Mini Review

Journal of Material Sciences & Applied Engineering

Predicting the Third Energy Horizon: Wind/Solar/Hydrogen

Kevin Kendall

Hydrogen United.org, Birmingham B15 3HE, UK

***Corresponding author:** Kevin Kendall, HydrogenUnited.org, Birmingham B15 3HE, UK.

Submitted: 03 May 2024 **Accepted:** 09 May 2024 **Published:** 17 May 2024

***Citation:** Kevin Kendall (2024) Predicting the Third Energy Horizon: Wind/Solar/Hydrogen J Mat Sci Apl Eng 3(3), 01-03.*

Abstract

As energy infrastructure is gradually changing from fossil fuel chimneys to electrical grid pylons, it is essential to consider the plausible third energy horizon of onshore Wind/Solar installations creating local Green Hydrogen to replace natural gas heating buildings and petroleum powering vehicles. In UK, large offshore and onshore wind turbines now produce around a third of grid power, giving almost 6% of total UK energy budget, while solar provides ten times less. This paper predicts how wind/solar might triple by 2050, especially to produce large quantities of Community Green Hydrogen locally to drive applications in transport, buildings, gas grids and other industries.

The dark UK horizon of combustion energy, with cities shrouded in smoke and citizens poisoned by toxic emissions, goes back further than 1300 when London imposed smoke control because coal fires were 'prejudicial to health' [1]. Yet, coal combustion has still not yet peaked worldwide, though the 45 satanic mill chimneys of Burnley in 1880 (Fig1a) have mostly been destroyed. These were replaced by electricity carrying pylons after the UK grid was created uniquely in 1935, despite much opposition to the 22000 metal monstrosities that followed (Fig 1b) [2]. This second horizon is now under challenge from citizens due to intrusive appearance and high costs [3, 4]. Meanwhile, wind turbines (Fig 1c) are being installed at increasing size and rate, forming a third horizon of 11000 UK wind generators that some people might find unacceptable but which save money for the average citizen [5]. How can this third horizon grow to compete with combustion and the electrical grid without offending local opposition [6]?

Figure 1:
Left: Burnley horizon in 1880;
Middle: Pylons picture from National Grid website;
Right: Hornsea 2 wind turbine offshore.

The best answer comes from considering problems displayed by the UK national electrical grid. The main issue is that the grid was first based on a small number of large power stations that could be removed from cities where people were being poisoned following the infamous 1952 London smog. This movement of power-station emissions from towns to rural locations stopped the city smog but caused forests and lakes in Europe to be poisoned. Meanwhile, rising costs of electrical transmission lines made UK the most expensive country for electricity, with Ireland being an odd exception [4]. We suggest that the age of huge rural power-stations is finished, and that new distributed power will be cheaper, more secure and less invasive than the present National Grid electric network.

In 2010, when the Grid was made to accept solar electricity by the Feed-In-Tarif legislation, with government subsidies then supporting £5000 capital costs, installing roof-top solar panels became popular in 4.8% of UK homes that began to generate green electricity [7, 8]. This scheme was stopped in 2019, when subsidies for capital costs were also cut back, leading to a large fall in house-top solar enthusiasm [9].

Secondly, the grid has failed to power huge industries like electric automobiles, to compete with petrol and diesel fuels that dominate our energy budget with massive carbon intensity. Only 2% penetration of battery electric vehicles has been achieved by 2023 after 15 years of introduction. It is difficult to charge an electric car offshore, while 8% of energy is wasted transporting offshore wind electricity to distant battery vehicles. In England, the grid is still only 40% green, much less than Scotland which has installed 1500 wind turbines generating almost 8GW of power to make the country self-sufficient in renewable electricity [9].

Third, the major problem is that the grid is a monopoly that makes large profits and stands in the way of progress, discouraging distributed power. Also, the grid charges big prices at peak times through their failure to install sufficient storage infrastructure to match big demand, while curtailing the distribution of renewable power when wind and solar sources are at their highest, wasting valuable green energy.

David Cameron effectively banned further onshore wind turbines in 2015, losing the concept of local distributed wind-power, though encouragement of more costly offshore wind produced significant investment for very large windfarms in the North Sea [10, 11]. Thus, while the number of UK onshore turbine numbers remained static near 8,600, offshore overtook by 2020, rising to 2,600 in 2021, now totalling more than 11,000 across UK, with a record for large turbine size [12].

The map (Fig 2 left) of installations by 2020 shows that there is a windfarm desert in the Midlands/South-West that needs to be corrected [13]. By constructing 10,000 onshore wind turbines individually 2 miles apart along UK motorways and rail-tracks, there would be little detraction from the landscape. Combining a 5MW wind turbine with 5MW of solar to produce 10MWp at each location would allow 100GWp of added UK capacity, sufficient to power all UK vehicles. Moreover, if these were based on private-wire mini-grid sites that also power local buildings, like the Rotherham ITM filling station in Fig 2 (middle), then there would be much lower cost for refuelling hydrogen buses, trucks, vans and cars of the future. This hydrogen station, built in 2015, is small at 0.225 MW but can fill 40 cars per day and has worked successfully to supply green hydrogen at £10/kg plus tax.

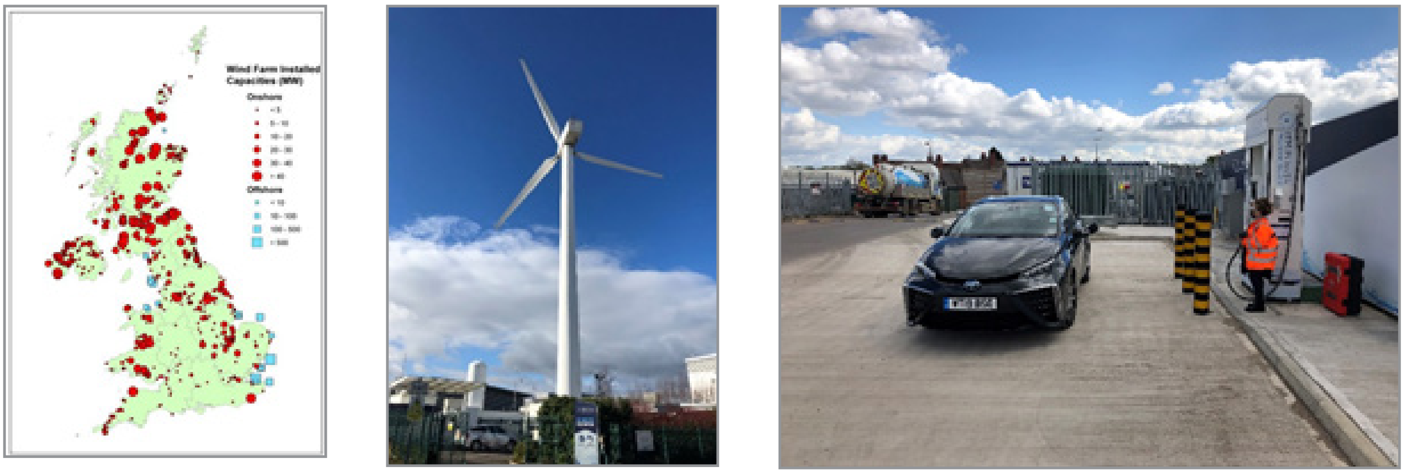

Figure 2:
Left: Map of UK wind turbines in 2021;
Middle: ITM hydrogen station at Rotherham using wind power directly to electrolyse, compress, store and dispense to hydrogen car, while connected to industry site mini-grid;
Right: Tyseley 3 MWe ITM station dispensing hydrogen made from grid electricity.

Fig 2 (right) is another ITM station, but this time in Birmingham powered by National Grid electricity, that is only 40% green and so expensive that the hydrogen price was raised to £23/kg in 2023.

The objective of this paper is to compare the two designs of Fig 2 in terms of levelized cost of hydrogen product. Since the two designs are small, we must first scale them up to 5MW wind plus 5MW solar, because 10MW is the requirement for filling hundreds of buses and trucks, which are the largest proposed off-takers of green hydrogen by 2030. The levelized costs are shown as $/kg of hydrogen in the table below, indicating the 4 main items: Capex, Finance cost, Opex, and Electricity, all based on 1kg of hydrogen produced [14].

Table of Costs

Costs $/kg	Direct onshore wind	Grid electricity
CAPEX	1	1
FINANCE	1	1
OPEX	0.5	0.5
ELECTRICITY	3	14
TOTAL	5.5	16.5

The calculation shows that the CAPEX, Finance and OPEX costs are the same for both designs, as the wind turbine is included in the electricity cost. Thus, the grid electricity is the big bottleneck, almost 5 times more than direct green onshore wind electricity, while being only 40% green. The total costs give direct onshore wind a factor 3 advantage over the grid when providing hydrogen for electric vehicles. This is not as low a cost as the future target $2/kg in the USA but indicates that progress towards that goal is possible. 5.5$/kg for hydrogen from onshore wind competes well with petrol, natural gas and electrical energy in UK at present and is likely to fall further as thousands of onshore installations are proved.

Keele University has experimental evidence that these numbers are correct, having run its two onshore wind turbines, 1MW each since April 2022 applied to a membrane electrolyser making hydrogen, together with a 4.4MW solar farm dominating summer months generation. The combined effect of scaling up wind turbines and adding solar panels on lowering cost of the green hydrogen produced is substantial but there is a limit to delivering large onshore wind turbines by road.

The conclusions are interesting because this third energy horizon of onshore wind turbines could realistically address the UK problems of combustion-energy in transport and buildings, that have not been solved by the Grid over a century. The National Grid is old and costly while being ugly and controversial. Onshore wind plus solar can beat the National Grid prices now and is likely to become more advantageous as production increases. Keele University has started to demonstrate these benefits [15]. It is possible that all heavy UK transport, now running on combustion, can go hydrogen-electric by 2050 by this onshore wind/solar power route. The third energy horizon of distributed onshore wind/solar hydrogen production could then overtake the Grid by 2050.

References

1. www.ace.mmu.ac.uk; British Parliamentary papers session 13, 1863; Report from Committee of the House of Commons.
2. https://www.thebressinghamgardens.com/oppose-the-pylons/
3. www.politico.eu/article/the-politics-of-pylons-the-u-k-s-next-big-net-zero-battle/
4. www.statista.com/statistics/263492/electricity-prices-in-selected-countries/
5. www.carbonbrief.org/wind-and-solar-are-30-50-cheaper-than-thought-admits-uk-government/
6. www.eenews.net/articles/why-do-people-dislike-wind-power-what-a-doe-lab-found/
7. www.ovoenergy.com/help/article/feed-in-tariffs
8. www.sunsave.energy/solar-panels-advice/uk-places/homes-with-solar
9. www.energyvoice.com/renewables-energy-transition/wind/490387/wind-power-scotland/
10. https://www.carbonbrief.org/analysis-cutting-the-green-crap-has-added-2-5bn-to-uk-energy-bills/
11. www.gov.uk/government/news/offshore-wind-energy-revolution-to-provide-a-third-of-all-uk-electricity-by-2030
12. https://www.bbc.co.uk/news/science-environment-62731923
13. https://www.gov.uk/government/statistics/wind-energy-in-the-uk-june-2021
14. Kendall K (2023) Economic green hydrogen for UK refueling stations and buildings. Renewable and Sustainable Energy. Published online.
15. Kendall K (2024) Low carbon integrated vehicles and buildings, Mech Eng Advances 2: 282-293.