Wind Energy- a Reality Check

The ERG Creag Riabhach Windfarm from the A836, Strath Vagastie, Sutherland

Organisations such as the Scottish Wild Land Group (SWLG), the John Muir trust and Mountaineering Scotland oppose on-shore windfarm development in areas designated as 'Wild Land', but their resolve and that of many of their members, is undermined by the very effective propaganda of the Renewables Industry which claims that wind power is cheap and green, a position that is backed by major energy companies like SSE and ScottishPower. Faced with the statement that wind power is cheap and green, opposition is viewed as short-sighted, selfish and irresponsible because greenhouse gas emissions are a proven threat to planet Earth. Indeed, many businesses like to dress their marketing material with an iconic image of a wind turbine. Such is the effectiveness of the renewable industry vested interests' lobbying of politicians of all persuasions, that all the political parties have, in their desire to woo voters, adopted wind power as their promise to deliver a future of cheap power and simultaneously 'save the planet'. In locations, where local opposition is anticipated, community payments are offered. Essentially a bribe.

There is a problem, though, and it goes much further than protecting wild land; wind power is not cheap. On the contrary it is probably the most expensive way of supplying a country's energy needs. Furthermore, a reliance on wind power as the nation's major future source of energy is to put the security of the national grid in real jeopardy. The first statement is, for the lay person, counter- intuitive. After all wind is free fuel. We could liken those that ridicule the claim that wind power is very expensive, to how Galileo was called a heretic for claiming the Earth circled the Sun, since that also was counter-intuitive to the lay observers. Like Galileo, a skilled physicist and astronomer, electricity power generation and transmission is challenging to understand when the vital 'whole system' analysis* is undertaken. I will try and explain what I mean by a 'whole system analysis' but first some basic background as to why wind power is expensive.

1. **Power output of a proposed windfarm** is always quoted and translated for lay persons into ' x number of homes powered'. This is intentionally misleading, since the average capacity factor for an on-shore wind farm is about 35%. This means that the annualised contribution of energy is only one third of the power figure quoted in megawatts. Operators quote power output and rarely the important figure, which is the actual energy produced, i.e., the megawatt hours. The remaining two thirds of the power has to come from nuclear, combined cycle gas turbine driven generation, biofuel generation and, for the UK, a miniscule hydro contribution and even coal.

2. **Wind generators are not synchronously connected** to the grid like conventional generators such as coal, gas & nuclear, so cannot provide the essential inertia of conventional generators. This is a difficult issue for those that do not have a physics or engineering background; put simply, inertia provides vital stability and fault protection. This means that synchronous compensators have to be strategically deployed at key points in the grid. Essentially these are very large ac electric motors coupled to large mass flywheels and connected permanently to the grid.

3. **In an advanced country**, industry, business and householders expect, indeed must be able to use as much, or as little energy whenever they require it with a delay measured in just a few milliseconds, i.e., the power network must have the capability of despatching energy constantly in step with demand. Operating a power grid and delivering electricity in real time to consumers is a logistical and technical challenge far greater than for any other product market. The power grid is tasked with delivering an invisible product, which cannot be stored, to customers who expect to receive it at the exact same second they need it. Grid operation is just-in-time management in its most extreme form. Moreover, if demand exceeds supply by even a small margin, there is a very significant chance that the whole system will collapse (blackout). To avoid this the System Operator must have dispatchable generation resources always available. From the earliest days this as been a core feature of the electricity supply industry. Wind generation is highly variable and unpredictable and cannot meet the essential dispatchable criteria. As long as wind represented a small proportion of the total generation resource this did not present a problem. Government, with powerful lobbying from environmentalists, has now committed to effectively meet all the UK's energy needs from renewables, with an emphasis on onshore deployment, particularly in Scotland. (The Scottish Government has ruled out nuclear, but Westminster has committed to a significant nuclear investment.)

4. **Conventional thermal generators,** using the stored high-density energy of fossil or nuclear fuels, have capacity factors of between 85% and 90%. It cannot be 100% because of outages for maintenance and refuelling (nuclear), but it is a simple expedient to spread the energy demand across a number of power stations to cover outages and unpredictable plant failures. As stated, wind power is not dispatchable so the only way to make it so is to provide an energy storage solution. The Scottish Government's 'Energy Strategy and Just Transition Strategy Paper' suggests pump storage and hydrogen will be the solution but makes no attempt to assess the scale and cost implications. Unfortunately, this is where the real pain and cost reside. Perhaps because it is such an ugly tale it has not been told.

5. **What then are the implications for Scotland's Landscape?** In one word, dire. By 2050 the electrical powering of all transport and heating will more than double the existing required generation demand. To achieve this, the onshore wind estate will need to be up to ten times its current level with a storage capacity of almost unimaginable size. To put this into some form of context I would suggest that pump storage will be the first call. Pump storage is an extremely useful tool for the power systems energy dispatcher because the time to start producing power involves minimal delay and is synchronous. It is an important resource to balance short term load changes, or unexpected plant outages. For example, the Loch Awe Cruachan pump storage system can produce 440MW and run for upwards of 17 hours. This equates to almost 7.5GigaWatt hours of energy.

6. **How many Cruachans** would be needed to support the politicians' dream? The problem arises from wind's unpredictability. It is not unprecedented for the Scottish wind fleet to be effectively becalmed for a period of three weeks. Even more worryingly, the whole of the UK and Western Europe can be under the influence of a large anticyclone or even a wide shallow low pressure system, where any contribution from wind is reduced to the trivial and interconnection to import energy from Europe might not be possible. To give some idea of the magnitude of this problem, from 25th May to 18th June 2023, Scotland was forced to import between one and almost three Gigawatts of power almost every day (average Scottish winter demand is almost five Gigawatt). Over this period the actual mean hourly transfer amounted to 500MW, despite Torness operating at full power. Fortunately for Scotland, on this occasion, the south of England and hence the southern North Sea wind fleet were generating. This, along with the large contribution (50%)

from generation derived from gas turbine generators, ensured that sufficient energy was available to export from England to meet the shortfall in Scotland.

An import of 500MW over a three-week spell of little or no wind in Scotland, amounts to over 250GWhr, or the stored energy of 33 pump storage schemes the size of Cruachan. To take the analogy further, if Torness had been decommissioned then the required number of Cruachan pump storage schemes would have needed to be 100! In addition, Scotland has the very important contribution of up to 1200MW from the Peterhead power station. I leave readers to contemplate what happens when the electricity demand increases by 100% and there is no Torness and no Peterhead. (The SSE Coire Glas Great Glen scheme claims an energy storage capacity of 17GWhr which alone could power Scotland for about 8 hours at our current level of demand. To meet Scotland's needs by 2050 and to cater for a three-week windless spell would require possibly 100 Coire Glas schemes).

7. **It will never happen** because not only is it beyond Scotland's physical geography, it would be astronomically expensive and fails to consider the associated transmission infrastructure that would be required with the consequential devastating destruction of peatland.

8. **Battery technology** is presently only capable of short storage support, ranging from minutes to hours and can be discounted. There are many other storage solutions such as molten salt heat batteries and heating fluids stored in abandoned mines, etc. All fail on the scale required.

9. **This leaves hydrogen** produced by electrolysis, using surplus wind power. While technically feasible and currently working at a small scale, there are many challenging issues to scale the storage and distribution to anywhere close to the proposed need, not least the need to store it at cryogenic temperatures and extreme pressure. The only simple green application is as a fuel cell component since combustion in air creates very large amounts of nitrous oxides, unless very complex catalyst and flame control techniques are used. Moreover, the process of electrolysis and subsequent reconversion to electrical energy incurs significant losses. Put simply, using hydrogen to compensate for wind's intermittent character, will be very expensive. Hydrogen is the most potent greenhouse gas and has the lowest molecular weight which ensures that leakage to the atmosphere will be a real issue.

10. **The case for Nuclear?** I am reluctant to suggest that the only way to address the problem is to make a case for nuclear and the retention of CCGT gas generation with carbon capture as a standby resource when the wind is not blowing. Many expert engineers believe that there is a strong case because nuclear, in addition to very low carbon emission, has all the attributes that wind lacks, vis, it is dispatchable, synchronous, provides inertia and requires modest land area and hence is a cheaper source of energy than wind, but this is not the place to set out the arguments for and against. Another possibility is load shedding and reliance on consumers installing their own battery storage. A kind of 'green' off-grid, third world solution.

11. **What is certain is that unless, or until, some intelligence is injected into governance, the destruction of Scotland's landscape will gather pace over the next ten years.**

Returning to the concept of a 'Whole System' analysis, it is clear that any strategy, dependent on wind, is a strategy which will result in very expensive electricity. The capital and interest charges alone would be crippling.

There is a more fundamental problem; the generation of electrical energy contributes about 20% of the UK's emissions and because 50% of the UK's emissions are off-shored in the form of imported materials, goods and food, the real contribution is only about 10%. Taking the world as a whole the UK produces just over 1% of global CO_2 emissions (China = 28%) and this underlines the futility of our Government's energy strategy.

Why did we get there? This is an article on its own. Briefly, following privatisation of the power industry, the central planning and risk analysis carried out by the Central Electricity Generating Board (CEGB) ceased with its demise in 1990, the idea being that the market would deliver a more competitive solution. Unfortunately, lacking a central controlling authority the multiple private companies, motivated to maximise returns and largely foreign owned, have no concern for the national interest. What strategy exists is determined by politicians who are influenced by vested private interests, their lack of knowledge of the complex technology and the naïvety of well- meaning environmental organisations.

Most independent professional engineers, with no affiliations, believe the establishment of an entirely independent National Energy Authority (NEA) is an urgent requirement. There is ample evidence to suggest that, on a levelized cost analysis, nuclear may be far cheaper than wind. Moreover, despite the capital and operating costs for onshore wind being less than offshore, the lower capacity factor and need for higher levels of storage/backup suggest on a whole system basis, the reverse might be true. It might even be that the high capital cost of tidal is offset by its diurnal and predictable character with modest storage requirements. We need an NEA to determine an optimum energy strategy which provides the lowest risk and cost solution compatible with the urgent need to reduce global emissions. Wind has a part to play but there are already too many windfarms and the sensible thing would be to put an immediate stop to any more being built.

To make any meaningful progress on tackling climate change, politicians need to turn their attention to the other 90% of material factors driving climate change. A very difficult task because it means curbing man's insatiable appetite for consumerism. The necessary legislation would make the legislators very unpopular, hence the easy but false message of promoting wind farms as a means of 'saving the planet'. A policy which amounts to mere tokenism and has severe environmental consequences. The only solution that will work, is to drastically reduce our energy needs.

Conclusion: For the present, approval and construction of wind farms, on-shore, or off-shore should cease immediately until sufficient energy storage is commissioned at the massive scale required, and/or dispatchable energy in the form of synchronous power from new nuclear or combined cycle gas turbine (with carbon capture) generation is available to keep Scotland energised when the wind is not blowing. There is no quick fix since the appropriate energy planning decisions should have been taken 25years ago. If a National Energy Authority is established and intelligent planning adopted, the 2050 'Net Zero' target could be achieved.

* **Whole System Analysis** – *The electricity system is a complex aggregation of distributed power generation resources interconnected by a high voltage transmission network (The National Grid) and an associated distribution system, connected by grid transformers to industry, transport and individual consumers. It is a dynamic system, transporting extremely high amounts of energy across the whole of the UK and has to be managed such that supply and demand are in almost perfect harmony every second, regardless of faults, weather changes and consumer demand, day and night. Unpredictable power input, the power losses and instability management of long transmission connections and the associated capex means that the actual cost at point of delivery can be several times the source cost. Whole System Analysis is the discipline that determines the real cost of any form of generation.*

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