Written evidence submitted by the UK Energy Research Centre

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Introduction to UKERC

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What role can, or should, nuclear power play in achieving net zero and UK energy security?

A consistent characteristic of low-carbon transition scenarios is the early and deep decarbonisation of the electricity system.[1] By the time new nuclear capacity comes on-stream in Wales, the UK electricity system should be decarbonised. New nuclear must therefore be viewed through the lens of competing with or complementing other forms of low-carbon electricity generation. New nuclear is unlikely to have any impact on UK energy security, or the current crisis, in the next decade.

We view energy security as the provision of a reliable and affordable energy supply. Nuclear power can contribute to a reliable zero-carbon UK electricity system, but there are likely to be lower cost alternatives and adopting nuclear will likely lead to higher bills for the UK public and for businesses. We explore this statement in the sections below.

Design of a reliable low-carbon electricity generation system

Wind and solar generation are likely to have the greatest role in electricity generation in the future. As their outputs are variable due to weather-dependence and inflexible,

[1] Ekins et al. (2013) Low-carbon, resilient scenarios for the UK energy system in 2050. UK Energy Research Centre.

there is a need for more flexible technologies to match overall electricity supply to demand. This includes other generation (e.g. biomass; hydrogen; nuclear), energy storage, interconnection, and demand-side measures. Storage and interconnection have the advantage of using excess generation when renewable generation output exceeds demand.

Nuclear has been identified as a large-output technology that can provide baseload generation when renewables are not generating due to adverse weather. Yet baseload is an economic rather than an energy security concept. The key question is whether a reliable electricity supply can be provided without new nuclear power. A recent paper, which is not yet peer-reviewed, examines this question for a range of UK weather years.[2] It concludes that the UK electricity system could operate reliably with 95% of generation from wind and solar without nuclear power.

Nuclear could provide a range of flexibility services to support the operation of the power system as well as to ensure the adequacy and security of supply at seasonal and longer-term. However, in each case there are alternatives:

- System Inertia: conventional power stations generate electricity at a frequency of 50 Hz. When they go off-line, the generator continues spinning for a period so the impact is not instantaneous. In contrast, wind and solar are inverter-based generators so do not have this spinning reserve, and so system frequency becomes more difficult to control. As nuclear power stations use conventional generators, they provide valuable system inertia to the power system to help stabilise system frequency. However, other options are available to provide inertia to mitigate the impacts of high rate of change of frequency (RoCoF), including biomass and hydrogen generation, battery storage, and synchronous condensers.[2]
- Compensating for excess renewable generation: while the focus of nuclear has been baseload, they have the technical capability to operate flexibly in a slow load-following mode – this has been exercised in the French power system.[3] This would enable nuclear power stations to reduce output at times of high wind and solar energy generation, but would increase the cost of generated electricity as capital costs account for much of the overall cost. Moreover, hydrogen turbines could provide much higher flexibility at much lower capital cost.

Economics of new nuclear generation with existing reactors

The Hinkley Point C plant has a guaranteed “strike price” for generation of £89.50/MWh.[4] The National Audit Office described this as a “high cost and risky deal in a changing energy marketplace”.[5] It is substantially higher than the strike prices agreed for new offshore wind generation, which in July 2022 was only

[2] Price et al. (2021) The role of new nuclear power in the UK's net-zero emissions energy system.
[3] Électricité de France (2020) The Contribution of French Nuclear Fleet to the Flexibility of the Electric System.
[4] Low Carbon Contracts Company (2022) Hinkley Point C.
[5] National Audit Office (2017) Hinkley Point C.

£37/MWh. Offshore wind costs have reduced substantially through innovation in recent years and the nuclear industry argues that the costs of further reactors will similarly reduce. However, plausible reductions would still lead to substantially higher generation costs than for wind, and there is anyway much scepticism that any substantial cost reductions could be achieved – for example, costs in the French nuclear programme tended to increase rather than reduce over time.[6]

Another argument made for nuclear is the deployment of high capacity with a small number of plants, since each pressurised water reactor (PWR) can exceed 1.5 GW. There are supply chain difficulties at present for offshore wind, particularly for specialist ships and power cables. However, substantially lower materials and labour is required for offshore wind than for nuclear, as reflected by the lower capital cost, and the lack of new plants over the last 30 years means the nuclear supply chain is immature. These factors suggest that offshore wind might be expected to be more scalable than nuclear, but we are not aware of strong evidence either way. Moreover, it is not clear whether the UK will gain greater economic benefits from wind or nuclear supply chains.

Nuclear power could reduce the exposure of the GB energy market to the volatile global natural gas market (and a future global hydrogen market, although the mechanics of a hydrogen market could be quite different). Owing to the unique fuel supply chain, under appropriate market mechanism, nuclear power stations can contribute to a long-term price stability for industrial customers in the wholesale electricity market.[7] However, the price would reflect the strike price so the strike price would need to be minimised in order to maximise industrial competitiveness. The Regulated Asset Base (RAB) model aims to reduce the strike price.

The costs of disposing of spent fuel and other waste, and decommissioning plants are not insubstantial. The Committee on Radioactive Waste Management (CoRWM) noted the debate about whether new nuclear plants should be commissioned while the UK does not have a long-term storage facility for used fuel, and the need to consider the implications of new build for a storage facility.[8] Moreover, the physical and economic impacts of an accident or incident could be very high. None of these issues affect other low-carbon generators.

Economics of new nuclear generation with new reactor designs

Third-generation PWR reactors are being built at Hinkley Point C and have been proposed for Wylfa and Sizewell. Fourth-generation reactors could provide economic or operational benefits through small modular designs or by operating at high temperatures, but have not been tested at scale.

Co-location of nuclear and hydrogen electrolysis plants could contribute to the production of clean hydrogen at hours when electricity from the nuclear plant is not

[6] Grubler (2010) The costs of the French nuclear scale-up: A case of negative learning by doing
[7] Gross et al. (2022) Can existing renewables and nuclear help keep prices down next winter?, UK Energy Research Centre
[8] Warren (2008) Discussion paper on CoRWM's position on nuclear new build.

needed by the grid.[9] In the case of Wylfa, its vicinity to the Cheshire salt cavern storage and the North West industrial cluster would enable low-carbon hydrogen production for seasonal storage and to decarbonise the industrial cluster.[10] A fourth-generation high-temperature reactor coupled to a solid-oxide electrolyser would enable substantially cheaper hydrogen production compared to an electrolyser powered only by renewable electricity, as cheaper high-temperature steam (600–800 °C) would replace part of the electricity input. However, similar benefits could be achieved by coupling another large heat source to a solid-oxide electrolyser, for example waste heat from the Port Talbot Steelworks, together with electricity from renewables.

What are the main challenges to delivering the UK Government's commitment to bring at least one large-scale nuclear project to final investment decision by the end of this Parliament?

The key challenge is to agree a business model that protects consumers and delivers electricity as cheaply as possible for consumers, given the high cost of new nuclear compared to other low-carbon generation technologies, while also securing sufficient investments to fund the plant. Nuclear has very high capital costs and a long lead time, and there are few organisations with sufficient investment reserves that are willing to accept the risks of funding new projects with long payback periods. This is why the UK Government is proposing to take part ownership and to underwrite construction risks using a RAB model.

How important is the finance model to ensuring a successful nuclear project, and is the regulated asset base (RAB) model the best one to deliver this?

New nuclear plants being built worldwide (e.g. EPR plants at Taishan, Olkiluoto, Flamanville and Hinkley Point) have generally been delivered late and overbudget. The strike price agreed for Hinkley Point C takes into account the risk and costs of late delivery to the investors.

The cost of capital for new projects is invariably high as it reflects the risk of losses. The regulated asset base model effectively transfers some of the risk of losses from the company to the UK public. By removing risk, the company can borrow at a lower rate, and a lower strike price would result. However, the use of the RAB model would move substantial financial risk to the public:

- If the plant were delivered on time and to budget, then the RAB model would underpin substantially lower costs to the public.
- The RAB model reduces the financial impact of exceeding the budget on investors so has lower incentives for at-cost delivery than the Hinkley Point C model. If the budget were exceeded, then it is not clear that the overall cost of electricity to the public would be lower than for the Hinkley Point C model.

[9] Exelon (2019) Demonstration of electrolyzer operation at a nuclear plant to allow for dynamic participation in an organized electricity market and in-house hydrogen supply.
[10] The Wylfa Magnox reactor had a similar role supplying electricity to a neighbouring aluminium manufacturing plant on Anglesey.

- If the project were abandoned, then the public would still pay part of the construction cost.
- If nuclear generation were primarily sold to industry in the wholesale market, then the result of going over-budget would be the public subsidising industrial electricity costs, in contrast to the Hinkley Point C model.

Given these potential situations, there is a need for independent research to examine the overall cost for a range of cost overrun scenarios.

What practical steps can the UK Government take to support the nuclear industry in developing a range of nuclear technologies, including small modular reactors?

We have no evidence to offer for this question.

What would the likely cost be to the taxpayer of the UK Government supporting the development of a new nuclear power station at Wylfa?

This would depend on the choice of business model and the type and size of the power station.

What is the potential economic impact for Wales of a new nuclear power station at Wylfa?

We have no evidence to offer for this question.

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