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False Wind Industry Claims about the Integration in Electric Grids of the Intermittent, Volatile and Unreliable Electricity from Wind Turbines

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False Wind Industry Claims about the Integration in Electric Grids of the Intermittent, Volatile and Unreliable Electricity from Wind Turbines

Wind industry developers, lobbyists, and other officials, and their supporters often claim that integration of the output of electricity from wind turbines in an electric grid and the need for backup generation is "not a problem" – at least until wind generating capacity reaches some percentage, such as 10%.

At best, the claim is a half-truth and more likely to be false. This brief paper provides some facts about electric grids and the implications of unreliable electricity from wind turbines so that people who are confronted by wind advocates' claims can know the truth.

<u>Facts about electric grids in non-technical terms</u>

1. Electric grids must be kept in balance – e.g., in terms of supply and demand, voltage and frequency -- at all times. In effect, this means that:

- **a.** When customers on an electric grid increase their demand for electricity (e.g., turn on more air conditioners), some generating unit on the grid must begin immediately to produce more electricity. When customers on the grid reduce their demand for electricity, the output from some generating unit must be cut back or turned off.

- **b.** When a generating unit fails or is taken off line for maintenance or repair, some other generating unit must begin producing more electricity or some other unit must be brought on line so that electricity output will be balanced with electricity demand.

- **c.** In certain circumstances (e.g., failure of several units at the same time, or peak electricity demand exceeding generating capacity in the control area), grid balance may have to be accomplished by customers' voluntary steps to reduce electricity use or "load shedding" (i.e., cutting service to some customers) accomplished by the grid managers.

2. Which unit or units are called upon to produce more or less electricity when grid imbalances occur depends on a variety of considerations including:

- **a.** The magnitude of the imbalance that must be corrected.

- **b.** How fast the actual or projected imbalance must be corrected.

- **c.** Which units are available to produce more or less electricity and how fast the output from those units can be increased or decreased. The output from some types of

generating units can be adjusted almost immediately.[1] Other generating units may be on line but running at less than full capacity and peak efficiency, and some units may be readily available because they are in "spinning reserve" mode.[2] Further, some generating units, such as gas-fired combustion turbines may be capable of starting up and producing electricity in as little as 15 to 30 minutes; while other units may require several hours for start up (e.g., units that burn coal to produce steam that is used to spin the turbines that produce electricity).

d. Availability of transmission line capacity between the generating unit and the area where the electricity demand increase occurs.

e. Requirements for maintaining voltage throughout the grid -- which may dictate the area where the generation must occur.

3. The owners or operators of all grids strive to have enough generation capacity in reserve to meet electricity demand at all times – even if there is an unexpected failure of a large generating unit (i.e., an "unscheduled outage") or a large, unexpected increase in electricity demand. As a practical matter this requires:

a. Sophisticated planning, including:
1) Estimates of customer demand in the hours, days, weeks and years ahead.
2) Knowledge of which units will be available to generate electricity during those same time periods.
3) Careful scheduling of planned generating unit outages (e.g., taking units out of service for maintenance, repair and overhaul) and planned work on transmission lines.

b. Having sufficient reliable, dispatchable[3] generating capacity available at all times to handle increased demand or replace any generating unit that fails unexpectedly. Generally, grid managers will seek to have at least enough "reserve" capacity to maintain reliability even if there is a failure of the largest unit on the grid (or largest interconnection if the grid is dependent on imported power).

c. The amount of "reserve" generating capacity available on a grid varies widely from time to time depending on customers' electricity demand and availability of generating units and transmission line capacity. When demand is low, reserve capacity (often stated in percentage terms) may be high; when demand is at high (or "peak") levels reserve capacity may be low or non-existent.

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[1] For example, (a) some generating units will be equipped and designated for "automatic generation control," which units are used to make relatively small but instantaneous adjustments to keep the grid in balance, and (b) hydropower units where electricity output can be changed very quickly by reducing or increasing water flow.
[2] "Spinning reserve" refers to units running and synchronized with the grid but not inputting electricity to the grid.
[3] "Dispatchable" means that the unit can be called upon to produce electricity when it is needed; i.e., it will be operable ("available") and have fuel needed to operate. Wind turbines cannot be considered "dispatchable" because they are able to produce electricity only when the wind is blowing in the right speed range.

4. While there are exceptions, grid managers generally plan for and manage transmission and generation capacity on an "economic dispatch" basis. That is, they run those generation units that will produce the total amount of electricity required at the lowest *variable* cost.[4]

Problems created when wind turbines are part of the generation mix

Electricity generated from wind is *qualitatively* different from electricity generated from reliable ("dispatchable") generating units and these differences must be taken into account by grid managers. (Ideally, these differences would be more widely taken into account by regulators and other government officials who are supposed to protect the interests of ordinary taxpayers and electric customers!)

For the following reasons, electricity from wind turbines is lower in quality and value than electricity from reliable, dispatchable generating units:

1. Electricity from wind turbines is intermittent, volatile, and unpredictable. Wind turbines produce electricity only when the wind is blowing in the right speed range at the site and height of the wind turbine. Today's turbines start producing electricity around 6-7 miles per hour (mph), reach rated capacity around 27 mph and shut down around 56 mph. Since wind speeds vary widely from minute to minute the electricity output is generally volatile. Except in the very short term, the approximate output -- which depends on wind speed -- is largely unpredictable.

   Unlike output from "dispatchable" generating units (i.e., those whose output can be counted on to provide electricity when it is needed), electricity from wind turbines may or may not reach the electric grid when predicted, thus making the task of grid planning and management more difficult.

2. While wind conditions vary widely from place to place, winds tend to be strongest at night and during winter months in much of the US. US EIA data on wind generation in 2004 indicate that electricity production in most of the US is likely to be lowest in August. However, in most areas of the US, electricity demand is highest on hot, weekday summer afternoons – often in August when air conditioning load is high.

   Illustrations can be found in US EIA data on actual generation from "wind farms."[5] For example, EIA data reported for the Backbone Mountain "wind farm" in West Virginia show that a total of 161,191 MWh of electricity produced during 2004, with 68% produced during

[4] As used in this context, "variable" costs are in contrast to "fixed" costs. "Fixed" costs are those that will be incurred whether or not a generating unit is producing electricity. Examples of "fixed" costs include the capital cost of the generating unit and the land, financing costs, taxes, insurance, employees that are incurred whether or not the unit is producing electricity. "Variable" costs are the additional costs incurred when the unit is producing electricity. For most generating units, the cost of fuel is the primary element of variable costs. "Variable" costs also include some operating and maintenance costs (e.g., more employees may be required when a unit is generating electricity than when it is not generating).

[5] US Energy Information Administration, Form 906-920 data base, 2004: http://www.eia.doe.gov/cneaf/electricity/page/eia906_920.html

six "winter" months[6] and 32% during "summer" months.[7] Even more pointed, 14.9% was produced in January while only 4.7% was produced in August.

3. Reliable generating units must always be immediately available to provide a balance for the intermittent, volatile and unreliable output from wind turbines and to serve as "backup" for wind turbines so that customers will be able to have electricity even when the wind is not blowing in the right speed range.

4. Wind turbines have little if any real "capacity value," the measure of the generating capacity that can really be counted on when needed to meet customers' demands, particularly when electricity demand is at peak levels. The data discussed in point 3, above, help demonstrate that wind turbines do not provide significant amounts of electricity during periods of peak electricity demand. The practical implication of this is that areas with growing peak electricity demand will need to add reliable, dispatchable generating capacity even if they already have built wind turbines.[8] Arbitrarily high "capacity values" assigned to "wind farms" by some grid managers or regulators are, in effect, an added subsidy at the expense of electric customers.[9]

   The situation in California in July 2006 provided a dramatic demonstration of how little grid managers can count on wind turbines for electric during periods of high electricity demand. The President and CEO of the California Independent System Operator (CA ISO), when testifying on August 9, 2006, before a State Senate Committee pointed out that:

   > "The contribution of the wind resources at the time of peak was less that 5% of total wind installed capacity."[10]

   This real world experience demonstrates that decisions by regulators and grid managers to arbitrary assign high "capacity factors" to wind turbines – such as the 20% value used by PJM – are way off base.

   Even the American Wind Energy Association (AWEA) is admitting the serious "capacity value" deficiency of wind turbines. While commenting on the California experience, an AWEA official stated:

   > "You really don't count on wind energy as capacity. It is different from other technologies because it can't be dispatched."[11]

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[6] November, December, January, February, March and April.
[7] May through October.
[8] Electric customers are likely to end up paying twice; once for the wind turbines and again for reliable capacity.
[9] In some electric grids, grid managers or regulators have been arbitrarily assigned high "capacity" values to "wind farms" -- such as 20% of their rated capacity. These are hidden subsidies since "wind farms" are seldom able to generate electricity at this level during periods of peak electricity demand.
[10] Mansour, Yakout, CA ISO President & CEO, Prepared statement for the California State senate Committee on Government Operations, August 9, 2006, p. 4.

5. Electric transmission lines serving "wind farms" tend to be used inefficiently. Lines serving these facilities must have enough capacity to handle the full rated capacity of the wind turbines – just in case the winds are blowing about 13 mph or above. However, as demonstrated by the relatively low capacity factors[12] experienced by wind turbines, that capacity is seldom fully used. This means that the unit cost of providing the transmission capacity for electricity from wind turbines tends to be higher than for reliable generating units that can be counted on when needed and which run at higher capacity factors.

So, what do the wind industry claims really mean and is there any truth in the claims?

Wind industry claims about the impact of their intermittent, unreliable output on electric grids are often vague. For example:

1. Industry developers, lobbyists, and other officials may claim that *existing* electric grids can "handle" the intermittent and highly variable output from "wind farms" without requiring more backup generation than is currently available. At least five points are important:

a. First, such a statement may be true *if* there is enough reserve generating capacity immediately available on the grid to keep the grid in balance at the time the "wind farm" is producing electricity, and that transmission capacity is also adequate at the time.

b. Second, it would *not* be true if these two conditions are not met. They are less likely to be met as the amount of wind generating capacity increases in relation to (i) the total generating capacity or (ii) at any time that reserves capacity is low in the area and the wind powered generation needs to be balanced and backed up.

c. Third, if electricity demand is growing in the areas being served by the grid, *reliable* generating capacity will have to be added (unless reserve capacity is already high) because the wind generating capacity can't be counted on when needed to meet peak demands. If wind capacity is added, reliable generating capacity will also have to be added. (In effect, electric customers will pay twice.)

d. Fourth, the fact that reliable generating capacity and transmission capacity *may now* be available to provide the balancing and backup services required to handle electricity from wind turbines does NOT mean that those services – and the additional burden on grid management -- are without cost. In fact, wind powered electric generation adds to

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[11] Quote from Christine Real de Azua, assistant director of communications for the American Wind Energy Association, in Platt's *Power Markets Week*, August 21, 2006, article entitled, "CAL-ISO offers sobering wind assessment: It's growing but can't be relied on as capacity," starting on p.1; quote appears on p. 21.

[12] A generating unit's capacity factor is calculated by dividing its actual output over some period of time (often 1 year) measured in kilowatt-hours (kWh) by its rated capacity times the hours in the period; e.g., 8760 hours in a year. For example, a "wind farm" with the rated capacity of 75 megawatts (75,000 kW) that produces 197,100,000 kWh of electricity in one year would have a capacity factor of 30%. (That is, 197,100,000 kWh divided by 75,000 kW x 8760 hours in a year. 197,100,000 divided by 657,000,000 = 30%).

costs (see below) and those costs are properly considered a part of the cost of the wind powered electricity.

2. If wind industry officials and lobbyists were to claim that existence of wind powered generation on an electric grid did not add to costs, their claim would certainly be *false.* As indicated, additional costs are caused by the wind generation and should be allocated to the owners of that generation. Those costs include (i) the cost of having the generation in place to balance and backup the wind generation, (ii) the wear and tear on the unit(s) that must ramp up or down – or be maintained in "spinning reserve" status, (iii) the added cost when the wind powered electricity doesn't show up on the grid when expected or shows up when not expected, (iv) the cost resulting from inefficient use of transmission capacity, and (v) the cost of any added burden on grid management.

3. So, how much wind generating capacity can be accommodated on an electric grid? There is no single answer to this question. The real answer will vary widely from one grid or control area to another, and will depend on the supply, demand and reserve situation at the time. More specifically:

a. As explained above, wind powered electric generation can be accommodate on an electric grid *if* the grid includes *enough* reliable, dispatchable generation, including some units equipped for automatic generation control, to provide the balancing and backup functions for the wind generation.

b. Whether there is "enough" of this capability will depend on:
1) The amount of generation reserves available and, perhaps, the type of generating unit.
2) Whether electricity demand is at high or peak levels on the grid or control area. There is much less flexibility to handle wind powered electricity when customers' electricity demands are high and reserve margins are narrow.
3) Whether enough transmission capacity is available at the time in the area where it is needed.

<u>Related, false and misleading wind industry claim: "Homes served".</u>

Wind industry developers, lobbyists, other officials and their supporters often make a related claim that is highly misleading, which claim is often picked up and repeated in the media. That is the claim about the number of "homes that would be served" by a "wind farm."

Specifically, statements are often made that "The planned 'wind farm' will provide enough electricity to serve __X__ homes."

Such a statement has some validity when used in connection with reliable, dispatchable generating units but is really untrue for intermittent sources of electricity such as wind that are available only when the wind is blowing in the right speed range.

The claimed number of "homes served" is often done by (a) taking a generating unit or "wind farm's" rated capacity (in MW or kW), (b) multiplying it by 8760 hours, and (c) then by a capacity factor (perhaps 28-32% for wind). The resulting number (in kWh) is then divided by the average number of kWh used annually by residential customers in the state where the unit or "wind farm" would be built.

In fact, NO homes are served by a "wind farm" because the electricity from a "wind farm" is intermittent and completely unavailable at times. Very few home owners or other residential customers – at least in the US – are willing to have such unreliable service.

The "homes served" metric has long been used by the electric industry and it has some validity for reliable, dispatchable generating units. Even then, the metric would be inappropriate to use with single cycle gas turbine or other generating unit that is designed and built for use only during periods of high ("peak") demand – unless it is made clear that the "homes served" number applied only during the peak demand period.

As indicated earlier, electricity from wind turbines is least likely to be available during hot summer weekday afternoons when electricity demand often peaks. Claims of "homes served" made in connection with wind generation are false claims.

Conclusions

Unfortunately, the wind industry and other wind energy advocates have, for years, greatly overstated the energy and environmental benefits of wind energy and understated the true environmental, ecological, economic, scenic, and property value costs. They have misled the public, media and government officials – and created a "popular wisdom" about wind energy and promoted the creation of faulty government policies, tax breaks and subsidies that will take years to correct. This brief paper deals with only two of the areas where the industry and its supporters use half-truths and false or misleading information.

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