Civil engineering insights into nuclear new build in the UK

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Purpose of this paper

This paper provides insight into the potential costs and benefits of the UK's proposed nuclear new-build programme, alongside an analysis of alternatives. It draws on lessons from existing projects and has been developed through discussions with ICE Fellows, senior sector stakeholders and available published evidence.

Overview

A growing population, economic uncertainty and an imperative to reduce carbon emissions to net zero by 2050 will place heavy demands on the UK's energy sector in the coming decades. In particular, the increased focus on energy security, the electrification of heat and transport and the growth of digital technologies is more than likely to double electricity consumption, according to forecasts by the Climate Change Committee in their Sixth Budget[1] and National Grid's Future Energy Scenarios.[2]

Since the rise in global prices following Russia's invasion of Ukraine, an additional consideration of 'long-term security of cost' has emerged, alongside the challenge of meeting emissions targets. As a result, the UK electricity system is likely to require more indigenous sources of energy in the future to ensure robustness. The recent announcement of the collaboration between Great British Energy and the Crown Estate has the potential to leverage private investment towards the UK's drive towards energy independence.[3]

Great British Energy

The Great British Energy Bill will establish a new, publicly owned company to develop and manage clean energy projects across the UK.[4] The company will work in partnership with the private sector to produce, store and distribute clean energy. An £8.3bn investment over the coming parliament will give the UK public a stake in the country's energy security. The government introduced the Bill on 25 July this year. The Bill will affect the whole of the UK, with Great British Energy headquartered in Scotland. The new Labour Government aims to double onshore wind, triple solar power and quadruple offshore wind by 2030. It has already taken steps to speed up the clean energy transition, including banning new licences for North Sea oil and gas drilling, greenlighting three major solar power projects in the east of England and ending an effective ban on onshore wind farms.

There have been some developments towards achieving this goal. Coal's share of generation has fallen from 47.5% in 2006 to just 1.3% by June 2024,[5] reflecting the ongoing shift towards cleaner energy sources. However, fossil fuels were still responsible for 37.7% of UK generation as of May 2024.[6] It is also worth noting that renewable energy has made significant progress, overtaking fossil fuels for the first time in 2023, with renewables providing 49.5% of electricity

[1] Climate Change Committee (2020) Sixth Carbon Budget
[2] National Energy System Operator (2024) Future Energy Scenarios (FES)
[3] Prime Minister's Office *et al.* (2024) New Great British Energy Partnership Launched to Turbocharge Energy Independence
[4] UK Parliament (2024) Great British Energy Bill
[5] Department for Energy Security and Net Zero (2024) Energy Trends and Prices statistical release: 27 June 2024
[6] Department for Energy Security and Net Zero (2024) Energy Trends and Prices statistical release: 30 May 2024

generation by major power producers.[7] In 2024, nuclear energy accounts for 12.2% of electric generation in the UK.[8] While this share has declined, nuclear power remains a low-carbon form of electricity production.

Electricity generation will become even more important in future as demand profiles across other infrastructure sectors evolve and digital technologies are widely embedded in the design of assets and networks. The importance of having a diverse energy generation mix cannot be overemphasised. Renewable energy must be invested in, but it must be supported by other energy sources. Different electricity generation technologies have different characteristics in terms of grid-connectivity and stabilisation, projected life, ability to deliver firm power and decommissioning requirements.

Clearly, generation methods that are reliable and resilient, providing security of supply and cost, will be highly prized. Yet, as many renewable technologies become ever more affordable, policymakers need to examine what place new nuclear has, and how it should be supported. More private investment will be required to prioritise new nuclear in the future, and ensure it is part of the energy mix provided by the current government.

About nuclear generation and new-build aspirations

The UK was the first nation to establish a civil nuclear programme, with Calder Hall connecting to the grid in 1956.[9] Despite this pioneering history, the UK has not built a nuclear power plant since 1995, when Sizewell B began generating electricity.

Nuclear power operates through much the same process as a carbon-fuelled power plant. It generates heat to transform a water supply to steam and power a turbine.[10] Nuclear has certain advantages over coal, oil and gas as it does not need to be continuously refuelled, will continue to provide power throughout its reaction and does not produce carbon emissions.[11]

The present generation of nuclear plants under development around the world is third generation and represents an evolution in fuel efficiency, safety and generation potential.

In the UK, EPR Pressurised Water Reactors (PWRs) are in the process of being constructed at Hinkley Point C and a similar station at Sizewell C is in development. Advanced Boiling Water Reactors (ABWRs) have been planned for deployment at Wylfa Newydd, in Anglesey, Wales, while former ABWR sites are being proposed as potential locations for Small Modular Nuclear Reactors (SMR).

The future of nuclear

The current situation is that there are only plans to build two more large new nuclear reactors before 2050, at Sizewell and Wylfa.[12] There are also plans to build Small Modular Nuclear Reactors (SMRs). The government has established a new nuclear organisation,[13] and one of its first actions has been to purchase land at Wylfa and Oldbury to facilitate large nuclear reactors and the first SMR.[14] The government's announcement of the partnership between Great British Energy and the Crown Estate, mentioned above, has the potential to leverage circa £60bn in private investment into the UK's drive for energy independence and clean power.[15]

[7] BBC News (2021) Renewable Energy Overtakes Fossil Fuels for First Time as UK's Biggest Source of Electricity in 2020
[8] Department for Energy Security and Net Zero (2024) Energy Trends and Prices statistical release: 30 May 2024
[9] Nuclear Waste Services (2018) The UK's Nuclear History
[10] World Nuclear Association (2020) How Does a Nuclear Reactor Work?
[11] World Nuclear Association (2017) The Nuclear Fuel Cycle
[12] Department for Energy Security and Net Zero *et al.* (2024) New Nuclear Power Plant Earmarked for North Wales
[13] Great British Nuclear (2023) Great British Nuclear: Overview
[14] Great British Nuclear *et al.* (2024) Great British Nuclear to Buy Two Hitachi Sites for New Nuclear Development
[15] Prime Minister's Office *et al.* (2024) New Great British Energy Partnership Launched to Turbocharge Energy Independence

The expectation is that both Great British Nuclear and Great British Energy will explore ways of working together, including how the functions of GB Nuclear can fit within the overarching framework of GB Energy. The government considers nuclear power to be an important part of a diverse energy mix. The technology provides consistent, reliable and decarbonised 'baseload' power and has a high load factor. This means that nuclear power can be relied upon to ensure minimum levels of power are met at any one time. This is important given the intermittent nature of renewables, the lack of storage capacity and the potential for price fluctuations for carbon-based fuels. It also means that nuclear has high availability.

According to the government, as of 2024, the average load factor for nuclear power in the UK is approximately 77.4%,[16] in comparison to 40.4% for gas,[17] 27.4% for offshore wind, 26.6% for onshore wind,[18] and 1.8% for coal.

Government policy on nuclear new build

To address the energy trilemma, the government has set out a policy for nuclear new build. This policy is guided by the 2011 National Policy Statement (NPS) for Nuclear Power Generation,[19] which was updated in 2018 following a 2017 consultation,[20] and the Nuclear Sector Deal (NSD).[21]

A new draft of the NPS was published for consultation, which closed in March 2024.[22] This proposes that the scope of EN-7 is broadened to apply to both gigawatt (GW) scale nuclear projects (exceeding 1,000 megawatts of nuclear capacity) and Small Modular Reactors (SMRs). EN-7 outlines the planning framework and criteria for the development of new nuclear power stations in the UK. The policy is crucial for guiding the expansion of nuclear power, aiming to increase nuclear capacity to 24GW by 2050.[23]

New capacity after 2025

In December 2020, the government launched a review of the energy National Policy Statements to ensure they reflected the government's energy priorities as set out in the Ten-Point Plan[24] and Energy White Paper.[25] Following the review, a consultation was launched to update EN-1 to EN-5, which are key overarching documents to guide the transition to a net-zero future, including for energy, fossil-fuel electricity generation, renewable energy, gas supply and electricity networks infrastructure. These documents collectively support the investment and development required to build the infrastructure needed for the UK's transition.[26] It was separately concluded that a new nuclear NPS for nuclear fission projects deployable after 2025 was required. The first step towards the proposed

Third-Generation Nuclear Technologies

Nuclear power plants use a sustained nuclear reactor to generate heat, which is then used to transform reserves of water to steam to drive turbines.

The current generation represents an evolution in fuel efficiency, safety and generation potential. There are two main types of reactor design:

Pressurised Water Reactors (PWRs)

The European Pressurised Reactor or Evolutionary Power Reactor (EPR) and the Chinese Hualong HPR1000 are examples of PWR designs. The EPR was first successfully deployed in Taishan, China, in 2018[1] and an EPR power plant is currently under construction at Hinkley Point C in the UK. The HPR1000 is currently under licensing review.[2]

Advanced Boiling Water Reactors (ABWRs)

ABWRs were first operated in Japan in 1996 and were accepted for use in the UK in 2017.

1 EDF (2019) China's Second EPR Reactor at Taishan Enters into Commercial Operation

2 Office for Nuclear Regulation and the Environment Agency (2019) Our Approach to Public and Stakeholder Engagement for the Generic Design Assessment (GDA) of the UK HPR1000 Nuclear Power Station

3 Hitachi (2020) ABWR Nuclear Power Plant

[16] UK Government (2018) Nuclear Electricity in the UK
[17] Statista (2023) UK: Plant Load Factor of Gas Turbine Stations 2021–2022
[18] Statista (2024) England: Onshore Wind Energy Load Factors 2019–2022
[19] Department for Energy Security and Net Zero (2011) National Policy Statement for Nuclear Power Generation (EN-6) Volume I of II; Department for Energy Security and Net Zero (2011) National Policy Statement for Nuclear Power Generation (EN-6) Volume II of II
[20] Department for Business, Energy and Industrial Strategy (2018) Government Response: Consultation on the Siting Criteria and Process for a New National Policy Statement for Nuclear Power with Single Reactor Capacity Over 1 Gigawatt Beyond 2025
[21] HM Government (2018) Industrial Strategy: Nuclear Sector Deal
[22] Department for Energy Security and Net Zero (2024) National Policy Statement for New Nuclear Power Generation: Consultation on the New Approach to Siting Beyond 2025
[23] Department for Energy Security and Net Zero (2024) National Policy Statements for Energy Infrastructure
[24] Department for Energy Security and Net Zero *et al.* (2020) The Ten-Point Plan for a Green Industrial Revolution
[25] Department for Energy Security and Net Zero (2020) Energy White Paper: Powering our Net Zero Future
[26] Ibid.

nuclear NPS, EN-7, is a consultation on the approach for assessing the potential suitability of sites for the deployment of new nuclear power stations.

The previous Conservative Government's intention was for these changes to deliver the ongoing flexibility needed to ensure there are enough sites to fulfil the country's nuclear ambitions. At the same time, the changes would ensure that the siting of new nuclear power stations is appropriately constrained and nuclear power stations are only sited in suitable locations. The new Labour Government has developed a mission-led approach for energy infrastructure and one of the first steps it has taken is to take ownership of the National Energy System Operator (NESO) from 1 October 2024.[27] Its initial objectives will be to bring electricity and gas network planning together to facilitate an optimal approach to transitioning to clean power.

The cost challenge of nuclear new build

According to the Science, Innovation and Technology Committee Report on delivering nuclear power,[28] the UK's nuclear energy policy has been characterised by intermittency since the first civil nuclear reactor was built in 1956. The government has contributed £385m to research and development in advanced nuclear technologies since 2020. The UK's nuclear power capacity, which currently contributes 15% of the UK's electricity needs, will fall substantially by 2028. This is due to the scheduled end of life for all plants except Sizewell B. The loss of a domestic, non-carbon-emitting source of baseload power has created a gap affecting future power supply.

The government's response, in its Energy Security Strategy, is to aim to achieve 24GW of nuclear capacity by 2050. The government has been investing in advanced nuclear technologies, including SMRs and advanced modular reactors, for this purpose. A more stable feature of UK nuclear policy has been the funding of fusion research and development. Government investment in Sizewell C, alongside the Regulated Asset Base (RAB) funding model, will help secure the first true replica nuclear project in UK history. There is also the need for a skilled workforce to achieve the government's nuclear energy ambition.

Finance and funding

The government initially chose to directly negotiate a price with nuclear providers, agreeing a strike price with EDF and CGN of £92.5 per megawatt hour (MWh) equivalent to 2012 prices for Hinkley Point C. This is a Contract for Difference (CfD) index-linked to CPI (Consumer Price Index), which is a crucial economic indicator that tracks the cost of living and is used to gauge inflation over time.[29]

The contract does remove some uncertainty for the bill payer, with any overrun and decommissioning costs being borne by the developers. Nonetheless, the agreed strike price factored in some risk protection for EDF and has drawn criticism from the Public Accounts Committee, which found that 'no one was protecting the interests of energy consumers in doing the deal', with an assessment on the impact to household bills which only 'went up to 2030' despite the 35-year length of the CfD.[30]

The subsequent reaction to this agreement may have complicated negotiations for other projects, most notably Wylfa Newydd, which suspended work after a failure to reach an agreement on financing and commercial arrangements.[31] It should be noted that the government has now changed its approach to financing nuclear technologies with the introduction of the concept of a Regulated Asset Base model (RAB).[32] This model significantly reduces the cost of new nuclear and

[27] Department for Energy Security and Net Zero *et al.* (2024) New Publicly Owned National Energy System Operator to Pave the Way to a Clean Energy Future
[28] Science, Innovation and Technology Committee (2023) Delivering Nuclear Power – Report Summary
[29] National Audit Office (2017) Hinkley Point C
[30] Committee of Public Accounts (2017) Hinkley Point C
[31] BBC News (2024) Wylfa Newydd - The complex history explained
[32] Department for Business, Energy and Industrial Strategy (2021) Future Funding for Nuclear Plants

although the consumer contribution starts when construction begins, rather than when energy is produced, it reduces overall costs to the consumer over the long term. The successful use of RAB financing for the now substantially completed Thames Tideway Tunnel[33] increases confidence in it as a financing mechanism for large infrastructure projects.

Developing the nuclear sector

The government set out an ambition to generate domestic jobs, improve earning power, support innovative design and construction and develop placemaking in the Nuclear Sector Deal (NSD). This includes provisions to make the nuclear sector in the UK more competitive. To enable this, the NSD set out enhanced support for skills leadership, investment in nuclear research, the establishment of a national supply chain and productivity improvement programme, alongside support for UK companies to maximise contract wins in the nuclear sector.[34]

Has this nuclear new-build policy been successful?

New capacity from 2025

Building permission for Sizewell C on the Suffolk coast,[35] which will generate 3.2 gigawatts (GW) of electricity, was granted in July 2022 and is expected to cost £20bn. There has been significant progress, with the project entering the construction phase in January 2024.[36] The government has consulted on the framework for investment (the RAB model),[37] alongside the publication of the civil nuclear roadmap,[38] and is expected to give its conclusions in the coming months.

The government announced the purchase of the former nuclear site at Wylfa in North Wales in March 2024.[39] The agreement to purchase the site, which also includes the Oldbury site in South Gloucestershire, was reached with its previous developer, Hitachi. The deal cost £160m.[40] The government's roadmap for nuclear power includes plans for a new power station of the same size and scale as Hinkley in Somerset. There are also plans for a series of SMRs, which can be partly assembled off-site and are cheaper. Wylfa is a site deemed suitable for both large-scale nuclear development and a number of SMRs.

Addressing rising costs

Construction of a modern nuclear power station is a capital-intensive exercise that can take many years.[41] Hinkley C is projected to cost £46bn.[42] The capital cost estimates for nuclear power that are being used to inform current government policy rely on costs escalating over the pre-construction and construction phase of the new-build programme at a level below those that have been experienced by past US and European nuclear build programmes.[43] The cost estimates for nuclear power in the UK are complex and have evolved over time, and have been influenced by factors including construction costs, financing and technological advancements.[44]

The Nuclear Sector Deal contains a target of reducing the costs of new nuclear plants by 30%, with an emphasis on advanced construction and manufacturing techniques.

[33] Tideway (2024) Tideway Annual Report Charts Successful Year as Super Sewer Testing Begins
[34] HM Government (2018) Industrial Strategy: Nuclear Sector Deal
[35] Sizewell C Sizewell C – A New Nuclear Power Station for Britain
[36] Sizewell C (2024) Largest Sizewell C Forum of the Year Offers Insight into Project's Progress
[37] Sizewell C Supply Chain Progress of the Sizewell C Project
[38] Department for Energy Security and Net Zero (2024) Civil Nuclear: Roadmap to 2050
[39] BBC News (2024) Budget: UK Government to Buy Wylfa Site in £160m Deal
[40] Department for Energy Security and Net Zero (2024) New Nuclear Power Plant Earmarked for North Wales
[41] Nuclear Energy Futures Centre for Doctoral Training (2020) The Economic Challenges of UK Nuclear New Build
[42] BBC News (2024) Hinkley C: UK Nuclear Plant Price Tag Could Rocket by a Third
[43] Imperial College Centre for Energy Policy and Technology (2012) Cost Estimates for Nuclear Power in the UK
[44] NDA (2019) Nuclear Provision: The Cost of Cleaning Up Britain's Historic Nuclear Sites

Finance and funding

In one of the most recent renewable energy auctions, Allocation Round 5 (AR5), no bids were received for offshore wind projects. This was due to the economic terms of the revenue support scheme being inadequate to support the financial decision to invest in new wind farms.[45]

For Allocation Round 6 (AR6), the government increased the ceiling price for offshore wind to £73/MWh, up from £44/MWh in AR5, to better reflect the current costs.[46] The AR6 auction was successful, with 4.9GW of new offshore wind projects awarded CfD's of £58.87/MWh.

Additionally, the cost of offshore transmission, which includes the infrastructure to transfer electricity from offshore wind farms to the onshore grid, represents approximately 10 to 15% of the Levelised Cost of Energy (LCOE) for offshore wind.[47]

The picture is also more complicated than a direct comparison on strike price. Hinkley Point C's strike price is fixed for 35 years but the plant has an operational life of 60 years, at which point electricity generated will likely be sold at market price. Renewable generation costs have continued to fall, but these generators have, with the exception of hydropower and tidal range power, a shorter operating life, and costs will increasingly need to factor in capacity support or storage to balance out intermittent generation.

As noted above, the government has consulted on adopting the Regulated Asset Base (RAB) model for new nuclear,[48] a proposal that the ICE believes is credible and offers the prospect of reduced costs to consumers over the long term, provided that detailed mechanisms can be developed for apportionment of risk, overruns on construction costs and schedules, regulation of approvals and payment sequencing. There must also be protections for consumers, to prevent them from being unfairly burdened with risk.[49]

Developing the nuclear sector

In developing Hinkley Point C, the government has met some of its Nuclear Sector Deal targets. Up to 64% of the construction costs of Hinkley Point C are being spent with UK companies and the project has created 25,000 domestic employment opportunities. In addition, 1,000 apprentice places are being funded and the project is providing £1.5 billion to the regional economy during the construction phase.[50] The development of skills and expertise in the nuclear field, for the first time since 1995, is of transferable benefit to nuclear research and potential future civil nuclear development.

Lessons from international nuclear projects

Given that there has been a significant gap in the building of new nuclear capacity in the UK, most developments in new nuclear have occurred abroad.

Most nuclear projects around the world have seen delays and cost increases. Taishan EPR was offline for more than a year due to the discovery of damaged fuel rods.[51] It was reconnected to the electricity grid in August 2022.[52] The Taishan EPR (European Pressurised Reactor) is a nuclear power plant located in Taishan, China. It features 2 EPR reactors,

[45] ORE Catapult (2023) Renewable Energy Auction Results in No Bids for Offshore Wind; BBC News (2023) No Bids for Offshore Wind in Government Auction
[46] Energy UK (2024) Energy UK Explains: Allocation Round 6 and the UK's Energy Security Goals; Department for Energy Security and Net Zero (2023) Boost for Offshore Wind as Government Raises Maximum Prices in Renewable Energy Auction
[47] ORE Catapult (2024) ORE Catapult is the UK's Leading Technology Innovation and Research Centre for Offshore Renewable Energy
[48] Department for Business, Energy and Industrial Strategy (2019) Regulated Asset Base (RAB) Model for Nuclear
[49] ICE (2019) ICE Response to BEIS Consultation on a Regulated Asset Base (RAB) Model for New Nuclear
[50] Department for Business, Energy and Industrial Strategy (2018) Hinkley Point C Wider Benefits Realisation Plan
[51] World Nuclear News (2022) Chinese EPR Resumes Power Supply after Extended Outage
[52] Ibid.

which are some of the most advanced in the world. The project is a joint venture between China General Nuclear group and Électricité de France (EDF).[53] Both units of the plants have been commercially operative since 2022.[54] The Olkiluoto 3(OL3) plant unit in Finland has started regular electricity production.[55] OL3 has a net output of approximately 1,600MW.[56] The Flamanville 3 EPR is a nuclear power plant located in Flamanville, France. It represents a significant advancement in nuclear technology and is part of France's broader strategy to maintain a low-carbon energy mix.[57] Connection to the national grid is scheduled before the end of autumn 2024.[58]

In addition to these projects, there have been significant developments in nuclear energy globally. The next generation of nuclear reactors is getting more advanced.[59] It is expected that between 2020 and 2026, 48 power reactors will be built globally.[60]

It is expected that the Regulated Asset Base (RAB) model could bring several positive changes to nuclear energy production in the UK. The RAB model is expected to reduce the cost of capital for new nuclear projects in the UK.[61] The previous Conservative Government anticipated that the new funding model would ultimately bring significant savings for nuclear projects as customers' initial payments would lower the overall cost of financing.[62] It is important to assess what the new Labour Government's approach will be to this financing model and whether it will continue along the same lines. The RAB model is expected to attract private investors, such as pension funds and insurers, thus reducing reliance on overseas investors.[63]

It is also expected the RAB model will lower consumer costs in the long term. By providing a more stable and lower rate of return for investors during the construction phase, the RAB model is expected to save consumers over £30bn on each larger-scale nuclear power station.[64] The model offers greater financial certainty, which can help prevent project cancellations and ensure the successful completion of new nuclear power stations.[65] The RAB model has been successfully used in Australia in the regulation of electricity and gas networks. It was first introduced in the mid-1990s and has provided a framework for investment in essential utility infrastructure.[66]

Lessons learnt from Hinkley Point C

With more reliable and affordable power generated domestically, the UK can reduce its dependency on fossil fuels and exposure to volatile global gas prices.[67]

The Hinkley Connection Project is a new high-voltage electricity connection between Bridgewater and Seabank, near Avonmouth, which introduces the use of new T pylons and undergrounding of cables in sensitive landscapes.[68] Valuable lessons have also been learnt from Hinkley Point C in terms of technology and the supply chain, as well as the social benefits of the unit. In relation to technology, Hinkley Point C uses the European Pressurised Reactor (EPR) technology. This is based on the most tried-and-tested nuclear reactor design, enhanced with advanced technological improvements.[69]

[53] EDF Energy (2018) Taishan 1, World's First EPR Connected to the Grid
[54] World Nuclear News (2019) World's Second EPR Starts Operations
[55] TVO OL3
[56] Ibid.
[57] EDF (2024) Update on the Flamanville EPR (8 May 2024)
[58] Ibid.
[59] MIT Technology Review (2024) The Next Generation of Nuclear Reactors is Getting More Advanced. Here's How.
[60] Power Technology (2020) New Nuclear Projects: Where and When will they be Built?
[61] Energy UK (2023) Nuclear Energy Financing Bill
[62] Norton Rose Fulbright (2022) Regulatory Trends: New Nuclear RAB Funding Model
[63] Department for Business, Energy and Industrial Strategy (2021) New Finance Model to Cut Cost of New Nuclear Power Stations
[64] Ibid.
[65] Ofgem Nuclear Regulated Asset Base (RAB) Model
[66] World Nuclear News (2020) Viewpoint: Combining the RAB and Alliance Models for New Nuclear in the UK; Oxera (2014) The Regulatory Asset Base and Regulatory Commitment
[67] Department for Business, Energy and Industrial Strategy (2021) New Finance Model to Cut Cost of New Nuclear Power Stations
[68] National Grid ET (2024) Hinkley Connection Project
[69] EDF Energy (2015) The EPR Technology that's Powering Hinkley Point C

In December 2023, the world's largest crane, Big Carl, lifted a 245-tonne steel dome onto Hinkley Point C's first reactor building.[70] This was a major construction milestone that allowed the next phase of work to accelerate and the first reactor to be installed the following year.[71] In addition, prefabrication and modular construction are key features of Hinkley Point C's construction. For example, the dome was made up of 38 prefabricated panels which were shipped to Hinkley Point C and welded together in an onsite factory.[72] Since the fabrication of the first dome, an improved approach has been taken in the fabrication of the second dome, while the 'factory' approach to manufacturing many elements that would have been constructed in situ is also providing substantial benefits.[73]

There have also been significant developments and benefits derived from the construction of Hinkley Point C. Up to 160 homes could be built within a few miles of the power station, with developers assuming workers will want to live near the site.[74] More than 8,000 people have been trained in Hinkley Point C's new Centres of Excellence for welding, electrical, mechanical and construction skills.[75] Almost a third of those trained come from areas designated as deprived.[76] It is a significant investment in the region's electricity network, which will enable the connection of new sources of low-carbon energy to homes and businesses.

The example of Hinkley Point C provides a blueprint for future nuclear power projects. These projects will help create a better-skilled workforce, stimulate the local economy and support the UK's transition to a low-carbon future.

Public sentiment around nuclear power generation

The ICE's public engagement work for *State of the Nation 2018: Infrastructure Investment* found that security of supply and climate change are key energy concerns for the public.[77] This does not, however, necessarily translate into support for nuclear power. According to YouGov, only a third of UK adults (33%) have a favourable view of nuclear energy, making it less popular than gas (40% favourability). Of those favourable, less than half (44%) want to see greater use of nuclear power, while 42% of all UK adults believe nuclear use should be reduced.[78]

Polling by the Nuclear Industry Association suggests that 65% of people think the country should keep using nuclear energy. 46% also say the country should keep using and build new nuclear reactors.[79]

There is general acceptance of the need for additional investment in energy generation, although there is little appetite for higher bills that are not tied to improvements in energy efficiency and carbon reduction. The public are also resistant to new large-scale nuclear infrastructure programmes, with a preference for investment in renewables.[80] According to the Institution of Mechanical Engineers, more than eight in ten people support electricity production from renewable energy sources.[81] The same poll, carried out by IMechE, does, however, demonstrate that there is little understanding of nuclear power and its potential benefits, particularly among younger people. Only 26% of people aged 18 to 24 understand that nuclear power is a low-carbon energy source, although this rises to 61% of those aged 65 to 74 years old.[82]

There is a need for politicians and the nuclear industry to coalesce around the benefits of nuclear and communicate a better story around this to the public to reduce misinformation that can generate subsequent opposition to projects.

[70] EDF Energy (2023) Big Carl's Spectacular Dome Lift Caps the Year at Hinkley Point C
[71] Ibid.
[72] Ibid.
[73] EDF Energy (2024) Big Modular Approach Pays Dividends at Hinkley Point C
[74] BBC News (2024) Hinkley Point C: More than 150 New Homes Planned
[75] EDF Energy (2024) Report Reveals the Positive Impact of Hinkley Point C
[76] Ibid.
[77] ICE (2018) State of the Nation 2018: Infrastructure Investment
[78] YouGov (2019) Shale Gas is Even Less Popular in UK than Coal
[79] Nuclear Industry Association (2024) Public Attitudes towards Nuclear Energy
[80] ICE (2018) State of the Nation 2018: Infrastructure Investment
[81] Institution of Mechanical Engineers (2020) Public Perceptions: Nuclear Power
[82] Institution of Mechanical Engineers (2020) Public Perceptions: Nuclear Power

Alternative approaches

Next-generation nuclear

The government is investing some £460 million into nuclear research and innovation, aiming to improve the efficiency of nuclear power as a generating source, particularly focusing on fuel, safety, design and construction.[83] Fourth-generation Fast Neutron Reactors, which could reprocess spent fuel from traditional nuclear power plants, and research into fusion, which could promise limitless power, are prominent research avenues. These technologies can also yield transferable benefits, through advancements in robotics, advanced materials and computing models.[84]

The UK Atomic Energy Authority (UKAEA) has appointed a consortium led by Atkins, alongside Assystem, as the Engineering Delivery Partner (EDP) for its Spherical Tokomak for Energy Production (STEP) programme.[85] The STEP programme aims to demonstrate the ability to generate net energy from fusion and determine how the plant will be maintained through its operational life.[86]

The first phase of the programme is to produce a concept design by the end of 2024.[87] The prototype will be a compact spherical tokomak, which is a type of fusion reactor designed to produce energy by fusing atomic nuclei, that connects to the national grid and generates more energy than it uses.[88] The STEP programme is a significant initiative that could revolutionise the UK's energy sector and contribute to the global effort to achieve a sustainable, low-carbon future.

Small Modular Reactors

Small Modular Reactors (SMRs) are a new generation of low-energy-output, low-hazard, compact and modular nuclear reactors. With the integration of inherent and passive safety measures, off-site construction and higher fuel burn-up rates, they promise a safer, lower-waste and reduced-risk venture, with earlier returns for investors.[89] SMRs are supported within the Nuclear Sector Deal. Several domestic consortiums, including one led by Rolls-Royce, which manufactures reactors for the UK's nuclear submarines, have the technology and expertise to build reactors.

SMRs could have certain advantages over large-scale third-generation nuclear plants, with some designs small enough to be built in factories and transported by road or rail.[90] This could allow for earlier adoption of standardised design, and economies of scale which could lead to reduced manufacturing times. Reactors could also be installed on location, significantly reducing construction times.[91] Rolls-Royce argues that an SMR reactor could provide 440 megawatts of electricity, enough to power a city the size of Leeds, and that a production line would be more affordable than a one-off bespoke major project.[92]

Multiple smaller reactors could be deployed more flexibly and the impact of shutdowns for maintenance would be reduced if rotated between multiple smaller generators. This is especially important if the need for a model that can provide baseload power is disrupted by innovations being undertaken by National Grid's Electricity System Operator (NESO), which manages electricity distribution for the grid. Multiple smaller nuclear reactors could respond more flexibly to energy demand, given that the ramp-up times for a reactor to adjust output are measured in days. Alternatively, a network of

[83] Department for Business, Energy and Industrial Strategy (2020) Funding for Nuclear Innovation
[84] Ibid.
[85] World Nuclear News (2022) UKAEA Appoints Consortium to Help Deliver STEP: New Nuclear
[86] UK Atomic Energy Agency STEP – Spherical Tokamak for Energy Production
[87] Ibid.
[88] Ibid.
[89] Ioanna Playbell, BEng, MSc (2017) Economy, Safety and Applicability of Small Modular Reactors
[90] International Atomic Energy Agency (2020) Small Modular Reactor (SMR) Regulators' Forum
[91] SMR Regulators' Forum/IAEA (2019) Report on Key Regulatory Interventions during a Small Modular Reactor Lifecycle
[92] Rolls-Royce (2018) UK SMR: A National Endeavour

SMRs could divert continuous energy production to convertible or energy-intensive industrial tasks, such as the production of hydrogen, energy storage or desalination plants, which are likely to become increasingly important.

SMRs do have potential drawbacks, however. Strategically sited large-scale nuclear plants would likely be easier to protect from security threats than multiple sites. SMRs could also have potentially higher operating costs as larger power plants reduce the cost per megawatt of electricity produced.[93]

As of 2024, there have been significant developments in the field of SMRs in the UK. The previous government launched a competition for financial support to develop SMRs.[94] Six companies were selected to advance to the next phase of this competition. It will be important to see what the new Labour Government decides, in line with their manifesto on how to advance this process, particularly as successful companies in the bidding process were meant to be announced in spring 2024, with contracts awarded by summer 2024.[95] Secretary of State for Energy Ed Miliband has committed to supporting the SMR programme and keeping to the timetable that has been set out; however, to ensure a successful rollout, there is still a long way to go.[96]

The previous government's ambition is for up to a quarter of all UK electricity to come from nuclear power by 2050.[97] Unlike conventional nuclear reactors that are built on site, SMRs are smaller, can be made in factories and could transform how power stations are built by making construction faster and less expensive.

Renewable power and evolution of the national grid

Renewables today offer affordable electricity, contribute substantially to the energy mix and, apart from carbon emissions in construction and transmission of power, can produce zero-carbon electricity. Apart from hydropower and tidal power, however, they have relatively short operating lives and provide intermittent generation, with generation outputs fluctuating depending on weather conditions.

The 2024 National Grid Future Energy Scenarios (FES) outlined three new pathways (Holistic Transition, Electric Engagement and Hydrogen Evolution) for the future of the whole energy system with a fourth counterfactual pathway for comparison purposes.[98] Each pathway considers how much energy might be needed and where it could come from, to build a picture of achieving net zero. The report emphasised the need for prioritising steps that will enable the delivery of cleaner and cheaper energy generation while ensuring a resilient system that delivers supply security for consumers.[99] It concludes that the decarbonisation of the energy system is the challenge of our generation. The FES creates the foundation upon which future network investment plans will be built.[100]

The FES report also notes that there needs to be decisive action within the next two years to deliver the fundamental changes required to achieve fair, affordable, sustainable and secure clean energy by 2050. The Review of Electricity Market Arrangements (REMA) is the UK government's policy to enable a net-zero power sector by 2035,[101] subject to the security of supply, while ensuring a fair deal for consumers. REMA was launched in the British Energy Security Strategy in April 2022, with an initial public consultation in July 2022.[102] This was followed by a second public consultation in March 2024.[103] The key conclusions from the recent consultation included an undertaking by the government to provide a summary of responses to the second consultation by summer 2024. The new Labour Government has not indicated a timeline for when the responses to the consultation will be published. In addition, the policy development phase of the

[93] Atkins (2015) Our Nuclear Future?
[94] Environmental Audit Committee (2023) What Role Can Small Modular Reactors Play in the UK's Move Away from Fossil Fuels?
[95] Department for Energy Security and Net Zero *et al.* (2023) Six Companies through to Next Stage of Nuclear Technology Competition
[96] iNews (2024) Inside Labour's Plan to Build 'Mini' Nuclear Reactors around UK
[97] Ibid.
[98] National Grid Energy System Operator (2023) Future Energy Scenarios 2023 Launches at the Science Museum in London
[99] National Grid Energy System Operator (2024) Future Energy Scenarios (FES)
[100] Ibid.
[101] Department for Energy, Security and Net Zero (2022) Review of Electricity Market Arrangements (REMA)
[102] Ibid.
[103] Ibid.

programme was expected to conclude by 2025, with full-scale implementation expected to begin from 2025 onwards. It is unclear how REMA interacts with the new Labour Government's 'Clean Energy Superpower' mission.[104]

Furthermore, the analysis suggests that reforming the electricity markets could reduce overall system costs by £35bn from 2030 to 2050.[105] The report also estimated that £275bn to £375bn in new capacity may be required.[106] The transformation of the National Grid Electricity System (ESO) into the National Energy Systems Operator (NESO) is a significant development in the UK's energy sector.[107] This was launched in 2024 and taken into public ownership in September 2024. The NESO will bring planning of Britain's electricity and gas networks under a single roof. It will be tasked with ensuring that Britain's energy system is secure and affordable, as well as forging a path to a sustainable future.

The transformation is a response to the need for wider adoption of technology and changes in consumer behaviour, as well as ensuring the right markets, networks and frameworks are in place.[108] The NESO will inherit and expand upon the roles previously held by National Grid ESO, encompassing a wide range of responsibilities across the energy sector.[109] Moreover, the NESO will drive the evolution of market arrangements across the whole energy system to facilitate security of energy supply and deliver investible markets at the most equitable costs to consumers.[110]

The grid faces a number of challenges. These include an increase in the number and location of new transmission links and the number of new power stations required, given the increase in electricity demand over the next 25 years. A challenge for the grid is the cost and size of battery response and finding the most cost-effective means to store large amounts of electricity. Nuclear power uses synchronously connected generators so will play an essential role in grid stabilisation.

Many renewable energy sources cannot be turned on and off as needed. This emphasises the need for a diverse energy mix, with different technologies working together, including large and small nuclear, modular renewables such as wind and solar, and large infrastructure solutions such as tidal and hydropower, including pumped storage. This will be particularly important if green hydrogen plays a future role, as hydrogen is only a storage medium and not an energy source. As previously stated, this furthers the case for a diverse energy mix.

In summary, it is imperative that the UK government implements the policies and measures outlined above to address concerns regarding energy security, affordability of costs to consumers and the requirement to support more indigenous sources of energy to ensure that emission targets are met. The recent announcement of the creation of GB Energy and its collaboration with the Crown Estate is a positive step towards leveraging private investment towards the UK's drive for energy independence. It is the ICE's view that all forms of low-carbon energy production will have a role to play, from nuclear to wind, solar to tidal, hydropower to hydrogen, and all forms of energy storage, short and long term.

About the ICE

The Institution of Civil Engineers (ICE) is a 97,000-strong global membership organisation with over 200 years of history.

It is a centre of engineering excellence, qualifying engineers and helping them maintain lifelong competence, assuring society that the infrastructure they create is safe, dependable and well designed.

Its network of experts offers trusted, impartial advice to politicians and decision-makers on how to build and adapt infrastructure to create a more sustainable world.

[104] Department for Energy, Security and Net Zero *et al.* (2024) First Mission Board Focuses on Immediate Action to Make Britain a Clean Energy Superpower
[105] Hansard (2024) Review of Electricity Market Arrangements: Second Consultation
[106] Ibid.
[107] National Grid Energy System Operator (2024) National Energy System Operator (NESO)
[108] Ibid.
[109] Modo Energy (2024) The Rise of NESO: The National Energy System Operator
[110] National Grid Energy System Operator (2024) National Energy System Operator (NESO)

This project supports the ICE's strategy by outlining the role of nuclear power in decarbonising the UK's infrastructure system.

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