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Embracing high penetrations of offshore wind power

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Great Britain has exceptional wind power potential. Our requirements for energy security, economic growth and energy affordability can be met if and only if we embrace that potential fully. By ~2050[1], we will require >100GW (rated) of offshore wind turbines installed around our shores producing >400 TWh of electricity each year (GB consumption is currently <300TWh) and supplying over 70% of all GB electricity. These wind turbines will cost >£200bn in 2026 money and at present wholesale rates of >£100/MWh[2], their electricity could be worth £40bn each year.

Policymakers and commentators tend to focus strongly on "keeping the lights on". They wrongly jump into "deductions" about the "need for dispatchable generation" and the "need for baseload power". It is certainly vital to a modern economy that electricity is available when required. However, the solutions adopted must also be informed strongly by how we will manage the times when inflexible generation (from wind, solar and nuclear power) exceeds demand. **This so-called "excess wind energy" is not free!** It is paid for in the capital expenditure and O&M costs. If "excess wind energy" was going to be minor, it could be acceptable simply to discard it. That is not the case.

In our future energy system, some **~30% of all energy collected by wind turbines will not be consumed directly**. Now, 30% of £40bn per year is £12bn per year - not a minor sum. We should already be thinking very carefully about how best to manage surpluses. The energy system modelling study that underpinned the 2023 Royal Society report on electricity storage[3] reveals that the cost-optimal solution involves multiple types of flexibility including *turn-down*[4], hydrogen stored in caverns[5], some medium-duration energy storage (MDES)[6] forms and very small quantities of gas-fired generation[7]. **Interconnectors and demand-side response will play relatively small roles**[8].

The UK is not presently travelling along the lowest-cost path towards an energy system providing secure, affordable and sustainable energy along with strong potential for economic growth. *Clean Power by 2030* has ambition of the correct magnitude but not the optimal direction.

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[1] If we achieve Net Zero by 2050 – which looks increasingly uncertain although we did make a legally-binding commitment to that.

[2] Wholesale electricity prices have ben >£100/MWh since July 9, 2026.

[3] https://royalsociety.org/news-resources/projects/low-carbon-energy-programme/large-scale-electricity-storage/

[4] In this context, *turn-down* is the term utilised to describe discarding some energy. The *turn-down* reduces what would otherwise be quite high costs for charging energy storage plant and it also reduces the volume of energy storage capacity required.

[5] Wind power has a particularly high inter-annual variation and storing hydrogen in salt caverns presents a reasonably cost-effective way to capture energy in years that have strong wind production and deploy some of that in less productive years.

[6] Compressed air energy storage (CAES) based on underground storage of pressurised air in salt caverns is just one form of MDES. Others include Liquid Air Energy Storage (LAES), pumped-thermal energy storage (PTES) and reversible liquefaction of CO_2.

[7] System optimisations indicate that the lowest-cost systems will generate <1% of consumed electricity from gas – sufficiently small that we can feasibly obtain all of that gas from anaerobic digestion or pyrolysis of organic wastes.

[8] Mainly because of correlation of wind power patterns with our Northern Europe neighbours who will also embrace wind strongly.

High wind-power resource, the imperative for thought-leadership in clean energy and low connectivity to the main continental electricity grid means that **GB will face challenges** of how to integrate high penetrations of offshore wind-power **earlier and more strongly than all of our neighbours** in continental Europe except Ireland. The positive perspective on these challenges is that they present GB and Ireland with a unique opportunity to exploit our common circumstances.

Neither GB nor Ireland has any indigenous large wind turbine manufacturer. We have factories making wind turbine blades, monopile structures, tower sections and internal structures, access platforms, cables and some other structures but "local content" is still well below 50% at present. Export of offshore wind components is limited[9]. GB and Ireland should certainly be doing much better from our own large markets.

Our current directions should be re-steered in several ways:

- **GB and Ireland should collaborate closely** – including taking serious steps to evaluate whether a single electricity system should operate across the "British Isles".
- **The data informing energy policy should be made open**[10] so that parties competent to run energy system models independently can explore alternative pathways and highlight possible concerns with existing directions
- **We should better coordinate** well-intentioned, but seemingly disparate, initiatives from different quarters dispensing taxpayers' money to develop flexibility solutions
- **Policy and markets should be stabilised** so that long-term investments can be made confidently and so that commitments that help our future grid are properly incentivised.
- **Significant attention should be given to integrating storage with wind turbines** – with SOME wind turbines charging storage directly rather than simply making electricity when it is windy.

Wind Integrated Storage (WIS) has a particularly compelling case – especially for GB and Ireland. Energy system optimisations indicate that it is the single most important form of "Medium Duration Energy Storage" for GB and Ireland. Engineering evaluations confirm that it is completely viable. **No new science or materials are required** and there is excellent potential to instigate a new industry manufacturing products first to serve our own needs and subsequently being exported worldwide to accelerate global Net Zero. Optimisations indicate that savings of ~1.5% on future energy costs can be achieved by properly embracing WIS (relative to the most optimal solution excluding WIS).

Anticipating a global market of ~400GW/year for wind turbine installation by 2050, **the market for WIS transmissions might easily exceed £50bn/year** at that point. GB could capture much of that. The wind turbine OEMs will not drive this development yet because market signals (under our control!) do not yet incentivise them to do that. This really will matter greatly in the not-too-distant future.

A few very small actions taken now could send positive ripples of change throughout the energy world and significantly improve our energy prosperity. The first action should be to commission a serious professional review on both the technical viability and the economic effects of WIS. Subject to that review concluding positively, the next step might be to open one or more competitions inviting competent parties to develop and demonstrate prototype solutions at small scale.

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[9] Notwithstanding that we export blades, cables and some electrical parts (busbars, power converters, and switchgear)

[10] The speaker was one of >30 energy system experts to co-sign a letter to DESNZ, NESO, Michael Shanks, Ed Miliband and Chris Stark in December 2024 calling for the data that underpins UK energy policy to be made fully open.