WHY GRID-CONNECTED WIND & SOLAR WON'T WORK

Written submission by Tim Rickman

This document explains a number of seldom explained points which alone severely limit the range of viable and up-scalable electrical grid supply technologies. It invites the reader to consider the possibility that the media and popular debate on low-carbon grid supply has for many years fundamentally misled policy on this subject, resulting in the waste of vast sums of public money and contributing to unnecessary continuing destruction of the environment.

The first few wind turbines and photovoltaic panels connected to the grid seemed to make sense at the time, because the electricity they produced replaced some of that generated from fossil fuels. It was popularly supposed in those days that a reduction in fossil fuel use would be enough to deal with climate change, whereas nowadays we know fossil fuel use must stop completely and without delay and, indeed, huge quantities of carbon must be removed from the atmosphere. In this new reality, more grid-connected wind and photovoltaic solar projects make our prospects worse, not better. Firstly, this is because such power sources produce rather little energy. This gives them a relatively high environmental impact and financial cost per unit of generated electricity, both in original fabrication and in continuing maintenance and eventual disposal. Secondly, it is because such generators are not **dependable** in that they cannot produce power when the grid demands it. Contrary to frequent stories in the popular media, there is no realistic prospect of it becoming feasible to store the intermittent energy produced by all the non-dependable generators so that the grid can receive electricity when needed and without interruption. The problem is not that the total power from non-dependable generators is a small percentage of their stated "nameplate" capacity (although it is). Rather, it is that the power which they can be relied upon to produce (even combined together over whole countries) is, at any random moment, virtually zero. It is simply not true that enough wind "is always blowing somewhere" within a practical transmission distance. Nor, of course, is it the case that somewhere in any country always has sunshine. Nearly 100% of non-dependable generation plant's stated capacity must therefore be duplicated with dependable generators, which at present are typically fossil fuelled (normally gas turbine) generating sets. Since wind and solar generation sometimes changes its output power rather suddenly, expensive batteries may also be added to give time for the dependable plant to start or increase power. The way in which the media has reported on the installation of such batteries has given the impression that enough electricity is now being stored by batteries to cover periods of low wind and sun (which often last many days) but, in reality, only enough electricity is typically stored to replace wind and photovoltaic generation for the first five to ten minutes after they cease generating, thus giving time for additional gas generators to be started. (Similar "peaking" batteries are sometimes also used to partially smooth out grid supply and demand mismatches over periods of up to a few hours, but, because of their limited size and great expense, these are not capable of making wind and solar generators serve as dependable generators either.)

It is questionable to what extent grid-connected wind and photovoltaic solar actually do reduce fossil fuel use by the grid. There is certainly a small decrease in the efficiency of gas turbines when they are obliged to work around abruptly varying supplies from wind and photovoltaic generators. This is because some turbines have to be kept running in order to be ready to step in quickly when required, and others must be run at less than optimum power to allow for output changes. The sudden changes in power, in themselves, also result in slightly higher wear and fuel use. However, apparently rather more significant is the fact that there is an incentive for generating companies to install cheaper but far less fuel-efficient open-cycle gas turbines (OCGT) instead of efficient closed-cycle gas turbines (CCGT) whenever the turbine is expected to be unused or under-used for much of its operating life. Consequently, wind and photovoltaic generation on the grid may, for a combination of these reasons, not reduce fossil fuel use at all.

Even if it were possible to store enough electricity to power the grid for weeks instead of minutes, natural variation in wind and sun means some months, years or decades inevitably provide only a fraction of the combined wind and solar energy which happened to be available in previous periods. In consequence, renewable and fuel-free energy from such sources normally can, almost by definition, only be used for things that don't need doing. There are a few power uses, such as pumping water, that can be delayed by hours or days, but most of them must be done eventually. There are very few power uses so trivial that they can be foregone altogether whenever energy turns out to be in short supply. Surely there is a limit to the number of decorative fairylights any nation will ever wish to deploy.

Fortunately, some low-carbon generation technologies are dependable, thus avoiding some of the problems described above. Hydro generation can suffer from long-term changes in rainfall, but it is certainly dependable, potentially nimble in changing its output power, very cheap, and fairly low carbon. Properly built, as has been usual in the developed world, it is also safer than most forms of fossil generation. It even lends itself to modifications which facilitate storage of small amounts of energy (although not enough to allow non-dependable generators like wind and photovoltaic to continuously serve the needs of the whole grid). Unfortunately, most of the best sites for hydro construction have already been used, so anything beyond modest future expansion seems unrealistic.

Nuclear is not inherently subject to the variations or unpredictabilities of weather. It is thus dependable. It is also very low carbon, apparently globally the safest of all generating sources, and potentially cheap. Fortunately, it does not suffer the constraint of limited suitable construction sites, and so is infinitely increasable in scale. In principle, reactors could be standardised and mass-produced much more quickly and cheaply than at present. Nuclear generation ideally runs continuously flat-out, since nuclear fuel is cheap and plentiful with low environmental impact, while changing reactor power has adverse operational and maintenance consequences. The famous inability of nuclear plants to "load follow" by reducing electrical output when the grid is over-supplied may therefore be dealt with by simply not using the surplus power, which can be seen as essentially free anyway. Nuclear is challenging to build because a large proportion of the total cost of running the plant over as much as a century is included in the sum that must be borrowed at the project start. Western governments also commonly legally or financially obstruct or disadvantage civil nuclear projects in progress so that they cannot provide adequate returns to their investors. Nevertheless, as the only infinitely up-scalable, near-zero-carbon, dependable and weather-independent power source, nuclear seems the generation technology necessary to save much of the world from climate change, if anything can.

An obvious next question is whether it must be nuclear alone, along with any existing hydro or similar dependable generating plant, that generates our electricity, or whether nuclear or hydro can productively be combined with intermittent non-dependable power sources such as wind or solar. For nuclear, the answer is clear. Since the generating capacity of the nuclear plant has to be sufficient to supply the grid's needs without any contribution from wind, solar and other non-dependable sources, and since the nuclear plant will probably continue to generate the necessary power in any case, there is simply no point in non-dependable generating technologies contributing power to the grid. It makes more sense for nuclear to do the job alone. This approach reduces operational inconvenience associated with sudden power changes around the grid, avoids much surplus power being pointlessly generated only to be wasted, and ensures the revenue from generation goes back to support the low-carbon technology that is, in reality, making the grid work. Obviously, since there is no point in building wind or solar generating plant in the first place, resources and money (often largely from public sources) can be saved there too. (*In simple terms, it works as follows. When there isn't wind or sun, you need nuclear. Then, when there is wind or sun, the nuclear is still there, generating all you need. So actually, you don't need the wind or solar generation.)* The same logic can sometimes apply where hydro is used to provide dispatch and thus takes on the role, at least in part, that we have just considered for nuclear. Unless the hydro plant has been built or retrofitted with generating turbines which are greatly oversized for the rate at which water is acquired in the reservoir, the fuel (which is water, of course) for the hydro plant has low cost and environmental impact in the same way that nuclear fuel does so, in some cases, there may be little point in saving it by letting non-dependable generators like wind or solar also contribute to the grid.

So, where does this leave non-dependable but grid-connected technologies like wind and photovoltaic solar? After all, fair numbers of such generators have already been installed around the UK. Can their output be made use of in any way, even if not to supply the needs of the grid? Again, perhaps surprisingly, the answer may generally turn out to be no. It is difficult to find economically rewarding uses for intermittent electricity, because any consumer plant bought to make use of it will have to justify the interest (actual or notional) being paid on the capital it embodies, even while the plant stands idle. Time will tell which industries can exist with capital costs so low and tolerance to enforced intermittent operation so high that they will find it worth being ready to use intermittent or non-existent electricity, but few such industries seem likely to emerge. In any case, wind turbines have significant maintenance costs and photovoltaic panels eventually need replacement, so electricity from them will not be entirely free. It should also be remembered that the dependable generation, particularly nuclear, will generate well above the grid's varying requirement nearly all of the time without incurring any significant additional cost, thus providing a competing source of intermittent electricity with economies of scale that undercut the price from wind and solar while providing a more constant service.

There are, of course, other ways of generating low-carbon power. Some of them are listed below.

Biomass is, in theory, a means of low-carbon electricity (or heat) generation. However, the low energy density of biomass tends to commonly result in nearly as much fossil fuel being used to grow and process it as would be used simply directly running a fossil fuelled generator. While dependable, it is not infinitely up-scalable, and it is likely not to represent a good use of land which might grow food instead. Still, low-carbon liquid fuels are urgently needed, and biomass of some sort is potentially one way (although probably not the best way) to supply them.

Gas from landfill and from similar sources is a fuel which contributes less to climate change if burned than if not, and it is cheap and potentially dependable, although not up-scalable.

Wave generation might be expected to suffer from the same range of problems as other attempts to harvest energy from naturally varying and diffuse sources like wind and solar. In particular, it is not dependable.

Tidal generation by in-flow turbines is problematic in the same ways as wave generation. Additionally, it seems unlikely to be very up-scalable, since there are a limited number of high power sites available.

Tidal generation using lagoons can be a little more practical than it might at first appear, since construction of several separate lagoons can smooth the output, and at least the tide is largely predictable. Lagoons built with a pumping feature can even store a little energy and make an energy profit on the deal. They do this by releasing the water to generate power when the difference in head between inside and outside is greater than it was when the water was pumped into the lagoon. Again, however, the storage potential is not sufficient to render other non-dependable generators useful to the grid at scale by making them continuous. The storage function of a tidal lagoon also comes at a disproportionate price, since sea level is obviously the least effective place to build a reservoir for electricity generation. (The same volume of water stored on a mountain top would store hundreds of times as much energy.) Tidal lagoons are low-carbon, but not infinitely up-scalable. Arguably, though, they are at least semi-dependable.

In summary, nuclear remains the only credible, weather-independent, low-carbon, dependable and infinitely up-scalable generating technology.

The need for extreme up-scalability, which was referred to repeatedly above, should be explained. It is not just the power for our existing requirements of industrial and domestic electricity which must be generated using low-carbon technologies. All our power must be low carbon, so power for any purpose should ideally be both created and used as electricity. Where this is not possible, less efficient liquid fuels can provide some alternative, probably still created largely from electricity. This implies a total low-carbon generating requirement which will be many times our current consumption of electricity alone. Added to this, carbon must somehow be removed from the atmosphere (as assumed in our existing legal carbon commitments, despite doubt over whether it is possible) inevitably requiring huge quantities of power. And, again somehow, the acidity of the oceans must quickly be corrected, requiring the equivalent of a thousand or so full-size power stations globally. Nuclear can provide this much power, whereas no combination of other low-carbon generating technologies has the faintest hope of doing so.

If one is persuaded that one particular type of technology, in this case nuclear, must be deployed at very great scale in order to combat an existential global emergency, projects involving or promoting other generating technologies take on a different complexion if they cannot contribute to that overwhelming imperative. In every instance, the issue appears as a contest between either building nuclear or building some alternative generation technology which will not contribute to any decisive role in our global attempt to survive the changing climate. Money expended on non-nuclear power generation projects is money denied to the one generation industry uniquely potentially able to tip back the balance away from global ecological collapse. Unless we break the current inertia in the nuclear construction industry and then allow civil nuclear industries to benefit fully from the economies of scale which will result from use of nuclear for future power generation projects, the outlook for humankind is bleak.

Civil nuclear power generation is, of course, a widely reviled industry (or, more correctly, collection of parts of industries). What continues to drive this entrenched opposition, and who benefits from nuclear's unpopularity? Environmental organisations certainly find that opposition to nuclear power remains lucrative in terms of subscriptions and retained supporter commitment, but the very fact that nuclear generation is globally up-scalable and effective within the new constraints of near-zero carbon emissions makes it a target for more powerful interests. Nuclear is the greatest threat to the immediate fortunes of the fossil fuel industries. Big oil and big gas therefore find themselves on the same side as the environmental anti-nuclear lobby, opposing a common adversary. It is difficult for many observers to believe that no support from either of these groupings ever passes to the other, even unknowingly, although there is little evidence of recent detailed collusion. Still, the press at all levels has somehow been supplied for many years with a plentiful and unrelenting flow of skilfully worded news items which appear, at least to scientifically untrained readers, to show the nuclear power industry in a bad light. At the same time, the alleged ever-greater achievements of wind and solar are lauded by press articles built on clearly deliberately deceptive use of statistics and inventive phrasing. If such stories are not read carefully, grid-connected wind and solar can seem to be proving themselves a success. The danger is that this soup of misunderstanding will result in continuing wasted investment in deployment of non-dependable generation, supported by equally wasted investment in gas-fuelled "back up" dependable generation, accompanied by unnecessary investment in batteries installed to help the grid cope with rapid transitions between the two, and infrastructure designed to reduce the risk from wind-and-solar-induced, grid-threatening disruptions or power shortages. Then, after the nation's required generating capacity has been bought several times over in these parallel (but still not viable, even in combination) forms, reality will dawn, then the necessary generating capacity will have to be paid for one final time in a technological form that actually does work. All the misguidedly purchased plant can then be decommissioned, if desired, and attempts made to sell it on what will presumably by then be flooded world markets for such equipment.

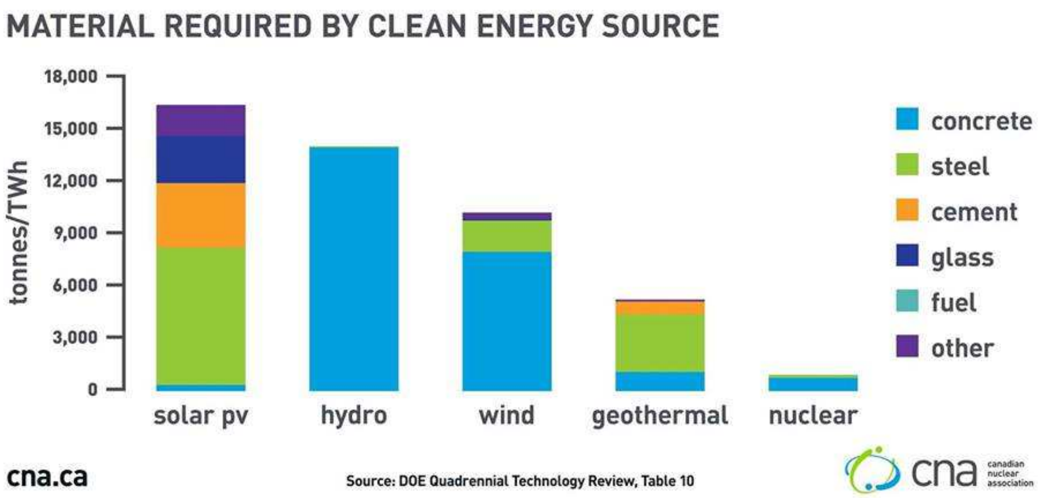
To summarise, the intention and true function of grid-connected wind and solar is to ensure continued fossil fuel use and to damage the financial viability of the only alternative to fossil fuel. In the same way that civil nuclear's many decades of economic difficulty and contraction can seem to have been a consequence of the fact that it works well and thus has represented a threat to other industries, the promotion and consequent rapid expansion of grid-connected wind and solar might seem to have stemmed from the very fact that these generating technologies can be relied upon to always work so badly.

Further reading: Unintended Consequences: The lie that killed millions and accelerated climate change. Author: George Erickson. http://www.tundracub.com/htmls/unintendedconsequences.html free PDF.

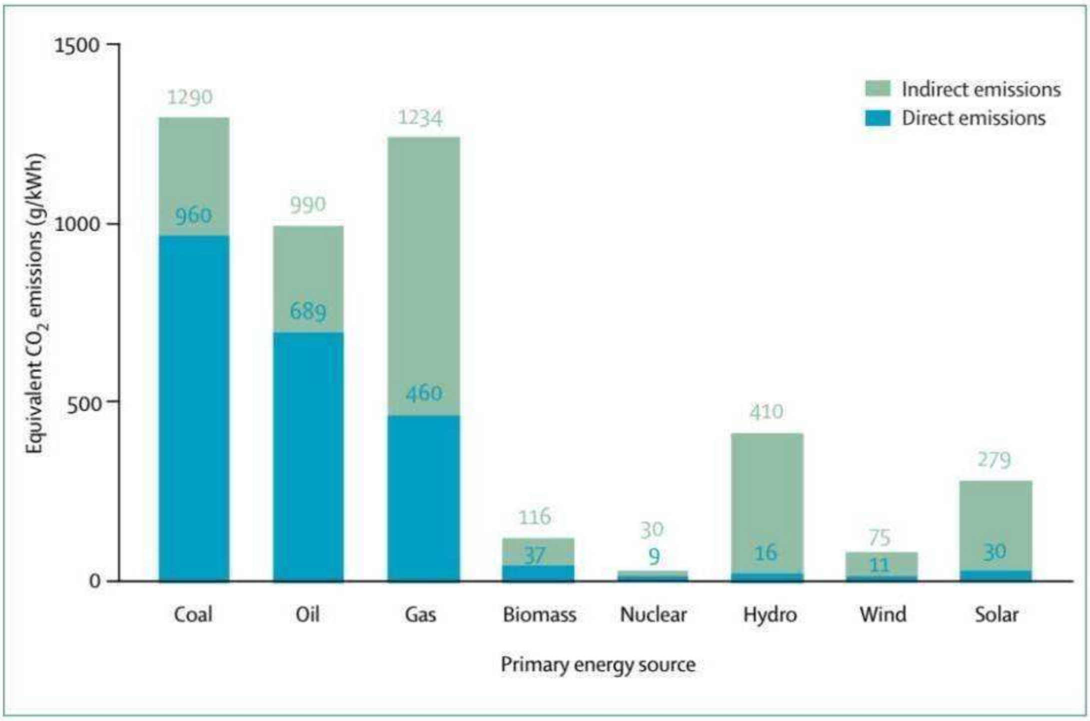
Graphs: Visual representations of various aspects of the performance of nuclear power generation are provided in Appendix 1 below. These have been extracted from various sources, and I cannot vouch for their accuracy.

Tim Rickman
12th December 2018
timrick3@yahoo.co.uk

Appendix 1
GRAPHICAL INFORMATION
from unverified 3rd party sources



Note: Nuclear fuel is included in the chart, but is not visible to the naked eye.



Full energy chain CO2 equivalent emissions by primary energy source.

Markandya, A., & Wilkinson, P. (2007). Electricity generation and health. *Lancet*, 370(9591), 979-990. doi:10.1016/S0140-6736(07)61253-7