Baseload nuclear power not needed in an all-renewable future

June 30, 2022 / Dave Andrews / Uncategorized /

Latest Research – Baseload generators such as nuclear power plants are not needed in an all-renewable future and their use would simply increase costs.

Claverton Energy Group email release – Wednesday, July 20, 2022

Sizewell C is much more expensive and slower to build than proven and reliable alternative low carbon solutions say elite Energy Think Tank

Latest Research – Baseload generators such as nuclear power plants are not needed in an all-renewable future and their use will almost certainly increase overall costs to consumers says elite Claverton Energy Group of experts. Professor Mark Barrett, from UCL, who has modeled the comparative costs of nuclear and renewable power, using hour-by-hour wind and solar data with 35 years of weather data , said:
"Nuclear power is more expensive and slower to build than renewables, particularly offshore wind.
7 GW of wind will generate about 40% more electricity

than Hinkley at about 30-50% of the cost per kWh and will be built in half the time. Neither wind nor nuclear plant operates all the time, so both will need backup. Modeling shows the total cost of a renewable generation to be less than nuclear and to be just as able to provide continuous power even with wind and solar droughts."
(- full quote from Prof Barrett at end of the piece.)

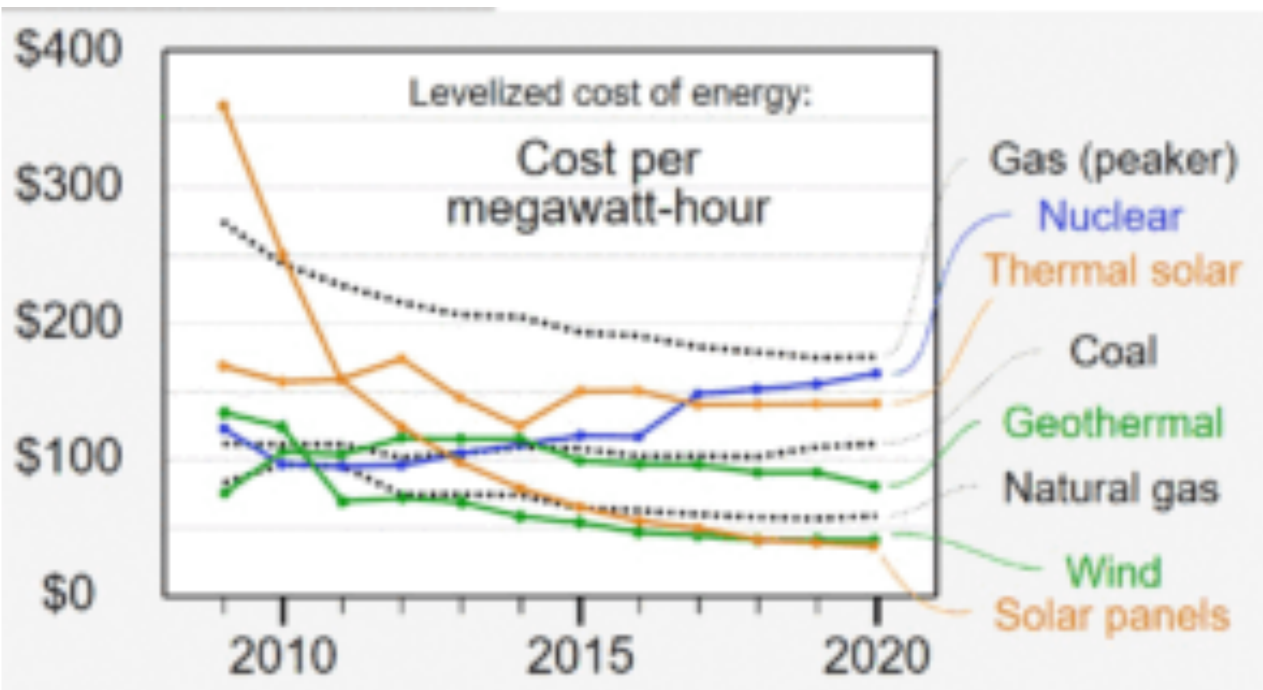

Fig 1. The above chart from Lazard shows how cheap wind and solar *individually* have become. But to work out the lowest cost mixture of plants for an ultra-reliable low carbon power and heat system, sophisticated modeling using many years of hourly weather data needs to be carried out.

This detailed modeling of the entire heat, power and transport system in the UK, has been carried out by a number of top-flight university researchers and shows that:

- The continuing fall in wind and solar energy costs, along with cheaper storage of heat and power means that an entirely renewable and highly reliable power supply as a replacement for fossil fuels for heating and transport through electrification is available to the UK at a lower cost than any alternative, even when wind and solar droughts (i.e. periods of low wind or solar) or imported fuel hiatus are considered.
- It is a myth to claim that nuclear energy is needed to provide baseload power (baseload is simply the minimum power level on the grid. This power can be provided by any suitable mix of generators including variable wind and solar if backup sources are provided.
- Because nuclear cannot readily be turned off for economic reasons, its presence on the grid limits the amount of much cheaper renewables that can be used, as nuclear would have to take precedence over renewables – thus they increase the total cost.
- Renewable electricity can be used to drive negative emission technologies so as to balance remaining emissions from hard sectors such as aviation and cement making these zero carbons.
- a baseload power source of any kind, but typically nuclear is NOT needed to provide baseload power demand (ie the power demand that is continuous 8760 / 24/7) – hydrogen-fueled generators + wind and solar + storage can do this but at a lower cost.
- Successive BEIS Chief Scientific Advisers have not

briefed ministers correctly on this important point and it is often wrongly reiterated by the BBC and other media e.g. The Economist – “Politicians need to tell voters that their desire for an energy transition that eschews both fossil fuels and nuclear power is a dangerous illusion” How to fix the world’s energy emergency without wrecking the environment | The Economist The Economist is simply not correct here.

- Researchers have simulated the entire power incl electrical vehicle demands, shipping fuel demand, along with building heating energy, for up to 35 years of hourly weather data (which included several wind and solar droughts/deficits), and using computer models found the cheapest mix of plants.
- The programs automatically tried a huge variety of different mixes of wind, solar, nuclear, heat and power storage, insulation levels, heating systems, district heating, heat pumps, interconnection to Europe – 15 different system elements. The analysis includes the costs of the different sources and elements and repeatedly rejects nuclear from the mix as it increases costs without increasing reliability.
- In fact, nuclear power in the UK and Europe has proven to be unreliable, and the nuclear waste problem is essentially unsolved in the UK. French nuclear is currently on 50% available.
- During high wind and solar surpluses electricity is sent to storage in batteries or thermal stores heated by large heat pumps, and to electrolyzers to make

hydrogen.

- During wind and solar deficits, heat, and power are withdrawn from the stores as required, and the stored hydrogen or ammonia created from the electrolysis of wind and solar can be used in generators to also produce power and heat.
- During winter peak demands with high winds and solar, all power can come from these renewable resources and surplus go to stores.
- During low solar and wind (wind and solar droughts), energy is withdrawn from stores.
- Since wind and solar, is so much cheaper in capital cost and operating cost, even if the attendant costs of storage are included, adding nuclear makes the whole mix of plant and its operation more expensive
- Wind and solar can be built in around 4 years and then function reliably, (albeit varying output with the wind and sunshine) whereas nuclear is notoriously likely to be many years late and over budget.
- Hinkley C is now 10 years late and many recent reactors have had to be taken offline due to faults that take a long time to address – the Chinese version of the EPR has been offline for over a year, since its start-up 3 years ago.
- In the simulations, natural gas and electric heating are largely replaced by either a) individual house heat pumps or b) larger heat pumps and district heating both of which have similar costs
- The simulations show that hydrogen heating for

buildings is roughly twice as expensive as a. the individual heat pump solutions b. district heating with heat pumps.

- David Andrews, C.Eng, M. Inst Energy, who was an invited expert on power generation for the EU's Energy Research Labs said "It is clear that the government should drop any future plans for nuclear energy such as Hinckley, as it takes far too long to build, is unreliable, and above all, a modern renewable-based system does not actually need Baseload Power generation. Research shows all our power, including the baseload power is provided more cheaply by renewable energy with heat and power storage."

Quotes:
Professor Mark Barret, from UCL who has been involved in much modeling of the comparative costs of nuclear power, said
"

Our careful modeling utilizing 35 years of weather data shows that nuclear power is more expensive and slow to build than renewables.
The Hinkley contract (*1): 'Hinkley Point C CfD provides a Strike Price for the developer of £92.50/MWh (2012 prices)' Inflation 2012-2022 is about 30% so the Hinkley strike price in today's money is about £120/MWh.
Hinkley's initial construction work started around 2015 and is due to start generating perhaps in 2026-2027 – 10

or more years' build time.
A recent offshore wind capacity auction (*2) of 7 GW resulted in a strike price of £43/MWh (in today's money) to be built in 5 years and operating in 2027. BEIS project wind costs to continue falling.
This latest 7 GW of wind will generate about 40% more electricity than Hinkley at 30-50% of the cost per kWh and will be built in half the time. Neither wind nor nuclear plant operates all the time, so both will need back-up, though the wind will need more than nuclear, assuming the latter operates reliably our modeling shows the extra cost to the wind of the backup is significantly below the alternative cost of nuclear
Renewables do not pose waste and security problems as do nuclear."

*1 https://www.gov.uk/government/collections/hinkley-point-c

*2 https://www.current-news.co.uk/news/almost-11gw-of-capacity-secured-in-biggest-cfd-auction-ever

David Andrews, C.Eng. M.Inst Energy. Chair of the Claverton Energy Groups said " "Sizewell C is an ill-advised investment because proven renewables, wind, solar, storage and low carbon wind drought back up in combination when analyzed in detailed are much cheaper and more reliable than nuclear energy"

ENDS

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“The Claverton Energy Group.... is one of UK’s premier independent Energy Think Tanks and is comprised of over one hundred highly experienced engineers, scientists, and academics who have worked in the energy field (nuclear, renewable energy, low energy housing, heating, transport, electrical grids, power stations, energy politics, etc.) often for their entire careers. The group, which has continuously debated energy technologies and energy policies online for 20 years, does not have unanimous agreement on all energy policies or technologies in general and does not collectively endorse this view reported here – although many members do. They are available to brief media on any energy-related points – heating, electricity generation, the environment, etc. technologies or policies **Claverton Energy Group, Victoria Place, Combe Down, Bath. BA2 5EY** **tyningroad@gmail.com** **07795 842295 / 01225 837978**

Further technical details

Low Cost & Ultra Reliable Low Carbon Energy from Wind and Solar Plus Storage, & Available 24/7 are Cheaper Than Other Power or Heat Sources and

Insulate Us from Fuel Price Shocks – Latest Research.

Summary
A number of detailed studies (refs below) based on detailed cost simulations of half hourly weather data over 35 years demonstrate that the cheapest source of continuously available and ultra-reliable, low carbon energy in the UK can be provided by a mix of offshore windfarms, solar energy and other well-known techniques such as heat and power storage. This option has been brought about by the dramatic fall in the cost of wind and solar energy, energy storage, and power transmission cables. There is no longer any requirement for specific "baseload power generation" or expensive and slow-to-build nuclear power as a backup for windless days.
These renewable sources are entirely homegrown and completely insulate us from the repeated economic shocks caused by fuel price volatility which go right back to 1973 and the first oil price shock; When all Japanese reactors went off-line after Fukushima, this caused a 3-fold increase in UK gas prices as Japan was forced to import more gas. Ukraine is another case in point. ~30% of the world's uranium comes from Russia or Russian-dominated countries eg Kazakhstan.
A bit comes from African countries perhaps heading for Chinese control and Australia is going renewable with lots of difficulties with developing new mines on aboriginal lands.
Also, uranium concentrations risk diminishing if the

resource use increases.

The fact is the UK has one of the world's best offshore wind resources. Perhaps surprisingly, the UK offshore area has sufficient sea area to generate not only the UK's, but all of Europe's power demand, opening up an electricity export bonanza for the UK. https://claverton-energy.com/two-terawatts-average-power-output-the-uk-offshore-wind-resource.html
Wind and solar energy are variable but they are largely predictable a few days ahead, and highly predictable one hour ahead. Whilst sometimes of very low output, nevertheless the detailed studies reported on here show they can be combined with other cost-effective and well-known technologies which store surplus energy during windy and sunny periods and release it during windless and sunless periods, and coupled with power connections between different regions, to provide a totally reliably power source, and thus match supply to demand at all times. These combinations offer a continuous ultra-reliable energy supply for both all electricity supply, electric vehicles, and building heating and at a lower overall cost than gas or nuclear power and without the CO_2 emissions of fossil fuels and exposure to international fuel prices.
It should be noted that the transformation of the grid that is implied by the reported work requires considerable and complex detailed engineering and modeling by experts in grid and power technology; This is in order to ensure that

the correct grid components in terms of transmission and distribution assets, storage, security, extra inertia assets, and the spatial positioning of the various generation assets is satisfactory and workable. But these are known issues and grid experts are currently working on the necessary large-scale changes to the Electricity Delivery system including Transmission and Distribution

This reliability means that we can design systems at reasonable cost which use negligible amounts of fossil fuels for heat and electricity supply. Low-cost peaking fossil plant would be used in exceptional conditions. For typical years the system would have net zero or even net negative emissions. We might use fossil fuels for purposes other than electricity or heat such as for aviation, but emission from these can be balanced with negative emissions, such as using direct air carbon capture technology, as yet unproven at scale.

Assuming Hinkley C costs, currently projected as 8000 £/kW, adding nuclear to the mix increases the total system cost without improving the reliability of a renewable system with storage.

Replacement of natural gas by hydrogen for heating in the existing gas network for heating is about twice as expensive as district heat with large heat pumps or individual heat pumps. It also has technical issues. See Ref – Dr. Starr – below

See Gallo Cassarino and Barrett (2021)

Gallo Cassarino, T., & Barrett, M. A. (2021). Meeting UK heat demands in zero emission renewable energy systems using storage and interconnectors. *Applied Energy*, *306*(PB), 118051. https://doi.org/10.1016/j.apenergy.2021.118051

Further detail

The proven technologies or procedures which can be combined with wind and solar include

- Transmission and storage of heat as hot water in district heating – DH pipes – very common in Scandinavia and Germany and to a small extent in UK.
- storage of electricity with electrical or compressed air/CO2 batteries
- The production of hydrogen from wind or solar via electrolysis (simply passing electricity through water creates hydrogen) during periods when renewable generation is surplus to the immediate power demand and its storage for use in industry or shipping use; and also releasing it for generation during low wind and solar periods later in conventional power stations such as turbines or engines.

The creation of hydrogen via electrolysis on a vast scale (see image below) is already envisaged by National Grid during three of its Energy Scenario: *"The supply and use of hydrogen is central to all of our net-zero scenarios and has a key role to play in helping the UK achieve net-zero by 2050. It can be stored over long periods and can*

provide
the low carbon, high-intensity heat needed for some applications."
https://www.nationalgrid.com/stories/journey-to-net-zero-stories/future-energy-scenarios-increased-role-bioenergy-and-hydrogen

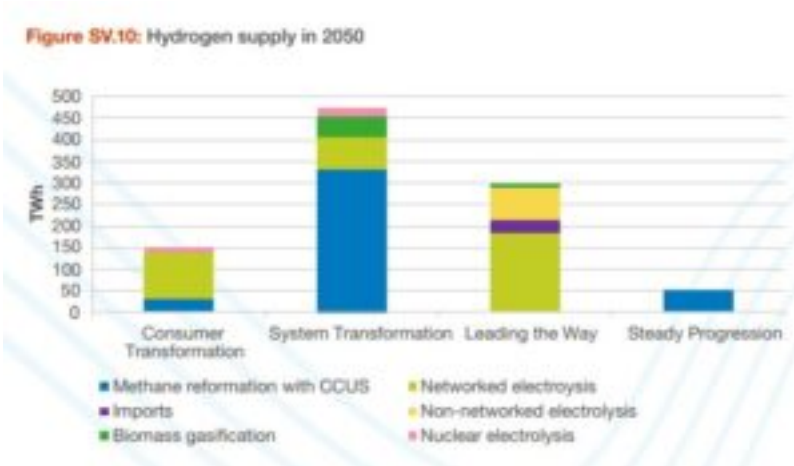

Fig 2. Above vast hydrogen from electrolysis is in National Grids scenario

- Hydrogen can be readily converted to ammonia for easy storage and transport and use as fuel during windless/sunless periods and as a fuel for ships – this is widely planned by the maritime industry.
- Increasing the capacity of power interconnectors connecting the UK to Europe. Interconnectors average out demands and renewable outputs across large regions and allow trade of surpluses and deficits. At any one time, weather systems, demands and renewables are different at different places. Whilst low wind and sun across Europe do occur from time to time, they tend to be relatively short-lived limiting the amount of electricity storage required.

> Recent published work shows that interconnectors can cut the total European electricity storage capacity required by 30 times. The interconnectors can be High Voltage Direct Current (HVDC) or the more common High Voltage Alternating Current (HVAC). HVDC has low overall losses over long distances – also the losses are much lower than conventional alternating current, AC transmission – 3% per 1000 km compared to 7% losses for the old HVAC on land, and much higher for submarine HVAC cables. E.g. [https://iea-etsap.org/E-TechDS/PDF/E12_el-t&d_KV_Apr2014_GSOK.pdf.](https://iea-etsap.org/E-TechDS/PDF/E12_el-t&d_KV_Apr2014_GSOK.pdf)

For low-temperature heat supply to buildings or industry, the leading (lowest cost) options are individual domestic consumer heat pumps or large heat pumps feeding District Heating (DH) networks (i.e., buried pipes carrying hot water from a central source to dwellings). Mass installation of individual air source heat pumps would require upgrades to the power network to handle the extra current which is perfectly feasible, whilst the use of District Heating would require the installation of large numbers of buried heating pipes also perfectly feasible and common practice in Europe. Whilst investment is required, these heating options have been costed and evaluated by various computer models (refs below) and shown to overall have a much lower total annual cost (i.e. fuel bills, maintenance, plus interest payments) than any other likely technology.

The optimum levels of insulation in existing and new dwellings (which in all cases depends on the heat supply costs) with these techniques does not justify a very large expenditure per house.

Other factors to consider include:

Hydrogen to replace natural gas for home heating is about twice the cost overall of the alternatives mentioned above, (i.e., large heat pumps with district heating or individual small heat pumps) and has technical issues particularly using 100% hydrogen in the existing gas grid.

Carbon capture and storage from fossil fuel does not remove all the carbon-dioxide created during burning.

Carbon capture and storage for the creation of hydrogen (blue hydrogen) from natural gas is also more expensive than hydrogen from electrolysis (green hydrogen).

Some energy uses, notably aviation, are very hard to decarbonize and will cause global warming. To balance these negative emissions, capturing CO2 from the air and storing it underground, will be required. But processes for this are commercially unproven so their use should be minimized.

BACKGROUND INFO:

Modelling and simulation

Various detailed costed modelling and simulations (some refs below) show that this all-renewable future can be achieved at affordable, low cost. The conclusion stated above is arrived at by detailed computer models of the cost and performance of 15 key elements in the energy supply system (such as more or less: wind turbines, battery storage, heat pumps, hydrogen, number of houses, district heating, electrolysis, insulation levels, power cables, etc.). The models simulate the operation of the 15 elements modelled in the system by feeding in up to 35 years of hourly weather data to ensure the basic engineering allows matching of variable demands and variable renewables to meet the heat and power demand in any hour sufficient reliability, and also calculates the cost of the total system.

These models often use an optimization program which model how changing one element (for example increasing insulation, or putting in a larger battery store, bigger heat pumps or hydrogen, or more or less wind turbines, etc.), affects the required size of the other systems. In optimization, the model varies the 15 principal elements mentioned earlier in such a way as to proceed towards lower-cost systems (see examples below) that meet the objectives such as minimum greenhouse gas emission, and provide the required energy services (heat and power) hour by hour across the year when subject to varying weather conditions but at the lowest cost. The optimum – i.e. lowest cost combination of elements, can thus be simulated using many years of hourly weather.

Build speed and reliability

Renewable energy, wind and solar can be built extremely quickly and on time – 4 years for a large wind farm, and they generally operate as planned once completed; nuclear power takes much longer to build – 10 – 15 years, is often late and overbudget and often fails with a long wait for rectifications, as per the Chinese reactors now off line for a year after start up. There are multi-year delays and budget overruns at the French, Finnish and UK reactors.

Sample output from the optimizer programs:

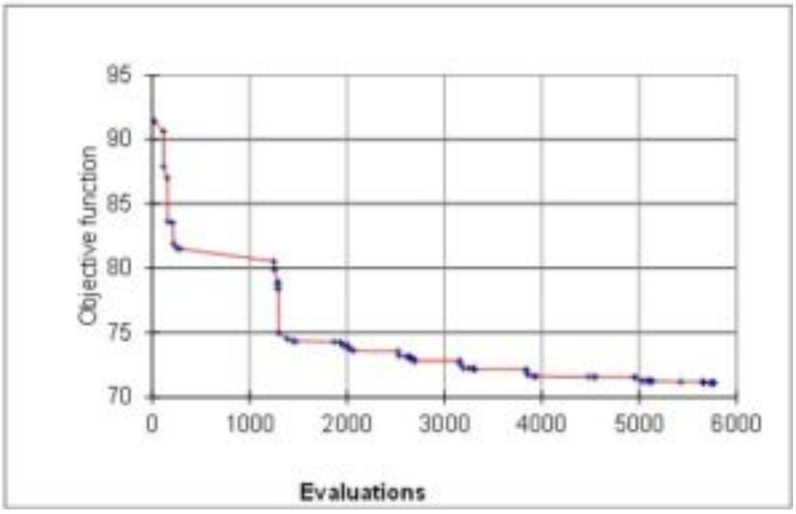

Fig 3 above is an example of how the optimizer program, as runs proceed, gradually drops the total cost of the system as moving from left to right it hunts for the minimum cost solution:

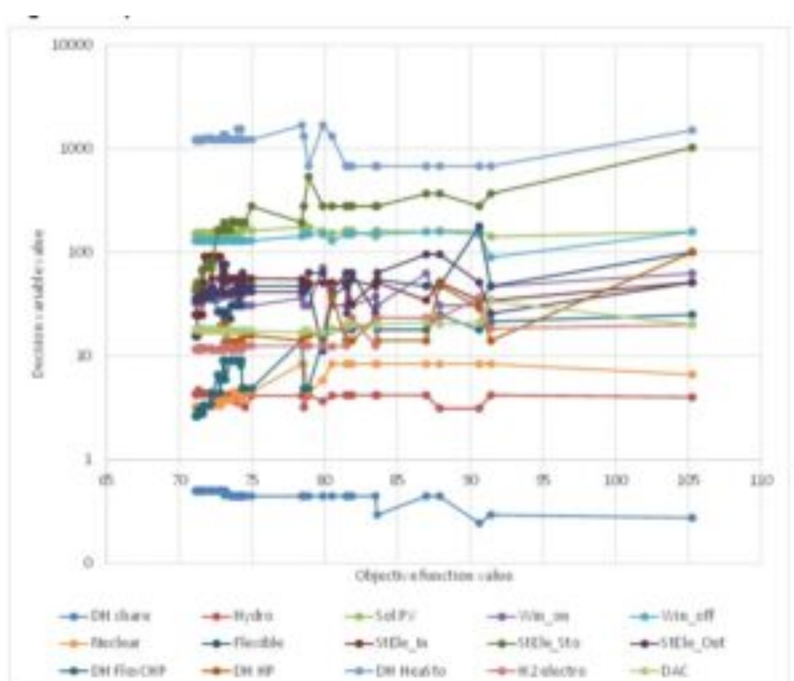

Fig 4 above is a sample read out of the optimizer

adjusting the input values of the various components – wind turbines, insulation, pv etc. as it finds the minimum cost solution:

It is important to note these simulations are not attempting to model in detail how such a system would be built and the necessary large-scale changes to the Electricity Delivery system including Transmission and Distribution that would be necessary. This would require more and different modelling by National Grid experts and a series of interactive iterations of the engineering work and the type of modelling reported here, and such work is currently on-going

References:

References for modelling work:

Barrett, M, Gallo Cassarino, T, (2021), Heating with steam methane reformed hydrogen, Research Paper, https://www.creds.ac.uk/publications/heating-with-steam-methane-reformed-hydrogen-a-survey-of-the-emissions-security-and-cost-implications-of-heating-with-hydrogen-produced-from-natural-gas/

Relative costs of nuclear, wind gas etc: https://www.lazard.com/media/451419/lazards-levelized-cost-of-energy-version-140.pdf

Gallo Cassarino, T. *et al.* (2019) 'Is a 100% renewable European power system feasible by 2050?', *Applied Energy*. Elsevier, 233–234(January 2018), pp. 1027–1050. doi: 10.1016/j.apenergy.2018.08.109.

Gallo Cassarino, T. and Barrett, M. A. (2021) 'Meeting UK heat demands in zero emission renewable energy systems

using storage and interconnectors', *Applied Energy*. Elsevier Ltd, 306(PB), p. 118051. doi: 10.1016/j.apenergy.2021.118051.
Gallo Cassarino, T., Sharp, E. and Barrett, M. (2018) 'The impact of social and weather drivers on the historical electricity demand in Europe', *Applied Energy*, 229. doi: 10.1016/j.apenergy.2018.07.108.
Siddiqui, S., Barrett, M. and Macadam, J. (2021) 'A high resolution spatiotemporal urban heat load model for gb', *Energies*, 14(14). doi: 10.3390/en14144078.
Siddiqui, S., Macadam, J. and Barrett, M. (2020) 'A novel method for forecasting electricity prices in a system with variable renewables and grid storage', *International Journal of Sustainable Energy Planning and Management*, 27(Special Issue), pp. 51–66. doi: 10.5278/ijsepm.3497.
Siddiqui, S., Macadam, J. and Barrett, M. (2021) 'The operation of district heating with heat pumps and thermal energy storage in a zero-emission scenario', *Energy Reports*. Elsevier Ltd, 7, pp. 176–183. doi: 10.1016/j.egyr.2021.08.157.
Dr.-Ing. Dipl.-Phys. Gregor Czisch
Low Cost but Totally Renewable Electricity Supply for a Huge Supply Area
http://transnational-renewables.org/Gregor_Czisch/projekte/LowCostEuropElSup_revised_for_AKE_2006.pdf

Other scenario modelling:

https://www.nationalgrid.com/stories/journey-to-net-zero-

stories/future-energy-scenarios-increased-role-bioenergy-and-hydrogen
https://ukerc8.dl.ac.uk/UCAT/PUBLICATIONS/Pathways_to_a_Low_Carbon_Economy_-_Energy_Systems_Modelling_UKERC_Energy_2050_Research_Report_1.pdf
https://www.nationalgrid.com/stories/journey-to-net-zero-stories/future-energy-scenarios-increased-role-bioenergy-and-hydrogen
Towards a low-carbon economy: scenarios and policies for the UK. PAUL EKINS, GABRIAL ANANDARAJAH & NEIL STRACHAN https://www.tandfonline.com/doi/abs/10.3763/cpol.2010.0126
https://www.gov.uk/government/news/plans-unveiled-to-decarbonise-uk-power-system-by-2035
https://www.nationalgrideso.com/news/great-britain-track-periods-zero-carbon-electricity-2025
https://www.pwc.co.uk/assets/pdf/100-percent-renewable-electricity.pdf
https://www.renewableenergyworld.com/wind-power/the-headlines-that-britain-never-thought-it-would-see-the-uk-to-be-100-powered-by-renewables/#gref
https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-Technical-Annex-Integrating-variable-renewables.pdf
https://vision.renewableuk.com/

Hydrogen

Dr. Fred Starr, Ex British Gas. https://www.energyinst.org/__data/assets/pdf_file/00

19/707302/Fred-Starrs-Hydrogen-Presentation.pdf

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Nuclear cannot ramp output up and down to meet varying wind / solar output

The French nuclear fleet ramping is limited. Professor Paul Dorfman quotes an EDF nuclear manager, saying they can ramp 9 times/ reactor/year. France also uses a huge hydro fleet to help with the deficit which UK does not have.

In France they:

1. Keep the nuclear generating steadily as much as it can.
2. Shift load with off-peak heating and other storage as much as possible.
3. Export any remaining nuclear (near zero avoidable cost) to countries with deficits beyond their own nuclear. This is most countries and is why France has been a major exporter.

Nuclear delays

Completion of the Hinkley Point C power station has been delayed again by around another year, meaning it will now be a decade behind its original schedule https://twitter.com/SkyNews/status/1527633772866412546

Nuclear fuel insecurity

~30% of the world's uranium comes from Russia or Russian dominated countries eg Kazakhstan.

A bit comes from African countries perhaps heading for Chinese control and Australia is going renewable with lots of difficulties with developing new mines on aboriginal lands.
Also, uranium concentrations risk diminishing if the resource use increases.

Useful energy statistics:
UK Energy Usage – What Fuel or Energy Source Do We Use for Industry, Heating, Transport Etc.?
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1006380/Energy_flow_chart_2020.pdf

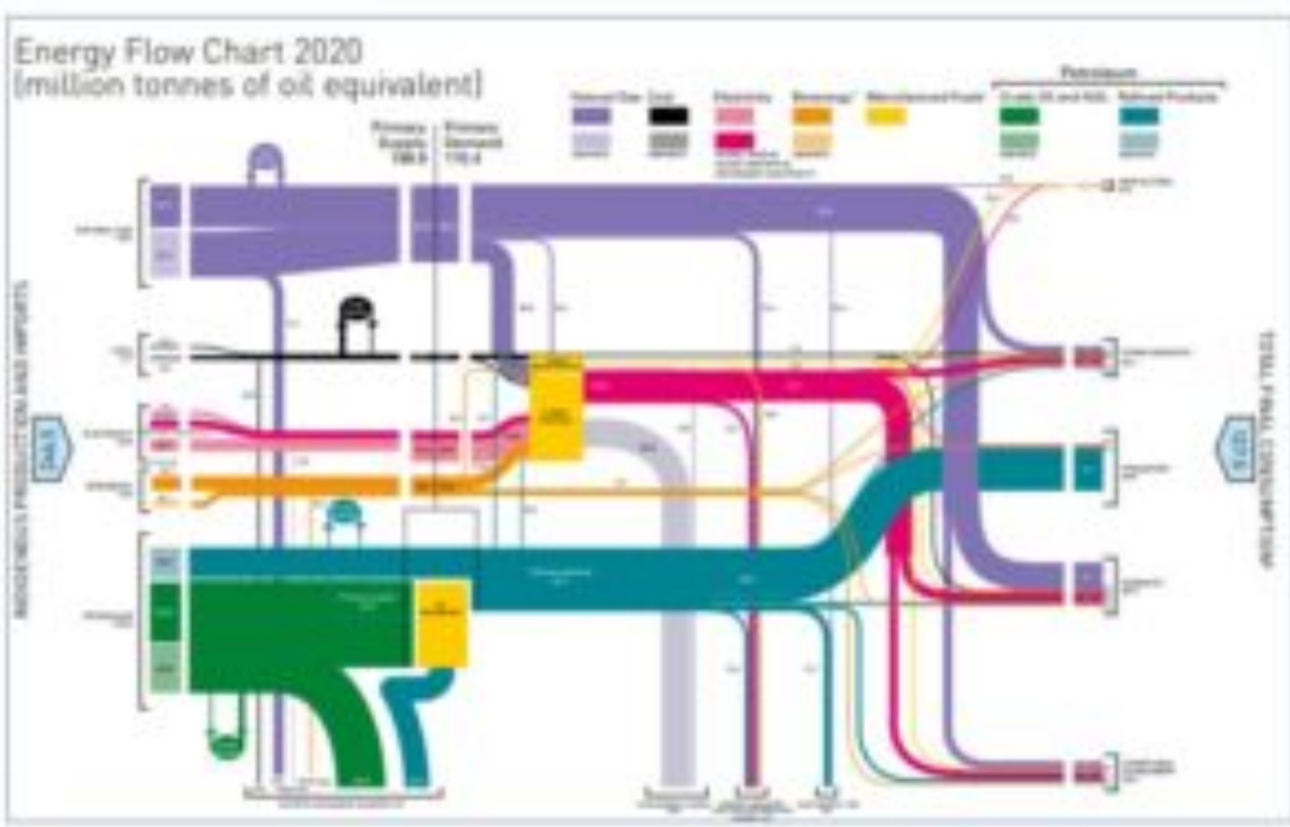

Fig 5 – The above chart has energy input on the left, and end us right

		How UK Ends Up Using Energy Final End Us			
Units	Iron and steel	Other Industry	Transport	Domestic	Offices commer

TWh/y	10	234	471	457	235
% of total end use of energy	0.74%	17%	33%	32%	17%

Fig 6 AboveFinal energy use numbers and their percentages.
Note: Below, electricity (the red lines to the right of the above diagr energy, but not all the energy we use is electricity, which is about 2(of energy..

Further energy info from energy experts
"The Claverton Energy Group.... is one of UK's premier independent and is comprised of over one hundred highly experienced engineers academics who have worked in the energy field (nuclear, renewable housing, heating, transport, electrical grids, power stations, energy for their entire careers. The group, which has continuously debated and energy policies online for 20 years, does not have unanimous a on all energy policies or technologies in general, and does not colle view reported here – although many members do. They are availabl any energy related points – heating, electricity generation, the envir technologies or policies **Claverton Energy Group, Victoria Place, (BA2 5EY tyningroad@gmail.com 07795 842295**

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END OF NOTES