for deployment rather than innovation, and as such are economically unwarranted.

Looking only at federal support for invention, GAO's theoretical arguments cannot by themselves justify such a policy. Empirical justification is also required, and GAO provides none. The wind turbine industry is global and dominated by large corporations (e.g. General Electric and Mitsubishi) that can fund innovative activities internally, and it is clear they do so as part of their competitive strategies. Further, wind innovators can and do have access to patents that protect their intellectual property against infringement. Other industries as "mature" as wind continually see competition to invent without reliance on subsidies, and I see no differences that might justify special treatment for wind.

One must ask why DOE even entertained requests for support from a developer who forecasted a return on equity of 30 percent for its project. The capital markets are eager to fund investments that promise such wealth to investors who are quickest to spot them. As for projects that "would not otherwise go forward," It appears likely that the capital markets have already judged them to be wasteful of the world's scarce resources. It is hard to believe that civil servants (spending taxpayers' money instead of their own) will have either the ability or the motivation to outperform markets in evaluating the best uses of the economy's scarce capital. Profitable projects do not need a federal payment, and unprofitable projects should never get one.

6. Please find attached a letter and fact sheet from a representative of the Cape Wind project addressing portions of your testimony for the hearing. Do you have any comments in response to the attached documents?

My testimony was intended to portray wind power issues in general terms rather than to evaluate Cape Wind, which I have never studied in detail and about which I have no firsthand knowledge. Cape Wind's transmission path to the regional grid will indeed be relatively short, but the same can be said about all but a few potential projects in a region as small and dense with transmission lines as New England. I also have no direct knowledge of Cape Wind's expected power production pattern over days and seasons. I am, however, aware that both supporters and opponents of the project agree that the prices to be paid for Cape Wind's power are considerably higher than those at which it can currently be obtained from reliable sources.

<u>Question from Rep. Randy Neugebauer</u>

1. Ability to generate wind power is greatest when that power is least valuable (at night), and least during the late afternoon, when the power is most valuable.

a. What technological gaps would need to be bridged in order to more easily facilitate storage of wind power and lower the cost of doing so?

Both governmental and private researchers are trying to develop technologies they hope will ultimately allow storage of wind-generated power that can transfer it to times when it is most valuable. Technologies under scrutiny range from compressed air to flywheels to advanced batteries, as well as pumped hydro storage in the few areas with appropriate geology. At present these technologies are neither economic nor scalable, but few in or out of government can claim much expertise in predicting what will be invented, and when. The U.S. should not base wind policies on a hope that inventions will materialize, and even if they do so there remain the problems and costs of integrating new technologies into the grid. Further, whether or not new storage technologies emerge the high costs of wind generation itself will probably remain.

b. Is any power lost in transmission, and if so, how much?

Power is lost in transmission due to resistance inherent in transmission lines. The Energy Information Administration estimates that in 2010 approximately 6.3 percent of all power generated in the U.S. was lost in this way. [*State Electricity Profiles 2012*, Table 10] Because electricity from all sources is commingled in the grid, there is no way to calculate the line losses of power from an individual generating plant.