# OVERBLOWN

Jon Boone

*THE LESS ONE KNOWS ABOUT THE UNIVERSE, THE EASIER IT IS TO EXPLAIN—*
Leon Brunschvicg

## TRUTH AND CONSEQUENCES

Energy journalist Robert Bryce recently broke the news to mainstream American media. In a hard-hitting article published in the Wall Street Journal, he reported the findings of a Colorado energy research study, which earlier this year concluded that industrial wind technology in the regions of Colorado and Texas it sampled neither reduced carbon dioxide ($CO_2$) emissions in the production of electricity nor rolled back consumption of fossil fuels.

The raison d'être of the wind industry is to abate significant levels of the greenhouse gas emissions many feel are causing precipitous and adverse warming trends in the earth's climate. Wind technology is also sold as an alternative source of power to coal-fired plants. Therefore, the American Wind Energy Association (AWEA), the trade organization for a constellation of limited liability wind companies, did not exactly welcome Bryce's report with arms open. Instead, AWEA spokesman Michael Goggin penned a stern riposte, which alleged that Bryce and others skeptical about the efficacy of wind technology were "lobbyists" for the fossil fuel industry, spreading lies "to avoid losing market share to wind energy," and compared Bryce and a range of people and organizations to the groups and pundits from the tobacco industry who once told Congress there was no causal link between cigarettes and cancer.

Goggin also produced evidence and testimonials in ABC fashion that he claimed validated "one of the *universally recognized and uncontestable* (italics added) benefits of wind energy: that (it) reduces the use of fossil fuels as well as the emissions and other environmental damage associated with producing and using these fuels." He further boasted there were "reams of government data and peer-reviewed studies" supporting the effectiveness of his employer's technology.

Before addressing AWEA's evidentiary offerings on behalf of wind's carbon saving/ fossil fuel slaying potential—a bit of clarifying context.

First, Bryce is an energy realist who writes to effect more informed energy discourse in the hope of achieving better energy policy. In a recent televised forum at the Manhattan Institute in which he introduced his recent book, *Power Hungry*, Bryce maintained he is not a political or economic ideologue, is bored with political labeling, and that his ideas result from the way he was "mugged" by the laws of physics. He believes the most effective way to transition from high usage of coal, which now provides nearly half of the nation's electricity and emits about a third of its $CO_2$ emissions, requires a rapid increased deployment of natural gas generators as a bridge to a pervasive use of nuclear technology. And he recommends that environmentally questionable coal extraction techniques, such as mountaintop removal, be made illegal—the sooner, the better. Hardly the words of a fossil fuel lobbyist.

Second, contrary to the carefully cultivated perception that wind is David to coal's Goliath, the record shows that people and corporations heavily involved with coal, natural gas, and oil are also involved with wind. In the 1990s, Enron's Ken Lay, helped by then Texas governor George W. Bush (today a leading wind booster), resurrected wind technology from the tomb that steam power had consigned it. Giant energy corporations swaddled in coal and oil production, such as Florida Power & Light, General Electric, BP, AES, and Siemens, are all intensely invested in wind. They claim to be "diversifying their energy portfolios." But do they also expect wind to reduce their fossil fuel market share?

Third, the National Academy of Science, in a report published in early 2007, concluded that, in the words of one of the researchers, "Wind power will thus not reduce carbon emissions; it will only slow the increase by a small amount."[1] Engineers and environmentalists in Britain, The Netherlands, Denmark, Canada, and Australia followed suit, publishing papers that are not only skeptical of wind's $CO_2$ offsetting abilities but also offer methodological accounting systems for scientifically calculating wind's carbon impact on the electricity grid. None are beholden to the fossil fuel industry and none are paid lobbyists like Goggin. All, including the NAS, have been rebuffed in their efforts to examine data on wind integration behavior at meaningful time intervals and amounts; instead, they've been told that such data is "proprietarily confidential," and can't be released without the consent of the affected wind companies. So much for the transparency and accountability that were once the pillars of public policy, not to mention the scientific precept of refutability.

A few sources do publish wind performance information, notably the Ontario IESO and, most thoroughly, the Bonneville Power Administration (BPA) in the Pacific Northwest. One can also get, with some digging, historic wind data on a plant-by-plant basis in New York and Pennsylvania. This information has clarified the peculiar nature of wind performance per se. But it is insufficient, for reasons explained later, to account for the way that "peculiar nature" affects the thermal performance of conventional generators throughout the grid system. And it is this phenomenon that intrigued the researchers from Colorado.

Fourth, it is true that the Independent Petroleum Association of the Mountain States (IPAMS, which is now the Western Energy Alliance) commissioned the Colorado report produced by Bentek Energy, an energy analytics firm based in Colorado. It is also true that Bentek was the *first* to get real time performance data at sufficiently fine-grained time intervals, using an ingenious methodological approach that examined the heat rate penalties of (particularly) coal plants intimately involved with wind integration. More on this later. What is astonishing, given the nearly universal aversion to sharing wind related performance data, is that Bentek got permission to do this at all. Bentek demonstrated that, in the regions it studied, the peculiar nature of wind performance caused coal plants to perform more inefficiently, "often resulting in greater $SO_2$, NOx, and $CO_2$ emissions than would have occurred if less wind energy were generated and coal generation was not cycled." The report concluded by recommending that Colorado and Texas begin replacing their older coal units with flexible fossil-fired natural gas units that produce half the emissions of coal plants.

Ironically, this is precisely the recommendation that the National Renewable Energy Lab (NREL) made in the EWITS study Goggin cited. It is also the basis of AWEA's own prescription for making wind variability work. On the one hand, Goggin rejects the Bentek study as a creature of the evil fossil fuel empire. But, without a hitch in his giddy-up, he then embraces language in that study that places fossil fuels in service to the white knights of wind. Whether this flop was noticed is unclear.

## HOW PECULIAR IS IT?

What's clear is that wind performance is very peculiar in terms of providing highly reliable and secure electricity at affordable cost. The following profile generally fits all industrial wind facilities, with their skyscraper-sized turbines placed five to a mile atop ridgelines for many miles along terrain or seabed. Because any wind "power" is a function of the cube of the wind speed along a narrow wind speed range (typically 9mph-33mph), small changes in wind speed translate into large changes in the amount of wind energy convertible to electricity. Consequently, wind generation is relentlessly fluctuating, according to the whimsy of its power source, between zero production, which occurs 10-15 % of the time, and its maximum possible performance, its rated capacity, which is achieved very rarely. Over the course of a year, a wind project, if sited in good wind territory, produces an average yield of about 25-30% of its rated capacity. About 60% of the time, it produces less. Whatever it does produce is constantly changing, moment-to-moment; no one can predict what it will produce at any future time. Wind's performance history also shows that wind plants generally produce most at times of least demand—and least at times of peak demand.[2]

Here's an example of routine wind flux, culled at random from a BPA posting for a brief period on January 1, 2009. BPA had 1600MW of installed wind. At this time, the actual wind generation was 443MW in the first minute. Five minutes later it was 454; then it was 476; then 489; then 505, etc. Three hours later it had fallen below 200MW–and continued downward.[3] Occasionally, wind production involves very wide swings across nearly the whole range of its rated capacity, dropping or rising precipitously in less than an hour.[4] Consider the impact of this flux if the installed wind capacity were 5000MW.

Wind volatility is somewhat like the fluctuations of demand as people and industries turn their appliances off and on at random—but is much more intense and difficult to manage. In fact, grid engineers often refer to wind as negative demand. Because of its uncontrollable, largely unpredictable fidgety nature, it destabilizes the grid even more than demand fluctuations do. Moreover, as AWEA's spokeswoman, Christine Real de

Azua, stated a few years ago: *"*You really don't count on wind energy as capacity. It is different from other technologies because it can't be dispatched*.*" The National Renewable Energy Lab last year said much the same: "Wind power cannot replace the need for many 'capacity resources'" and that any capacity value for wind is "a bonus, but not a necessity." [5] This has serious implications for efficient grid performance.

We expect electricity to be reliable, affordable, and secure, which is made difficult and more costly because *supply and demand must match continuously*. Unlike the water supply, large amounts of electricity can't be stored, despite century old quests, led by Edison, to invent such battery storage systems. AWEA's oft-trumpeted storage fix is pumped hydro, which generally can't respond fast enough to accommodate rapid changes in wind output. (Other kinds of storage are frequently cited but they are not practical, generally available, or economically feasible.)

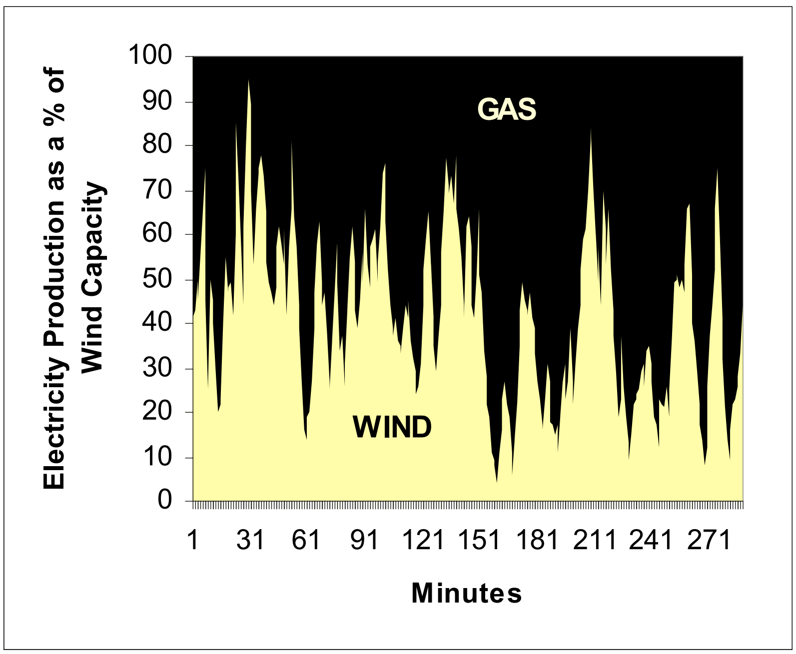
Until recently, demand fluctuations were the primary reason for grid instability because they are constantly breaking off their connection with supply, putting the two out of balance. However, demand flux is acceptable, even desirable (unless one is a grid manager), because having electricity whenever desired is so important to both economic productivity and quality of life. To preserve this freedom, electricity supply was made as stable, controllable, reliable as possible, so that precise amounts of supply could be dispatched—or retracted—to balance demand flux immediately. For example, if demand slackens by 5MW, then exactly 5MW of production is withdrawn from the grid, typically under automatic generation controls. Conversely, if there is 10MW of increased demand, then exactly 10MW of supply is ratcheted up. This kind of manageability is known as capacity value.

Conventional generators—coal, natural gas, nuclear, and hydro, which together account for 95% of the nation's electricity power—must pass stringent tests of reliability and precision performance before they are deployed. All of their electricity generation is capable of being dispatched on command, since they have firm capacity—typically producing their rated capacities when asked to do so, maintaining a steady energy level throughout their operating time except when they are called upon to ramp up or back in response to demand changes. These generators are then placed in an ensemble, each having a role to play, some providing for base load, others for peak and load balancing purposes. There is much behind-the-scenes tumult involved as many types of conventional generations converge at just the right time so that people and industries can be served without fuss or bother at the flip of a switch.

Unreliable wind volatility is the antithesis of supply stability; it has no capacity value. What most experts don't properly account for, even those who understand the data, is the difference in the production delivery between conventional power units and wind, which is typically masked by snapshot reports of wind performance data that don't reveal wind's continuous skitter. The former provides their whole power (their rated capacity) at a controlled rate, unless asked to change by grid operators. Wind provides energy in fits and starts, always staggering its way around the grid, never controllable and rarely predictable except when shut down—in the process always entangled with supportive prosthetics—conventional generation—to make its production appear whole, steady, and precise. Beyond this, wind production is often inimical to demand requirements. For example, California's independent system operator rarely sees more than 5% of wind's installed capacity during the summer peak periods. It is this trait that is so "peculiar," given the requirement for reliability and grid security.

Figure 1 illustrates the supportive prosthetics concept with the wind mirroring production required, typically by fossil fuel plants, to make wind output useful—i.e., steady and reliable, as described above. As is evident, wind output is a much smaller part of a larger fuel mix but enmeshed in a yin yang mode where polar or seemingly contrary forces are existentially interconnected and interdependent. As in the old song lyric, "you can't have one without the other."

**Figure 1 – Illustration of the Wind Mirroring Concept**




Indeed, since wind's average annual production rarely exceeds 30% of its installed capacity, electricity production from more than 70% of any wind project's installed capacity must routinely come from conventional generation that performs inefficiently as it quickly ramps up and back to balance wind's tempestuous ebb and flow. This is not "supporting" or back-up generation but rather proactive, reliable power that must be actively entangled with wind to make it work. Moreover, from the perspective of system reliability planning, wind requires conventional generators to cover nearly 100% of its installed capacity. (Even so, wind's capacity value is zero in real time.) And all this is in addition to the requirement to balance demand fluctuations. What must infill the breach when wind production falls by 10MW? What must be running when 1000MW of installed wind is producing nothing? In terms of energy--or even power—density, one cannot equate the production from any wind installation with that of the output of a conventional generator. One should only compare apples that produce capacity value--the ability to deliver precise increments of power—and have them withdrawn—on demand. Ms. Real de Azua was even more discerning than she realized. Since, by AWEA's own admission, wind provides no capacity and cannot be dispatched, it can only be a supernumerary supplement—but one that requires much supplementation.

Wind is hardly new technology. It has been, along with water and horses, a mainstay "fuel" for a variety of machines hitched to the power needs of the human enterprise for thousands of years, always a tail-wagging-the-dog technology doing work on its own schedule. Wind provides sporadic energy to any grid, not modern power capacity. Its fuel is so energy diffuse that it cannot be converted to a continuous stream of steady power that people can control at *their* beck and call. This is why the Dutch stopped using windmills to grind grain and pump water hundreds of years ago, when steam engines were introduced. It's why the vaunted Clipper ships of yore reside in museums. And why gliders don't provide commercial transportation. Unlike modern machines, they may not work when or how we wish. As Williams S. Jevons wrote 150 years ago:

> *The first great requisite of motive power is that it shall be wholly at our command, to be exerted when, and where, and in what degree we desire. The wind, for instance, as a direct motive power, is wholly inapplicable to a system of machine labour.*[6]

The real issue for modern societies is *power* production, not energy of itself—and this is particularly true for electricity. Not just power production but rather, as energy expert Tom Tanton has said, the quality of the power production, taking into account the frequency, voltage, and harmonics that must be precisely congruent to achieve the reciprocal convergence essential for proactive modern power performance.[7]

Can wind technology be harnessed, as AWEA maintains, to replace or supplement modern machines that fill their tanks with sufficiently energy dense fuels—coal, natural gas, nuclear, impounded water—to meet modern power quality expectations? If so, what are the consequences—for consumer costs and for any thermal activity involved with wind integration?

In truth, energy produced from wind is so erratic that it can't be converted to modern power requirements--unless that energy is "fortified" with external energy to make it dense enough for modern power needs, as we will see. This "external energy" must also be accounted for.

*FACTS ARE STUBBORN, BUT STATISTICS ARE MORE PLIABLE* ---Mark Twain

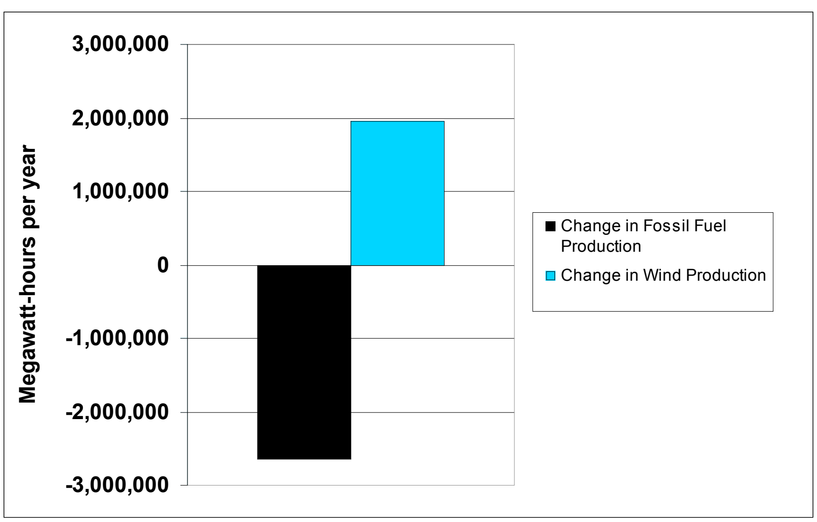
The Bentek study showed that wind volatility in the sampled regions of Colorado and Texas caused more $CO_2$ emissions than would have been the case with less wind and more efficient coal plants. Using mostly sub-hourly performance data, Bentek was able to "examine in detail how coal, gas and wind interact and the resulting emissions implications." In general, the research team found that wind, typically much more active at night at times of least demand, was more entangled with base load coal plants, since most of the flexible, more costly gas plants were dispatched for use during the day, at times of higher demand. As Bryce reported, the repeated cycling—ramping up and back—of coal plants, with their higher $CO_2$ concentrations, created heat rate penalties that produced a greater volume of $CO_2$ emissions. The coal plants in a wind balancing role were operating more inefficiently, and thus required more fuel, much in the way an automobile does when driven in stop-and-go traffic. As noted earlier, Bentek then recommended that better results for carbon emissions offsets could be produced by introducing more responsive natural gas units on the system, in part replacing the coal plants with machines that burned 50% cleaner.

AWEA maintains this study must have been seriously flawed, since, as more wind was installed on the systems, USEIA data showed that $CO_2$ and other greenhouse gas emissions between 2007 and 2008 were reduced, and, within both states, coal and natural gas consumption fell as well. Goggin then quotes Frank Prager, who "pointed out the flaws…in the (Bentek) study and reconfirmed that wind…significantly reduced fossil fuel use and emissions…." As vice president of environmental policy for the energy company, Prager is not a disinterested party. But it's the evidence that's important, not his testimonial.

Let's look at the evidence more closely. The statistics that AWEA presents are accurate—as far they go. But there is more to the story. The wind trade association neglected to mention that both states increased their net imports of out-of-state electricity capacity by an amount that *exceeded* the reductions in in-state fossil fuel use.

Figure 1 illustrates what AEWA claims to be the case:

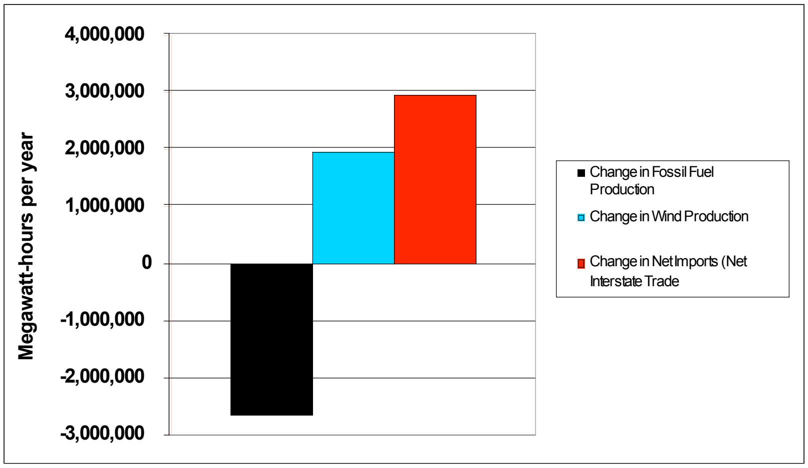
**Figure 2 – Isolating Changes in Fossil Fuel and Wind Electricity Production in Colorado for 2008**




Source: DOE EIA[8]

However, to get a broader picture, it is necessary to look to other DOE data, which includes interstate traffic in electricity. In 2008, Colorado had net imports of 3,604,000 MWh of electricity, and Figure 3 adds this to the Figure 2 representation.

**Figure 3 – Isolating Changes in Fossil Fuel and Wind Electricity Production and Net Imports in Colorado for 2008**




Source: DOE EIA[9]

Consequently, there is another more plausible explanation for the reduction in fossil fuel use and greenhouse gas emissions in Colorado: increased net imports. Moreover, the imported electricity was most likely firm capacity from fossil fuel, nuclear or hydro plants. If so, this completely circumvents the entire problem caused by increased wind volatility, which is a greater issue than steady operation at lower utilization. As an official from the Ontario IESO once said, "It is better to have a reduced capability that is available when needed than a greater capability that is only available when it is not needed." The import/export of firm capacity makes sense. But the import/export of wind makes sense only in the world of government-mandated good intentions—gone awry, essentially paying others to spread the dysfunction around while jamming up transmission lines with low quality power.

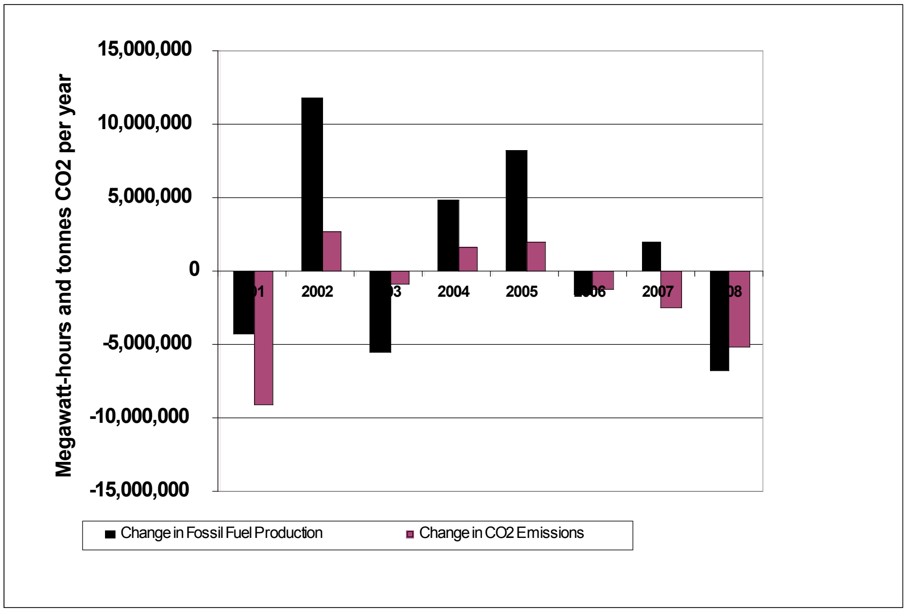
If anything, this confirms the Bentek findings, reinforcing the view that increasing wind volatility imposes thermal inefficiencies throughout the system, ultimately saving no conventional fuels and, in the case Bentek studied, increasing $CO_2$ emissions. AWEA has confused correlation with causation. Simply because there was a decrease in in-state fossil fuel use does not mean increased wind generation was responsible. As the Noble laureate Richard Feynman once said about scientific integrity: "if you're doing an experiment, you should report everything that you think might make it invalid–not only what you think is right about it: other causes that could possibly explain your results; and things you thought of that you've eliminated by some other experiment, and how they worked–to make sure the other fellow can tell they have been eliminated."[10]

The same situation occurred in the Texas study area. Increased net imports from other states also more than compensated for reductions over this time period in in-state fossil fuel use. Moreover, USEIA state-by-state data show that, from 2005 through 2007, $CO_2$ emissions in Colorado had increased steadily, despite increasing numbers of wind projects. For Colorado, $CO_2$ emissions were 41.2 million metric tons in 2005; by 2008, there were 41.5 million metric tons, down slightly from 2007 levels of 43.4. In Texas, the situation over the entire decade shows ups and downs along a fairly steady state, varying only by 9%. In 2000, emissions were 264.4 million metric tons—a decade high. By 2005, emissions were 260.7; by 2008, they had declined to 252.1, down from the previous year's total of 257.1, for reasons, as in Colorado, that can be accounted for by an increase in net imports, among other reasons. (For those interested in whether or not wind reduces Danish $CO_2$, check out increased imports of hydro [not just exported wind to Scandinavia] and the higher efficiency of newly installed CHP plants.)

A review of the history of changes in fossil fuel generated electricity and net imports provides further support for the thesis that imports are the source of reduced fossil fuel plant use. Since 2000, and before the introduction of much wind activity, there are years that show similar change patterns. One year shows substantial growth in in-state generation and much reduced imports, and other years show small amounts of change in in-state generation and imports, representing a more-or-less steady-state condition. Further motivation for changes on a year-to-year basis may reflect wholesale pricing conditions at the time. Nationally, grid managers at the beginning of the decade anticipated demand increases of more than 2% annually, and called for new power plants to meet it. When demand actually decreased because of the economic crash in 2007, any new plant that came on line in that year, replacing an older unit that was to be retired in 2008, could have been responsible for an increase in MW for 2007—and then a sudden reduction in 2008. Alternatively, some of these plants now supply more than is needed because of reduced demand, and are dispatched less often than originally intended.

Despite the plausibility of the net import case for the small reductions in fossil fuel use and greenhouse gas emissions in 2008, much uncertainty nonetheless remains about what is actually happening. The variables involved are highly complex and one should examine them both individually and as they interact. Although, because so many things are possible, it is *possible* that wind may have played a role, that idea must compete with more probable events. Figure 4 rather dramatically illustrates there is more at play than changes in fossil fuel production affecting $CO_2$ emissions levels, since the two phenomena don't appear well correlated.

**Figure 4 – Annual Changes in Fossil Fuel Plant Production and $CO_2$ Emissions for Texas**




Source: DOE EIA[11]

AWEA's contention that there exists "overwhelming evidence," "indisputable data," and "uncontestable benefits" to support its belief that wind is a potent off-setter of emissions is, at best, disingenuous and probably spurious. It is definitely not derived from scientifically vetted evidence. Whatever claims are made for wind should not ignore a grid's requirement for capacity, in most cases in the form of highly inefficient fossil-fuel plant operation used to balance unreliable and erratic wind production.

This is particularly true in any discussion about AWEA's claim that wind has "nearly zero marginal operating costs" compared to conventional generation. It should. Considering that its capital plant is almost wholly subsidized by public dollars (note the other elephant in Bryce's article was the high per energy unit subsidy for wind), one should wonder why wind charges a dime for its product (on some grids, it must). Even so, comparing the costs of capacity-less wind to the costs—at any level of consideration—of firm capacity plants seems incredibly silly. It is only appropriate that a third-string minor league first baseman, who made the team because his father contributed to the stadium fund, costs less than the major league's Babe Ruth. And let's agree that the nearly zero operational marginal cost of a soapbox derby vehicle, which at least has some manageable capacity, is incomparably less than a Boeing 747.

*SCIENCE IS THE DISINTERESTED SEARCH FOR THE OBJECTIVE TRUTH ABOUT THE MATERIAL WORLD. –*
Richard Dawkins

It is true, as AWEA notes, that any wind production must displace some existing generation, but only in terms of electricity, not any of the underlying energy forms transposed *into* electricity. It is rather due to the stricture that supply match perfectly with demand at all times (and this is another oversimplification of a complicated situation). Just as the grid must reduce supply in precise increments to keep pace with specific reductions in demand—or increase supply in just the right increments to keep pace with increasing demand, the grid must respond to increased wind penetration, which, to a grid operator, looks much like a reduction in demand. Since wind plants are continuously generating between zero and 100% of their rated capacity, always in flux, providing who knows what for any future time, conventional generation must infill any reduction in wind energy at the precise increment of that reduction and, conversely, it must be withdrawn in increments that match any wind increases. If wind generation were merely intermittent and unpredictable while producing at a steady rate, it might achieve some of its claims about backing down coal. However, its relentless variability imposes daunting challenges for wind integration. Clever engineering schemes can mask the problem, but not without imposing increased costs and thermal activity.

Any fossil fuel saved when it is sporadically displaced by wind is often consumed in even greater volume as it is called upon to compensate for wind's relentless skittering—the phenomenon described by Bentek. Wind existentially reduces the efficiency of these compensatory plants, raising the heat rate penalties of older, less efficient coal plants such that they may be forced to emit 40% more $CO_2$ than when operating efficiently. Even efficient penalties of 2% can increase emissions up to 16%.[12] Depending upon the fossil-fired plant involved and the circumstances, a reduction in output in response to the addition of wind "can cause a very small reduction in the efficiency of that fossil-fueled power plant," as AWEA claims. But over time, these inefficiencies accumulate. But where is the evidence for any of this activity in the real world, aside from the Bentek study?

Evidently, AWEA understands and agrees with Bentek's recommendation that its product would do much better paired with "more flexible, less polluting natural gas units." The association knows nuclear plants are not designed for load balancing purposes and that cycling coal-fired boilers in a wind following role is just as problematic, as AWEA obliquely conceded. Yet as Australian engineer, Peter Lang, has shown, even the best possible thermal entanglement with wind, comprised of both open and combined cycle natural gas systems, can save only 15% more $CO_2$ than can be achieved by the natural gas systems alone, without any wind. However, the direct and indirect costs of replacing coal with such a tandem would insure that all grid-connected Americans would see their utility bills skyrocket, given wind's capital costs, which, on per kWh production basis, are on a par with nuclear's.[13]

Inefficient use of natural gas systems with wind, such as responsive open cycle units normally used only at peak demand, would save no carbon dioxide emissions. And as Canadian Kent Hawkins shows, modeling a combination of coal and natural gas for wind balancing results in more carbon emissions than would be the case without any wind, despite wind's huge capital costs. Moreover, as Lang has said, " So wind cannot contribute to reducing capital investment in generating plants. Wind is simply an additional capital investment." And one that seems entirely unnecessary if the goal is reduced $CO_2$ emissions.

Any valid attempt to measure the effects of wind integration must account for all the variables at play, including what generation wind displaces, what generation is used to follow and balance its volatility, the cycling rates and heat rates, type of fuels, even voltage regulation systems, among other things. All of these back end factors must be tallied and weighed against any initial carbon savings claimed for wind at the front end. Here's how energy expert Tom Hewson, in an article for Power Magazine, summarized the havoc wind's presence plays on economic dispatch:

> *…new wind generation will displace highest incremental cost generation on the regional powerpool margin. This marginal generator constantly changes throughout the day due to continuing load fluctuations. This constantly changing market makes it extremely difficult to predict what resources would be displaced throughout a given year. Without use of a regional dispatch model in combination with the project generation profile, wind developer consultants make simplifying and often flawed assumptions. These assumptions often center on the displaced generation being either coal-fired generation or a weighted average regional blend of fossil fuel generation. Given that higher cost gas and oil can be on the margin, a weight average fossil fuel average that better reflects the dominant baseload generation resources (more heavily coal based) result in even overestimating displaced emission characteristics for their selected historical period.*[14]

One should add that not only does the marginal UNIT change, but so does that unit's operating characteristics (i.e., ramping heat rate) and the need to match actual wind speed data and (via performance of its turbines) wind output.[15]

Given the inherent complexity, it is problematic to speculate about how wind volatility either lowers price or improves reliability on the spot market, as AWEA stoutly affirms that it does. Regional transmission operators are obliged to obtain the lowest cost set of suppliers to achieve high reliability, often deploying "redispatch" rebundling of the power mix to solve impromptu predicaments. Consequently, spot market prices are contingent on many conditions within a series of priorities, some of them temporal, some functional, some related to scheduling. For most regions, about 90% of the spot market supply is purchased in a day-ahead auction in which wind rarely participates since it cannot assure firm delivery 24 hours in advance (and would be liable for financial penalties). Instead, it usually participates in the real-time, at-the-moment market, which historically accounts for only 10% of the overall spot market. In this situation, if wind can deliver, conventional generators may back down and still receive the agreed marginal price set from the day before while saving fuel—a good deal for particularly natural gas generators in many areas of the country. However, in areas like Texas, where there is no day-ahead spot market, wind is responsible for eroding natural gas prices, as the Wall Street Journal reported last March. Suffice it to say, as Lisa Linowes once did, "*Since the price paid for 90% of the generation is established twenty-four hours in advance of the power day, any low-cost participation from wind will have only a marginal impact on prices limited to those resources operating within the real-time market.*"[16]

Government projections, particularly those from the National Renewable Energy Lab, that show wind can provide a substantial percentage of electricity in the United States while substantially reducing $CO_2$ emissions are uncontaminated by reality; they have no more credibility than college football polls. Simulations based upon even hourly dispatch models without considering the gustiness of the wind and the corresponding heat rate penalties yield incomplete, if not duplicitous, information about a complex process—while assumptions about wind's ability to replace generation one-to-one are cartoonish misrepresentations of reality. The NREL projections do not even try to account for the impact of thermal cycling events in response to wind volatility. Politically correct but untested testimonials from independent grid operators are equally problematic.

Measurement of greenhouse gas emissions is imprecise and statistical. Power plants are apparently not equipped with monitoring sensors; consequently, emission data is not based on direct observation. Rather, it is derived by plugging in numbers according to a formula, factoring information about fuel type and operating hours, estimating a plant's thermal efficiency, and then leavening all that with a coefficient that calculates the pounds of $CO_2$ produced by particular fossil fuels. It is unlikely that these averages are computed at time frames less than a day, which greatly disguises the effects of minute-to-minute wind flux. In short, reported numbers are typically formed from indirect model calculations, which themselves are fraught with a series of estimates.

Any statistician familiar with the problem of "averages" knows the difficulty of using them to explain complex phenomena. Wind behavior is different than the rather straight on performance of conventional generation. As stated earlier, trying to describe wind activity with snapshots at any given time masks its volatility, making it seem steady and sober, deceptively giving the impression that the energy yield from wind is the same as that from conventional sources.

For the purpose of more accurately accounting for the way wind volatility distorts the general formula in use for calculating emissions production, given the present limitations for direct measurement, load dispatch analyses at, say, 15-minute intervals, should be the preferred modeling *tool*, italicized here to emphasize that models are merely a means of examining reality, not reality itself. They would allow a much better look at the way routine wind flux affects the overall thermal activity within the grid.

## WHAT THE USEIA DATA REALLY SHOW

No one with knowledge about how $CO_2$ emission data is estimated should say they represent objective reality, as AWEA does, for the possibility of plus or minus error is non trivial. With this in mind, let's look more closely at what the USEIA has actually said about wind and carbon emissions, in context. Here's what Bryce had reported in his WSJ article: "The U.S. Energy Information Administration (EIA) has estimated the potential savings from a nationwide 25% renewable electricity standard…. Best-case scenario: about 306 million tons less $CO_2$ by 2030. Given that the agency expects annual U.S. carbon emissions to be about 6.2 billion tons in 2030, that expected reduction will only equal about 4.9% of emissions nationwide." There is a worst-case scenario: all that wind will produce virtually no reductions, a conclusion of the National Academy of Science.[17]

Bryce also reported that the NREL believes that if 20% of the electricity in the eastern US came from wind, "the likely reduction in carbon emissions would be less than 200 million tons per year," not even a drop in the bucket, as we will see.

Here's what the USEIA national generation mix data for 2007 and 2008 reveals:

- US electricity demand in 2008 fell 0.9% from the previous year. Peak summer demand fell 3.8%. Coal generation declined 1.5%; natural gas, 1.5%; nuclear, 0.3%. $CO_2$ emissions fell 2.5%--"*largely due to decreased fuels consumption*," explained the USEIA commentary.

- During this period, wind generation increased 60.7 percent, from 34.5 million MWh in 2007 to 55.4 million MWh in 2008.

- The overall improvement in the average natural gas capacity factor since 2003 reflects both the increased reliance on combined cycle generation to meet energy requirements and further efficiency gains in combined cycle generation technology, leading to lower $CO_2$ emissions.

- Sulfur dioxide (SO2) emissions fell 13.4 percent, from 9.0 to 7.8 million metric tons, between 2007 and 2008. This amounts to the largest year-over-year decline since 1995. *The large reductions in $SO_2$ in 2008 resulted in part from a decline in fuel consumption but mostly from the installation of emissions reduction equipment in response to the Environmental Protection Agency's Clean Air Interstate Rule.*

- "Estimated carbon dioxide emissions by U.S. electric generators and combined heat and power facilities fell 2.5 percent from 2007 to 2008 (from 2,540 million metric tons to 2,477 million metric tons*), largely due to a fall in fuel consumption at electric power plants*." (italics added)

The substantial increase in installed wind clearly had little to do with reductions in $CO_2$ and other greenhouse gasses. Rather, according to the USEIA, they were almost entirely due to reductions in demand, with corresponding reductions in generation. There were additional reductions of $CO_2$ emissions attributed to increased use of more efficient CCGT units. *Significant* $CO_2$ reductions at a national level in 2008 *cannot* be tied to wind, even indirectly. And, most likely, *no* $CO_2$ reductions can be ineluctably credited to wind activity.

According to the USEIA, the total US electricity-related emissions of greenhouse gases in 2008 were 2,499.8 mmt of carbon dioxide equivalent ($CO_2e$), or about 35% of total US greenhouse gas emissions. In 2009, it experienced a decline of 205 mmt, the largest in recent times. Moreover, this 4% drop in the carbon intensity of the electric power sector, was

> *primarily due to fuel switching as the price of coal rose 6.8 percent from 2008 to 2009 while the comparable price of natural gas fell 48 percent on a per Btu basis. The carbon content of natural gas is about 45 percent lower than the carbon content of coal and modern natural gas generation plants that can compete to supply base load electricity often use significantly less energy input to produce a kilowatt-hour of electricity than a typical coal-fired generation plant. For both of these reasons, increased use of natural gas in place of coal* ***caused*** *the sector's carbon intensity to decrease.* (bold added)

In discussing 2009 $CO_2$ reductions, the EIA does state wind was responsible for avoiding 39 mmt. This was 19% of the total claimed $CO_2$ emissions drop for the year—205 mmt—which also factored reduced demand and improved nuclear (26 mmt) and natural gas (82mmt) efficiency. However, since the total $CO_2$ emissions tied to electricity production for the year was 2295 mmt, the 39 mmt from wind contributed only 1.6% of the total—a thimbleful, despite the presence of over 35000MW of installed wind capacity. And even this may have substantially overstated the case for wind, given the margin for error inherent in the EIA's emission savings projection from wind, which also did not account for wind-induced emissions from inefficient cycling.

*EXTRAORDINARY CLAIMS REQUIRE EXTRAORDINARY PROOF*------Marcello Truzzi

Any explanation about causation must honestly and transparently account for all variables at play. It should not consist of cherry picked items favorable to a particular agenda while ignoring other, less favorable factors.

Dr. Truzzi also recounted who is obligated to do what in the process of investigating, vetting, and validating explanation:

> *In science, the burden of proof falls upon the claimant; and the more extraordinary a claim, the heavier is the burden of proof demanded. The true skeptic takes an agnostic position, one that says the claim is not proved rather than disproved. He asserts that the claimant has not borne the burden of proof and that science must continue to build its cognitive map of reality without incorporating the extraordinary claim as a new "fact." Since the true skeptic*

> *does not assert a claim, he has no burden to prove anything. He just goes on using the established theories of "conventional science" as usual. But if a critic asserts that there is evidence for disproof, that he has a negative hypothesis—saying, for instance, that a seeming [paranormal] result was actually due to an artifact—he is making a claim and therefore also has to bear a burden of proof.*[18]

AWEA's extraordinary claim is this: That an ancient source of energy, which relentlessly, continuously, destabilizes the balance between supply and demand, is highly variable and unresponsive, and provides no capacity value while inimical to demand cycles, can effectively replace the capacity of modern machines and their fuels, in the process removing significant amounts of greenhouse gas emissions that are the by-product of the burning of those fuels. This claim is particularly egregious given that wind does not even provide modern power performance–only desultory energy. Since energy is the ability to do work and power is the rate work is done, wind technology delivers fluctuating power at a rate appropriate for 1810, not 2010.

The assertion that wind technology is a necessary, let alone sufficient, cause of reductions in the use of fossil fuels and their various emissions cannot withstand even casual scrutiny, for there are, in virtually every case, other much more plausible causes for any $CO_2$ or fossil fuel reductions—viz, a falling away of demand, substitution of other fuels, improvements in conventional machine efficiencies, even changes in weather conditions.

Even more bizarre than AWEA's extraordinary claim is its assault on the bedrock scientific principle of refutability, what scientists call "falsifiability." Any claim about truth in the material world must be testable using standards of empirical evidence to determine if it is false. Because an assertion is "falsifiable" does not mean it is false. Rather, it means that if the statement were false, then its falsehood could be demonstrated. By hiding the way wind affects overall grid thermal behavior behind proprietary confidentiality laws, not allowing disinterested, independent observations of the relevant phenomena, wind's limited liability companies remain mired in what Feynman once called "cargo cult science." AWEA could claim there are 1352 angels sitting on a pin in Nashville. But if that pin were sealed away in a safe deposit box controlled only by AWEA and the bank, how could anyone test it for truth? What is even more outrageous is the way government has abetted this absurdity, passing laws assuring "confidentiality," while regulators look the other way and the Department of Energy engages in promotional, very hypothetical, wind "studies" alienated from reality.

With over 100,000 massive wind turbines around the world—35,000 plus in North America—not one coal plant has closed due to the installation of any wind projects. Nor is there empirical evidence that there is less coal burned per unit of electricity produced as a specific consequence of wind. Ontario has long promised to retire (but has never been able to do so) *all* its coal plants. Officials tout that they will be replaced by wind. To hedge its renewable energy bet, the Ontario government is building natural-gas facilities as insurance against new wind projects. In other words, the province expects to replace coal with natural gas, not wind. The latter could not exist without either hydro, which presently provides the province about 25% of total generation (wind is about one percent) or flexible natural gas generators. Projections by the Ontario Power Authority depend upon planned conservation savings and natural gas, not wind, as a means of displacing coal. Similarly, boasts by the former governor of Kansas that her state would not approve a new coal plant because of its increasingly expansive wind projects conveniently forgot to mention how the state had planned to increase its importation of natural gas–at higher cost. Many new coal plants are in the offing, both in the United States and throughout the world—even in Kansas, since the new governor, "recognizing the need for baseload power," struck a deal allowing one new coal plant in the western part of the state.[19]

Depending upon government sanctioned secrecy of its performance data and therefore confident that there would be no fact checking in the real world, AWEA has exploited the arcane, very complex nature of greenhouse gas emissions—arcane because so few have knowledge about it and complex because of its incredible scale and the difficulties involved with actual measurement. It then produced highly selective evidence based upon a series of hypothetical projections, mathematical models with incomplete information, and well-crafted but ultimately vacuous statements such as "one of the universally recognized and uncontestable benefits of wind energy…." Everyone should dust off and reread Darrell Huff's classic, *How to Lie with Statistics*.

LET'S GET REAL

Wind technology is NOT *universally recognized* for its ability to reduce $CO_2$ emissions, for many have contested that presumption. And, in the wake of Bryce's article, many more will soon join the fray. According to their calculations, whatever wind produces will replace some existing conventional generation for a brief and highly fluctuating time; but in terms of overall fuel use, wind production rarely "saves" anything and, in most cases, as shown in the Bentek study, requires that more fuel be consumed in highly inefficient ways over time. The Bentek study is supported by the work of engineers like Kent Hawkins in Canada (here and here), Peter Lang in Australia (here and here), Bryan Leyland in New Zealand, Jim Oswald in Britain, C. le Pair and Kees de Groot in The Netherlands, and several studies in Germany, Spain and Denmark, some of which are summarized in Bryce's latest book.

Responding to both the letter and spirit of Truzzi's charge, critics of wind technology not only have cast doubt upon AWEA's claims, showing that the organization has not met the requisite burden of proof, but they also offer a means of testing their thesis that wind does not offset much $CO_2$. Lang, Le Pair/De Groot, Oswald, and Hawkins have independently developed differing methodologies for assessing wind's potential to engage greenhouse gas emissions, and they are in remarkable agreement about their conclusion: that the higher wind penetration on virtually any grid system, the greater potential for more $CO_2$ emissions than would be the case without any wind at all.

These methodologies now must be tested against reality, made so difficult because of proprietary confidentiality laws that shield wind performance activity from critical scrutiny. Thus far, only Bentek has been graced with this opportunity.

Consider just a few of the questions that must be answered and the issues that must be properly accounted for, at minimum:

- The amount of conventional generation necessary when wind is producing nothing?

- The amount of conventional generation necessary to infill the gap between when a 100MW wind project is producing, say, 50MW in one minute and, minutes later, only 40MW?

- The amount and pace of conventional generation that must be withdrawn when that wind project increases its yield quickly, moving, say, from producing 10MW in one minute and, 15 minutes later, 80MW? This may not be consequential for any grid in terms of security, particularly large grids like the PJM with over 140,000MW of peak demand generation. But even this relatively trifling flux has cost and emissions consequences, which should be properly assessed.

In most cases around the country, the answers will involve coal plants, as they do in Texas and Colorado, Minnesota and, especially, Iowa, working highly inefficiently. The heat rate penalties involved logically lead to more fuel use—which exhausts more $CO_2$ emissions. However, even in those areas where natural gas generators can serve as the principle means of balancing wind flux, inefficient cycling would remain an issue, subverting CO2 emissions offsets, as Lang and Hawkins predict.

Logic also dictates, in answer to these questions, that any grid must be able to support the entire range of wind flux--from zero to the highest installed wind capacity. Therefore, a grid must have a 1:1 compensatory generation for wind available at all times. Moreover, with more wind penetration, additional conventional generation must be brought on board to keep the grid's reserve margins intact. AWEA’s footnoted statement that there is existing reserve capacity available to cope with the loss of a large generating set that can be used to “back up” wind, is seriously misleading. Such reserves provide for grid security; using them to mollycoddle wind flux should be a breach of priority and protocol. In the real world, wind can only be a small bit player in a much larger machine complex, a complex made more inefficient because of wind caprice.

Allowing researchers access to wind performance data (wind speeds, etc) at appropriate time intervals will advance the cause of knowledge. But it will also have practical policy uses, for it would permit the public subsidies now provisioning wind projects to be indexed to functional measurements showing how much $CO_2$ and fossil fuel wind actually reduces, so that the public—and policy makers—would know the value obtained for those tax dollars. It would also inform the various renewable portfolio standard laws, which now only require “deployment” of technologies like wind. The way such laws are presently written, there is nothing whatsoever requiring wind to “do” anything, nothing mandating that wind output show that it, and nothing else, is responsible for reducing $CO_2$ emissions and fossil fuel consumption. (This is equally true for Renewable Energy

Credits and stock portfolio reports.) Since there is no physical accountability, RPS laws today could mandate deployment of pixie dust, subsidize it, and obtain the same "benefit" presently derived from wind.

Looking at the evidence provided on behalf of wind technology, which is *at best* equivocal, and critical analyses like Bentek's that expose the technology's limitations, perhaps it's fair to conclude by extending AWEA's distasteful analogy. Those who claim that wind technology can abate meaningful levels of $CO_2$ emissions would admire the three-pack a day guy who decides to improve his health by smoking four packs of filtered cigarettes instead.

Jon Boone
Oakland, MD
September 8, 2010

ENDNOTES

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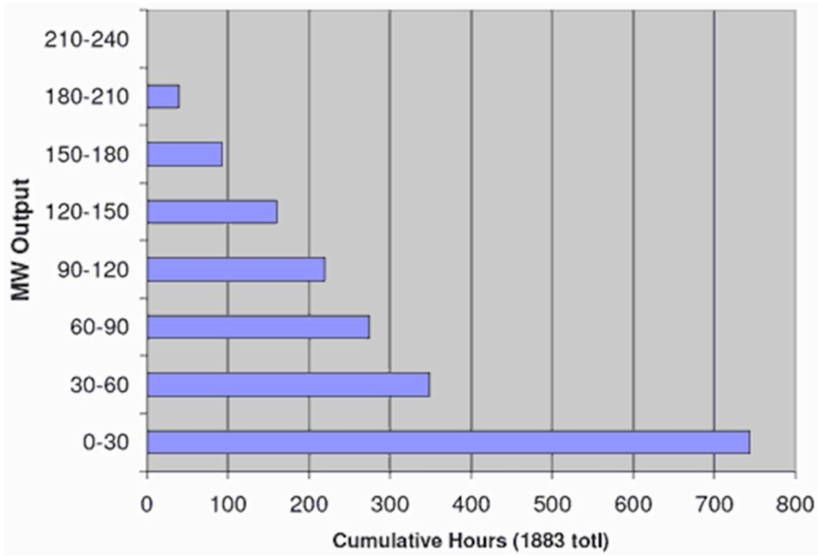
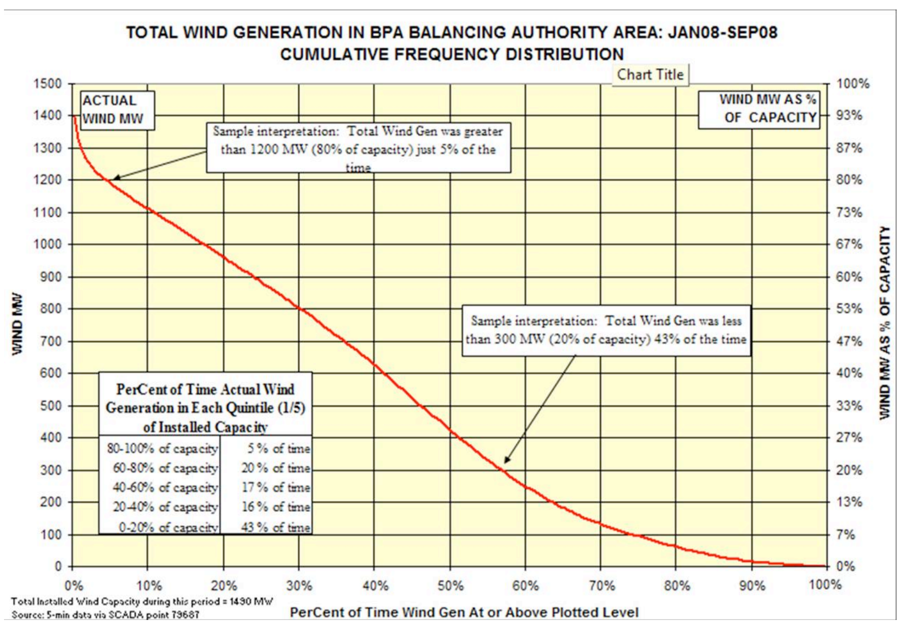
[1] A highlight of the report from its press release, as shared by Rick Webb, a member of the committee who prepared the report and a senior scientist with the Department of Environmental Sciences, University of Virginia, in an email, May 10, 2007.

[2] This is evident throughout the world. See the links to wind performance at the Ontario IESO and BPA. See also the 2004 and 2005 Wind Reports for Germany done by E.ON Netz. See also an independent chart of wind performance in Ontario:
http://h1ripoff.blogspot.com/2010/09/wind-production-in-ontario.html
and an example of capacity factor performance:
http://windconcernsontario.wordpress.com/2010/07/06/capacity-factor-of-ontario-wind-energy-generating-facilities-4/ . In the BPA in 2008, wind's capacity factor was 14%. Jim Oswald's PowerPoint presentation, *UK Windfarm Performance 2005, Based on Ofgem: ROC Data*, is a good summary of wind performance in Britain.

Note the following graphs, the first provided by Eric Rosenbloom showing the performance of New York's largest wind plant, Maple Ridge, located in Tug Hill, with an installed capacity of 231MW. The second, from the BPA, shows the percentage (frequency) of wind's rated capacity distributed throughout a season.

**Maple Ridge Wind Plant – July to September 2006**




[3] See the BPA graph, *Total Load & Wind Generation in the BPA Control Area.* Beginning 1/09, at 5 min increments, updated monthly.

[4] As wind surged in the BPA, with an installed capacity of 1600MW, from 150MW at 9:50 reaching1350MW 90 minutes later on December 29, 2008. See also, http://www.thenewstribune.com/2010/07/18/1268388/can-wind-power-be-too-much-of.html

[5] In Platts Power Markets Week Delivered by Yakout Mansour. President & CEO of CAIESO, August 21, 2006. Whieldon, Esther, *CAL-ISO Offers Sobering Wind Assessment: It's Growing but can't be Relied On as Capacity*. See: http://construction.ecnext.com/coms2/summary_0249-190132_ITM_platts. See also: DOE's 20% wind power by 2030: http://www.20percentwind.org/20percent_Summary_Presentation.pdf

[6] William Stanley Jevons, *The Coal Question* (1865), p. 122.

[7] Tom Tanton, personal email dated September 1, 2010.

[8] U.S. Energy Information Administration. Independent Statistics and Analysis, Colorado Electricity Profile (2008 edition), table 5. http://www.eia.doe.gov/cneaf/electricity/st_profiles/colorado.html

[9] U.S. Energy Information Administration. Independent Statistics and Analysis, Colorado Electricity Profile (2008 edition), tables 5 and 10. http://www.eia.doe.gov/cneaf/electricity/st_profiles/colorado.html

[10] http://www.lhup.edu/~DSIMANEK/cargocul.htm. Adapted from his commencement address at Caltech in 1974

[11] U.S. Energy Information Administration. Independent Statistics and Analysis, Texas Electricity Profile (2008 edition), tables 5 and 7. http://www.eia.doe.gov/cneaf/electricity/st_profiles/texas.html

[12] When coal-fired turbines are frequently and rapidly ramped up and down to compensate for wind variation, "the unit emission of CO2 per kWh increases ...to cope with load. This can easily be 2% or more...depending on the degree of r1amp-down. On a coal-fired boiler, a 2% reduction in efficiency increases the unit emissions from 950 grams per kWh to nearly 1,100 grams per kWh, a change of 150 grams per kWh...."—a 16% increase in emissions." David White, *Reduction in Carbon Dioxide Emissions: Estimating the Potential Contribution from Wind Power*, December 2004, page 16, Renewable Energy Foundation http://www.ref.org.uk/Files/david.white.wind.co2.saving.12.04.pdf

[13] William Tucker, *Obama's Nuclear Power Breakthrough*, The Wall Street Journal, February 26, 2010: http://online.wsj.com/article/SB10001424052748703787304575075413484405770.html

[14] Tom Hewson, "Calculating Wind Power's Environmental Benefits."Power Engineering. July 2009: http://www.evainc.com/Publications/windpowerbenefit.pdf

[15] Tom Tanton, personal email dated August 21, 2010, and, personal email, dated August 27, 2010.

[16] See Russell Gold, *Natural Gas Tilts at Windmills in Power Feud*, The Wall Street Journal, March 2, 2010. See also John Chandley, How RTOs Establish Spot Market Prices (and How This Helps to Keep the Lights On), PJM Interconnection, September 27, 2007: http://www.pjm.com/~/media/documents/reports/spot-market-prices-j-chandley.ashx. See also Ross Baldick, *Single Clearing Price in Electricity Markets*, University of Texas at Austin, February 18, 2009: http://works.bepress.com/cgi/viewcontent.cgi?article=1156&context=cramton.. Quote taken from Lisa Linowes' essay, WindAction, March, 2010: http://www.windaction.org/faqs/26050. Special thanks to Tom Stacy for providing the Chandley article.

[17] The NAS worst-case scenario—1.2% reductions. "Wind power will offset emissions of carbon dioxide by 1.2-4.5% from the levels of emissions that would otherwise occur from electricity generation."

[18] Marcello Truzzi, *On Pseudo-Skepticism, Zetetic Scholar, 12/13, pp3-4, 1987*

[19] http://green.blogs.nytimes.com/2009/05/05/a-deal-on-coal-in-kansas/