The Oil Drum: Europe
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

Gore sets goal of 100% carbon-free electricity by 2020

Posted by Jerome a Paris on July 18, 2008 - 9:55am in The Oil Drum: Europe
Topic: Policy/Politics
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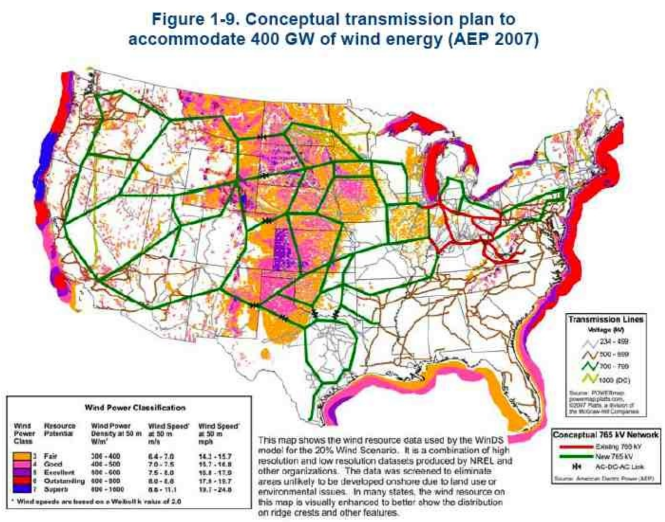
Al Gore has made a major speech in Washington this morning, setting out an ambitious goal for the USA to produce all of its electricity from carbon-free sources by 2020. I thought I'd comment on the technical feasibility of the plan, and the underlying economics of such an endeavour.



from the Department of Energy's recently published study about bringing wind power to 20% of total generation

The short answer is: while 100% is probably unrealistic, it's not unreasonable to expect to be able to get pretty close to that number (say, in the 50-90% range) in that timeframe, and it is very likely that it makes a LOT of sense economically.

Disclosure (or reminder)*: I am an investment banker for the energy sector. I do a lot of work with the wind sector, as the posts in my wind power series attest, but not only. Whether a pipeline or a wind farm, the job of a project financier is to ensure that the projects make sense for all interested parties (including the regulator) in the long run, and wind projects have to meet the same hurdles as other power plants or oil fields. Thus I'm supposed to remain level-headed when discussing wind projects!*

Today, the USA generates roughly 4,000 TWh of electricity from close to 1,000 GW of installed capacity:

Table 2.2. Existing Capacity by Energy Source, 2006
(Megawatts)

Energy Source	Number of Generators	Generator Nameplate Capacity
Coal[1]	1,493	335,830
Petroleum[2]	3,744	64,318
Natural Gas[3]	5,470	442,945
Other Gases[4]	105	2,563
Nuclear	104	105,585
Hydroelectric Conventional[5]	3,988	77,419
Other Renewables[6]	1,823	26,470
Pumped Storage	150	19,569
Other[7]	47	976
Total	**16,924**	**1,075,677**

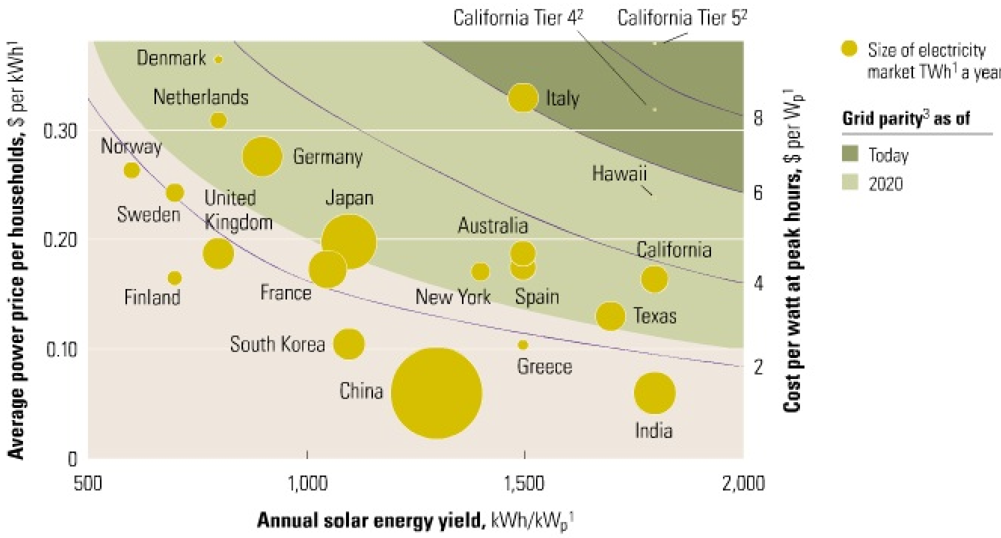
[1] Anthracite, bituminous coal, subbituminous coal, lignite, waste coal, and synthetic coal

Table 1.1. Net Generation by Energy Source by Type of Producer, 1995 through 2006
(Thousand Megawatthours)

Period	Coal[1]	Petroleum [2]	Natural Gas	Other Gases[3]	Nuclear	Hydroelectric Conventional[4]	Other Renewables[5]	Hydroelectric Pumped Storage[6]	Other[7]	Total
Total (All Sectors)										
1995	1,709,426	74,554	496,058	13,870	673,402	310,833	73,965	-2,725	4,104	3,353,487
1996	1,795,196	81,411	455,056	14,356	674,729	347,162	75,796	-3,088	3,571	3,444,188
1997	1,845,016	92,555	479,399	13,351	628,644	356,453	77,183	-4,040	3,612	3,492,172
1998	1,873,516	128,800	531,257	13,492	673,702	323,336	77,088	-4,467	3,571	3,620,295
1999	1,881,087	118,061	556,396	14,126	728,254	319,536	79,423	-6,097	4,024	3,694,810
2000	1,966,265	111,221	601,038	13,955	753,893	275,573	80,906	-5,539	4,794	3,802,105
2001	1,903,956	124,880	639,129	9,039	768,826	216,961	70,769[R]	-8,823	11,906[R]	3,736,644
2002	1,933,130	94,567	691,006	11,463	780,064	264,329	79,109[R]	-8,743	13,527[R]	3,858,452
2003	1,973,737	119,406	649,908	15,600	763,733	275,806	79,487[R]	-8,535	14,045[R]	3,883,185
2004	1,978,620	120,771[R]	708,854[R]	16,766	788,528	268,417	82,604[R]	-8,488	14,483[R]	3,970,555
2005	2,013,179	122,522	757,974	16,317	781,986	270,321[R]	87,213[R]	-6,558	12,468[R]	4,055,423[R]
2006	1,990,926	64,364	813,044	16,060	787,219	289,246	96,423	-6,558	13,977	4,064,702

It is important to note right away that MWs of capacity and MWhs of generated electricity are by no means proportional. There is more gas-fired capacity than coal-fired capacity (440GW vs 330GW), but coal-fired plants generate two and a half times more power (2,000 TWh vs 800 TWh). It is useful to note in that respect that the capacity utilisation of non-hydro renewables are pretty close to that of the overall system (with 100 TWh generated from 26GW of capacity in 2006).

Today, a plan to be in a position to generate between 2,000 and 3,000 TWh of electricity from renewables (taking into account the 1,000 TWh per year provided by nuclear and hydro, which are expected to remain in place) will necessarily focus to a large extent on the large-scale development of wind farms, which is the only renewable technology which is already industrially tested and has a levelised generation cost in the same range as today's conventional power sources, in the single-digit cent-per-kilowatthour range. Solar is likely to play its part as well: it will keep on growing massively from its current low levels, but more effort is still required to bring its cost down from the current 20-30c/kWh range, something which is expected to happen in the next decade.



¹kWh = kilowatt hour; kWp = kilowatt peak; TWh = terawatt hour; Wp = watt peak; the annual solar yield is the amount of electricity generated by a south-facing 1 kW peak-rated module in 1 year, or the equivalent number of hours that the module operates at peak rating.
²Tier 4 and 5 are names of regulated forms of electricity generation and usage.
³Unsubsidized cost to end users of solar energy equals cost of conventional electricity.

Source: CIA country files; European Photovoltaic Policy Group; Eurostat; Pacific Gas & Electric (PG&E); Public Policy Institute of New York State; McKinsey Global Institute analysis

Source: McKinsey Global Institute

For the simplicity of this discussion, I will focus on wind, given that it presents a bigger challenge on the intermittency front (which the inclusion of solar can only help improve), and that it would drive the ecohnomics of such a plan given its larger scale deployment.

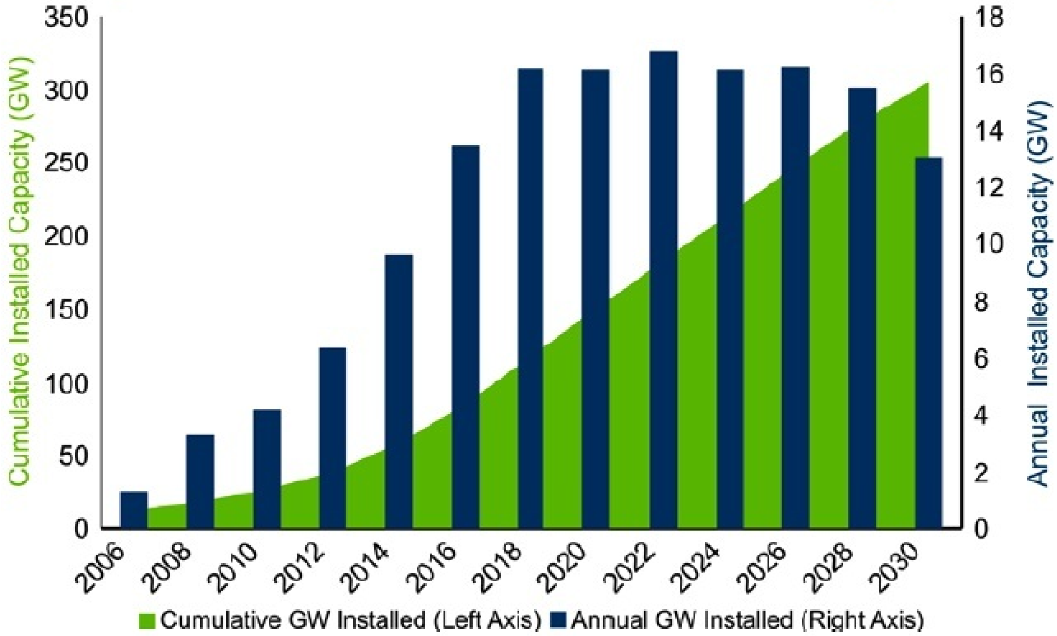
The main questions, of course are as follows:
1) is it technically feasible to build the requisite capacity within 12 years?
2) what will it cost, and what will it mean for power prices?
3) how can the intermittency issue be dealt with?

Technical feasibility
To get 2,000 TWh of electricity from wind, roughly 800GW of wind power capacity would be needed, considering that windfarms would get an annual production equivalent to 2,500 full hours (a pretty conservative estimate, given that the existing wind farms are closer to 3,000 hours today). 800GW is roughly equal to 30 times the currently installed capacity (which should reach about 23GW at the end of this year) and 100 times the capacity installed in 2008 (expected to be close to 8,000MW, after 5,000MW were installed in 2007).

To build 800 GW in 12 years would require a significant increase in annual installations - but actually not an unrealistic one.

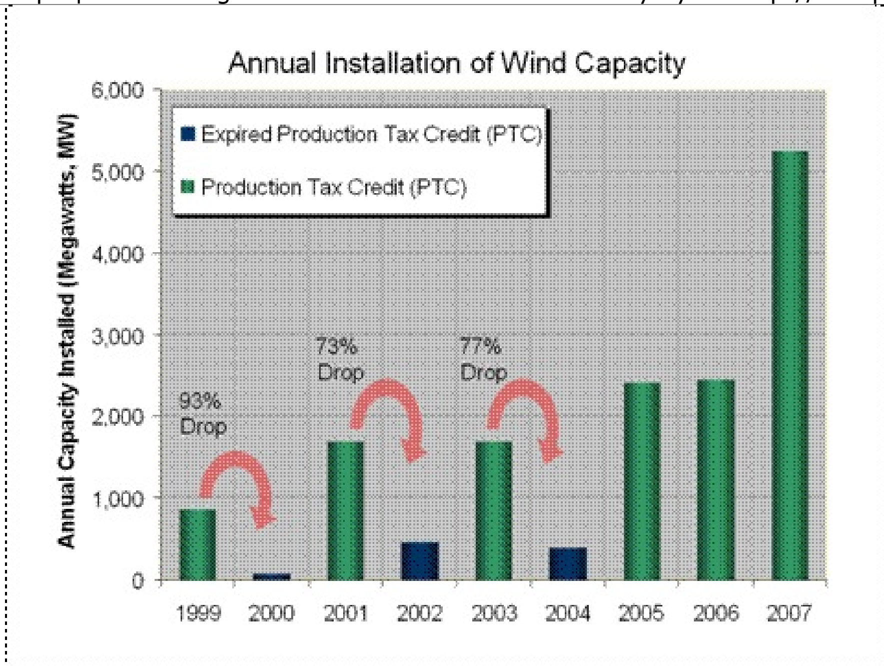
The Department of Energy recently published a study about bringing wind power to 20% of total generation, which provides the following timeframe:

Figure 1-11. Annual and cumulative wind installations by 2030



This is for a less ambitious plan: 300GW by 2030, so you'd roughly have to quadruple that to get to 800GW by 2020, but one might note that the DoE only expects 4GW to be built in 2008, ie *less than the reality without any big plan to boost things up*... A realistic target would be to have 80GW of installations, ie 10 times this year's level, within 5 years. That would give the time to ramp up production, by building factories, training workers, and ensuring that the supply chain follows suit. What would make this possible is for the industry to have the certainty that the investment are required.

What has hampered the development of the industry has been the regulatory uncertainty, in particular in the US with the long saga of the timely renewal (or not) of the PTC ("production tax credit", the federal 10-year tax credit equal to 2c/kWh for power from renewable sources), which caused demand to crash and then brutally rebound from one year to the other. This caused installed capacity to collapse several times in the past few years in the US, causing mayhem in the industry worldwide:

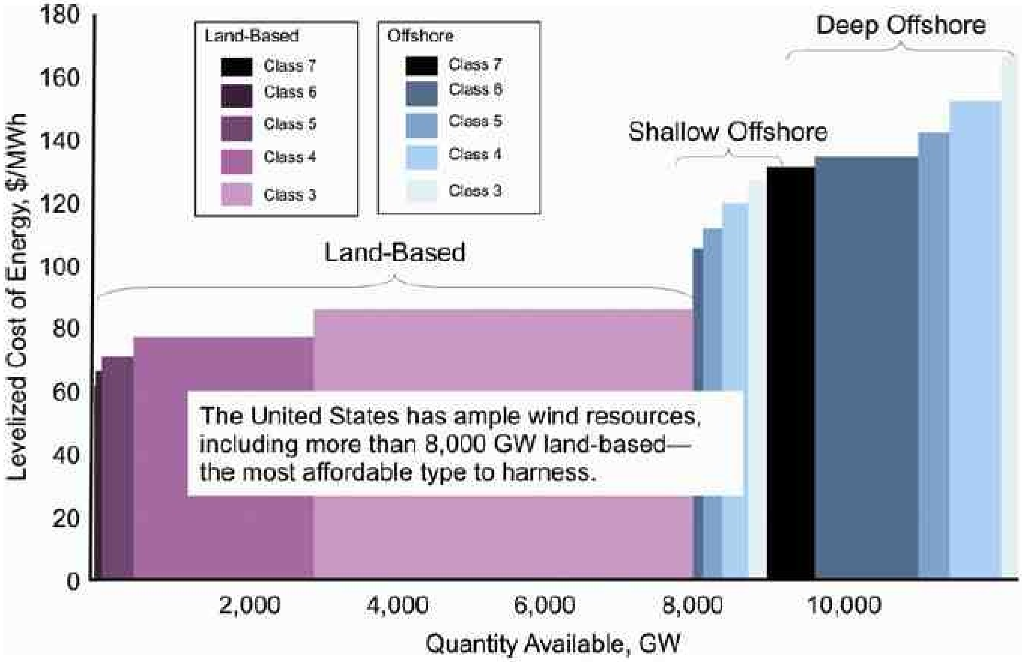


Source: AWEA

With predictable, guaranteed demand over the next decade, the industry could step up its investments across the supply chain in order to provide the requisite number of generators. The technology is understood, it calls upon industries that are much larger than the pure wind sector (mechanical engineering and civil works, mainly) and which have a large employment pool. Access to resources is tight today, as it across all industry, but we're not talking world-changing volumes either (for instance, if you count about 50 tons of steel per MW, you'd need 4 millon tons of steel per year, ie less than a percent of total world production). And again, a strategic plan with predictable production figures and guaranteed demand would allow to lock in supplies early on in the process, providing stability (and early cahsflows) to all suppliers down the chain.

In terms of wind resources, the USA has more than enough potential to find enough sites to install such capacity with wind resources providing cost competitive production , as noted in the DoE report (which alos notes that more than 1,000GW could be connected to the existing grid at low cost):

Figure 1-5. Supply curve for wind energy—current bus-bar energy costs



Altogether, the plan would require boosting investment in wind production capacity to about $100-150 billion per year, a significant number but hardly one that would require a complete retooling of the US economy. With a stable regulatory framework (presumably provided if this were made a national priority) and guaranteed demand (which could come via very simple mechanisms, like a feed-in tariffs, ie mandatory purchases by local utilities at regulated rates), there is absolutely no reason to doubt that this could be done.

I'll address the requirement to boost the grid separately below.

the economics of such a plan

Wind power economics are quite simple: most of the levelised production cost per MWh comes from the initial investment. It is thus naturally sensitive to investment costs, and even more so to financing costs, both of which are determined at the time of construction. Once a windfarm is built, its production costs are essentially set for the rest of its operating life, ie 20-25 years. The fixed nature of its cost base makes it a difficult bet in a deregulated universe, where prices can swing wildy (including to low prices that can be insufficient for the windfarm to service its debt burden, thus the requirement for feed-in tariffs or similar mechanisms to guarantee a floor to wind electricity). But such fixed prices make wind a great proposition at times of increasing oil&gas costs: wind power prices will NOT increase even if oil & gas or coal prices continue to go up, as is quite possible.

Thus wind power is a wonderful hedge against future energy prices. And given that today it already costs less than power from a ges-fired plant (the plants that typically drive the price of electricity on wholesale markets), it is both competitive and likely to remain so in the coming years.

And given the cost structure of wind, a very simple way for government to support wind at very little cost would be to provide funding for the sector at low interest rates. One big advantage of government is its ability to borrow at lower rates - indeed, government sets the lowest rates that are by the rest of the economy. By passing on its low cost of funding to wind developments, the final cost of wind power could be lowered significantly, and passed on to consumers (banks would still be required to hold onto operational and other risks linked to wind production, they would just get cheaper funding for that specific purpose, which the'd have to fully pass on to projects.

Germany has successfully used such a mechanism for years).

Studies in Germany and Denmark show that wind power lowers wholesale prices by 30 to 70% when wind blows, and that the overall savings for consumers far outstrip the cost of guaranteeing to wind producers a regulated tariff. Ironically, the more wind power there is in the system, and the lower the wholesale marker price will be most of the time, which means that the regulated tariff remains a necessity to ensure that wind producers are able to pay off the debt linked to their initial investment. But that regulated tariff is known, is realtively low, and,again, will not need to increase over time, thus ensuring to consumers similarly stable retail prices.

If anything, wind is likely to stabilise prices, or even bring them down *whatever the prices of oil, natural gas or coal*. Also, as the DoE report notes, beyond the potential benefits of reducing greenhouse gas emissions, switching to wind would have massive advantages in terms of lower water use for the power sector.

The DoE study concluded that the cost of strengthening the grid would be around $20 billion in today's dollars. Given the larger scale of the Gore plan compared to the DoE plan, a cost of $100 billion for grid reinforcement seems a reasonable estimate, which would represent less than 5% of the total investment programme,and thus have a similarly minor impact on ultimate production costs.

Dealing with intermittency
Of course, the big question with such an ambitious plan is how to deal with the intrinsic intermittency of wind power, which may not be available when electricity is actually needed. Given that power is almost impossible to store (except where hydro is available on a large scale, and pending potential progress on batteries), this is a very real issue.

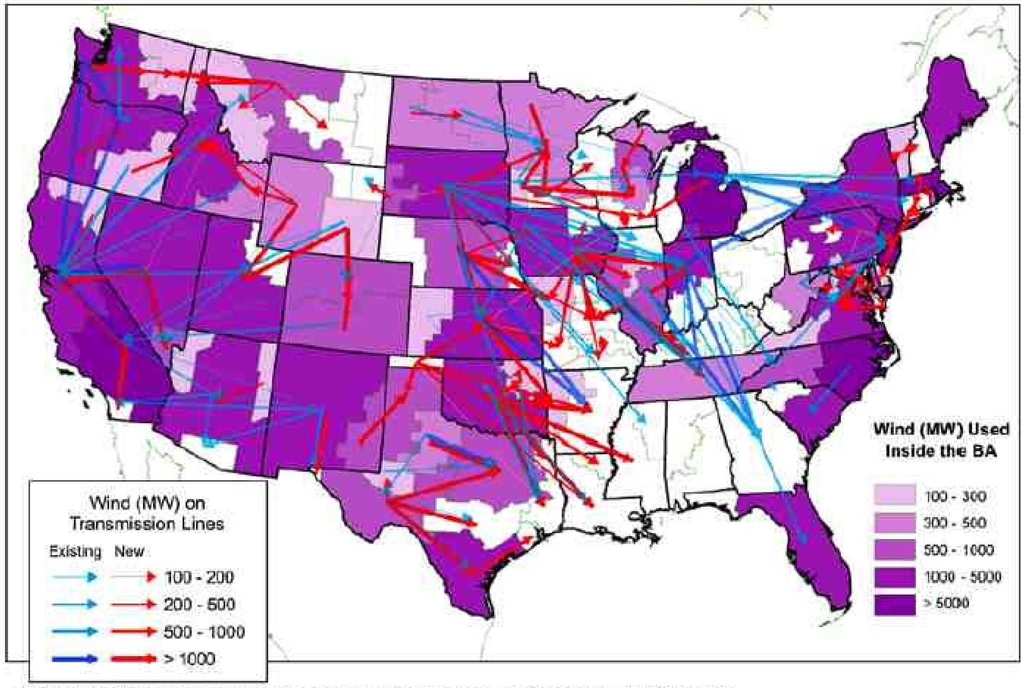
But there are actually several answers to that:

- one is that, provided that the network is able to shift electricity around, you can rely on the fact that the USA has several independent wind regimes, and thus that there will almost always be wind somewhere that can be carried around. Obviously, this does mean a serious effort to reinforce the network, and to connect the now mostly separate regional grids, but that's precisely where the federal government could have a decisive say within such a plan, and push a reinforcement and development of the grid on a coordinated national basis. As a good example coming from a territory which is much smaller than the USA, (but which also has at least 3 independent wind regions) I note that the French grid operator, RTE, long extremely wary of wind power and its unreliability, had this to say in its latest annual report (big PDF, in French, see p.49):

  > The second point is about wind's contribution to peak demand: despite wind's intermittency, wind farms reduce the need in thermal power plants to ensure the requisite level of supply security. One can speak of substituted capacity.
  > The capacity substitution rate (ratio of thermal capacity replaced to installed wind capacity) is close to the average capacity factor of wind farms in winter (around 30%) for a small proportion of wind in the system (a few GW). It goes down as that proportion increases, but remains above 20% with around 15GW of wind power.

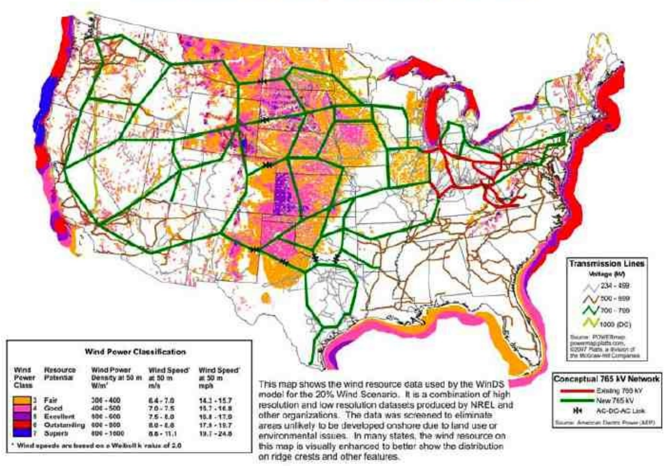
  Similarly, the UK network operator put up a report that noted that the expected intermittency of the national wind portfolio would not appear to pose a technical ceiling on the amount of wind generation that may be accommodated and adequately managed. The DoE, in its own study, hasidentified the improvements that would be require to the network to absorb more wind power and be able to use it around the country:

Figure 1-8. All new electrical generation including wind energy would require expansion of U.S. transmission by 2030



Total Between Balancing Areas Transfer >= 100 MW (all power classes, land-based and offshore) in 2030.
Wind power can be used locally within a Balancing Area (BA), represented by purple shading, or transferred out of the area on new or existing transmission lines, represented by red or blue arrows. Arrows originate and terminate at the centroid of the BA for visualization purposes; they do not represent physical locations of transmission lines.

Figure 1-9. Conceptual transmission plan to accommodate 400 GW of wind energy (AEP 2007)



;

- the second answer is that spare capacity will be needed occasionally, and that this is actually not a big deal. As noted at the beginning of this post, gas-fired capacity is already used at much lower overall rates than coal-fired plants. They can be kept in place. With 440GW of gas-fired capacity, and taking into account the oil-based, nuclear and hydro capacity, demand can be assured at pretty much any point in the demand curve even without wind. The important thing to note is that keeping that capacity in place does not mean using it. MWH substitution does not require MW substitution to the same extent:

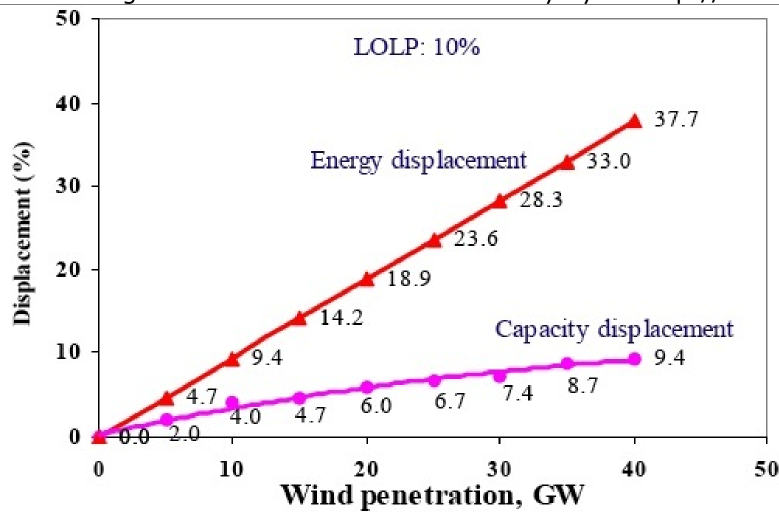


Figure 9. - Conventional capacity and energy displacement at various levels of wind penetration

from the UK study linked to above

Carbon emissions come from using the capacity, not from keeping it available. Using that capacity every now and then will generate some emissions, but that will only represent a small fraction of today's emissions, especially supposing that it is coal-fired capacity that is eliminated thanks to the arrival of wind and solar. And as many gas-fire plants are already geared, to a large extent, to be used only for fractions of the time, their economics will easily tolerate such use. It should also be noted that the production profile of solar and of offshore wind matches electricity demand a lot better than onshore wind, so their development (which I ma voluntarily ignoring here) will further help in that respect;

- the third answer is that there are a number of small changes to electricity consumption patterns that can be used to reduce the requirement for peak capacity. Industry has long agreed to sign interruptible contracts, benefitting from lower prices for power in exchange for the right by the utilities or the network to cut them off at short notice; a lot of our power consumption is not time sensitive and could thus also be made to switch off in times of need. And this is an area where government could easily play a role, by mandating standards for all electricity consuming equipment, making them able to "talk" to the network and indicate their status (not interruptible, interruptible at identified times, interruptible at will).

Overall, network operators with actual wind experience seem confident that a combination of additional investment, smart grid management, and maintaining available (but not using much) a large gas-fired capacity can make it possible to cope with large amounts of wind power in the system.

While a goal of 100% of carbon-free electricity is probably unrealistic, it therefore seems possible to get pretty close to that, especially if nuclear and hydro are included in the mix. A plan that announced a specific goal of 40-50% of wind-generated electricity by 2020 and 10-20% of solar, with the appropriate feed-in mechanisms, demand guarantees for manufacturers and investment in the grid would therefore be realistic, make economic sense, and fulfill two major strategic goals: reduce carbon emissions, and lower fossil fuel demand.

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