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Renewable Electricity Beats UK Grid

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ABSTRACT

The objective of this paper is to show that local renewable energy in Britain can compete well with the traditional National Grid and deliver costs that are less than half the current prices. First, the history of green electricity originally invented in England is summarized. Then the high prices of electricity in Britain are defined, showing that reduced costs are now possible through renewables because the UK monopoly National Grid is past its peak. Renewables, such as Solar and Wind, fluctuate and are not 100% available, suggesting that big energy storage is necessary, yet this has never been properly integrated into the National Grid. Hydrogen is the best molecule for storing and transporting energy in a composite tube trailer carrying 33MWh typically. When combined with solar panels and a large wind turbine, energy generation is in excess that can be converted to hydrogen stored in composite cylinders, filling renewable generation gaps with Combined Heat and Power (CHP) from zero emission fuel cells. An example of a large village site approaching this concept is described in detail, though failing in several aspects. The conclusion is that Solar plus Wind plus Hydrogen energy storage can be successful if the site scale is correct, such that appropriate solar/wind/hydrogen generation is installed, and the Grid is connected for back-up of the private wire system. Payback time of 3 to 4 years and savings on energy bills near £60M for each site over ten years should incentivize this innovation.

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Abbreviations
CHP : Combined Heat and Power
UK : United Kingdom
AC : Alternating Current
TWh : Tera Watt hours
GWh : Giga Watt hours
MWh : Mega Watt hours
£/MWh : Pounds per Mega Watt hour
LCOE : Levelised Cost of Electricity
LFSCOE : Levelised Full System Cost of Electricity

Introduction

The first proof that electric lights could be powered by renewable energy was demonstrated by William Armstrong near Newcastle in Rothbury, North-East England during 1878 [1]. Baron Armstrong was an industrialist who made his fortune from guns, battleships and other engineering products, funding his new Cragside mansion on a 900-hectare estate in the hills where he installed an Archimedes screw on his reservoir, then a Siemens hydro-power dynamo (Figure 1) to generate green electricity first for arc-lamps in 1878 and later in 1980 to power the new filament light-bulbs invented by his Newcastle colleague Joseph Swan [2].

Figure 1: Left: Armstrong's Archimedes Screw Driving a Dynamo; Right: Siemens Hydro-Powered Generator in Cragside House

Edison was developing competing filament bulbs in New York during the 1870s but used coal as fuel to generate electricity, starting sales to 82 customers in 1882. Unfortunately, Britain followed Edison's coal rather than Armstrong's hydro-power and fossil power dominated UK until 1984 when 200,000 miners were sacked and English coal combustion declined, while natural gas began to power the National Grid generator stations, with the last UK coal-fired power station demolished in 2024.

Armstrong had a vision that 'coal…used wastefully…in all its applications' would run out by 2063 which is remarkably close to the predicted shutdown of Chinese coal power stations to approach carbon neutral in 2060. The purpose of this paper is to describe how renewables should now replace fossil fuels, simultaneously reduce costs when properly apply.

The high price of UK Grid electricity, approaching £400/MWh, is higher than any other country on the planet (Figure 2). This diagram compares a typical home using 3000 kWh each year in different countries to define the electricity bill each month [3]. The list of 30 countries is limited and does not show the lowest price: Turkmenistan at £10/MWh is 40 times more economic than Britain and therefore is less likely to support renewables [4]. Of course, the domestic user pays very much more than the wholesale electricity price that may be as low as 100£/MWh, typically three or 4 times more because of standing charges and other taxes not related to the true cost [4]. A naïve user might think that the retail bills should drop as the grid electrical delivery lowered 30% over 15 years, but this is not the case. Profits have to be made by the bloated energy companies that demand citizen payments.

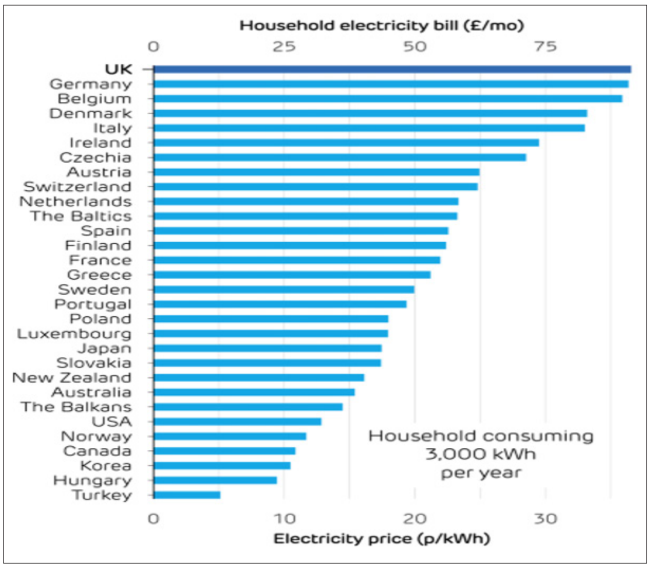

Figure 2: Diagram showing how UK Grid Electricity Is Most Expensive, Electricinsights 2024

Britain was the first nation with an interconnected electricity system started in 1901 at the Neptune Bank Power station on Tyneside, defined by Charles Merz and rising fast to become the largest network in Europe by 1912. Other towns and cities around the UK built powerlines covering small areas that were not connected but soon agreed that integration across the country was a wonderful idea, becoming reality in 1926 to 1933. In 1925, Lord Weir was asked by the UK government to combine the piecemeal generation and transmission industries. Merz was consulted and The Electricity Supply Act was published in 1926 to create a 'Gridiron' system using the new Central Electricity Board to standardize the 132kV 50 Hz AC network. This year 2026, we celebrate almost a century of electric Grid, which essentially has not changed substantially, and is now in decline.

Not many companies survive over 100 years, typically one out of 200 in USA. It is worth considering how long the Grid can survive when issues like competition, energy storage and renewables generation have been largely ignored, making UK costs rise too high in the electricity market, causing more economic businesses to overtake [5]. The original concept was to connect 122 of the largest coal-fired city power-stations, mainly using overhead wires on pylons, the first being constructed in Edinburgh in 1928, giving a complete Grid in 1933, plus total integration by 1938. Growth of UK electricity was exponential as the separate companies joined forces, as indicated in Figure 3 showing rapid rise until the peak in 2005. There was a slight blip during World War II, followed by nationalization during 1948 creating the British Electricity Authority that raised the voltage to 275kV, then to 400kV in 1965 when output hit 30GW. But the main difficulty arose when the coal miners went on strike from 1973 to 1984, causing mass sackings and movement towards natural gas from the North Sea as the main fuel. The Prime Minister Margaret Thatcher then sold the Grid for £5.2 billion in 1990, estimated to be 7 times less than the true value. This has now been a monopoly for 36 years causing chaos because the regulator OFGEM failed to keep prices low. Electricity competition has not been applied in UK.

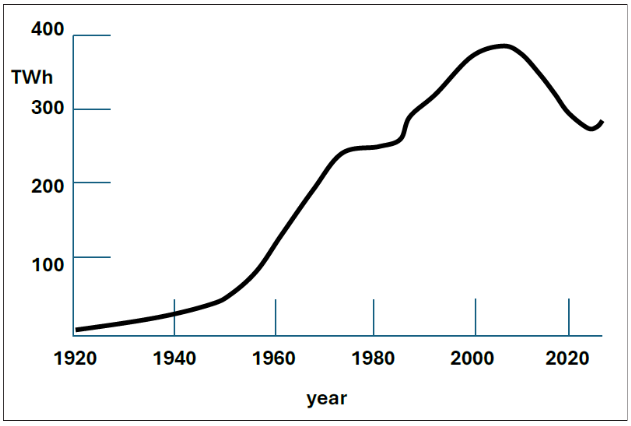

Figure 3: Smoothed Electrical Energy TWh Produced Annually by UK National Grid, peaking in 2005

Energy storage has been a major problem for the Grid, with pumped hydro installed in 1984 and now lithium batteries storing about 20GWh which contrasts with the British gas network that stores near 10,000GWh. This is a long-term failure that reflects on Norway which makes 91% of its electricity from hydropower in reservoirs, compared to 2% in Britain. At present it is impossible without storage for the Grid to handle wind and solar intermittent generation at a fair price [5].

A final blow is the application of biomass renewable electricity which started with Drax power station adding wood to coal in 2003, then burning 100% waste wood in 2014. but shipping 6Mt/a from America and causing huge carbon emissions. 40TWh of biomass were used in 2024, with the benefit of continuous generation, producing 7% of total UK electric output. Wind and solar are future renewable sources of electricity generation but are only available intermittently, which is a problem yet to be solved. The aim of this paper is to consider how Wind plus Solar plus Hydrogen can achieve this.

Materials and Methods

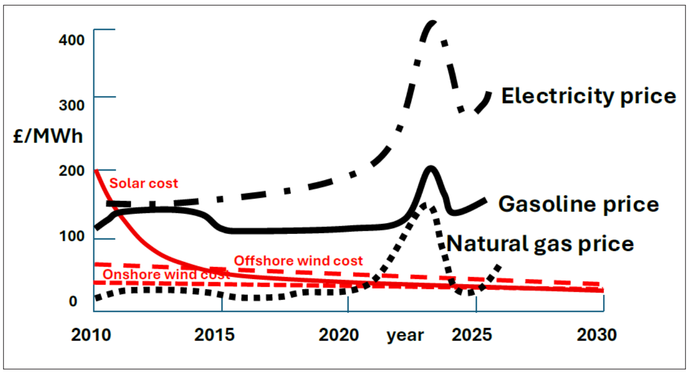

Figure 4: Diagram showing in black the smoothed UK prices from 2020 to 2030 of electricity, petrol and gas to compare in red the costs of solar, offshore wind and onshore wind energy

The present energy situation in Britain is shown as £/MWh in Figure 4, illustrating in black the fossil fuel energy prices that include grid electricity, gasoline in transport, and natural gas for heating homes among many other applications. Renewables costs are in red, falling fast over 15 years.

The first impact of these curves is that the black lines shoot up rapidly and fluctuate as global wars are engaged, whereas the red lines continue to drop. Wind and solar costs have remained low. For example, onshore wind costs rose by 26% from 2022 to 2023 and solar rose by 17% whereas grid price rose by more than 100% [6]. The Iran war starting in February 2026 is likely to increase Grid bills again. Fossil prices are shown because the cost of natural gas seems to be arbitrary, dictated by big companies working international markets [7].

The factor 8 difference between 2026 UK grid electricity price and wind/solar costs gives an incentive to relegate the grid to back-up only, while saving on electricity and other fossil energy bills by using wind and solar which are much cheaper than coal when comparing Levelised Cost of Electricity (LCOE) shown in table 1. But Levelised Full System Cost of Electricity (LFSCOE) calculated by the Grid makes wind and solar almost ten times more expensive than it really is, demonstrating that the Grid cannot easily handle fluctuating renewable electricity [8].

Table 1: Showing that Solar and Wind are the Cheapest in LCOE (Levelised cost of electricity), but appear to be more costly than coal in LFSCOE (Full System FS) calculated by the Grid which has a problem with fluctuating renewable energy sources

SOURCE	LCOE	LFSCOE
COAL	76	90
WIND	40	291
SOLAR	36	413

The key issue of renewables like wind and solar is that such electricity generation is never continuous, but may peak for an hour each day but then drops to zero as darkness falls or breeze drops. Thus, it is misleading to define solar panels by peak power. To attain 4kW peak power on a UK rooftop, about 12 panels are needed, but the total energy produced in a day might only be 10kWh, near the 0.4kW average that a household uses in Birmingham UK. Many factors influence the average power and it is worth detailed calculations as in The Green Watt website USA [9].

Lithium batteries to store the solar power for use at night are much more cost effective now, and buying a 10kWh battery for £3000 is reasonable in UK during 2026. Consequently, a typical UK home covered with 12 solar panels, plus a 10kW battery including installation can cost £11,000 that pays back in 9 years. This is too long to expect investors to get excited: 3-year payback is much more attractive.

China has been leading the world in coal for electric power, yet is also a leader in solar panels which give cheaper electricity as shown in Table 1. Moving from coal to solar electricity in China would cut electricity costs in half. 2025 was the year when China manufactured almost 1 billion solar panels, and installed extra peak power near 315GW plus 119GW of wind turbines, giving a total solar contribution of 1.2TW with wind at 0.64TW, doubling every 3 years as shown in Figure 5 [10].

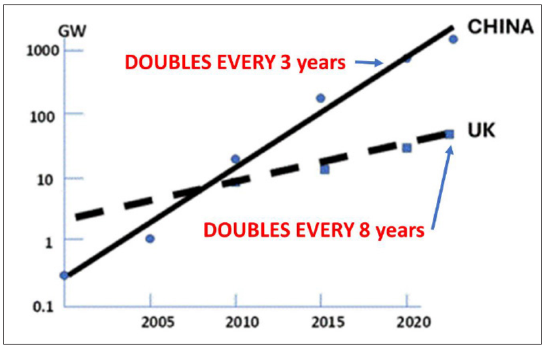

Figure 5: China Overtakes Britain by Installing Solar and Wind Power, Doubling Every 3 Years

China got ahead around 2010, especially in solar, since UK was focussing on offshore wind turbines based in the North Sea. UK solar installed in 2025 was 2.8GW giving a total energy of 18 TWh whereas wind was delivering a total of 85TWh energy, 24GW of total power [11]. UK has been doubling wind and solar every 8 years, but the new government is aiming to double again by 2030, raising the gradient of the exponential line to compete with China's 3-year doubling record.

Britain has a further problem because solar radiation at high latitudes like Orkney is low in December and availability is poor. This is the time of year when energy and heat are vital. Therefore, wind power is more appropriate as strong winter breezes are more usual in the Scottish islands. However, solar is much better in summer, so the combination of solar and wind together is the optimum across the full year, as mentioned in 2006 [12].

Results

Figure 6 shows the installation and solar results from a 1000acre village site near Birmingham for solar generation when there was no wind on the equinox day 21 September 2022. 4.4 MW of solar panels were installed in an open field, with two wind turbines close by to generate 1MW each. Planning permission was not allowed for a single large wind turbine 5MWpeak because such a big structure would have had a negative effect on the view. An electrolyzer was installed to produce 0.1MW of green hydrogen from surplus renewable electricity, but this was too small. 5 MW would be more satisfactory. Another problem was the Grid would not accept more than 3MW of surplus energy at mid-day when the full sun was available. Curtailment by the Grid wasted renewable electricity. Some storage of electric energy in a 2MWh lithium battery container was available but this turned out to be too low to fill the gaps in renewable generation [13].

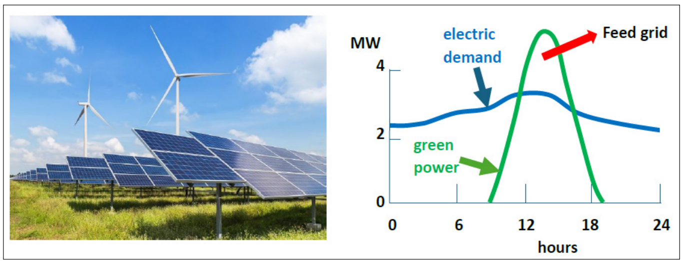

Figure 6: Left: Wind and Solar Installation on the site; Right: Smoothed Results for Solar Power Feeding the Site Electricity Demand During One Full Day

The conclusion was that the solar generation was insufficient, the battery and hydrogen energy storage was too low and the bright sunshine was only paying 20% of the electricity demand bill, since the Grid payment for feeding in the excess solar was much lower than the true value. Figure 6 was smoothed and does not show the fluctuations due to clouds blocking the sun. The Grid connection was used to buffer these oscillations and it would have been more economic for the lithium battery to maintain the voltage. In addition, the Grid limited the energy admitted, so solar energy above the limit was wasted by curtailment [14].

Recommendations following this result were three-fold:

- Increase the renewable solar generation substantially
- Do not feed the Grid with excess power
- Generate 5MW of hydrogen at peak periods, then fill the gaps with combined heat and power from fuel cells.

Figure 7 shows the effects of these modifications. The solar energy can only pay the site electricity bills directly between 10am and 6pm. This leaves 67% of the bill that can be covered by storing excess solar as green hydrogen that can then be converted into combined heat and power (CHP) using fuel cells. The value of the 700kg of stored hydrogen is approximately £7000 which could be shipped for sale when necessary. If insufficient hydrogen is in the store, another ton could be shipped in. Also, the Grid can be used to fill the gaps in renewable power, but only as a back-up supplier.

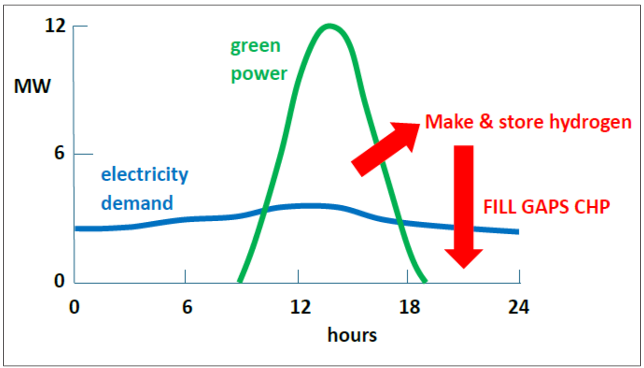

Figure 7: Raising the solar power by a factor 3 to 12 MW pays a third of the bill between 10am and 6pm while the solar excess power is stored as hydrogen gas that can later fill the gaps in renewable energy from 6pm to 10am

Discussion

Measuring the shortcomings of this village site, with inadequate wind, solar and hydrogen, allows a new design to be produced, depending on the annual energy bill, based on electricity, gas and gasoline for vehicles. The annual energy usage was 63 GWh, of which the electricity was most expensive at £4.3 million, gas costing £2.9 million and vehicles costing 2.0 million, leading to a total energy bill of £9.2 million. Calculation of the annual bill for 12MW of solar, 5MW of wind and 5MW electrolyzer making hydrogen gave the result of £3.2 million, thereby saving £6 million each year. The total Capex and Opex sum was about £24 million, suggesting payback near 3 to 4 years, with savings over the following decade of £60 million.

Therefore, the innovative design for renewables beating the Grid for a village of 12,000 people receiving a present energy bill of £9.2 million may be shown in Figure 8.

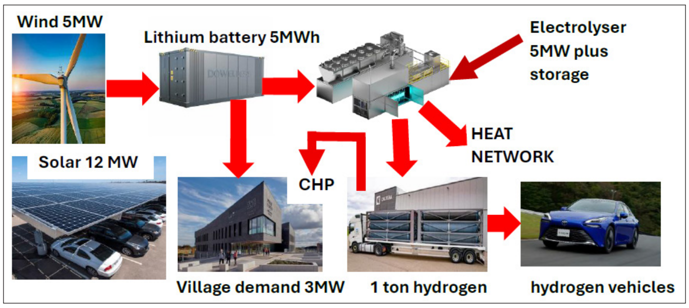

Figure 8: Innovative Design of the Village Site Shown in Figure 6 Moving from 15% Green to Near 100% By Installing Solar Plus Wind Plus Hydrogen

The private wire site has a grid connection that currently supplies most of the electrical energy, but this is to be replaced by solar plus wind plus hydrogen, relegating the grid to back-up only.

Solar is shown in Figure 8 as a car park covered in 12 MW of panels but also includes roofs and open fields containing solar installations. The other main source of electrical power is the 5 MW wind turbine. Used together, solar and wind will leave a gap that can be filled by hydrogen energy stored in 1 ton tube trailers, then converted to CHP using fuel cells. Most of this hydrogen is made using the 5MW electrolyzer when excess green electricity is produced by sun and wind. The hydrogen is stored at 500bar and can be used also to refuel hydrogen buses, trucks and cars, or maybe sold through shipping to other users. Such hybrid renewable energy generation and storage has been reviewed recently [15-18].

Conclusions

The main conclusion is that the UK electricity Grid is so expensive that it can be beaten by installing renewables such as solar plus wind plus hydrogen energy storage.

Electric power from renewables was invented during the 1870s in Rothbury England by William Armstrong who used hydropower to illuminate his estate in a mini-grid, using the filament light bulbs invented by Joseph Swan.

Britain was the first country to build a national electric grid network linking cities, towns and villages starting in 1926, powered by coal which was first developed for electricity generation by Edison in New York in 1882. This UK Grid was very successful, expanding exponentially over many years, but peaked in 2005 and is now in decline, even though it only provides 21% of UK energy, which is mainly fossil oil and gas.

Transition from fossil fuels to renewable Grid electricity should be completed by 2030 in UK but the cutting of oil and gas for transport and heating is currently slight and is planned to take 20 more years.

The innovation of Solar plus Wind plus Hydrogen in villages defines a novel way forward integrating electricity, heat and transport for communities that use the electric National Grid as back-up only. Hydrogen is made by electrolysis when wind and solar are in excess, stored in lightweight cylinders, then converted by fuel cells to combined heat and power during low wind and solar generation. Alternatively, hydrogen can be shipped in and out of the green village using tube trailers.

The size of the private wire community is important to the rapid pay-back time and to the savings over subsequent years. Typically, the number of people in the village may range from 1000 to 30000 [19]. Several sites are being developed discretely now. Pay-back time around 3 years and savings on energy bills near £60M for a single site over ten years should incentivize this innovation.

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Conflicts of Interest: The author declares no conflicts of interest.

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