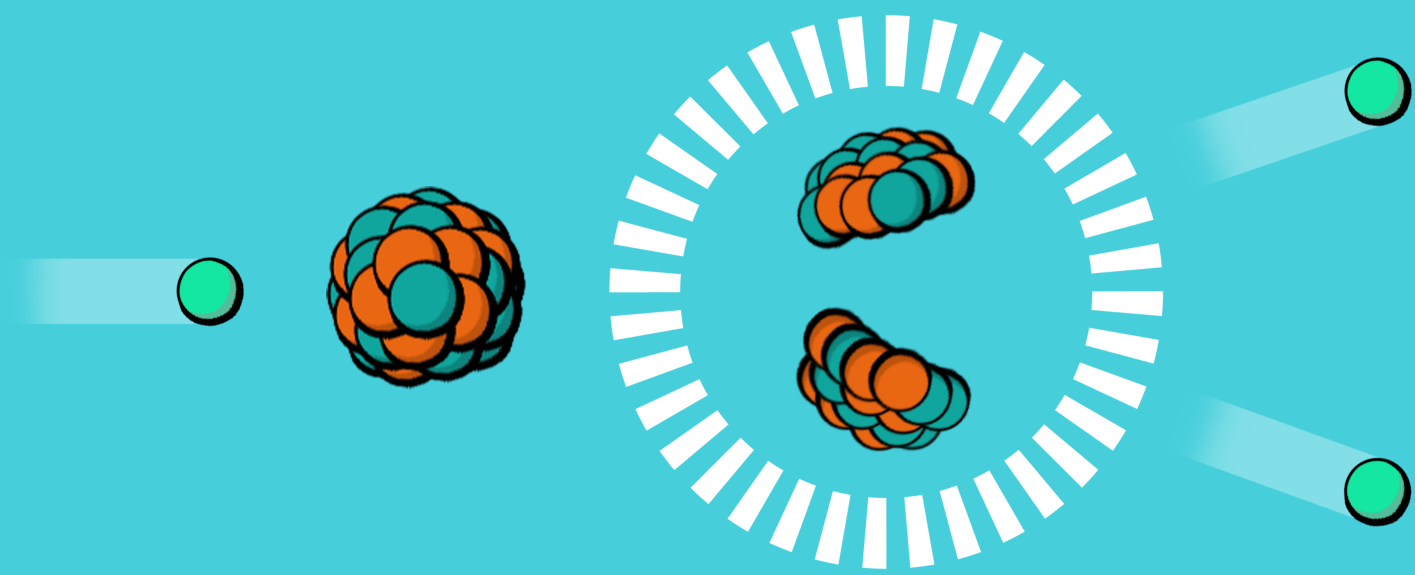
House of Commons

Science, Innovation and Technology Committee

Delivering nuclear power

Eighth Report of Session 2022–23



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Eighth Report of Session 2022–23

Report, together with formal minutes relating to the report

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Science, Innovation and Technology Committee

The Science, Innovation and Technology Select Committee is appointed by the House of Commons to examine the expenditure, administration and policy of the Department for Science, Innovation and Technology, and associated public bodies. It also exists to ensure that Government policies and decision-making across departments are based on solid scientific evidence and advice.

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The following staff also worked for the Committee during this inquiry: Gina Degtyareva (Former Senior Select Committee Media Officer)

Specialist Advisers

Josh Buckland (Partner, Flint Global) served as a Specialist Adviser to the Committee during this inquiry.

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Summary

An intermittent history

1) During the seven decades since the UK built the world's first civil nuclear reactor in 1956, Britain's nuclear energy policy has been characterised by intermittency.

2) Between the 1955 White Paper 'A Programme of Nuclear Power' and 1979, 17 nuclear power stations were approved: ten Magnox followed by seven advanced gas-cooled reactor (AGR) plants. There was then a gap before Sizewell B, the pressurised water reactor (PWR) plant, was approved in 1987 and came online in 1995. It then took 21 years for another nuclear new build to be approved—the European pressurised reactor (EPR) at Hinkley Point C was approved in 2016 but is not due to come online until 2027. Since then, discussions about building new reactors at Wylfa on Anglesey and at Moorside in Cumbria foundered. But the Government is in negotiations over a second EPR facility at Sizewell. And the Government has, since 2020, contributed £385 million to research and development in advanced nuclear technologies (including small modular reactors and advanced modular reactors).

3) A more stable feature of UK nuclear policy has been the funding of fusion research and development. For example, the Joint European Torus (JET), the central facility of the European Union's Fusion Programme, has been hosted at the Culham site since 1983. That programme has yet to produce a commercially deployable source of energy from fusion.

The power gap

4) The legacy of this intermittent history is that nuclear power which, from about 5.5 gigawatts (GW) of nuclear capacity, currently contributes 15% of the UK's electricity needs, will fall substantially by 2028, when all plants bar Sizewell B are scheduled to come to the end of their lives. Even when Hinkley Point C comes online, nuclear capacity will remain below current levels because of the expected retirements.

5) The UK's legal commitment to net zero greenhouse gas emissions by 2050; worries about the security of imported fossil fuels heightened by the consequences of Russia's invasion of Ukraine; and the expected shift toward higher electricity demand as part of the overall energy mix, mean that the loss of contribution of a domestic, non-carbon emitting source of baseload power (also known as firm or dispatchable power) has created a gap in our future supply of power.

6) The Government's response, in its Energy Security Strategy, published in April 2022, is to aim to achieve 24 GW of nuclear capacity by 2050. This is an ambitious aim: it equates to three times current nuclear capacity, even before plant retirements, and it is almost double the highest nuclear installed capacity the UK has ever achieved. The Government estimated that nuclear power will then contribute around 25% of the UK's electricity supply.[1]

1 HM Government, Energy Security Strategy, 7 April 2022

7) The Government has also said that it wishes to deploy small modular reactors (SMRs). No SMR is as yet commercially operational, but SMRs are envisaged to be (ultimately) cheaper to manufacture, quicker to construct, and more flexible in where they could be sited.

8) It is not clear what proportion of the Government's 24 GW ambition for nuclear power by 2050 will be accounted for by SMRs. The Government has also said that it will sponsor the development of a future generation of nuclear reactors, known as advanced modular reactors (AMRs) or Generation IV reactor technologies, and will continue research and development into fusion technologies—although it does not expect the latter to contribute to commercial electricity supplies by 2050.

9) We believe that the Government is right to identify nuclear power as an important contributor to meeting our future electricity needs. Given the otherwise declining contribution of nuclear power, this ambition requires a substantial programme of nuclear new build.

10) The power gap that has opened up in the supply of nuclear energy was—since it results from the retirement of ageing plants without their timely replacement—foreseeable and should have been acted upon by previous governments. That it was not, is consistent with an intermittent commitment to nuclear power which has characterised UK policy for most of the period since civil nuclear power was first deployed.

Targets are not a strategy

11) The recently announced Government target of 24 GW of nuclear generating capacity by 2050, and the aspiration of deploying a new nuclear reactor every year are statements of ambition.[2] But they do not amount to a strategy that will ensure that such capacity is built. Witnesses to our inquiry characterised the Government's Energy Security Strategy, published in April 2022, as more of a "wish list" than a strategy to achieve those ambitions.

12) A year after the Energy Security Strategy was published, an Energy Security Plan, was issued in March 2023. But it did not include much further information about how the Energy Security Strategy would be implemented.

13) Even taken together, the 2022 Energy Security Strategy and the 2023 Energy Security Plan, do not amount to the comprehensive, detailed and specific strategy that we believe is required if the Government's aspirations are to be delivered.

The need for a Nuclear Strategic Plan

14) To be able to achieve the Government's target of 24 GW of nuclear power by 2050 requires a large number of actions to be taken in an orderly and timely way, not only by Government but by a wide range of other parties, including: developers; regulators; fuel suppliers; providers of finance; educational and training institutions; and other suppliers.

2 HM Government, British Energy Security Strategy, 7 April 2022, p 21

15) One of the lessons of the 70-year history of civil nuclear power in the UK is that there is advantage in a stable, actionable set of policies and dependable commitments made on behalf of governments. Policies and commitments need to endure beyond terms of office of a particular administration, such are the long timeframes associated with nuclear development.

16) Where such continuity and predictability has been absent—whether because of stop-start policies, ambiguity of commitment or long delays in making decisions—this has usually been at the expense of the cost-effectiveness and the performance of the UK nuclear industry as a system.

17) A Nuclear Strategic Plan must go beyond high-level aspirations: it must be a specific plan bringing together many particular decisions to be taken according to a clear timeframe upon which others can rely.

18) A true strategic plan must also be integrative. It should bring together the actions and decisions required to the range of parties involved, inside and outside of government, and ensure that they are coherent and coordinated with each other, rather than pulling in different directions.

19) A first step was taken towards this approach in the negotiation and agreement of the Nuclear Sector Deal in 2018. This initial agreement between the Government, regulators, research bodies and commercial companies in the UK nuclear industry, set out agreed mutual actions on areas such as technology, licencing and skills development. It was envisaged that this would be the first of a deepening series of Nuclear Sector Deals, but there has been no further progress in the intended direction.

20) In each of the areas we examined closely—new gigawatt-scale nuclear; advanced nuclear technologies; fusion; financing; skills; regulation; and decommissioning and waste management—the repeated requirement from witnesses from across the nuclear industry was for a much clearer and more concrete strategic plan, and one which involved commitments from a wide range of stakeholders.

21) Therefore, a core recommendation of our inquiry is that the Government should develop and publish a clear Nuclear Strategic Plan, which:

- includes decisions needed in the short, medium and long term;
- contains specific dates at which decisions will be made, and what information is needed for those decisions to be made;
- is drawn up in conjunction with the relevant organisations in the nuclear industry, and is jointly-owned by all, in the manner of the Nuclear Sector Deal; and
- has the support of Parliament as a whole and stakeholders outside the Government in order to agree a set of policies which go beyond the lifetime of any single administration, as is required given the 60-year plus life of many of the decisions required to be made.

22) We recommend that such a comprehensive Nuclear Strategic Plan should be drawn up, consulted upon and agreed before the end of the current Parliament in 2024.

A clearer role of Great British Nuclear

23) A new nuclear body, Great British Nuclear (GBN), was announced in April 2022 to help new nuclear projects through to deployment. In March 2023, the Government confirmed that GBN would come into existence imminently and would be initially tasked with running a competition to select small modular reactor designs.

24) A common theme of evidence to our inquiry was ambiguity as to what GBN's role would be. Simon Bowen—since appointed interim chair of GBN—told us that GBN requires statutory powers. In May 2023, the Government announced, during the second reading of the Energy Bill 2022–23, that it would amend the Bill to provide GBN will the powers it required to support the UK's nuclear industry. We are pleased to see this progress, as during our Inquiry the Government had not been able to provide us with any clarity on GBN's role or how it would be set up.

25) Having said this, there is still ambiguity over what GBN's exact remit will be in the future, beyond running a SMR competition. We recommend that the Government should set out a more comprehensive statement of GBN's remit, operational model and budget, and its intended role with respect to ministers and government departments. Within this detail, the Government should clearly define what the role for GBN will be on supporting new nuclear projects beyond the initial SMR competition, including in relation to gigawatt size projects beyond Sizewell C and AMRs.

Clarity on future gigawatt-scale nuclear

26) There is ambiguity over what proportion of the Government's 24 GW target by 2050 will be met by new gigawatt-scale power plants, as opposed to advanced nuclear technologies.

27) The National Infrastructure Commission has previously said the Government should only support one additional large-scale plant before 2025, after Hinkley Point C. Simon Bowen, on the other hand, said that there should be three more and that a fleet approach offers value for money.

28) The Government should provide greater clarity on the mix of reactor technologies it expects to deploy to meet its 24 GW aim—whether gigawatt- scale, SMRs or AMRs. Very large-scale plants require very significant financing and the timeline of when they are planned to be built will be important. In addition, major decisions on the part of multiple organisations and companies will depend on whether there is a dependable and foreseeable stream of new build over the next 25 years. This has vital implications for cost and the establishment of a bigger nuclear supply chain.

29) If the intention is that there should be multiple new gigawatt-scale reactors, the Government needs to come to a decision on whether it will favour serial versions of the same technology—with the benefit of knowledge and resources being transferable from

one project to another—or to favour the competitive dynamic and greater resilience to type failure that would come from deploying different technologies. A Nuclear Strategic Plan must set out clearly the resolution of both questions.

Life extensions should be granted to existing reactors where safe

30) During the hiatus that is inevitable before new nuclear power can contribute to the UK's energy supply, it is possible that the lives of some of the existing fleet of nuclear reactors could be safely extended. The functioning AGR's are requiring more regular maintenance and safety inspections, and no life extensions could be contemplated without a rigorous safety case provided to and accepted by the Office for Nuclear Regulation (ONR). EDF announced in March 2023 plans to extend the lives of two of the remaining five nuclear power stations—Heysham 1 and Hartlepool—until early 2026 rather than March 2024 as planned.

31) We believe that it is reasonable for EDF to seek life extensions to extend their contribution to the grid if, and only if, the ONR's judgement is that they can be operated safely, as is currently the case. A Nuclear Strategic Plan should spell out how the current reactor fleet, through life extensions, will contribute to the Government's ambitions of 24 GW from nuclear by 2050.

A strategic plan for small modular reactors and advanced modular reactors

32) SMRs are a type of nuclear reactor that are intended to be largely prefabricated at dedicated manufacturing facilities and then assembled at approved sites. This form of construction is anticipated (with replicated use) to cut the costs of nuclear construction, reduce the risks of overruns, and—because of this and their smaller capital outlay—make the reactors easier to finance commercially at a time when gigawatt-scale reactors have proved too much for commercial balance sheets to bear.

33) SMRs have not yet achieved commercial deployment. But in the UK, the Government has decided to invest £210 million, alongside £280 million contributed by commercial funds, to a consortium—Rolls-Royce SMR—with the intention of developing the design to generic design assessment (GDA) approval, the process for which it entered in March 2022. The Rolls-Royce SMR design would have a generation capacity of 470 megawatt (MW) per reactor.

34) The Rolls-Royce SMR consortium in evidence to our inquiry said that if it received a contract from a customer by the end of 2023, it could have reactors contributing electricity by 2031–2. Other companies have criticised the Government's decision to award research funding only to Rolls-Royce SMR—albeit following a competition—rather than a wider range of potential suppliers.

35) GBN has been tasked with running an exercise to choose between alternative SMR propositions—including Rolls-Royce SMR and its competitors. At this stage it is unclear what contribution the Government expects SMRs to make to its 24 GW target.

36) In developing a Nuclear Strategic Plan the Government should answer the questions of:

- what deployment of SMRs it wants to see, if any;
- what technologies and vendors it intends to deploy, and whether they will be from a single supplier or multiple suppliers;
- what sites should SMRs be located at; and
- what financial model would be used to pay for the contribution of SMRs to electricity supply?

37) Each of these questions will require a clear answer if vendors are to be able to take decisions on whether and when to take the next steps towards eventually deploying SMRs.

38) AMRs also offer important advantages in terms of cost and the potential for co-generation. But if they are to advance, the research and development needs to move from the desk and the lab towards demonstrators, and this will require the Government to make decisions as to which technologies to fund. The Government should continue its support for the AMR Research, Development and Demonstration programme and ensure that it takes decisions on funding particular technologies and projects without delay, so that it keeps pace with competitors.

Financing nuclear power

39) Gigawatt-scale nuclear projects cost tens of billions of pounds to plan and construct before a single unit of electricity is generated. Their long period of construction, complexity, and subordination to potentially variable regulatory standards have been associated with large cost-over runs and delays. For all of these reasons, and more, the financing of gigawatt-scale new nuclear power has proved formidably challenging. Most civil nuclear nations have built new nuclear power stations on the public sector balance sheet, as did the UK for all of its existing nuclear power stations. Hinkley Point C has been financed off the Government balance sheet by the French Government-owned utility EDF and Chinese CGN. Its construction is proceeding in return for a 35 year Contract for Difference (CfD) fixed at £92.50/MWh in 2012 prices. The conceived cost of construction has increased from £18 billion at the time of the final investment decision to £32 Billion in 2023 and its completion date is now forecast to be 2027, around two years after EDF's estimate at the time of Final Investment Decision (FID). It is important to note that the estimates of that cost overrun as result of the CfD model are not to be met by UK consumer or taxpayer, but by the companies. The CfD runs for 35 years from start-up during the 2025–2029 period. If the plant is not generating electricity by 2029 then the contract would be shortened by one year up until 2033 after which the contract will be cancelled and EDF will not receive any top-up revenues from the CfD.

40) Given the demonstrated unwillingness of private investors to take on all of the construction risk of gigawatt scale nuclear plants through the CfD model, it is inevitable that a public-private risk sharing model should be contemplated if new gigawatt-scale

plants are to be constructed. The Regulated Asset Base (RAB) model—which has been given Royal Assent in the Nuclear Energy (Financing) Act is one such. However, the model entails significant uncertainties and downsides. Chief among these is that although the financing of a plant should be cheaper in headline terms than a model in which the private sector shoulders all construction risk, the extent to which this represents value for money depends on the financial value of the construction risk being absorbed by the public balance sheet. The consumer or taxpayer is taking an unknown and uncertain risk of cost overruns, yet disburses funds from day one without earning a return.

41) The Government should show how this offers value for money to taxpayers and should be open to other alternative partnerships between the public and private sectors as practised in other countries. The choice to proceed with gigawatt-scale nuclear power should not be made without robust estimates of its value for money, including the financial value of the construction risk being assumed by taxpayers or billpayers. A headline lower cost than Hinkley Point C is not justified if the value of the risk is too great. This is true even if it forces a conclusion that—for all its other advantages—gigawatt scale new nuclear is not financeable on defensible terms, and that the UK's nuclear ambition would need to be pursued through other nuclear technologies.

42) So far, the Government has not published financial figures which allow the cost of this risk transfer to be known. The Government must publish figures, before signing contracts for new gigawatt-scale nuclear, which allow a proper assessment of value for money to be made, including setting out the level and potential cost of construction risk to be borne by the consumer or taxpayer.

43) It may be the case that the size of capital outlay means that private investors will not repeat a CfD contract for new nuclear, whatever the price. But the lack of alternative choices should not mean that any terms will be acceptable for a RAB financed plant. The Government should make, and disclose, its best estimate of the value of the risk that would be taken on by the public, and a clear plan of how those risks can be managed through incentives during the development, construction and operational phase of the project's lifetime.

44) The Government should publish details of how the estimated savings from using the RAB model for funding Sizewell C were calculated, and provide clarity for the funding structure, by publishing the Heads of Terms for the agreed RAB funding model for that project.

A strategic plan for nuclear skills

45) Even without new nuclear builds, the nuclear industry needs to recruit or train 50,000 new employees over the next 20 years, as a relatively older workforce retires. And if the Government's 24 GW target is to be met, the current workforce of over 65,000 people will need to more than double, requiring between 75,000 and 150,000 new recruits.

46) Careers in the nuclear industry are well paid—the average salary in 2021 was £47,000, 80% higher than the UK's average salary. Work is focused in areas of the country where pay and employment is lower—40% of civil nuclear jobs are located in the 25% most deprived local authority areas.

47) The nuclear sector offers very attractive prospects for good careers with longer term security than exists in most industries. People who work in the nuclear industry find their roles rewarding and stimulating, although we heard evidence of the sector having an "image problem" in the competition for STEM qualified graduates and trainees, compared with well-known employers in the tech sector and sectors such as advanced automotive. The stalled history of nuclear new builds prior to Hinkley Point C may also have contributed to the nuclear sector not being considered by some potential recruits as a destination of choice.

48) Attracting and training the workforce which is required to meet the Government's ambition for nuclear, needs co-ordinated actions by the whole sector: Government, existing nuclear operators, developers, regulators and educational institutions. The Nuclear Skills Strategy Group—which brings together many of the employers in the industry—has produced a strategic plan for what recruitment and training is needed in the future and how a workforce (which is predominantly male and white) can draw on a wider pool of talent.

49) As with the Government's strategy, we have now reached the point in which high level goals need to be turned into specific commitments by individual organisations by particular dates.

50) Many of the skills that are needed in the sector are not specifically 'nuclear skills' but rather expertise and experience with more general applications, such as those in construction project management and engineering. We heard evidence that the nuclear industry should be more open to bringing in people with such skills from other sectors—not only to expand the range of talent available, but also to guard against the risk that the nuclear industry becomes too insular and impervious to different ways of doing things.

51) Much of the training of new nuclear recruits to nuclear jobs will be done through apprenticeships. In such cases there needs to be close working between employers and colleges, including the National College for Nuclear, to ensure that the curriculum is developed, and its development properly resourced, in advance of need and so in advance of the payment that comes through student enrolment.

52) If the nuclear sector is to expand it will also require more graduates and highly qualified workers. Witnesses to our inquiry were concerned that the current output of graduates and postgraduates with expertise in nuclear technologies was not adequate to the needs of the industry, even before expansion of the sector. Universities and other higher education and research institutions should be engaged as part of a clear and specific strategic plan to ensure that the capacity is in place to provide the necessary courses, to be able to deliver the expertise needed to meet the Government's strategic objectives.

Decommissioning

53) Previous decades of mismanagement of nuclear decommissioning in the UK—from inadequate provision for decommissioning costs, to record keeping so negligent as to have left ponds of radioactive waste whose content in unknown—has made the responsibilities of the Nuclear Decommissioning Authority (NDA) some of the most challenging, complex and consequential of any organisation in Britain today. The NDA has made progress in the last five years in simplifying its structure, making more credible estimates of the costs of decommissioning, and replacing complex and opaque subcontractor arrangements with more straightforward ones. The vast annual budget for the NDA—necessarily between £3.5 billion and £4 billion—and the critical importance of its work means that the performance of the NDA must be kept under close review by the Government and Parliament, and that it should have a strong relationship with the Department for Energy Security and Net Zero, the Treasury and the Prime Minister's office.

54) The experience and expertise which the NDA has in civil nuclear decommissioning is more than any other country in the world, as a result of the UK being the world's first civil nuclear nation. The NDA's expertise's can be deployed globally, as countries who were later in constructing civil nuclear power stations than the UK seek to safely and economically decommission their reactors. This is a tremendous export opportunity for the UK's expertise which can raise revenue for the NDA and therefore taxpayers.

55) The NDA should establish, with the involvement of Government, a long-term plan to expand this international work while maintaining a thorough and dependable service within the UK.

56) Most of the nuclear waste that the UK must safely handle and dispose of has already been produced by previous nuclear installations. The incremental waste generated by new nuclear power plants is not likely to be a material factor in decisions on approving new gigawatt-scale plants. We note, however, evidence presented to us which indicated that SMRs and AMRs would produce waste which may require different handling.

57) It is imperative that a clear understanding of the waste consequences of new nuclear technologies, how it will be dealt with, and at what cost, should be part of the decision-making on whether or not to deploy these technologies.

1 Introduction

1. The UK's current nuclear power capacity is around 5.5–6 gigawatts (GW),[3] enough to generate 15% of our electricity needs. Yet all but one of the UK's nine currently operational civil nuclear reactors are scheduled to be shut down by 2028.[4] Predicted increases in electricity requirements due the decarbonisation of sectors such as transport,[5] and the commitments of the Net Zero Strategy,[6] require the UK to significantly increase its capacity for low-carbon electricity generation.

2. In April 2022 the Government set out its aim to increase domestic energy production in the Energy Security Strategy.[7] As part of this strategy, the Government said that it aimed to provide up to 25% of the UK's electricity from nuclear energy generation by increasing nuclear capacity from around 5.5 GW in 2022,[8] to 24 GW by 2050.[9]

3. We heard in our inquiry that a range of nuclear technologies, currently at various stages of technical readiness, could contribute to the UK's nuclear capacity targets.[10] In addition to well established gigawatt-scale reactor technologies (of which the European Pressurised Water Reactors (EPR) being built at Hinkley Point C is an example),[11] new technologies such as small and advanced modular reactors (SMRs and AMRs), are being developed.[12] However, there remains uncertainty on the precise mix of technologies and deployment timescales that will make up the future UK nuclear new build programme.[13]

Our inquiry

4. We launched an inquiry to examine how the Government could achieve the ambitions for nuclear energy that were set out in its Energy Security Strategy. We sought views on: what Government support would be required to establish new nuclear projects and ensure that the UK's electricity supply was not impacted by the high proportion of reactors scheduled for decommissioning; the challenges associated with bringing new technologies such as SMRs and AMRs to the grid; and how the UK should improve its approach to handling both legacy and new nuclear waste.

3 This value is based on the combined capacities of: Hartlepool, Heysham I, Heysham II, Torness and Sizewell (B). At any one time, the UK's nuclear output might be lower due to reactor shutdowns.
4 Current nuclear reactor capacity in the UK is approximately 5.5 GW. The only current reactor expected to remain operational after 2028 is Sizewell B with a capacity of 1.2 GW; *Nuclear Energy (Financing Bill) 2021–22*, Briefing Paper CBP9356, House of Commons Library, January 2022
5 McKinsey & Company, Global Energy Perspective 2022, Executive summary p 10
6 Department for Business, Energy and Industrial Strategy, Net Zero strategy: Build Back Greener, 19 October 2021, p 19
7 HM Government, British Energy Security Strategy, 7 April 2022
8 Q60
9 HM Government, British Energy Security Strategy, 7 April 2022, p 21
10 For example see: National Nuclear Laboratory (NCL0040); Rolls-Royce SMR Limited (NCL0021); Last Energy (NCL0015); MoltexFlex (NCL0038); Tokamak Energy Ltd (NCL0039); First Light Fusion (NCL0031); Terrestrial Energy (NCL0046)
11 EDF, The reactor at Hinkley Point C, accessed 30 March 2023
12 The Government is providing support for developing these technologies in the nuclear and fusion sectors through national laboratories, grants and technology competitions.
13 National Nuclear Laboratory (NCL0040); Nuclear Futures Institute, Bangor University (NCL0011); Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010)

5. We have published over 75 written submissions to the inquiry's call for evidence, and took oral evidence from 35 witnesses from the UK and around the world, including academics, business leaders from the nuclear industry, representatives from nuclear sector public bodies, the industry advisor for Great British Nuclear, and the Minster for Energy and Climate, Rt Hon Graham Stuart MP. We visited Culham Science Centre to learn about the fusion technologies and companies that are being developed there and visited the Hinkley Point C nuclear power plant currently under construction in Somerset. To assist us with our work, we appointed Joshua Buckland, Partner at Flint Global and former Energy Adviser to the Secretary of State for Business, Energy and Industrial Strategy (2018–19), as a Specialist Adviser for our inquiry.

Key definitions for the nuclear sector

6. Before we present the findings of our inquiry, this section describes some of the key technical terms that are relevant to the nuclear sector.

Nuclear fission reactors

7. Nuclear reactors work by harnessing the energy produced in a fission reaction to produce heat. Fission occurs when a heavy nucleus, normally Uranium-235, absorbs a free neutron and becomes unstable, causing it to split apart. The splitting (fission) of uranium produces fission products, including more free neutrons and energy. In a nuclear reactor, the free neutrons produced by one fission event can collide with more uranium, creating a chain reaction that releases large amounts of energy. This energy, in the form of heat, is used to generate steam which turns a turbine to produce electricity.[14]

Reactor generations

8. Nuclear reactor designs can be categorised by successive "generation-types" which is defined by key technical and safety features of the reactor.

- **Generation I** included the UK's first commercial reactor design, known as the Magnox reactors, as they used a **Mag**nesium **n**on-**ox**idising alloy to clad the fuel rods. 26 of these reactors were built at 11 sites between 1956 and 1971. All have now been shut down with the last, Wylfa Unit 1 taken offline in 2015;[15]

- **Generation II** reactors include all currently operating commercial nuclear reactors in the UK. They include pressurised water reactors (PWRs), such as the reactor used at Sizewell B, and the eight advanced gas-cooled reactors (AGRs), located at Hartlepool, Heysham and Torness, which make up the rest of the UK fleet;[16]

- **Generation III and III+** are advanced PWRs that have improved safety features, higher fuel efficiency, and take less energy to run. Generation III+ are essentially the same as Generation III reactors but with enhanced safety features. Most SMRs and the new reactors currently under construction use Generation III or III+ designs; and

14 *Nuclear Energy (Financing Bill) 2021–22*, Briefing Paper CBP9356, House of Commons Library, January 2022
15 World Nuclear Association, Nuclear Development in the United Kingdom, last updated October 2016
16 World Nuclear Association, Nuclear Development in the United Kingdom, last updated October 2016

- **Generation IV** reactors, are also known as AMRs which use novel coolants or fuels, and could potentially be used to provide heat or hydrogen as well as electricity.[17] Despite these reactors being conceptualised since the 2000s, they remain in the early design and research phase. Industry experts predict the first of these reactors will be built within the 2030s.[18]

Co-generation

9. Currently reactors are used to produce electricity, but the heat generated by the nuclear power plants could be used to produce a range of products such as industrial heat, desalination, and hydrogen. This is known as co-generation. Co-generation can improve the thermal efficiency of a reactor as currently around 65% of the energy is lost as waste heat.[19] EDF, the developer of Hinkley Point C and Sizewell C (covered in Chapters 2 and 6), is planning to add heat extraction capability to the proposed new reactors at Sizewell to allow for co-generation.[20] Developers of many AMRs, (see Chapter 3) are also planning to use the heat generated in their reactors for co-generation purposes.

Public bodies in the civil nuclear sector

10. A number of public bodies and Governmental departments are involved in the civil nuclear and fusion sectors. The Department for Energy Security and Net Zero (DESNZ) was established in February 2023 and took on the civil nuclear fission and fusion portfolio from its predecessor, the Department for Business, Energy and Industrial Strategy (BEIS). The new department oversees the following organisations:

- **The Nuclear Decommissioning Authority (NDA) and its subsidiary Nuclear Waste Services (NWS):** The NDA is a non-departmental public body which is responsible for overseeing the UK's nuclear decommissioning and waste management projects. The NWS, established in January 2022, is part of the NDA and is tasked with waste management and storage, including proposed geological disposal facilities (see Chapter 8);

- **UK Atomic Energy Authority (UKAEA): an** executive non-departmental public body, sponsored by DESNZ, whose core aim is to position the UK as a leader in sustainable nuclear energy.

- **Great British Nuclear (GBN):** A new body, announced in April 2022 in the Energy Security Strategy, that will "enable nuclear projects and support the UK's nuclear industry". GBN works with DESNZ and will operate through the limited company British Nuclear Fuels Limited.[21]

11. Other Governmental departments oversee the regulation of nuclear projects:

- The Department for Work and Pensions sponsors the **Office for Nuclear Regulation (ONR)**, which is responsible for regulating the safety and security

17 International Atomic Energy Agency, Advances in Small Modular Reactor Technology Developments, September 2020
18 Nuclear Industry Association (NCL0012)
19 The Royal Society, Nuclear cogeneration: civil nuclear energy in a low-carbon future, October 2020, p 6
20 Qq88–93
21 HM Government, Powering Up Britain, 30 March 2023, p 19

of the entire nuclear sector including; the existing fleet of operating reactors; fuel manufacturing and reprocessing facilities; waste management, including transport and decommissioning sites; defence sites, and the regulation of the design and construction of new nuclear facilities.

- The Department for Environment, Food & Rural Affairs (DEFRA) and in Wales, the Welsh Government, oversee the Environment Agency and Natural Resources Wales respectively, which are involved in the environmental aspects of planning nuclear construction in England and Wales respectively.

Aims of this Report

12. In this Report we assess the Government's plans for delivering a civil nuclear new build programme and make recommendations on what the Government should do to achieve this ambition of up to 24 GW of nuclear power by 2050. We also explore how the UK can improve its approach to decommissioning its legacy, current and future nuclear fleet:

- In Chapter 2 we discuss the current UK nuclear energy policy and evaluate the state of the current nuclear programme;
- In Chapter 3 we assess the merits of advanced nuclear technologies and explore their readiness for deployment;
- In Chapter 4 we explore the UK's fusion sector and examine the possible timeframe for commercialisation;
- In Chapter 5 we examine the nuclear sector's skills and supply chain requirements;
- In Chapter 6 we evaluate the funding and financing models for gigawatt-scale reactors and the inclusion of nuclear energy generation in green financing policies;
- In Chapter 7 we consider the regulatory systems for new nuclear build in the UK including provisions for siting and new reactor designs; and
- In Chapter 8 we appraise the current and future status of nuclear decommissioning and evaluate permanent disposal policies for radioactive waste.

2 The Government's aim of delivering 24 GW of nuclear power by 2050

Background: History of UK civil nuclear power

13. The world's first civil nuclear power plant was opened at Calder Hall, West Cumbria, in 1956.[22] During the seven decades since, Britain's nuclear energy policy has been characterised by intermittency.[23] Between the 1955 White Paper 'A Programme of Nuclear Power' and 1979,[24] 17 nuclear power stations were approved: ten Magnox followed by seven AGR plants. There was then a gap before Sizewell B, the PWR plant was approved in 1987 and came online in 1995.[25] The 2003 White Paper 'Our energy future - creating a low carbon economy' then abandoned the use of nuclear,[26] before another White Paper just five years later in 2008 re-introduced its use for securing the UK's low-energy energy supply.[27] This intermittent approach to nuclear policy caused a further 21-year gap before another nuclear new build was approved—the EPR at Hinkley Point C was approved in 2016 but is not due to come online until 2027.[28] Since then, discussions about building new reactors at Wylfa on Anglesey and at Moorside in Cumbria foundered. However, the Government is now in negotiations over a second EPR facility at Sizewell.[29]

14. The legacy of this intermittent history is that the UK's nuclear power supplies will fall substantially by 2028, even if life extensions currently being discussed are authorised. In 2021 the UK generated about 15% of its electricity requirements from about 5.5 GW of nuclear capacity.[30] As of Spring 2023, the UK had nine operational reactors in five power plants (Table 1 summarises the UK's current civil nuclear reactor fleet), eight of which were expected to be permanently shut down by 2028, leaving a capacity of around 1.2 GW.

22 Calder Hall was a dual-purpose nuclear power plant which supplied the first nuclear power for the National Grid (in addition to producing plutonium for military purposes).
23 Cf. Tony Wooldridge and Stephen Druce, *Golden Egg or Poisoned Chalice? The story of nuclear power in the UK* (Northampton, 2019) pp 1–10
24 HM Government, A Programme of Nuclear Power, 1955
25 Nuclear Decommissioning Authority, Fact sheet: operating a nuclear power reactor, accessed 9 June 2023
26 Department of Trade and Industry, Our energy future - creating a low carbon economy, 24 February 2003
27 Department for Business, Enterprise & Regulatory Reform, Meeting the Energy Challenge, January 2008
28 Department for Business, Energy & Industrial Strategy, Government confirms Hinkley Point C project following new agreement in principle with EDF, 15 September 2016
29 BBC News, Sizewell C nuclear power plant backed by government, 29 November 2022
30 Q60

Table 1: Current UK nuclear power plants

Location	Reactor Technology	Reactor Generation	Capacity (MWe)[31]	First Power	Expected Shutdown
Hartlepool	Advanced gas-cooled Reactor (AGR)	Generation II	595 & 585	1983 & 1984	2026
Heysham I	Advanced gas-cooled Reactor (AGR)	Generation II	580 & 575	1983 & 1984	2026
Heysham II	Advanced gas-cooled Reactor (AGR)	Generation II	2 x 610	1988	2028
Torness	Advanced gas-cooled Reactor (AGR)	Generation II	590 & 595	1988 & 1989	2028
Sizewell (B)	Pressurised Water Reactor (PWR)	Generation II	1198	1995	2035

Source: *Nuclear Energy (Financing Bill) 2021–22*, Briefing Paper CBP9356, House of Commons Library, January 2022; EDF energy, Nuclear reactor lifetime management, accessed March 2023

UK energy needs

15. Several factors have led the Government to consider its approach to securing the UK's future energy supplies. These include:

- the UK's legal commitment to net zero greenhouse gas emissions by 2050;
- worries about the security of imported fossil fuels, heightened by the consequences of Russia's invasion of Ukraine; and
- the predicted shift toward electricity as the primary form of energy supply. In the UK, energy used in the form of electricity (as opposed to other fuels such as oil and natural gas) is expected to grow from approximately 29% (in 2019) to 51% by 2050.[32] This is partly due to electrification of sectors such as heating and transport, as the UK and much of the world seeks to reduce its reliance on fossil fuels.

16. The Government's response, in its Energy Security Strategy, published in April 2022, is to aim to achieve 24 GW of nuclear capacity by 2050, which would account for 25% of the UK's electricity demands.[33] The Strategy highlighted that nuclear power would play a key part in supplying the UK with 'baseload' electricity.

31 Unit of power—megawatt equivalent.
32 McKinsey & Company, Facing the future: Net zero and the UK electricity sector, 10 February 2022
33 HM Government, Energy Security Strategy, 7 April 2022

17. The majority of contributors to this inquiry said that nuclear is a suitable source of the UK's electricity needs as it can provide low-carbon 'baseload' energy.[34] Unlike intermittent renewables such as wind or solar, once a nuclear reactor is up and running it produces consistent electricity supplies.[35]

18. Some witnesses told us that nuclear should be part of the UK's broad mix of low-carbon energy sources but said that nuclear would need to provide a flexible energy output if it were to accommodate renewables.[36] Whilst advanced nuclear technologies are expected to be able to 'load-follow'[37] and therefore provide variable levels of electricity output,[38] in his oral evidence, Dr Paul Dorfman, described the inability of current nuclear reactors to vary electricity output as a limitation of current nuclear technologies.[39]

19. Whilst the combination of nuclear power for baseload electricity, the use of intermittent renewables, and the electrification of fossil fuel-based industries, could help to reduce the UK's reliance on countries such as Russia, the UK might inadvertently create other unfavourable dependencies. Solar photovoltaic (PV) plants, wind farms and electric vehicles (EVs) will require critical minerals, such as nickel, copper, lithium, and cobalt, to build.[40] There are already concerns about the UK's supplies of critical minerals, especially as China dominates the critical mineral market, refining 68% of nickel globally, 40% of copper, 59% of lithium, and 73% of cobalt.[41] The UK must ensure that by moving away from reliance on certain countries for fossil fuels, it does not create dependencies on other countries that could be problematic and risk the UK's energy security and independence.

20. The case for gigawatt scale nuclear made by the Government in its Energy Security Strategy is partly about attaining net zero and partly about increasing the security of our domestic energy security supplied. However, the security contribution has to take into account the question of fuel supply (discussed at the end of this Chapter). It is also the case that the concentration of power generation in a small number of very large facilities means that were there any future malign activity by a hostile actor to target one or more of these plants, the impact on our resilience would be concomitantly greater than a more distributed system of smaller capacity generators, whether nuclear, renewables, or fossil fuel.

34 Baseload is the permanent minimum load that a power system is required to deliver. Historically baseload has been supplied by fossil fuels and nuclear which are sometimes described as "continuous power" (though all generators are prone to outages). Baseload is also known as firm or dispatchable power.

35 NNB GenCo (SZC) Limited (NCL0049); Dassault Systems (NCL0002); Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010); Imperial College London (NCL0026); Rolls-Royce SMR Limited (NCL0021)

36 Imperial College London (NCL0026); Nuclear Futures Institute, Bangor University (NCL0011); Nuclear Industry Association (NCL0012); Henry Royce Institute (NCL0030); Prospect Trade Union (NCL0013)

37 Load-following is a when a power station can adjust its power output as demand for electricity fluctuates throughout the day.

38 Nuclear Industry Association (NCL0012)

39 Q46

40 International Energy Agency, The Role of Critical Minerals in Clean Energy Transitions, accessed 9 June 2023

41 The Times, Who owns the Earth? The scramble for minerals turns critical, 1 May 2022; International Energy Agency, The Role of Critical Minerals in Clean Energy Transitions, accessed 9 June 2023; Statista, Production share of critical minerals worldwide as of 2022, by majority producing country, January 2023

21. A view expressed within the Committee was that the justification of new nuclear power as contributing to the UK's target of net zero greenhouse gas emissions by 2050 amounted to basing an extremely costly policy on an inappropriate foundation. In making our recommendations we repeat the call that we made in our report on *The Role of Hydrogen in achieving Net Zero* for the Government to publish an assessment of the cost of achieving net zero by 2050.[42]

The power gap

22. All civil nuclear reactors in the UK (see Table 1, above) are operated and majority owned by France's state-owned EDF which operates in the UK under the subsidiary EDF Energy.[43] All but one of these reactors is scheduled to come offline and begin the process of decommissioning by 2028.[44] This will result in a large drop in carbon-free electricity production by 2028, which is in the context of a predicted increase in UK electricity demand by that year.[45]

23. The 2022 Public Accounts Committee report, 'The Future of Advanced Gas-Cooled Reactors', highlighted that despite the decommissioning dates having been known for decades, energy generation will "significantly reduce" before new nuclear reactors are operational.[46]

24. In its written evidence, EDF argued that there would be a need for non-renewable sources of energy in the UK to replace the role of nuclear reactors. It said:

> The UK's electricity supply has sufficient capacity to meet demand in the short-term. However, the issue will be that loss of zero carbon nuclear from the grid means that gas-fired generation will be called on to fill the gap until new nuclear is available. This means a short-term upsurge in [carbon dioxide] emissions per [kilowatt hour (kWh)], and an increasing exposure of the UK electricity market to prices set in global gas markets.[47]

25. In early February 2022, the Permanent Secretary for the then BEIS, Sarah Munby, told the Public Accounts Committee that the Government was not concerned about electricity capacity as it would use the capacity market,[48] to buy electricity ahead of time.[49] However, since Russia's invasion of Ukraine, the security of the UK's energy systems has been called into question.[50]

42 Science and Technology Committee, Fourth Report of Session 2022–23, The role of hydrogen in achieving Net Zero, HC 199, para 7
43 Centrica Plc has 20% interest in the operational UK nuclear power generation fleet.
44 All but one of these reactors are Generation II advanced gas-cooled reactors (AGR), a design specific to the UK. Sizewell B, the most recent nuclear powerplant to be built in the UK, is a pressurised water reactor (PWR) a type of Generation II+ light water reactor. Details of reactor generations can be found in Chapter 1.
45 McKinsey & Company, Global Energy Perspective 2022, Executive summary, p 10
46 Public Accounts Committee, Third Report of the Session 2022–23, Future of the Advanced Gas-cooled Reactors, HC118, para 4
47 EDF Energy (NCL0057)
48 A Government policy created as part of the Electricity Market Reform in the Energy Act 2013. The market involves a competitive auction and successful bidders are paid to provide extra capacity to the grid if necessary.
49 Oral Evidence taken before the Public Affairs Committee on 7 February 2022, HC 1050, Q7 [Ms Munby]
50 HC Deb, 5 July 2022, col 309WH, [Westminster Hall]

26. We acknowledge that it is too late to replace the UK's nuclear capacity before the shutdown of the majority of the UK's fleet. When we asked what lessons can be learned from the near simultaneous loss of capacity Professor Laurence Williams OBE, Emeritus Professor of Nuclear Regulation and Safety at Imperial College London, told us:

> Going forward, you need to have a long-term strategic plan as to how you are going to use nuclear energy, so that you do not get in the situation where you will shut them all down at one time over a very short period without having something else to take over from them.[51]

Life extensions

27. The operational life of a nuclear reactor can be extended beyond its original predicted technical lifespan. All current AGRs are operating within a life extension period, with all expected to be shut down by 2028. Further life extensions are unlikely to be granted for operation past this date. The pressurised water reactor at Sizewell B, is still operating within its original lifespan and is the only reactor currently generating power that is expected to remain operational after 2028. EDF is expecting to extend the life of Sizewell B, by an additional 20 years to 2055.[52] Despite this, the UK will still see a large drop in the nuclear power output due to the AGR reactors that are coming offline by 2028. Mark Foy, Chief Executive and Chief Nuclear Inspector at the ONR, told us that life extensions were only granted if the operator could prove a safety case:

> We are looking to ensure that at all times the reactors can be safely shut down. EDF is considering—it is EDF's decision—whether it wants to make the case for lifetime extension. We have been very clear with EDF that we will consider any case it wishes to make with regard to extending the life of the current fleet of operating reactors, but we will be looking for that really clear justification that they can continue to be safely operated.[53]

28. The feasibility of plant lifetime extension also depends on whether the nuclear operator decides it is economically viable to continue running a nuclear power plant. Some stakeholders recommended that, to maintain energy security, the Government should intervene and subsidise operating the power plants to ensure the life of current reactors could be extended if safe to do so.[54] A spokesperson for EDF, responding to the Public Accounts Committee report, said it would only consider delaying the decommissioning of the reactors currently offline if the Government asked directly.[55]

29. When we asked if the Government had asked EDF to delay decommissioning, Paul Spence, Director of Strategy and Corporate Affairs for EDF, said that there had been no more conversations regarding the possible reactivation of the three AGRs: Hunterston, Hinkley Point B and Dungeness B.[56] He also told us that, whilst possible, it was not economically viable to restart reactors that had begun the decommissioning process.[57]

51 Q37
52 EDF Energy (NCL0057)
53 Q421
54 Nuclear Futures Institute, Bangor University (NCL0011); Prospect Trade Union (NCL0013); Assystem (NCL0025); Jacobs UK (NCL0034); Professor Stephen Garwood (NCL0009)
55 New Civil Engineer, MPs call for decommissioning delay for UK's ageing nuclear power stations, 20 May 2022
56 Q63
57 Q62

30. In March 2023, EDF announced plans to extend the lives of two of the UK's five remaining nuclear power stations. Heysham 1 and Hartlepool had been due to close in March 2024,[58] but they will now be kept open until early 2026.[59]

31. **We conclude that it is reasonable for EDF to seek life extensions to extend their contribution to the grid if, and only if, the Office for Nuclear Regulation's judgement is that they can be safely operational as is currently the case.**

32. ***The new Nuclear Strategic Plan, that we recommend, must spell out how the current reactor fleet, through life extensions, will contribute to the Government's ambition of 24 GW from nuclear by 2050.***

Policy for new nuclear

33. The Government's Energy Security Strategy, published on 7 April 2022, set out the following goals for building new nuclear fission plants:

- Achieve up to 24 GW of electricity from nuclear by 2050 (three times current output), providing around a quarter of the UK's electricity supply;
- Take one project to Final Investment Decision (FID) in this Parliament and two projects in the next Parliament, including SMR; and
- Progress up to eight new reactors by 2030, therefore delivering "the equivalent" of one reactor a year, instead of one per decade.[60]

34. Since February 2023, the newly formed DESNZ is overseeing the delivery of the Energy Security Strategy.

35. Many witnesses welcomed the ambition of achieving 24 GW of energy from nuclear by 2050.[61] However, they also acknowledged that delivering this target would be challenging and would require policy and financial support from the Government.[62] The Nuclear Futures Institute at Bangor University wrote:

> The current stated UK Government goal of having 24 GW of nuclear power by 2050 (25% of the predicted UK energy needs) presents a considerable challenge. The 24 GW of nuclear power is almost double the nuclear installed capacity the UK has achieved in the past, which peaked at 12.96 GW in 1999.[63]

58 Q63
59 EDF Energy, EDF confirms plans to keep turbines turning at Heysham 1 and Hartlepool power stations, 9 March 2023
60 HM Government, British Energy Security Strategy, 7 April 2022, p 21
61 Nuclear Futures Institute, Bangor University (NCL0011); Prospect Trade Union (NCL0013); Henry Royce Institute (NCL0030); Jacobs UK (NCL0034); Nuclear Innovation & Research Advisory Board (NCL0042)
62 Nuleaf (Nuclear Legacy Advisory Forum) (NCL0022); North West Nuclear Arc (NCL0023); Nuclear Futures Institute, Bangor University (NCL0011); Jacobs UK (NCL0034); EDF Energy (NCL0057); Urenco (NCL0055); University of Bristol (NCL0051); National Nuclear Laboratory (NCL0040)
63 Nuclear Futures Institute, Bangor University (NCL0011); World Nuclear Association, Nuclear Power in the United Kingdom, updated April 2023

36. The National Audit Office report on 'Decarbonising the power sector' found that the Government had set "stretching ambitions" for delivering new nuclear power,[64] that would need multiple new reactors to be deployed quicker than has previously been achieved in the UK.[65]

37. The nuclear industry specifically stressed the need for a detailed delivery plan,[66] with proposed projects, timelines and policy support.[67] The North West Nuclear Arc, a cluster of nuclear academic, industry and construction stakeholders based in the North West of England, warned in its written evidence that, without a detailed delivery plan, the Government's aims for nuclear energy were unlikely to be achieved.[68] This view was supported by the trade union Prospect, which represents nuclear industry professionals, which wrote:

> We therefore welcome the targets for nuclear power set out in the British Energy Security Strategy published earlier this year. The government's commitment to deploy up to 24 GW of nuclear capacity by 2050, which could provide a quarter of our electricity needs, is the right scale of ambition given the energy challenges we face. We also welcome the government's aim to approve up to eight new nuclear reactors by 2030 and the establishment of the GBN vehicle to support this goal.
>
> However, our central message to the committee is that ambitious targets must be backed up by equally ambitious strategies to achieve them. We are concerned that the government lacks a comprehensive plan to deliver the promised new generation of nuclear power at the speed and scale required.[69]

38. In his oral evidence, Professor Michael Grubb, Professor of Energy and Climate Change at University College London, described the Energy Security Strategy as a "wish list":

> I must admit that I and several colleagues looked at that and thought, "Yes, we've read this before. We've read these ambitions on nuclear power several times before." There is nothing in it really about whether or how it could credibly deliver and overcome the problems encountered in the past. It was just the wish list that we had seen before, as far as I could tell.[70]

39. When we questioned the then Minister for Energy and Climate, Rt Hon Graham Stuart MP, on the Government's continued commitment to the aims set out by the Energy Security Strategy, he acknowledged that he could not guarantee they would be reached:[71]

64 National Audit Office, Decarbonising the power sector, Session 2022–23, HC 1131, 1 March 2023, p 5
65 National Audit Office, Decarbonising the power sector, Session 2022–23, HC 1131, 1 March 2023, p 8
66 Jacobs UK (NCL0034); Urenco (NCL0055); Cwmni Egino (NCL0005); Civil Engineering Contractors Association (NCL0008); Nuclear Futures Institute, Bangor University (NCL0011); Prospect Trade Union (NCL0013)
67 Nuclear Futures Institute, Bangor University (NCL0011)
68 North West Nuclear Arc (NCL0023)
69 Prospect Trade Union (NCL0013)
70 Q18
71 Q476

> […] I am not saying that we will definitely have 25% of our electricity from nuclear. That is our ambition; that is our thinking; but as technology, prices and the economics develop, we want tensions between these technologies to deliver it.[72]

40. On 30 March 2023, the Government published 'Powering up Britain: Energy Security Plan,' that set out its key commitments on nuclear. In it the Government said it would:

- Deliver a programme of new nuclear projects beyond Hinkley Point C and Sizewell C.
- Set up GBN, with the responsibility to lead delivery of the new nuclear programme, backed with the funding it needs.
- Launch a competitive process to select the best SMR technologies, with the first phase commencing in April 2023; and
- Support the development of advanced modular reactors through the Advanced Nuclear Fund to support a demonstration by the early 2030s.[73]

The plan did not give full details on the project pipeline but said that it would "comprise a mixture of technologies including SMRs, AMRs and gigawatt-scale reactors" and said that GBN will be the "arms-length body responsible for driving delivery of new nuclear projects, backed with the funding it needs".[74]

41. **Gigawatt-scale nuclear power stations use a known and well understood technology that can deliver dependable low carbon baseload electricity to the grid. Nuclear power is therefore an important option and could be used to produce a domestic supply of baseload power to the UK as part of the low carbon energy mix required to achieve the Government's goals of increasing energy security and achieving net zero by 2050. However, the question of energy security must engage with the questions of sourcing of fuel and the risks of having a concentration of generating capacity in very large plants, which could be susceptible to outages as a result of technical problems or as a target for malign actors. The Government's aim to bring up to 24 gigawatts of nuclear-powered electricity to the grid by 2050 is commensurate with its net zero ambitions but currently lacks a comprehensive plan to achieve it. We welcome the Government's intention of "building a project pipeline" of nuclear projects but agree with industry that the details of this pipeline must be published by Government, if investments in new nuclear are to proceed in time.**

42. ***Setting a notably stretching target requires a credible pathway towards its delivery. The Government should publish a clear delivery plan, a Nuclear Strategic Plan, for its nuclear project pipeline, backed up by detailed figures of projected energy production from nuclear for the years leading up to 2050, and be developed in collaboration with and engaging the confidence of the whole sector. This Nuclear Strategic Plan should include interim targets for nuclear energy production in 2035, 2040 and 2045.***

72 Q476
73 HM Government, Powering Up Britain: Energy Security Plan, 30 March 2023, p 31
74 HM Government, Powering Up Britain: Energy Security Plan, 30 March 2023, pp 31–32

Great British Nuclear

43. The establishment of a new nuclear body, GBN, was announced in April 2022 as part of the Energy Security Strategy and is charged with helping nuclear projects through the development process. In May 2022, Simon Bowen was appointed as Industry Adviser to the then BEIS and tasked with leading and helping to drive forward government proposals for GBN. A common theme of evidence to our inquiry was ambiguity as to what GBN's role would be.[75] Roles suggested by those giving evidence included:

- Providing coordination and leadership to deliver a new nuclear programme;[76]
- Deciding what technologies will be deployed in the UK and which sites will be used;[77]
- Improving the diversity of the workforce and coordinating future long-term skills for nuclear including providing centralised apprenticeships;[78]
- Managing and developing finance models for nuclear projects;[79]
- Integrating Research and Development funding with the UK's nuclear programme, providing a path to deployment for new technologies;[80] and
- Taking on the role of a developer to allow land use change from nuclear decommissioning to building new power plants.[81]

44. The above list contains a wide range of putative roles and activities for GBN. Professor Grubb, of University College London, told us that GBN appeared to have multiple yet conflicting roles.[82]

45. After his appointment as industry advisor to the proposed GBN in April 2022, Mr Bowen and his team were tasked with determining the scope and structure of the body. Within 100 days of his appointment Mr Bowen presented a report to Prime Minister Truss in September 2022 which included 25 recommendations for GBN.[83] Yet, as of 18 July 2023 Mr Bowen's report remains unpublished. When we asked what the reason for the delay was, Mr Bowen told us that it was a question for Ministers.[84]

46. **In his previous role as industry advisor to Great British Nuclear, Simon Bowen produced a report proposing what function and form Great British Nuclear should take. This report was delivered to the Government in September 2022.**

75 EDF Energy (NCL0057); Cwmni Egino (NCL0005); Environment Agency (NCL0019); Cumbria Local Enterprise Partnership (NCL0028); Cavendish Nuclear (NCL0041); Nuclear Innovation & Research Advisory Board (NCL0042); Copeland Borough Council (NCL0007); North West Nuclear Arc (NCL0023);
76 National Nuclear Laboratory (NCL0040); Q55, Q134, Q153
77 Q118, Q113
78 Q143, Q165, Q158
79 Q134
80 Cwmni Egino (NCL0005)
81 Jacobs UK (NCL0034)
82 Q26
83 Q384
84 Q396

47. ***The Government should publish the report and recommendations submitted by Simon Bowen, industrial adviser to Great British Nuclear, and his team on the purpose of Great British Nuclear, alongside the Government response to this report.***

48. Whilst his report to Government remains unpublished, Mr Bowen told our Committee the activities he expected GBN to be involved with. These were to:

i) decide where new nuclear projects are built;

ii) work with industry and the market to identify appropriate funding models for projects;

iii) facilitate collaboration within the nuclear sector to address the skills shortage; and

iv) provide technical support for policymakers on selecting reactor technologies for a new nuclear build programme.[85]

49. To achieve the above, Mr Bowen recommended that GBN should take the form of an arms-length non-departmental Government body and that legislation would be required to grant GBN the freedom it required for procuring contracts and to provide competitive salaries to staff.[86] When we asked the Minister and officials when the necessary legislation would be introduced, Declan Burke, Director for Nuclear Projects and Development at the then BEIS, told us:

> We are working with Simon [Bowen] and the team around the exact form that GBN will take and what it will mean in terms of legislative requirements. If it did require legislation, we could still get on with it in shadow form, so you could make a start without having it in place; you could have things running in parallel where legislation required.[87]

At the time, neither Mr Burke or Minister Stuart could provide clarity on when the legislation would be introduced or if it would be passed within the current Parliament.[88]

50. In addition to his recommendations on the legislation required, Mr Bowen also suggested that a single minister be appointed to hold responsibility for the UK's nuclear programme.[89] On 7 February Andrew Bowie MP was appointed as the first Minister for Nuclear and Networks within DESNZ. GBN is included in the responsibilities of the new role.[90]

51. On 15 March, in the Spring Budget 2023, the Chancellor of the Exchequer, Rt Hon Jeremy Hunt MP confirmed that the launch of GBN would go ahead.[91] The Government later stated in its Powering Up Britain: Energy Security Plan (published on 30 March 2023) that GBN would focus on delivering SMRs and launched a competition for both domestic and international vendors for SMR reactor designs (more details on this are covered in

85 Qq401–403
86 Q397
87 Q478
88 Qq478–481
89 Q408
90 Department for Energy Security and Net Zero, Parliamentary Under Secretary of State (Minister for Nuclear and Networks), accessed March 2023
91 HM Treasury, Spring Budget 2023, HC 1183 para 3.85

Chapter 3).[92] The Plan also outlined that GBN would operate *via* an existing company, British Nuclear Fuels Limited (BNFL),[93] with Simon Bowen as the Interim Chair of GBN and Director of BNFL.[94] However, neither the 2023 Spring Budget or the Energy Security Plan provided further clarity on the role of GBN after running the SMR competition, what funding had been allocated to it, or if legislation would be introduced to establish it fully.

52. Later, on 9 May 2023, during the second reading of the Energy Bill 2022–23,[95] the Secretary of State for Energy Security and Net Zero, Rt Hon Grant Shapps MP, announced that the Government would table amendments to the Bill that would:

> … provide Great British Nuclear, a new flagship body, with the power to enable nuclear projects and support the UK's nuclear industry with a specific role to support Government in rebuilding our civil nuclear industry.[96]

The amendments were tabled on 14 June 2022,[97] and a corresponding Energy Bill factsheet set out how some details of how the Government plans to legislate the role of GBN. According to the amendments and factsheet, the Energy Bill 2022–23 will grant the Secretary of State the authority to classify a publicly owned company as GBN.[98] In the factsheet the Government set out its reasons for establishing GBN as a company:

> Being a company, rather than a statutory corporation like the NDA for example, means that GBN's general powers will be derived from the Companies Act 2006. This ensures that GBN can do anything that a company can do in the nuclear sector, as long as it does so in line with objects set by government and the other provisions of the legislation. For example, GBN may set up subsidiaries to lead individual projects, which could be joint ventures with the private sector.[99]

53. The amendments also set out further details about GBN's:

- Role—GBN's statutory role will be to facilitate nuclear generation projects, according to government's policies.
- Power of direction—the Secretary of State will have the power to issue directions to GBN, after consultation with GBN has occurred. Any directions will be laid before Parliament.

92 HM Government, Powering Up Britain: Energy Security Plan, 30 March 2023 p 32
93 BNFL was originally established in 1971 and underwent multiple episodes of restructuring prior before being incorporated as a private limited company in 2004. It was a manufacturer of nuclear fuel and largely responsible for running the Magnox reactor sites. As the Magnox sites moved to decommissioning phase, the Nuclear Decommissioning Authority was established and took responsibility for BNFL's nuclear sites. BNFL has therefore been dormant since around 2010.
94 HM Government, Companies House British Nuclear Fuels Limited: People, accessed May 2023; HM Government, Powering Up Britain: Energy Security Plan, 30 March 2023 p 32; HM Government, Shapps sets out plans to drive multi billion pound investment in energy revolution, 30 March 2023
95 The Government's Energy Bill 2022–23 was introduced in the House of Lords on 6 July 2022. The Bill was introduced to the House of Commons on 25 April 2023. Second reading in the Commons took place on 9 May 2023. As of 18 July 2023, the Bill was at Report stage. For more details on the Bill see: House of Commons Library, Research Briefing: Energy Bill [HL] 2022–23: Overview, 5 May 2023
96 HC Deb, 9 March 2023, col 249 [Commons Chamber]
97 Energy Bill [HL] (Amendment Paper), Committee Stage, 14 June 2023
98 Department for Energy Security and Net Zero, Energy Security Bill factsheet: Great British Nuclear, 9 May 2023
99 Department for Energy Security and Net Zero, Energy Security Bill factsheet: Great British Nuclear, 9 May 2023

- Financial assistance—the Secretary of State will be able to provide financial assistance to GBN.[100]

54. On 18 July 2023, the Government made a long-awaited announcement on the role that GBN would take.[101] The announcement included some further details about the SMR selection process that GBN would run.[102] It said:

> There is a process currently underway to identify the best, most appropriate, SMR technologies:
>
> 1) market intelligence gathering, which concluded in June 2023
>
> 2) technology initial down selection, launched in July, concluding in Autumn 2023 with the next phase to launch as quickly as possible after that
>
> 3) successful technologies will be supported to be ready to enable a Final Investment Decision (FID) by 2029. This will entail funding to support technology development and site-specific design; a close partnership with GBN, which will be ready and able to provide developer capability; and support in accessing sites.

The announcement did not include details of any specific funding that would be allocated to the selection process, but it did say that the competition could " … result in billions of pounds of public and private sector investment in SMR projects in the UK". It was reported, however, that during GBN's launch event, the Secretary of State for Energy Security & Net Zero, the Rt Hon Grant Shapps MP, suggested that £20 billion could be invested in the roll-out of SMRs, with the Independent writing that the Government had " … floated a potential £20 billion plan backing the development of smaller scale nuclear technology projects".[103] The article went onto say that the "£20 billion is not a spending commitment but Mr Shapps indicated that the figure showed how serious ministers were about the development of the smaller, more agile, nuclear reactors".[104] The £20 billion figure was not included the official announcement by Government, suggesting some ambiguity on plans for funding SMR roll-out.

55. Aside from the SMR competition, the Government said that it remained "committed to the mega projects of Hinkley Point C and Sizewell C and will work with GBN to consider the potential role of further large gigawatt-scale nuclear power plants in the UK energy mix".

56. **The 2050 target for nuclear of 24 GW needs a plan to achieve it, which must include clarity on the bodies and institutions that will deliver it. After asking the Department to provide more clarity on what legislation will be required to ensure that Great British Nuclear can operate as intended, we are pleased to see that the Government has tabled amendments to the Energy Bill 2022–23 to include this legislation. Having said this, there are still some points of ambiguity over exactly how Great British Nuclear will**

100 Department for Energy Security and Net Zero, Energy Security Bill factsheet: Great British Nuclear, 9 May 2023
101 HM Government, AMR Research, Development and Demonstration: Phase B (2023–2025): successful organisations, 18 July 2023
102 Great British Nuclear, Small Modular Reactors: competitive technology selection process, 18 July 2023
103 See, for example: The Times, £20bn set aside to develop small nuclear power stations, 18 July 2023 and Independent, 'Nuclear renaissance' promised as Government banks on small reactors plan, 18 July 2023
104 Independent, 'Nuclear renaissance' promised as Government banks on small reactors plan, 18 July 2023

function and what activities it will carry out beyond running a small modular reactor competition. We expected further clarity to given in the Government's launch of GBN in July 2023, but the announcement only included details of the SMR competition and the allocation of funds that had already been announced.

57. ***In response to this Report, the Government should set out additional detail on how Government will intersect with Great British Nuclear, including details of Great British Nuclear's exact remit and funding model, and the formal split of responsibilities with the Department for Energy Security and Net Zero. To aid this, the Government should publish the required secondary legislation that will support the creation of Great British Nuclear. Within this detail, the Government should clearly define what the role for Great British Nuclear will be on supporting new nuclear projects beyond the initial small modular reactors competition, including in relation to gigawatt size projects beyond Sizewell C and deployment of advanced modular reactors when technologically ready.***

58. **In its July 2023 announcement on Great British Nuclear, the Government said that it would use the small modular reactor technology selection process (SMR TSP) to identify those reactor companies best able to reach a project Final Investment Decision (FID) by the end of 2029. The FID would include funding to support site access and site-specific design. Therefore, some of the more time-consuming aspects of building new nuclear projects, namely site-specific regulation and relevant licencing, would not begin for any successful SMR design until after 2029. This new timeline would go beyond the dates that many of the SMR developers have proposed is possible for SMR reactors to supply energy to the grid, namely the early 2030s.**

59. ***The Government should take steps to advance the ability for FIDs to be taken before 2029 and provide a detailed timeline of when it expects the winner or winners of GBN's SMR technology selection process to begin commercially supplying electricity to the UK.***

The UK's nuclear operators

60. Currently there is only one nuclear operator within the UK, EDF Energy, which owns and runs the entire civil nuclear reactor fleet. There was disagreement among contributors to this inquiry as to whether the UK should look to have multiple operators of large-scale nuclear power plants. In its evidence, EDF stated that it would be quicker to expand current operating capabilities than to establish new operators.[105] This was mainly due to challenges in navigating the UK's nuclear licencing and regulatory system,[106] which Professor Williams told us relied on experienced operators.[107]

61. We took evidence from other nuclear developers, who were looking to deploy reactors in the UK, during this inquiry. Unsurprisingly they favoured diversity of operators. Representatives from GE-Hitachi and Last Energy believed that diversity in operators allowed for market competition and provided other benefits such as collaborative working and avoiding 'group think'.[108] Michelle Catts, Senior Vice-President, Nuclear Programmes at GE Hitachi Nuclear Energy, explained to us that in her experience the US civil nuclear system benefitted from having multiple operators within it:

105 EDF Energy (NCL0057)
106 Q111
107 Q43
108 Last Energy (NCL0015); Q118; Q112

> From my perspective, they run longer and there are fewer issues. It is that sharing of information, without people getting into a groupthink mentality. I see great advantages in having more than one operator. I do not think that you would necessarily get anywhere faster with just one operator.[109]

62. Some industry stakeholders said that to reach the Government targets for nuclear capacity by 2050, multiple operators were needed to be brought to the UK, especially if there were plans to deploy advanced reactor technologies.[110] Importantly, this opinion was shared by Mark Foy, Chief Executive & Chief Nuclear Inspector at the ONR, who told the Committee:

> With the new-build ambition that has been expressed by GBN for 24 GW by 2050, there will have to be more than one operator, I suspect—but that creates opportunities. There are other global operators of nuclear facilities, and they have the opportunity to come into the UK and be part of a project—a proposal—to deploy nuclear reactor technologies in the United Kingdom. Indeed, our philosophy of enabling is that, once those prospective operators are identified, we are more than happy to sit down and work with them to let them know what the UK framework is like, what opportunities there are for them to come into the UK, and what our expectations are as a regulator.[111]

63. **Gigawatt-scale nuclear power plants require UK experience—of the supply chain, regulatory processes and the wider energy sector—to deliver projects efficiently. However, the UK may benefit in the future from multiple operators of small and advanced, nuclear power technologies as they have the potential to provide market competition, collaboration opportunities and prevent a groupthink mentality.**

64. ***The Government should provide sufficient resources to nuclear regulators, to support potential new operators of small and advanced modular reactor technologies to enter the UK energy market.***

Nuclear new build

65. The most advanced new nuclear power plant projects in the UK are Hinkley Point C, which began construction in 2017 in Somerset, and the proposed Sizewell C in Suffolk, which is expected to begin construction in 2024.[112]

66. There have been two attempts at building gigawatt-scale nuclear reactors since Sizewell B was completed in 1995. However, neither of these initiatives[113]—Wylfa and Moorside—progressed to final investment decision (see Chapter 7).

109 Q118

110 Nuclear Innovation & Research Advisory Board (NCL0042); Terrestrial Energy (NCL0046); Nuclear Futures Institute, Bangor University (NCL0011)

111 Q426

112 See: The Financial Times, Sizewell C nuclear plant funding drive likely to take until end of 2024, 3 March 2023

113 NuGen and Horizon were subsidiary companies of Toshiba and Hitachi respectively. Both companies were looking to build gigawatt-scale power plants within the UK, with Horizon aiming to develop the Wylfa site in Wales and NuGen the Moorside site in Cumbria.

67. When Hinkley Point C was granted final approval in 2016 it was expected to begin generating electricity in 2025 at a cost of £18 billion.[114] It will use a UK EPR technology, adapted from EDF's EPR in operation elsewhere. Opponents of this reactor design said that EDF encountered problems previously with the construction and deployment of the EPR design with delays to Flamanville 3 in France, Taishan in China, and Olkiluoto 3 in Finland causing significant cost over runs.[115]

68. Delays related to the Covid-19 pandemic and unforeseen construction challenges caused by ground conditions led to EDF revising the estimates for completion of Hinkley Point C to June 2027 and costs to £25–26 billion.[116] Since giving evidence to this inquiry, EDF revised this estimate and predicted a further rise to £32 billion due to inflation and a risk of an additional 15-month delay.[117]

69. During our inquiry we visited the Hinkley Point C site and saw first-hand the scale of the project. It was clear that, as the UK's first new nuclear build in a generation, many lessons were being learned. A standardised approach to nuclear construction that focuses on next-of-a-kind deployment could allow the nuclear industry to benefit from these lessons. EDF expects the construction of its next nuclear power plant, Sizewell C, to make use of the skills, supply chains and knowledge gained from building Hinkley Point C,[118] with Julia Pyke, Sizewell C Director of Finance at EDF, saying:

> We are very much planning to build Sizewell as, effectively, Hinkley unit 3, taking the same trajectory of learning to build the exact same above-ground design.[119]

70. Whether the UK EPR is the suitable technology choice for nuclear new builds in the UK beyond Sizewell C will depend on the success of this knowledge transfer. The "value for money"[120] that Mr Bowen said would come from building a fleet of standardised gigawatt scale nuclear reactors would become apparent if both the cost and construction overruns experienced at Hinkley Point C are significantly reduced for the Sizewell C project.

Future gigawatt reactors

71. Sizewell C is the most advanced project after Hinkley Point C with EDF expecting construction to start in 2024 following a FID in 2023.[121] However there is speculation that the FID may not be made until late 2024, which would cause delays to construction.[122]

72. The National Infrastructure Commission in its 2018 assessment recommended that the Government "should not agree support for more than one nuclear power station, beyond Hinkley Point C, before 2025".[123] In contrast to this, Simon Bowen told us he believed the UK needed to build two more gigawatt nuclear power stations *after* Sizewell C,

114 Department for Business, Energy & Industrial Strategy, Government confirms Hinkley Point C project following new agreement in principle with EDF, 15 September 2016
115 Stop Sizewell C, Together Against Sizewell C, People against Wylfa B, Blackwater against New Nuclear Group (NCL0044)
116 Q69
117 EDF, Annual results 2022, 17 February 2023, p 25
118 NNB GenCo (SZC) Limited (NCL0049)
119 Q71
120 Q411
121 Q84
122 The Financial Times, Sizewell C nuclear plant funding drive likely to take until end of 2024, 3 March 2023
123 National Infrastructure Commission, National Infrastructure Assessment, July 2018, p 32

in addition to SMRs, to achieve the aims of the Energy Security Strategy.[124] When asked by the Welsh Affairs Select Committee if he believed these should be the same design as Sizewell C he said:

> It does not necessarily need to be, but it could be. What I have said previously is that we have to take a little bit of a step back and look at the optimum technology for the next gigawatt reactor. It may well be the EPR, which is the EDF design, but it may be another design. It could be one of the many that exists around the world. I think we need to have another look at those to make sure that we end up with resilience through the diversification of technology. That makes sense. Now it may well be that through the analysis you end up saying, "Actually, it makes sense to go for a fleet of EPRs and get the benefit from that," but I do think we need to stop and check that the logic makes sense and gives us all the outcomes that we need.[125]

Supply chain needs

73. Many experts in the nuclear sector consider the challenge of achieving the aims of the British Energy Security Strategy as not a question of UK technical capability, but of financing (discussed in Chapter 6) and supply chain capacity.[126] The University of Bristol said in its written evidence:

> The UK does not currently have the skills or supply chain to support one reactor design, let alone multiple reactor designs.[127]

74. There is strong competition for resources and materials both within the UK and internationally. Domestic large infrastructure projects such as High Speed 2 and the acceleration of the nuclear programmes in France draw on the same supply chain needed for nuclear new build within the UK.[128] Other nuclear sector stakeholders identified the lack of a clear project pipeline as a barrier to establishing a strong nuclear supply chain in the UK.[129]

75. Some contributors to this inquiry involved in nuclear power plant construction were more optimistic in the UK's abilities to develop a supply chain to support a new nuclear programme, but stressed that Government intervention was required.[130] Tom Samson, then Chief Executive Officer of Rolls-Royce SMR, emphasised the need for a clear commitment to deploy a forward nuclear programme to expand the UK supply chain:

> The supply chain needs a demand signal, and it is the same with skills. I have every confidence that in the UK, and globally, the supply chain can

124 Qq413–416
125 Oral evidence taken before the Welsh Affairs Committee on 22 February 2023, HC (2022–23) 240, [Mr Bowen] Q215
126 Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010); Copeland Borough Council (NCL0007); Assystem (NCL0025); Jacobs UK (NCL0034); NUVIA Ltd (NCL0033); Institution of Mechanical Engineers (NCL0037); Terrestrial Energy (NCL0046); EDF Energy (NCL0057); Westinghouse Electric Company (NCL0054); National Infrastructure Commission (NCL0061)
127 University of Bristol (NCL0051)
128 NUVIA Ltd (NCL0033); Copeland Borough Council (NCL0007)
129 Cwmni Egino (NCL0005); Professor Stephen Garwood (NCL0009); Nuclear Futures Institute, Bangor University (NCL0011); Nuclear Industry Association (NCL0012)
130 Professor Stephen Garwood (NCL0009); Assystem (NCL0025); Jacobs UK (NCL0034); Last Energy (NCL0015)

> respond to this challenge, but we have to provide it with the demand signal. Talking about deployment and ambitions to build nuclear is not the same as having an actual commitment to deploy.[131]

76. ***The Government should provide clarity on how it plans to achieve its 24 gigawatt aim, and the expected timeline for these. This should include details of:***

   a) ***the target mix of reactor technologies, including the desired number of future gigawatt scale reactors, that the Government will support; and***

   b) ***a detailed timeline for when new projects are expected to be completed.***

77. **An essential requirement will be to resolve of the questions of whether a standardised fleet of nuclear power plants, using serial versions of the same reactor technology, has the potential to benefit the UK as new knowledge and resources can be transferred from one project to the next, reducing the risk of construction and cost overruns. The inevitable objection that such a strategy embeds the risk that operational issues identified with one power plant could affect the entire fleet can be mitigated be using tried and tested underlying technologies and engineering and careful sequencing of any innovation.**

78. ***The Government, through Great British Nuclear, must choose between the potential cost benefits of a standardised nuclear fleet of gigawatt reactors and the energy security and resilience that a diversity of reactor designs provides.***

Fuel

79. The conflict in Ukraine has underlined the importance of achieving greater energy independence and utilizing low-carbon domestic energy sources. The UK is in a unique position regarding nuclear fuel competencies as it has both the expertise and facilities for the complete nuclear fuel cycle following the importation of uranium ore.[132] Laurent Odeh, Chief Commercial Officer of Urenco, a British-German-Dutch nuclear fuel consortium in which the UK Government holds a 33% stake, told us:

> The current world energy crisis is creating a spotlight on the fuel cycle. The UK is uniquely positioned to have all the chains in the fuel cycle: conversion, enrichment and fabrication. We should not undermine that competency.[133]

80. Uranium ore is converted and enriched prior to fuel fabrication.[134] Globally commercial uranium enrichment is carried out by four main companies at various facilities worldwide:[135] Urenco (UK), Orano (France), Rosatom (Russia) and CNNC (China).[136]

131 Q176
132 Urenco (NCL0055)
133 Q246
134 Following mining and milling of uranium ore, the uranium is converted into a gas and then enriched to increase the amount of fissile Uranium-235 present. The enriched gas is then transformed into fuel rods which is then placed in a nuclear reactor.
135 World Nuclear Association, Uranium Enrichment, last updated October 2022
136 CNNC is a major domestic supplier with minimal export portfolio

81. Since the conflict in Ukraine, nuclear fuel producers have been asked to increase capacity in enrichment services to fill the gap left by Russia's imposed exit from the market.[137] At the April 2023 G7 energy summit in Japan, the UK, US, Canada, Japan and France announced they would form an alliance aimed at displacing Russia from the international nuclear fuel market.[138] On 8 June 2023, US President Joe Biden and the Prime Minister Rishi Sunak unveiled the 'Atlantic Declaration for a Twenty-First Century U.S.-UK Economic Partnership'.[139] As part of this economic partnership the U.S and the UK launched a one-year Joint Clean Energy Supply Chain Action Plan, which in part aims to identify ways to minimise reliance on Russian fuel, supplies, and services.[140]

82. Urenco is the second largest supplier of nuclear fuel worldwide behind Rosatom.[141] Mr Odeh said that the expansion of UK enrichment facilities was possible, but would require both national and international policy assurances to stimulate investment:

> If we start thinking about potential expansion, we are moving from a world where there is ample capacity but the biggest player is disqualifying itself. It creates in the western world a shortage of capacity. Before we are able to make those investments in additional capacity, we need to ensure that we have the right policy framework—at the moment, there is nothing disqualifying Russia from delivering the fuel—and that we have enough support from our utility customers through long-term contracts.[142]

83. We note that the UK's only civil nuclear operator, EDF, plans to source nuclear fuel services from the French majority owned Framatome and Orano for the new Hinkley Point C power plant.[143] Evidence submitted to this inquiry argued that the UK can meet all nuclear fuel needs itself and so contribute to domestic energy security.[144] In addition to enrichment facilities supplied by Urenco, the UK also has domestic nuclear fuel fabrication capabilities based at Springfields, in Lancashire, which was established in 1946. The trade union Prospect said there was an opportunity to oblige contractually new nuclear power plants to source fuel domestically to contribute to UK energy sovereignty.[145]

84. The Government's Nuclear Fuel Fund, launched in January 2023, aims to preserve the UK's front end nuclear fuel cycle capabilities.[146] Although commercial enrichment facilities could readily invest in expansion, they will require a supportive policy framework and long-term contracts to ensure future market share both within the UK

137 Q241; Urenco (NCL0066)
138 Department for Energy Security and Net Zero, New nuclear fuel agreement alongside G7 seeks to isolate Putin's Russia, 16 April 2023
139 Department for Business and Trade, Foreign, Commonwealth and Development Office, Prime Minister's Office, 10 Downing Street, The Atlantic Declaration, 8 June 2023
140 Department for Business and Trade, Foreign, Commonwealth and Development Office, Prime Minister's Office, 10 Downing Street, The Atlantic Declaration, 8 June 2023
141 Q246
142 Q251
143 EDF, Universal Registration Document 2021, 17 March 2022, p 27
144 Westinghouse Electric Company (NCL0054); Nuclear Innovation & Research Advisory Board (NCL0042)
145 Prospect Trade Union (NCL0013)
146 Department for Business, Energy and Industrial Strategy (NCL0006); Department for Energy Security and Net Zero and Department for Business, Energy & Industrial Strategy, Nuclear Fuel Fund, 2 January 2023

and internationally to incentivise investment. Witnesses also highlighted the need for a strategic approach, in addition to investment, to optimise fuel resources and maintain UK nuclear fuel resilience.[147]

Closed fuel system

85. It is possible to close fully the nuclear fuel cycle by reprocessing spent uranium and using this as a fuel source within nuclear reactors. The UK has historical expertise in developing and operating fully closed nuclear fuel systems. However, for advanced reactor technologies more research is needed in this area.[148] Benefits of a closed nuclear full cycle include:

- Sustainability—recycling nuclear fuel improves overall fuel efficiency. This is particularly beneficial if the cost of mined uranium is high.[149]
- Waste reduction—the quantities of radioactive waste to be sent to final disposal and current spent fuel stockpiles can be used.[150] The longevity of radioactivity can also be reduced as the waste products from recycled nuclear fuel are different and are radioactive for less time.[151]
- Energy security—recycling spent fuels reduces reliance on uranium ore imports.[152]

86. The recycling of reprocessed uranium (RepU) for reuse in reactors requires a conversion step prior to enrichment that is different to the virgin fuel fabrication process. Currently only Russia can convert RepU, yet Dr Robin Taylor, Senior Research Fellow, National Nuclear Laboratory said:

> The development of a domestic capability to convert and re-enrich reprocessed uranium would provide additional energy independence and security and reduce the materials for disposal in the [Geological Disposal Facility].[153]

87. Mr Odeh said Urenco had the technical capabilities to convert RepU and would consider investing in the area if there was a market need.[154] In December 2022, the Government directly awarded £13 million from the Nuclear Fuel Fund to Westinghouse to reinstate the conversion capabilities for reprocessing uranium at the Springfields site in Lancashire.[155]

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147 Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010); Prospect Trade Union (NCL0013); National Nuclear Laboratory (NCL0040); Nuclear Innovation & Research Advisory Board (NCL0042)

148 Imperial College London (NCL0026); Nuclear Futures Institute, Bangor University (NCL0011); Nuclear Innovation & Research Advisory Board (NCL0042); Committee on Radioactive Waste Management (NCL0053)

149 Dr Robin Taylor (NCL0071)

150 Dr Robin Taylor (NCL0071)

151 Imperial College London (NCL0026)

152 Nuclear Futures Institute, Bangor University (NCL0011)

153 Dr Robin Taylor (NCL0071)

154 Q254

155 Department for Business, Energy & Industrial Strategy, £102 million government backing for nuclear and hydrogen innovation in the UK, accessed 7 February 2023

88. As part of the Atlantic Declaration, a U.S.-UK Joint Action Group on Energy Security and Affordability (the JAG) was set up to identify near-term actions to "encourage the establishment of new infrastructure and end-to-end fuel cycle capabilities by 2030" in both the US and the UK.[156] The declarations states that, through the JAG, the near and long-term actions will be identified and decided upon by the end of 2023.

89. **The UK is an international market leader in the manufacture of nuclear fuels and is uniquely positioned with the capability of delivering the entire nuclear fuel cycle. The nuclear fuel sector in the UK has the potential to increase enrichment capacity, which can provide security for domestic nuclear fuel supply chain and further export opportunities.**

90. ***By publishing a detailed Nuclear Strategic Plan, as we recommend, which includes the types and number of reactors to be built in the UK, the Government should provide a signal to the nuclear fuel industry to step up and increased its end-to-end fuel manufacturing capacity. The Government should set out in the Nuclear Strategic Plan how it will capitalise on the strengths of the UK's nuclear fuel supply chain to secure a resilient supply of nuclear fuel for any new planned reactors and develop further export opportunities.***

156 Department for Business and Trade, Foreign, Commonwealth and Development Office, Prime Minister's Office, 10 Downing Street, The Atlantic Declaration, 8 June 2023

3 Advanced nuclear technologies

91. Advanced nuclear technologies (ANTs) refer to a wide range of innovative nuclear reactor technologies, including SMRs and AMRs, which are at various stages of development.[157] SMRs and AMRs are expected to be quicker and cheaper to build, with their modular design allowing components of the reactor to be factory built and then assembled on site.[158] Having said this, as neither of these technologies have been deployed commercially, the full extent of the proposed cost savings including cost of construction and cost per megawatt-hour remains unknown. The cost of financing SMR and AMR builds also remains unknown, compared to gigawatt reactors.

92. SMRs and AMRs are also predicted to offer functionalities such as the production of high temperature heat for industrial or domestic use or the efficient production of hydrogen.[159] In 2020, the Government announced an Advanced Nuclear Fund of £385 million to support the development of SMRs and AMRs.[160]

93. SMRs, often defined as a Generation III+ technology (see Chapter 1), are generally based on existing nuclear reactor designs, but on a smaller scale. The International Atomic Energy Agency (IAEA) defines SMRs as reactors producing up to 300 megawatts (MW) of electric power, which is about one-third of the generating capacity of traditional nuclear power reactors.[161] Rolls-Royce SMR (see below) apply the term to their 470 MW reactor design, even though it is strictly outside of the IAEA definition.[162]

94. The term AMR usually refers to a variety of Generation IV reactor technologies which are at an earlier stage of development than SMRs. In addition to the benefits of modularity, AMRs tend to use novel cooling systems or fuels.[163]

95. Neither SMRs nor AMRs are ready for commercial deployment. SMRs involve known and proven technologies and are therefore expected to be available to be deployed to the grid in the 2030s.[164] AMRs, on the other hand, still require a significant amount of research and development, with demonstrator reactors not expected before the 2030s with the earliest possibilities for connection to the grid later.[165]

Small modular reactors

96. During our inquiry witnesses proposed that SMRs could deliver nuclear power cheaper and more quickly, than gigawatt-scale reactors.[166] Because most SMR designs are based on well understood reactor technologies, witnesses highlighted that the challenges

157 Office for Nuclear Regulation, Advanced Nuclear Technologies (ANTs), 20 September 2022; Department for Business, Energy & Industrial Strategy, Advanced Nuclear Technologies, 4 January 2023
158 Department for Business, Energy and Industrial Strategy (NCL0006); Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010)
159 Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010)
160 HM Government, The Ten Point Plan for a Green Industrial Revolution, 18 November 2020, p 12
161 International Atomic Energy Agency, What are Small Modular Reactors?, 4 November 2021
162 Rolls-Royce SMR, Small Modular Reactors, 19 April 2023
163 Department for Business, Energy & Industrial Strategy, Advanced Nuclear Technologies, 4 January 2023
164 Imperial College London (NCL0026)
165 Nuclear Industry Association (NCL0012)
166 Qq3–4; Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010)

for deployment are mostly in manufacturing, regulation, and having a supply chain that is ready for demand.[167] Gethin Jenkins, Head of Safety and Licensing at Last Energy, a company that is developing SMRs, agreed:

> There is nothing too novel or different about the technology itself. The technology isn't necessarily the challenge. We believe that the challenge is more in the deployment model and how you bring, design, plan, construct, and operate small modular reactors.[168]

Despite SMR reactor technologies being reasonably well understood, the then BEIS said that modularisation and off-site construction had not been attempted previously for the majority of components for nuclear projects, therefore these new "innovations posed unknown risks".[169]

97. Another key challenge for SMR deployment that witnesses raised was on siting. Mr Jenkins pointed out that the Government's current siting policy was "very much aimed at gigawatt power stations",[170] and explained that SMRs could have more value if built at other sites, including close to industrial users.[171] A further discussion on siting of new nuclear can be found in Chapter 7.

98. In November 2021, the Government, through its arm's length research and innovation body, UK Research and Innovation (UKRI), announced that it would invest £210 million in supporting research and development by Rolls-Royce SMR (see below) matched by over £250 million of private sector funding.[172] Whilst several contributors to our inquiry approved of Government support for Rolls-Royce SMR,[173] some criticised the Government for backing only one SMR developer.[174] Last Energy, a US based SMR manufacturer with an ambition to reach the UK market, warned that investing early in a single SMR vendor would increase supply chain costs and prevent market competition:

> From Last Energy's perspective, excessive Government funding for early-stage development activities crowds out new entrants and innovation and corrupts incentives for private companies.[175]

Last Energy argued that when government tries to choose a single developer too early in such a development process, it decreases competition and increases supply chain costs, leading to a "nuclear premium". The company recommended that:

167 Professor Stephen Garwood (NCL0009); Nuclear Futures Institute, Bangor University (NCL0011); Last Energy (NCL0015); Rolls-Royce SMR Limited (NCL0021); Institution of Mechanical Engineers (NCL0037); National Nuclear Laboratory (NCL0040); Professor Stephen Garwood (NCL0009); Nuclear Futures Institute, Bangor University (NCL0011); Last Energy (NCL0015); Rolls-Royce SMR Limited (NCL0021); Institution of Mechanical Engineers (NCL0037); National Nuclear Laboratory (NCL0040); Nuclear Innovation & Research Advisory Board (NCL0042)

168 Q191

169 Department for Business, Energy and Industrial Strategy (NCL0006)

170 Q175

171 Q179

172 Department for Business, Energy and Industrial Strategy, UK backs new small nuclear technology with £210 million, 9 November 2021

173 Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010); NUVIA Ltd (NCL0033); Imperial College London (NCL0026)

174 Terrestrial Energy (NCL0046)

175 Last Energy (NCL0015)

> … the Government should focus on establishing policies and market rules to create incentives for private industry, and enable private capital markets to allocate funding appropriately.[176]

Rolls-Royce SMR

99. Since 2015, Rolls-Royce SMR, which is a consortium made up private and public sector nuclear actors,[177] has been developing a small reactor using the PWR design, a well understood technology that has been used in over 300 nuclear power plants around the world.[178] The Rolls-Royce SMR is expected to be factory-built, with major components transportable to site and a target assembly period of 500 days[179] with a 60-year operating lifetime for the reactor. Each Rolls-Royce SMR is expected to generate 470 MW of electrical energy, the equivalent power required by about one million homes (Hinkley Point C, which will generate 3.2 GW, will power six million homes) but, Rolls-Royce SMR expect its SMR to "occupy around one tenth of the size of a conventional nuclear generation site".[180]

100. To build its SMRs, Rolls-Royce says it intends to build three factories in the UK.[181] For the first, where heavy pressure vessels will be manufactured, Rolls-Royce SMR announced a shortlist of three sites on 19 December 2022. These are:

- The International Advanced Manufacturing Park (IAMP), Sunderland and South Tyneside
- Teesworks, Teesside
- Gateway, Deeside.[182]

When giving evidence to us Tom Samson, the then Chief Executive Officer of Rolls-Royce SMR, told us that Rolls-Royce SMR was targeting a delivery price of around £75/MWh[183] (in comparison, the agreed strike price for Hinkley Point C was £92.50/MWh, in 2012 terms), and that costs "may end up at less than £2 billion per unit".[184] When asked whether this cost per unit included the cost of the construction of the factories, Mr Samson responded:

> No. The cost of the construction of the factories is a cost that would sit on our balance sheet as a company. We would have to make the choice between whether we have a significant enough demand signal to invest in factories and whether we have to buy the product from the supply chain. The factory cost is a cost that would be invested in by our shareholders.[185]

176 Last Energy (NCL0015)
177 The Rolls-Royce SMR consortium includes: Assystem, Atkins, BAM Nuttall, Jacobs, Keppel Fels, Laing O'Rourke, National Nuclear Laboratory, the Nuclear Advanced Manufacturing Research Centre and TWI
178 Rolls-Royce SMR Limited (NCL0021)
179 500 days is a target once multiple units are manufactured
180 Rolls-Royce SMR Limited (NCL0021)
181 Oral evidence taken on 25 January 2023, HC (2022–23) 240, Q181 [Alastair Evans]
182 Rolls-Royce SMR, Final shortlist announced for first Rolls-Royce SMR factory, 19 December 2022
183 Megawatt hour (MWh). All strike prices are expressed in 2012 values
184 Q212
185 Q213

101. Rolls-Royce SMR submitted its design to the UK generic design assessment (GDA) process (the GDA process is discussed further in Chapter 7 of this Report) in November 2021,[186] and in March 2022 the ONR began the GDA,[187] a process that takes between four and six years. Rolls-Royce SMR entered Step 2 of the GDA in April 2023 and it aims to conclude Step 2 in July 2024, and then to complete Step 3 (Detailed Assessment), in August 2026.[188] When giving evidence to us on the 23 November 2022, Mr Samson said that if it received a commitment from a "customer" to buy its technology by the end of 2023 (therefore before the GDA is completed), that it could have reactors on the grid by 2031–32.[189] With a view to the UK Government being that customer, and seeking that timetable, Mr Samson said that Rolls-Royce SMR needed to start in-depth discussions and negotiations with government:

> We are really keen to move now with the Government into negotiations—to begin discussions on a structure for how we can deploy the technology in the UK. […] That negotiation will take probably the best part of a year so that, by the end of next year, we will be in a position where we can, I hope, create a construct that we can then have a commitment from, allowing us to start building factories, preparing the sites and deploying the technology.
>
> […] We have been having discussions over the last few months with officials and we are keen to continue that momentum over the coming weeks and months.[190]

Despite these clearly stated ambitions from Rolls-Royce SMR, on 8 January 2023, the Sunday Times reported that a funding deal for Rolls-Royce SMR was "not expected to materialise for at least another 12 months, amid a row in government over the cost of Britain's wider nuclear ambitions" and that the Treasury would not approve a significant funding deal until the technology completes the second step of the GDA, which was not expected to happen until 2024.[191] The article suggested that within Whitehall there was uncertainty about the scale of investment that would be made available for SMRs and that the Government was looking at other SMR suppliers, such as GE Hitachi, as well as Rolls-Royce SMR.[192] GE Hitachi, from whom we also took evidence, were developing an SMR called the BWRX-300, which would provide 300 MW power.[193] GE Hitachi has been selected by Ontario Power Generation (OPG) to deploy its SMR in Darlington, Canada. OPG have submitted a licence application to the Canadian authorities for the construction of the SMR, which they claim they could complete by late 2028.[194] In December 2022, GE Hitachi submitted its application to enter the GDA for the BWRX-300 in the UK.[195]

On 25 January 2023, just over two months after our evidence session with them, Rolls-Royce SMR gave evidence to the Welsh Affairs Committee as part of its inquiry into nuclear power. Compared to the testimony that they gave us, the witnesses from Rolls-Royce SMR

186 Rolls-Royce SMR, Rolls-Royce SMR milestone as first regulatory step initiated, 17 November 2021
187 Office for Nuclear Regulation, Rolls-Royce SMR Limited to enter Step 1 of GDA, 1 April 2022
188 HM Government, GDA Step 1 statement: summary on the Rolls-Royce SMR, 3 April 2023
189 Q199
190 Q175
191 The Sunday Times, Delay to small nuclear reactors as ministers battle over costs, 8 January 2023
192 The Sunday Times, Delay to small nuclear reactors as ministers battle over costs, 8 January 2023
193 GE Hitachi, The BWRX-300 small modular reactor, accessed 21 March 2023; Q101
194 GE Hitachi, The BWRX-300 small modular reactor, accessed 21 March 2023; Q101
195 GE Hitachi, GE Hitachi Submits Generic Design Assessment Application in the UK for the BWRX-300 Small Modular Reactor, 20 December 2022

raised concerns about the lack of progress of its discussions with the Government about securing an order for its reactor. Alastair Evans, Director of Corporate and Government Affairs at Rolls-Royce SMR, claimed that Rolls-Royce SMR's progress was being limited by a lack of demand signal from the Government:

> We secured £210 million of taxpayers' money. That enabled us to find £280 million of equity from the private market. […] There are still gaps in the jigsaw and that is the challenge. The frustration is that, since we were given our £210 million of taxpayers' money, I cannot point to anything that has changed in that period that gives us clarity on siting, funding or developer. We have had positive signals on 24 GW. That is all very positive, but I cannot point you to anything tangible that you could take to a board or take to the finance community and raise capital against.[196]

102. When we questioned the then responsible Minister, Rt Hon Graham Stuart MP (now Minister of State for Energy Security and Net Zero in that department established on 7 February 2023), about the Government's plans to engage with Rolls-Royce SMR, he told us that the Government intended to carry out a "downselection" process to narrow the field[197] for SMR technologies that would be "open to companies, including Rolls-Royce".[198] He went on to confirm that the Government is looking to other companies apart from Rolls-Royce for SMR technologies:

> We have already given £210 million to Rolls-Royce. That expresses a pretty high level of confidence in it, but I think a downselection by the end of this year will send an even stronger signal to whichever companies we are working with at that point.[199]

103. On 15 March, the Spring Budget 2023 announced that GBN would be established shortly and its focus would be to "launch the first staged competition for Small Modular Reactors".[200] The Budget said that it was the Government's ambition to "attract the best designs from both domestic and international vendors" and "select the leading technologies by the end of this year and if demonstrated to be viable, co-fund this exciting new technology in the UK". The Government's Energy Security Plan, published on 30 March 2023, provided some further detail on the selection process, stating that a market engagement phase would take place in April, followed by a process to narrow the field of potential partners and suppliers launched in summer and an assessment and decision on "leading technologies" completed in Autumn.[201]

104. On 3 March 2023, Nuclear Engineering International, a media outlet covering the nuclear power industry, reported that Rolls-Royce SMR had said that it would "run out of cash by the end of 2024". Alastair Evans, Government & Corporate Affairs Director at Rolls-Royce SMR was reported to have said:

196 Oral evidence taken on 25 January 2023, HC (2022–23) 240, Q194 [Alastair Evans]
197 Law insider defines downselection as a "means of limiting the competitive pool to those contractors most likely to offer a successful solution"
198 Qq482–483
199 Q484
200 HM Treasury, Spring Budget 2023, 15 March 2023, p 64
201 HM Government, Powering Up Britain: Energy Security Plan, 30 March 2023, p 34

> We aren't asking the government to make an order [for the nuclear units] today but we need to start negotiations on a deployment plan by the middle of this year. We are facing a cliff edge, by December 2024 the money will have run out.[202]

Whilst the consortium continues to seek clarity on whether the UK Government intends to enter further negotiations, Rolls-Royce SMR had signed several Memoranda of Understanding (MoU) with several other countries. In 2017, Rolls-Royce signed an MoU with state-owned Jordan Atomic Energy Commission to "conduct a technical feasibility study for the construction of a Rolls-Royce SMR Jordan".[203] In March 2020, Turkey's state-owned EUAS International ICC (Turkey's Electricity Generation Corporation) signed an MoU with Rolls-Royce to evaluate the technical, economical and legal applicability of SMRs; and the possibility of joint production of SMRs.[204] In November 2020 Rolls-Royce announced an agreement with Czech Republic utility CEZ,[205] and held further talks in January 2023 to assess potential deployment there.[206] In March 2021, Rolls-Royce signed an MoU with Fermi Energia, an Estonian-based company, to study the potential deployment of SMRs in Estonia.[207] Most recently, in February 2023, Rolls-Royce and state-owned Polish group Industria signed a Memorandum of Intent (MoI) to collaborate on deploying SMRs in the country.[208]

105. **The Government is at a cross-roads in its policy on small modular reactors (SMRs). So far it has funded a consortium led by Rolls-Royce with over £210 million of research and development funds to develop a concept SMR design, and now, to further develop the design to the extent that it can pass the generic design assessment process. That public funding was matched with £280 million from the private sector. It has subsequently announced that Great British Nuclear will launch and administer a competition in which other vendors' technology would be assessed. What is then required is a set of pivotal decision on the actual deployment of, rather than research into, SMRs.**

106. **It is not uncommon, in the face of an unclear strategy or unresolved internal arguments about financing, for governments to defer decisions rather than take them. But this would be the wrong course. The UK risks losing the advantage of the public investment that has already been made; as well as contributing to the ambiguity in our future energy supply; and perpetuating a level of policy risk that is likely to drive a risk premium on costs, to the detriment of the taxpayer and billpayer.**

107. ***In developing a Nuclear Strategic Plan the Government should answer the questions of:***

- ***what deployment of SMRs it wants to see, if any;***

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202 Nuclear Engineering International, Rolls-Royce SMR faces financial problems, 3 March 2023
203 Rolls-Royce SMR, Rolls-Royce signs collaboration agreement with Jordan for small modular reactor technology, 9 November 2017
204 Rolls-Royce, Rolls-Royce and Turkey's EUAS International ICC agree study for compact nuclear power stations, 19 March 2020
205 Rolls-Royce, Rolls-Royce signs MoU with CEZ for compact nuclear power station, 9 November 2020
206 Rolls-Royce SMR, Factory-built nuclear power plants could be operating in Czech Republic by early 2030s, 25 January 2023
207 Rolls-Royce, Rolls-Royce signs MoU with Fermi Energia for compact nuclear power stations, 2 March 2021
208 World Nuclear News, Poland's Industria selects Rolls-Royce SMR for green energy plans, 9 February 2023

- ***what technologies and vendors it intends to deploy, and whether they will be from a single supplier or multiple suppliers;***
- ***what sites should SMRs be located at; and***
- ***what financial model would be used to support the contribution of SMRs to electricity supply?***

Advanced modular reactors

108. AMRs, also known as Generation IV reactor technologies (see Chapter 1), are intended to have various advantages over previous generations of nuclear reactors, such as:

- increased fuel efficiency, including the re-use of nuclear waste streams
- reduced waste production
- better value for money
- higher safety standards
- being proliferation resistant (i.e. avoiding the potential of making materials that could be used to make nuclear weapons).[209]

109. As well as advantages in design, AMRs are expected to be used to contribute to the decarbonisation of other sectors through co-generation, due to the very high temperatures used in some AMR reactor types.[210] On this subject, the Dalton Nuclear Policy Group wrote:

> The main advantage of these AMR reactors in contributing towards Net Zero is the opportunity to use the high temperature heat for industrial or domestic heating and/or for the efficient production of hydrogen or synthetic hydrocarbon fuels, alongside the potential to generate electricity from the reactor itself. This opens the door to a domestic energy supplies that would contribute to the decarbonisation of sectors such as heating and transport, as well as generating low carbon electricity.[211]

Technical challenges associated with AMRs

110. Although there was significant consensus on the opportunities that AMR technologies could bring, written evidence to our inquiry also identified a number of technical challenges that need to be addressed to bring AMRs to the grid.[212] The National Nuclear Laboratory (NNL) explained that AMRs were less technically mature than SMRs and that further research was required to fully develop these technologies. The Royce Institute summarised some of the technical challenges associated with AMRs:

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209 Institution of Mechanical Engineers, What is generation IV?, accessed 8 March 2023

210 Q228

211 Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010)

212 Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010); Nuclear Futures Institute, Bangor University (NCL0011); Henry Royce Institute (NCL0030); Jacobs UK (NCL0034); Institution of Mechanical Engineers (NCL0037); National Nuclear Laboratory (NCL0040); Nuclear Innovation & Research Advisory Board (NCL0042)

> The higher thermal gradients, higher radiation-induced damage, more corrosive environments, greater cyclic loading and gas production place significantly greater demands on the materials' selections, not only for the reactor pressure vessel itself, but also on the pipework, heat exchangers, turbines etc.
>
> The qualification of new fuels and graphite for AMRs will require lengthy and complex verification, validation, and testing protocols.
>
> Heat from AMRs has the potential to be used for synthetic fuel or hydrogen production, but the coupling technology is yet to be economically demonstrated (hydrogen can have serious deleterious impacts on material properties).[213]

111. In its evidence, the Institution of Mechanical Engineers (IMechE) said that these challenges were "large but not insurmountable," but argued that public sector research laboratories would need to be utilised to support private sector research, for example, to provide material test facilities, that would otherwise be too expensive for a private enterprises to run.[214] The Dalton Nuclear Policy Group and NNL also highlighted this issue, pointing out that some of the required research facilities were currently based outside the UK.[215]

Funding the development of AMRs

112. Some witnesses proposed that the role of the Government's investment in AMR technology should be focused on early-stage research and development such as demonstration reactors prior to the technology being commercially ready.[216] For example in its evidence, Cavendish Nuclear said:

> We request that the UK Government continues to provide (or facilitates) funding for projects to be developed to an appropriate level of maturity for investors to take on, recognising the different characteristics of large and smaller units (for example, on quantum of capital per project, length of construction/borrowing, and risk factors).[217]

On the other hand, Last Energy, opposed early government financial support for new nuclear technologies and argued that it " … crowds out new entrants and innovation, and corrupts incentives for private companies". It argued that the Government should instead focus on "establishing policies and market rules to create incentives for private industry, and enable private capital markets to allocate funding appropriately".[218] This has been demonstrated to work in the fusion sector, as discussed in Chapter 4.

213 Henry Royce Institute (NCL0030)
214 Institution of Mechanical Engineers (NCL0037)
215 Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010); National Nuclear Laboratory (NCL0040)
216 Cwmni Egino (NCL0005); Institution of Mechanical Engineers (NCL0037); Cavendish Nuclear (NCL0041); Westinghouse Electric Company (NCL0054)
217 Cavendish Nuclear (NCL0041)
218 Last Energy (NCL0015)

113. The Government has provided funding for the development of AMRs. In November 2020 the Ten Point Plan for a Green Industrial Revolution,[219] announced the Government's intention to invest up to £170 million through the Advanced Nuclear Fund.[220] This fund was used to support the AMR Research, Development and Demonstration Programme, which aimed to support an AMR demonstration by the early 2030s.[221]

AMR reactor types

114. Unlike SMRs, which are mainly based on one reactor type, the Generation IV International forum has identified six AMR designs that are under development worldwide.[222] The reactor types are classified by the speed of the neutrons and the type of coolant used, as follows:

- (Very) High Temperature Gas Reactors ((V)HTGR)
- Sodium-Cooled Fast Reactors (SFR)
- Supercritical Water-Cooled Reactors (SCWR)
- Gas-cooled Fast Reactors (GFR)
- Lead-cooled Fast Reactors (LFR)
- Molten Salt Reactors (MSR).

115. In December 2021, the Government confirmed its preference for HTGRs as the technology of choice for AMRs in its AMR Research, Development and Demonstration (AMR RD&D) programme.[223] Prior to confirming its choice of reactor type, the Government ran a consultation seeking views on whether the Government should commit to developing the HTGR through the AMR RD&D programme. Out of 60 responses from a range of supply chain companies, academic institutions, regional bodies, industry organisations and private individuals:

- 38 were in favour of the Government's preference to support HTGRs for the AMR Research, Development and Demonstration programme
- 16 were not in favour
- 6 were neither for nor against.[224]

116. Consistent with this, the evidence received throughout our inquiry suggested a split of opinion on whether the Government should have committed to the HTGR technology. Whilst some witnesses praised the Government for selecting HTGR as its

219 HM Government, The ten point plan for a green industrial revolution, 18 November 2020
220 HM Government, Advanced Nuclear Technologies, updated 4 January 2023
221 Department for Business, Energy & Industrial Strategy, Potential of high temperature gas reactors to support the AMR RD&D programme: call for evidence, last updated 2 December 2021
222 Generation IV International forum, Generation IV International forum 2021 annual report, accessed 8 March 2021
223 Department for Business, Energy & Industrial Strategy, Potential of high temperature gas reactors to support the AMR RD&D programme: call for evidence, last updated 2 December 2021
224 Department for Business, Energy & Industrial Strategy, Potential of high temperature gas reactors to support the AMR RD&D programme: call for evidence, last updated 2 December 2021

preferred technology,[225] MoltexFLEX, a developer of a molten salt reactor, suggested that the Government should fund different AMR designs to ensure that the optimal reactor design can be found:

> In the latest round of funding for AMR projects in the UK, the former BEIS has shown a preference for HTGRs. We would like to see more resources allocated to the Nuclear Sector Deal to allow the then BEIS to fund different AMR designs.
>
> Backing a limited number of reactor designs and technologies puts the role of nuclear power in the UK's energy security and low-carbon future at risk. Primarily, the UK has chosen to support traditional and costly PWR designs for new large-scale plants, and larger-scale SMRs, as well as HTGRs for smaller-output SMRs.
>
> As these are new technologies, no one can be sure which will eventually provide the optimal solution for the UK. Betting so big on a limited number of reactor designs could likewise limit the UK's energy future. There is a narrow window of opportunity to ensure that the UK can become a source of true nuclear power innovation.[226]

117. This sentiment was echoed by Dr Ian Scott, Chief Scientist at MoltexFLEX Ltd., who said that the Government was putting all its eggs in one basket and argued that the UK "should be creating an enabling environment to allow multiple technologies to compete in this country".[227]

118. When we asked witnesses about why the Government had made this selection, Dr Fiona Rayment, Chief Scientific Officer at the NNL, said that of the AMR reactors designs, the HTGR was "pretty mature in comparison with the other systems".[228] She also argued that one of the key benefits of the HTGR design was its ability to help decarbonise other sectors by providing high quality process heat which could be used directly or used to make hydrogen.[229] In our evidence session with ministers, Declan Burke, who at the time was Director for Nuclear Projects and Development at the then BEIS, explained the preference for HTGRs but said that the Government was open to consider other technologies. He said:

> I think there is a bit of a focus on high-temperature gas reactors given the UK's capability and history around advanced gas reactors. The primary focus at the moment is more around HTGRs in terms of technology choices, but we speak to lots of different technology providers in the market about other technology solutions. There is an open dialogue with other technology providers, but there is a particular focus given our historic capability on the gas side.[230]

225 Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010); NUVIA Ltd (NCL0033)
226 MoltexFlex (NCL0038)
227 Q230
228 Q229
229 Q230
230 Q485

119. To accelerate progress in this area, the Dalton Nuclear Policy Group called on the Government to maintain momentum within the AMR RR&D programme, by selecting specific HTGR vendors that it will take forward.[231] Phase B of the AMR RR&D programme involved a competition to award up to £55 million to up to two projects that would demonstrate HTGR technology by the early 2030s.[232] On 18 July 2023, the Government announced the two successful projects:

- up to £15 million to National Nuclear Laboratory in Warrington, in collaboration with the Japanese Atomic Energy Agency, to accelerate the design of a modular HTGR;
- up to £22.5 million to Ultra Safe Nuclear Corporation UK in Warrington to further develop the design of a high temperature micro modular reactor, a type of AMR suited to UK industrial demands including hydrogen and sustainable aviation fuel production.[233]

The Government also announced £16 million funding for the National Nuclear Laboratory, again working with the Japanese Atomic Energy Agency, to develop the coated particle fuel required for HTGRs.[234]

120. **From the commissioning of Calder Hall in the 1950s, the UK has always had a strong capability in nuclear research and development. At a time where there is a global commitment to reduce carbon emissions and to reduce dependence on fossil fuels for reasons of energy security, the UK's capability in new nuclear technologies is a strength.**

121. **Whilst investment by Government in early stage and demonstrator reactors will drive forward innovation for advanced modular reactors (AMRs), bringing them closer to commercialisation, what is also important is the UK having a regulatory environment and incentives for private investment. This has been demonstrated to work in the UK's fusion sector, where as well as strong Government funded demonstrator programme, the regulatory system, skills environment and developing supply chain, is attracting private companies and private investment to the UK.**

122. **AMRs may offer new advantages in terms of cost and the potential for co-generation. But if they are to advance the research and development needs to move from the desk and the lab towards demonstrators, and this will require the Government to make decisions as to which technologies to fund.**

123. ***The Government should continue its support for the Advanced Modular Reactor Research, Development and Demonstration programme and ensure that it takes decisions on funding particular technologies and projects without delay, so that it keeps pace with competitors.***

231 Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010)

232 Department for Energy Security and Net Zero and Department for Business, Energy & Industrial Strategy, Advanced Modular Reactor (AMR) Research, Development and Demonstration Programme, last updated 21 February 2023

233 HM Government, AMR Research, Development and Demonstration: Phase B (2023–2025): successful organisations, 18 July 2023

234 HM Government, AMR Research, Development and Demonstration: Phase B (2023–2025): successful organisations, 18 July 2023

Advanced nuclear fuels

124. Some advanced nuclear technologies, such as the HTGR mentioned above require new fuels to be developed.[235] The Government described the deployment of SMR and AMR technologies as a "chicken-egg" challenge.[236] This was because companies were unwilling to invest in advanced fuels without a market, yet AMR developers cannot attract investment without a fuel source. Russia is currently the main manufacturer of some the fuels required for advanced nuclear reactors such as High-Assay, Low-Enriched Uranium (HALEU) fuel.[237] Urenco, a British-Dutch-German nuclear fuel consortium, said it had the capabilities to provide advanced fuels commercially but needed a customer base. Urenco said:

> Currently, the only source of advanced fuel for a commercial enricher is Russia. The length of time it takes to establish the funding, address regulatory issues, and then construct the necessary fuel cycle infrastructure creates unique challenges to the front-end nuclear fuel supply chain needed to bring advanced reactors to market. Moreover, this capacity will not develop commercially without a sustained customer base, and the advanced reactors that need advanced fuels cannot be deployed without a supply of fuel.[238]

125. Laurent Odeh, Chief Commercial Officer at Urenco agreed with the Government's 'chicken-and-egg' analogy and looked for Government support for Urenco to become a commercial supplier for advanced fuels.[239]

126. The Government launched its £75 million Nuclear Fuel Fund in January 2023 which was seen as a 'welcome step forward' by the nuclear fuel industry.[240] In comparison, the US, one of the UK's main competitors for providing nuclear fuel to western countries, has invested $700 million in advanced fuel development as part of the US Inflation Reduction Act.[241]

127. On 18 July 2023, the Government announced that £22.3 million from the Nuclear Fuel Fund would fund eight projects to develop future fuels.[242] Project winners included:

- Westinghouse Springfields nuclear fuel plant, to manufacture new nuclear fuels for the UK and international markets;
- Urenco UK, to enrich uranium to higher levels and develop advanced nuclear fuels including HALEU;
- Nuclear Transport Solutions, a subsidiary of the Nuclear Decommissioning Authority, to develop new transport methods for advanced nuclear fuels; and
- MoltexFLEX, an advanced modular reactor developer, to build and operate rigs for the development of molten salt fuel.

235 Imperial College London (NCL0026); Urenco (NCL0055); University of Bristol (NCL0051)
236 Department for Business, Energy and Industrial Strategy (NCL0006)
237 Nuclear Innovation & Research Advisory Board (NCL0042)
238 Urenco (NCL0055)
239 Q243
240 Urenco (NCL0055)
241 World Nuclear News, Inflation Reduction Act makes 'down payment' on HALEU, 23 August 2022
242 Department for Energy Security and Net Zero, Nuclear Fuel Fund successful projects, 18 July 2023

128. **The UK is a leading global player in uranium enrichment and nuclear fuel fabrication and has the potential to replace Russia's contribution to the global supply chain of advanced fuels. We welcome the launch and allocation of funding from the Nuclear Fuel Fund to support the development of the capabilities needed to meet current and future nuclear fuel demands.**

4 Fusion

Principles of fusion

129. Fission involves harnessing the energy released when large nuclei are split into smaller nuclei. In contrast, fusion technologies, of which none are yet commercially viable, seek to capture the energy released when light-weight atoms are fused together.[243] Fusion is said to have several distinct advantages as an energy source,[244] which include:

- fuel abundance: the fuels required for fusion are widely available;[245]
- high energy density: fusion produces more energy per gram of fuel than any other energy generating process;[246]
- no chain reaction: unlike fission, fusion is not based on a chain reaction and can be switched off quickly, making it inherently safer than fission;[247]
- shorter-lived waste: in contrast to fission, where highly radioactive waste is produced that must be stored for thousands of years, the waste product of a fusion reaction is non-radioactive helium. Having said this, the high energy neutrons produced in a fusion reaction will damage the reactor materials, resulting in intermediate radioactive waste that will have to be managed and stored in the long-term;[248]
- baseload power: unlike wind and solar, fusion does not rely on external factors so can provide consistent baseload power;[249] and
- carbon-free: helium will be the only product of the fusion process—no greenhouse gases will be produced.[250]

These advantages led a range of academics, trade organisations, and private fusion companies, to propose that fusion would play a key role in the longer-term decarbonisation of global energy production,[251] a point that Professor Sir Ian Chapman, Chief Executive

243 Office of Nuclear Energy, Fission and Fusion: What is the Difference, 1 April 2021
244 Department for Business, Energy & Industrial Strategy, Towards fusion energy: the UK fusion strategy, 1 October 2021
245 Department for Business, Energy and Industrial Strategy (NCL0006), Nuclear Futures Institute, Bangor University (NCL0011), UK Atomic Energy Authority (NCL0016), Imperial College London (NCL0026), Commonwealth Fusion Systems (NCL0035), Commonwealth Fusion Systems (NCL0035), General Fusion (NCL0043)
246 Department for Business, Energy and Industrial Strategy (NCL0006), Nuclear Futures Institute, Bangor University (NCL0011), Henry Royce Institute (NCL0030)
247 UK Atomic Energy Authority (NCL0016), Assystem (NCL0025), Commonwealth Fusion Systems (NCL0035), Tokamak Energy Ltd (NCL0039)
248 Civil Engineering Contractors Association (NCL0008), Nuclear Futures Institute, Bangor University (NCL0011), UK Atomic Energy Authority (NCL0016), Assystem (NCL0025), Imperial College London (NCL0026), Commonwealth Fusion Systems (NCL0035), Commonwealth Fusion Systems (NCL0035), Tokamak Energy Ltd (NCL0039)
249 Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010), UK Atomic Energy Authority (NCL0016), Assystem (NCL0025), Tokamak Energy Ltd (NCL0039), General Fusion (NCL0043)
250 Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010), Assystem (NCL0025), Imperial College London (NCL0026), Tokamak Energy Ltd (NCL0039), General Fusion (NCL0043)
251 Department for Business, Energy and Industrial Strategy (NCL0006), Civil Engineering Contractors Association (NCL0008), Commonwealth Fusion Systems (NCL0035), UK Atomic Energy Authority (NCL0016)

Officer of the UKAEA, advocated in our oral evidence session on fusion.[252] However, many witnesses believed that fusion technology will not be developed in time to contribute materially to net zero by 2050.[253] In its recently published 'UK Net Zero Research and Innovation Framework: Delivery plan 2022–2025,' the Government suggested that it agreed with this timescale, stating that fusion "could be an important solution with an impact beyond 2050".[254] This is largely due to the range of technical challenges that still need to be addressed for commercially viable fusion to be achieved.

Technical challenges to be addressed

130. Although research on fusion has been carried out since the 1950s,[255] net energy output from a fusion reaction was only achieved for the first time in December 2022 at the National Ignition Facility at the Lawrence Livermore National Laboratory in California. Even then, only 3.15 megajoules was produced (enough to boil a few kettles).[256] This is because the conditions required to stimulate fusion reactions, which are like those found in the Sun, are extremely hard to achieve. In the Sun, fusion reactions take place at temperatures about 10 million degrees Celsius. Achieving fusion reactions on Earth at a similar temperature is not possible, because Earth does not possess the same gravitational pressure present at the centre of the Sun. On Earth, plasma must be heated to extremely high temperatures, reaching as high as 150 million degrees Celsius. This temperature is far hotter than anywhere else in our solar system—even the centre of the Sun.[257] These conditions are hard to achieve. They additionally pose a requirement for extremely specialist materials to be used to build the fusion reactor, which are yet to be developed and present significant engineering challenges.[258]

The UK's fusion sector

131. The UK is one of the world leaders in publicly and privately funded fusion research and development. The national fusion research and development programme is led by the UKAEA. The UKAEA is an executive non-departmental public body, sponsored by the DESNZ, whose core aim is to position the UK as a leader in sustainable nuclear energy.[259] UKAEA is responsible for delivering the UK Government's Fusion Strategy, which was published in October 2021.[260] During our inquiry, we visited Culham Science Centre and saw first-hand the wide-ranging and world-leading fusion capabilities that UKAEA has built over many decades.

252 Oral evidence taken on 25 May 2022, HC (2022–23) 230, Q63 [Professor Chapman]
253 Cwmni Egino (NCL0005), Professor Stephen Garwood (NCL0009), Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010), Nuclear Futures Institute, Bangor University (NCL0011), Imperial College London (NCL0026)
254 HM Government, UK Net Zero Research and Innovation Framework: Delivery plan 2022–2025, 30 March 2023, p 46
255 EURO*fusion*, History of Fusion, accessed 3 February 2023
256 Lawrence Livermore National Laboratory, NIF's Fusion Ignition Shot Hailed as Historic Scientific Feat, 14 December 2022
257 The Conversation, Limitless power arriving too late: why fusion won't help us decarbonise, 24 February 2022
258 Henry Royce Institute, Materials for Fusion, accessed 7 February 2023
259 UK Atomic Energy Authority (NCL0016)
260 Department for Business, Energy & Industrial Strategy, Towards fusion energy: the UK fusion strategy, 1 October 2021

The UK's interaction with Euratom

132. As well as UK-led facilities which are discussed in more detail below, the Joint European Torus (JET), the central facility of the European Union's Fusion Programme, has been hosted at the Culham site since 1983.[261] JET is the largest and most successful fusion facility in the world to date, with over 350 scientists and engineers from across Europe contributing to the programme.[262] JET is a circular tokamak[263] reactor that uses the magnetic confinement approach to achieve fusion (see Box 1 for an explanation of approaches to fusion). In February 2022, JET broke the record for the power generated in a tokamak. 59 megajoules of energy was produced for five seconds, more than doubling the previous record that was set in 1997. This is equivalent to the energy required to boil around 60 kettles.[264] The fusion reaction was limited to five seconds because JET's copper magnets and cooling systems were only capable of handling the heat required for the fusion reaction for this short period of time. The aim of JET was therefore not to maximise output to produce net energy during its experiments. Instead, it was used as a facility to study and optimise the processes occurring inside a tokamak.[265]

133. JET is due to be decommissioned after almost 40 years of operation at the end of 2023. The JET decommissioning programme aims to help define the requirements for the safe and ethical delivery of fusion decommissioning and repurposing.[266] The lessons learnt throughout its lifetime have fed into the design of ITER (discussed below), as well as building up the UK's knowledge and capabilities, in both public and private settings. During our oral evidence session on fusion, Professor Sir Ian Chapman, Chief Executive Officer of UKAEA, described the JET programme as having "immeasurable benefit" to the UK:

> You could contend that the UK is genuinely the world leader in fusion research; it has the largest fusion research organisation on the planet, and that is because we host JET. We have a breadth of capability that we would not have if it weren't for our hosting JET. It is both a literal and metaphorical magnet—it brings thousands of people into the UK to do work at our campus. We have become a hub and an attractor for talent and capabilities and a whole supply chain has grown around it.[267]

261 UK Atomic Energy Authority (NCL0016)
262 Culham Centre for Fusion Energy, JET: the Joint European Torus, accessed 7 February 2023
263 The tokamak uses powerful external magnetic fields to confine and control the hot plasma of fusion fuels in a ring-shaped container called a 'torus'.
264 Culham Centre for Fusion Energy, Fusion energy record demonstrates powerplant future, 9 February 2022
265 Institute for Plasma Science and Technology JET: Background information, accessed 7 February 2023
266 UK Atomic Energy Authority, JET Decommissioning and Repurposing, 9 November 2022
267 Oral evidence taken on 25 May 2022, HC (2022–23) 230, Q80 [Professor Chapman]

Box 1: Approaches to achieving fusion

Magnetic confinement

Magnetic confinement fusion (MCF), is where a hot, electrically charged gas–or 'plasma'–is controlled with magnets inside a doughnut-shaped vacuum chamber known as a tokamak. Once the plasma, which contains the hydrogen isotopes deuterium and tritium, reaches the correct temperatures (between 150 and 300 million degrees Celsius) the light elements fuse and produce energy.[268]

Inertial confinement

In inertial confinement fusion (ICF), ion beams or laser beams are used to compress a small deuterium-tritium fuel pellet to extremely high densities. When a critical point is reached, the pellet is ignited through shock wave heating.[269]

Projectile fusion

Projectile fusion is a new approach to ICF which used a high velocity projectile in place of ion or laser beams. The projectile impacts a target containing fusion fuel. The target must focus the energy of the projectile, imploding the fuel to the temperatures and densities needed to make it fuse.[270]

Magnetised target fusion

Magnetised Target Fusion (MTF) combines features of MCF and ICF. A preheated-magnetised target is compressed to increase the fuel density and temperature and trigger fusion. The density of the fuel is lower than when the ICF approach is used, which leads to a slower reaction rate over a longer period.[271]

134. When completed, ITER will be the world's largest tokamak device. Sited in southern France, 35 nations including the UK,[272] have collaborated to build ITER. The overall aim for ITER is for it to become the first experimental fusion device in the world to produce ten times more deuterium-tritium fusion energy than the input energy injected into the fuel (500 MW output from 50 MW input).[273]

135. The ITER and JET programmes are led by EURO*fusion*, the European Consortium for the Development of Fusion Energy, which supports and funds fusion research activities on behalf of Euratom (See Box 2 for details on Euratom).[274] The UK's participation in Euratom (and therefore EURO*fusion*) has been affected in a similar way as its participation in the Horizon Europe programme—the level of UK participation remains uncertain due to ongoing negotiations between the UK and the EU. On 2 February 2022, we asked the Science Minister George Freeman MP about the UK's participation in Euratom. Mr Freeman told the Committee that Euratom was impossible for the UK to reproduce on its own, as collaboration and access to facilities in Europe was necessary for its success.[275]

268 ITER, What is a tokamak?, accessed 16 March 2023
269 International Atomic Energy Authority, Nuclear Fusion Basics, 8 October 2010
270 First Light Fusion, Projectile fusion, accessed 16 March 2023
271 International Atomic Energy Authority, Magnetised target fusion-an overview, 1993
272 ITER members are: China, the European Union (through Euratom), India, Japan, Korea, Russia, the United Kingdom and the United States
273 ITER, What is ITER?, accessed 7 February 2023
274 EURO*fusion*, Realising fusion energy, accessed 7 February 2023
275 Oral evidence taken on 2 February 2022, HC (2021–22) 606, Q262 [George Freeman]

He reiterated this on the 22 March 2022, when giving evidence to the House of Lords Science and Technology Committee, saying that the UK's fusion programme would "really suffer" if the UK was no longer able to participate in Euratom.[276]

In oral evidence at our session on fusion in May 2022, Professor Chapman highlighted that the UK's international collaboration on fusion, and as a result the UK's fusion excellence, was under threat due to the delays to association to Euratom, adding:

> While the preferred route is an association to Euratom, we have now been in a sort of no man's land for 16 months, with one foot in and one foot out. That situation cannot last forever, so we do need a decision.[277]

During our visit to Culham Science Campus in January 2023 experts from UKAEA again raised the damage that the continued uncertainty of association was causing. On 24 January 2023, we therefore wrote to the Secretary of State for the then BEIS, Rt Hon Grant Shapps MP, asking him to set out:

a) When [he would] make an announcement on the decision whether to focus on launching an alternative Euratom programme; and

b) When [he intended] to publish the details of said alternative.[278]

The agreement of the Windsor Framework in February 2023[279] raised the prospect of developments regarding association to Horizon, and therefore Euratom, particularly after the President of the European Commission Ursula von der Leyen said that negotiations could start "immediately".[280] On 5 April 2023, we received a response to our letter which agreed that the lack of progress on association with Euratom was frustrating, and welcomed the "EU's recent openness to discussions, following two years of delays".[281]

136. On 5 July 2023, it was reported that the UK and EU negotiators had agreed a draft deal on Horizon Europe, which the Prime Minister, the Rt Hon Rishi Sunak MP, was due to review. Reports suggested that the draft deal did not include association with Euratom and that a government official said that the Government and UK nuclear sector considered Euratom "poor value for money".[282] It was later reported, on 11 July 2023, that talks between the UK and EU were ongoing and the Prime Minister was seeking a deal that would "work for the UK and [was] in the UK's best interests".[283]

276 Oral evidence taken before the House of Lords Science and Technology Committee on 22 March 2022, Delivering a UK science and technology strategy, Evidence Session No.11, Q85 [George Freeman]
277 Oral evidence taken on 25 May 2022, HC (2022–23) 230, Q83 [Professor Chapman]
278 Correspondence from the Committee to Rt Hon Grant Shapps MP, Secretary of State for the Department for Business, Energy and Industrial Strategy, relating to the UK's participation in Euratom, 1 February 2023
279 HM Government, The Windsor Framework: a new way forward, February 2023
280 Science Business, Northern Ireland deal opens door to "immediate" talks on UK Horizon Europe association, says von der Leyen, 27 February 2023
281 Correspondence from the Andrew Bowie MP, Minister for Nuclear and Networks for the Department for Energy Security and Net Zero, relating to the UK's participation in Euratom, 5 April 2023
282 Politico, Britain and EU agree draft Horizon deal, 5 July 2023
283 Politico, Horizon Europe deal needs to work for UK taxpayers, says Rishi Sunak, 11 July 2023

Box 2: The Euratom programme

The Euratom Research and Training Programme (2021–2025) is a complementary funding programme to Horizon Europe which covers nuclear research and innovation. Using the same instruments and rules for participation as Horizon Europe, it has a budget of €1.38 billion (for the period 2021–2025), which is broken down as follows:

- €583 million for indirect actions in fusion research and development;
- €266 million for indirect actions in nuclear fission, safety, and radiation protection; and
- €532 million for direct actions undertaken by the Joint Research Centre.

Source: European Commission, Euratom Research and Training Programme, accessed 7 February 2023

UKAEA's programme of work

137. Aside from its work on JET and ITER, UKAEA runs, and is developing a wide range of fusion research facilities, including:

- MAST Upgrade—a facility leading research into compact fusion devices.
- Materials Research Facility (MRF)—a new UK facility for micro-characterisation of materials now open to university and industry users. It is part of the National Nuclear User Facility.
- Remote Applications in Challenging Environments facility (RACE)—conducting research and development and commercial activities in the field of Robotics and Autonomous Systems.
- Fusion Technology Facilities at Culham and Rotherham—developing manufacturing techniques and testing components for fusion powerplants.
- The Hydrogen-3 Advanced Technology (H3AT) centre—researching fuel technology for fusion power; in particular, tritium—one of the two main fuels needed for commercial fusion.
- Oxfordshire Advanced Skills (OAS)—a training centre enabling Oxfordshire business to offer young people hi-tech and engineering apprenticeships of the highest quality.[284]

In addition, the UKAEA flagship programme is the design of a prototype UK fusion power plant—the Spherical Tokamak for Energy Production (STEP).[285] The programme, which was launched in October 2019, is backed by £220 million of government funding.[286] UKAEA aim to complete the project, which will deliver at least 100 MW to the national grid, by 2040.[287] Professor Chapman told us he believed this goal is achievable,[288] despite the fact that the ITER programme, which began construction in 2010, will not be

284 UK Atomic Energy Authority (NCL0016)
285 Culham Centre for Fusion Energy, STEP, accessed 9 February 2023
286 HM Government, UK to take a big 'STEP' to fusion electricity, 3 October 2019
287 UK Atomic Energy Authority (NCL0016); Department for Business, Energy and Industrial Strategy, Towards Fusion Energy, October 2021
288 Oral evidence taken on 25 May 2022, HC (2022–23) 230, Q70 [Professor Chapman]

fully operational until 2035 at the earliest.[289] In October 2022, West Burton, in North Nottinghamshire, was chosen to be the home of the STEP plant,[290] and more recently, on 6 February 2023, the Government established UK Industrial Fusion Solutions Ltd (UKIFS), which will act as a delivery body for the STEP programme.[291] The new organisation is a company limited by shares which will work with industry to deliver the STEP prototype plant. We view this as a positive move, especially as the written evidence that UKAEA submitted to our inquiry highlighted that the STEP programme needed to be "structured in an appropriate fashion to be able to raise private investment in future tranches of the programme".[292]

Private fusion sector

138. As well as the strong publicly funded programme of work that UKAEA is carrying out, the UK has a growing range of commercial companies conducting fusion research and building pilot scale demonstration reactors.[293] These private companies are often targeting more ambitious timelines for connecting their powerplants to the grid,[294] with a 2022 survey of commercial companies revealed that 93% of companies believed that "fusion electricity will be on the grid in the 2030s or before".[295] For example:

- First Light Fusion, an Oxford University spin-out company that uses the projectile fusion approach (see Box 2, above), are hoping to show net gain in 2027 and connect a power plant to the grid in the 2030s.[296] First Light Fusion will build its demonstration campus at UKAEA's Culham Campus.[297]

- Commonwealth Fusion Systems, based near Boston, Massachusetts, hopes to have its first plant, using a compact tokamak technology, operating in the early 2030s.[298]

- Tokamak Energy, a company based near Oxford which is developing a spherical tokamak, aims to deliver commercial fusion power in the 2030s.[299] Tokamak Energy will build its next prototype device at UKAEA's Culham Campus.[300]

- General Fusion, a Canadian company that uses a Magnetised Target approach, plans to commence construction of its demonstration plant at Culham in 2023, and aims to connect a commercial plant to the grid in the early 2030s.[301]

289 World Nuclear News, ITER fusion project preparing to outline revised timetable, 11 July 2022
290 UK Atomic Energy Authority, West Burton selected as home of STEP fusion plant, 6 October 2022
291 Department for Business, Energy & Industrial Strategy, UK takes major STEP towards near limitless, low-carbon energy, February 2023
292 UK Atomic Energy Authority (NCL0016)
293 UK Atomic Energy Authority (NCL0016); First Light Fusion (NCL0031); Commonwealth Fusion Systems (NCL0035); Tokamak Energy Ltd (NCL0039); General Fusion (NCL0043)
294 Assystem (NCL0025)
295 Fusion Industry Association, The global fusion industry in 2022, accessed 10 February 2023
296 First Light Fusion (NCL0031)
297 UK Atomic Energy Authority, First Light Fusion to build demonstration facility at UKAEA's Culham Campus, 25 January 2023
298 Commonwealth Fusion Systems (NCL0035)
299 Tokamak Energy Ltd (NCL0039)
300 UK Atomic Energy Authority, Tokamak Energy's fusion prototype to be built at UKAEA's campus, 10 February 2023
301 General Fusion (NCL0043)

139. The attractiveness the UKAEA's growing fusion cluster is clearly demonstrated by the fact that three of the companies mentioned above will build their next demonstration plants at the Culham Campus. This includes General Fusion, a Canadian Company, that noted in its evidence that UKAEA holds "vast reservoirs of expertise and knowledge", and spoke about the importance of private/public collaborations:

> Partnerships that skilfully combine the best of government expertise with private sector entrepreneurial drive are the most likely to succeed. Funding that directly supports joint work between public and private sectors can accelerate progress, provided that it does not impair the agility of the private sector.[302]

140. The UK Government also received praise for its forward-thinking approach to fusion regulation.[303] In October 2021, the Government published a Green Paper which outlines its proposals for a regulatory framework for fusion energy in the UK.[304] Based on this and the results of the consultation ran on the Green Paper, the Government has brought forward legislation in the Energy Security Bill that will establish the fusion regulatory framework.[305] The regulations will take a different approach to the current nuclear site licencing regime, because of the lower hazards of fusion compared with fission. As such, fusion will continue to be regulated in the UK by the Health and Safety Executive and environmental regulators, rather than by the ONR. Expert witnesses to our Inquiry, commended this approach, with Professor Andrew Sherry, Chair in Materials and Structures, University of Manchester, suggesting that this approach was attracting inward investment and persuading companies to move to the UK.[306]

Fusion's contribution to net zero by 2050

141. Although several companies have set out ambitious aims, advances in fusion are unlikely to happen soon enough to allow reactors to be deployed in time to make a significant contribution to the UK's 2050 net zero aim.[307] Even if they do, the cost per unit of energy may be too high to make them competitive with mature technologies such as wind, solar, and fission reactors.[308] Having said this, written evidence to our inquiry highlighted that fusion research will have "significant secondary benefits", including the development of transferable technologies, including in the fields of high temperature superconducting magnets, artificial intelligence (AI), cryogenic materials, and robotics.[309] The economic benefits of fusion research and development have also been estimated, with a 2020 report by the consultancy London Economics assessing that the total economic

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302 General Fusion (NCL0043)

303 General Fusion (NCL0043), Oral evidence taken on 25 May 2022, HC (2022–23) 230, Q67 [Professor Garwood and Professor Chapman]

304 Department for Business, Energy & Industrial Strategy, Towards Fusion Energy: The UK Government's proposals for a regulatory framework for fusion energy, 24 December 2021

305 Department for Business, Energy & Industrial Strategy, Energy Security Bill factsheet: Fusion regulation, 29 December 2022

306 Oral evidence taken on 25 May 2022, HC (2022–23) 230, Q105 [Professor Sherry]

307 Cwmni Egino (NCL0005), Professor Stephen Garwood (NCL0009), Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010), Nuclear Futures Institute, Bangor University (NCL0011), Imperial College London (NCL0026); Oral evidence taken on 25 May 2022, HC (2022–23) 230, Q42 [Dr Luce], Q42 [Professor Garwood], Q97 [Professor Sherry],

308 Assystem (NCL0025)

309 Assystem (NCL0025), Henry Royce Institute (NCL0030)

impact of UKAEA to the UK economy is estimated to have been between £1.3 billion and £1.4 billion in Gross Value Added (GVA), compared to £350 million of public investment into UKAEA's fusion research, over the period 2009/10–2018/19.[310]

142. **The work of the UK Atomic Energy Authority has resulted in a thriving research and development fusion cluster at the Culham Science Centre in Oxfordshire. As well as operating the world's leading torus and spherical fusion reactors, the Culham facility benefits from being part of a consortium of 30 fusion research organisations and universities from 25 European countries and has attracted private companies from around the world, many of which plan to build demonstrator reactors at Culham.**

143. **Since 2010, the UK public investment into fusion research and development has totalled around £970 million. All such investment of taxpayer funds has alternative uses, whether in science, energy, or other fields. Sceptics of fusion argue, in the much-repeated phrase, that the benefits of fusion are always 20 years away—with the implication that such funds could be better spent elsewhere. It is true that fusion is highly unlikely to make a material contribution to electricity generation by 2050, in the time to contribute to our net zero commitment being met. It is also true that there are many risks, uncertainties, and dependencies—such as the development of materials—that mean that fusion may not in the foreseeable timeframe realise it tantalising potential.**

144. **However, in recent months breakthroughs have been made in fusion research, including doubling of the record for power generated in a tokamak; there is a growing number of private fusion companies clustered in Culham and the UK is a leading nation in the ITER project.**

145. **We believe that it is not the time to abandon our long-standing commitment to fusion, just at the point when it is giving cause for optimism; when the zero-carbon imperative is strong; when we have an internationally admired and well-run organisation in the UK Atomic Energy Authority, and when positive spill-over effects are being felt from the research.**

146. ***To maximise the benefits that we gain from investment in fusion requires a long-term approach to give confidence and stability to investors and international partners and so we recommend that fusion is a part of the Government's long-term energy plan.***

310 London Economics (on behalf of the Department for Business, Energy & Industrial Strategy), The impact of the UK's public investments in UKAEA fusion research, January 2020, p 5

5 Nuclear skills gap

147. If the UK is to achieve a contribution of 24 GW of nuclear power by 2050 it will need to plan for, and achieve, a massive increase in the nuclear workforce, with a concomitant requirement for skills training at every level from apprentice to postgraduate.

148. A strategic plan for nuclear must include a dependable forward plan to provide such training, sufficient in volume and quality to meet the needs of an expanding sector. It needs to integrate the contributions of a range of organisations–developers, firms in the supply chain, institutions of further education and higher education and government agencies.

149. Evidence given to us by the global engineering and consultancy company Assystem said:

> A sizeable immediate challenge is addressing the UK's engineering skills gap, which, unless remedied, will make the 24GW by 2050 target impossible to deliver.[311]

Current nuclear workforce

150. In 2022 the civil nuclear sector employed over 64,500 people, of which 16,900 worked in decommissioning.[312] Many jobs in the nuclear industry are well paid. In 2021, the median salary in the nuclear sector was £47,000—80% higher than the median salary for all employee jobs in the UK of £25,990.[313]

151. Consistent with the distribution of nuclear sites being away from major conurbations, nuclear jobs are disproportionately in areas of lower employment and higher deprivation. Over 60% of nuclear jobs in the UK North West or South West England,[314] with 40% of civil nuclear jobs located in the 25% most deprived local authority areas.[315]

152. Unsurprisingly, given the ageing fleet of nuclear facilities outside Hinkley Point C, the UK nuclear workforce is relatively old. In 2021, 39% of the nuclear workforce was over 50, compared to 32% of the working population as a whole.[316] EDF told us that it was necessary to—and the company had—recruited to the sector in advance of the beginning of construction at Hinkley Point C.[317]

153. The UK nuclear workforce lacks diversity. In 2021 20% of the nuclear workforce was female and 38.7% of apprenticeships were taken up by females.[318] Targets set in 2018 to achieve 50% of female apprenticeships by 2021 were not met.[319]

311 Assystem (NCL0025)
312 Nuclear Decommissioning Authority, Annual Report and Accounts 2021/22, July 2022, p 21; Nuclear Industry Association, Jobs Map, September 2022
313 Nuclear Industry Association, Delivering Value, January 2023, p 9
314 As defined by the Index of Multiple Deprivation (IMD); Nuclear Industry Association, Jobs Map, September 2022
315 Nuclear Industry Association, Delivering Value, January 2023, p 14
316 Engineering Construction Industry Training Board, Workforce Census 2021 Nuclear, 2021, p 15; Office for National Statistics, Changing trends and recent shortages in the labour market, UK, 20 December 2021
317 Q74
318 Nuclear Skills Strategy Group, Nuclear Workforce Assessment 2021, p 32
319 HM Government, Nuclear Sector Deal, 27 June 2018

154. Witnesses agreed that the nuclear industry conforms to the lack of diversity seen in other STEM sectors. We have recently published a report into *Diversity and inclusion in STEM*,[320] which received written evidence from the nuclear industry. Specific concerns were raised by the trade union Prospect on the lack of ethnic diversity within the nuclear sector:

> … the nuclear industry, while recently making inroads towards gender balance, has a very poor record on ethnic diversity. We have heard senior leaders in the sector attribute that weakness to the geography of nuclear facilities, although many of the roles under Prospect's portfolio are of the quality that workers relocate for.[321]

155. The 2021 Nuclear Workforce Census received data from nine companies working in the nuclear sector representing 2,244 workers, of which 94.21% declared their ethnicity as white.[322] The lack of ethnic diversity in the nuclear sector has also been observed in other countries, with similar disparities seen in France.[323]

The required nuclear workforce

156. The Nuclear Skills Strategy Group is the industry's employer-led partnership for skills planning, covering the civil and defence segments of the industry, including power generation, new build, decommissioning, waste management and research and development.

157. Because of the relatively older current UK nuclear workforce, 50,000 full time equivalent employees would need to be recruited by 2040, even without an expansion of nuclear power in the UK.[324]

158. Under a scenario which envisages 19 GW of nuclear capacity by 2050—a fifth less than the Government's own target—the Nuclear Skills Strategy Group expects that around 180,000 workers will need to be recruited by 2050—including an average of 7,234 recruits each year until 2028,[325] compared to the current inflow of around 3,000 a year.[326] Recently, vacancies in the nuclear sector are running at twice the rate of the general engineering and construction sector.[327]

159. It is clear that because of the relatively older age profile of the present civil nuclear workforce, an increasing number of people must be recruited to the industry even if it were to undergo no expansion. If expansion is anywhere approaching the Government's 24 GW target, a massive recruitment will need to be made. And this at a time when global nuclear energy generation is predicted to increase by 39% by 2050, with around 60 reactors currently under construction in 30 countries.[328]

320 Science and Technology Committee, Fifth Report of Session 2022–23, Diversity and inclusion in STEM, HC 95, 23 March 2023
321 Written evidence taken by the Science and Technology Committee for its inquiry into Diversity and Inclusion in STEM, Nuclear Skills Strategy Group, DIV0031
322 Engineering Construction Industry Training Board, Workforce Census 2021 Nuclear, 2021, p 15
323 Jacobs (NCL0067)
324 Nuclear Skills Strategy Group, Nuclear Workforce Assessment 2021, p 20
325 Nuclear Skills Strategy Group, Nuclear Workforce Assessment 2021, p 14
326 Q155
327 Engineering Construction Industry Training Board, Workforce Census 2021 Nuclear, 2021, p 5
328 World Nuclear Association, Plans For New Reactors Worldwide, updated February 2023, accessed February 2023; International Energy Agency, World Energy Outlook 2021, December 2021, p 321 and p 200

Nuclear's image problem

160. In order to succeed in expanding recruitment into the nuclear sector, employers will be in competition with other choices for everyone from prospective apprentices to STEM graduates. The reputation and attractiveness of the sector as a place to work is therefore material.

161. Witnesses positively described the jobs within the nuclear sector as 'interesting',[329] 'fantastic', 'long-term and well paid'.[330] However, they referenced the need to change public perception of nuclear careers to attract more people into the industry.[331] For example, Professor Katherine Morris, Lead for Nuclear Environment and Waste Management, Dalton Nuclear Institute, described how her students and others thought negatively of careers within decommissioning and waste management.[332] Simon Bowen, Industry Advisor to GBN, explained how nuclear is not seen as attractive when compared to other sectors:

> The nuclear industry has an image problem. You can dress it in whichever way you like—we do. Can we compete with the likes of McLaren to bring in software engineers? Probably not, because McLaren is seen to be something that is more attractive.[333]

162. **It is not surprising that the nuclear sector has not been the industry of choice for many STEM specialists embarking on a career. At a time when no new nuclear plants had been approved for decades, this was a sector thought by some not to be one with a bright future in which to contemplate a lifetime career specialisation.**

163. **However, if the Government and the nuclear industry credibly adopt a stable, long term plan of growing the nuclear sector, there are very significant attractions to recruitment: new build and new technologies involve innovation and technical advances; the timescales of nuclear commitments offers the prospect of enduring careers; the global revival of nuclear power offers international opportunities; and financial rewards are likely to remain high.**

164. ***As part of a strategic approach to nuclear, the Government and the industry should set out steps deliberately to communicate to school-leavers, graduates and to those changing careers, the particular advantages of choosing to work in the nuclear industry.***

Nuclear skills and skills for nuclear

165. Due to the attrition of the existing workforce and the employment requirements of expanded nuclear activity, a large number of people new to the industry will need to be trained during the years ahead.

166. Skills engaged in the sector are often thought of as either 'skills for nuclear' or 'nuclear skills'.

329 Q143
330 Q165
331 Q162; Institution of Mechanical Engineers (NCL0037)
332 Q333
333 Q405

167. 'Nuclear skills' are those skills and training that are specific to the nuclear industry and might include the training required for operating nuclear reactors, nuclear safety professionals and nuclear-coded welders. Ivan Baldwin of Bechtel told us only 20% of the roles needed to deliver nuclear power are specific to the nuclear industry and therefore "nuclear skills".[334]

168. 'Skills for nuclear' refers to the training and expertise that is found in people across a range of sectors that can be applied to the nuclear industry, but are not specific to nuclear. Construction project management and electrical engineering are all STEM skills that can be used in a wide range of sectors, of which nuclear power is one.

169. In order to meet the needs of an expanding industry, it will be important to draw from a wide group of potential recruits. Dawn James, Vice-President of Nuclear Power at Jacobs, proudly described to us the training programmes her company had developed for those entering the sector from other industries.[335] However, the nuclear industry has, in the view of some witnesses, been more closed to entry from other science, technology and engineering backgrounds than needs to be the case. Simon Bowen, the Interim Chair of GBN, concluded:

> There is a degree of nuclear snobbery… we do make it a little bit special– and it is not. There are very few skills that are specific nuclear skills. The industry is dominated by general engineering, project management and safety skills, which you can bring in from multiple industries. We are doing so very successfully. We just have to up the numbers, but we must not create a problem elsewhere.[336]

> This view is not unique to the new build sector. In his inquiry into the award of the Magnox decommissioning contract by the NDA, Mr Steve Holliday, observed that:

> The culture of an organisation is at the heart of what it and its employees do, and how they do it. The NDA has world class expertise in nuclear decommissioning, but needs to realise that 'nuclear is not an island', and that there is much to be learned from comparable sectors grappling with complex infrastructure and costly, long term commitments.[337]

170. **It is highly desirable that, in expanding employment in the sector, opportunities should continue to be broadened to people from sectors other than nuclear. Apart from the wider pool of talent available, it is important there should be flows into and out of the nuclear industry from other industries. The risk for any industry that is too insulated from others is that it can be insular and impervious to different ways of thinking that are practiced in other industries. At a time of such rapid technological change and innovation, it is important that the nuclear industry participates in this movement, and avoids the degrees of groupthink in which a relatively small number of people move between a relatively small number of organisations within the same sector.**

334 Q154
335 Q161
336 Q406
337 Department for Energy Security and Net Zero and Department for Business, Energy & Industrial Strategy, Magnox Inquiry: final report, 4 March 2021, p 32 para 4.37

171. ***As a matter of strategic planning, the Government and the sector should, at a time of expansion, deliberately increase the permeability of the sector to other commercial, engineering and scientific sectors.***

The Nuclear Skills Strategy Group

172. The Nuclear Skills Strategy Group (NSSG) has been previously referred to as the nuclear industry's employer-led strategic partnership for skills. It is an asset that such a body exists because a strategic plan needs to bring together the range of employers in the sector, including the supply chain.

173. The NSSG has produced a strategic plan, based on a number of alternative scenarios for what recruitment the industry will need. Like the Government's Energy Security Strategy and Energy Security Plan, the NSSG's Strategic Plan for Skills—last updated in 2020—is now at the point when relatively high-level goals and aspirations need to be turned into concrete commitments by individual organisations by particular dates.

Apprenticeships for the nuclear sector

174. In order to attract a new generation of people who choose to begin their careers in the nuclear sector, or to allow other mid-career workers to equip the sector with relevant skills, apprenticeships and further education have great importance.

175. EDF told us that the construction of Hinkley Point C has already given rise to 1,000 new apprenticeships and it expects 1,500 to be generated by Sizewell C should it proceed.[338]

Box 3: The National College for Nuclear

Many of these apprenticeships are provided in partnership with the National College for Nuclear.

The National College for Nuclear was established in 2018 as part of the Government's 2017 Industrial Strategy and has campuses in the major nuclear hubs in the UK; Cumbria (Lakes College) and Somerset (Bridgwater & Taunton College).[339]

The college aims to form partnerships between industry employers, regulators, skills bodies and training providers to create a curriculum that aligns with the demands of the nuclear industry.

176. So far, apprenticeships programmes have been arranged for Hinkley Point C at the Bridgwater & Taunton College working with the National College for Nuclear. Evidence submitted to this Inquiry from the College said that there is no current funding mechanism to support curriculum development including recruitment and the production of learning materials prior to pupil enrolment.[340]

177. **We were impressed by the obviously effective working relationship between the National College for Nuclear and the Hinkley Point C Project. In this case, the training provided, and the apprenticeships offered, are clearly tied to a specific employer and site. We were concerned that there was a lack of clarity on who should**

338 Q74
339 Department for Education, New National College for the nuclear industry launches, 7 February 2018
340 Matt Tudor (Director of Strategy & Partnerships at Bridgewater & Taunton College) (NCL0076)

fund the development of the curriculum and teaching materials for courses mounted exclusively to serve the needs of a particular employer. ***The Government and the Nuclear Skills Strategic Groups should develop a clear protocol on this. Should further nuclear new build proceed, with multiple organisations in the developer and in the supply chain requiring apprenticeships, there must be no delay in developing courses arising from ambiguity on who pays for that development.***

Higher education for nuclear

178. Nuclear skills are also developed in higher education settings such as universities and institutes. Graduate and post-graduate workers take up the smallest proportion of required nuclear workforce, yet these skills take the most time and resources to develop.[341] Academic stakeholders praised the development of Centres of Doctoral Training (CDTs) to help address the nuclear skills shortage,[342] as CDTs use a funding model that enables industry to leverage private investment against research council funds.[343]

179. Nuclear clusters bring together academia and industry in geographic regions with a strong nuclear footprint such as the North West Nuclear Arc,[344] and the South West Nuclear Hub.[345] These clusters benefit the nuclear sector and provide a strategic alliance between the academic, industrial and public sector members. However, some academics have called for an expansion in the universities and institutes that can provide courses in nuclear science and engineering outside these historical nuclear centres.[346] This expansion would benefit the industry as it will provide a diversity of thought to create more innovative solutions, as well as benefitting UK workers by broadening the reach of a well-paid industry.[347] Professor Paul Norman, Professor of Nuclear Physics and Nuclear Energy Director at the Birmingham Centre for Nuclear Education and Research, told us that companies were still concerned with the low number of graduates that have the appropriate nuclear expertise. Providing more opportunities to study nuclear engineering and sciences at universities could address this gap.[348]

Competitive pay in the nuclear sector

180. Jobs within the nuclear sector are generally well paid, with median salaries 1.8 times the national average.[349] However, we heard concerns that there was disparity in the pay available in different parts of the sector. Whilst nuclear power stations are operated by the private sector, some decommissioning, regulatory, research and training roles are within public sector bodies which are covered by civil service pay guidance.

341 Nuclear Innovation & Research Advisory Board (NCL0042)
342 Imperial College London (NCL0026); Nuclear Innovation & Research Advisory Board (NCL0042)
343 Imperial College London (NCL0026)
344 Members of the North West Nuclear Arc include: Urenco, EDF, The University of Manchester Dalton Institute, Bangor University, The National Nuclear laboratory and Sellafield.
345 Members of the South West Nuclear Hub include: The University of Oxford, The University of Plymouth, Cavendish Nuclear, Jacobs and Nuclear Advanced Manufacturing Research Centre
346 Imperial College London (NCL0026); University of Bristol (NCL0051)
347 University of Bristol (NCL0051)
348 Q33
349 The median salary was £25,990 for all employee jobs in the UK in 2021 while that in the civil nuclear industry amounted to £46,704. Nuclear Industry Association, Delivering Value, Jan 2023, p 9

181. As we described in paragraph 145, pay levels in the nuclear sector are relatively high. But within the sector there are anomalies. Specifically, important public sector bodies such as the UKAEA, the NNL, the NDA and the Environment Agency are subject to civil service pay remit guidance which restricts salaries that can be paid.[350]

182. In a sector where skills can be applied in a variety of organisations, and—in the case of research bodies—where competition with universities and overseas scientific bodies is substantial, there is a serious risk that some vital organisations to the operation of the nuclear sector will be constrained in their ability to recruit and retain staff of the required number and quality.

183. Within nuclear regulation, not all regulators are constrained by public sector pay limitations, leading to unequal access to resources and to competition for skilled workers between regulators. Mark Foy from the ONR told us that retention was high within the organisation, and he did not envisage challenges in recruitment if and when capacity needed to be increased.[351] He also said that the ONR attracts workers from other regulatory bodies as well as industry.[352] Conversely, the Environment Agency in its written evidence said:

> Recruitment and retention of regulatory resources are already under pressure from a range of factors including industry demand and uncompetitive salaries. This should be addressed to ensure that the competency and capability of regulators can meet the demands of the new build programme.[353]

184. The disparity within nuclear regulation resources can be seen directly in the salary bands offered. The lowest grade Environment Agency nuclear regulator (band N1a) salary range begins at £50,001,[354] whereas the equivalent salary band (band 3) at the ONR would start at £71,033.[355]

185. ***In line with Sir Paul Nurse's recommendations for greater flexibility on pay with conditions for Public Sector Research Establishments,[356] we recommend that a consistent set of pay flexibilities should be applied to public bodies in the sector with financial discipline applied through the overall budgets for bodies.***

350 Cabinet Office, Civil Service Pay Remit Guidance, 2023 to 2024 14 April 2023
351 Q431
352 Q424
353 Environment Agency (NCL0019)
354 Environment Agency, Environment Agency Jobs, accessed 8 Feb 2023
355 Office for Nuclear Regulation, Freedom of Information request ONR inspector pay grades, 23 June 2021
356 Department for Science, Innovation and Technology, Independent Review of the Research, Development and Innovation Organisational Landscape, 6 March 2023, pp 19–20

6 Financing

186. Every nuclear power station that has ever operated in the UK has been built on the public sector balance sheet, financed by taxpayers' funds. This has also been the usual model for other civil nuclear nations around the world. Hinkley Point C, currently under construction, is unique in that it is being financed off the UK Government's balance sheet by the French government owned EDF and Chinese CGN. But this financing model—a Contract for Difference (CfD)—has proved impossible to replicate for further nuclear reactors. This has led the Government to consider a different approach—accepting construction risk onto the public balance sheet through a Regulatory Asset Base (RAB) model. This is one of a number of ways in which governments around the world have sought to combine public funding with private sector construction and operation. Other funding models, using different combinations of public and private funding, used around the world are shown in Table 2. While it seems likely that a CfD model, insulating the taxpayer from construction risk, is not repeatable, the proposed RAB model itself has notable deficiencies, chief among which is understanding the value of construction risk taxpayers or billpayers would absorb.

187. Gigawatt-scale nuclear construction projects rank among the most costly capital projects ever undertaken anywhere in the world with current cost predictions for the Hinkley Point C reaching £32 billion.[357]

188. Witnesses to our inquiry, including the Government, said the financing costs are the largest proportion of the overall cost of nuclear power plants.[358] The Nuclear Energy (Financing) Act 2022, which aimed to reduce the cost of financing for nuclear projects, was introduced mainly to try to address this challenge.[359]

Financing new nuclear

189. Table 2 summarises international approaches to funding new nuclear builds. This section will focus on the two funding models currently considered for new civil nuclear projects within the UK.

357 EDF, Annual results 2022, 17 February 2023, p 25

358 Department for Business, Energy and Industrial Strategy (NCL0006); Nuclear Futures Institute, Bangor University (NCL0011)

359 *Nuclear Energy (Financing Bill) 2021–22*, Briefing Paper CBP9356, House of Commons Library, January 2022

Table 2: International approaches to financing nuclear power stations

Structure	Description	Examples
Public	Government directly finances a project either through full public ownership, or an injection of a mix of either equity or debt, into a project company. Availability depends on government policy and market design. Typically takes place in markets where governments are also involved in owning and operating energy utilities. Government involvement in a project, even if indirect (e.g. a government holds a majority stake in the utility), usually makes it much easier to raise private debt at a reasonable rate of interest.	China, and previously used in the UK for all currently operational nuclear power stations.
Investor/ cooperative financing	Private investment may be facilitated through cooperative investment models, where a group of investors raise debt and equity for a project, and share the risk related to doing so. Investors are typically wholesalers, retailers or large industrial companies.	Finland through the Mankala model and France (between 2005 and 2010) with the Exceltium consortium.
Power Purchase Agreement (PPA)	A PPA is an agreement between an electricity generator and a purchaser. The agreement stipulates the price and amount, as well as the term over which, the buyer purchases power from the seller. The PPA is then used to raise funding for project construction. Buyers are typically wholesalers or similar that require secure supply at a fixed price (e.g. grid operators). PPAs may or may not be guaranteed by host governments.	Akkuyu nuclear power plant, Turkey. PPA with Turkish power wholesaler, Tetas. Average price of 12.35 ¢/kWh for 15 years covering 70% of production from units 1&2 and 30% from 3&4.
Contracts for Difference (CfD)	A CfD is a long-term contract between an operator and a counterparty, which might be a government company, set up to represent the interests of electricity customers. For more details see below.	Hinkley Point C, UK and now being considered for use in EU countries.[360]
Loan Guarantees	Typically, these are extended to projects that are otherwise fully commercial arrangements between a plant's owners and lenders. Guarantees vary, but may provide lenders with assurance of full repayment including interest, or may simply protect a lender against a certain portion of potential losses.	USA, for the development of Vogtle 3&4.
Government-Government financing	Governments with strong domestic nuclear energy industries may seek to support export activities. As with domestic projects, support may be direct or indirect. A state-owned utility may make an equity investment in a foreign project or support the project indirectly using an export credit agency (ECA).	China National Nuclear Corporation (CNNC) provided a loan of $9–10 billion to the Pakistan Atomic Energy Commission to build two ACP1000 reactors at the Karachi nuclear power plant.

Source: World Nuclear Association, Financing Nuclear Energy, accessed April 2023

360 Euractiv, What to expect from the EU's power market revamp, 8 March 2023

Contracts for Difference

190. Hinkley Point C is being financed using the CfD model which was developed by the Government to support low-carbon electricity generation. The then BEIS described the purpose of CfDs as to:

> […] incentivise investment in renewable energy by providing developers of projects with high upfront costs and long lifetimes with direct protection from volatile wholesale prices, and they protect consumers from paying increased support costs when electricity prices are high.[361]

191. CfDs create a private contract between the renewable or low-carbon electricity generator and the Low Carbon Contracts Company (LCCC), a private company owned by the Government. CfDs include a strike price, which is a guaranteed price for energy generated. This guarantees a level of revenue for private finance providers over a set period of the operation of the asset, whatever is the actual market price of its output at the time.[362] If the market price for electricity is below the strike price when the power plant is operational, the costs of the additional payments are ultimately passed on to the consumer *via* energy bills. If the market price exceeds the strike price the operator must pay back the difference, meaning customers may benefit from the difference.[363] In effect, under CfDs, the consumer takes on the market price risk from the operator.

192. Hinkley Point C was given final approval by the Government on 15 September 2016 with a strike price of £92.50/MWh (in 2012 prices) which is index linked to inflation.[364] Reports from the National Audit Office and Public Accounts Committee have said that although it considers that there is a strategic case for nuclear power, the Hinkley deal offers poor value for money for consumers as the price, fixed for 35 years (compared to 15 years for renewable energy projects), is seen as "locking" customers into paying a higher price than subsequent falls in renewable prices would have delivered.[365] Since Russia's invasion of Ukraine, electricity prices have increased from the previous declining trends. The strike price offered for Hinkley Point C was less than half the market rate for electricity in December 2022 in real terms.[366] Prices have since reduced, but the strike price remained less than the current market rate, as of May 2023.[367]

193. In return for a guaranteed price for its output, operators under the CfD model for Hinkley Point C take responsibility for the majority of the risks of construction, increases in supply chain costs or project delays, as well as the initial level of operating costs for the reactors.[368] The Nuclear Futures Institute (NFI) said in its written evidence that it considered this model "not very successful" because the risks and the size of the capital

361 Department for Business, Energy & Industrial Strategy, Contracts for Difference, updated 14 December 2022
362 The 'Strike price' is a set price for electricity produced by the finished power station and is secured for a certain number of years. The developer is guaranteed this price, so if the market rate for electricity drops below the strike price, the developer is paid the difference.
363 *Nuclear Energy (Financing Bill) 2021–22*, Briefing Paper CBP9356, House of Commons Library, January 2022
364 Department for Business, Energy & Industrial Strategy, Government confirms Hinkley Point C project following new agreement in principle with EDF, 15 September 2016
365 House of Commons, Public Accounts Committee, Third Report of Session 2017–19, Hinkley Point C, HC 393, p 5–7; National Audit Office, Hinkley Point C, 23 June 2017, p 12
366 Price of electricity week commencing 26 December 2022 £219.56/MWh, Wholesale market indicators| Ofgem. As of May 2023, the current strike price for Hinkley Point C is £106.12 /MWh Hinkley Point C| Low Carbon Contracts Company
367 Price of electricity week commencing 29 May 2023 £104.33/MWh, Wholesale market indicators| Ofgem.
368 Q261; National Audit Office, Hinkley Point C, 23 June 2017, p 53

requires more expensive financing or that financing may be impossible to arrange.[369] NFI calculated that approximately 67% of the price of Hinkley Point C was associated with financing.[370] The cost of financing has increased further in recent months, such that in February 2023 EDF predicted the cost of Hinkley Point C had risen by 20% in a year because of rising interest rates.[371] The cost of financing Hinkley Point C under CfDs, in which construction and finance risk was with the developer and operator not the consumer or taxpayer, was recognised as a concern at the time it was agreed, with the National Audit Office in 2017 reporting that:

> While committing the developer to bearing the construction risks means taxpayers and consumers are protected from costs overrunning, consumers could end up paying more for [Hinkley Point C's] electricity than if the government had shared these risks.[372]

Although the National Audit Office said this in 2017, it should be said that the rising cost of the government now issuing its own debt over the last year shows that the cost to the taxpayer could also have increased under an alternative model.

194. The UK's nuclear operators are all subsidiaries wholly owned by French state-owned EDF, which are managing both the Hinkley Point C (in which China General Nuclear holds a 33.5% stake)[373] and Sizewell C projects, as well as Sizewell B and the fleet of AGR reactors still in service. Previous attempts by other companies to enter the UK's nuclear sector have not been successful, mostly due to difficulties in raising commercial investment funds for projects to proceed:[374]

- Hitachi declined to continue investing in the proposed Horizon nuclear power plant project at Wylfa, Anglesey, Wales in January 2019 despite having spent £2 billion on the project. It said the reason for withdrawal was that it had been unable to establish a viable means of funding the project;[375] and

- Toshiba discontinued work towards planning a power station using the Westinghouse AP1000 reactor at Moorside, adjacent to Sellafield sites in Cumbria, in 2018 after failing to find a buyer for its NuGen division that was developing the site. In the statement announcing their withdrawal, Toshiba said it was "the economically rational decision" to withdraw.[376]

195. In the case of the Horizon project, the UK Government had explored a potential novel public-private financing model with the company whereby the Government would hold a one third equity stake in the project in addition to offering a strike price of £75/MWh (in 2012 prices).[377] However, one witness to our inquiry pointed out that there is a "desire of investors to tread a well-used pathway rather than find themselves guinea pigs for a

369 Nuclear Futures Institute, Bangor University (NCL0011)
370 Nuclear Futures Institute, Bangor University (NCL0011)
371 Financial Times, EDF faces shouldering more of soaring bill for Hinkley Point, 17 February 2023
372 National Audit Office, Hinkley Point C, 23 June 2017, p 12
373 Department of Energy & Climate Change, Hinkley Point C to power six million UK homes, 21 October 2015
374 Cwmni Egino (NCL0005); Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010)
375 Hitachi, Hitachi to end business operations on the UK nuclear power stations construction project, 16 September 2020
376 Toshiba Corporation, Press Release, 8 November 2018
377 Q265; The Guardian, Hitachi scraps £16bn nuclear power station in Wales, 17 January 2019

new approach".[378] The failure to be able to commercially finance Horizon and NuGen demonstrated that the risks associated with a developer-focused CfD model were too high for the market to bear.[379] Faced with this, the Government initiated work on exploring whether an alternative model, the RAB model, could be a workable and acceptable model for the construction of new gigawatt nuclear power plants.[380]

The Regulated Asset Base (RAB) model

196. In March 2022, the Nuclear Energy (Financing) Act 2022 was enacted allowing the use of the RAB model to be extended for use for new nuclear projects.[381] RAB models have already been in use in the UK for major projects such as the Thames Tideway Tunnel. Sizewell C would be the first nuclear build to use a RAB financing model.

197. Under the RAB model, an economic regulator is given the power to levy a charge on consumers, the proceeds of which go towards financing the construction of new infrastructure. For new nuclear plants, electricity suppliers would be required to pay an assured amount to fund construction of nuclear power plants and would be permitted to pass this charge on to their customers. According to the Government, the RAB model would reduce the overall cost of a project by reducing financing costs over the construction period, compared to a model in which the cost of construction was financed exclusively from the return provided by operating the plant in the future.[382] A RAB model seeks to address the high and potentially unfeasible costs of constructing new nuclear plants in two ways:

i) Sharing a greater degree of construction and operating risks with consumers, and in the case of low probability/high risk events the taxpayer, to reduce the risk element in the cost of capital;[383] and

ii) Providing a revenue from day one during construction thereby reducing the financing costs of a lengthy construction period for nuclear projects, before revenue from electricity generation comes on stream.

Revenue from the RAB model

198. Under the RAB model the nuclear company would receive a revenue stream during construction and operation, and would include a £/MWh price, known as the 'allowed revenue,' calculated by the regulator Ofgem.[384] This is similar to the CfD guaranteed strike price. However, with the RAB model the £/MWh is reviewed regularly and can vary. During construction and under a RAB model, energy suppliers would be charged a share of the allowed revenue, based on their market share at the time, which they can pass on to consumers. This means consumers would start paying for nuclear projects through

378 Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010)
379 Cwmni Egino (NCL0005); Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010); Prospect Trade Union (NCL0013)
380 Copeland Borough Council (NCL0007); Civil Engineering Contractors Association (NCL0008); Nuclear Futures Institute, Bangor University (NCL0011); Institution of Mechanical Engineers (NCL0037); Cavendish Nuclear (NCL0041); Nuclear Innovation & Research Advisory Board (NCL0042); Westinghouse Electric Company (NCL0054); EDF Energy (NCL0057)
381 Nuclear Energy (Financing) Act 2022
382 Department for Business, Energy and Industrial Strategy (NCL0006)
383 Q261
384 Office of Gas and Electricity Markets (Ofgem), Annual Report and Accounts, 15 July 2022, p 12

their energy bills as soon as construction begins. In 2021 the Government predicted that on average less than £1 a month would be added to a typical household's energy bill during the construction phase of any new gigawatt-scale nuclear power plant.[385]

199. As the allowed revenue is variable and can be adjusted if circumstances change throughout the nuclear construction project, some experts critical of the model say that the true cost to the consumer is unknown and would "appear to consumers, rightly, like signing a blank cheque".[386] Once a nuclear power plant is generating energy, the RAB model functions in a similar way to the CfD mechanism currently being used for Hinkley Point C.

Response to the use of the RAB model for financing Sizewell C

200. Many contributors to this inquiry supported the expansion of the RAB model to include nuclear power plants.[387] Dr Tim Stone, Chair of the Nuclear Industry Association, argued that the use of the RAB model would make Sizewell C around 30–33% cheaper than the cost of Hinkley Point C.[388] The Government itself estimated that using a RAB rather than a CfD model for new nuclear power plants would save consumers between £30bn and £80bn.[389] However, there was some confusion on how these savings were calculated. The Minister told us that the source of savings was the reduction in the cost of financing calculated over the 60-year lifetime of a generic reactor.[390] Whilst acknowledging that the RAB model would reduce costs, Josh Buckland, a Partner at Flint Global, said that he could not calculate these values from available published sources and that it would be helpful if the Government were to publish its analysis.[391]

201. A major benefit to the nuclear developer of the RAB model is the ability of the utility to raise revenue during the construction of the plant.[392] It is argued that this could widen the pool of investors willing to participate in nuclear projects earlier in the project lifecycle.[393] By attracting private investment into nuclear projects, the Government would reduce its now sizeable £700 million (50%) stake in Sizewell C once construction begins.[394] Doing so allows the development of a so-called circular funding model,[395] which Simon Bowen, now the Interim Chair of GBN said was key to funding a new nuclear programme.[396]

385 Department for Business, Energy & Industrial Strategy, New finance model to cut cost of new nuclear power stations, 26 October 2021
386 Nuclear Consulting Group, The Proposed RAB Financing Method, 2019, p 11
387 Department for Business, Energy and Industrial Strategy (NCL0006); EDF Energy (NCL0057); Nuclear Futures Institute, Bangor University (NCL0011); Nuclear Innovation & Research Advisory Board (NCL0042)
388 Q144
389 *Nuclear Energy (Financing Bill) 2021–22 HL Bill 89 of 2021–22*, Library Briefing LLN-2022–0002, House of Lords Library, January 2022; Q500
390 Q500
391 Q268
392 Nuclear Futures Institute, Bangor University (NCL0011)
393 Rolls-Royce SMR Limited (NCL0021)
394 HM Government, UK government takes major steps forward to secure Britain's energy independence, 29 November 2022
395 A circular funding model allows the Government to invest in early stages of a project which is returned once private investment is raised. The initial public investment can then be used for further projects within a nuclear programme.
396 Q407

In the long-term this would require attracting private investment at rates that offer value for money,[397] with construction risk minimised,[398] which the RAB model was intended to address.

202. One of the principal criticisms of the RAB model is that the majority of construction risk, including the costs of delays in construction work, is transferred partly to consumers and away from the developers.[399] Mr Richardson from the National Infrastructure Commission argued that the RAB model does nothing to "inherently improve project management", and shifting the construction risk to consumers disincentives delivering projects on time.[400] However, Mr Buckland said that the features of the RAB model meant that the risk to developers would not be removed but capped, allowing a level of confidence for investors so they would demand lower levels of return.[401] Capping of developer risk from the RAB model means that an unknown and variable burden of construction cost is put on consumers and conceivably, should costs be unsupportable, taxpayers.

203. A further cost to consumers is advancing money paid through bills before any electricity is generated, the counterfactual use of which could be used to generate positive returns for the consumer through investments or savings. Mr Richardson told the committee that:

> [The RAB model] basically asks consumers to lend money to the project at zero interest. That is a cost to consumers, but that cost does not appear in any of the maths when you look at the cost of a project under the RAB. You are not saying, "The consumers could put their money in the bank or the stock market and get a return on it". So that cost disappears from the maths, but it is a real cost, none the less, and it is perfectly possible to calculate what it is and re-establish it.[402]

204. Other committees have highlighted the similarities of the RAB model with financing structures in the US, which resulted in an average 18% increase in consumer bills to cover the costs for failed nuclear projects.[403] However, the proposed RAB model in the UK differs from these structures, to the extent that the developer would share a proportion of the risk and cost overruns.

205. However, the exact details of the deal made between EDF and the Government, including proportions of risk allocation and consequences in case of cancellation are unknown.[404] This makes it difficult to form a view on how reasonable the proposed approach is.

397 Q407
398 Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010); Nuclear Futures Institute, Bangor University (NCL0011)
399 Q123
400 Q123
401 Q261
402 Q123
403 Oral evidence taken before the Welsh Affairs Committee on 16 November 2022, HC (2022–23) 240, 16 November 2022, Q63 [Ms Pyke]
404 Q264, Q501

206. Mr Buckland told us that financing structures for new nuclear projects require a balance between risk and the cost of exposure to that risk:

> The challenge for politicians as they think about the right financing model for Government is what their risk appetite is, between placing the financial risk with the private sector and paying more for it, or, alternatively, placing it on the taxpayer or the consumer but accepting that the state may have to pick up the bill for that risk if it materialises down the line.[405]

207. As we set out in paragraph 14, civil nuclear power in the UK has a chequered history. Initially, it was a by-product of the rush to create nuclear weapons. Calder Hall was the first nuclear plant to generate energy at scale and 26 Magnox reactors were built in total. These proved expensive to construct and operate, meaning they struggled to compete economically with some coal and oil-fired power stations. Subsequently, the UK went its own way with the construction of advanced gas cooled reactors. In developing AGR technology it was envisaged that this reactor design could be sold overseas. In practice, none were. The UK then decided to back Westinghouse's PWRs. Nine were planned but the programme fell behind schedule and was never completed. In 2003 an Energy White Paper abandoned the use of nuclear power, before another White Paper just five years later in 2008 re-introduced its use, justified by the then UK target of 80% reductions in greenhouse gas emissions by 2050.

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405 Q261
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407 Q144
408 *Nuclear Energy (Financing Bill) 2021–22 HL Bill 89 of 2021–22*, Library Briefing LLN-2022–0002, House of Lords Library, January 2022; Q500
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By attracting private investment into nuclear projects, the Government would reduce its now sizeable £700 million (50%) stake in Sizewell C once construction begins.[413] Doing so allows the development of a so-called circular funding model,[414] which Simon Bowen, now the Interim Chair of GBN said was key to funding a new nuclear programme.[415] In the long-term this would require attracting private investment at rates that offer value for money,[416] with construction risk minimised,[417] which the RAB model was intended to address.

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413 HM Government, UK government takes major steps forward to secure Britain's energy independence, 29 November 2022
414 A circular funding model allows the Government to invest in early stages of a project which is returned once private investment is raised. The initial public investment can then be used for further projects within a nuclear programme.
415 Q407
416 Q407
417 Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010); Nuclear Futures Institute, Bangor University (NCL0011)
418 Q123
419 Q123
420 Q261
421 Q123
422 Oral evidence taken before the Welsh Affairs Committee on 16 November 2022, HC (2022–23) 240, 16 November 2022, Q63 [Ms Pyke]

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> The challenge for politicians as they think about the right financing model for Government is what their risk appetite is, between placing the financial risk with the private sector and paying more for it, or, alternatively, placing it on the taxpayer or the consumer but accepting that the state may have to pick up the bill for that risk if it materialises down the line.[424]

215. As we set out in paragraph 14, civil nuclear power in the UK has a chequered history. Initially, it was a by-product of the rush to create nuclear weapons. Calder Hall was the first nuclear plant to generate energy at scale and 26 Magnox reactors were built in total. These proved expensive to construct and operate, meaning they struggled to compete economically with some coal and oil-fired power stations. Subsequently, the UK went its own way with the construction of advanced gas cooled reactors. In developing AGR technology it was envisaged that this reactor design could be sold overseas. In practice, none were. The UK then decided to back Westinghouse's PWRs. Nine were planned but the programme fell behind schedule and was never completed. In 2003 an Energy White Paper abandoned the use of nuclear power, before another White Paper just five years later in 2008 re-introduced its use, justified by the then UK target of 80% reductions in greenhouse gas emissions by 2050.

216. **Gigawatt-scale nuclear projects cost tens of billions of pounds to plan and construct before a single unit of electricity is generated. Their long period of construction, complexity, and subordination to potentially variable regulatory standards have been associated with large cost-over runs and delays. For all of these reasons, and more, the financing of gigawatt-scale new nuclear power has proved formidably challenging. Most civil nuclear nations have built new nuclear power stations on the public sector balance sheet, as did the UK for all of its existing nuclear power stations. Hinkley Point C has been financed off the Government balance sheet by the French Government-owned utility EDF and Chinese CGN. Its construction is proceeding in return for a 35 year Contract for Difference (CfD) fixed at £92.50/MWh in 2012 prices. The conceived cost of construction has increased from £18 billion at the time of the final investment decision to £32 Billion in 2023 and its completion date is now forecast to be 2027, around two years after EDF's estimate at the time of Final Investment Decision (FID). It is important to note that the estimates of that cost overrun as result of the CfD model are not to be met by UK consumer or taxpayer, but by the companies. The CfD runs for 35 years from start-up during the 2025–2029 period. If the plant is not generating electricity by 2029 then the contract would be shortened by one year up until 2033 after which the contract will be cancelled and EDF will not receive any top-up revenues from the CfD.**

423 Q264, Q501
424 Q261

217. **Given the demonstrated unwillingness of private investors to take on all of the construction risk of gigawatt scale nuclear plants through the CfD model, it is inevitable that a public-private risk sharing model should be contemplated if new gigawatt-scale plants are to be constructed. The Regulated Asset Base (RAB) model—which has been given Royal Assent in the Nuclear Energy (Financing) Act is one such. However, the model entails significant uncertainties and downsides. Chief among these is that although the financing of a plant should be cheaper in headline terms than a model in which the private sector shoulders all construction risk, the extent to which this represents value for money depends on the financial value of the construction risk being absorbed by the public balance sheet. The consumer or taxpayer is taking an unknown and uncertain risk of cost overruns, yet disburses funds from day one without earning a return.**

218. ***The Government should show how this offers value for money to taxpayers and should be open to other alternative partnerships between the public and private sectors as practised in other countries (including those set out in Table 2).*** **The choice to proceed with gigawatt-scale nuclear power should not be made without robust estimates of its value for money, including the financial value of the construction risk being assumed by taxpayers or billpayers. A headline lower cost than Hinkley Point C is not justified if the value of the risk is too great. This is true even if it forces a conclusion that—for all its other advantages—gigawatt scale new nuclear is not financeable on defensible terms, and that the UK's nuclear ambition would need to be pursued through other nuclear technologies.**

219. ***So far, the Government has not published financial figures which allow the cost of this risk transfer to be known. The Government must publish figures, before signing contracts for new gigawatt-scale nuclear, which allow a proper assessment of value for money to be made, including setting out the level and potential cost of construction risk to be borne by the consumer or taxpayer.***

220. ***It may be the case that the size of capital outlay means that private investors will not repeat a CfD contract for new nuclear, whatever the price. But the lack of alternative choices should not mean that any terms will be acceptable for a RAB financed plant. The Government should make, and disclose, its best estimate of the value of the risk that would be taken on by the public, and a clear plan of how those risks can be managed through incentives during the development, construction and operational phase of the project's lifetime.***

221. ***The Government should publish details of how the estimated savings from using the RAB model for funding Sizewell C were calculated, and provide clarity for the funding structure, by publishing the Heads of Terms for the agreed RAB funding model for that project.***

Funding advanced nuclear technologies

222. There was no consensus among developers of advanced nuclear technologies such as SMRs or AMRs on the funding model best suited to finance deployment of these technologies. As discussed above, AMRs are still mostly in the development phase, while some SMRs are predicted to be ready for deployment within the next ten years.[425]

425 Nuclear Industry Association (NCL0012)

223. Unlike gigawatt-scale reactors, the investment risk for SMRs is associated with technology readiness rather than the capital costs of large infrastructure projects.[426] Witnesses to our inquiry expected that the first few units would require some form of government support for development and deployment, following which private investment would take over the commercial roll-out of further units.[427]

224. SMRs are not currently eligible for CfD in the Government financing of clean energy.[428] However, given the undeniable success associated with CfDs in the construction of renewables, this model was favoured by SMR developers who gave evidence to this inquiry.[429] Some witnesses also suggested that the RAB model,[430] or versions of it,[431] may also be appropriate.

225. **This is an important moment for the future of small modular reactors (SMRs) as we set out in Chapter 3. Following the £500 million Government and investor funded development of an SMR concept through to the beginning stages of regulatory approval. Clarity is needed on the Government's plans to deploy the technology if it completes the generic design assessment. This includes deciding on what financing model will be made available should the policy be to deploy SMRs in supplying power to the grid. The Contracts for Difference (CfD) model has proved successful in financing and driving down the costs of clean energy. Key to the success of CfDs for renewables to date has been competition between potential operators which has driven down the price paid for electricity generation.**

226. ***If a single supplier of SMRs were to be available, either through Government choice or following the Generic Design Assessment process, the CfD auction model will not be suitable. As part of a clear and specific strategy for SMRs, the Government should come to a view quickly on what financial model would be available for the initial deployment and communicate this clearly to developers.***

Green financing in the UK

UK Green Taxonomy

227. The UK Green Taxonomy is a proposed classification system established by the UK Government to provide a clear framework by which investors or companies can more easily consider the sustainability of investments or activities. The Taxonomy aims to assist investors in identifying energy-related activities that will support the net zero transition, and also to give official status to definitions of green investments on which market participants may rely.[432]

426 Q272
427 National Nuclear Laboratory (NCL0040); Expert Finance Working Group on Small Nuclear Reactors, Market framework for financing small nuclear, August 2018, pp 5–7
428 Last Energy (NCL0015)
429 Last Energy (NCL0015); Rolls-Royce SMR Limited (NCL0021)
430 Rolls-Royce SMR Limited (NCL0021)
431 Q267
432 HM Treasury, UK Green Taxonomy, 9 June 2021

International approaches

228. The European Union Taxonomy Regulation provides investors with guidance on economic activities that can be considered environmentally sustainable.[433] Nuclear energy was originally left out of the initial Delegated Act, but further assessment concluded that nuclear technology should be classified as sustainable.[434] As a result, the European Commission took steps to include nuclear energy in the taxonomy but set out requirements that were more restrictive than for other energy technologies included in the first Delegated Act. The special requirements include:

- The use of accident-tolerant fuels, which are being designed to withstand a loss-of-coolant accident[435] and are not yet commercially available for all reactor types, should be set out in the technical screening criteria for all existing plants and Gen III new-build by the year 2025;
- The project must have been notified to the European Commission, and the European Commission has given its view whether all criteria have been satisfactorily addressed; and
- A final high-level waste repository (most likely a Geological disposal facility (GDF)) to be operational by 2050, and for final disposal facilities for low and intermediate-level waste to be operational in the country where a given project is based.[436]

Inclusion of nuclear in the UK Green Taxonomy

229. The inclusion of nuclear in the UK Green Taxonomy could be expected to allow for more private investment and lending for nuclear projects by widening the investor base, for example to include pension funds with sustainability mandates.[437]

230. The Government established an Energy Working Group to advise on the development of a green taxonomy screening criteria in the energy sector. Dr Fiona Rayment, a member of the group, in her oral evidence argued that nuclear should be treated equally with other low-carbon energy generation technologies and have access to affordable finance.[438] This view was supported by many witnesses in the written evidence, who called for nuclear energy generation to be considered fairly for inclusion in the Green Taxonomy.[439] Dr Fiona Rayment advocated a level playing field for all clean energy generation technologies once the criteria for inclusion was confirmed, saying:

> We should set the criteria [for the UK Green Taxonomy] and analyse all of the potential energy solutions against those criteria and not make separate

433 European Commission, EU taxonomy for sustainable activities, 12 July 2021
434 Commission regulation, EC 2021/2139
435 Research into accident tolerant fuels began after the Fukushima accident in 2011 where the water which cooled the reactor leaked away causing the cladding surrounding the fuel assemblies in the reactor to overheat and fail. New fuels are being designed to withstand a loss of coolant accident for longer or even indefinitely as compared to current materials. The benefits also increase the passive safety of the reactor and so may reduce potential costs of new nuclear build by removing backup safety systems.
436 Commission regulation EC 2022/1214,
437 Newcleo (NCL0062); Urenco (NCL0055); Institution of Mechanical Engineers (NCL0037)
438 Q270
439 Henry Royce Institute (NCL0030); Urenco (NCL0055); Nuclear Industry Association (NCL0012)

> decisions for specific technologies. If nuclear meets the criteria, my view is that it should be included, and should be treated like anything else, on a level playing field.[440]

231. In the Spring Budget 2023, The Chancellor of the Exchequer, Rt Hon Jeremy Hunt MP confirmed nuclear energy's inclusion in a new Green Taxonomy "subject to consultation".[441] The consultation is expected to take place in Autumn 2023.[442]

UK Government Green Financing Framework

232. The 2021 UK Government Green Financing Framework described how the Government planned to finance green projects through the issuance of Green Gilts and Green Savings Bonds, which it said would be critical in tackling climate change and other environmental challenges.[443] The framework set out the basis for identification, selection, verification, and reporting of the green projects that are eligible for such financing. Under "exclusions", the framework said:

> Recognising that many sustainable investors have exclusionary criteria in place around nuclear energy, the UK government will not finance any nuclear energy-related expenditures under the Framework.[444]

233. The then BEIS said that it supported the inclusion of nuclear in the UK Green Taxonomy.[445] When questioned on the conflicting policy between the Green Taxonomy and the Green Financing Framework, Declan Burke, then Director for Nuclear Projects and Development at the then BEIS told us that inclusion of nuclear in the green taxonomy could influence updates to nuclear's access to the Green Financing Framework as:

> …the Treasury has said that it will keep a constant review of the green gilt framework, based on things such as the taxonomy.[446]

234. **We welcome the proposed inclusion of nuclear energy generation in the UK Green Taxonomy as it reflects the low-carbon contribution of nuclear power and may make new building projects more attractive to private investors as with other low-carbon energy generators.**

235. ***The Government should conduct and publish the results of its consultation quickly, and during this time review nuclear energy's access to the Green Financing Framework with a view to ensuring consistency and addressing the contradiction between the two.***

440 Q274
441 HM Treasury, Spring Budget 2023, HC 1183, para 3.86
442 HM Government, Mobilising Green Investment, 30 March 2023, p 10
443 HM Treasury, UK Government Green Financing Framework, June 2021, p 10
444 HM Treasury, UK Government Green Financing Framework, June 2021, p 18
445 Department for Business, Energy and Industrial Strategy (NCL0006)
446 Q503

7 Regulation and location

236. The ONR was formed in 2011. Together with the Environment Agency and Natural Resources Wales, the ONR is responsible for licensing and regulating nuclear projects in the UK. The ONR became an independent public corporation in April 2014, as part of the Energy Act 2013, and from then was no longer part of the civil service.[447]

Generic Design Assessment

237. The GDA process focuses on the design of a civil nuclear reactor and is not site-specific. It contains a number of steps, with the assessment becoming increasingly detailed with each following step. The GDA process currently takes between four and five years, and its purpose is to ensure that any new UK nuclear power station meets the required standards of safety, security, environmental protection and waste management. Entry to the GDA is controlled by DESNZ and is carried out by the ONR in conjunction with the Environment Agency. Current reactors that have completed the GDA are in Table 3.

Table 3: Reactor designs that have entered the Generic Design Assessment

Company	Reactor Design	GDA status	Identified Sites	Construction status
Areva and EDF	UK EPR	Completed (December 2012)	Hinkley Point C and Sizewell C	Under construction/ site works beginning
Westinghouse	AP1000	Completed (March 2017)	Wylfa	Developing proposals and conducted exploratory talks with the Government448
Hitachi-GE	ABWR	Completed (December 2017)	Wylfa	Discontinued in 2020
EDF and China General Nuclear (CGN)	UK HPR1000	Completed (February 2022)	Bradwell B	Developing proposals
Rolls-Royce SMR	SMR	Submitted (March 2022)	Multiple proposed sites	Developing proposals

Source: Office for Nuclear Regulation, Assessment of reactors, accessed April 2023

238. The regulators modernised the GDA in 2020, considering lessons from previous assessments and recognising the emergence of advanced nuclear technologies.[449] The modernised GDA has three steps for ONR and Environment Agency to conduct, and companies may now choose to leave the process, with the option of re-entering the GDA once the second step is complete.

447 Energy Act 2013

448 Declan Burke, the then Director of Nuclear Projects and Development, Department of Business, Energy and Industrial Strategy (BEIS) confirmed in 2021 that the Government at the time were in regular discussions with the consortium proposing to build a nuclear power station at Wylfa using the AP1000 reactor technology. Oral evidence taken before the Welsh Affairs Committee on 23 September 2021, HC (2021–22) 622, [Mr Burke] Q49

449 Environment Agency (NCL0019)

239. Witnesses from the nuclear sector praised the UK GDA, for example, Professor Francis Livens, Director of the Dalton Institute, described it as the "gold standard".[450] Tom Samson, then Chief Executive Officer of Rolls-Royce SMR, agreed with this sentiment, telling us:

> Our regulatory process is world-recognised as one of the highest regulatory standards. It is a good thing for us to be in the GDA, with the ONR, the Environment Agency and Natural Resources Wales as environmental and nuclear regulators.[451]

240. We also heard how the GDA is well-regarded internationally, and was even cited as attracting developers to the UK, an example being Last Energy, a Washington-based SMR developer.[452]

241. In the US regulatory system, reactor vendors are required to meet specific standards from a prescriptive list. The UK's GDA however, has a set of high level regulatory goals, and it is the responsibility of the vendor to decide how the goals are achieved and to provide the regulator with substantiate evidence that the risks have been reduced so far as reasonably practicable.[453] The GDA's goal-based approach provides flexibility but relies on the competencies of both the regulator and reactor developer.[454] For all its high standing, the process was described by the Welsh Government's nuclear developer company Cwmni Egino as expensive and lengthy.[455] There have been requests from SMR developers to allow pre-engagement with the regulators, so that developers could test technologies against regulatory scrutiny and understand what was required prior to entering the GDA.[456] Michael Drury, from Terrestrial Energy, praised the pre-engagement step that has been made available to AMR developers, as part of the Government's 2020 AMR Feasibility and Development Competition, and called for its extension to other technologies.[457]

Capacity issues

242. Many witnesses to this inquiry expressed concern that there is a lack of resources within the nuclear regulators to process the increased number of GDAs expected.[458] Two nuclear companies told us they were in discussions with the then BEIS to enter the GDA,[459] but the Dalton Nuclear Policy Group warned that simultaneous applications would require work to be subject to prioritisation, which could cause further delays to the approval process.[460]

450 Q42
451 Q205
452 Q205
453 Q43
454 Q43
455 Cwmni Egino (NCL0005)
456 Q115
457 Q108
458 Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010); Environment Agency (NCL0019); Imperial College London (NCL0026); EDF Energy (NCL0057); Urenco (NCL0055)
459 Q101, Q193
460 Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010)

243. Mark Foy, Chief Executive and Chief Nuclear Inspector at the ONR, assured us that whilst he was aware of industry concerns regarding regulatory capacity for new nuclear, he believed that the ONR was ' … geared to that':[461]

> I am satisfied that we have sufficient capability effectively to regulate the industry as we currently understand and assume it will be shaped.
>
> In terms of new-build activities, we are aware of the defence programme, and are geared to regulate that effectively. We have made assumptions with regard to the shape of the new nuclear sector. Again, we are resourced with capability and capacity to do that, through generic design assessment and licensing. Those assumptions—just to be clear about what they are in the immediate future—are continuing with Hinkley Point C and Sizewell C regulation, and the generic design assessment of the Rolls-Royce SMR design. We are also assuming that we will be asked to undertake a number of generic design assessments for some of the SMR technologies that are currently being considered for entry into generic design assessment by the then BEIS.[462]

244. However, this evidence from the ONR was not wholly consistent with the written submission by the Environment Agency, another nuclear regulator, which said its resources were under pressure:

> The expanding work on new nuclear requires sufficient regulatory resources to deliver it and avoid programme delays. Recruitment and retention of regulatory resources are already under pressure from a range of factors including industry demand and uncompetitive salaries. This should be addressed to ensure that the competency and capability of regulators can meet the demands of the new build programme.[463]

245. As previously discussed in Chapter 5, it is vital that all regulators have the resources they need to provide the regulation that is needed for the safety and security of the UK's nuclear programme.

International collaboration for regulating reactors

246. International collaboration between nuclear regulators was proposed in several pieces of evidence from the nuclear industry as a means to improve the efficiency of the GDA process.[464] This approach has been explored by regulators in other countries, with Canada and the USA completing their first collaborative report on licensing SMRs in 2021.[465] Some developers wanted to see a more standardised universal approach to regulation, through the IAEA. However, witnesses felt that this approach would take a long time to establish, and may be set back by the fact that many Governments of nuclear nations desire sovereignty over nuclear programmes.[466]

461 Q432
462 Q430
463 Environment Agency (NCL0019)
464 Cavendish Nuclear (NCL0041); Nuclear Industry Association (NCL0012); Terrestrial Energy (NCL0046) Q101
465 World Nuclear News, Regulators complete first licensing cooperation, 12 August 2021
466 Q119

247. Mark Foy of the ONR was keen to emphasise the ONR's support for international regulatory collaboration and the benefits of developing agreements with other regulators:

> If the Canadians are progressing a particular technology and have done the assessments, I do not particularly need to do those assessments again; so I would be using them—a fellow regulator—effectively as part of the supply chain to provide me with their assessments. I do not have to spend the time and money to complete the assessments to inform my decision around generic design assessment.[467]

He also explained how the UK would benefit more from separate bi and tri-lateral agreements with national bodies, especially for SMR technologies, and that a more global approach would take a long time to deliver.[468]

248. **The Office for Nuclear Regulation (ONR) Generic Design Assessment's (GDA) goal-based approach is well regarded internationally and is intended to be adaptable for any new technology. We welcome the work that the ONR has done to modify the GDA to allow more flexibility for new reactor designs that seek to enter the UK market.**

249. **Some witnesses are concerned that the GDA has capacity constraints and is a lengthy and expensive process given that there are no site-specific guarantees afterwards. Whilst acknowledging the need for UK sovereignty over regulations, witnesses pointed out the considerable overlap of the technical approval process for new reactors between established nuclear nations.**

250. ***The Government should consider how it could reduce the GDA application timelines and the required resources through international collaborations between regulators, and should provide access to pre-engagement for new nuclear developers prior to entering the GDA. The ONR should examine ways to recognize, in whole or part, safety approvals for mature reactor designs granted by partner countries with similarly high standards to capitalise on work previously done.***

251. ***The Government should ensure as part of a specific and detailed nuclear strategy that the ONR, the Environment Agency and Natural Resources Wales have the necessary resources to process applications from the growing range and number of applicants in a reasonable timeframe.***

252. ***Whilst the ONR has recently adapted the GDA to be more suitable for small modular reactor (SMR) technologies, to date no SMR design has completed the entire three step process. The ONR should reflect, both during and after the first SMR has completed the GDA, on the lessons to be learned on efficiency and applying appropriate safety cases for these smaller technologies, from other similar bodies, such as the Environment Agency and Health and Safety Executive that regulate Fusion energy facilities.***

467 Q429
468 Qq434–435

Improving efficiency of nuclear regulation and licensing

253. Some nuclear industry witnesses identified the prospect of bottlenecks in licensing and regulation as a barrier to reaching the 24 GW target for new nuclear, although they emphasised that rigorous regulation was vital for safety and public support.[469] Some expressed concern over the length of time it took for nuclear power plants to go through the UK's regulatory processes which include GDAs, and site specific licensing and consent.[470] Rolls-Royce SMR said that it expects that the regulatory process will take longer than the building of one of its reactors,[471] with its representative telling the Welsh Affairs Committee:

> Reflecting on the large nuclear experience, the status quo is that you do your GDA for four to five years, then you start your DCO [Development Consent Order] for five to six years, then you start talking to the Government about how you pay for it all.[472]

254. Development Consent Orders (DCOs) are needed for nationally significant infrastructure projects, such as wind farms, regional airports and nuclear power plants, as required in the Planning Act 2008.[473] The purpose of the DCO is for large scale development projects to give the necessary planning permission and other related consents that they need without having to apply separately for each consent.[474] Despite the intention of improving efficiency of the planning process, Rolls-Royce SMR told the Welsh Affairs Committee how DCOs are seasonally dependant, and therefore can significantly increase planning timelines if not started in a specific month:

> The first thing you need to do to get your development consent order moving is your environmental permits. You need two years of analysis at your site. If you do not start that in March this year, you lose a year. You have to start it on a seasonal cycle. If we do not start this March, that is a one year delay automatically, because we then cannot start until March 2024.[475]

255. Evidence submitted to our inquiry recommended that the regulatory process should be 'streamlined'.[476] For example lessons could be learned from the Covid-19 pandemic vaccine licencing programme to accelerate regulatory approvals to allows parts of the processes run in parallel rather than sequentially.[477] Rolls-Royce SMR said in its evidence that allowing it to work on site-specific regulation such as the DCOs whilst its designs were undergoing the GDA, would speed up the entire regulatory process.[478] Mark Foy of the ONR broadly agreed with this proposal.

469 Last Energy (NCL0015); Nuclear Industry Association (NCL0012)
470 Nuclear Futures Institute, Bangor University (NCL0011); Civil Engineering Contractors Association (NCL0008)
471 Rolls-Royce SMR Limited (NCL0021)
472 Oral evidence taken before the Welsh Affairs Committee on 25 January 2023, HC (2022–23) 240, [Mr Salisbury] Q190
473 Planning Act 2008
474 *Planning for Nationally Significant Infrastructure Projects*, Briefing Paper 06881, House of Commons Library, 17 July 2017
475 Oral evidence taken before the Welsh Affairs Committee on 25 January 2023, HC (2022–23) 240, [Mr Evans] Q188
476 Department for Business, Energy and Industrial Strategy (NCL0006); Last Energy (NCL0015); Institution of Mechanical Engineers (NCL0037)
477 Imperial College London (NCL0026); Civil Engineering Contractors Association (NCL0008)
478 Rolls-Royce SMR Limited (NCL0021)

However, he warned that the maturity of reactor technology and the experience of the vendors dictated whether or not it was possible:

> That is a really opportune way to streamline the process. We are not creating any shortcuts, or anything like that. You are still doing the robust generic design assessment, and assessment of the design, but commencing licensing at the same time really helps to shorten the timescales to achieving the licence and then being able to deploy the reactor technology on the site. At the moment, the practice has been for us to complete the design assessment and then commence licensing of the organisation. There are real opportunities there, and we are open to that.
>
> The challenge is the capability in the organisations. Generic design assessment timescales are normally dictated by the maturity of the design—some of the technologies that have been talked about in the past have been relatively immature—and by the capability of the vendor organisation to submit the documentation that is required. That is not just the experience in the UK. It is the experience elsewhere of colleagues in other countries.[479]

256. Michael Drury, Managing Director of UK Operations, Terrestrial Energy considered that running the GDA and DCOs concurrently would be challenging for a first commercial reactor but there was an opportunity to run later site-specific processes in parallel after a GDA was completed.[480]

257. **Although the reputation and integrity of UK nuclear regulation must be maintained, there are opportunities to improve the efficiencies of nuclear regulation by running processes such as the Generic Design Assessment (GDA), and site licencing, in parallel.**

258. ***The Government should work with regulators, devolved administrations, local authorities, industry leaders, and others to streamline planning and environmental requirements wherever possible. The Office for Nuclear Regulation should look for opportunities to run the Development Consent Orders and the GDA in parallel for experienced vendors who have already successfully completed the GDA with other reactor designs or who have reactor technology that has been approved by other regulators.***

Siting new nuclear

259. The current specific planning regime for energy infrastructure projects in the UK is set out in the energy National Policy Statements (NPS), with nuclear being covered by EN-6.[481] Under EN-6, which was published in 2011, the UK has eight designated new nuclear sites: Hinkley, Sizewell, Heysham, Hartlepool, Bradwell, Wylfa, Oldbury and Moorside. Evidence provided to this inquiry said that there was a need to update the EN-6,[482] as it will shortly be out of date and currently only applies to nuclear power infrastructure with

479 Q437

480 Qq116–117

481 Department of energy and Climate Change, National Policy Statement for Nuclear Power Generation (EN-6), July 2011

482 EDF Energy (NCL0057); Nuclear Industry Association (NCL0012); Nuclear Futures Institute, Bangor University (NCL0011)

a capacity greater than 1 GW and was in place to "… facilitate the delivery of new nuclear power electricity generation on some or all of the sites listed in this NPS by the end of 2025".[483]

260. Five of the six energy sector NPS documents, which cover fossil fuels, renewable energy, oil and gas supply and storage, and electricity networks, were the subject of a 2021 BEIS consultation.[484] When speaking to us during this inquiry in November 2022 James Richardson, Chief Economist, National Infrastructure Commission (NIC), told us he had seen the draft updates over a year ago and that he expected that they would be published shortly.[485] However, since then, the Government re-opened the consultation for the energy NPSs, with the consultation closing on 23 June 2023.[486]

261. The nuclear energy NPS (EN-6) was the only one not included in the 2021 updates. This is despite a clear commitment given in 2020 to revise EN-6.[487] Evidence submitted to this inquiry from both the public and private nuclear sectors, urged that the NPS EN-6 be updated quickly to provide necessary clarity to the sector,[488] and include provisions for sites for SMR technologies.[489]

262. Rt Hon Graham Stuart MP, who at the time was Minister for Energy and Climate for the Department for the then BEIS, assured us that the Government would have a new nuclear NPS in place before 2026.[490] Yet, the Nationally Significant Infrastructure policy paper published on 23 February 2023 stated that:

> … a new NPS for Nuclear Power Generation (EN-7) which will also cover smaller reactors is being developed, aiming for designation by early 2025, and a separate NPS for nuclear fusion is also planned.[491]

263. It is not clear why the Minister should have extended the prospective timeline for the nuclear NPS by almost a year.

Siting small modular reactors

264. The Nuclear Industry Association (NIA) in its evidence suggested that new nuclear technologies should have a separate process to approve siting to that used for gigawatt-scale reactors and that this should specifically feature the use of brownfield sites.[492] Gethin Jenkins, Head of Safety and Licensing at Last Energy, explained that a major benefit of SMRs was that the technology could be sited near industrial clusters to provide both electricity and co-generation products such as heat or hydrogen.[493] However, Rolls-Royce SMR said

483 Department of Energy and Climate Change, National Policy Statement for Nuclear Power Generation (EN-6), July 2011, p 33
484 Department for Energy Security and Net Zero and Department for Business, Energy & Industrial Strategy, Planning for new energy infrastructure: review of energy National Policy Statements, 15 November 2021
485 Q129
486 HM Government, Powering Up Britain Energy Security Plan, 30 March 2023, p 30; Department of Energy Security and Net Zero, Planning for new energy infrastructure: revisions to National Policy Statements, accessed 14 April 2023
487 Q133
488 EDF Energy (NCL0057); Qq129–133
489 Environment Agency (NCL0019); Nuclear Industry Association (NCL0012)
490 Q512
491 Department for Levelling Up, Housing & Communities, Nationally Significant Infrastructure: action plan for reforms to the planning process, 23 February 2023
492 Nuclear Industry Association (NCL0012)
493 Q208

its reactors could provide enough energy to reach the 24 GW target by building only on the eight existing nuclear sites, but required the Government to provide clarity on which sites it could use.[494] Tom Samson, then Chief Executive Officer of Rolls-Royce SMR, told us that using existing licenced nuclear sites could attract industry to these areas, although in the medium to long-term, sites previously occupied by coal-fired power stations could also be used, but would require more work to assess planning considerations.[495]

265. Evidence from some industry witnesses argued that GBN should take responsibility for identifying new sites for both large reactors and SMRs,[496] noting that the UKAEA recently carried out this role to find a home for its STEP programme.[497]

266. **Given that the Minister envisaged a three-year timeline to develop, consult upon, and designate a new nuclear National Policy Statement (NPS), and that as of 18 July 2023 the consultation stage had not even started, we are concerned that there may be a creeping delay in updating the NPS for new nuclear. This would not only send the wrong signal to a sector poised for investment but could cause delays in deployment. New nuclear developers require knowledge of where a reactor can be built if they are to advance their plans.**

267. ***The Government should progress the consultation on the new NPS EN-7 for nuclear power and should meet its previously stated deadline of early 2025, and ideally publish the new NPS earlier than the deadline. Any update should identify where reactors smaller than 1 GW can be sited, as well as sites for larger reactors.***

494 Q169, Oral evidence taken before the Welsh Affairs Committee on 25 January 2023, HC (2022–23) 240, [Mr Evans] Q193

495 Q181

496 Q113

497 Nuclear Industry Association (NCL0012)

8 Nuclear decommissioning and waste

268. Decommissioning refers to the process in which fuel is removed from a nuclear power station and transferred to a safe storage facility; the plant and its facilities are dismantled; and the site is restored to an agreed end state and ready for re-use.[498] As the world's first civil nuclear nation, the UK has one of the largest nuclear decommissioning and waste management programmes in the world, with over 17 sites currently undergoing decommissioning.[499] This decommissioning programme is led by the NDA, an executive non-departmental public body which is sponsored by DESNZ.[500]

269. The UK's decommissioning landscape is complex, reflecting the complex history of the UK's nuclear sector. During the immediate post-war and Cold War period, the UK nuclear industry was focused on producing material for Britain's nuclear deterrent.[501] Subsequently, facilities which had been focused on military uses were turned into power stations, with the first civil nuclear reactor, Calder Hall 1, supplying energy to the grid from 1956.[502] In total, 26 similar reactors, the Magnox type, were built between 1956 and 1971,[503] across 12 sites around the UK, from Somerset to Sutherland. The NDA is responsible for the decommissioning of all of these 12 sites, as well as other research centres, fuel-related facilities, and Sellafield, which has the largest radioactive inventory in the UK and the most complex facilities in Britain to decommission.[504] Shockingly little focus was placed on what would happen after these sites were closed down, especially during the immediate post-war and cold war period, decommissioning was not designed into these facilities, and as such the clean-up mission is extremely challenging.

Rising and uncertain decommissioning costs

Legacy waste clean-up

270. The NDA has predicted that its decommissioning work will take more than 100 years,[505] and cost around £148 billion in today's prices.[506] Despite this, witnesses, including the NDA and the then BEIS (which previously held responsibility for the NDA), suggested that the exact timescales and costs of the decommissioning programme remain uncertain.[507] Most of these costs are attributable to the complex clean-up mission associated with the Sellafield site, which hosts the so-called "legacy waste" produced during the UK's early military and civil programmes,[508] which Professor Katherine Morris, Lead for Nuclear Environment and Waste Management at the Dalton Nuclear Institute said was "three quarters of the total" cost of the NDA's decommissioning programme.[509]

498 EDF, Nuclear decommissioning, accessed 20 February 2023
499 Nuclear Decommissioning Authority, About us, accessed 20 February 2023
500 HM Government, Policy Paper: Making Government Deliver for the British People, 7 February 2023
501 Nuclear Decommissioning Authority, About us, accessed 20 February 2023
502 Institute of Civil Engineers, Calder Hall nuclear power station, accessed 20 February 2023
503 World Nuclear Association, Nuclear Development in the United Kingdom, updated October 2016
504 Nuclear Decommissioning Authority, About us, accessed 20 February 2023; Cumbria Local Enterprise Partnership (NCL0028)
505 Nuclear Decommissioning Authority, About us, accessed 20 February 2023
506 Q441
507 Q358; Department for Business, Energy and Industrial Strategy (NCL0006); Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010)
508 Cumbria Local Enterprise Partnership (NCL0028)
509 Q289

The reasons for this were described in our oral evidence session with experts from the decommissioning sector. Professor Claire Corkhill, who is a member of the Committee on Radioactive Waste Management (CoRWM), which provides "independent scrutiny and transparent advice to the UK governments on the long-term management of higher activity radioactive wastes",[510] described her experiences of a visit to Sellafield:

> The main point to highlight is that it is the management of the complexity that is the challenge. There are many different moving parts and groups of people that have to interact, communicate and share the same goals, so that they can get to the final point where buildings are decommissioned. We saw the Magnox swarf storage silo facility, which is leaking radioactive effluent into the ground. The ONR has commissioned action to try to clean that up. When we saw the facility, and the decommissioning operation, it was likened to emptying a dustbin with a teaspoon. They have to take out individual pieces of waste one at a time and assess them before they can, ultimately, empty the entire building so that they can fix the leak. That complexity involves many moving parts and lots of organisation, in terms of management. It is understandable that because of that, and the level of hazard, it will take a considerable time.[511]

271. It was made clear to us that adequate forward planning had not been made when many of the waste silos that exist at Sellafield were established, and that this is constraining the safe clean-up of these silos. Dr Robin Taylor, Senior Research Fellow at the NNL, said that this was likely due to the "drivers" being different during the 1950 and '60s civil and defence nuclear programmes, but explained that there was now a much better understanding of the need to plan decommissioning into new nuclear projects.[512] When we asked Clive Nixon, Group Chief Nuclear Strategy Officer at the NDA, if he thought that the costs associated with the legacy waste programme were now more certain, he told us:

> I would very much like to think so, but there are no guarantees in this. As I said, many of the things we are doing are first of a kind. I think there was some reflection previously that a major part of our liabilities provision is based on the historical separation activities associated with defence and early nuclear rather than reactors, which I think are the focus of this session. Yes, I think we are in a good place, but there is still significant uncertainty, as I recounted, so we cannot guarantee what the cost will be and how long it will take; it is a multidecade programme.[513]

Decommissioning the Magnox fleet

272. In November 2020, the Public Accounts Committee criticised the NDA's management of the decommissioning of the Magnox fleet of reactors and called for the NDA to do more to establish more detailed and accurate costings and timings for the decommissioning of these plants.[514] At the time of writing, the NDA estimated that the cost of decommissioning

510 Committee on Radioactive Waste Management, About us, accessed 14 April 2023
511 Q286
512 Q295
513 Q359
514 Public Accounts Committee, Twenty-Eighth Report of Session 2019–21, The Nuclear Decommissioning Authority's management of the Magnox contract, HC 653

the Magnox sites was between £6.9 billion and £8.7 billion, which was previously between £1.3 billion and £3.1 billion, in other words, between 23% and 55%, more than the original estimate made, just three years earlier, in 2017.[515] It also estimated that it would take between 12 and 15 years for all of the Magnox sites to reach the care and maintenance stage of the decommissioning process.[516]

Decommissioning the Advanced Gas-cooled Reactor fleet

273. In addition to the Magnox sites, the NDA will take responsibility for the decommissioning of EDF's fleet of AGRs, the majority of which will have been shut down by the end of this decade. In June 2021, the UK Government and EDF agreed arrangements for decommissioning of the AGR stations. EDF is responsible for defueling, and then will work closely with the NDA to transfer the ownership of the stations to the NDA.[517] In May 2022, another report by the Public Accounts Committee, concluded that the NDA's approach to funding the decommissioning of this set of reactors also needed to be improved.[518] The estimated decommissioning costs had increased from £12.6 billion in 2004–05 to £23.5 billion in 2020–21 in 2021 terms.

Decommissioning new nuclear

274. Since the first two fleets of nuclear reactors (the Magnox and AGR fleets) were built, the Government has implemented legislation that required the decommissioning costs of any new nuclear reactors to be provided for upfront.[519] The Energy Act 2008 requires prospective operators of new nuclear power stations to submit a Funded Decommissioning Programme (FDP) to the relevant Secretary of State for approval before nuclear-related construction can begin.[520] An FDP is intended to ensure that operators regularly put funding aside throughout the operating life of the plant to meet the future cost of decommissioning, and allows the Government to carefully monitor an operator's decommissioning plans. This approach was welcomed by witnesses to our inquiry, with the North West Nuclear Arc explaining that this would allow decommissioning costs to be managed from the beginning of a new nuclear project.[521] SMR technology developers also agreed with the FDP model, adding that it ensures that new reactors are designed with decommissioning in mind, unlike the approach taken in the past.[522]

275. During our inquiry we heard important evidence that a new fleet of nuclear reactors was unlikely to make a substantial difference to the total quantity of waste that NDA would have to manage, and therefore the cost of handling new wastes would be minimal compared to the costs associated with the UK's legacy waste. In our first evidence session, Professor Paul Norman, Professor of Nuclear Physics and Nuclear Energy Director at the Birmingham Centre for Nuclear Education and Research, said:

515 Public Accounts Committee, Twenty-Eighth Report of Session 2019–21, The Nuclear Decommissioning Authority's management of the Magnox contract, HC 653, para 4
516 Public Accounts Committee, Twenty-Eighth Report of Session 2019–21, The Nuclear Decommissioning Authority's management of the Magnox contract, HC 653, p 5, para 1
517 Department for Business, Energy & Industrial Strategy, Decommissioning agreement reached on advanced gas cooled reactor (AGR) nuclear power stations, 23 June 2021
518 Public Accounts Committee, Third Report of Session 2022–23, The future of the Advanced Gas-cooled Reactors, HC 118
519 Department for Business, Energy and Industrial Strategy (NCL0006)
520 Energy Act 2008, section 45
521 North West Nuclear Arc (NCL0023)
522 Last Energy (NCL0015); Rolls-Royce SMR Limited (NCL0021)

> My feeling is that the waste problem is barely changed by new reactor build. Virtually all our wastes are historical. We will only add in the order of a few percent to that waste problem by building new reactors. It is not a problem that you want, but it is a problem that we have, mostly from our historical use of nuclear power and our testing of nuclear weapons and so forth. That problem is already there, unfortunately. New build will barely affect it at all.[523]

Despite the likely negligible influence on costs, some witnesses proposed that wastes produced for advanced nuclear technologies could require different disposal techniques.[524] The Committee of Nuclear Waste Management said that whilst SMRs were likely to produce waste with similar characteristics to the current fleet of AGRs, the waste streams from AMRs could have different chemical properties, radioactivity levels and volumes, and would likely require new decommissioning and storage approaches.[525]

Developing new technologies for decommissioning

276. Witnesses told us that the NDA should seek to reduce costs by developing new technologies to improve decommissioning processes.[526] Nuleaf (the radioactive waste management and nuclear decommissioning interest group of the Local Government Association) and the NNL pointed out that research and innovation for decommissioning was likely to have spin off benefits for other industries and the wider economy.[527] In oral evidence, Coryhn Parr said that the NDA and NWS, the organisation which is responsible for the UK's nuclear waste management programme, were investigating new waste treatment types that could improve safety or reduce waste volumes.[528] In addition, in the NWS Corporate Strategy that was published in April 2023, they set out that one of its three core strategic objectives was to "accelerate decommissioning by innovation".[529] The NDA also provided further details on its development of new technologies in follow-up written evidence. These included the development of: autonomous sorting of waste; remote monitoring; and advanced robotics.[530] With regard to waiting for new technologies to become available, some witnesses advised caution. Cavendish Nuclear and the Dalton Nuclear Policy Group (a group based at the University of Manchester that uses an evidence-based approach to offer advice to policy-makers) suggested that it was important that the decommissioning process was not delayed to await new technologies appearing.[531]

523 Q31
524 Committee on Radioactive Waste Management (NCL0053)
525 Committee on Radioactive Waste Management (NCL0053), Committee on Radioactive Waste Management (NCL0073)
526 Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010); Jacobs UK (NCL0034)
527 Nuleaf (Nuclear Legacy Advisory Forum) (NCL0022); National Nuclear Laboratory (NCL0040)
528 Q367
529 Nuclear Waste Services, NWS Corporate Strategy, 25 April 2023
530 Nuclear Decommissioning Authority (NCL0074)
531 Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010); Cavendish Nuclear (NCL0041)

Taking advantage of the UK's decommissioning expertise

277. The NDA, partly because of the UK's early position in civil nuclear, and therefore experience of decommissioning, has expertise which is relevant to other countries. For example, Assystem (a French company that provides engineering services) noted that the UK was an international leader in "solving First of a Kind (FOAK), complex decommissioning challenges, hosting a plethora of world-leading experience".[532]

278. The NDA in recent years has earned between £600 million and £1 billion per year in revenue, compared to its taxpayer funding of £3.5 to £4 billion.[533] During oral evidence, David Peattie, Chief Executive Officer of the NDA, explained how this revenue was earnt:

> We earn money from EDF UK. I suppose that in a way that is international because it comes ultimately from French taxpayers. We have the world's leading maritime shipping business for nuclear material. We have three ships based in Barrow-in-Furness, and we are world leaders. We have just done a move of mixed oxide fuel from France to Japan with two of our ships. Indeed, we are the go-to organisation for complex and difficult moves around the world. We have done it to Australia, Slovenia, the US and other European countries. That can earn us a good return for those ships. Our captive rail company, Direct Rail Services, is a UK freight company. We have about 80 locomotive trains and a couple of hundred ASLEF [Associated Society of Locomotive Engineers and Firemen] members. Every day typically in the UK one train will be moving nuclear material around from the reactors to Sellafield and back again to help refuel. We also have a contract with Tesco. You might see our trains on the west coast mainline pulling Tesco goods to keep them off the roads. Therefore, as well as keeping the lights on we help to keep the shelves full.[534]

279. Mr Peattie said that the NDA was looking to do more to leverage its expertise, for example through providing technical advice to countries such as Japan, Canada, the US and Ukraine.[535] Assystem argued that the UK should grow its international decommissioning programmes, not only for the purpose of earning revenue but to develop knowledge and drive down costs for the UK.[536] Notwithstanding the opportunity for export earning, Mr Peattie told us that 99% of the NDA's workforce is focused on its domestic task. Mr Peattie recognised the export opportunity that the NDA is presented with.[537]

280. **Decades of mismanagement of nuclear decommissioning in the UK—from inadequate provision for decommissioning costs, to record keeping so negligent as to have left ponds of radioactive waste whose content in unknown—has made the responsibilities of the Nuclear Decommissioning Authority (NDA) some of the most challenging, complex and consequential of any organisation in Britain today. The NDA has made progress in the last five years in simplifying its structure, making more credible estimates of the costs of decommissioning, and replacing complex and opaque subcontractor arrangements with more straightforward ones. The vast annual**

532 Assystem (NCL0025)
533 Q441; Nuclear Decommissioning Authority, NDA Annual Report and Accounts 2021 to 2022, 14 July 2022
534 Q455
535 Qq457–458
536 Assystem (NCL0025)
537 Q458

budget for the NDA—necessarily between £3.5 billion and £4 billion—and the critical importance of its work means that the performance of the NDA must be kept under close review by the Government and Parliament, and that it should have a strong relationship with the Department for Energy Security and Net Zero, the Treasury and the Prime Minister's office.

281. **The experience and expertise which the NDA has in civil nuclear decommissioning is more than any other country in the world, as a result of the head start the UK has had in being the world's first civil nuclear nation. As countries who were later in constructing civil nuclear power stations have to turn to safely and economically decommission them, the NDA's expertise can be deployed globally. This is a tremendous export opportunity for the UK expertise which can raise revenue.**

282. ***The NDA should establish, with the involvement of government, a long-term plan to expand this international work while monitoring a thorough and dependable service within the UK.***

283. **Most of the nuclear waste that the UK must safely handle and dispose of has already been produced by previous nuclear installations. The incremental waste generated by new nuclear power plants is not likely to be a material factor in decisions on approving new gigawatt-scale plants. We note, however, evidence presented to us that indicated that small modular reactors and advanced modular reactors would produce waste which may require different handling.**

284. ***It is imperative that a clear understanding of the waste consequences of new nuclear technologies, how it will be dealt with and at what cost, should be part of the decision-making on approving the case of these technologies.***

Geological Disposal Facility

The history of the UK's Geological Disposal Facility programme

285. Since 2006, the Government's strategy for radioactive waste management has centred on the development of a GDF for the long-term storage of the UK's higher activity radioactive waste.[538] Radioactive waste is currently stored in specially engineered containers across 20 surface-based sites around the UK. Although these surface stores are designed to be safe for around 100 years, and to withstand severe weather and earthquakes, and are heavily protected against terrorist attacks, they require continual monitoring and periodic refurbishment, which results in additional costs, and concerns over long-term safety.[539] To address this problem, the Government plans to build a GDF. Geological disposal involves isolating radioactive waste deep underground, at a depth between 200 metres and 1 kilometre, inside a suitable rock volume to ensure that no harmful quantities of radioactivity reach the surface. A GDF would be a highly engineered structure, consisting of multiple barriers that would provide protection over hundreds of thousands of years.[540]

538 Committee on Radioactive Waste Management, Managing our Radioactive Waste Safely, July 2006; HM Government, Managing radioactive waste safely: a framework for implementing geological disposal, 1 June 2008

539 Nuclear Waste Services, Geological Disposal - a programme like no other, 3 November 2020

540 HL Bill 39, Explanatory Notes, 6 July 2022, para 75; Nuclear Waste Services, Geological Disposal - a programme like no other, 3 November 2020

286. The Government's original strategy for a GDF, set out in a 2008 White Paper, 'Managing radioactive waste safely: a framework for implementing geological disposal',[541] was developed in a response to a 2006 recommendation by the CoRWM.[542] It advocated a voluntarism or partnership approach to finding a site for the GDF under which communities would be invited to open up discussions, without commitment, with the Government on the possibility of hosting the GDF in the future. Despite the policy being in place for over 14 years, a host community is yet to be finally identified.

287. After several unsuccessful community engagement processes, the Government published an updated framework for the long-term management of higher activity radioactive waste in 2018. The framework reiterated the Government's commitment to moving towards the use of a GDF and set out how it would work with communities to find a suitable location.[543] At the time of publication of this framework, the Government estimated that the process of identifying and selecting a site for GDF could take around 15 to 20 years, because of the detailed site investigation that would need to take place to understand the geological conditions and be sure that a facility in that location would securely isolate and contain waste.

Views on the development of a Geological Disposal Facility

288. We received evidence from a wide range of stakeholders in support of the development of a GDF,[544] with several submissions asserting that the development of a GDF was necessary to ensure the confidence in any new nuclear projects.[545] Assystem wrote that a GDF was the most "economically and technically feasible waste storage solution" and that the delivery of one was the "foundation stone for the UK's short-, medium- and long-term nuclear strategies.[546] Similarly, Cwmni Egino, a development company established by the Welsh Government to drive development of new nuclear in Wales, said that a GDF was critical to developers being able to demonstrate an end-to-end solution for nuclear waste.[547] Professor Claire Corkhill, a member of the CoRWM, also suggested that the lack of certainty on the delivery date of the GDF was constraining the UK's decommissioning programme. Reflecting on a recent visit to Sellafield, she said:

> […] the lack of certainty on a delivery date for a geological disposal facility somewhat constrains the timescales for decommissioning, and increases uncertainty in planning the decommissioning. While there is a first waste emplacement date for the geological disposal facility of the 2050s, a number—by no means all—of the employees [at Sellafield] we spoke to were very sceptical. That scepticism about there being a geological disposal

541 HM Government, Managing radioactive waste safely: a framework for implementing geological disposal, 1 June 2008

542 Committee on Radioactive Waste Management, Managing our Radioactive Waste Safely, July 2006

543 Department for Business, Energy & Industrial Strategy, Implementing geological disposal – working with communities: long term management of higher activity radioactive waste, 19 December 2018

544 Cwmni Egino (NCL0005); Civil Engineering Contractors Association (NCL0008); Environment Agency (NCL0019); Assystem (NCL0025); Henry Royce Institute (NCL0030); Committee on Radioactive Waste Management (NCL0053); EDF Energy (NCL0057)

545 Civil Engineering Contractors Association (NCL0008); Assystem (NCL0025); National Nuclear Laboratory (NCL0040)

546 Assystem (NCL0025)

547 Cwmni Egino (NCL0005)

> facility pervades in the planning. For every 10 years without a geological disposal facility Sellafield needs to build another store, and each store costs several hundred million pounds.[548]

Having said this, when we asked experts whether new nuclear projects should go ahead without a GDF being constructed, they were clear that the plan to create a GDF provided a "credible pathway" for nuclear waste and that new nuclear projects should therefore continue.[549]

Finding a site for a Geological Disposal Facility

289. The framework for implementing the GDF siting process in England was set out in the 2018 White Paper, 'Implementing Geological Disposal—Working with communities'.[550] The process for finding a site is unique as it requires a willing community to host the facility, as NWS have set out:

> Working Groups and Community Partnerships have been formed in different areas of the country to start exploring whether a GDF is right for their area and whether their area is right for a GDF. This will be a consent-based, partnership approach, with Right of Withdrawal by the community right up to a Test of Public Support.[551]

GDF Community Partnerships have been set up in four locations: Allerdale,[552] Mid Copeland,[553] and South Copeland,[554] in Cumbria and Theddlethorpe in Lincolnshire.[555] These partnerships aim to promote positive engagement on identifying potential GDF sites within the local community. As part of the funding process, funding is provided to the local community for "initiatives supporting economic development opportunities, improving community well-being, or enhancing the local environment".[556]

290. Overall, stakeholders agreed that a local engagement process, with Right of Withdrawal by the community and a Test of Public Support, was the correct approach to securing a site for a GDF,[557] but some witnesses raised concerns about how the programme was being implemented. In its written evidence to this inquiry, Nuleaf, the Nuclear Legacy Advisor Forum, said that further clarity on the scale of the investment that would be made in the local community could increase the chances of finding a host for the project:

> As the GDF requires a consenting host community, local people need to have a clear understanding of the amount of additional investment that will be provided. They also need to be involved in effective engagement

548 Q287
549 Qq290–291; Qq300–303
550 Department for Business, Energy & Industrial Strategy, Implementing geological disposal – working with communities: long term management of higher activity radioactive waste, 19 December 2018
551 Nuclear Waste Services, Geological Disposal - a programme like no other, 3 November 2020
552 Allerdale GDF Community Partnership, accessed 27 February 2023
553 Mid Copeland GDF Community Partnership, accessed 27 February 2023
554 South Copeland GDF Community Partnership, accessed 27 February 2023
555 Theddlethorpe GDF Community Partnership, accessed 27 February 2023
556 Nuclear Waste Services, Community Guidance, accessed 6 December 2022
557 NUVIA Ltd (NCL0033), Imperial College London (NCL0026), Committee on Radioactive Waste Management (NCL0053)

> processes to help shape their vision for the area and understand how the additional investment could help drive the positive economic, social and environmental outcomes they seek.[558]

In the first stage of the community partnership process the community can bid for up to £1 million annually. This will increase to £2.5 million annually for communities that progress to the next stage of the process, which will involve deep borehole investigations.[559] As well as increasing certainty of long-term investment in the community partnership areas, Professor Corkhill said that it would be beneficial to have more communities involved with the site selection process. This came after we pointed out that the four community partnerships were, in reality, situated in just two areas: West Cumbria and Lincolnshire.[560] Professor Corkhill conceded that NWS were constrained in doing so by its budget: "It would like to have more communities, but it only has enough budget to run four".[561]

291. Whilst the Civil Engineering Contractors Association felt that the community partnership engagement process was progressing too slowly,[562] the Dalton Nuclear Policy Group said that the Government's current approach, to allow the community to control the development, timing, and implementation of the Test of Public Support, was welcome and more likely to result in public acceptance.[563]

292. During our inquiry we sought to understand how NWS intends to balance the community consent process, and finding a site with suitable geology. In terms of appropriate geology, NWS said that "there is a large range of potentially suitable geological settings for a GDF. There is no single best or most suitable type of geology for a GDF".[564] Professor Corkhill confirmed this in oral evidence when she told us that there was a level of flexibility in the geology of the site, as the waste would be disposed of in several levels of containment, which would be engineered to suit the host geology.[565] She did, however, caveat this by saying that less favourable geologies resulted in the need for more expensive containment. She highlighted that this was the case in Sweden and Finland, who were using five centimetre thick copper containers, as they were building their GDFs in granite, whereas France could use cheaper containers as its repository was being built in clay. Whilst Professor Corkhill did not want to identify the optimal location (in terms of geology) for the UK's GDF, she did point out that clay was a "perfect type of geology" for a GDF.[566] In our final evidence session, David Peattie, Chief Executive Officer of the NDA said that, if necessary, the GDF could be designed at extra cost in a "less favourable geology," suggesting that this might have to be done if a willing community was found in an area with more challenging geology. He was of the view that this was more likely than forcing an unwilling community to host a GDF in an area with optimal geology.[567]

558 Nuleaf (Nuclear Legacy Advisory Forum) (NCL0022)
559 Nuclear Waste Services, Community Guidance, accessed 6 December 2022, p 24
560 Q325
561 Q325
562 Civil Engineering Contractors Association (NCL0008)
563 Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010)
564 Nuclear Waste Services, GDF—Community Guidance, accessed 27 March 2023, p 15
565 Q328
566 Qq326–328
567 Qq452–454

Predicted timescales and costs of the Geological Disposal Facility

293. There was some uncertainty over when a GDF would become operational. In its evidence to the inquiry, the then BEIS said:

> Current expectations are that a GDF could become operational in the 2050s, but timings may change depending on the complexity of the geological and site suitability investigations.[568]

In oral evidence, Corhyn Parr, Chief Executive, Office of NWS, said that progress was starting to be made on the GDF programme and that NWS would choose two communities (out of the four currently undergoing engagement activities), where it was "technically feasible to build a GDF", by about 2025–26.[569] However, in the NWS Corporate Strategy that was published in April 2023, after this evidence was taken, NWS set out a later date of 2026–27 for making a decision on communities to be taken forward to "deep borehole investigation and increased community investment".[570]

Corhyn Parr went on to say that over the following 15 to 22 years NWS would carry out borehole tests and complete the full design and safety case of the GDF. The construction of the GDF would be expected to start between 2040 and 2047, with the first waste being placed in the GDF in the 2050s.[571]

294. When we asked Ms Parr how the Government could speed up the programme of work, she only confirmed that she said:

> This is a very credible programme that we can stand behind. We have some great communities and some good geologies that we are looking at, so we are really confident in those dates. We are of course looking for opportunities to work within our own constraints, and with the permissioning, governance and oversight that is required for a programme at this stage, to see if we can accelerate any of those decision timescales.[572]

295. As well as relatively uncertain timescales, the costs of establishing the GDF are also hard to pin down, with NWS estimating them at somewhere between £20 billion and £50 billion,[573] whilst a high-level cost review published by the CoRWM in October 2022 predicted that costs would be between £20.1 billion and £40.2 billion.[574] In its evidence, CoRWM said that the construction costs of a GDF were uncertain due to a "range of factors, not least the type of geology and hydrogeology of the site that is selected" and explained that "advanced tunnelling techniques offer the prospects for reducing uncertainties and giving greater clarity on costs".[575]

568 Department for Business, Energy and Industrial Strategy (NCL0006)
569 Q371
570 Nuclear Waste Services, NWS Corporate Strategy, 25 April 2023
571 Qq371–373
572 Q374
573 Q375; Nuclear Waste Services, GDF Annual Report 2020–21, accessed 27 February 2023
574 Committee of Radioactive Waste Management, GDF high level cost review, October 2022
575 Committee on Radioactive Waste Management (NCL0053)

296. **Since 2006, Government policy has been to establish a Geological Disposal Facility (GDF) for the long-term storage of nuclear waste. Despite this, Nuclear Waste Services, which is the body responsible for establishing a GDF, is not at the point of having found a community willing to host a GDF or to be able to conduct the detailed geological investigation required to establish a suitable site for a GDF. The timelines and costs for building a GDF are also uncertain.**

297. ***The first waste is not expected to be placed into a Geological Disposal Facility (GDF) until the 2050s and until then, there is sufficient interim storage for both current and predicted future nuclear waste. The Government should continue work to identify a site for a GDF which will be geologically safe, and which will enjoy the confidence of the local community. Given that interim storage has been used for over 50 years and that waste from new nuclear facilities would be a small addition to the stock of waste held, we do not believe that new nuclear plants should be halted until a GDF facility has been established.***

Conclusions and recommendations

The Government's aim of delivering 24 GW of nuclear power by 2050

1. We conclude that it is reasonable for EDF to seek life extensions to extend their contribution to the grid if, and only if, the Office for Nuclear Regulation's judgement is that they can be safely operational as is currently the case. (Paragraph 31)

2. *The new Nuclear Strategic Plan, that we recommend, must spell out how the current reactor fleet, through life extensions, will contribute to the Government's ambition of 24 GW from nuclear by 2050.* (Paragraph 32)

3. Gigawatt-scale nuclear power stations use a known and well understood technology that can deliver dependable low carbon baseload electricity to the grid. Nuclear power is therefore an important option and could be used to produce a domestic supply of baseload power to the UK as part of the low carbon energy mix required to achieve the Government's goals of increasing energy security and achieving net zero by 2050. However, the question of energy security must engage with the questions of sourcing of fuel and the risks of having a concentration of generating capacity in very large plants, which could be susceptible to outages as a result of technical problems or as a target for malign actors. The Government's aim to bring up to 24 gigawatts of nuclear-powered electricity to the grid by 2050 is commensurate with its net zero ambitions but currently lacks a comprehensive plan to achieve it. We welcome the Government's intention of "building a project pipeline" of nuclear projects but agree with industry that the details of this pipeline must be published by Government, if investments in new nuclear are to proceed in time. (Paragraph 41)

4. *Setting a notably stretching target requires a credible pathway towards its delivery. The Government should publish a clear delivery plan, a Nuclear Strategic Plan, for its nuclear project pipeline, backed up by detailed figures of projected energy production from nuclear for the years leading up to 2050, and be developed in collaboration with and engaging the confidence of the whole sector. This Nuclear Strategic Plan should include interim targets for nuclear energy production in 2035, 2040 and 2045.* (Paragraph 42)

5. In his previous role as industry advisor to Great British Nuclear, Simon Bowen produced a report proposing what function and form Great British Nuclear should take. This report was delivered to the Government in September 2022. (Paragraph 46)

6. *The Government should publish the report and recommendations submitted by Simon Bowen, industrial adviser to Great British Nuclear, and his team on the purpose of Great British Nuclear, alongside the Government response to this report.* (Paragraph 47)

7. The 2050 target for nuclear of 24 GW needs a plan to achieve it, which must include clarity on the bodies and institutions that will deliver it. After asking the Department to provide more clarity on what legislation will be required to ensure that Great British Nuclear can operate as intended, we are pleased to see that the Government has tabled amendments to the Energy Bill 2022–23 to include this legislation. Having said this, there are still some points of ambiguity over exactly how Great

British Nuclear will function and what activities it will carry out beyond running a small modular reactor competition. We expected further clarity to given in the Government's launch of GBN in July 2023, but the announcement only included details of the SMR competition and the allocation of funds that had already been announced. (Paragraph 56)

8. *In response to this Report, the Government should set out additional detail on how Government will intersect with Great British Nuclear, including details of Great British Nuclear's exact remit and funding model, and the formal split of responsibilities with the Department for Energy Security and Net Zero. To aid this, the Government should publish the required secondary legislation that will support the creation of Great British Nuclear. Within this detail, the Government should clearly define what the role for Great British Nuclear will be on supporting new nuclear projects beyond the initial small modular reactors competition, including in relation to gigawatt size projects beyond Sizewell C and deployment of advanced modular reactors when technologically ready.* (Paragraph 57)

9. In its July 2023 announcement on Great British Nuclear, the Government said that it would use the small modular reactor technology selection process (SMR TSP) to identify those reactor companies best able to reach a project Final Investment Decision (FID) by the end of 2029. The FID would include funding to support site access and site-specific design. Therefore, some of the more time-consuming aspects of building new nuclear projects, namely site-specific regulation and relevant licencing, would not begin for any successful SMR design until after 2029. This new timeline would go beyond the dates that many of the SMR developers have proposed is possible for SMR reactors to supply energy to the grid, namely the early 2030s. (Paragraph 58)

10. *The Government should take steps to advance the ability for FIDs to be taken before 2029 and provide a detailed timeline of when it expects the winner or winners of GBN's SMR technology selection process to begin commercially supplying electricity to the UK.* (Paragraph 59)

11. Gigawatt-scale nuclear power plants require UK experience—of the supply chain, regulatory processes and the wider energy sector—to deliver projects efficiently. However, the UK may benefit in the future from multiple operators of small and advanced, nuclear power technologies as they have the potential to provide market competition, collaboration opportunities and prevent a groupthink mentality. (Paragraph 63)

12. *The Government should provide sufficient resources to nuclear regulators, to support potential new operators of small and advanced modular reactor technologies to enter the UK energy market.* (Paragraph 64)

13. *The Government should provide clarity on how it plans to achieve its 24 gigawatt aim, and the expected timeline for these. This should include details of:*

    a) *the target mix of reactor technologies, including the desired number of future gigawatt scale reactors, that the Government will support; and*

    b) *a detailed timeline for when new projects are expected to be completed.* (Paragraph 76)

14. An essential requirement will be to resolve of the questions of whether a standardised fleet of nuclear power plants, using serial versions of the same reactor technology, has the potential to benefit the UK as new knowledge and resources can be transferred from one project to the next, reducing the risk of construction and cost overruns. The inevitable objection that such a strategy embeds the risk that operational issues identified with one power plant could affect the entire fleet can be mitigated be using tried and tested underlying technologies and engineering and careful sequencing of any innovation. (Paragraph 77)

15. *The Government, through Great British Nuclear, must choose between the potential cost benefits of a standardised nuclear fleet of gigawatt reactors and the energy security and resilience that a diversity of reactor designs provides.* (Paragraph 78)

16. The UK is an international market leader in the manufacture of nuclear fuels and is uniquely positioned with the capability of delivering the entire nuclear fuel cycle. The nuclear fuel sector in the UK has the potential to increase enrichment capacity, which can provide security for domestic nuclear fuel supply chain and further export opportunities. (Paragraph 89)

17. *By publishing a detailed Nuclear Strategic Plan, as we recommend, which includes the types and number of reactors to be built in the UK, the Government should provide a signal to the nuclear fuel industry to step up and increased its end-to-end fuel manufacturing capacity. The Government should set out in the Nuclear Strategic Plan how it will capitalise on the strengths of the UK's nuclear fuel supply chain to secure a resilient supply of nuclear fuel for any new planned reactors and develop further export opportunities.* (Paragraph 90)

Advanced nuclear technologies

18. The Government is at a cross-roads in its policy on small modular reactors (SMRs). So far it has funded a consortium led by Rolls-Royce with over £210 million of research and development funds to develop a concept SMR design, and now, to further develop the design to the extent that it can pass the generic design assessment process. That public funding was matched with £280 million from the private sector. It has subsequently announced that Great British Nuclear will launch and administer a competition in which other vendors' technology would be assessed. What is then required is a set of pivotal decision on the actual deployment of, rather than research into, SMRs. (Paragraph 105)

19. It is not uncommon, in the face of an unclear strategy or unresolved internal arguments about financing, for governments to defer decisions rather than take them. But this would be the wrong course. The UK risks losing the advantage of

the public investment that has already been made; as well as contributing to the ambiguity in our future energy supply; and perpetuating a level of policy risk that is likely to drive a risk premium on costs, to the detriment of the taxpayer and billpayer. (Paragraph 106)

20. *In developing a Nuclear Strategic Plan the Government should answer the questions of:*

    - *what deployment of SMRs it wants to see, if any;*
    - *what technologies and vendors it intends to deploy, and whether they will be from a single supplier or multiple suppliers;*
    - *what sites should SMRs be located at; and*
    - *what financial model would be used to support the contribution of SMRs to electricity supply?* (Paragraph 107)

21. From the commissioning of Calder Hall in the 1950s, the UK has always had a strong capability in nuclear research and development. At a time where there is a global commitment to reduce carbon emissions and to reduce dependence on fossil fuels for reasons of energy security, the UK's capability in new nuclear technologies is a strength. (Paragraph 120)

22. Whilst investment by Government in early stage and demonstrator reactors will drive forward innovation for advanced modular reactors (AMRs), bringing them closer to commercialisation, what is also important is the UK having a regulatory environment and incentives for private investment. This has been demonstrated to work in the UK's fusion sector, where as well as strong Government funded demonstrator programme, the regulatory system, skills environment and developing supply chain, is attracting private companies and private investment to the UK. (Paragraph 121)

23. AMRs may offer new advantages in terms of cost and the potential for co-generation. But if they are to advance the research and development needs to move from the desk and the lab towards demonstrators, and this will require the Government to make decisions as to which technologies to fund. (Paragraph 122)

24. *The Government should continue its support for the Advanced Modular Reactor Research, Development and Demonstration programme and ensure that it takes decisions on funding particular technologies and projects without delay, so that it keeps pace with competitors.* (Paragraph 123)

25. The UK is a leading global player in uranium enrichment and nuclear fuel fabrication and has the potential to replace Russia's contribution to the global supply chain of advanced fuels. We welcome the launch and allocation of funding from the Nuclear Fuel Fund to support the development of the capabilities needed to meet current and future nuclear fuel demands. (Paragraph 128)

Fusion

26. The work of the UK Atomic Energy Authority has resulted in a thriving research and development fusion cluster at the Culham Science Centre in Oxfordshire. As well as operating the world's leading torus and spherical fusion reactors, the Culham facility benefits from being part of a consortium of 30 fusion research organisations and universities from 25 European countries and has attracted private companies from around the world, many of which plan to build demonstrator reactors at Culham. (Paragraph 142)

27. Since 2010, the UK public investment into fusion research and development has totalled around £970 million. All such investment of taxpayer funds has alternative uses, whether in science, energy, or other fields. Sceptics of fusion argue, in the much-repeated phrase, that the benefits of fusion are always 20 years away—with the implication that such funds could be better spent elsewhere. It is true that fusion is highly unlikely to make a material contribution to electricity generation by 2050, in the time to contribute to our net zero commitment being met. It is also true that there are many risks, uncertainties, and dependencies—such as the development of materials—that mean that fusion may not in the foreseeable timeframe realise it tantalising potential. (Paragraph 143)

28. However, in recent months breakthroughs have been made in fusion research, including doubling of the record for power generated in a tokamak; there is a growing number of private fusion companies clustered in Culham and the UK is a leading nation in the ITER project. (Paragraph 144)

29. We believe that it is not the time to abandon our long-standing commitment to fusion, just at the point when it is giving cause for optimism; when the zero-carbon imperative is strong; when we have an internationally admired and well-run organisation in the UK Atomic Energy Authority, and when positive spill-over effects are being felt from the research. (Paragraph 145)

30. *To maximise the benefits that we gain from investment in fusion requires a long-term approach to give confidence and stability to investors and international partners and so we recommend that fusion is a part of the Government's long-term energy plan.* (Paragraph 146)

Nuclear skills gap

31. It is not surprising that the nuclear sector has not been the industry of choice for many STEM specialists embarking on a career. At a time when no new nuclear plants had been approved for decades, this was a sector thought by some not to be one with a bright future in which to contemplate a lifetime career specialisation. (Paragraph 162)

32. However, if the Government and the nuclear industry credibly adopt a stable, long term plan of growing the nuclear sector, there are very significant attractions to recruitment: new build and new technologies involve innovation and technical

advances; the timescales of nuclear commitments offers the prospect of enduring careers; the global revival of nuclear power offers international opportunities; and financial rewards are likely to remain high. (Paragraph 163)

33. *As part of a strategic approach to nuclear, the Government and the industry should set out steps deliberately to communicate to school-leavers, graduates and to those changing careers, the particular advantages of choosing to work in the nuclear industry.* (Paragraph 164)

34. It is highly desirable that, in expanding employment in the sector, opportunities should continue to be broadened to people from sectors other than nuclear. Apart from the wider pool of talent available, it is important there should be flows into and out of the nuclear industry from other industries. The risk for any industry that is too insulated from others is that it can be insular and impervious to different ways of thinking that are practiced in other industries. At a time of such rapid technological change and innovation, it is important that the nuclear industry participates in this movement, and avoids the degrees of groupthink in which a relatively small number of people move between a relatively small number of organisations within the same sector. (Paragraph 170)

35. *As a matter of strategic planning, the Government and the sector should, at a time of expansion, deliberately increase the permeability of the sector to other commercial, engineering and scientific sectors.* (Paragraph 171)

36. We were impressed by the obviously effective working relationship between the National College for Nuclear and the Hinkley Point C Project. In this case, the training provided, and the apprenticeships offered, are clearly tied to a specific employer and site. We were concerned that there was a lack of clarity on who should fund the development of the curriculum and teaching materials for courses mounted exclusively to serve the needs of a particular employer. *The Government and the Nuclear Skills Strategic Groups should develop a clear protocol on this. Should further nuclear new build proceed, with multiple organisations in the developer and in the supply chain requiring apprenticeships, there must be no delay in developing courses arising from ambiguity on who pays for that development.* (Paragraph 177)

37. *In line with Sir Paul Nurse's recommendations for greater flexibility on pay with conditions for Public Sector Research Establishments, we recommend that a consistent set of pay flexibilities should be applied to public bodies in the sector with financial discipline applied through the overall budgets for bodies.* (Paragraph 185)

Financing

38. Gigawatt-scale nuclear projects cost tens of billions of pounds to plan and construct before a single unit of electricity is generated. Their long period of construction, complexity, and subordination to potentially variable regulatory standards have been associated with large cost-over runs and delays. For all of these reasons, and more, the financing of gigawatt-scale new nuclear power has proved formidably challenging. Most civil nuclear nations have built new nuclear power stations on the public sector balance sheet, as did the UK for all of its existing nuclear power stations. Hinkley Point C has been financed off the Government balance sheet by

the French Government-owned utility EDF and Chinese CGN. Its construction is proceeding in return for a 35 year Contract for Difference (CfD) fixed at £92.50/MWh in 2012 prices. The conceived cost of construction has increased from £18 billion at the time of the final investment decision to £32 Billion in 2023 and its completion date is now forecast to be 2027, around two years after EDF's estimate at the time of Final Investment Decision (FID). It is important to note that the estimates of that cost overrun as result of the CfD model are not to be met by UK consumer or taxpayer, but by the companies. The CfD runs for 35 years from start-up during the 2025–2029 period. If the plant is not generating electricity by 2029 then the contract would be shortened by one year up until 2033 after which the contract will be cancelled and EDF will not receive any top-up revenues from the CfD. (Paragraph 216)

39. Given the demonstrated unwillingness of private investors to take on all of the construction risk of gigawatt scale nuclear plants through the CfD model, it is inevitable that a public-private risk sharing model should be contemplated if new gigawatt-scale plants are to be constructed. The Regulated Asset Base (RAB) model—which has been given Royal Assent in the Nuclear Energy (Financing) Act is one such. However, the model entails significant uncertainties and downsides. Chief among these is that although the financing of a plant should be cheaper in headline terms than a model in which the private sector shoulders all construction risk, the extent to which this represents value for money depends on the financial value of the construction risk being absorbed by the public balance sheet. The consumer or taxpayer is taking an unknown and uncertain risk of cost overruns, yet disburses funds from day one without earning a return. (Paragraph 217)

40. *The Government should show how this offers value for money to taxpayers and should be open to other alternative partnerships between the public and private sectors as practised in other countries (including those set out in Table 2).* The choice to proceed with gigawatt-scale nuclear power should not be made without robust estimates of its value for money, including the financial value of the construction risk being assumed by taxpayers or billpayers. A headline lower cost than Hinkley Point C is not justified if the value of the risk is too great. This is true even if it forces a conclusion that—for all its other advantages—gigawatt scale new nuclear is not financeable on defensible terms, and that the UK's nuclear ambition would need to be pursued through other nuclear technologies.(Paragraph 218)

41. *So far, the Government has not published financial figures which allow the cost of this risk transfer to be known. The Government must publish figures, before signing contracts for new gigawatt-scale nuclear, which allow a proper assessment of value for money to be made, including setting out the level and potential cost of construction risk to be borne by the consumer or taxpayer.* (Paragraph 219)

42. *It may be the case that the size of capital outlay means that private investors will not repeat a CfD contract for new nuclear, whatever the price. But the lack of alternative choices should not mean that any terms will be acceptable for a RAB financed plant. The Government should make, and disclose, its best estimate of the value of the risk that would be taken on by the public, and a clear plan of how those risks can be managed through incentives during the development, construction and operational phase of the project's lifetime.* (Paragraph 220)

43. *The Government should publish details of how the estimated savings from using the RAB model for funding Sizewell C were calculated, and provide clarity for the funding structure, by publishing the Heads of Terms for the agreed RAB funding model for that project.* (Paragraph 221)

44. This is an important moment for the future of small modular reactors (SMRs) as we set out in Chapter 3. Following the £500 million Government and investor funded development of an SMR concept through to the beginning stages of regulatory approval. Clarity is needed on the Government's plans to deploy the technology if it completes the generic design assessment. This includes deciding on what financing model will be made available should the policy be to deploy SMRs in supplying power to the grid. The Contracts for Difference (CfD) model has proved successful in financing and driving down the costs of clean energy. Key to the success of CfDs for renewables to date has been competition between potential operators which has driven down the price paid for electricity generation. (Paragraph 225)

45. *If a single supplier of SMRs were to be available, either through Government choice or following the Generic Design Assessment process, the CfD auction model will not be suitable. As part of a clear and specific strategy for SMRs, the Government should come to a view quickly on what financial model would be available for the initial deployment and communicate this clearly to developers.* (Paragraph 226)

46. We welcome the proposed inclusion of nuclear energy generation in the UK Green Taxonomy as it reflects the low-carbon contribution of nuclear power and may make new building projects more attractive to private investors as with other low-carbon energy generators. (Paragraph 234)

47. *The Government should conduct and publish the results of its consultation quickly, and during this time review nuclear energy's access to the Green Financing Framework with a view to ensuring consistency and addressing the contradiction between the two.* (Paragraph 235)

Regulation and location

48. The Office for Nuclear Regulation (ONR) Generic Design Assessment's (GDA) goal-based approach is well regarded internationally and is intended to be adaptable for any new technology. We welcome the work that the ONR has done to modify the GDA to allow more flexibility for new reactor designs that seek to enter the UK market. (Paragraph 248)

49. Some witnesses are concerned that the GDA has capacity constraints and is a lengthy and expensive process given that there are no site-specific guarantees afterwards. Whilst acknowledging the need for UK sovereignty over regulations, witnesses pointed out the considerable overlap of the technical approval process for new reactors between established nuclear nations. (Paragraph 249)

50. *The Government should consider how it could reduce the GDA application timelines and the required resources through international collaborations between regulators, and should provide access to pre-engagement for new nuclear developers prior to*

entering the GDA. The ONR should examine ways to recognize, in whole or part, safety approvals for mature reactor designs granted by partner countries with similarly high standards to capitalise on work previously done. (Paragraph 250)

51. *The Government should ensure as part of a specific and detailed nuclear strategy that the ONR, the Environment Agency and Natural Resources Wales have the necessary resources to process applications from the growing range and number of applicants in a reasonable timeframe.* (Paragraph 251)

52. *Whilst the ONR has recently adapted the GDA to be more suitable for small modular reactor (SMR) technologies, to date no SMR design has completed the entire three step process. The ONR should reflect, both during and after the first SMR has completed the GDA, on the lessons to be learned on efficiency and applying appropriate safety cases for these smaller technologies, from other similar bodies, such as the Environment Agency and Health and Safety Executive that regulate Fusion energy facilities.* (Paragraph 252)

53. Although the reputation and integrity of UK nuclear regulation must be maintained, there are opportunities to improve the efficiencies of nuclear regulation by running processes such as the Generic Design Assessment (GDA), and site licencing, in parallel. (Paragraph 257)

54. *The Government should work with regulators, devolved administrations, local authorities, industry leaders, and others to streamline planning and environmental requirements wherever possible. The Office for Nuclear Regulation should look for opportunities to run the Development Consent Orders and the GDA in parallel for experienced vendors who have already successfully completed the GDA with other reactor designs or who have reactor technology that has been approved by other regulators.* (Paragraph 258)

55. Given that the Minister envisaged a three-year timeline to develop, consult upon, and designate a new nuclear National Policy Statement (NPS), and that as of 18 July 2023 the consultation stage had not even started, we are concerned that there may be a creeping delay in updating the NPS for new nuclear. This would not only send the wrong signal to a sector poised for investment but could cause delays in deployment. New nuclear developers require knowledge of where a reactor can be built if they are to advance their plans. (Paragraph 266)

56. *The Government should progress the consultation on the new NPS EN-7 for nuclear power and should meet its previously stated deadline of early 2025, and ideally publish the new NPS earlier than the deadline. Any update should identify where reactors smaller than 1 GW can be sited, as well as sites for larger reactors.* (Paragraph 267)

Nuclear decommissioning and waste

57. Decades of mismanagement of nuclear decommissioning in the UK—from inadequate provision for decommissioning costs, to record keeping so negligent as to have left ponds of radioactive waste whose content in unknown—has made the responsibilities of the Nuclear Decommissioning Authority (NDA) some of the most challenging, complex and consequential of any organisation in Britain today. The

NDA has made progress in the last five years in simplifying its structure, making more credible estimates of the costs of decommissioning, and replacing complex and opaque subcontractor arrangements with more straightforward ones. The vast annual budget for the NDA—necessarily between £3.5 billion and £4 billion—and the critical importance of its work means that the performance of the NDA must be kept under close review by the Government and Parliament, and that it should have a strong relationship with the Department for Energy Security and Net Zero, the Treasury and the Prime Minister's office. (Paragraph 280)

58. The experience and expertise which the NDA has in civil nuclear decommissioning is more than any other country in the world, as a result of the head start the UK has had in being the world's first civil nuclear nation. As countries who were later in constructing civil nuclear power stations have to turn to safely and economically decommission them, the NDA's expertise can be deployed globally. This is a tremendous export opportunity for the UK expertise which can raise revenue. (Paragraph 281)

59. The NDA should establish, with the involvement of government, a long-term plan to expand this international work while monitoring a thorough and dependable service within the UK. (Paragraph 282)

60. Most of the nuclear waste that the UK must safely handle and dispose of has already been produced by previous nuclear installations. The incremental waste generated by new nuclear power plants is not likely to be a material factor in decisions on approving new gigawatt-scale plants. We note, however, evidence presented to us that indicated that small modular reactors and advanced modular reactors would produce waste which may require different handling. (Paragraph 283)

61. *It is imperative that a clear understanding of the waste consequences of new nuclear technologies, how it will be dealt with and at what cost, should be part of the decision-making on approving the case of these technologies.* (Paragraph 284)

62. Since 2006, Government policy has been to establish a Geological Disposal Facility (GDF) for the long-term storage of nuclear waste. Despite this, Nuclear Waste Services, which is the body responsible for establishing a GDF, is not at the point of having found a community willing to host a GDF or to be able to conduct the detailed geological investigation required to establish a suitable site for a GDF. The timelines and costs for building a GDF are also uncertain. (Paragraph 296)

63. *The first waste is not expected to be placed into a Geological Disposal Facility (GDF) until the 2050s and until then, there is sufficient interim storage for both current and predicted future nuclear waste. The Government should continue work to identify a site for a GDF which will be geologically safe, and which will enjoy the confidence of the local community. Given that interim storage has been used for over 50 years and that waste from new nuclear facilities would be a small addition to the stock of waste held, we do not believe that new nuclear plants should be halted until a GDF facility has been established.* (Paragraph 297)

Formal minutes

Wednesday 19 July 2023

Greg Clark, in the Chair

Chris Clarkson

Tracey Crouch

Katherine Fletcher

Rebecca Long-Bailey

Stephen Metcalfe

Graham Stringer

Draft Report (*Delivering nuclear power*), proposed by the Chair, brought up and read.

Ordered, That the draft Report be read a second time, paragraph by paragraph.

Paragraphs 1 to 207 read and agreed to.

New Paragraph—(Graham Stringer)—brought up and read as follows:

The Government has not assessed the cost and benefit of its Net Zero policy to the United Kingdom, yet this is the basis of its decision to invest heavily in nuclear power of which the costs and benefits are also unestimated. Until a full regulatory impact assessment has been carried out for the two policies, no decisions should be taken to invest in and build new nuclear reactors.

Question put, That the paragraph be read a second time.

The Committee divided:

Ayes, 1	Noes, 5
Graham Stringer	Chris Clarkson
	Tracey Crouch
	Katherine Fletcher
	Rebecca Long-Bailey
	Stephen Metcalfe

Question accordingly disagreed to.

Paragraphs 208 to 297 read and agreed to.

Summary agreed to.

Resolved, That the Report be the Eighth Report of the Committee to the House.

Ordered, That the Chair make the Report to the House.

Ordered, That embargoed copies of the Report be made available, in accordance with the provisions of Standing Order No. 134.

Adjournment

Adjourned till Wednesday 6 September 2023 at 9.20am.

Witnesses

The following witnesses gave evidence. Transcripts can be viewed on the inquiry publications page of the Committee's website.

Wednesday 02 November 2022

Professor Paul Norman, Professor of Nuclear Physics and Energy Director, Birmingham Centre for Nuclear Education and Research; **Professor Michael Grubb**, Professor of Energy and Climate Change, University College London Q1–95

Professor Francis Livens, Director, Dalton Institute; **Dr Paul Dorfman**, Chair, Nuclear Consulting Group; **Professor Laurence Williams**, Visiting Professor, Imperial College London Q34–59

Julia Pyke, Sizewell C Director of Finance, EDF; **Paul Spence**, Director of Strategy and Corporate Affairs, EDF Q60–95

Wednesday 09 November 2022

Michelle Catts, Senior Vice President, Nuclear Programs, GE Hitachi Nuclear Energy; **Michael Drury**, Managing Director of UK Operation, Terrestrial Energy Q96–122

Dawn James, Vice-President of Nuclear Power, Jacobs; **Dr Tim Stone CBE**, Chairman, Nuclear Industry Association; **James Richardson**, Chief Economist, National Infrastructure Commission Q123–153

Ivan Baldwin, Business Development Director, Bechtel; **Corhyn Parr**, Chair, Nuclear Skills Strategy Group Q154–165

Wednesday 23 November 2022

Gethin Jenkins, Head of Safety and Licensing, Last Energy; **Tom Samson**, CEO, Rolls-Royce SMR Q166–219

John Eldridge, Principal Engineer, U-Battery; **Dr Fiona Rayment OBE**, Chief Scientific Officer, National Nuclear Laboratory; **Dr Ian Scott**, Chief Scientist, MoltexFLEX Limited Q220–241

Tim Abram, Westinghouse Chair in Nuclear Fuel Technology, University of Manchester; **Laurent Odeh**, Chief Commercial Officer, Urenco Q242–258

Wednesday 07 December 2022

Josh Buckland, Partner, Flint Global; **Dr Fiona Rayment OBE**, Chief Scientific Officer, National Nuclear Laboratory Q259–285

Wednesday 14 December 2022

Dr Robin Taylor, Senior Research Fellow, National Nuclear Laboratory; **Professor Claire Corkhill**, Member, Committee on Radioactive Waste Management; **Professor Katherine Morris**, Lead for Nuclear Environment and Waste Theme, Dalton Nuclear Institute Q286–341

Claes Thegerström, Former President, Swedish Nuclear Fuel and Waste Management Co; **Janne Mokka**, President and CEO, Posiva Oy Q342–355

Wednesday 18 January 2023

Published written evidence

The following written evidence was received and can be viewed on the inquiry publications page of the Committee's website.

NCL numbers are generated by the evidence processing system and so may not be complete.

1 Assystem (NCL0025)

2 BSC, John Higgs (NCL0069)

3 Bond, Dr Alan (Associate Professor in Environmental Management, University of East Anglia) (NCL0020)

4 Cavendish Nuclear (NCL0041)

5 Civil Engineering Contractors Association (NCL0008)

6 Committee on Radioactive Waste Management (NCL0053, NCL0073)

7 Commonwealth Fusion Systems (NCL0035)

8 Copeland Borough Council (NCL0007)

9 Cumbria Local Enterprise Partnership (NCL0028)

10 Cwmni Egino (NCL0005)

11 Dalton Nuclear Policy Group (part of The University of Manchester's Dalton Nuclear Institute) (NCL0010)

12 Dassault Systemes (NCL0002)

13 Department for Business, Energy and Industrial Strategy (NCL0006, NCL0075)

14 EDF (NCL0060)

15 EDF Energy (NCL0057)

16 Eaglen, Dr Chris (Management, Chris Eaglen) (NCL0001, NCL0003, NCL0004)

17 Environment Agency (NCL0019)

18 First Light Fusion (NCL0031)

19 Garwood, Professor Stephen (NCL0009)

20 General Fusion (NCL0043)

21 Grantham Institute, Imperial College London (NCL0029)

22 Henry Royce Institute (NCL0030)

23 Imperial College London (NCL0026)

24 Institution of Mechanical Engineers (NCL0037)

25 Jacobs (NCL0067)

26 Jacobs UK (NCL0034)

27 Laing O'Rourke (NCL0070)

28 Last Energy (NCL0015)

29 Lord Clanmorris; and Norman, Professor Paul (NCL0072)

30 Mineral Products Association (NCL0032)

31 MoltexFLEX Clean Energy (NCL0065)

32 MoltexFlex (NCL0038)

33 Morris, Professor Katherine (Professor of Environmental Radioactivity and Academic Lead Nuclear Waste Services RSO, The University of Manchester) (NCL0068)

34 Newcleo (NCL0062)

35 NNB GenCo (SZC) Limited (NCL0049)

36 NUVIA Ltd (NCL0033)

37 National Infrastructure Commission (NCL0061)

38 National Nuclear Laboratory (NCL0040)

39 Norman, Professor Paul (Professor of Nuclear Physics and Nuclear Energy director, Birmingham Centre for Nuclear Education and Research) (NCL0059)

40 North West Nuclear Arc (NCL0023)

41 Nuclear Consulting Group (NCG) (NCL0014)

42 Nuclear Decommissioning Authority (NCL0024, NCL0074)

43 Nuclear Futures Institute, Bangor University (NCL0011)

44 Nuclear Industry Association (NCL0012, NCL0063)

45 Nuclear Innovation & Research Advisory Board (NCL0042)

46 Nuclear Skills Strategy Group (NCL0036)

47 Nuleaf (Nuclear Legacy Advisory Forum) (NCL0022)

48 People Against Wylfa B / Pobl Atal Wylfa B (NCL0047)

49 Prospect Trade Union (NCL0013)

50 Rolls-Royce SMR Limited (NCL0021)

51 Stirling, Prof Andy (Professor of Science & Technology Policy (SPRU - Science Policy Research Unit), University of Sussex); Johnstone, Dr Philip (Senior Research Fellow (SPRU - Science Policy Research Unit), University of Sussex); and Mackerron, Prof Gordon (Professor Of Science And Technology Policy (SPRU - Science Policy Research Unit), University of Sussex) (NCL0052)

52 Stop Sizewell C; Together Against Sizewell C; People against Wylfa B; and Blackwater against New Nuclear Group (NCL0044)

53 Taylor, Dr Robin (NCL0071)

54 Terrestrial Energy (NCL0046)

55 The Geological Society (NCL0027)

56 Tokamak Energy Ltd (NCL0039)

57 Tudor, Matt (Director of Strategy & Partnerships, Bridgewater & Taunton College) (NCL0076)

58 UK Atomic Energy Authority (NCL0016)

59 UKRI - Innovate - Low Cost Nuclear Challenge (NCL0058)

60 University of Bristol (NCL0051)

61 Urenco (NCL0055, NCL0066)

62 Westinghouse Electric Company (NCL0054)

List of Reports from the Committee during the current Parliament

All publications from the Committee are available on the publications page of the Committee's website.

Session 2022–23

Number	Title	Reference
1st	Pre-appointment hearing for the Executive Chair of Research England	HC 636
2nd	UK space strategy and UK satellite infrastructure	HC 100
3rd	My Science Inquiry	HC 618
4th	The role of Hydrogen in achieving Net Zero	HC 99
5th	Diversity and Inclusion in STEM	HC 95
6th	Reproducibility and Research Integrity	HC 101
7th	UK space strategy and UK satellite infrastructure: reviewing the licencing regime for launch	HC 1717

Session 2021–22

Number	Title	Reference
1st	Direct-to-consumer genomic testing	HC 94
2nd	Pre-appointment hearing for the Chair of UK Research and Innovation	HC 358
3rd	Coronavirus: lessons learned to date	HC 92

Session 2019–21

Number	Title	Reference
1st	The UK response to covid-19: use of scientific advice	HC 136
2nd	5G market diversification and wider lessons for critical and emerging technologies	HC 450
3rd	A new UK research funding agency	HC 778