THE IMPORTANCE OF BEING DISPATCHABLE

Written submission by Tim Rickman
to UK House of Commons Welsh Affairs Committee
on the subject of renewable energy in Wales

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1. This document is not an attempt to comment comprehensively on generation types. Instead, it explains a number of seldom explained points which alone severely limit the range of viable and 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.

2. 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 immediately 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 very 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. Secondly, it is because such generators are not "dispatchable" 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 surplus energy that they produce at other times for later grid use. The problem is not that the total power they generate is a small percentage of their supposed capacity (although it is). Rather, it is that the power which they can be relied upon to produce (even combined together over much of Europe) is, at any random moment, virtually zero. It is simply not true that "the wind is always blowing somewhere" and nor, of course, is it the case that somewhere in developed Europe always has sunshine. 100% of non-dispatchable generation plant's stated capacity must therefore be duplicated with dispatchable generators, which at present are fossil fuelled (normally gas turbine) generating sets. Since wind and solar generation stops generating more suddenly than a traditional generating plant, expensive batteries are also required to give time for the dispatchable 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, throughout developed Europe, often last many days) but, in reality, only enough electricity is 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.

3. 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 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 these reasons, not reduce fossil fuel use at all.

4. Fortunately, some low-carbon generation technologies are dispatchable, thus avoiding the problems described above. Hydro generation is very cheap, very dispatchable, potentially nimble in changing its output power, 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-dispatchable generators like wind and photovoltaic to usefully serve the grid at scale). Unfortunately, most of the best sites for hydro construction have already been used, so anything beyond modest future expansion seems unrealistic.

5. Nuclear, although traditionally run continuously flat-out as a "baseload" contributor to the grid, can also change its output power fairly quickly if such a feature has been specified in the original design (as is normal nowadays). It is also dispatchable, very low carbon, apparently globally the safest of all generating sources, and potentially cheap (although not at present as cheap as hydro). Fortunately, it does not suffer the constraint of limited suitable construction sites, and so is infinitely scalable. In principle, small reactors could be mass-produced quickly and relatively cheaply, and bigger ones should be at least standardised. However, the contemporary approach of western governments to building nuclear is dysfunctional to the point of near-complete stagnation, and there are no signs yet of this changing. Nevertheless, as the only infinitely scalable, near-zero-carbon, dispatchable power source, nuclear seems the generation technology necessary to save much of the world from climate change, if anything can.

6. An obvious next question is whether it must be nuclear alone, along with any existing hydro or similar dispatchable generating plant, that generates our electricity, or whether nuclear or hydro can productively be combined with non-dispatchable intermittent power sources such as wind or solar. For nuclear, the answer is clear. Since the generating capacity of the nuclear plant must already be sufficient to supply the grid's needs without any contribution at all from wind, solar and other non-dispatchable sources, and since the financial cost and environmental impact of nuclear fuel are very low, there is simply no point in other generating technologies contributing power to the grid. It makes more sense for nuclear to do the job alone. This also reduces unnecessary plant wear and operational inconvenience associated with sudden changes in output, and ensures the revenue from generation goes back to support the technology that is, in reality,

making the grid work. 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, for any reason, built with generating turbines which are oversized for the rate at which water is acquired in the reservoir, the fuel (water, of course) for the hydro plant has low cost and environmental impact in the same way that nuclear fuel does, so there is little point in saving it by letting non-dispatchable generators like wind or solar also contribute to the grid.

7. So, where does this leave non-dispatchable 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 often 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. Time will tell what industries can exist with capital costs so low and tolerance to enforced intermittent operation so high that they will find it worth paying anything at all for intermittent electricity, but few 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 dispatchable generators, nuclear and hydro, can generate well above the grid's varying requirement nearly all of the time without incurring any significant additional fuel cost, so they provide a competing source of intermittent electricity with economies of scale which may allow them to undercut the price from wind and solar while providing a more constant service.

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

9. **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 dispatchable, it is not infinitely 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.

10. **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 dispatchable, although not scalable.

11. **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 dispatchable.

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

13. **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-dispatchable generators useful to the grid at scale. 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 scalable. Arguably, though, they are at least semi-dispatchable.

14. In summary, nuclear remains the only credible, very-low-carbon, dispatchable and infinitely scalable generating technology.

15. The need for extreme 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 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.

16. 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 have a 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.

17. 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 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 no recent evidence of collusion has come to light. 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 itself a success. The danger is that this soup of misunderstanding will result in continuing wasted investment in deployment of non-dispatchable generation, supported by equally wasted investment in gas-fuelled "back up" dispatchable generation, accompanied by unnecessary investment in batteries installed to help the grid cope with rapid transitions between the two, possibly even followed by one or two expensive but ultimately doomed attempts at real grid-scale (non-peaking) electricity storage. 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 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.

18. To summarise, 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 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.

19. Graphical representations of various aspects of the performance of nuclear power generation are provided below. These have been extracted from various sources, and I cannot vouch for their accuracy.

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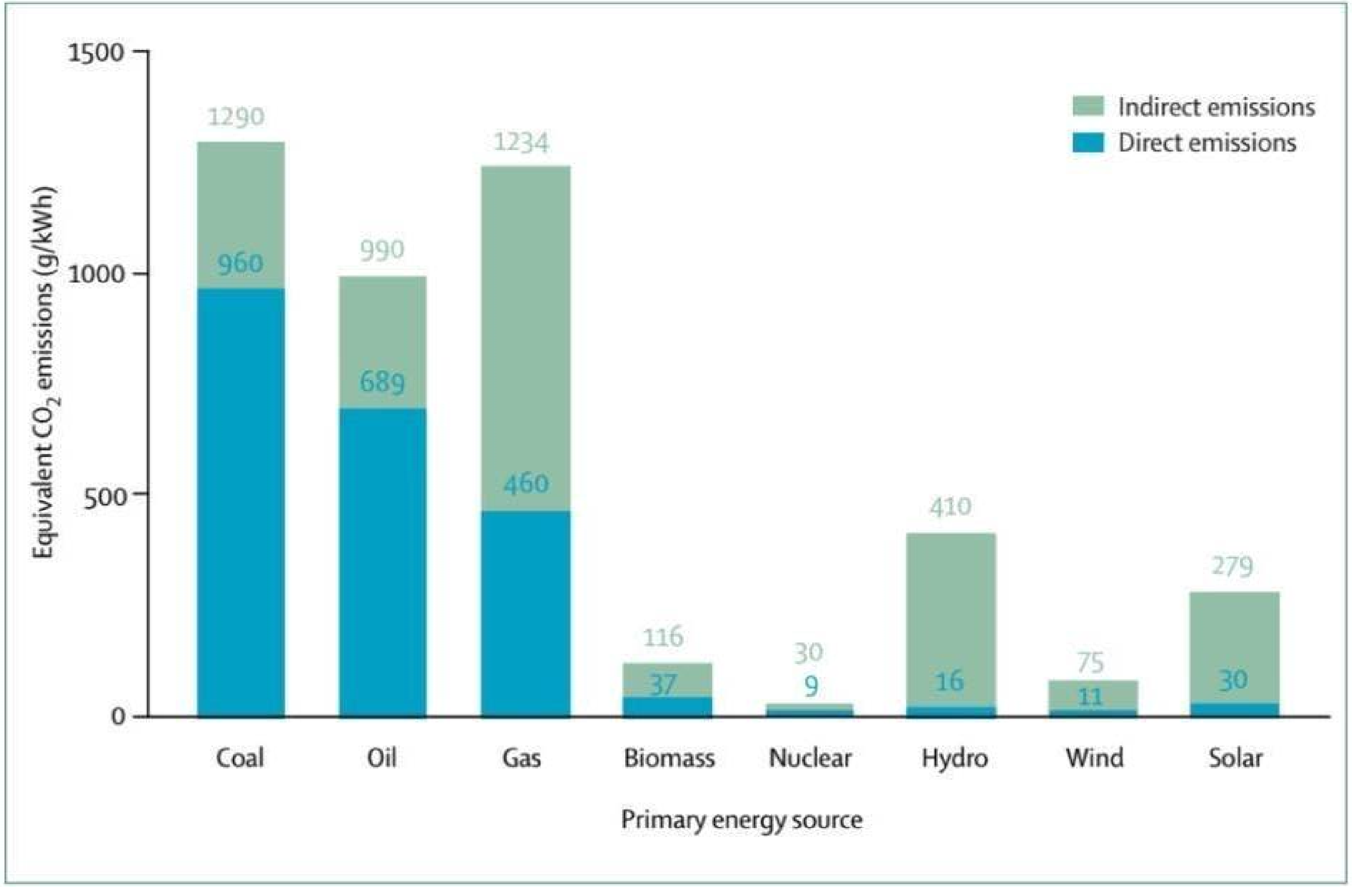
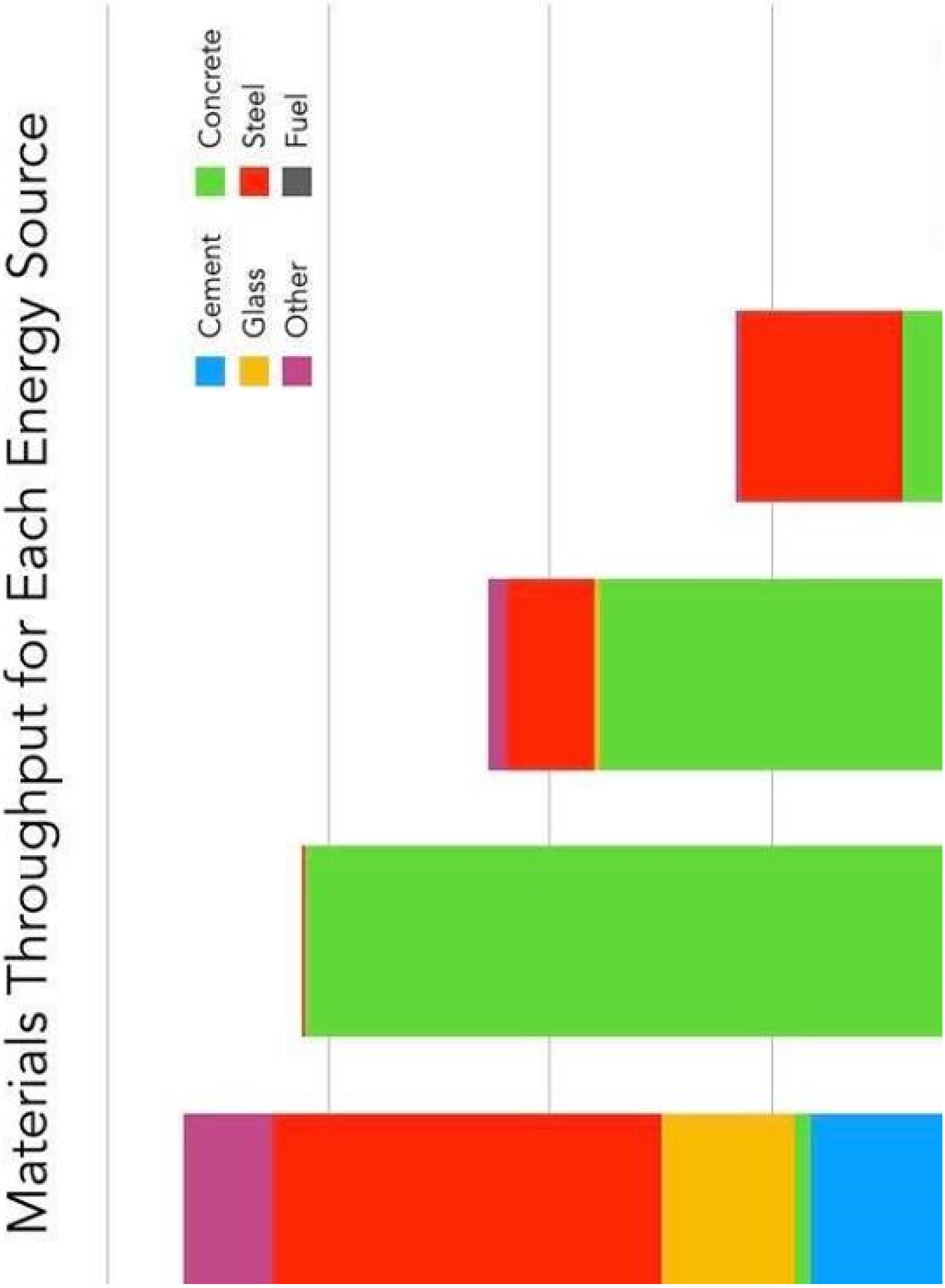
Tim Rickman is not employed or supported by anyone, has no known financial interest in any matter relating to this document, and is not a subscribing member of any significantly related organisation or group.



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


Materials Throughput for Each Energy Source
Cement
Concrete
Glass
Steel
Other
Fuel

Nuclear: The Safest Energy Source of All
Deaths per terawatt hour by energy source
The nuclear bar should be ~0.0013, not 0.04.
The 2008 UNSCEAR update on their Chernobyl Report changed the "4000" future deaths from cancer to undetectable future deaths. With that reduction, the deaths per TWh drop accordingly.
0.0013
0.04
0.15
0.44
1.4
4.0
36.0
161.0
Nuclear
Wind
Solar
Hydro
Natural Gas
Oil
Coal
0
40
80
120
160
200
deaths per TWh
Source: nextbigfuture.com