No2NuclearPower

nuClear news

No.131 April 2021

1. The Government's Ideas About Balancing Renewables Don't Make Sense

Doug Parr, Chief Science Officer at Greenpeace UK, has been trying to explain how the Government continues to justify continued emphasis on new nuclear power development when the cost of renewables has fallen so far, and as more evidence accumulates to show that running the energy system on 100% is perfectly feasible. (1)

The Government blames intermittency - the sun doesn't always shine and the wind doesn't always blow. What do we do when there isn't enough solar or wind power? We can max out on the electrical connections to other countries, demand response and batteries but there's still a gap, which is why, according to the Government, we still need nuclear. Doug Parr says to fill that 'gap' we need some form of long-term storage for renewable power. Enter hydrogen as the storage fuel that could fill the gap. Hydrogen produced from renewable power (known commonly as 'green hydrogen') is producing a lot of excitement in lots of countries.

In 3 of the 5 Climate Change Committee scenarios no more nuclear capacity is required other than that under construction or already built. But the UK government's Modelling 2050 study (2) seems weighted against the uptake of hydrogen to provide this 'balancing' service to the grid. The viability of green hydrogen to contribute to a very high renewables system is constrained by 2 assumptions. Firstly, that only 20TWh will be available in 2050, and secondly it will cost £1.2/kg in 2020 prices (or $1.68/kg at today's exchange rate).

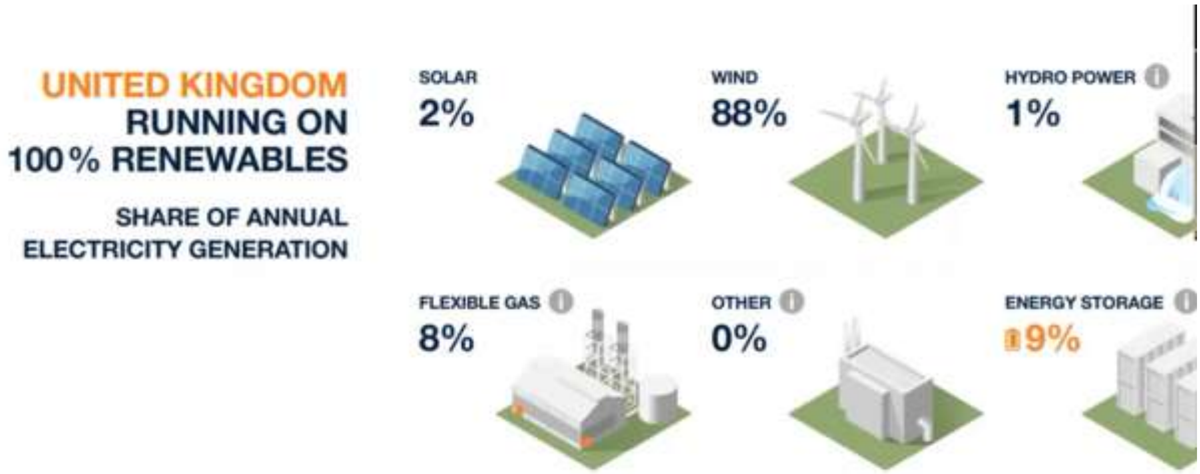
These 2 critical assumptions contrast sharply with Climate Change Committee where their central 'balanced pathway' scenario reaches nearly 100TWh by 2050, with other scenarios going higher still. (3) And cost assumptions from the Head of BloombergNEF, the leading analysts in this space, say:

"*By 2050, therefore, extrapolating long-standing trends in renewable power and electrolyzer costs… BloombergNEF estimates that green hydrogen will be available at between $0.8 and $1.0 per kilo. I would not be surprised to see it go below that.*" (4) (And incidentally "*By 2030, it will make little economic sense to build blue hydrogen production facilities in most countries, unless space constraints are an issue for renewables.*") (5)

In fact, although Secretary of State Kwasi Kwarteng says: "*nuclear power is essential. We have done all the modelling. We need what is called firm or dispatchable power in order to balance the system*," (6) a look at the modelling study suggests that with a burgeoning hydrogen sector, the cost difference between 'high nuclear' and 'low nuclear' scenarios is low to non-existent, because the 'firm power' that Mr Kwarteng wants is provided by the stored hydrogen. So, even the Modelling 2050 study does not require nuclear in the way he implies.

80% renewables by 2030

A Wärtsilä power system modelling study shows that the UK could easily achieve a permanent 62% renewable generation, even with the energy system as it is today. Hence, the UK could be spearheading energy transition, setting a target to 80% renewables by the end of the decade, and 100% before 2050. (7)



The Wärtsilä UK-specific Energy Transition Lab -report, shows what is possible to achieve based on the current policy ambitions, technical constraints and market structures that govern the energy system in UK today. Flexibility is the key to unlocking higher levels of renewables in the next 10 years and enabling a pathway to a net-zero energy system by 2050 or before. (8)

Wärtsilä has produced an Atlas of 100% Renewable Energy which shows the cost-optimal capacity mix for 100% renewable electricity systems in 145 countries and regions around the world. This shows that flexibility - in the shape of future-proof gas engines, energy storage and optimisation - can enable the massive expansion of renewables we need, and also be the lowest cost route to decarbonisation. The addition of balancer engines alongside energy storage would save almost 40% compared to the cost of achieving the transition with storage alone. By developing a healthy eco system of technologies, Wärtsilä shows that we can empower renewables to become baseload. (9)

Mark Jacobson

In April 2019 Stanford University issued a collection of abstracts from 47 peer reviewed papers (10) from 12 independent research groups supporting the result that energy for electricity, transportation, building heating/cooling, and/or industry can be supplied reliably with 100% or near-100% renewable energy at difference locations worldwide. This has now been updated with 56 peer-reviewed journal articles from 18 independent research groups. (11) Many of the journal articles are available online. One of the new papers, by Mark Jacobson develops a model to balance future thermal loads consistently with future renewable supplies. Grid stability in 24 world regions encompassing 143 countries is then examined. Low-cost solutions are found everywhere. Building heat loads are found to correlate strongly with wind energy supply aggregated over large, cold regions. Thus, wind energy in most climates can help to meet seasonal heat loads, thereby helping to reduce the cost of energy. (12) Another paper evaluates Green New Deal solutions for 143 countries. The solutions involve transitioning all energy to 100% clean, renewable wind-water-solar (WWS) energy, efficiency, and storage, while avoiding blackouts, creating millions more jobs than lost and requiring little land. Thus, 100% WWS needs less energy, costs less, and creates more jobs than current energy. (13) A third paper looks at flexible electricity generation, grid exchange and storage for the transition to a 100% renewable energy system in Europe. (14)

Scientists 100% Renewables Declaration

A global energy system powered by 100 per cent renewable energy (100 per cent RE) is not only possible but also has the potential to "save money, create jobs and wealth, save lives, and get humanity ahead of the curve to prevent runaway climate change," said Tony Seba, CEO of think tank RethinkX, and one of the authors of a declaration by the Global 100% RE Strategy Group. The 100% RE Strategy Group's 10-point declaration summarizes hundreds of studies that show 100 per cent RE is technically and economically possible and could happen quickly with the right policies. Amongst the more than 40 signatories to the declaration are well-known climate scientists are Michael Mann of Penn State University and Hans Joachim Schellnhuber, Founder and Director Emeritus of the Potsdam Institute for Climate Impact Research in Germany. Studies show that creating the new 100% RE system will stimulate investments of trillions of dollars and create millions more jobs than lost worldwide says Brian Vad Mathiesen, Professor in Energy Planning and Renewable Energy Systems at Aalborg University. (15)

The signatories of the declaration say that countries and companies can and should aim for 100% renewable electricity no later than 2030, and 100% renewable energy (covering other sectors beyond electricity) by 2035. The 7 core scientists who formed the initiative, the initial signatories, highlighted that the meagre target of 100% zero emissions by 2050 is unfortunately common. That just won't cut it. And there's no reason it has to be so far out. It is completely viable and technically practical to transition much more quickly, especially considering how important a quick transition is to a stable climate and liveable society. "A 100% RE system will be more cost effective than will a future system based primarily on fossil and nuclear power. The transformation to 100% renewables will boost the global economy, create millions more jobs than lost, and substantially reduce health problems and mortality due to pollution." (16)

To date, 11 countries have reached or exceeded 100% renewable electricity; 12 countries have passed laws to reach 100% renewable electricity by 2030; 49 countries have passed laws to reach 100% renewable electricity by 2050; 14 U.S. states and territories have passed laws or executive orders to reach up to 100% renewable electricity by between 2030 and 2050; over 300 cities worldwide have passed laws to reach 100% renewable electricity by no later than 2050; and over 280 international businesses have committed to 100% renewables across their global operations. However, only Denmark has passed laws to reach 100% renewable energy across all sectors, and it is by 2050. (17)

In the UK, the Association for Renewable Energy and Clean Technology (REA) says we can reach 100% renewable electricity by 2032, with clean technology providing 200,000 new jobs. REA's 'Strategy for Renewable Energy and Clean Technologies', outlines how clean technology uptake can boost job growth and push the nation towards its net-zero emissions target set for 2050. (18)

Pumped Storage

A study by Imperial College London has found that 4500MW of new long duration pumped hydro storage could save up to £690m per year in energy system costs by 2050. The study, for pumped hydro with 90GWh of storage, is focused on the benefits of new long-duration pumped hydro storage in Scotland, as the current most established long-duration energy storage technology. It was commissioned by SSE Renewables via Imperial Consultants. The main benefit of long duration storage, compared to short duration batteries, is being able to continuously charge up the storage with excess renewables and also discharge power to the grid for several hours or days when wind and solar output is low. (19)

SSE is working on plans for a bumper development in the Highlands at the Coire Glas which is expected to have 1.5GW capacity. (20)

One company, RheEnergise, has invented a fluid called R-19, which is two and a half times denser than water for use in pumped storage. According to RheEnergise, R-19 provides more than double the energy when compared to conventional low-density hydropower systems. As part of the process, the high-density fluid is pumped uphill between storage tanks at times of low energy demand with associated low prices. As demand and energy prices rise, the non-corrosive fluid is released downhill and passes through turbines to generate electricity and supply power to the grid. The technology could use hillsides across the UK to provide the country's energy system with a new long-life source of underground hydro-powered energy storage, the company said. (21)

Smart Homes

Meanwhile, tech-savvy, money-saving homeowners can turn their houses into energy-efficient "eco-systems" using solar panels to produce electricity, and storing it in their electric car or a battery pack overnight. In some cases, electric vehicle owners are able to buy cheaper and greener energy overnight and sell it back to the grid at peak times, cutting their bills substantially.

Using a "vehicle-to-grid" system allows electric vehicle owners to make money by selling power back to the grid when demand is high, while charging their batteries when supply is plentiful. A Nissan Leaf, for example, has a battery large enough to power a home for two days. Vehicle-to-grid systems aren't available with all suppliers or for all electric vehicles, and the deals that are available currently take the form of small-scale trials, such as Octopus Energy's Powerloop trial, which will run until March next year. Energy provider Ovo said that customers on its vehicle-to-grid tariff have saved up to £800 a year on their energy bills.

Octopus's Powerloop bundle includes a leased Nissan Leaf. Octopus credits customers £30 off their lease per month for completing 12 "V2G" sessions. Other householders with home batteries and solar panels can store unused electricity in their batteries and make use of it when grid electricity is expensive. (22)

A German study found that households with PV systems can reduce their electricity-related CO_2 emissions by 45%, but with a battery added this can increase to 85%. (23)

Government Consultation

Meanwhile, the Government's latest consultation (which closed on 8th March) on balancing renewables: '*Enabling a high renewable, net zero electricity system: call for evidence*' doesn't make sense according to Dave Toke. The Government seems to want windfarms and solar farms to be responsible for assuring power delivery all the time - something that is not even fossil fuel and nuclear power plants are required to do. But it is ignoring the most practical options for balancing fluctuating renewables.

The Government could help balance renewables much better by scrapping plans to give more extremely expensive contracts to nuclear power plant and instead spending some of the savings on measures which genuinely help balance renewables. Amongst the techniques necessary for balancing renewables that the Government ignores in their call for evidence are: encouraging energy suppliers to bring in half-hour pricing tariffs for all consumers; this can help shape demand to suit the availability of power supplies; giving requirements and ambitious targets to Distribution Companies to hold 'flexibility auctions' whereby regional distribution networks hold competitive auctions to enable a range of players to offer demand reductions when needed, so helping balance renewables. Encouraging thermal as well as other types of storage both at the level of the individual building (hot water tanks) and also through district heating systems served by large scale heat pumps with large long term hot water stores. (24)

Heat Pumps Cost Effective

Air-source heat pumps are by far the most cost-effective, low carbon means of heating European homes, with household energy bills likely to cost around half that of running hydrogen boilers, according to research by the International Council on Clean Transportation (ICCT). Even if natural gas costs were 50 per cent lower and renewable electricity prices 50 per cent higher, heat pumps would still be the front runner option for heating homes in terms of operating costs, compared to green hydrogen-only technologies. Including installation, maintenance, and electricity bills, it estimates heat pumps would cost around €579 a year for the average single-family household in the EU, while the total average costs for a hydrogen boiler would come to around €1,271 each year. Moreover, heat pumps were also found to be more efficient than hydrogen boilers, because the former transfer rather than generate heat. The study estimates heat pumps would be around three to six times more energy efficient than renewable hydrogen boilers in EU homes, due to efficiency losses in the production, storage, and transportation of green hydrogen. (25)

The government is currently proposing a target of 600,000 heat pumps to be installed annually by 2028. This is an ambitious goal, but it will fall far short of deployment levels needed to meet a net zero target. The scale of change required is a challenging one and will require a longer-term and more coordinated set of policy interventions than the limited measures presently planned by the Government. Key elements of a package proposed by RAP to 2030 include: Raising the ambition for heat pump deployment; Establishing a heat pump council this year; Scaling up financial support using capital grants starting in 2021; Permanently restructuring fiscal and pricing signals by the end of this parliament; Signalling the intention to regulate for all segments of the home heating market this year. (26)

1. 100% Renewables 27th March 2021 https://100percentrenewableuk.org/government-rubbishes-hydrogen-in-bid-to-boost-new-nuclear-power
2. BEIS 14th December 2020 https://www.gov.uk/government/publications/modelling-2050-electricity-system-analysis
3. CCC, 6th Carbon Budget, P.152, Fig 3.5c https://www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-The-UKs-path-to-Net-Zero.pdf
4. BNEF 8th Oct 2020 https://about.bnef.com/blog/liebreich-separating-hype-from-hydrogen-part-one-the-supply-side/
5. Recharge News 7th April 2021 https://www.rechargenews.com/energy-transition/by-2030-blue-hydrogen-will-make-little-economic-sense-versus-green-bnef/2-1-991590
6. BEIS Committee 19th January 2021 (page 23) https://committees.parliament.uk/oralevidence/1543/pdf/
7. Wartsila 22nd March 2021 https://www.wartsila.com/energy/learn-more/downloads/webinar/finding-an-optimum-path-to-accelerate-decarbonisation/
8. Wartsila 22nd Nov 2020 https://www.wartsila.com/energy/transition-lab/reports/optimising-the-uks-shift-to-a-renewable-powered-economy
9. Current 16th April 2021 https://www.current-news.co.uk/blogs/how-flexibility-can-enable-a-100-renewable-energy-future
10. See https://www.no2nuclearpower.org.uk/wp/wp-content/uploads/2020/09/100PercentPaperAbstracts.pdf
11. See http://web.stanford.edu/group/efmh/jacobson/Articles/I/CombiningRenew/100PercentPaperAbstracts.pdf
12. Jacobson, M *On the correlation between building heat demand and wind energy supply and how it helps to avoid blackouts,* Smart Energy March 2021 https://reader.elsevier.com/reader/sd/pii/S2666955221000095?token=87C165AD597B60C87A2A8FB755361A07F9F3B50A354D757975D6C07690A26FD4503F65B2812B8CD692C2E624B457C808&originRegion=eu-west-1&originCreation=20210412092110
13. Jacobson, M. Delucchi, M et al. *Impacts of Green New Deal Energy Plans on Grid Stability, Jobs, Health and Climate in 143 Countries*, One Earth, December 2019. https://reader.elsevier.com/reader/sd/pii/S2590332219302258?token=09437CC648F0039923977AF69C966A7DC815C15D9D963B06578314A755FD6B8484BD3F9E5AE08AA9B5B9701FD5BA84DC&originRegion=eu-west-1&originCreation=20210412092612
14. Child, M et al. *Flexible electricity generation, grid exchange and storage for the transition to a 100% renewable energy system in Europe,* Renewable Energy, February 2019, https://reader.elsevier.com/reader/sd/pii/S0960148119302319?token=24633C6432F10CEA2CF7FAF95DDED7C59FF663685E1230C47B341648A7E279F19DCD33D35FAE4A4964185D552767384C&originRegion=eu-west-1&originCreation=20210412094151
15. Yahoo News 1st March 2021 https://ca.news.yahoo.com/news/100-renewable-energy-could-power-184300141.html
16. Clean Technica 10th April 2021 https://cleantechnica.com/2021/04/10/47-scientists-world-should-go-100-renewable-electricity-by-2030/amp/ The declaration is here: https://global100restrategygroup.org/wp-content/uploads/2021/02/Joint-Declaration-of-the-Global-100-RE-Strategy-Group-210208.pdf

17. https://global100restrategygroup.org/
18. Edie 24th Feb 2021 https://www.edie.net/news/6/UK-can-create-200-000-jobs-through-clean-technology-drive/
19. RE News 18th Feb 2021 https://renews.biz/66582/pumped-hydro-can-save-700m-a-year-in-system-costs/
20. Herald 19th Feb 2021 https://www.heraldscotland.com/business_hq/19101838.highlands-jobs-prospect-power-plant-project-goes-ahead/
21. Power Technology 8th February 2021 https://www.power-technology.com/news/rheenergise-develops-pumped-hydro-technology-to-store-clean-power/
22. Telegraph 3rd March 2021 https://www.telegraph.co.uk/money/consumer-affairs/used-electric-car-power-home-cut-energy-bills/
23. PV Magazine 26th February 2021 https://www.pv-magazine.com/2021/02/26/batteries-double-co2-savings-of-households-with-pv-systems/
24. 100% Renewables 27th February 2021 https://100percentrenewableuk.org/seven-reasons-why-the-governments-ideas-on-balancing-renewables-dont-make-sense
25. Business Green 11th March 2021 https://www.businessgreen.com/news/4028370/study-heat-pumps-cheaper-hydrogen-heating-eu-homes
26. RAP 24th March 2021 https://www.raponline.org/knowledge-center/getting-track-net-zero-policy-package-heat-pump-mass-market-uk/

2. Tidal power unlocking significant international opportunity

The House of Commons Environmental Audit Committee says government can do more to advance tidal energy projects to market, arguing 'the benefits outweigh the costs'. The Committee said the tidal sector can make "*a significant and distinct contribution*" to the UK's energy mix, and its potential benefits "*merit government support for the development of this sector*" to a stage where significant commercial investments can be attracted. Suggestions include funding detailed studies to take tidal range projects beyond concept stage, discussing an administrative price strike for tidal stream projects in upcoming contracts for difference auctions, and considering a power purchase agreement model to avoid costs being passed onto household bills. (1)

The Committee heard that current tidal stream projects in development already have the capacity to deliver 1GW of electricity to the grid. The EAC recognises the benefits of tidal stream technology in boosting technology clusters in coastal locations with optimal tidal flow, increasing inward investment and driving the development of specialist supply chains, which are principally UK-based. There is also significant export potential, with UK knowledge and expertise helping other nations with tidal power projects. However, the EAC heard that tidal range projects – such as lagoons and barrages – are stuck at the concept stage, without sufficient funding to undertake studies required to secure further backing to assess long-term viability. (2)

The company behind the MeyGen tidal energy project in the Pentland Firth has achieved "*a huge milestone*" after installing a turbine in Japan. According to Simec Atlantis Energy (SAE), the equipment has produced 10 megawatt hours of electricity in its first 10 days of operation. The turbine is based on the AR1500 model which is one of the four tidal arrays in operation at the MeyGen site in the Inner Sound and was built at Nigg in Ross-shire. It was assembled and tested in nine weeks before being shipped to Japan. (3)

A Simec spokesman said: "*We expect the buildout of MeyGen will unlock significant international opportunity for further projects and continue the reduction in the cost of energy from tidal generation towards that of more established forms of renewable generation.Once operational, this project will be the largest tidal array ever built and continues to be a pioneer and a flagship for both the industry and the technology globally. Operationally, MeyGen provides vital learning to help the design and development for our future projects.*" (4)

Another company, Nova Innovation, is set to install a series of underwater turbines in the Sound of Islay: the narrow strait between the islands of Islay and Jura in the Inner Hebrides to power local Scotch whisky distilleries. (5)

Orbital Marine Power has launched a groundbreaking new tidal turbine manufactured in Dundee. It is the world's most powerful tidal turbine, the Orbital O2 2MW. It will be transferred to the European Marine Energy Centre (EMEC) off the Orkney Islands. (6)

1. NS Energy 31st March 2021 https://www.nsenergybusiness.com/news/industry-news/uk-government-tidal-energy-eac/
2. House of Commons 31st March 2021 https://committees.parliament.uk/committee/62/environmental-audit-committee/news/153640/mps-urge-government-to-seize-tidal-power-potential/
3. John O'Groat Journal 19th Feb 2021 https://www.johnogroat-journal.co.uk/news/watch-tidal-power-pioneered-in-pentland-firth-is-installed-in-japanese-waters-228492/
4. John O'Groat Journal 10th April 2021 https://www.johnogroat-journal.co.uk/news/meygen-could-be-a-flagship-project-for-tidal-energy-indust-234431/
5. Engineering & Technology 3rd Feb 2021 https://eandt.theiet.org/content/articles/2021/02/scotch-whisky-distilleries-to-be-powered-by-tidal-power/
6. Energy Voice 14th April 2021 https://www.energyvoice.com/renewables-energy-transition/wave-tidal/uk-wave-tidal/314599/worlds-most-powerful-tidal-turbine-to-be-launched-in-dundee-next-week/

3. Johnson Loves Pie in the Sky

We saw in June 2020 (nuClear News No. 126) how the Nuclear Innovation and Research Advisory Board (NIRAB) has been advising the Department for Business, Energy and Industrial Strategy (BEIS) that we need three streams of nuclear product development and deployment:

• large-scale Light Water Reactors (LWRs), which are currently available and suitable for baseload electricity generation;

• small modular reactors (SMRs), which are based on the same proven technology and can offer additional flexibility to meet local energy needs;

• advanced modular reactors (AMRs), which typically have a higher temperature output, enabling them to contribute to decarbonisation through heat and hydrogen production, as well as generate electricity at competitive costs.

Small modular and advanced nuclear reactors are proposed, supposedly, as potential ways of dealing with some of the problems of large nuclear reactors —specifically economic competitiveness, risk of accidents, link to proliferation and production of waste. Yet Gregory Jaczko, Former Chair US Nuclear Regulatory Commission, says Advanced Nuclear Technologies should only be supported "*if they can compete with renewables & storage on deployment cost & speed, public safety, waste disposal, operational flexibility & global security. There are none today*." (1)

The UK Government's Policy Paper on 'Advanced Nuclear Technologies' (ANTs) specifies two broad categories of ANT. Firstly, Generation III water-cooled reactors similar to existing nuclear power station reactors but smaller, it calls Small Modular Reactors (SMRs). This is despite the fact that the Rolls Royce design which it is supporting is 470MW – much larger than the maximum 300MW defined by IAEA as small.

Secondly, Generation IV which use novel cooling systems or fuels to offer new functionality (such as industrial process heat) it calls Advanced Modular Reactors (AMRs). (2)

In July 2019 the UK Government gave an initial £18m to Rolls-Royce to help them develop the design for an SMR. This was to be matched with funding from the consortium led by Rolls-Royce (and including Assystem, SNC Lavalin/Atkins, Wood, Arup, Laing O'Rourke, BAM Nuttall, Siemens, National Nuclear Laboratory, and Nuclear AMRC). (3)

A year earlier, in June 2018, as part of the UK government's £200 million Nuclear Sector Deal, £56 million was put towards the development and licensing of advanced modular reactor designs. Eight non-light water reactor (non-LWR) vendors each received £4 million to perform detailed technical and commercial feasibility studies. Those vendors were Advanced Reactor Concepts, DBD, LeadCold, Moltex Energy, Tokamak Energy, U-Battery Developments, Ultra Safe Nuclear Corporation (USNC), and Westinghouse Electric Company UK. (4) This was Phase One of the Advanced Modular Reactor (AMR) Feasibility and Development Project. Then in July 2020 Phase Two was announced with 3 AMRs receiving a share of £40m: U-Battery (4MW high temperature reactor), Westinghouse (450MW lead-cooled fast reactor) & Tokamak (fusion). A possible further £5m was also made available to regulators to support this. (5)

In November 2020, Boris Johnson's 10 Point Plan confirmed the Government's commitment to advancing large, small and advanced reactors, and announced an Advanced Nuclear Fund of up to £385 million which included:

- funding of up to £215 million for Small Modular Reactors (SMRs);
- up to £170 million for Advanced Modular Reactors (AMRs);
- up to £40 million to develop regulatory frameworks and support UK supply chains to help bring these technologies to market.

According to the Energy & Climate Change Intelligence Unit (ECIU) the investment in small modular reactors (SMRs) was less than expected. "*If I was in the SMR game I'd be disappointed with this because £2bn support for a small initial fleet of reactors has been paired back to just over £500M*." (6)

Professor Steve Thomas says the 3 AMRs are unlikely to be available before 2045 if ever – much too late to be any help in tackling the climate emergency. (7)

The Rolls Royce (RR) SMR design is still at an early stage. It was only announced in 2016. It is slightly larger than the first unit at Fukushima (470MW vs 439MW) and much larger than the Trawsfynydd Magnox reactors, which were 250MW. Rolls Royce claims the first reactor could be operational by 2030, but it's hard to see how this can be achieved. Even if achieved it is probably too late. By 2030 only Sizewell B and possibly Hinkley Point C will be operating and if the UK is to meet its targets of reducing greenhouse gas emissions by 68% by 2030 and 78% by 2035, we should by then be well on the road to a low carbon economy with a limited nuclear capacity.

Thomas says SMRs will only proceed if the risk to RR money is minimal. That means RR will only put serious effort into design development with government guarantees given now, before the design exists, and it has been reviewed by ONR, a demonstration plant has been completed, and costs are known.

Rolls-Royce told the House of Lords Science and Technology Committee in 2016 that 7GW of power would "*be of sufficient scale to provide a commercial return on investment from a UK-developed SMR, but it would not be sufficient to create a long-term, sustainable business for UK plc*." Therefore, any SMR manufacturer would have to look to export markets to make a return on their investment.

Rolls Royce is making extraordinary demands on the UK Government that it must commit to before further significant development work takes place. Thomas says RR would need:

- Exclusive access to UK market;
- Matched funding (minimum) up to end of Generic Design Assessment;

- Sharing of costs for production line facilities (to produce 2 reactors per year);
- Guaranteed orders for 7GW (16 reactors).

UK taxpayers would have to provide a large proportion of the cost of design development, navigating the regulators design assessment and assist in the setting up of component production lines. It would also have to guarantee orders for a minimum of 16 reactors, which, even on Rolls Royce's unrealistic cost estimate, would be a commitment to spend nearly £30bn before it has progressed beyond a conceptual design. The first plant must be made using production lines so all 16 reactors must be ordered now & by the time the first is completed, another 8 will be on their way. (8)

Rolls Royce claims a construction time of 4 years & costs (after 5 units) of £1.8bn (£3800/kW), which means electricity at £40-60/MWh. These claims are extraordinary but very similar to those made for Hinkley Point C. In 2000, it had been claimed the EPR would be built in four years or less and would cost $1000/kW (about £800/kW). In fact, all EPR's that have been built have gone far over budget and all will take much more than 4 years to construct. The latest cost estimate for Hinkley Point C is about £27bn (2020 money) or about £8400/kW. Rolls Royce's claims must therefore be taken with a very large pinch of salt.

Steve Thomas comments:

"*The UK Government's 'Green Industrial Revolution' 10-point plan of November 2020 seemed to include a major strengthening of the commitment to Small Modular Reactors (SMRs). However, closer examination shows much of the money is far from committed and the focus is on technologies that have little chance of contributing to meeting the UK's target of zero-carbon by 2050. There remains no firm commitment to the Rolls Royce SMR and it must be hoped the government is unwilling to gamble the huge sums of money Rolls Royce is demanding to be promised if it is to progress the design from the early stage it is currently at.*"

NuScale

In Jan 2021, a UK company, Shearwater, announced a partnership with US NuScale to develop 3GW hybrid off-shore wind/SMR plant to produce electricity & hydrogen. (9) The NuScale option, whether as a standalone plant or a hybrid with offshore wind, suffers from the fact that while the individual reactors are small, they are designed to be in as cluster of 12 - about 1GW capacity - making it effectively a large reactor. Until a project being built in the USA is completed and operating efficiently and economically, it will remain an unproven and risky investment.

The NuScale SMR design is further ahead than Rolls Royce's, since they have been working on it since 2003. It is a 77MW reactor designed to be deployed in clusters of 12 – so 924MW altogether. NuScale has only one potential project - Utah Associated Municipal Power Systems (UAMPS) - with USDOE funding for part of the project but not sufficient investors yet for rest of project.

M.V. Ramana (Liu Institute for Global Issues, School of Public Policy and Global Affairs, The University of British Columbia) argues that higher construction and operational costs per unit of electricity generation capacity will make electricity from SMRs more expensive than electricity from large nuclear power plants. An assessment of the markets for these technologies, suggests they are inadequate to justify constructing the necessary manufacturing facilities. (10)

Economics of scale would suggest that SMRs would be more expensive per unit of electricity than large-scale reactors. Proponents argue that they can make up for the lost economies of scale by savings through mass and modularized manufacture in factories and resultant learning. Learning in this context refers primarily to the reduction of cost with increased construction. It is often quantified through a learning rate, which is defined as the percentage cost reduction associated with a doubling of units produced. Sustained learning would require just one or two standard reactor designs to be built in large quantities. However, there are roughly six dozen SMR designs are in various stages of development in multiple countries.

Although there is no data on jobs from SMRs—because SMRs have not been deployed at any meaningful level to measure employment figures—the literature is clear that nuclear power generates fewer jobs than renewables like solar and wind energy per unit of energy generated. (11) (12)

Several advocates have argued that SMRs are capable of load following to balance intermittent renewables. From a technical point of view, shutting down, restarting, or varying the output power are all more challenging for nuclear power plants, especially water-cooled reactors, compared to other electricity sources. Further, although load following may be technically possible, operating reactors in this mode would decrease their economic competitiveness. The challenge arises from the fact that nuclear power plants have high fixed (capital) costs. Therefore, it makes more economic sense to operate them continuously near their maximum capacity in order to improve the return on investment. Given the already poor economic prospects for SMRs, this penalty will essentially rule out deployment of these technologies in a load-following mode.

Ramana concludes that pursuing SMRs will only worsen the problem of poor economics that has plagued nuclear power and make it harder for nuclear power to compete with renewable sources of electricity. The scenario is even more bleak as we look to the future because other sources of electricity supply, in particular combinations of renewables and storage technologies such as batteries, are fast becoming cheaper. Finally, because there is no evidence of adequate demand, it is financially not viable to set up the manufacturing facilities needed to mass produce SMRs and advanced reactors. All of these problems might just end up reinforcing The Economist magazine's observation from the turn of the century: "*nuclear power, which early advocates thought would be 'too cheap to meter', is more likely to be remembered as too costly to matter*".

Professor Dave Elliott is also sceptical about claims that SMRs can reduce costs. Delivery of power at £40-60/MWh is promised, but there is still some way to go before any project actually goes ahead and we can see if the promises hold up in practice. He says most designs are basically variants of ideas proposed, and in some cases tested, many decades ago, but mostly then abandoned. The most developed is the NuScale reactor, which is basically PWR technology. Rolls Royce is also promoting a mini-PWR design, which, it is claimed, will be ready for grid use by 2030. Some of the other SMR proposals are less developed and may take more time to get to that stage. But it is claimed that one of the more novel design, the Natrium fast reactor system, proposed by Terrapower and backed by Bill Gates, will be on line this decade. Given that this makes use of liquid sodium and molten salt heat storage, that is quite a claim.

If they are going to be economically viable, some say that SMRs will have to be run in Combined Heat and Power 'Cogen' mode, supplying heat for local used, as well as power for the grid. That implies that they will have to sited in or near large heat loads i.e. in or near urban areas. Will local residents be keen to have mini-nuclear plants nearby? That issue is already being discussed in the USA, with some urban resistance emerging. A key issue in that context is that it has been argued that since they allegedly will be safer, SMRs will not need to have such large evacuation zones as is the norm for standard reactors, most of which are sited in relatively remote area. (13)

"Advanced" is not always better

The Union of Concerned Scientists (UCS), examines all the proposed new types of reactor under development in the US and fails to find any that could be developed in time to help deal with the urgent need to cut carbon emissions.

The US government is spending $600 million on supporting these prototypes. While the report goes into details only about the many designs of small and medium-sized reactors being developed by US companies, it is a serious blow to the worldwide nuclear industry because the technologies are all similar to those also being underwritten by taxpayers in Canada, the UK, Russia and China. This is a market the World Economic Forum claimed in January could be worth $300 billion by 2040. Edwin Lyman, who wrote the report, and is the director of nuclear power safety in the UCS Climate and Energy Program, thinks the WEF estimate is extremely unlikely. He comments on nuclear power in general: "*The technology has fundamental safety and security disadvantages compared with other low-carbon sources*." He says none of the new reactors appears to solve any of these problems. The industry's claims that their designs could cost less, be built quickly, reduce the production of nuclear waste, use uranium more efficiently and reduce the risk of nuclear proliferation have yet to be proved. The developers have also yet to demonstrate that the new generation of reactors has improved safety features enabling them to shut down quickly in the event of attack or accident. (14)

One of the industry's ideas for using the power from these reactors to produce "green hydrogen" for use in transport or back-up energy production is technically feasible, but it seems likely that renewable energies like wind and solar could produce the hydrogen far more cheaply, the report says.

"Advanced" reactors often present greater proliferation risks, says Lyman. "*In many cases, they are worse with regard to ... safety, and the potential for severe accidents and potential nuclear proliferation. 'Advanced' Isn't Always Better*". (15)

Lyman says, if nuclear power is to play an expanded role in helping address climate change, newly built reactors must be demonstrably safer and more secure than current generation reactors. Unfortunately, most "advanced" nuclear reactors are anything but. A comprehensive analysis of the most prominent and well-funded non-light-water reactor (NLWR) designs concluded that they are not likely to be significantly safer than today's nuclear plants and pose even more safety, proliferation, and environmental risks than the current fleet. (16)

1. The Hill 23rd February 2021 https://thehill.com/opinion/energy-environment/539991-climate-change-and-advanced-nuclear-solutions
2. BEIS Nov 2020 https://www.gov.uk/government/publications/advanced-nuclear-technologies/advanced-nuclear-technologies
3. Times 11th Aug 2019 https://www.thetimes.co.uk/article/mini-nuclear-reactors-to-power-the-north-m5qtbfvc7
4. Reuters 11th Sept 2019 https://www.reutersevents.com/nuclear/rolls-royce-group-wins-funding-uk-smr-race-gathers-pace
5. BEIS 10th July 2020 https://www.gov.uk/government/publications/advanced-modular-reactor-amr-feasibility-and-development-project#history
6. New Civil Engineer 19th Nov 2020 https://www.newcivilengineer.com/latest/future-of-wylfa-and-sizewell-c-nuclear-developments-still-unclear-despite-government-green-plan-19-11-2020/
7. What are the prospects for small modular nuclear reactors coming to Wylfa or Trawsfynydd: Presentation to NFLA WELSH FORUM WEBINAR April 9, 2021 https://www.nuclearpolicy.info/wp/wp-content/uploads/2021/04/Steve_Thomas_NFLA_SMR_prospects.pdf and Small & Advanced Modular Nuclear Reactors and the UK – low carbon energy panacea or another nuclear 'white elephant' project? NFLA, April 2021 https://www.nuclearpolicy.info/wp/wp-content/uploads/2021/04/NFLA_New_Nuclear_Monitor_No65_SMR_in_the_UK.pdf
8. Rolls-Royce plc – Written evidence 16th Feb 2017 http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/science-and-technology-committee-lords/priorities-for-nuclear-research-and-technologies/written/47158.html & House of Lords Science and Technology Committee, 2017 Nuclear research and technology: Breaking the cycle of indecision https://publications.parliament.uk/pa/ld201617/ldselect/ldsctech/160/160.pdf
9. BBC 16th Jan 2021 https://www.bbc.co.uk/news/uk-wales-55682005
10. M.V. Ramana, "Small Modular and Advanced Nuclear Reactors: A Reality Check", IEEE Access, 9th March 2021 https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9374057
11. Z. Kis, N. Pandya, and R. H. E. M. Koppelaar, "Electricity generation technologies: Comparison of materials use, energy return on investment, jobs creation and CO2 emissions reduction," Energy Policy, vol. 120, pp. 144–157, Sep. 2018, https://www.sciencedirect.com/science/article/abs/pii/S0301421518303239
12. M.Wei,S.Patadia, and D.M.Kammen,"Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US?" Energy Policy, vol. 38, no. 2, pp. 919–931, Feb. 2010. https://www.sciencedirect.com/science/article/abs/pii/S0301421509007915
13. Renew Extra Weekly 27th Feb 2021 https://renewextraweekly.blogspot.com/2021/02/small-nuclear-reactors.html
14. Climate News Network 24th March 2021 https://climatenewsnetwork.net/small-nuclear-power-plants-no-use-in-climate-crisis/
15. Reuters 18th March 2021 https://www.reuters.com/article/idUSKBN2BA0CP
16. USUCSA 18th March 2021 https://ucsusa.org/resources/advanced-isnt-always-better

4. Fusion

STEP (Spherical Tokamak for Energy Production) is described as "*an ambitious programme to design and build a prototype fusion power plant*". It is a UK Atomic Energy Authority (UKAEA) programme, currently with £222 million funding from the UK Government to produce a concept design by 2024. The programme is promising 'billions' of pounds to accelerate progress towards commercially viable fusion power, through design and construction of a prototype fusion reactor by around 2040/50.

In Autumn 2020, the UKAEA called on communities across the UK to volunteer to host a prototype fusion reactor. UKAEA will now make a recommendation to the Secretary of State for BEIS on the most suitable locations for STEP following a rigorous process of assessment using a defined set of key criteria. Nominations to host STEP closed on 31 March 2021. (1)

A survey of local press suggests the following sites have put themselves forward, or at least have seriously considered it.

Dounreay in Caithness

Chapelcross in Dumfries and Galloway (2)

West Burton A power station and Ratcliffe-on-Soar in Nottinghamshire (3)

Former nuclear sites in Berkley and Oldbury in Gloucestershire (4)

Moorside adjacent to Sellafield (5)

Heysham in Lancaster (6)

Scientists for Global Responsibility director, Dr Stuart Parkinson says "*Nuclear fusion will almost certainly make no contribution to reaching climate targets*".

Proponents believe fusion reactors could solve the climate-change crisis by providing inexhaustible energy with zero emissions and no chance of a meltdown. But the challenge of creating fusion reactions is enormous: Scientists and engineers essentially have to create a small star. Hydrogen must be heated to about 100 million degrees Celsius — six times hotter than the sun's core. At that temperature, hydrogen is no longer a gas but a plasma, a soupy mix of charged particles that is incredibly difficult to sustain. Scientists have been trying to contain the plasma using a tokamak, a doughnut-shaped structure with an extremely strong magnetic field, but thus far have been successful only for seconds.

The biggest project in the world is ITER, a tokamak the size of 60 soccer fields that is under construction in France and is expected to operate in 2035. ITER, which means "the way" in Latin and originally stood for International Thermonuclear Experimental Reactor, is a joint effort of the European Union, U.S., U.K., China, Russia, Japan, India, and South Korea. Preliminary experiments are being done at a mock-up facility in Britain. But several retired fusion physicists, including Ernesto Mazzucato and Daniel Jassby of Princeton's Plasma Physics Lab, have described ITER as a boondoggle run by bureaucrats that is likely to waste its potential cost of up to $65 billion. (7)

The NFLA says its five key concerns with nuclear fusion are:

• Nuclear fusion, like nuclear fission, still produces significant quantities of radioactive waste.

• Radioactive tritium emissions would be released as part of the fusion process.

• A large water source for cooling would be required.

• It costs huge sums of money that the public exchequer cannot afford.

• Any delivery of it will come too late to seriously tackle the effects of climate change. (8)

The problems

The reality is that fusion reactors, if ever operated, would produce by-products that are far from harmless. In addition, most (around 80%) of the output energy would be in the form of high-energy neutrons which would lead to structural damage, large amounts of radioactive waste and the need for much biological shielding to protect operators and the public nearby.

Fusion plants can best be viewed as gigantic exercises in tritium recycling, and, if the plant were ever constructed, large amounts of radioactive tritium (~1018 Bq per year) would be released into the atmosphere and via the cooling water. This would contaminate all areas downwind and downstream. Some nuclear scientists think that tritium is a "weak" nuclide but the reality is the opposite: (see The Hazards of Tritium - Dr Ian Fairlie (9)). If an explosion and/or fire occurred (tritium and deuterium are both flammable), the amounts of radioactivity released would be even greater and would constitute a nuclear disaster.

Fusion reactors would also be subject to the major problems associated with fission reactors, including large-scale cooling demands, and high construction and operational costs. The structure, damaged by neutron bombardment, would need to be replaced periodically, resulting in large amounts of radioactive wastes for which there is no current solution in the UK.

Dr Daniel Jassby who worked for 25 years in areas of plasma physics and neutron production related to fusion energy research and development has written two informative articles on the myriad problems with nuclear fusion for the Bulletin of Atomic Scientists. He concludes "*When you consider we get solar and wind energy for free, to rely on fusion reaction would be foolish*". (10)

In short, nuclear fusion would not provide cheap, clean, safe or healthy energy but it would have strong links with materials necessary for nuclear weapons.

---

1. UKAEA (accessed) 21st April 2021 https://step.ukaea.uk/wp-content/uploads/2020/12/STEP_Background-Document.pdf
2. Ferret 11th March 2021 https://theferret.scot/scottish-sites-nuclear-fusion-reactor/

3. Lincolnshire Live 11th March 2021 https://www.lincolnshirelive.co.uk/news/local-news/council-reveals-new-nuclear-power-5127815
4. Energy Live News 19th March 2021 https://www.energylivenews.com/2021/03/19/will-gloucestershire-become-home-to-worlds-first-fusion-power-station/
5. Carlisle News & Star 17th March 2021 https://www.newsandstar.co.uk/news/19164273.enthusiastic-support-copeland-prototype-nuclear-fusion-reactor-bid/
6. Lancaster Guardian 29th March 2021 https://www.lancasterguardian.co.uk/news/uk-news/momentum-gathers-for-the-next-step-in-heyshams-energy-future-3182619
7. The Week 28th March 2021 https://theweek.com/articles/973971/nuclear-fusion-answer
8. NFLA Briefing September 2020 https://www.nuclearpolicy.info/wp/wp-content/uploads/2020/09/NFLA_New_Nuclear_Monitor_No62_Nuclear_fusion_sites.pdf
9. Dr Ian Fairlie 13th March 2020 https://www.ianfairlie.org/news/the-hazards-of-tritium/
10. "Fusion reactors: Not what they're cracked up to be" – by Daniel Jassby, April 19, 2017: https://thebulletin.org/2017/04/fusion-reactors-not-what-theyre-cracked-up-to-be/ and "ITER is a showcase … for the drawbacks of fusion energy" – by Daniel Jassby, February 14, 2018: https://thebulletin.org/2018/02/iter-is-a-showcase-for-the-drawbacks-of-fusion-energy/