A drag on windpower

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 ECN recently published an article from Eurekalert! on the limits of large scale wind power [1]. I thought it might be a good idea to go to the source [2] to find out if the posted article reflected the actual paper. (Hat tip to Watts Up With That [3] for the link to the source)

The first thing I found without any effort at all (it was in the abstract) is that the Eureka people got the previous maximum-estimated wind source number wrong. Eureka claims a maximum of "between 2 and 7 watts per square meter", while the paper states "assumed that wind power production of 2–4 W m^2." That is an overestimate on the high end of almost 2X. So right away, it looks worse than it is. And it is already bad enough.

To understand the next quote from the paper, you will have to understand Capacity Factor (CF). Capacity Factor is the average output of a wind turbine compared to the rated maximum output of a turbine. A 3 Megawatt (MW) wind turbine that averages 1 MW output has a CF of 33.3.

> *Similarly, using hourly data from all the wind farms in Texas which has the largest wind capacity in the US over 2007–2008 the average CF was only 27.8 [9]. The US National Energy Modeling System assumes a maximum CF for onshore wind of 40% in 2010 growing to 46% in 2030 [10].*

In other words, the estimate the government uses is already an overestimate. The overestimate may be as little as 44%, but it could be much larger. And the estimate of CF is going up, while real CF is likely going down. No wonder the turbine makers need a subsidy. Without it, reality might intrude.

> *Fitch et al [20] note that the turbines producing the least amount of electricity are on the farthest downstream edge of their simulated wind farm, thus it is possible that if their wind farm was larger in size they would have seen an even larger reduction in production.*

Well, what do you know? Bigger wind farms produce less electricity because of upstream blocking. What does that say? Big wind farms are a good idea from the standpoint of ease of installation and a bad idea from the standpoint of energy production. The bigger, the worse.

The heart of the matter:

> *It is evident that the spacing of the turbines is critical for maximum energy production from wind, and that the collective effect of wind turbines can play a strong role in limiting wind power extraction at these scales.*

Another cause of reductions in possible total wind power resource is that, currently, turbine sites are carefully chosen to maximize average output. What happens when you have to put them everywhere to capture as much energy as possible?

> *The even-spacing assumption may be realistic for large-scale wind resource studies, because at the very large total wind capacities contemplated, there would be less opportunity to choose the best possible sites.*

The authors now give some real numbers to go with their descriptions. I have bolded the most critical point.

> *Our results suggest that power production as a function on increasing turbine density begins to saturate below 1 W m^2 and that it will be difficult to attain large-scale wind power production with a power density of much greater than 1.2 W m^2* ***contradicting the assumptions in common estimates*** *of global wind power capacity [2–4].*

How about the environmental impact of large-scale wind farms aside from changing wind speeds over a large area?

> *If we consider the environmental impact of large-scale wind farms by looking at the average temperature change times the area impacted, it is plausible that even at a small density large wind farms may still have a relevant environmental impact. In other words, we should not assess the environmental impact as simply the magnitude of the warming, but also by the area impacted by the warming.*

They cause warming? But I thought wind farms were supposed to reduce warming? In any case, what that tells us is that large-scale wind farms might be helpful in keeping us out of an ice age and will produce electrical energy as a byproduct. Handy.

I take issue with their assumptions about CO2, methane, etc. (which I assume is what they mean by greenhouse gases), but otherwise I think this next quote better

explains their results.

> *...it is important to note that the warming that will occur due to wind energy turbines, is very different than warming due to green house gases, in that the warming is primarily local, depends on the stability of the atmosphere, and has a finite limit locally in magnitude due to the depth of mixing occurring. The choice of a winter season illustrates the upper bounds of this environmental impact. During summer, especially in regions that experience a convective mixed layer during the day, the warming is much less. When considering possible environmental impacts it is important to look at periods when we expect the biggest impact in order to identify the upper bounds of possible impacts. Note that these impacts may or may not be harmful; our goal is simply to assess their magnitude.*

The bottom line? The more turbines we install once the best sites are covered, the less economic they will be. And note - this study does not even account for the fact that the wind energy may be produced when it is not needed. That situation is so bad that in fact that there have been cases where the wind energy has a negative cost. (i.e., The wind farms pay the grid to take their electricity [4] so they can collect their government provided subsidy.) Nice work if you can get it.

M. Simon's e-mail can be found on the sidebar at Space-Time Productions [5].

Engineering is the art of making what you want from what you can get at a profit.

Links:
[1] http://www.ecnmag.com/news/2013/02/rethinking-wind-power
[2] http://iopscience.iop.org/1748-9326/8/1/015021/
[3] http://wattsupwiththat.com/2013/02/25/rethinking-wind-power-harvard-study-shows-it-to-be-overestimated/
[4] http://www.americanprogress.org/issues/green/report/2012/10/10/41100/wind-power-helps-to-lower-electricity-prices/
[5] http://spacetimepro.blogspot.com/