THE ENEMY WITHIN

Wind and solar power - helping or hindering?

To destroy your enemy's machine, don't attack it from outside. Place a part inside it that appears to help its function but that will, in reality, ruin it.

I have decided to start this essay with my conclusion and work back, because it is easier to explain that way. My conclusion about grid-connected wind and solar generation is that it has been promoted and expanded because it can never work. That has been done in order to wreck our attempts to stop using fossil fuel. Who might want to do that? The fossil fuel industry, obviously. And the wind and solar renewables industry. And some "environmental" organisations whose supporters pay them to promote renewables and oppose competing technologies like nuclear. And anyone else that wants to curry public favour or advance their careers by fitting in with the dominant "emperor's new clothes" trend of our time. So that's pretty much everyone. In fact, some of these actors have no interest in seeing our electricity grid, power infrastructure, industrial base or society continuing to function at all. For example, Russia supplies some of the gas that is now necessary to support use of wind and solar by various European grids.

The fossil fuel industries have conducted campaigns in the past to mislead the gullible citizens of our docile democracies. In the USA, related industries are known to have successfully worked together in the past to destroy competition. For example, in the 1930s and 40s, motor fuel producers, vehicle and tyre manufacturers, and road construction firms together bought up the popular, clean and efficient electric street car (tram) systems in US cities, replaced the trams with diesel buses, quickly tore up the tram lines and burned the trams, then allowed the bus service to degrade in each city so that residents were forced to buy cars. Nowadays, the mainstream media, internet, and even quasi-governmental and industry technical reports are drenched in anti-nuclear propaganda that is sometimes so strategically astute and artfully worded that we must suspect some politically savvy origin. The nuclear industry is often accused (without evidence) of paying media shills, but the global fossil fuel industry and the states that most depend on it are immensely more wealthy and have an established sinister record of deceptive behaviour. I think similar forces are now clandestinely promoting wind and solar for our grid precisely because they know these technologies will never work. Or, they know that, to the very limited extent that wind and solar might ever be made to work, the struggle to use them will cripple our capabilities and leave us helpless. But, that's only my conclusion, and my conclusion is not the point of this piece (although I will repeatedly refer to deliberate sabotage as a device to try to explain myself). It doesn't matter whether, after reading this, you think grid-connected wind and solar is disastrous on purpose or by accident. But I hope to explain why many of us have come to believe the proportion of "weaponized" wind and solar on the grid should be zero.

There are three types of low-carbon generation, each with their own characteristics. Nuclear runs continuously flat-out, briefly stopping every 18 months or so at a time of low power demand to change and rearrange its fuel and carry out any maintenance. Nuclear fuel is inexhaustible, cheap and low in environmental impact, and nuclear reactors tend to be damaged by changing power, so it is usually better for them to just waste surplus power rather than to avoid producing it. Hydro can vary its output quickly and comfortably as required to match the grid's ever-changing power requirements, and this helps to conserve its fuel (water). Hydro makes an ideal partner to nuclear, and it can even be modified to store limited amounts of surplus power by pumping water uphill, but unfortunately there are few suitable hydro-generation sites beyond those already in use. As a result, grids that are blessed with lots of hydro power will be encouraged by market forces to sell much of it at a high price so that neighbouring grids can build less nuclear. Therefore, few grids are ever likely to have as much hydro as they would like. Wind, solar and similar generation types (like wave or tidal flow) produce power whenever the feel like it, in whatever quantity they feel like it, and cannot be controlled except by wasting any excess power. The most that they can be relied upon to produce at any random moment is virtually nothing, and this has important implications for the grid. A fourth type of generation, gas, is not low-carbon, but is used at present because its power can be varied to fill in the gaps created by changing grid power demand and changing wind and solar power supply.

At present, entirely fossil-fuelled generation, such as coal or gas, is slowly being replaced by wind and/or solar combined with a fossil fuel backup (which is normally gas). This might be theoretically expected to reduce CO2 emissions. In practice, though, a need for rapid changes in generated power and the inevitable low utilisation of plant encourages installation of cheap, responsive, inefficient open circuit gas turbines (OCGT) instead of fuel-efficient closed circuit gas turbines (CCGT) which are inflexible and cost more to buy. As a result, it is difficult to be absolutely certain whether current proportions of wind and/or solar generation really have reduced CO2 emissions below what would have been achieved with gas generation alone. We do know, however, that simplistically predicted CO2 reductions become inexorably harder to achieve as the proportion of wind and solar increases on any grid powered in this way. In any case, we must stop using fossil gas as soon as possible in order to reach zero carbon, and doing so will require that we find some other way of making supply match demand, second by second. Unfortunately, despite many contrary claims, there is essentially no near-term possibility of it becoming feasible to economically store enough electricity to power whole grids during periods without wind or sun. Nor, again despite popular sentiment, can these shortfalls realistically be dealt with by transmitting intermittent power over long distances across continents, nor by using economic measures to force demand to continuously fit supply.

For the world's future zero-fossil-carbon grids, a combination of two facts dictates which electricity sources can be used. First, the minimum combined power from wind, solar, and other intermittent sources is, regardless of location, effectively zero. Second, there is no point in adjusting the output power nuclear stations to anything below flat out, either for short periods or for longer, because in practice it does not save fuel or resources or money. In order to recover the huge initial capital cost of nuclear generating plant, nuclear electricity generally needs to be generated at maximum power continuously, then sold if a market can be found for it or wasted if it no use can be found. In the simplest analysis, this means there is no point in having intermittent sources like wind and solar on a zero-fossil-carbon grid. That is because, when intermittents do not generate, the whole resultant shortfall will have to be made up by nuclear, but the same nuclear generating capacity required to occasionally fill in for intermittents can more efficiently and cheaply do the whole job all the time on its own without any help.

A slightly more sophisticated analysis than this can take account of the limited amount of hydro power available to a grid. Such an approach might suggest that the amount of wind and solar power a grid can make use of is not, in fact, absolute zero. However, it is still very limited, because power from intermittents is likely to be wasted if it ever exceeds the instantaneous maximum that can be provided by hydro power. Within the range where increases or decreases in wind and solar can be compensated for by corresponding decreases or increases in hydro power output (assuming the infrastructure can react in such a way in practice) the power from wind and solar might appear useful. Beyond that, the grid sometimes has no use for the power from wind and solar generators, and neither the grid nor anyone else should be forced to pay for it. Several European countries have already installed far more wind and solar generating capacity than their fair share of Europe's hydro capacity, with their citizens and electricity consumers paying heavily for that decision. What is more, it should not be unquestioningly assumed that installed wind and solar capacity serves any useful function even when it can indeed be exceeded in potential instantaneous power from hydro capacity. When the valuable flexibility provided by hydro capacity is used up in allowing wind or solar to be part of the grid, that flexibility cannot also be counted on to supplement nuclear. The result is that nuclear capacity must be over-built, resulting in wasted power and wasted capacity, decreasing the financial viability of nuclear and discouraging investment, with consequent continued delay in any progress towards rational decarbonisation.

The generation types also vary in another respect. Some just produce vastly more energy than others. This can be quantified with reference to things like the area of land they need, the disruption or environmental impact or danger they cause, or their cost or resource use. Crucially, comparison must be made of the total useful energy they eventually produce during their lifespan against the fossil carbon required to build, maintain and decommission them. Hydro and nuclear perform well by this indicator.

The electricity grid has always operated, and largely will continue to, on the basis that it will cope with whatever demand happens to occur. It provides very limited price incentives to induce consumers to avoid demanding domestic power at particular moments that it may find difficult to supply and has only primitive methods for coping if demand exceeds supply. Society as a whole operates on similar lines, and it is difficult for any industrial society to do otherwise. But our zero-fossil-carbon future must be supplied with energy from extremely inflexible power sources (mainly nuclear plants running flat out) and with very limited (mostly hydro) storage. High quality energy such as electricity can hardly be stored at all. Synthetic liquid fuels are easier to store in bulk, but the rate at which they will be consumed means even vast volumes of storage will equate to rather short time periods of consumption. Lower quality energy like heat can be stored cheaply in fairly large quantities, for example by heating or cooling rock. But, no store of any kind is infinite. Every energy store will eventually either overflow or run dry. So, in future, either much energy will have to be wasted or we will have to go without some of the energy we want. How big will this shortfall or waste actually be? An answer, such as there is one, can be guessed by considering the degree of intermittency of the various generating sources, and that of demand from the grid itself. So how might one quantify intermittency?

An obvious measure of intermittency is the ratio of maximum to minimum power. The power demand from an electrical grid, for example, might typically vary by a factor of about two. Photovoltaic solar panels vary from some maximum value in sunlight to nothing at night, making the ratio effectively infinite. The theoretical instantaneous power in the wind is proportional to the cube of the windspeed so, for instance, windspeed increasing from 3 mph to 30 mph theoretically increases electrical power generation one thousand fold. Less theoretically, when the wind turbines reach their maximum operating limit, they may abruptly shut down and go back to generating nothing. Such changes can happen within seconds.

As previously noted, the usefulness of a generating technology is related much less to how much electricity it produces than to how much it can be relied upon to produce - in other words, its minimum dependable electrical output. That is because the design and operation of the grid is based on being able to supply whatever is needed so, in general, power that might not turn up when required is effectively useless, even if it does in fact happen to turn up at exactly the right moment. Even for electricity grids covering much of a continent, that minimum normally remains virtually zero for wind, photovoltaic solar, or any combination of the two. A commonly quoted value for generating plant is its nameplate capacity, which indicates the maximum electrical power it can produce. One might expect a high value for this to be good but, for intermittent plant like solar and wind, high nameplate capacity tends to indicate its ability to cause problems for the grid by perpetually threatening to actually produce that much power, financially undermining the case for installing efficient low-carbon plant to generate it reliably instead.

Short-term intermittency, over a few hours or days or months, is the most obvious problem. The demand for power and the supply available from wind and solar varies wildly over these periods, and batteries can only economically store minutes or hours of electricity at grid scale. But there is also intermittency over years and decades. One ten-year time period may only provide three-quarters of the energy from wind and solar that was provided in previous such periods. The resultant total shortfall in energy is therefore colossal, and beyond any conceivable remedy through energy storage. Again as already noted, this means that in future, either we will have to frequently go without much of the energy that society depends on or we will have to waste much (or quite possibly most) of the energy we produce. This problem is most obvious when considering wind and solar, but it also applies in a general sense to all future energy supplies. Hydro, for example, relies on rainfall, which varies from winter to winter. Our demand for energy also unavoidably varies. Even nuclear, whose output is constant, can only produce as much power as it has been built to generate. If we will ever need more power than that fixed amount, we will need to have built more nuclear plants and to have kept them running in readiness for a time when power from them might be required. Consequently, until that time, much or most of their output has to go to waste, unless we can find some extra use for it.

Perhaps surprisingly, even the inevitable variations in entirely off-grid power consumption and generation must also be expected to contribute to the grid and society's problems of power variability. For example, in a fossil-carbon-free world, a solar panel that directly powers an off-grid irrigation pump must be so oversized that much of its output is normally wasted, or the inevitable occasional electricity shortfall will probably be corrected by the use of power which has come through some grid, or else the farmer must be willing to watch a crop fail from lack of water. Our power future, without the current bottomless well of fossil fuel, will be a very inflexible place.

It is not shortage of power as such that will be our inevitable problem, therefore, but rather intermittency, variation, and overall mismatch of supply and demand. Wind and solar stand out as particularly troublesome offenders in this respect, because of their inherent characteristic of creating huge and uncontrollable variations in output while providing virtually zero reliable power, along with substantial other environmental, financial and social impacts. An obvious question is why so much money has been spent on deploying a form of generation that provides none of the one thing we require (reliable output) while inflicting upon us vast quantities of the things we know will plague us (variation and intermittency). An almost equally obvious answer is that not everyone wants our energy policy to work because there are people, notably fossil fuel industries and their foreign and domestic beneficiaries, who benefit by its failure. For those powerful groups, the limited potential for wind and solar to do useful work is of less interest than their far greater ability to do harm, especially with help from continuing near-suicidal national energy policies.

Just as energy storage in a zero-fossil-carbon world is bound at times to either eventually run dry or overflow, uses for power tend to do the same thing. If something is worth doing, it is important that it does actually always get done. But, using surplus power to do it means it might not get done. So pumping irrigation water or drainage seems ruled out as a use for surplus (but also potentially non-existent) power, as does space or water heating, and all but the most superfluous decorative lighting. Similarly, no matter how welcome some power-consuming activity is, there is normally a limit to how much of that activity can productively be undertaken. So irrigation, drainage, heating and lighting seem to have limited potential for this reason too. In order to avoid either perennially wasting energy or running short of something important, we will have to look harder. How about desalination? That uses lots of energy, and seawater will never run out, and fresh water is certainly useful stuff. But again, no fresh water is certainly too little if you do actually need it. And is it still possible eventually to have too much of it? Fortunately, a lot of energy makes rather little desalinated water, so at least it will take longer before any reservoir overflows due to it containing too much fresh water. Arguably at least, that extra time could allow some change in infrastructure to take place in order to use more of the stuff or create less. The potential to refill depleted aquifers also offers an effectively unlimited use for desalinisation, with less immediate need for concern over whether it might be done too much or too slowly. Another appealing use for surplus power is removal of CO_2 from the atmosphere or oceans, or correction of ocean acidity. Here, for sure, is something we will not manage to do too much of. In fact, inevitably, we will do too little. This should remind us that, if surplus power is not forthcoming, we might in fact find ourselves for long periods doing none of it at all, with devastating planetary results (not that exactly such a current situation seems to be bothering people much).

Having found something to do with our surplus power, can we be sure it will actually be done? After all, the plant to use power in any way costs money to buy, and that is reflected in a continuing notional or actual interest cost, plus some continuing expense of maintaining the plant, no matter how seldom or how little it is used. If those plant capital and other costs are high, or the price for surplus power not low (or negative) enough, or the supply of power is too infrequent or spasmodic, no one will want to use the power and it will be discarded (just as is typically done now). We can predict that the most nearly continuous power will find a buyer or user first, leaving a remaining surplus that has become even more intermittent because of this. From that less attractive remainder, someone may again take the most nearly continuous layer, leaving something less useful still. Eventually, no one will want what is left, and it will have to be discarded. That discarded power will, however, represent a considerable amount of generated energy in total, especially since the cube function for wind power tends to result in the peaks of power production being very high, with a consequent large area of graph under the higher parts of the curve. The resultant wastage further reduces the already limited extent to which the supposedly fossil-free energy produced by wind and solar exceeds the fossil energy put into building and maintaining it.

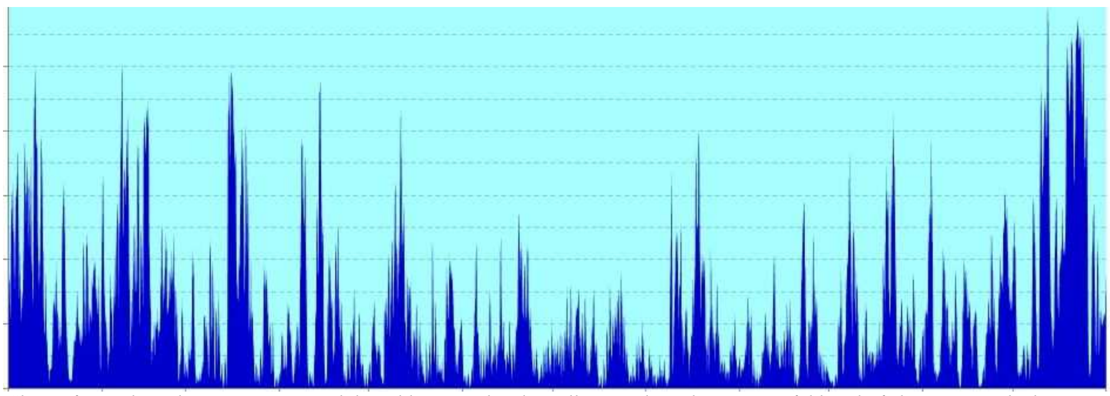

Chart of actual wind power. Horizontal dotted lines on the chart illustrate how the most useful band of electricity at the bottom of the chart will most preferentially be bought and consumed, then the band above it, and so on. Soon, the remaining electricity above some horizontal line will not be considered worth using so it will be discarded, although it still contains a substantial percentage of the original total collected energy.

There is another problem. Inevitably, by very virtue of their limitless nature, the most dependable uses which we have identified, like filling aquifers with fresh water or removing CO2 from the atmosphere, do not provide a profit. Even if the power to do them were reliable and continuous and the plant were therefore fully employed, who would do those things without payment? How much less chance is there of them getting done with intermittent power that wastes much or most of the investment put into the plant? No one does these tasks at the moment, after all, despite plenty of evidence that they need doing. Instead, when we have surplus electricity, we throw it away. Will money be somehow found to use the most spasmodic and ineffective power to suck CO2 from the air or recharge aquifers? I doubt it. Maybe a little of that will happen, but I suggest it will be done mainly using the true surplus that is a by-product of reliable nuclear energy, not by the expensively created surplus from a bizarre and artificially supported industry that only ever makes off-cuts.

The future will certainly not be short of intermittent power. Nuclear, which would achieve nothing by reducing its output, will be producing vast amounts of surplus nearly all the time. If wind and solar generation continues in future, all of its output will also be available. The intermittent power from both of these sources will compete for a very limited (and, as we have seen, mostly not commercially viable) market. The market value, and indeed the real value, of intermittent power will certainly be low or zero or negative. What commercial reason will the wind and solar generating industry have to continue to even exist? The answer then will be, I suggest, the same as the answer now. The purpose and main function of wind and solar is not to generate low-carbon power, nor to sell to any true market, but to serve political and financial interests and to damage the prospects of the nuclear generation industry. At present this is done by creating demand for "back up" gas, displacing or delaying nuclear, and leading us down the pointless path (along which we will have to retrace our steps) towards a largely gas-fired grid. Money which could have built nuclear has been, and continues to be, committed to an alternative, high-carbon, gas and renewables generating base which in future will be a liability rather than an asset. In future, wind and solar will continue their work of sabotage, probably still paid for by us, by flooding the market and grid with surplus power. Either the powerful fossil fuel lobby will demand that nuclear be repeatedly elbowed aside so that superfluous wind and solar power can be artificially provided with a buyer, or the wholly intermittent power from wind and solar will be used simply to saturate the market and destroy any demand for the surplus that nuclear inevitably produces as part of its function as a reliable generator. But, I hear you thinking, surely we can avoid that? I doubt it, because if we possessed enough sense or integrity to avoid such a disastrous future, we would already have avoided the mess we are in now. Specifically, we would not have let the obvious fantasy of wind and solar distract us from building nuclear power. I would be less sure of my dire predictions if I could believe that our current misguided policies came about by accident or foolishness, but I have watched for years as we have been guided towards this mess by unknown actors who are clearly skilled and hostile. We can be absolutely certain that they (or someone else) will make the greatest possible destructive use of their decades of work in undermining our future. We can be almost equally confident that our national politicians will help them by continuing to provide policies like those that gave massive handouts to voters who added a few photovoltaic panels to their roofs and thereafter pretended to sell useful electricity to the grid, while in reality selling votes. The owners of those panels have now become comfortably used to being bribed every quarter, and they will expect to continue forever to be overpaid for the trickle of low-quality power they intermittently generate (regardless of whether the grid actually wants it). It seems to me that, while panels remain on roofs and in fields and ranks of turbines still stand, we will never be safe from the madness and deceit of grid-connected intermittent renewables.

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