The Low Benefit of Industrial Wind

Eric Rosenbloom — January 20, 2006

Driving the desire for industrial wind power is the conviction that it will help reduce fossil and/or nuclear fuel use. Thus the local impacts of large wind turbine installations — with their clearing of trees, substantial concrete foundations, new roads, transmission support, flashing lights, and grinding noise — are thought to be justified by a greater good of healthier air and water, reduction of carbon emissions, and moving away from harmful mining and fuel wars. These are all without question important goals.

While the wind power industry tends to downplay its negative effects, many conservation groups call for careful siting and ongoing study to minimize them. There is debate, therefore, about the impacts but not about the benefits. Even the most cautious of advocates do not doubt, for example, that "every kilowatt-hour generated by wind is a kilowatt-hour not generated by a dirty fuel."

That may be true for a small home turbine with substantial battery storage, but such a formula is, at best, overly simplistic for large turbines meant to supply the grid. The evidence from countries that already have a large proportion of wind power suggests that it has very little, if any, effect on the use of other sources. This is not surprising when one learns how the grid works: A rise in wind power most likely just causes a thermal plant to switch from generation to standby, in which mode it continues to burn fuel.

Documents

"Impact of Wind Power Generation in Ireland on the Operation of Conventional Plant and the Economic Implications," ESB National Grid, February 2004, available at: www.eirgrid.com/EirGridPortal/uploads/Publications/Wind%20Impact%20Study%20-%20main%20report.pdf

This study by the Irish grid manager finds that the benefits of wind-generated power are small and that they decrease as more wind power is added to the system. Their model generously assumes that all energy produced from wind facilities would be used and did not consider output fluctuations within time periods of less than an hour.

They describe three problems that mitigate the benefits of wind power:

» large amount of extra energy required to start up thermal generators that would otherwise not have been turned off

» mechanical stresses of more frequent ramping of production levels up and down

» increased prices of energy necessary to pay for any lower usage of thermal plants.

Wind plants add more capacity (requiring more infrastructure) with almost no reduction of non-wind capacity, the latter of which must be used more inefficiently than otherwise. As for CO_2 reduction, the study concludes,

> The cost of CO_2 abatement arising from using large levels of wind energy penetration appears high relative to other alternatives.

Their model generously assumes that all energy produced from wind facilities is used and disregards output fluctuations within time periods of less than an hour. And they did not consider at all the environmental toll of expanded industrial wind development.

- "Response to the House of Lords Science and Technology Select Committee Inquiry Into the Practicalities of Developing Renewable Energy," Royal Academy of Engineering, October 2003, available at: www.raeng.org.uk/policy/responses/pdf/practicalities_of_developing_renewable_energy.pdf

Table 4 of this report shows that even with generous assumptions of wind power performance, as its share of generating capacity increases, its ability to displace conventional sources decreases — the conclusion also reached by EirGrid (preceding) and E.ON Netz (following). To meet the U.K.'s peak of 50,000 MW for 90 of 100 winters, 59,000 MW of conventional capacity is currently maintained along with 500 MW of wind plant. If the amount of wind is increased to the 2010 target of 7,500 MW, 57,000 MW of conventional capacity must still be kept. With the 2020 target of 25,000 MW of wind, conventional capacity is still at 55,000 MW. That is, wind power is essentially adding surplus capacity rather than replacing conventional plants.

> From wind data records covering the whole of mainland UK, there is a sizeable probability of little or no wind blowing across the entire country, regardless of the capacity installed. Figure 1 illustrates the situation where a hypothetical wind power capacity of 7,300 MW installed throughout the country is correlated with actual Met Office wind data. The most likely power output nationally is seen to be less than 200 MW.

Figure 1 of the report shows that one third of the time, widespread wind power facilities in the U.K. (which boasts the best wind resource in Europe) would be producing at less than 14% of capacity. They would be producing at less than 8% capacity a fourth of the time and at 4% or less for 11% of the time.

- "Green Mountain Power Wind Power Project Third-Year Operating Experience: 1999–2000," U.S. Department of Energy–Electric Power Research Institute [EPRI] Wind Turbine Verification Program, December 2002, available at: epriweb.com/public/000000000001000960.pdf

EPRI reported that the ridgeline facility in Searsburg, Vermont, produced no electricity at all — not even a trickle — almost 40% of the time:

> On average, the Searsburg turbines generate electricity more than 60% of the time. ... Individual turbines generated electricity 51% to 75% of the time during the third year, and from 45% to 77% of the time during the second year. The turbine generation time is related to both wind speed and availability.

- "Wind Report 2005," E.ON Netz, available at: www.eon-energie.de/bestellsystem/frameset_eng.php?choosenBu=eonenergie&choosenId=1725

E.ON Netz manages the transmission grid in Schleswig-Holstein and Lower Saxony, about a third of Germany, hosting 7,050 MW of Germany's 16,394 MW installed wind-generating capacity at the end of 2004. The total production in their system was 11.3 TW-h in 2004, representing an average feed of 1,295 MW (18.3% of capacity).

> Wind energy is only able to replace traditional power stations to a limited extent. Their dependence on the prevailing wind conditions means that wind power has a limited load factor even when technically available. It is not possible to guarantee its use for the continual cover of electricity consumption. Consequently, traditional power stations with capacities equal to 90% of the installed wind power capacity [a little over the maximum historical wind power infeed] must be permanently online in order to guarantee power supply at all times.

Graphs in this report (and the similar 2004 report) show that half of the time, wind power infeed is less than two-thirds of its annual average. It is greater than its annual average only a third of the time.

A similar power vs. time curve applies to all wind power facilities, whether their annual average output in relation to rated capacity is higher or lower than those in Germany. The 11-turbine facility in Searsburg, Vermont, produces no power at all more than a third of the time.

> Both cold wintry periods and periods of summer heat are attributable to stable high-pressure weather systems. Low wind levels are meteorologically symptomatic of such high pressure weather systems. This means that in these periods, the contribution made by wind energy to meeting electricity consumption demand is correspondingly low. ...
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> The feed-in capacity can change frequently within a few hours. This is shown in the Christmas week from 20 to 26 December 2004. Whilst wind power feed-in at 9.15 am on Christmas Eve reached its maximum for the year at 6,024 MW, it fell to below 2,000 MW within only 10 hours, a difference of over 4,000 MW. This corresponds to the capacity of 8×500 MW coal fired power station blocks. On Boxing Day, wind power feed-in in the E.ON grid fell to below 40 MW. ...
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> In 2004 two major German studies investigated the size of contribution that wind farms make towards guaranteed capacity. Both studies separately came to virtually identical conclusions, that wind energy currently contributes to the secure production capacity of the system, by providing 8% of its installed capacity.
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> As wind power capacity rises, the lower availability of the wind farms determines the reliability of the system as a whole to an ever increasing extent. Consequently the greater reliability of traditional power stations becomes increasingly eclipsed. As a result, the relative contribution of wind power to the guaranteed capacity of our supply system up to the year 2020 will fall continuously to around 4%. In concrete terms, this means that in 2020, with a forecast wind power capacity of over 48,000 MW, 2,000 MW of traditional power production can be replaced by these wind farms. ...
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> [[T]he increased use of wind power in Germany has resulted in uncontrollable fluctuations occurring on the generation side due to the random character of wind power feed-in. This significantly increases the demands placed on the control balancing process [and bringing about rising grid costs. The massive increase in the construction of new wind power plants in recent years has greatly increased the need for wind-related reserve capacity.—*Wind Report 2004*].

That is, wind power construction must be accompanied by almost equal construction of new conventional power plants, which will be used very nearly as much as if the wind turbines were not there.

"Danish Wind: Too Good to be True?" David J. White, *The Utilities Journal*, July 2004, available at: www.aweo.org/White-DenmarkTooGood.pdf

> Denmark has installed 3,100 MW of wind turbine capacity to date, which is in theory capable of generating 20% of the country's electricity demand. Of that capacity, 2,374 MW is located in western Denmark (Jutland and Funen). The statistic is misleading because it implies that 20% of Denmark's power is supplied continuously from its wind capacity, but the figure appears to be a promotional statistic rather than a factual representation of the supply pattern.
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> Jutland has cable connections to Norway, Sweden and Germany with a capacity of 2,750 MW. In other words, it has the means of exporting all of its wind production. The 2003 annual report of Eltra, the western Denmark transmission company, suggests an export figure of 84% of total wind production to these countries in 2003, with figures that ramped up rapidly over previous years as Denmark found that it could not absorb wind output into the domestic system."
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> There is no CO_2 saving in Danish exchange with Norway and Sweden because wind power only displaces CO_2-free generated power. When the power is consumed in Denmark itself, fluctuations in wind output have to be managed by the operation of fossil-fired capacity below optimum efficiency in order to stabilise the grid (ie, spinning reserve). Elsam, the Jutland power generator, stated as recently as May 27th at a meeting of the Danish Wind Energy Association with the Danish government that increasing wind power does not decrease CO_2 emissions. Ireland has drawn similar conclusions based on its experience that *the rate of change of wind speed can drop faster than the rate at which fossil-fuelled capacity can be started up* [emphasis added]. Hence spinning reserve is essential, although it leads to a minimal CO_2 saving on the system. Innogy made the same observation about the operation of the UK system [D. Tolley, presentation to Institute of Mechanical Engineers, January 2003].

The result is that, while wind-generated power itself is CO_2-free, the saving to the whole power system is not proportional to the amount of fossil-fuelled power that it displaces. The operation of fossil-fired capacity as spinning reserve emits more CO_2/kWh than if the use of that plant were optimised, thus offsetting much of the benefit of wind.

☙ Flemming Nissen, head of development, Elsam (operating 404 MW of wind power in Denmark), presentation to "Vind eller forsvind" conference, Copenhagen, May 27, 2004

Increased development of wind turbines does not reduce Danish CO_2 emissions.

☙ "Windfarms provide no useful electricity," Richard S. Courtney, presentation to conference of Groups Opposed to Windfarms in the UK, 2004, available at: www.aweo.org/windCourtney1.html

Electricity is wanted all the time but the demand for electricity varies from hour to hour, day to day, and month to month. The electricity grid has to match the supply of electricity to the demand for it at all times. This is difficult because power stations cannot be switched on and off as demand varies [because they take so long—several hours to a couple of days—to warm up].

The problem of matching electricity supply to varying demand is overcome by operating power stations in three modes called "base load," "generation," and "spinning standby."

Some power stations operate all the time providing electricity to the grid, and they are said to provide "base load."

Other power stations also operate all the time but do not provide electricity all the time. They burn (or fission) their fuel to boil water and superheat the resulting steam which is fed to the steam turbines that are thus kept hot and spinning all the time. Of course, they emit all the emissions from use of their fuel all the time. But some of this time they dump heat from their cooling towers instead of generating electricity, and they are then said to be operating "spinning standby."

One or more power stations can be instantly switched from spinning standby to provide electricity to match an increase to demand for electricity. It is said to be operating 'generation' when it is providing electricity. Power stations are switched between spinning standby and generation as demand for electricity changes. ...

Windfarms only provide electricity when the wind is strong enough and not too strong. As they suddenly provide electricity when the wind changes, the grid operator must match this changed supply of electricity to the existing demand for electricity. This is achieved by switching a power station to spinning standby mode. That power station continues to operate in this mode so it can provide electricity when the windfarm stops supplying electricity because the wind has changed again.

Windfarms only force power stations to operate more spinning standby. They provide no useful electricity and make no reduction to emissions from power generation. Indeed, the windfarm is the *cause* of emissions from a power station operating spinning standby in support of the windfarm.

Summary

¶ The addition of industrial wind power, which is nondispatchable and varies according to the wind, requires corresponding maintenance and eventually addition of back-up conventional power, along with expansion of transmission capacity.

¶ The accommodation of wind power causes thermal plants to run less efficiently, adding to financial costs and increasing emissions.

¶ Spinning standby power must be kept burning to cover the short-term fluctuations of wind power. Thus, while wind power may displace generation of power from such plants, it does not displace the burning of fuel in them — the heat is simply diverted.

The most glaring cost of big wind is industrial development of rural and wild areas, which inarguably degrades rather than improves our common environment. That is impossible to justify if the benefits claimed by the industry's sales material are in fact an illusion, propped up by subsidies and artificial markets for "indulgence credits" which allow the flouting of emissions caps and renewable energy targets.

Addendum

Why then do utilities generally support wind as a renewable power source? Actually, they don't. In Japan, as reported by Asahi *Shinbun* on May 18, 2005, utilities severely limit the amount of wind power on their systems, because, as documented above, "introducing too much of the electricity, whose supply can fluctuate wildly, can cause problems for utilities' power grids. ... If there is no wind, the utilities must rely entirely on other facilities. And even when wind power can satisfy all of the demand, they must continue operating thermal generators to be ready for any abrupt shortfalls in wind power." With so-called market solutions such as renewable portfolio standards (RPS), utilities must buy a specified proportion of their power from renewable sources or buy credits equal to their shortfall. As long as they can say that, for example, 20% of their power comes from wind, it doesn't matter if they're burning as much nonrenewable fuel as ever to back it up. Most importantly, however, "green credits" are generated in addition to actual electricity. They are tokens of the renewable energy already sold but are much more valuable. Burdened with the directive to buy renewable energy, utilities want to be a part of wind power development so they can share in the lucrative sale of the credits. Ironically, analyses for New Jersey utilities and by the U.S. Energy Information Agency have shown that the only effect on emissions that an RPS might have is to drive down the cost of exceeding emissions caps or missing renewables targets.

With rising fuel prices, however, many utilities have started to demand actual useful energy targets from wind facilities. As *Renewable Energy Access* reported on Nov. 7, 2005, from an American Wind Energy Association financing workshop in New York City, this has worried investors. Wind turbines can not provide base load power and are unreliable providers of peak load power; they do provide, however, the very marketable appearance of green energy, though not actual relief from other sources.

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This paper is available at: www.aweo.org/LowBenefit.pdf.