Department for
Energy Security
& Net Zero

CIVIL NUCLEAR: ROADMAP TO 2050

January 2024

CP 1009

Civil Nuclear: Roadmap to 2050

Presented to Parliament by the Secretary of State for Energy Security and Net Zero

by Command of His Majesty

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MINISTERIAL FOREWORD

For much of the 20th century, nuclear power was touted as the future. In 1931, before he became Prime Minister, Winston Churchill predicted nuclear energy would bring advances 'incomparably greater than those produced by the steam-engine'. Two decades later, with Churchill in his second term, construction began on the world's first commercial nuclear power plant at Calder Hall in Cumbria, promising a new era of cheaper, cleaner, more reliable energy. When the oil crises of the 1970s sparked chaos in energy markets, nuclear was again marketed as the saviour. But concerns over safety and affordability persisted, and by the 1980s, public opinion was turning against nuclear in the UK. Slowly, we began to fall behind.

Yet today, our nuclear industry is re-awakening. As part of a massive investment in home-produced clean energy, nuclear will offer the reliable, resilient, and low-carbon power we need to reach net zero by 2050, and ensure our energy security, so we're never dependent on the likes of Putin again.

In the UK, we have set an ambition for up to 24 Gigawatts (GW) of nuclear capacity by 2050, which would cover up to a quarter of the country's projected electricity demand.

We have also joined more than 20 nations including the US, France, Ghana and the UAE, in endorsing the net zero nuclear declaration, calling for a global tripling of nuclear energy by 2050.

This government has always been supportive of nuclear power, and I am proud that every currently operational nuclear power station in the UK was switched on under a Conservative government. But we also recognise that there is much further to go if we are to truly achieve Churchill's vision.

Now, after a year which saw both the launch of Great British Nuclear (GBN) and the passing of the Energy Act 2023, I am proud to say we are turning pledges into action with our most ambitious civil nuclear strategy in decades.[1]

Not only does this Roadmap set a clear path for the growth of nuclear fission, including the production of domestic fuel and regular investment decisions in new projects, it also explains how we will develop the skills and supply chains required to support this rapidly growing industry. Furthermore, it acknowledges the crucial importance of the nuclear industry to our national security, both in terms of energy supply and the defence nuclear enterprise, making clear that we are looking to identify opportunities to align the two across government, while meeting our commitments to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT).

1 This Roadmap covers nuclear fission only. An update of our nuclear fusion energy strategy was published in 2023, see https://www.gov.uk/government/publications/towards-fusion-energy-the-uk-fusion-strategy

Transforming our energy mix to make us greener and more independent is a huge undertaking, but the UK is uniquely placed to succeed. Our decades of nuclear experience have provided a legacy of experienced workers and world-leading academic institutions, as well as expertise in the whole nuclear life cycle, from our fuel production at Westinghouse, to the decommissioning and radioactive waste management by the Nuclear Decommissioning Authority (NDA), which works with partners including Japan and the United States. The UK is also a world leader in nuclear safety and security – thanks to our commitment to rigorous regulation and the creation of the internationally recognised Office for Nuclear Regulation (ONR).

The reality is that few other countries boast the nuclear credentials we do. So, as this immense technology takes off on a global scale, we want to harness our unique strengths and become a leading nuclear energy nation once again.

This Roadmap can help us achieve that by providing direction for future decisions, and strengthening ties with those who know the industry best – our nuclear workers and industry leaders.

And by making nuclear a central pillar of our energy mix in this way, I'm confident this generation will be the one that finally seizes its full potential, and delivers the 'incomparable' energy supply Churchill predicted almost a century ago.

RT HON CLAIRE COUTINHO MP
Secretary of State for
Energy Security & Net Zero

EXECUTIVE SUMMARY

Why do we need a Civil Nuclear Roadmap?

The UK led the world becoming the first country to split the atom. This was followed in 1956 by the world's first civil nuclear programme and a nuclear power station at Calder Hall, Windscale. At its peak in the mid-1990s, the UK generated approximately 13GW of power from nuclear energy, but this has slipped to only around 6GW today. This stands in stark contrast to our modern understanding of nuclear power as the only current form of reliable, secure, low carbon electricity which can be deployed at scale in the UK and as a key component in the drive for net zero. Accordingly, the government has taken the decision to reverse decades of under-investment and to recover the UK's global leadership in civil nuclear.

This Roadmap sets out the pathway to a UK resurgence in civil nuclear, covering both the long-term strategy and the near-term enabling policies we are pursuing. The aim is to demonstrate how nuclear power can and will contribute to the government's push to reach net zero by 2050 and, in so doing, to strengthen the UK's energy security. There is no credible pathway to net zero nor energy security without nuclear power and now is the time to act.

The purpose of this Roadmap is to send an unambiguous signal to the nuclear sector and investors, setting out how we expect UK nuclear deployment to happen, a timeline for the key decisions and actions, and clarity over the role government and industry should play in supporting and enabling this delivery. The challenges of net zero by 2050 and energy security demand urgent action, and the UK government stands ready to act.

The pathway to 2050

Our goals and actions over the next twelve months will lay the foundation of long-term strategy in the nuclear sector. We are:

- Launching consultations on Alternative Routes to Market for New Nuclear Projects and a new approach to siting nuclear within the National Policy Statement (NPS) (with a consultation on the draft NPS to follow), that will further inform our civil nuclear policy.
- Publishing a Nuclear Skills Taskforce report alongside a Defence Nuclear Enterprise Command Paper, explaining how we will ensure our civil and military nuclear ambitions address our shared challenges and opportunities.
- Completing the GBN-led Small Modular Reactor (SMR) technology selection process, announcing which technologies will be supported to achieve Final Investment Decision (FID) by 2029.
- Seeking to reach FID on Sizewell C (SZC) before the end of this Parliament.
- Monitoring the construction of Reactor Units 1 and 2 at Hinkley Point C (HPC) by EDF Energy so that our first new nuclear project in a generation can come online later this decade.
- Publishing a response to our consultation on nuclear decommissioning and managing radioactive substances, including radioactive waste.

For longer-term clarity we are also now committing to:

- Exploring a further large-scale reactor project and setting out timelines and processes this Parliament, subject to a SZC FID.
- Aiming to secure investment decisions to deliver 3-7GW every five years from 2030 to 2044, to meet our ambition to deploy up to 24GW of nuclear power by 2050.

- Developing government policy to support investment in advanced nuclear technologies, following the Alternative Routes to Market consultation.

The role of Great British Nuclear (GBN)

GBN has rapidly established itself as the government's delivery body for new nuclear and has started this vital mission by delivering the SMR competition to help deliver net zero and promote energy security. This roadmap sets out the role of GBN, which will also:

- Deliver other parts of government civil nuclear programme
- Advise government on a broad range of industry and sectoral barriers to investment.

Siting and land usage

The current nuclear NPS was designated in 2011 and focused on GW-scale nuclear developments. Now an NPS is required which can facilitate the rollout of SMRs and Advanced Modular Reactors (AMRs) (alongside GW-scale projects), to meet our ambition for up to 24GW by 2050. While we recognise the potential advantages of the existing sites designated under EN-6 remain, making them potentially suitable for nuclear development beyond 2025, we also need a greater diversity of sites. We will therefore seek to introduce a flexible approach to nuclear siting, subject to consultation on the new National Policy Statement. This would set out clear criteria for future siting of new technologies and could open up opportunities to capitalise on the greater number of deployment scenarios and potential end-uses of different nuclear technologies. Our commitments are that:

- Nuclear generation projects will have 'critical national priority' status in the planning system.
- The government will seek to develop a new flexible approach to nuclear siting, subject to consultation on the new National Policy statement.
- Community engagement will remain integral to the siting process.
- The NDA will periodically publish a prospectus stating which of its land holdings will soon become available for reuse. Where there is commercial interest in available land, the NDA and the government will run fair and transparent processes to lease or option land, with the assumption being that sites go first to new nuclear projects, where that is feasible and represents value for money.

Regulating and streamlining the future of nuclear development

Having an internationally respected regulatory regime is a key strength for the UK as the government fulfils its ambition to make Britain the best place in the world to invest in nuclear. This Roadmap sets out opportunities for flexibility and optimisation in regulation, potentially reducing the timescales for completion of a Generic Design Assessment (GDA) by up to 50%, while maintaining the highest safety and security standards (as overseen by the ONR) and environmental protection (as overseen by the Environment Agency (EA) in England, Natural Resources Wales in Wales, and Scottish Environment Protection Agency in Scotland). Our commitments are that:

- We are launching a new 'smarter regulation challenge' for industry: through the Alternative Routes to Market Consultation we are calling on industry to identify how we can reduce bureaucracy to drive efficiencies in the deployment of new projects, making sure Britain is ready to regulate new nuclear.

- We are introducing wide-ranging Nationally Significant Infrastructure Project reforms to ensure the planning system overall can support the UK's future infrastructure needs by making the planning system better, faster, greener, fairer, and more resilient.
- We are reforming the existing environmental assessment processes of Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA) with Environmental Outcomes Reports (EOR). EOR will be an outcomes-based approach to assessment that is streamlined, fit for purpose and places the government's environmental commitments at the centre of decision-making.
- ONR will work to streamline design assessment and licensing processes, to realise efficiencies, and to prepare itself for new market entrants and alternative development models.
- ONR and EA will launch a framework for early regulatory engagement for vendors seeking to enter the UK market.
- ONR and EA will publish guidance to GDA requesting parties on how to maximise the use of overseas regulatory assessment and expectations for moving from a two-step GDA to licensing and permitting.
- ONR and EA will continue to work with mature regulatory bodies to facilitate greater international collaboration, enabling the sharing of regulatory assessments and maximising the value of overseas regulatory work.

Financing and funding models

Historically, one of the greatest challenges to nuclear development has been financing. This Roadmap explains how future investors and developers can engage with government on the suitability of available financing models. A further boost for investor confidence follows from a reiteration of the government's ambition to accede to the Convention on Supplementary Compensation for Nuclear Damage. Our commitments are that:

- Investors and developers of new nuclear projects will be able to engage with government on the suitability of Contract for Difference (CfD) and Regulated Asset Base (RAB) financing models.
- The government will seek accession to the Convention on Supplementary Compensation for Nuclear Damage (CSC) to strengthen our Nuclear Third-Party Liability regime, supporting investment into the sector.
- The government will consult on the inclusion of nuclear in the Green Taxonomy, helping gain access to new investment incentives.

UK nuclear fuel cycle

Building on our existing world-leading expertise and capabilities, we are taking significant steps to ensure access to a secure and resilient supply of nuclear fuel for the reactors of today and tomorrow. Our commitments are that:

- We will regenerate and grow the UK's domestic fuel cycle capabilities.
- We will remove any remaining Russian fuel and uranium supply to the UK by 2030 and work with our international partners to end international dependence on Russia and build shared, resilient allied supply chains free from the risk of political leverage.

- We will deliver UK High Assay Low Enriched Uranium (HALEU) enrichment and deconversion capability by investing up to £300 million alongside industry.
- The NDA will progress decommissioning on the Springfields site to make space for new capabilities to be developed.
- We will accelerate the delivery of UK fuel cycle projects investing up to £10 million under the Nuclear Fuel Fund (NFF), including in nuclear fuel capability and expertise development, and HALEU deconversion.
- We are providing clarity to vendors by committing not to support the use of plutonium stored at Sellafield by Advanced Nuclear Technologies whilst high hazard reduction activities are prioritised at Sellafield.

Nuclear innovation and R&D

The UK possesses an extensive nuclear infrastructure and government has made significant investments in further developing UK capabilities and nuclear R&D across the nuclear fuel cycle. This Roadmap sets out further ambitions, including:

- Aiming to deliver a High Temperature Gas Reactor Demonstration by the 2030s.
- Considering investment options ahead of the next Spending Review in recognition of the importance of a domestic research reactor and UK proton source for research and medical radionuclide supply.

Decommissioning and waste management

As we scale up our ambition, we need to be ready to dispose of additional nuclear waste, while continuing to take care of our nuclear legacy. In the Roadmap we set out our commitments to:

- build a Geological Disposal Facility (GDF) that will be able to accommodate waste from up to 24GW.
- publish an updated UK wide policy framework for nuclear decommissioning and managing radioactive substances, including radioactive waste.
- review policy on funded decommissioning programmes to ensure it remains suitable for new nuclear and protects future generations from bearing the costs of decommissioning.

The nuclear workforce of tomorrow

There is a significant skills challenge – and opportunity for UK employment – with the nuclear new build programme. Following the launch of the Nuclear Skills Taskforce in 2023, this Roadmap sets out the government's plans to tackle challenges in developing the nuclear skills pipeline and to improve the diversity of the UK's nuclear workforce. Our commitments are that:

- The government will continue to work closely with colleagues across the nuclear and other sectors, to develop the nuclear skills pipeline.
- The government will work in collaboration with key stakeholders to prioritise:
  a. Increasing the number of people entering the workforce and developing future leaders.
  b. Communication and collaboration to raise the profile of the nuclear sector while promoting nuclear sector jobs and opportunities.
  c. The diversity of our workforce, and enhancing the benefits of nuclear sector careers, especially in lower socio-economic level areas.

Developing the nuclear supply chain

To meet our future nuclear ambitions, we need to ensure the UK has a resilient supply chain with the required capabilities and capacity to meet the demands of ramping up our nuclear deployment and delivering our existing decommissioning requirements. Setting out our wider nuclear ambitions in this Roadmap is a crucial step in providing the nuclear industry with the certainty it needs to invest in the supply chain. Beyond that, our commitments are that:

- The Department for Energy Security and Net Zero (DESNZ) will work jointly with the Ministry of Defence (MoD) and key delivery partners to identify and tackle common supply chain challenges to ensure that we have a resilient nuclear supply chain.
- The government will continue to engage with industry to identify barriers to entry and develop the necessary polices to help create more accessible opportunities for the supply chain.
- The government will support the industry to develop and deploy innovative ways of working, such as advanced manufacturing practices, to help UK business compete for more opportunities domestically and internationally.

Delivering the Roadmap

The government's ambition in the new nuclear space does not end with this Roadmap. We will continue to engage with the sector as we develop our future policies, and we will monitor progress to make sure we are on track to meeting our ambitions. Our commitments are that:

- DESNZ will work jointly with MoD and the nuclear sector to recast and refresh the Nuclear Industry Council, including developing a programme of work aligned to the Roadmap for the Council to deliver.
- We will review our engagement strategy with local governments and communities that are hosting or exploring nuclear opportunities to ensure that insights from these fora are reflected in the evolution of the Roadmap, our policy making, and objectives.
- We will monitor the impact of our enabling policies, alongside whether progress is on track to meet the overall civil nuclear ambition.
- We will publish a Roadmap 'update' by the end of 2025.

PART I: THE GOVERNMENT'S ROADMAP FOR NUCLEAR POWER

1. Introduction: Why do we need a Civil Nuclear Roadmap?

The case for nuclear

The government remains committed to reaching net zero by 2050 and nuclear is a key part of achieving that ambition. There is no credible pathway to net zero without nuclear and we envisage all forms of nuclear technologies, from SMRs and AMRs to large-scale nuclear, being part of our energy mix to complement intermittent technologies like wind and solar and the uncertainties of energy storage technologies.[2]

Nuclear is also a critical part of the energy mix that will allow us to ensure energy security in the long term. The UK is currently a net importer of energy, mainly in the form of imported gas and oil. Energy imports are vulnerable to extreme events, such as a sustained cold spell across Europe with low wind that diverts gas shipments to the continent or, as occurred in 2022 with Putin's illegal invasion of Ukraine, geopolitical incidents.[3] Such extreme events reduce energy resilience in the UK, increasing the chance that an additional energy shock leads to power disruption and results in spikes in domestic energy prices.

The UK's nuclear electricity generation share has fallen from 27% in the 1990s to around 15% today.[4] Nuclear's share of generation is expected to fall further until HPC is due to come online later this decade. At the same time, the electrification of transport, homes, and industry over the coming decades will drive up the demand for electricity by an estimated 50% by 2035, doubling or even trebling by 2050.[5] It is therefore essential that we increase the amount of homegrown electricity to meet this demand, so we are more self-sufficient and protected against future energy crises, in addition to avoiding millions of tonnes of carbon dioxide being released from unabated fossil fuel power generation.

This can be achieved by delivering a significant share of power through dependable low-carbon nuclear that takes into consideration the environment and provides a steady source of energy generation to complement intermittent renewables. Nuclear is the only form of reliable, low carbon electricity generation that has been proven at scale in the UK. Nuclear is typically around 30 to 40 times more land efficient than a solar farm of the same output.[6]

2 The path to net zero is through a series of carbon budgets which drive a step-by-step reduction in our emissions up to 2050. Carbon budgets are set by Parliament on the advice of the independent Committee on Climate Change (CCC) and include contribution from new nuclear.

3 BEIS, Digest of UK Energy Statistics, https://www.gov.uk/government/statistics/digest-of-uk-energy-statistics-dukes-2020.

4 Department for Business, Energy and Industrial Strategy (2019), Energy Trends; March 2019, p. 64; Department for Energy Security and Net Zero (2023). Digest of UK Energy Statistics Annual data for UK, 2022, p. 5.

5 https://www.theccc.org.uk/publication/sixth-carbon-budget/

6 Figure informed by a range of sources for average land use and output of nuclear plants and ground based solar installations, including the following publicly available sources: Our World In Data article on land use (2022) (https://ourworldindata.org/land-use-per-energy-source) and UNECE report on Integrated Life-cycle Assessment (2022) (https://carbonneutrality.unece.org/). There are a wider range of figures if comparisons are made between specific installations.

Further, innovation in the nuclear sector creates exciting opportunities to use nuclear energy for more than just low-carbon electricity generation, including hydrogen production for heat or electric vehicles, direct heat for homes or industry, medical isotopes for diagnosis and treatment of diseases such as cancer, and nuclear waste management. Applications such as these could be key to helping wider industry decarbonise.

The case for nuclear is clear and to meet our ambitions we need to learn lessons from the past few decades. The UK was the first country in the world to deploy commercial nuclear power, but more recently our nuclear programme has been piecemeal with few reactors deployed at the scale needed to bring down costs over time. A first-of-its-kind single pressurized water reactor was completed at Sizewell B in 1995. It was built to budget and now contributes 1.2GW towards the UK's energy mix. But it remains the most modern reactor in the UK nuclear fleet, as no further nuclear plant construction was commenced until the government consented the development of Hinkley Point C in 2013.

This led to the loss of key skills in the supply chain, reduced investor confidence in the UK, and the erosion of expertise in government. New nuclear projects now take the best part of a decade to go through approval and can involve tens of thousands of pages of regulatory assessment. This must change if we are to achieve our ambitions for net zero and safeguard the UK's energy security in decades to come.

Our commitment to nuclear

In the Ten Point Plan for a Green Industrial Revolution[7] and the Energy White Paper 2020,[8] the government confirmed its commitment to nuclear power and the development of advanced nuclear technologies in Britain. We went further in the British Energy Security Strategy[9] and Powering up Britain Energy Security Plan.[10] There we committed to an overall ambition of delivering up to 24GW of nuclear power capacity by 2050 to achieve energy security and net zero goals while delivering value for money for taxpayers.

Since 2020 we have made great strides to embed the revitalisation of Britain's nuclear sector. We have:

- supported the construction of the HPC nuclear power plant in Somerset, the first nuclear project in Britain since Sizewell B came online in 1995, bringing wide-ranging economic benefits to the region (see case study).
- started negotiations on and then became a shareholder in the SZC project, planned as a replica of HPC. To date the government has committed to £1.2bn of investment to support the project's development.
- passed the Nuclear Energy (Financing) Act 2022, establishing use of the RAB model for nuclear, designed to help attract private investment in new nuclear projects, whilst achieving better value for money for consumers. SZC was the first project designated as being capable of using the RAB model.

7 https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution
8 https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future
9 https://www.gov.uk/government/publications/british-energy-security-strategy/british-energy-security-strategy
10 https://www.gov.uk/government/publications/powering-up-britain/powering-up-britain-energy-security-plan

- supported the development of SMR technologies via the Future Nuclear Enabling Fund (FNEF)[11] and low-cost nuclear challenge.[12]
- supported the development of AMR technologies via the AMR Research, Development and Demonstration (RD&D) programme.
- completed the statutory post-implementation review of the ONR ensuring it is fit to regulate for the future.
- launched GBN to help deliver new nuclear projects and passed legislation in the Energy Act 2023 to give GBN the scope it needs to be a flexible delivery vehicle in the long term.
- tasked GBN to lead a competitive technology selection process to select SMR technologies best able to achieve FID by 2029, with a view to delivering electricity to the grid in the mid-2030s.

Our work to date has clearly demonstrated the benefits nuclear brings, not just to our energy system, but also the environment and wider society. Investment in nuclear, from new build nuclear through to decommissioning and clean-up of the UK's nuclear legacy,[13] has been able to reinvigorate communities, supporting the government levelling-up agenda through creating training and employment opportunities. The Nuclear Industry Association (NIA) estimate that almost 40% of direct employment in the civil nuclear sector occurs in the most deprived 25% of local authorities in England, and this figure rises to 48% in Scotland.[14] Since more than half of civil nuclear jobs are in rural areas, well-paid nuclear roles also combat the rural-urban wage gap.

11 https://www.gov.uk/government/publications/future-nuclear-enabling-fund-fnef
12 https://www.ukri.org/what-we-do/browse-our-areas-of-investment-and-support/low-cost-nuclear/
13 Nuclear Decommissioning Authority Strategy, published March 2021, Chapter 8.10: Socio-Economics. https://www.gov.uk/government/publications/nuclear-decommissioning-authority-strategy-effective-from-march-2021
14 Nuclear Industry Association Report, Delivering Value: The Economic Impact of the Civil Nuclear Industry, p. 14, published January 2023, https://www.niauk.org/delivering-value

Case study: Socio-economic impact of the HPC project

HPC is the first new nuclear power station to be built in the UK in a generation and since its commencement in 2016 has provided an enormous boost to both the local and national economy. Through close collaboration with further education sector, including Bridgwater and Taunton College, the project has delivered a large number of job and training opportunities and helped revitalise the UK's nuclear sector. In their 2023 Socio-Economic Impact Report[15] EDF highlight that the HPC project is on course to meet or beat many of its original targets for investment and jobs.

On investment, EDF state that:

- 64% of HPC's contracts will go to UK-based companies, up from an original target of 57%.
- Spending with South-West based companies is now £5.3bn with 1,300 companies.
- Investment in local infrastructure and community support has reached £139m.
- £14.5m of grant funding has been provided to fund local projects, with an additional £700k invested in tourism.
- HPC's contracts are also supporting and creating thousands of jobs across Britain. For example, more than £1.8bn has been spent with companies in the North of England. In North Wales, a new factory opened to make specialised pipework, creating 200 new skilled jobs.

On jobs and training, EDF state that:

- HPC will offer 30,000 new training places between now and completion, helping local people join the project as it hits peak construction activity.
- To date, 1,131 apprentices have been trained – surpassing the original target of 1,000 apprentices for the whole project.
- HPC's £24m investment in education, skills, and employment, including at 3 new Centres for Excellence in welding, electrical and mechanical skills will enable trainees to upgrade their skills and earning potential by joining the work to fit miles of pipes, cables, equipment, and control systems.

15 EDF Socio-economic Impact Report 2023. https://www.edfenergy.com/energy/nuclear-new-build-projects/hinkley-point-c/realising-socio-economic-benefits

Our vision for the future

To reach our civil nuclear ambitions we need to go beyond our current commitments to give the nuclear sector, investors, regulators, local governments, international partners, and other key stakeholders confidence in the government's long-term plans. We need to commit to a strategically sequenced pipeline of nuclear projects, which provides the nuclear sector with long-term certainty. A programmatic approach enables expertise to move between projects and will also create opportunities to reduce the cost and risk of new projects through learning and replication, which in the long term translates to lower costs for consumers.

In this Roadmap we are reconfirming our ambition to deploy up to 24GW of nuclear power by 2050, and setting out how we expect nuclear deployment to happen, the major decisions government will make concern new nuclear projects, and the role it will play in supporting this new build programme through its wider enabling policies. We want to provide a clear signal to the nuclear sector and set out how government and industry will need to work together to reach this nuclear ambition, whilst maintaining our high standards of safety, security and environmental protection. By doing so, we can support development decisions, improve investor confidence, and provide the greater certainty needed to enable the UK nuclear supply chain to match this ambition.

> **" However, we need to be clear that there will remain uncertainty. As we pursue our ambitions, we need to be flexible about the technologies we pursue, and the exact role government takes in supporting their deployment over the coming decades.**

We are now launching a nuclear programme that supports a wide range of future nuclear technologies. As it progresses, we will have further clarity on the best mix of technologies to enable reliable nuclear energy while providing value for money to taxpayers. We are also seeking to decrease the reliance on government over time and the private sector to take a lead in delivering new nuclear.

We are publishing this Roadmap to coincide with launch of two consultations that will inform our future policy: a new approach to siting new nuclear power generation beyond 2025, and the Alternative Routes to Market for New Nuclear Projects. The siting consultation is the first step in developing a new nuclear NPS to provide clear guidance on future siting of nuclear power stations to give industry and investors the confidence they need to deliver projects at speed.[16] The Alternative Routes to Market consultation seeks views on how government can enable different routes to market for new advanced nuclear technologies.[17]

16 https://www.gov.uk/government/consultations/alternative-routes-to-market-for-new-nuclear-projects
17 https://www.gov.uk/government/consultations/approach-to-siting-new-nuclear-power-stations-beyond-2025

The next twelve months will see key actions taken by government that will lay the foundation of long-term strategy in the nuclear sector:

- launch of Alternative Route to Market and siting consultations
- publication of Nuclear Skills Taskforce report
- publication of Nuclear Defence Command paper
- publication of government response to Alternative Routes to Market and siting consultations
- publication of draft nuclear NPS (EN-7) for consultation
- announcement of successful vendors in SMR selection process
- designation of new nuclear NPS (EN7)
- Targeted SZC FID
- update on exploration of further large reactor

2. The Pathway to 2050

We are clear that to deliver our ambitions on nuclear capacity by 2050, we will need to go further across a wide spectrum of nuclear technologies – from SMRs to large-scale nuclear power stations and emerging AMRs. This means providing the market with the confidence to make the right technological and supply chain investments.

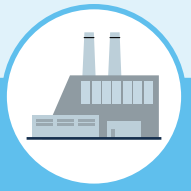
The government's programmatic approach to delivering nuclear must therefore be ambitious in breadth and depth with clear signals around how we will select and fund the best technologies, both first-of-a-kind and those able to deliver fleet and replication benefits. Safety, security, safeguards, and environmental protection by design will remain key principles in all our technology development.

DIFFERENT TYPES OF NUCLEAR TECHNOLOGIES

Large-Scale Nuclear Reactor

Large-scale nuclear is a very low-carbon technology, which provides reliable baseload power to compliment renewable generation from a very small land area.

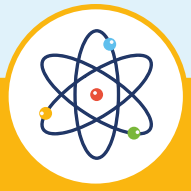
- Ca. 440 reactors currently operating globally, with 9 in the UK across 5 sites
- The current UK nuclear fleet powers the equivalent of around 13m homes from an area of less than one square mile
- Modern large-scale reactors output ranges from c1.1GW to c.1.6GW
- 2 reactors at Hinkley Point C currently under construction, with an expected lifetime of 60 years, and combined output of 3.2GW



Small Modular Reactor (SMR)

Small Modular Reactors are smaller versions of conventional water-cooled nuclear reactors.

- They use existing technology deployed in smaller units (< 500 MW)
- They have an innovative model for manufacturing and construction (modular build/manufacture)
- Heat output around 300°C
- Potential future outputs: desalination, hydrogen production, district heating



Advanced Modular Reactor (AMR)

AMRs are the next generation of nuclear power. These reactors use novel and innovative fuels, coolants, and technologies to generate high grade heat.

- Include a variety of different reactor types
- Heat output around 500-900°C
- Potential future outputs: high temperature heat for difficult-to-decarbonise industries; hydrogen production

The existing fleet

The UK has 4 generating Advanced Gas-cooled Reactors (AGR) power stations (Heysham 1 and 2, Hartlepool and Torness) and a Pressured Water Reactor power station, Sizewell B, in Suffolk. Combined, the existing fleet has a capacity of ca. 6GW. In 2022, the electricity generated from the fleet was enough to power the equivalent of over 13 million homes and around 16 million tonnes of CO_2 emissions were avoided (when compared with gas generation), which is comparable to taking around 7 million cars off the UK's roads.

Although the AGR fleet is ageing and the remaining stations are currently expected to close between 2026 and 2028, it has performed beyond original expectations, providing additional years of generation across the whole fleet. The government is pleased to see the industry, working with the UK regulators, ensuring the capabilities and capacity at the AGR sites are maintained as we develop our new build programme.

Sizewell B

Sizewell B is scheduled to come offline in 2035. As evidenced by other Pressurised Water Reactors internationally, extension of the asset by 20+ years should be technically feasible. The decision to extend Sizewell B will be for EDF to make following the conclusion of feasibility studies, investment appraisal, and will need to be accompanied by a safety case approved by the ONR. If it proceeds, the extension of Sizewell B will secure 1.2GW of nuclear energy to 2055+.

Current development projects

Hinkley Point C (HPC)

In 2016, government agreed to support the first new nuclear power station in a generation at HPC in Somerset through provision of a 35-year CfD price support. Once online, HPC will provide 3.2GW of electricity for around 60 years. The HPC company has not only invested in and borne first-of-a-kind in UK costs for a European Pressurised Water Reactor (EPR) design, but also invested and borne the first-of-a-generation costs for new nuclear in UK – setting up a supply chain, skilling workers and building capability. Future projects, whatever the design, will be able to build on this.

In February 2023 the Reactor Pressure Vessel (RPV) was delivered to HPC site – the first to be built for a British power station in more than 30 years. In December 2023, a crane lifted the 245-tonne steel dome to close the first reactor building, and in 2024, the RPV will be inserted into the Unit 1 reactor building via the Equipment Hatch.

Sizewell C (SZC)

SZC's development began in 2012, with the start of public consultations on the project. Like its sister project HPC, SZC would be comprised of 2 EPR reactors, capable of generating a further 3.2GW of electricity and powering the equivalent of around another 6 million homes. SZC is expected to start operations in the mid-2030s, subject to a FID and the start of construction.

Formal negotiations between the developer and government were announced in December 2020, alongside publication of the Energy White Paper. In November 2022, government became a shareholder in the SZC project with EDF, through a historic investment of c.£700m. In total the government has committed to £1.2bn of investment to support the project's development.

As an above ground replica of HPC, SZC would benefit from the lessons learned and established supply chain of that project – benefits that are already being demonstrated between reactors 1 and 2 at HPC – providing higher levels of maturity and de-risking the project.

In September 2023, government, alongside the project company, started a process to bring private equity investment into SZC, using the newly established RAB model for nuclear.

SMRs

Since summer 2023, significant progress has been made to drive forward SMR development in Britain. GBN's technology selection process has focused on bringing forward those technologies from around the world best able to deploy in the mid-2030s. In autumn 2023, the six companies successfully down-selected were announced. These vendors will be invited to participate in the next stage of the process.

By replicating more modular designs, we expect SMRs to reduce the cost of nuclear power. Nuclear projects that are cheaper and lower risk will be more investable and more sustainable as we strive to deliver our ambitions.

To deliver energy security while driving down costs our long-term ambition is the deployment of fleets of SMRs in the UK. Developing a fleet could create huge opportunities to develop UK manufacturing and nuclear services supply chains, and drive exports.

Large-scale nuclear

It will be challenging to reach our ambitions without at least the option of further large-scale nuclear projects. Such technologies have been the backbone of the UK energy sector since the 1950s and will continue to be for decades to come.

We are committed to exploring a further large-scale reactor project beyond SZC. We will set out timelines and process by the end of this Parliament, subject to a SZC FID. This means the UK will look to deploy both SMRs and further large-scale nuclear in parallel over the next decade, providing the supply chain the certainty it needs to invest in skills and local communities.

AMRs

AMRs can offer decarbonisation capability beyond power provision, including high-grade steam/heat and hydrogen production. We have already committed to research and development investment to deploy an AMR High Temperature Gas Reactor demonstration unit by the early 2030s (see chapter 8).

We are now going further and in the Alternative Routes to Market consultation, published alongside this Roadmap, will be gathering evidence to inform future policy options on how government can support the sector to bring forward investment. We will set out in our consultation response further detail on our ambition to help AMR vendors quickly progress projects.

Long-term decisions

Accompanying progress of the GBN-led SMR programme, we are exploring a further large-scale project alongside market-led AMR projects over the next decade, collectively marking what is just the start of the government's ambition for Britain's long-term nuclear programme. Delivering our ambitions means adopting a steady drumbeat approach to nuclear capacity decisions out to the mid-2040s.

As outlined in the British Energy Security Strategy (2022) and the Powering Up Britain strategy (2023), the government remains committed to an ambition to deliver up to 24GW by 2050. This flexibility is necessary to meet the demands decarbonisation will place on all low carbon technologies and to avoid predetermining a particular decarbonisation pathway.

To achieve this ambition, beyond our current commitment to one FID this parliament and two FIDs in the next parliament, we will aim to secure investment decisions to deliver 3-7GW every five years from 2030 to 2044. This ensures government retains appropriate optionality to achieve 24GW, while also providing industry the certainty it needs to maximise nuclear replication benefits, especially those of SMRs, where these are deemed value for money. The 3-7GW capacity range is considered the right balance between maintaining flexibility to respond to the needs of the power sector, providing sector confidence, and ensuring a low-cost energy system over the coming decades.

During the 2030s alone, decisions could be needed on projects delivering at least 10GW of nuclear generation capacity. Importantly, the UK will need to sustain this level of nuclear beyond 2050, which means continuing to consider nuclear requirements for decades to come, provided the technology remains value for money. We are also keen for the role of government to decrease over time and the private sector to take a lead in delivering new nuclear.

As set out, it is likely this capacity will constitute a combination of technologies, across SMRs, AMRs and large-scale projects. Over time, it will become clear which offer the best value for money and delivery certainty.

The Pathway to 2050 – our commitments in summary

1. We are committing to explore a further large-scale reactor project beyond SZC.
2. We are committing to deploy SMRs in the UK, unlocking the benefits of modularisation and replication.
3. We remain committed to deploying up to 24GW by 2050 and to achieve this aim will aim to secure investment decisions to deliver 3-7GW every five years from 2030 to 2044.
4. We will develop a strong government support offer for private sector AMR vendors, following the Alternative Routes to Market consultation.

3. The Role of Great British Nuclear (GBN)

Government has committed to a programmatic approach to the delivery of new nuclear projects in Britain, giving industry and investors the confidence needed to deliver projects at pace and reducing costs through learning and replication. To deliver this, in spring 2023 we launched GBN, an arm's-length body with the vital role of driving delivery of new nuclear projects on behalf of government.

The government is grateful to Simon Bowen, appointed by the then Prime Minister and Secretary of State, for his leadership and expertise during the scoping and initial set-up phase of GBN. Simon Bowen drew input from a diverse group of experts across government and industry to help develop government policy underpinning the purpose, design, and functions of GBN, including its set-up and the approach to the SMR technology selection process launched in 2023. Simon is currently interim Chair of GBN and in this capacity continues to offer the government advice and to help build up the organisation's capability and skills.

GBN is sponsored by DESNZ and will work closely with government to deliver government policy on new nuclear power projects. As new nuclear has a very long lead time, GBN is designed to be a flexible delivery vehicle that may undertake different activities, assuming and relinquishing responsibilities over time.

The government has moved at speed to establish GBN in legislation. The Energy Act 2023 sets out GBN's role to 'facilitate the design, construction, commissioning and operation of nuclear energy generation projects for the purpose of furthering any policies published by His Majesty's government'.[18] This legislation ensures that GBN has the long-term operational mandate needed to carry out its role and establishes it as an agile, adaptable organisation.

Current focus

GBN's initial priority is to run a competitive technical selection process to select the SMR technologies most likely to achieve a FID by 2029 and deliver operational projects in the mid-2030s, potentially releasing multi-billion pounds of private and public investment. This seeks to be the fastest competition of its type in the world. Alongside its role in leading this process, GBN will access sites and establish delivery capability to bring projects forward. The chosen technologies will receive an unprecedented level of support: 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 potential benefits of this approach include cost savings from replication efficiencies and economies of scale, as well as providing the necessary certainty to the supply chain to stimulate competition and encourage private sector investment. It demonstrates that government is delivering on its priorities to partner with the nuclear industry and jointly spearhead the future of nuclear technologies.

Technology selection process

- In July 2023 GBN launched a technology selection process, inviting SMR technology vendors to register their interest in the technology selection process.

18 https://www.legislation.gov.uk/ukpga/2023/52/enacted

- Six companies have been successful in the initial stage of the competition and will be invited to submit bids for contracts.
- Once technologies have been assessed and contract award decisions made, the second phase of the programme will be the progression of projects towards FID decisions in 2029.

Future focus

GBN has in place an experienced interim executive team, led by CEO Gwen Parry-Jones and Chair Simon Bowen, which is working at pace to build capability within the organisation. Permanent recruitment is set to take place over the course of 2024, when GBN will also establish its permanent office presence to support its growth.

GBN will continue to support the needs of the nuclear sector by performing two key functions: a delivery and advisory role.

GBN's delivery function

GBN is building its capability to lead the delivery of the government's future nuclear programme, and its current focus is on delivering the SMR programme. As government's nuclear programme progresses, GBN will respond and broaden its delivery focus. While SMRs represent the important next step in the nuclear programme, the government remains committed to the full spectrum of nuclear technologies and will work with GBN to consider how both large-scale and advanced nuclear technologies could contribute to UK energy security.

In addition to the market engagement response provided by the technology selection process, the Alternative Routes to Market consultation will offer invaluable insights into the opportunities within the industry. The government is particularly keen to understand where and how GBN could support the private sector to bring forward projects.

GBN's advisory function

As the government's expert delivery body and given its technical, commercial and industry expertise, GBN will advise the government on new nuclear policy and strategy. This includes programme delivery and processes, and programme design. GBN currently acts as an advisor to government on the SMR programme, with a strong initial focus on building capability to enable it to manage multiple nuclear projects. In the longer term it is expected that this function will expand in line with the scope of its delivery role, with GBN advising government on a broad range of industry and sectoral barriers to development.

The Role of GBN – our commitments in summary

1. GBN will deliver the SMR competition to help deliver net zero and promote energy security.
2. GBN's role will broaden to delivering other parts of government civil nuclear programme.
3. GBN will advise government on a broad range of industry and sectoral barriers to investment.

PART II: A VIBRANT CIVIL NUCLEAR SECTOR

To reach our ambitions for the deployment of new civil nuclear in Britain we need joined-up enabling policies. We have laid the foundation for a resilient civil nuclear sector and are now going further and accelerating efforts to make Britain one of the best places in the world to invest in civil nuclear power. Key to our approach is working alongside the nuclear defence sector, where this is appropriate, and engaging with like-minded international partners.

Civil-defence collaboration

As outlined in the Integrated Review Refresh,[19] government will proactively look for opportunities to align delivery of the civil and defence nuclear enterprises, whilst maintaining the highest standards of non-proliferation. Utilising the deep nuclear expertise across the combined sectors, we will address our shared challenges and opportunities such as developing and sustaining our skilled workforce, managing nuclear legacies, and developing new technologies.

Collaboration across the civil and defence nuclear enterprises will help boost the resilience of our sectors and help us access vital skills and capabilities to deliver our energy security ambitions and national defence requirements. In the chapters below, we outline current and future joint initiatives around fuel supply, skills, and supply chain development.

Following this Roadmap, later this spring, government will also publish the Defence Nuclear Enterprise Command Paper as well as the recommendations of the Nuclear Skills Taskforce concerning the actions that the nuclear sector can take to meet the nuclear skills demand across civil and defence.

International collaboration

The safe and secure roll-out of civil nuclear is vital to the global fight against climate change. Ensuring resilient and secure nuclear supply chains, free from the risk of political interference and leverage, is essential for every country's energy security. Nuclear exists in a global context: no country has an entirely domestic nuclear supply-chain, so our collective security is dependent on a globally interconnected market.

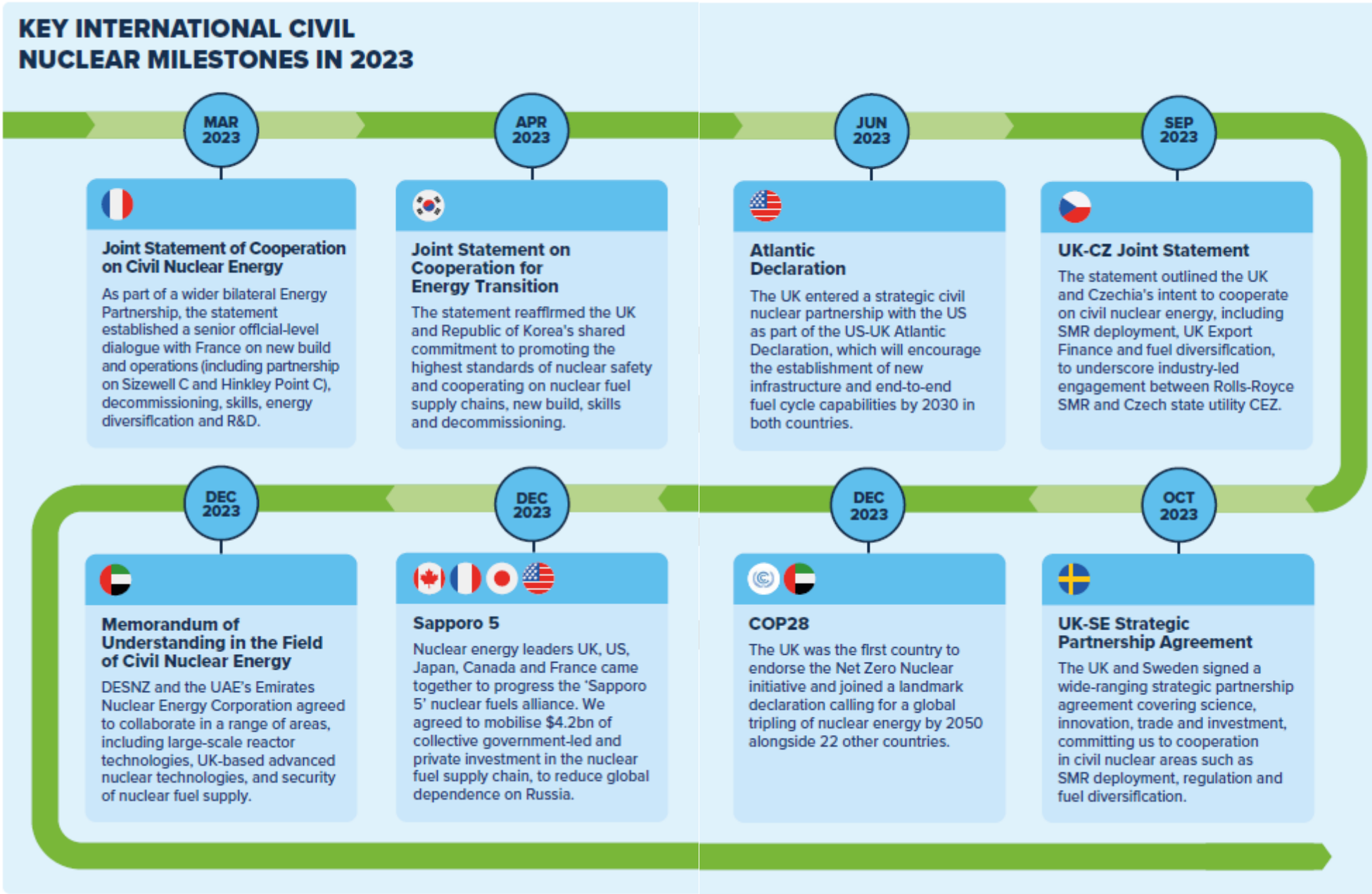
DESNZ is the department with lead responsibility for international civil nuclear policy issues on behalf of the United Kingdom. Our mission is to ensure the safe and responsible deployment of civil nuclear globally; to uphold and protect the global non-proliferation regime, and ensure the UK honours its obligations in that; and to work with our allies and partners in areas of shared mutual interest to deliver resilient and secure nuclear supply chains.

We believe that UK technology, expertise and capability can be at the forefront of a global nuclear renaissance. Civil nuclear has been at the heart of our work at the G7, and is central to the Atlantic Declaration between the United Kingdom and the United States. We are proud of the way the UK, the US, France, Canada and Japan have come together under the Sapporo Agreement to strengthen our collective supply chains and reduce dependency on Russia.

In this Roadmap, we set out how the UK intends to provide international leadership and work with its allies in areas such as nuclear safety, supply chain, skills and diversity, R&D collaboration and international financing for new nuclear infrastructure, as countries across the world accelerate deployment of nuclear technologies.

19 https://www.gov.uk/government/publications/integrated-review-refresh-2023-responding-to-a-more-contested-and-volatile-world

KEY INTERNATIONAL CIVIL NUCLEAR MILESTONES IN 2023



4. Siting and land usage

Large-scale commercial nuclear power generation has taken place at 19 licensed sites in the UK[20] and many more places are involved in supporting nuclear waste management, fuel fabrication and nuclear power research and development. However, on current plans only a few sites will still host nuclear power plants by 2040. To reach our ambitions for nuclear power by 2050, we believe that additional sites beyond those designated in the EN-6 NPS will be required for nuclear power stations, along with greater ongoing flexibility in the site selection process to enable new technologies.

> **“ The potential advantages of the sites listed in the existing NPS remain, and their role is recognised in EN-6, but additionally we will create space for developers and communities to tell us the best places to put nuclear power.**

Subject to consultation, GBN or other bodies may also play a facilitative role to aid siting activities in future, especially where this can help save time in the project development process.

Our planning policy

A crucial enabler for achieving our nuclear ambitions is an effective planning policy framework. Planning consent is required for all new projects and, for Nationally Significant Infrastructure Projects (NSIPs) such as nuclear power, this consent is applied for under the terms set out in the Planning Act 2008. The government recognises the vital importance of having a fair, fast, and efficient planning system and is prioritising a number of improvements which will support nuclear and other energy technologies.

The framework and need case for energy infrastructure is set out in the energy NPSs.[21] These policy statements only cover England and Wales, as Scotland and Northern Ireland are not covered by the Planning Act 2008. The current nuclear NPS (EN-6) was designated in 2011 and listed 8 sites potentially suitable for the deployment of GW-scale developments by the end of 2025. These sites were selected following a site nomination process and were assessed at the strategic level for their potential suitability using a range of criteria that cover safety and security, environmental protection, and operational factors.

Alongside this Roadmap the government is consulting on its proposed approach for determining how new nuclear developments could be sited beyond 2025. This is the first step towards developing a new nuclear NPS (EN-7). The government intends to consult on a draft of EN-7 in 2024 and to formally designate the new nuclear NPS in 2025.

20 Berkeley; Bradwell; Calder Hall; Chapelcross; Dungeness A; Dungeness B; Hartlepool; Heysham 1; Heysham 2; Hinkley Point A; Hinkley Point B; Hunterston A; Hunterston B; Oldbury; Sizewell A; Sizewell B; Torness; Trawsfynydd; Wylfa.

21 https://www.gov.uk/government/publications/national-policy-statements-for-energy-infrastructure

Ahead of that, we have laid before Parliament and published the updated over-arching NPS (EN-1),[22] which will apply to nuclear power alongside other nationally significant energy infrastructure once approved by Parliament and designated, which is expected early in 2024.

Recognising the advances in nuclear technologies, and the need for additional sites to meet the UK's nuclear ambitions, a new approach to siting is proposed and for the first time SMRs and AMRs generating heat and power will be brought into the planning policy framework in EN-7 alongside GW-scale projects. The new nuclear NPS will then be regularly reviewed to further support the up to 24GW ambition by 2050.

Our proposed approach

The advance in nuclear technologies and our enhanced nuclear ambitions suggest we need a new approach to siting of new developments post 2025. Of the eight sites currently listed in the existing NPS, two (HPC and SZC) have been granted development consent. This does not leave enough viable sites to meet our nuclear ambitions, and new generations of nuclear technology (SMR and AMR) are likely to be deployed more flexibly. In practice, we need all the possible nuclear sites to be used for nuclear, in order to meet our power needs.

To provide further opportunity for identifying sites for new nuclear power stations beyond 2025, it is proposed that EN-7 will not specify a limited set of locations for nuclear development as EN-6 did.

We will give developers a clear set of criteria to apply in choosing sites to build on, giving them clarity – but also flexibility – to find sites which work best for them. These include considerations around nuclear safety and security, environmental protection and operational requirements. We will also not set a time limit for how long developers have to identify their sites, nor require that they develop them by a certain deadline.

Furthermore, the revised EN-1 provides the overarching needs case for new nuclear development and introduces a critical national priority policy for low carbon infrastructure, which includes nuclear electricity generation. In practice this means an enhanced presumption in favour of granting consent to applications for low carbon NSIPs in the decision-making process. Applicants for critical national priority infrastructure must continue to show how their application meets legal and regulatory requirements, such as Habitats Regulations Assessments, and must demonstrate that the mitigation hierarchy has been applied. This approach will provide greater flexibility in the siting of new nuclear projects, including advanced nuclear technologies, while also ensuring that nuclear projects are sited in suitable locations, taking the relevant safety, environmental and operational assessments into account.

22 https://www.gov.uk/government/collections/national-policy-statements-for-energy-infrastructure

Community engagement will remain central to the development of projects at each site. As set out in the Planning Act 2008 and Planning Inspectorate (PINS) guidance, a developer will need to work with the host authorities and communities, as well as statutory bodies and other key stakeholders, to shape the proposals that will inform statutory consultation requirements and an application for a Development Consent Order (DCO). Further engagement with all affected parties will be undertaken as part of the wider regulatory processes that need to be completed prior to the construction and operation of a power station.

The sites listed in EN-6 are likely to have many factors which continue to make them potentially suitable for consideration for new nuclear development in the future. We recognise the importance of factors, such as a skilled workforce and geographical attributes, that the sites listed in EN-6 possess, which make these sites relevant for consideration for future nuclear projects. EN-6, and the site assessments incorporated within it, are likely to continue to be important and relevant to the Secretary of State's development consent decisions for projects, until EN-7 is designated. Furthermore, EN-6 may remain an important and relevant consideration in planning decisions on current and future nuclear projects at sites listed in EN-6 deployable after 2025. We will set this out in EN-7 so that developers can be assured of their siting choices, whether proposing a formerly designated site or a newly identified one.

A key benefit of the move to a criteria-based approach to site selection is that it empowers developers to select sites that best match their technology and enables other potential locations beyond the sites listed in EN-6 to be considered. This will allow communities beyond those locations previously listed to benefit from nuclear, while the robust criteria will ensure only suitable sites progress through the planning process. This will provide developers with greater flexibility to find a suitable site for their project and reflects the changes in the nuclear technology landscape since EN-6 was designated.

This new and enabling approach will open up more opportunities to capitalise on the greater number of deployment scenarios and potential end uses of advanced nuclear technologies, such as the potential for SMRs or AMRs to provide high-temperature heat to help decarbonise industry, while the siting criteria will ensure safety, environmental and operational standards are maintained.

It also enables future iterations of the nuclear NPS to appropriately reflect the move towards a more strategic planning of network assets, as will be set out in the Centralised Strategic Network Plan (CSNP) and the Strategic Spatial Energy Plan (SSEP). Further detail on how this will work will be forthcoming in early 2024.

Collectively, our new strategy will ensure communities beyond those locations listed in EN-6 can benefit from nuclear and will help us hit our ambition of up to 24GW of nuclear power by 2050.

UK CIVIL NUCLEAR SITES (ENGLAND, WALES AND SCOTLAND)

This map represents commercially generating reactors only and there may be more than one reactor at each site.

(No nuclear power stations in Northern Ireland)

Access to NDA land

Government recognises that existing and former nuclear licensed sites remain attractive to many prospective nuclear developers because these sites have characteristics that support nuclear projects due to previous nuclear use and availability of skilled nuclear workforces. The NDA, an arm's-length body of government, owns sites across the UK, which could be available for new nuclear, subject to satisfying the relevant planning, licensing and permitting requirements.

The NDA's mission is to clean up these sites safely, securely and cost effectively, leaving them ready for their next use which could include reuse within the nuclear sector. The government and the NDA recognise that it is not always clear when sites might become available for reuse or how developers might acquire them. The NDA therefore commits to periodically publishing a prospectus stating which of its land holdings will soon become available for reuse.

Where there is commercial interest in available land, the NDA and the government will run fair and transparent processes to lease or option land. To support prospective developers with considering the suitability of NDA land holdings, companies may also request access to available NDA sites for survey purposes. The government recognises the attractiveness of these sites for deploying future nuclear generation assets, as opposed to other commercial uses.

Siting and land usage – our commitments in summary

1. The government will seek to develop a new flexible approach to nuclear siting, subject to consultation on the new National Policy statement.
2. Community engagement will remain integral to the siting process.
3. The NDA will periodically publish a prospectus stating which of its land holdings will soon become available for reuse. Where there is commercial interest in available land, the NDA and the government will run fair and transparent processes to lease or option land, with the assumption being that sites go first to new nuclear projects, where that is feasible and represents value for money.

5. Regulating and streamlining the future of nuclear development

Protecting our nation is our top priority and a continued commitment to nuclear safety, security, environmental protection, non-proliferation and planning remains at the core of our approach to nuclear energy.

However, we do recognise that navigating the permitting, licensing and regulatory landscape for new nuclear power plants can be complex. Operators and developers need to engage with planning processes, specific radiological and nuclear regulatory processes, such as the ONR's nuclear site licensing process (and GDA, if they choose to do so) and environmental regulation by the relevant environment agency that applies to all infrastructure builds.

In recognition of this, government has already taken great strides to streamline and enhance the efficiency of the planning processes. For example, our recently announced planning reforms included £5.6 million for digital transformation of PINS processes, in addition to a 70% increase in the number of inspectors for nationally significant infrastructure projects.

As we look to speed up deployment of new nuclear, we are working with the nuclear sector, PINS and nuclear and environmental regulators to go further and find approaches that maximise efficiency and reduce the burden for developers and operators, without compromising safety, security, safeguards and environmental protection within the UK and internationally, or the ability of the public to engage with decisions about major infrastructure projects.

Planning reforms

In 2023, government launched a package of broader NSIP reforms to ensure the planning system overall can support the UK's future infrastructure needs by making the planning system better, faster, greener, fairer, and more resilient. The package, which was consulted on earlier in 2023, will help streamline the planning process.[23] The reforms include:

- introducing a new fast-track option for certain nationally significant infrastructure projects, where defined quality standards are met.
- moving to a more outcomes-based approach to environmental issues.
- putting more emphasis and committing more resource to the pre-application stage, including the option of a premium service for developers provided by PINS and the statutory advisory bodies such as Natural England.
- making a commitment to update NPSs more regularly.

Additionally, we are improving capacity and capability of statutory nature conservation bodies in the planning system through the introduction of cost-recovery, allowing services resourcing to meet demand. This will be accompanied by performance monitoring arrangements that ensure bodies are held accountable. These bodies are also undertaking workforce planning to better understand how to overcome a challenging recruitment market. All of these reforms are expected to support future nuclear applications.

23 https://www.gov.uk/government/publications/nationally-significant-infrastructure-projects-nsip-reforms-action-plan

The overarching energy NPS (EN-1) (updated version due to be designated in early 2024), will be strengthened by classifying new nationally significant low carbon infrastructure, including nuclear power, as a 'critical national priority' for planning purposes.

Further to this, through the Levelling Up and Regeneration Act 2023, we have introduced Environmental Outcome Reports (EORs) to replace the EU systems of Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA). The new EOR framework will allow the government to introduce an outcomes-based approach to assessment – a streamlined system that is fit for purpose – ensuring the assessment process properly supports decision-makers so that decisions are made on the best possible information.

Nuclear regulation

The UK has a well-respected regulatory system, with established regulators, which reflects international best practice. The independent nuclear regulators, the ONR, the EA (in England), Natural Resources Wales, and the Scottish Environmental Protection Agency, play a major role in ensuring safe, secure operation and decommissioning of the UK's nuclear sites and, where relevant, that new reactors are deployed and operated safely, and the environment is protected. Since the UK's departure from the EU, the ONR has also applied Nuclear Safeguards to sites in the UK.

Nuclear security regulations seek to protect nuclear sites from theft, sabotage, unauthorised access, illegal transfer of nuclear materials, or other malicious acts. The UK has signed up to international conventions including the Amended Convention for the Physical Protection of Nuclear Material (ACPPNM) which underpin our commitment to nuclear security.[24]

The UK's approach to nuclear safety aims to maintain high standards of operational nuclear and radiological safety and environmental protection within a robust regulatory framework. It requires a strong safety culture characterised by learning and continuous improvement. The UK is a signatory of the key international legal instruments relating to nuclear and radiological safety.[25] These conventions provide an effective and credible legal framework agreed by the international community, which the UK values and has played a key part in formulating. The UK recognises the International Atomic Energy Agency's (IAEA) safety standards as the primary standards that its safety framework is measured against and routinely welcomes IAEA peer review missions.

Nuclear safeguards are a series of technical measures applied to sites and materials to prevent the misuse of civil nuclear sites and proliferation of materials for military purposes. The UK has signed up to several key agreements with the IAEA, including the UK's Voluntary Offer

24 https://www.iaea.org/publications/documents/conventions/convention-physical-protection-nuclear-material-and-its-amendment. The UK recognises the IAEA's security standards alongside domestic regulation.

25 Convention on Nuclear Safety (CNS); The Convention on Early Notification of a Nuclear Accident; The Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency; The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (JoC).

Agreement and Additional Protocol which create obligations on the UK to implement nuclear safeguards.[26]

ONR currently regulates nuclear safety, civil nuclear security and safeguards, and conventional health and safety at the 35 licensed nuclear sites in Britain. It also carries out nuclear site licensing in the UK and is currently in the process of assessing an application for a new nuclear site licence for the construction and operation of 2 UK EPR units at SZC. As well as this, the ONR also regulates the surface transport of radioactive material in the UK such as by road and rail and they permission transport packages for sea (surface) and air transport.

The EA makes sure nuclear companies and the sites they operate in England meet high standards of environmental protection throughout design and construction, operation and decommissioning. The EA regulates 27 nuclear sites in England and provides support to Natural Resources Wales for its regulation of 2 nuclear sites in Wales. EA also regulates the use and disposal of radioactive substances at a further 1,200 sites in England. In 2023 the EA issued the environmental permits required for the operation of SZC, which has applied for a nuclear site licence.

ONR and EA also undertake the assessment of new reactor designs proposed for deployment and are currently carrying out a GDA of the Rolls Royce SMR.

Support for innovation

Creating a space in which industry can explore new solutions and ways of working is vital to enabling innovation within the nuclear sector. Using the government's Pioneer Fund, ONR and the EA have developed a ground-breaking project to explore the regulation of artificial intelligence (AI) within the nuclear industry. This project piloted a nuclear regulatory sandbox process, using AI as the test case. Regulatory sandboxing allows industry to explore with regulators how innovation proposals can progress to deployment. It has contributed to developing a regulatory benchmark for AI, a technology that could have significant safety, security and environmental opportunities and challenges in the nuclear sector.

In addition, ONR has launched a range of services through its innovation hub, including expert panels and regulatory advice, to enable to industry to explore options ahead of formal regulatory processes. It continues to develop its own staff to ensure it is ready to regulate innovative solutions as they come forward.

Ready to regulate

In 2021 the government undertook the Post Implementation Review of ONR, 7 years after it had been established following the Energy Act 2013. The Review considered ONR's purpose and functions, governance, accountability, efficacy, and efficiency. It also considered whether and how ONR needed to evolve to support future nuclear development and innovation, including as part of the government's net zero objectives.

26 https://www.iaea.org/publications/documents/infcircs/agreement-between-the-united-kingdom-of-great-britain-and-northern-ireland-and-the-international-atomic-energy-agency-for-the-application-of-safe-guards-in-the-united-kingdom-of-great-britain-and-northern-ireland-in

The review endorsed ONR's effectiveness as a regulator and readiness to regulate new nuclear and made recommendations to support the ongoing improvement of the regulator's approach to innovation, enabling regulation and targeted intervention. ONR has workstreams ongoing to address these recommendations and a report on progress will be published in July 2024. The actions it is taking include:

- Revising guidance to ensure that cost of changes is justified by benefits to safety, security, safeguards.
- Cultural changes to embed constructive challenge at all levels, internally and between ONR and industry.
- Improving consistency and proportionality through strengthened internal oversight and reviews of regulation.

Streamlining regulatory processes

In the financial year 23/24, government provided direct funding to ONR to review its approach to and process for design assessment and nuclear site licensing to identify opportunities for simplification and streamlining, on top of funding in previous years to support a review by ONR and EA of the GDA process.

The GDA process is an internationally recognised feature of the UK's approach to regulating new nuclear power stations. It is an upfront, non-site-specific assessment of a design that allows vendors, developers and investors to gain early insight as to the acceptability of designs prior to making significant financial and resource commitments.

The Rolls Royce SMR is the first design to undergo assessment under the new process and is expected to be completed to the agreed schedule. The flexibility of GDA means that the regulators have started the assessment whilst the design is still being developed to enable future site-specific deployment.

Whilst not mandatory, GDA allows engagement with regulators ahead of site acquisition. It can start with the reactor technology vendors before a site-specific project has commenced and while the design is still being finalised, and its completion can be done in parallel to formal licensing and permitting. The GDA process identifies regulatory issues ahead of construction, which can reduce risk and uncertainty and inform decision making for future licensing, permitting and construction activities.

Through funding from DESNZ, work has already been undertaken to further improve the GDA process, building on learning from experience of applying the process in full to a number of reactor designs. A revised process was launched in 2019, introducing greater flexibility.

ONR and EA have previously undertaken work to benchmark the GDA process against similar 'pre-licensing' processes in other countries, notably the USA and Canada, to ensure consistency with international good practice. Together with the regulators, we are committed to further exploring opportunities to streamline regulatory processes, as set out in the British Energy Security Strategy, and simplifying access to regulatory engagement.

Key to this is maximising the value of overseas regulatory assessments of reactor designs that have been completed and greater collaboration and sharing of expertise across regulatory bodies that are assessing the same technology on a similar timeframe. These activities have the potential to significantly reduce the overall assessment timeframes for vendors.

Overall, the regulators' streamlining work includes:

- Launching a transparent framework for vendors seeking early engagement with regulators prior to entering formal regulatory processes, allowing vendors the opportunity to develop their understanding of regulatory pathways and requirements.
- Building on the flexibility of the modernised GDA process, development and publication of further guidance on the differences in requirements between a two-step and three-step GDA, and the expectations on the reactor technology vendors and future operators on how to move from a two-step GDA to nuclear site licensing, environmental permitting and construction.
- Realising efficiencies through maximising the use made of regulatory assessments undertaken in other countries on designs proposed for Britain and using trusted relationships with mature international regulators to collaborate on and share assessment of reactor designs to minimise burden and timescales where possible.
- Bringing forward proposals to revise the nuclear site licensing process to introduce further efficiencies and ensure alternative development models are catered for, e.g. where a vendor, developer and operator are different entities, enabling more flexible deployment models.
- Bringing forward proposals to further optimise the effectiveness and efficiency of the EA's permitting process.

As a result of these measures, we expect that there is significant potential for streamlining and acceleration. Subject to the maturity of the technology and design, and the level of comparability between the GDA processes and those of any other well-established regulatory bodies who have assessed and licensed the design against international standards, the timescales for completion of a GDA could potentially be reduced by up to 50%.[27]

Working with industry

As part of our work to support industry, we have established the Nuclear Standards Forum (NSF). This is a senior-level DESNZ-chaired group that brings government, regulators and the nuclear sector together to enable common understanding of key strategic issues for UK nuclear standards framework and promote change initiatives. The objective of the group is to explore more efficient, cost-effective ways of meeting regulatory requirements.

The NSF has set out to gather evidence on the extent to which issues such as inconsistencies in approaches to safety may be driving up the costs of running nuclear power plants and explore whether there are opportunities for improvement. Work through this group is intended to support industry in identifying where it could be more efficient in the way in which it operates, e.g. in producing and applying more standard designs and processes, and in how it prepares safety cases for the regulator.

27 Timescale reflects achievement of a Step Three Statement from EA and DAC from ONR.

Reducing bureaucracy and launching a new 'smarter regulation challenge'

Whilst all these initiatives will drive improvements in the planning and regulatory systems, we know there is more to do. We know we have some of the best technical and regulatory expertise in nuclear in the world, so we are launching a new 'smarter regulation challenge' for industry to help us identify further opportunities to reduce bureaucracy and drive efficiencies in the deployment of new projects. Through the Alternative Routes to Market consultation we are seeking feedback to help identify reforms to the planning and regulatory systems, the underlying legislation, and engagement with regulators that will help drive the nuclear renaissance in the UK. Following the evidence received we will assess the need for a further, more targeted and focused consultation later in 2024.

Regulating and streamlining the future of nuclear development – our commitments in summary

1. We are introducing wide-ranging NSIP reforms to ensure the planning system overall can support the UK's future infrastructure needs by making the planning system better, faster, greener, fairer, and more resilient.
2. We are reforming the existing environmental assessment processes of SEA and EIA with EOR. EOR will be an outcomes-based approach to assessment that is streamlined and places the government's environmental commitments at the centre of decision-making.
3. ONR is working to streamline design assessment and licensing processes, to realise efficiencies, and to prepare itself for new market entrants and alternative development models.
4. ONR and EA will launch a framework for early regulatory engagement for vendors seeking to enter the UK market.
5. ONR and EA will publish guidance to GDA requesting parties on how to maximise the use of overseas regulatory assessment and expectations for moving from a two-step GDA to licensing and permitting.
6. ONR and EA will continue to work with mature regulatory bodies to facilitate greater international collaboration, enabling the sharing of regulatory assessments and maximising the value of overseas regulatory work.
7. We are launching a new 'smarter regulation challenge' for industry: through the Alternative Routes to Market Consultation we are calling on industry to identify how we can reduce bureaucracy, to drive efficiencies in the deployment of new projects.

6. Financing and funding models

Financing is one of the major barriers to the development and deployment of new nuclear, due to high upfront costs and long construction periods. Nuclear projects have found it difficult to raise large sums of capital from financial markets when there is uncertainty around future returns. The government's aim is to create approaches to the financing, design, construction, commissioning, and operation of new nuclear projects that can deliver value for money for electricity consumers, whilst achieving a fair and appropriate allocation of risks between investors, consumers and taxpayers.

With this in mind, government has made available funding models to support the financing of nuclear projects. These include the CfD model agreed for HPC and the RAB funding model which is planned to be deployed at SZC. The role of government in the future funding of nuclear projects will be flexible, accounting for the various needs of different projects and technologies, whilst continuing to create opportunities for private investment and achieving best outcomes for consumers.

> **" The government's Alternative Routes to Market consultation, published alongside this Roadmap, seeks further views from stakeholders on the policies required to support financing of nuclear projects.**

In addition to enabling access to clear and robust funding models, we are taking further steps to make UK nuclear projects investable. This includes enhancing our Nuclear Third-Party Liability (NTPL) regime, as well as consulting on including nuclear in the UK's Green Taxonomy.

Nuclear funding models

The government wants to ensure that developers and investors have options when assessing the most appropriate way to fund a nuclear project. This is why government has created both the CfD and RAB funding models as possible approaches to funding future projects. The most appropriate model will vary project by project, dependent on its design maturity, potential replication benefits and siting. Investors and developers will be able to engage with the government of either of these options.

Contracts for Difference (CfD)

The CfD model was developed to provide support for low-carbon energy infrastructure projects that would not otherwise have been financed.[28] A CfD gives investors certainty by providing a fixed price per unit of electricity. This reduces the risk of lower-than-expected returns which, in turn, lowers the cost of financing new power generating capacity.

Under the CfD model, for each MWh of electricity generated, the generator is paid the difference between the strike price and the market reference price for electricity sold into the market for the duration of the contract. In the scenario where the market reference price rises above the strike price, the generator will pay back the difference.

28 https://www.gov.uk/government/collections/contracts-for-difference

HPC was funded through a CfD. Once generating electricity, HPC should receive a guaranteed Strike Price of £92.50/MWh (2012 prices) for 35 years, thus providing long-term reassurance to developers and shareholders.

Regulated Asset Base (RAB) model

The government has continued to explore and develop further opportunities (beyond the CfD model) to support the sector. This is why the Nuclear Energy (Financing) Act 2022 introduced the RAB funding model.[29] The RAB is a well understood approach that has previously mobilised significant quantities of investment into infrastructure projects in other sectors. It gives an eligible company the right to a regulated revenue stream throughout the construction, commissioning and operations phase, unlike the CfD which provides revenue only once the power station is generating electricity.

In the case of nuclear, the RAB revenue stream will be funded by a charge placed on electricity suppliers, with the expectation that this will ultimately come from consumers through their electricity bills.[30] It can, therefore, bring significant amounts of private investment into nuclear projects at relatively low cost. Given that the cost of finance is the main driver of overall project costs, this should lead to better value for money for consumers over the life of a nuclear project. The RAB will be provided alongside a bespoke government support package, to protect against high-impact, low-probability risks that the market is otherwise unable to address.

In November 2022, the DESNZ Secretary of State designated SZC as eligible to benefit from a RAB model, subject to all later relevant approvals. The decision reflected agreement by HMG that the project was both sufficiently mature to warrant designation and was likely to result in value for money.

Assessments against these criteria will be undertaken on any future decisions to designate additional nuclear projects.

29 https://www.legislation.gov.uk/ukpga/2022/15/contents/enacted
30 https://www.gov.uk/government/publications/development-costs-and-the-nuclear-regulated-asset-base-rab-model

REGULATED ASSET BASE (RAB) MODEL

The RAB model is designed to address the issues faced by projects with high upfront costs and long construction timelines.

It does this by sharing risk between investors, consumers and taxpayers.

This risk sharing includes the project receiving payments from the start of construction.

This can reduce financing costs, a key driver of project budget.

Additional measures

Nuclear Third-Party Liability (NTPL)

To further remove potential investment barriers into the UK nuclear sector, and bring benefits to future exports, we will seek to establish international nuclear third-party liability treaty relations with partners across Europe and Asia and America.

NTPL treaties are vitally important for the nuclear sector. They are important for providing that liability for nuclear incidents is exclusively and strictly channelled to the licensed operator, thereby protecting investors and others in the supply chain from compensation claims by third party victims. This gives them increased confidence to invest in nuclear. Under these treaties, claims are heard in the jurisdiction where an incident occurs, thus avoiding forum shopping whilst bringing clarity to victims on where claims should be made.

The UK has a well-established NTPL regime that has supported investment into the sector and safeguarded the interests of victims. The UK is currently party to the Paris Convention on Third Party Liability in the Field of Nuclear Energy (Paris Convention) and the Brussels Convention Supplementary to the Paris Convention on Third Party Liability in the Field of Nuclear Energy (Brussels Supplementary Convention). These are implemented domestically via the Nuclear Installations Act 1965. Collectively, they ensure that liability for nuclear damage is channelled to the operator of the nuclear installation, set the limit of operator liability, and require the operator to have sufficient financial coverage in place to meet claims.

NTPL regimes are critical to safeguarding the interests of potential victims. They ensure minimum levels of compensation are available and, in the case of the Brussels Supplementary Convention and the Convention on Supplementary Compensation for Nuclear Damage (CSC), establish internationally pooled funds that are used to compensate victims, thus further increasing the amount of compensation available.

The UK is looking to further enhance its NTPL regime by seeking accession to the CSC. This is trailblazing, as we would potentially be the first Paris Convention country to join the CSC. We have recently taken a key step towards this, having passed legislation in the Energy Act 2023 to enable accession.[31] There will now be a period where the UK moves towards CSC implementation and accession in which we will work closely with industry and international partners.

Accession to the CSC will increase the number of countries the UK has NTPL treaty relations with, including establishing treaty relations with key international partners. At present there are 11 members of the CSC, and more may join in the future. An anticipated benefit of CSC accession is that by increasing the number of countries the UK has NTPL treaty links with we can further remove some potential barriers to investment into the UK nuclear sector and bring benefits to future exports.

Green Taxonomy

As set out in the 2023 Green Finance Strategy,[32] the UK Green Taxonomy will provide a system for the classification of economic activities as environmentally sustainable. A Green Taxonomy can provide an important tool for enabling the supply of relevant and reliable sustainability information into the market, driving an increase in financing for activities that support the transition to net zero and deliver on UK environmental objectives. It can also support efforts to counter greenwashing and improve market integrity.

During the March 2023 Budget, the Chancellor announced that nuclear power would, subject to consultation, be classed as 'environmentally sustainable' in the Taxonomy, giving it access to the same investment incentives as renewables.

Financing and funding models – our commitments in summary

1. Investors and developers of new nuclear projects will be able to engage with government on the suitability of CfD and RAB financing models.
2. We will seek accession to the CSC to enhance our Nuclear Third-Party Liability regime, supporting investment into the sector.
3. We will consult on the inclusion of nuclear in the Green Taxonomy, helping gain access to new investment incentives.

31 https://www.legislation.gov.uk/ukpga/2023/52/section/305/enacted
32 https://www.gov.uk/government/publications/green-finance-strategy

7. UK nuclear fuel cycle

The fuel cycle underpins both government's net zero and national security objectives. The UK is a world leader in nuclear fuel production, with domestic capability in uranium enrichment and in fuel fabrication in the North-West of England. As the UK embarks on a nuclear renaissance, our ability to deliver this in a way that continues to enable our national security outcomes depends on the UK regenerating its domestic fuel cycle capabilities. This involves:

1. Commercial scale fuel production operations across the front end of the fuel cycle, including conversion, enrichment, deconversion and fuel fabrication, for Low Enriched Uranium (LEU) and new, higher assay fuels (HALEU).

2. Research and innovation in new and advanced, uranium based, nuclear fuels, underpinned by analytical capabilities, to improve fuel safety, efficiency and quality.

3. An experienced workforce, underpinned by experts from across academia, national laboratories, industry, government, and regulators. For more on skills and workforce please refer to Chapter 10.

Fuel supply and national security

A secure and resilient supply of nuclear fuel is essential to our current and future energy security. It has also been identified, by government and the UK nuclear sector, as a major obstacle to the deployment of advanced nuclear technologies.

The UK has many decades of world-leading experience in the production of nuclear fuel, particularly in enrichment at Capenhurst, and conversion and fuel fabrication at Springfields. These sites and their capabilities are critical assets for the UK. We are working with industry, and allied international partners, to build on this and to develop the next generation of nuclear fuel capabilities. These capabilities will support new nuclear deployment in the UK and overseas, maintaining the highest standards of non-proliferation and with consideration of waste and legacy management.

The illegal invasion of Ukraine by Russia reinforced the importance of nuclear to deliver energy security, and the need for secure and resilient fuel supply. Together with allies, the UK must ensure that we are not dependent on Russia for nuclear fuel. Nor must we allow new dependencies to emerge elsewhere which could leave us exposed to political leverage and at risk of supply disruption.

We have publicly committed to reducing global dependence on Russia through the Sapporo agreement, along with the US, France, Japan and Canada.[33] This commitment was reaffirmed in the Atlantic Declaration 2023.[34] In this Roadmap we go further still and commit to removing any Russian fuel and uranium supply to the UK by 2030 and to working with our international partners to end international dependence on Russia and build shared, resilient allied supply chains.

To bring the UK's nuclear ambitions forward, to support global nuclear deployment, and to ensure global diversification from Russia, we recognise that additional supply chain capacity for conversion, enrichment and deconversion is needed. This will both deliver our own energy security and economic resilience, and also support our allies and partners, and other like-minded countries, in strengthening the security of their own supply chains. We recognise the unique importance of the UK's two existing nuclear fuel sites, at Capenhurst and Springfields, in delivering our nuclear ambitions, and that we may need to give particular consideration to the nature of these sites. We also recognise that we may need to consider whether additional nuclear fuel sites are required.

Fuels for the future

In addition to building capacity for LEU supply, which is used by the current reactor fleet, it is vital for the UK to develop fuel production capabilities for the next generation of fuels for our future advanced reactors. This will comprise a variety of different reactor technologies with different fuel requirements, and the UK will require capabilities for both LEU+ and HALEU fuels. The HALEU market is projected to be worth several billion pounds by 2040.

In support of the Atlantic Declaration, we commit to establishing full front-end fuel cycle capabilities (conversion, enrichment, deconversion, fabrication) for enriched uranium up to 19.75% by the end of this decade, and to doing this in partnership with industry.

Through the Nuclear Fuel Fund (NFF) we are already investing in fuel production capabilities for the future.[35] We have committed to:

- Developing additional conversion capacity to meet emerging global demand and reducing dependence on Russia. The government has awarded £13m (matched by industry) towards re-establishing Non-Irradiated Uranium (NIU) and Reprocessed Uranium (RepU) conversion capability at Springfields. This will improve the sustainability of our fuel cycle by developing a pathway to onshore re-use of existing uranium inventories and provide an alternative capability to Russia. Our ambition for Springfields is to see full commercial

33 https://www.gov.uk/government/news/new-nuclear-fuel-agreement-alongside-g7-seeks-to-isolate-putins-russia
34 https://www.gov.uk/government/publications/the-atlantic-declaration/the-atlantic-declaration
35 https://www.gov.uk/government/publications/nuclear-fuel-fund-nff-projects-awarded-funding/nuclear-fuel-fund-successful-projects

conversion services, for RepU and NIU returning to the site by the end of the decade, delivering around an additional 7,500 tonnes of conversion capacity to the global market, in partnership with Westinghouse.
- Supporting the development of a UK supply chain for production of HALEU, including enrichment, deconversion and transport solutions. Together with industry we have already committed over £12m to kickstart the first step in this essential supply chain for advanced reactors.
- The development of accident tolerant fuels, which will deliver cost, efficiency, and safety benefits. DESNZ and industry are investing £9m to enable LEU+ (uranium enriched up to 10% Uranium-235) supply in the UK by 2025.
- Investing £8 million, jointly with industry, to support new fabrication capabilities for advanced Light Water Reactor (LWR) fuels.
- Developing UK capabilities to fuel the next generation of reactors, through HMG and industry joint investment of over £14m in advanced fuel fabrication.

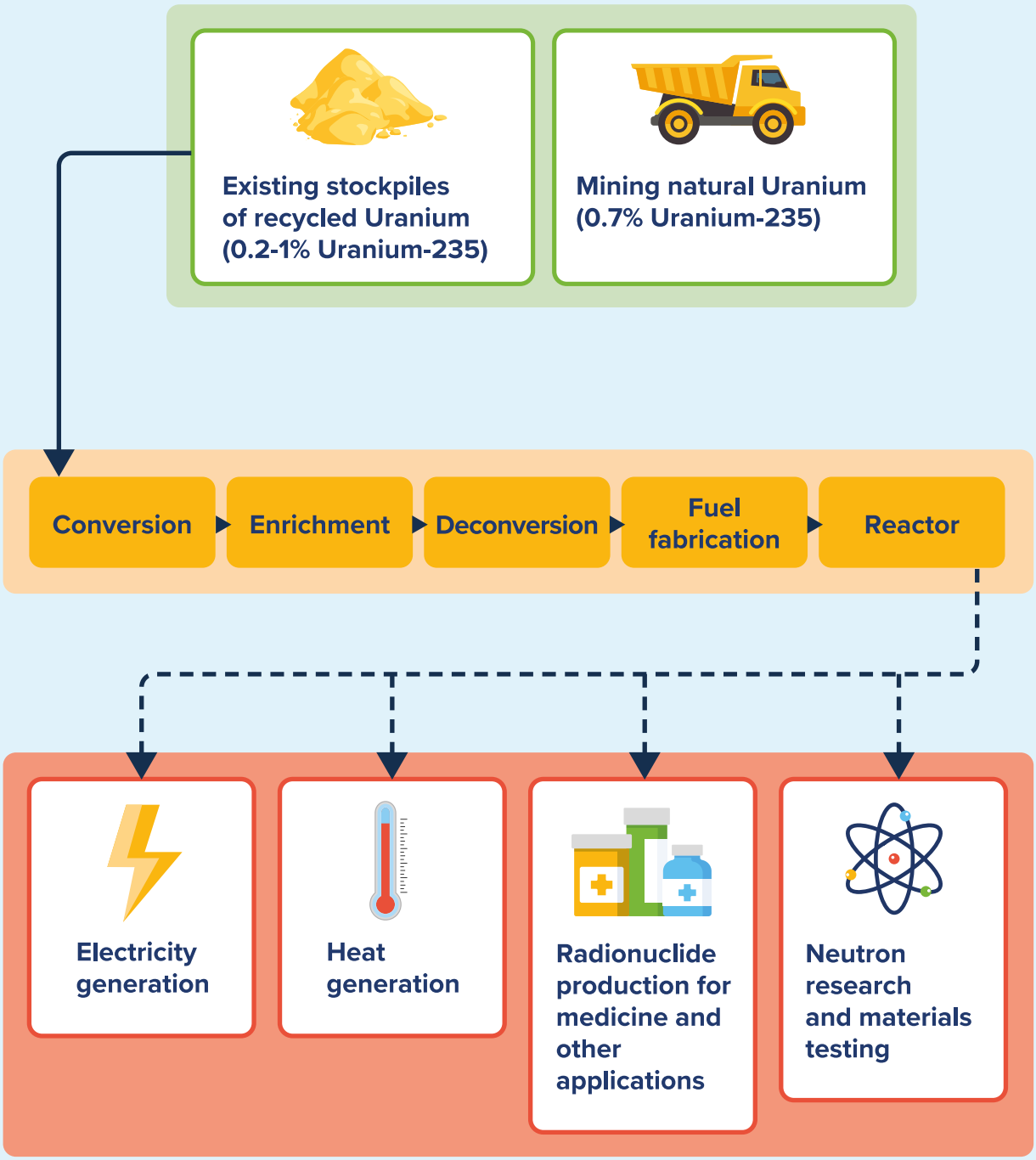
In this Roadmap, DESNZ are pleased to confirm our commitment to:
- Investing up to £300m in a UK HALEU Fuels Programme through the Green Industries Growth Accelerator Fund. We aim to establish HALEU enrichment and routes to deconversion capabilities by the end of the decade. The above is subject to value for money and government approvals, and HMG will be co-funding the programme alongside the private sector.
- The NDA progressing decommissioning on the Springfields site to make space for new capabilities to be developed.

Under the NFF, DESNZ will also be investing:
- up to £6m in a Uranics Innovation Centre at the National Nuclear Laboratory (NNL) in partnership with UK universities, to support the development of front end fuels capabilities and expertise in the UK.
- up to £3.35m in the NNL to undertake a concept design of a HALEU deconversion test facility, in support of building domestic capability to support a UK HALEU programme.
- up to £800,000 in a siting study for the location of potential new nuclear fuel production facilities in the UK.

The UK is also investing in developing the next generation of uranium fuels for AMRs, with a focus on Coated Particle Fuel (CPF) for High Temperature Gas Reactors (HTGR) and research and development for molten salt fuels. The AMR RD&D programme recently awarded £16m to the NNL to develop and scale up a fabrication route for CPFs.

We are also supporting advanced uranium fuel development for micro-reactors, which, in addition to civil terrestrial applications, could be used for defence and extraterrestrial applications in the future.

FRONT END FUEL CAPABILITY



Case Study: HALEU and Urenco

The next generation of nuclear reactors will have different characteristics to those that have come before. AMRs, which are smaller than traditional light water reactors, and capable of operating at higher temperatures, are expected to make a significant contribution to decarbonisation, as governments and companies look to use these reactors to decarbonise broader elements of their energy systems. These new designs will require a higher enrichment level. Currently, Russia is the only country that can supply commercially viable HALEU.

Urenco, a UK headquartered international supplier of enriched nuclear materials, has recently been awarded over £9.5 million in match funding from the government's Nuclear Fuel Fund to help develop LEU+ and HALEU enrichment capability at their Capenhurst site in Cheshire. This will be used to develop capabilities to produce and handle higher enriched uranium products in the UK supply chain. It includes the delivery of optioneering, requirements definition, site layout, initial safety case, early security works and concept design.

The project's aim is to support a High Assay Low Enriched Uranium Facility (HALEUF) to enable future reactor's coming online. The HALEUF-UK facility shall be designed from the outset to accommodate future expansion and will improve the UK's long-term, domestic enrichment capabilities for low-enriched uranium and high-assay low-enriched uranium.

Seizing these opportunities will require overcoming various technical, economic, and planning challenges. These include the availability of design, engineering and project management resources; the availability of core equipment supply chain; establishing contractual commitments for HALEU; and finalising the licencing framework and transportation requirements for these advanced fuels. Targeted cooperation between the government and the civil nuclear sector to address these challenges will ultimately strengthen the UK nuclear supply chain to meet the UK's domestic energy, environmental, and societal ambitions.

Plutonium-based fuels

The safe and secure management of civil separated plutonium is a priority for the government. All civil separated plutonium in the UK has been consolidated at the Sellafield site.

The UK will not support the use of plutonium stored at Sellafield by advanced nuclear technologies, whilst high hazard risk reduction activities are prioritised at site.

UK nuclear fuel cycle – Our commitments in summary

1. We will regenerate and grow the UK's domestic fuel cycle capabilities.
2. We will remove any remaining Russian fuel and uranium supply to the UK by 2030 and work with our international partners to end international dependence on Russia and build shared, resilient allied supply chains free from the risk of political leverage.
3. We will deliver UK HALEU enrichment and deconversion capability by investing up to £300 million alongside industry.
4. The NDA will progress decommissioning on the Springfields site to make space for new capabilities to be developed.
5. We will accelerate the delivery of UK fuel cycle projects investing up to £10 million under the Nuclear Fuel Fund, including in nuclear fuel capability and expertise development, and HALEU deconversion.
6. We are providing clarity to vendors by committing not to support the use of plutonium stored at Sellafield by Advanced Nuclear Technologies whilst high hazard reduction activities are prioritised at Sellafield.

8. Nuclear innovation and R&D

Whilst the nuclear fuel cycle is at the heart of our nuclear infrastructure, the UK also requires a set of critical supporting capabilities, such as capabilities in analytics, materials handling, waste and spent fuel management, and research facilities.

Central to these is the UK's network of national laboratories, including NNL and National Physical Laboratory, as well as the NDA and Nuclear Waste Services (NWS). These institutions and the connected capabilities are essential to the safe and secure operation of the UK nuclear fleet, decommissioning and radioactive waste management, and to sustaining our critical civil and defence nuclear programmes.

Furthermore, these institutions play a key role in preparations for the successful deployment of new nuclear technologies.

UK Research and Innovation (UKRI) plays a key role in supporting research cutting across nuclear power generation, including on advanced nuclear technologies, reactor plant life extension, and efficient and safer fuels. The strategic focus for this research area are the national research priorities identified by a range of partners, including the Nuclear Innovation and Research Advisory Board (NIRAB), DESNZ, the Energy Innovation Board,[36] the NDA, and NNL.

36 https://www.gov.uk/government/groups/energy-innovation-board

Case study: Investing in NNL's nuclear capabilities

NNL is the UK's national laboratory for nuclear fission R&D. Central to its role is maintaining and developing sovereign nuclear skills, capabilities, and R&D infrastructure for the use and benefit of the nuclear sector.

NNL is a custodian of a unique set of facilities and capabilities, including 4 world-leading laboratories in the Northwest of England that enable nuclear research and development. Ensuring NNL's infrastructure is maintained, equipped with the latest technology, and ready for service is vital for the successful delivery of DESNZ's and wider government objectives. DESNZ has supported NNL with funding of £120 million since 2020 to refurbish and modernise existing assets, add new capabilities and capacity, and to ensure that NNL has an effective set of facilities that stand ready to support and enable future nuclear programmes of strategic national importance.

Since 2019, NNL has also received a total of £64.5m to develop its fuel capabilities as part of the Advanced Fuel Cycle Programme and associated extensions. This has been used to build UK expertise and know-how on CPF, Accident Tolerant Fuels, and other advanced fuel manufacture. As a result, NNL has the knowledge and experience to work with the broader supply chain, including the academic sector, to scale-up the CPF process for potential commercialisation. Recently, NNL has been awarded £16m via a match funded grant to develop designs for a pilot scale CPF facility and end to end production capability.

NNL also operates the UK's primary alpha handling facilities and plays a key role in growing these skills and maintaining the UK's world leading expertise in the field. Alpha skills are required to work on programmes related to alpha-emitting materials, which underpin activities across the UK's nuclear sector. From analysis and repacking of spent fuel to the extraction of radioactive isotopes for exciting innovations in the medical and space sectors, these skills are crucial, and expertise can take a decade to build. NNL is a founding member of UK Alpha Resilience and Capability Programme, a collaboration between the UK government and the nuclear sector, which seeks to identify targeted projects and investments in specialist nuclear skills, expertise, and facilities.[37]

As we want to ensure that NNL continues to be able to deliver its mission to accelerate the deployment of fission and support energy security, defence, and health objectives, we are currently undertaking a strategic review of the laboratory, to assess the role and capabilities it should have in the future. This review is due to be completed by the end of financial year 2023/24.

37 https://www.nnl.co.uk/innovation-science-and-technology/showreel/collaborations/alpha-resilience-and-capability/

Investment in nuclear technologies

The 2020 Energy White Paper and the Ten Point Plan established the £385m Advanced Nuclear Fund (ANF) to support the development of SMRs and AMRs, and the Energy Security Strategy further committed to accelerating the development of advanced nuclear technologies.

AMR demonstrator programme

The ANF includes funding for an AMR RD&D programme, which has as its goal to enable an AMR demonstration in the early 2030s (at the latest). The AMR RD&D programme will also increase our understanding of the potential of AMRs and their technology and regulatory challenges and will increase market confidence in AMR technologies as investable propositions.

Phase A competition of the RD&D programme launched in 2022, aiming to identify and understand the feasibility of credible, cost-effective, and innovative HTGR reactor and fuel solutions that could best decarbonise heat and hydrogen. This unlocked private investment as government intervention helped de-risk key R&D and stimulated the supply chain to develop HTGR technology.

Phase B aims to provide funding to 2 vendors, alongside 50% matched funding, to advance designs to at least the level of maturity required to enter the regulatory review process by March 2025. The programme is designed to identify and deliver the optimal technology demonstration, maximising the impact that HTGRs could have on achieving the UK's net-zero target by 2050.

We are developing options for the next phase (Phase C) of HTGR development beyond March 2025 – which would deliver the government's commitment of an AMR demonstrator by the early 2030s.

We aim to commence Phase C from 2025 and are working with the two Phase B vendors to develop their plans for our subsequent assessment and deployment decisions.

Access to international irradiation facilities

The UK has also recently become a member of the Nuclear Energy Alliance (NEA) Second Framework for Irradiation Experiments (FIDES-II), which supports the fuel and material experimental needs of nuclear safety regulators, technical support organisations, research institutions, and industry, and safeguards experimental knowledge for future generations. FIDES-II connects a global network of research facilities to perform high-priority experiments through Joint ExpErimental Programmes (JEEPs).

UK membership to FIDES-II provides access to irradiation facilities for both research and training that would be vastly more expensive to pursue unilaterally. The research outputs will support in-service understanding of current nuclear technology and reduce the time, risk, and cost of successfully developing and deploying new nuclear technology across the nuclear enterprise.

Medical radionuclide supply

Nuclear materials, also known as radionuclides, are used to diagnose and treat patients across the NHS. The UK has limited radionuclide production capability, which leaves us reliant on imports and vulnerable to future shortages. It is critical that the UK continues to maintain access to the nuclear medicines it needs.

Government has identified this capability gap and is currently delivering the up to £6m Medical Radionuclide Innovation Programme (MRIP) to develop the UK radionuclide supply chain.

Government is expected to take a decision on future intervention in supply, such as the need for radionuclide production technologies like a research reactor or accelerator, before March 2025. DESNZ will continue to work closely with the Welsh Government as their proposal for a research reactor in North Wales develops.

Case Study: NNL and nuclear medicine

Targeted Alpha Therapy (TAT) is an emerging cancer treatment that uses radioactive drugs to kill cancer cells. With no current UK production routes, research into TAT in the UK is dependent upon the import and availability of these radionuclides. In addition, the radioactivity of these radionuclides is short-lived, meaning that imported isotopes can often not be used as they will have decayed away by the time they get to the UK and into the hospital.

These radionuclides are produced in specialised nuclear reactors or other irradiation facilities across the world. A number of these facilities are aging and are likely to be closed in the near term. However, in some cases radionuclides can also be recovered from the material left over from reprocessing spent nuclear fuel. In the UK, these materials are owned by the NDA. The NNL has been developing chemical techniques to extract the valuable radionuclides from these materials, enabling the radionuclides to be potentially reused for the treatment of cancers.

Recently, NNL has been successful in securing funding through DESNZ's MRIP towards work on the extraction of Lead-212. This work has developed a process known as Thorium Extraction Technology Ion Separation (THETIS) and has successfully extracted Thorium-228 from legacy material. This isotope of Thorium decays into a radioactive form of Lead called Lead-212, which is under development for use in cancer treatments. Having been successfully demonstrated at laboratory scale, the next step, which the MRIP funding will support, is to demonstrate that the process can be successfully scaled up to provide enough material of suitable purity for in-depth characterisation and pharmaceutical development.

Establishing this new source of radionuclides is the first step in making the promise of TAT a reality for UK patients. It will provide the radioactive starting material necessary for the development and optimisation of these treatments, and for the patient benefits to be determined in clinical trials. Through the Radionuclides for Health UK network, led by Queen Mary University of London and King's College London, NNL has been partnering with academics and clinicians with expertise in radiopharmaceutical development and clinical translation, with the aim of developing a route to the clinic for targeted alpha therapy.

Success in this context will enable a sovereign supply of specific and powerful cancer treating agents, using the UK supply chain, UK intellectual property, UK owned source material, and UK owned facilities. The supply of Lead-212 will help stimulate academic, industrial, and clinical research, and rapidly lead to the ability to treat thousands of patients per annum, with the source material able to sustain such supply for many decades.

Extraterrestrial Nuclear Applications

Nuclear power has the potential to dramatically increase the duration of future space missions and their scientific value. Radioisotope Power Sources (RPSs or 'space batteries') use the heat of radioactive decay to provide a constant supply of energy, independent of sunlight, over decades or more, making them critical for planetary deep space exploration. Radioisotope Heater Units (RHU) use natural decay heat directly to maintain operating temperatures for spacecraft instruments in the extreme cold of space. Radioisotope Thermo-electric Generators (RTG) use the natural decay heat to generate electricity.

Americium-241 (Am-241) is a heat producing radioisotope. Since 2009, NNL have demonstrated a unique capability to harvest Am-241 from the UK's civil separated Plutonium inventory. In November 2022, as an enabler of European Space Agency's (ESA) European Devices Using Radioisotope Energy (ENDURE) programme, NNL was awarded £19.2m by UK Space Agency (UKSA) for a new facility in their existing laboratory at Sellafield (known as PuMA-2), where Am-241 will be extracted to power a full-scale RPS for the European Space Agency's lunar missions in the early 2030s.

" For the first time in history, a RPS travelling to space will be powered by British radioisotope fuel.

In March 2023, UKSA announced £2.9 million of new funding to back research by Rolls Royce into how nuclear power could be used to support a future moon base for astronauts. Relatively small and lightweight compared to other power systems, a nuclear micro-reactor could enable continuous power regardless of location, available sunlight, and other environmental conditions. The project will deliver an initial demonstration of a UK lunar modular nuclear reactor. Rolls Royce plan to have a reactor ready to send to the Moon by 2029. Micro-reactors will require next generation CPF.

Nuclear space power is anticipated to create new skilled jobs across the UK. For example, the PuMA-2 laboratory will act as a national platform for radionuclide extraction, with around 50% of its time devoted to other R&D and skills development, such as alpha handling.

DESNZ will continue to develop and invest in R&D and the development of the strategic capabilities required for a UK nuclear renaissance.

Nuclear infrastructure and R&D – our commitments in summary

1. Government is aiming to deliver a High Temperature Gas Reactor Demonstration by the 2030s.
2. Government is considering investment options ahead of the next Spending Review in recognition of the importance of a domestic research reactor and UK proton source for research and medical radionuclide supply.

9. Decommissioning and taking care of our nuclear legacy – gearing up to dispose of waste from up to 24GW

Building new nuclear power stations with decommissioning and effective waste management solutions from the start will be a critical part of how we will deliver our nuclear ambitions.

As the world's pioneer of civil nuclear power, the UK already has one of the largest nuclear decommissioning and waste management programmes in the world. We have learned from the UK's complex nuclear history and will build on the expertise we have developed to continue to make sure we have effective plans to deal with our current and future legacies of nuclear power.

We will also ensure that the UK's status as a world leader on nuclear decommissioning expertise is used on the global stage to influence practices and policies on the safe and economic decommissioning of nuclear reactors.

Decommissioning by design

Unlike the first generation of UK nuclear power stations, decommissioning has been integrated into the design of more recent stations, such as HPC. Decommissioning by design means ensuring that developers must use the development and construction phases to integrate relevant technical and management approaches to enable the more timely and efficient delivery of decommissioning.

Regulatory assessments of new nuclear builds include explicit consideration of how any proposed design will meet the regulators' expectations for decommissioning and release from regulatory control. This includes:

- Managing spent fuel and radioactive waste
- Managing the decommissioning (dismantling and demolition) of the station once it has ceased generating (as well as the station's associated structures)
- Remediating land in the station's site

This approach also involves setting aside adequate funding during the period the station is generating power to subsequently manage the costs of all these activities.

Geological Disposal Facility (GDF)

While the current inventory of spent nuclear fuel and radioactive waste is either stored on nuclear power station sites or at NDA sites such as Sellafield, our long-term strategy for finally disposing of the most highly active radioactive waste inventory is to develop an engineered GDF. A GDF will isolate and contain radioactive waste within the multiple barriers of the solid waste forms, containers, engineered backfill, and suitable rock, at a depth between 200 and 1000 metres underground to ensure that no harmful quantities of radioactivity reach the surface.

A process is well underway to identify a suitable site in which to develop a GDF that has suitable geology and the support of a local community. The first waste is not expected to be placed into a GDF until the 2050s. Until then, there is sufficient interim storage for our legacy waste, waste from our existing nuclear fleet and waste from currently planned future plants. As interim storage has proved safe and secure for over 50 years, we are confident that radioactive waste and spent fuel from new nuclear projects can be safely stored pending final disposal in a GDF.

While a site has yet to be confirmed, we are confident that once constructed, a GDF will be able to meet the requirements of needing to dispose of spent fuel from up to 24GW of new nuclear projects.

Managing spent fuel

Spent fuel can either be managed through interim storage prior to final disposal or through reprocessing. Interim storage involves safely and securely storing the spent fuel, potentially for several decades, until it is conditioned and permanently disposed of as waste in a GDF or reprocessed. Decisions on the management of spent fuel are a matter for the owner of the spent fuel.

The UK reprocessed spent fuel on an industrial scale from the 1950s to 2022. Commercial industrial scale reprocessing came to an end in the UK with the closure of the Thermal Oxide Reprocessing Plant in 2018. There is currently no industrial scale reprocessing in the UK. The government has not received any credible proposals from industry to restart reprocessing and has no plans to pursue, or provide financial support for, industrial scale reprocessing of spent nuclear fuel.

In the absence of reprocessing proposals from industry, owners of spent fuel, including from new or advanced reactors, should proceed on the basis that spent fuel will not be reprocessed and waste management plans, including financing, should reflect this.

Next steps

Radioactive substances policy

In light of the ambition to deliver up to 24GW of nuclear power by 2050, we are updating our policies on nuclear decommissioning and managing radioactive substances to ensure they are fit for the future.

Following consultation in 2023,[38] we expect to publish in spring 2024 a new UK wide policy that seeks to enable more sustainable and effective management of radioactive substances and nuclear decommissioning. This new policy is designed to encourage operators and regulators to drive innovation and efficiencies in decommissioning and radioactive waste management, whilst maintaining high standards of safety, security, and environmental protection. Key elements of the policy included:

- A proposal to amend our approach to disposal in England and Wales so that less hazardous parts of our radioactive waste inventory can be safely disposed of in a ‘near surface’ disposal facility, potentially saving hundreds of millions of pounds and enabling quicker decommissioning. Any such facility would be subject to further planning approval and securing the necessary environmental permits.
- New and updated policies on managing spent nuclear fuel and nuclear materials to give owners of spent fuel and uranium clarity on how the government expects these materials to be managed.

38 https://www.gov.uk/government/consultations/managing-radioactive-substances-and-nuclear-decommissioning

Funded Decommissioning Programme

The Funded Decommissioning Programme policy is a well-established framework that ensures the costs of nuclear decommissioning and waste management and disposal are met. The framework incorporates lessons from the past and ensures the taxpayer doesn't have to bear these costs in future. Provision must be made for:

- full costs of decommissioning installations
- full costs of managing and disposing of waste and spent fuel safely and securely
- ensuring the risk of recourse to public funds is remote.

These provisions will continue to ensure the cost burden for the decommissioning of any new stations that are built are not left to be placed on future generations.

For new nuclear development business models, whether large-scale reactors, SMRs and AMRs, we will review the framework to ensure it remains suitable, making any necessary revisions or improvements based on recent application of the existing policy.

Waste management

The UK is developing an integrated waste management approach that will ensure that we use the most effective waste management approaches for the different types of waste that we will need to deal with.

Our strategic advisers in the NDA will need to be satisfied that developers and potential operators are clear on the nature of packaging and storage required for future waste and the need for suitable arrangements for this. The waste and spent fuel will need to be assessed by NWS and our regulators to ensure it can be disposed of safely, securely and satisfy environmental standards in our current and planned facilities.

We will consider how to develop clarity on where the responsibility for delivery of different phases of waste management and decommissioning will rest.

Decommissioning and taking care of our nuclear legacy – our commitments in summary

1. The government will build a GDF that will be able to accommodate waste from up to 24GW.
2. The government will aim to publish an updated UK wide policy framework for nuclear decommissioning and managing radioactive substances, including radioactive waste.
3. The government will review policy on funded decommissioning programmes to ensure it remains suitable for new nuclear and protects future generations from bearing the costs of decommissioning.

10. The nuclear workforce of tomorrow

A highly skilled workforce is a key enabler of government's nuclear power ambitions and the UK will need to significantly increase this workforce over the coming years.

The Nuclear Skills Strategy Group (NSSG) estimates that in 2023 we had around 83,000 people working in the civil and defence nuclear sectors. Their latest modelling, from employer data, indicates the number of workers in the sectors will need to increase to between around 150,000 to 180,000 by 2043 in a 24GW scenario, dependent upon the level of defence activity.[39] Civil demand is currently higher than defence, due to HPC construction, but this will change over time when construction-based peaks are replaced by a smaller specialist operational workforce.

A further challenge to the sector is workforce demographics as 10% of the workforce are aged 60 or above and are moving closer to retirement. The percentage of women in nuclear is around 21.4%[40] with industry committing to reach 40% by 2030.

Alongside shortages in highly skilled nuclear specialists, including welders and safety case engineers, there is also a shortage in the pipeline of new entrants for those with the wider skills for nuclear, such as construction and project management.

The civil nuclear sector is a source of highly paid jobs that also have a strong regional dimension. Prospect union estimates that close to two thirds of nuclear jobs are located in the North West or South West of England, where the civil nuclear industry is estimated to contribute £1 in every £50 of economic output. To support existing, as well as upcoming civil nuclear projects, we need a step change to ensure supply meets demand.

Our actions to date

The UK already delivers high-quality apprenticeships, undergraduate degrees and vocational qualifications for the nuclear sector. Our world-class universities provide a pipeline of STEM graduates into the sector and host some of the most advanced facilities for the development of academic and industry-based research scientists. There are also six nuclear specific apprenticeship standards ranging from Levels two to six (including the L6 Nuclear Scientist & Nuclear Engineer degree apprenticeship).

In addition, we offer many employer-supported training initiatives to deliver the skills needed both at present and in the future, delivered in part by the sector's own National College for Nuclear. Recognising that the skills needed to support the sector are vast, the government, including through the Department for Education (DfE), is working in partnership with employers, training providers, and skills agencies to ensure that the supply of skills can meet future requirements.

Nuclear Skills Strategy Group

The government works closely with the NSSG, an employer-led network representing the civil and defence nuclear sectors in the UK. NSSG has provided the industry-wide expertise needed to understand key skills issues and helped set a strategic direction

39 NSSG 2023 Workforce Assessment https://www.nssguk.com/nuclear-workforce-assessment/. These estimates are Full Time Equivalent (FTE) direct and indirect jobs estimates, and the current workforce figure for 2023 includes a modelled component for the civil supply chain.

40 NSSG 2023 Workforce Assessment https://www.nssguk.com/nuclear-workforce-assessment/

for the sector. In 2022, the NSSG announced the establishment of a Nuclear Skills Strategy Board (NSSB), bringing together government as well as nuclear stakeholders and leaders. Recognising the scale of the challenge, the NSSG has worked with industry to identify their most significant skills risks which can be addressed collaboratively.

Nuclear Skills Taskforce

To further respond to the scale of this challenge, DESNZ in collaboration with MoD, launched the Nuclear Skills Taskforce (NSTF) in August 2023. The Taskforce will turbocharge action on nuclear skills and support existing industry-led programmes and marks the start of longer-term strategic collaboration between DESNZ and MoD to develop the future capabilities needed for delivering the ambitious civil nuclear and defence programmes. The NSTF is working with defence and civil nuclear stakeholders including the NSSG, as well as DfE, to develop a range of proposed recommendations to grow the supply and diversity of skilled workers in the nuclear sector, including through scaling up existing activity.

As Chair of the Taskforce, Sir Simon Bollom, has also established the Nuclear Skills Executive Council which brings together CEOs from across the sector, along with critical stakeholders to act as an executive board and decision-making forum for the NSTF.

Next steps

The NSTF is in the final stages of reviewing its proposed recommendations, due to be published in early 2024. This will set out the action that the UK nuclear sector can take to ensure we have sufficient and appropriate nuclear skills to deliver our nuclear ambitions. It will champion the roles of government, industry, and academia as part of collaborative action in response to achieving a shared goal.

These proposals are expected to focus on:

- Attracting mid-career and lateral entrants whose existing skills and expertise can be utilised in the nuclear sector. This will be driven through targeted communications campaigns that increase the profile of nuclear skills opportunities generally and attract new talent.
- Increasing the number of apprentices and ensuring that the nuclear sector can keep up with demand without comprising the quality of training or career opportunities.
- Providing bursary schemes and sponsorships for STEM subjects to increase the number of graduates entering the civil and defence nuclear sectors and offering placements and workplace opportunities.
- Establishing opportunities for movement across the sector.
- Fostering specialised scientific nuclear skills to support the technical delivery of new build programmes, including through increased opportunities for PhD students.
- Offering cross-sector leadership opportunities for high potential talent to encourage collaboration across the sector and build a network of future nuclear sector leaders.
- Retaining employees and ensuring the transfer of skills and technical knowledge including through mentorship of the next generation and offering flexible working patterns.
- Recruiting and promoting nuclear jobs and career opportunities through establishing regional hubs and promoting the social benefits of working in nuclear through investment in skills in the regions.
- Sector-led design and development of optimised core training curriculum and interventions for critical skills to respond to the evolving needs of the sector.

Case study: Energus Nuclear Graduates scheme

Energus, on behalf of the NDA, has created a comprehensive, two-year nuclear graduates programme. Graduates are sponsored by prominent employers across the nuclear sector including government agencies and are offered secondments as well as learning and development opportunities. In addition to being provided with a dedicated sponsor for the duration of the programme, on completion of the programme, graduates are supported in finding a permanent role within their sponsor organisation. 98% of all graduates move on to a full-time career in the nuclear sector; 93% of graduates see an increase in their employability skills; and 86% see the programme establish them on a route to management in their companies.[41] Through the programme, NDA and Energus are creating a pipeline of new generation engineers, scientists and business professionals with an understanding and awareness of the political and commercial aspects of the industry, towards tackling the biggest challenges in nuclear.

Gender Balance in the Nuclear Sector

As we look to build skills and capabilities, we must make sure that the opportunities we are creating are opportunities for all. We are committed to increasing the number of women in the workforce, including through:

- Highlighting the work of Women in Nuclear UK (WiNUK), who have launched the Nuclear Sector Gender Roadmap and the Nuclear Sector Gender Commitment in collaboration with the NSSG.[42] The Roadmap sets out a plan of action across 5 themes: Attraction, Retention, Indicators, Industry Guidance and Enablers. This is accompanied by a Commitment Pledge which sees employers as well as individuals pledging their support to achieving the target of a 40% female workforce by 2030.
- Working with the Nuclear Energy Alliance (NEA), who are playing a leading role on establishing greater parity on gender balance across NEA member countries. Through close collaboration between DESNZ, NNL, WiNUK, and NSSG, the UK chairs and leads the NEA's Gender Balance Task Group. The Task Group works to collect data on the challenges to achieving gender balance in STEM and leadership positions in the nuclear sector, and to develop international policy to help countries enhance the contributions of women. The group promotes targeted communications, engagement, and educational activities to advance the participation and visibility of women in the sector.

41 Energus Nuclear Graduates, https://nucleargraduates.com/
42 https://www.winuk.org.uk/wp-content/uploads/2020/10/nssg-win-sector-gender-roadmap_web.pdf

Case Study: EDF investing in the UK's nuclear future

To enable the construction of HPC, EDF has made a significant investment in education, skills and training. This includes the creation of 3 new Centres of Excellence specialising in welding, electrical skills and mechanical engineering. Over 1,100 apprentices have been trained at HPC so far,[43] exceeding the original target of 1,000. The programme's success is attributed to the project's ongoing outreach and close collaboration with the FE sector. This includes the partnership with Bridgwater and Taunton College, with EDF supporting the college in delivering essential specialist training. SZC is already building on the success shown in the South West and has set its own target of 1,500 apprenticeships.[44] Students from colleges in the East of England have secured apprenticeships at HPC as part of a 'skills conveyor system', with the intention to return and support the delivery of SZC. In addition to bringing new workers into the sector, over the last decade EDF has helped over 500 people move from existing stations and offices across to support HPC.

Green Jobs Plan

The government has also established a Green Jobs Delivery Group (GJDG)[45] co-chaired by Amanda Solloway, Minister of State in DESNZ and Michael Lewis, CEO of Uniper Energy, to drive forward action on jobs, skills and the workforce to support the transition to net zero, energy security and towards the UK's environmental targets, in close collaboration with DfE.

The GJDG is working towards publishing a Green Jobs Plan in the first half of 2024 to highlight specific actions and solutions needed by government and industry to ensure we have the skilled workforce to deliver our net zero, nature and energy security targets. This includes work to attract more new and mid-career entrants, actions to further equality, diversity and inclusion, working through regional workforce planning and to examine how we tailor the skills offer to respond to the need for more modular training and apprenticeships. With nuclear as a key focus area, the group is working closely with the NSTF and the NSSB to explore opportunities for effective collaboration, reflecting that some of the shortages experienced by the nuclear sector are shared with other energy sectors.

43 Hinkley Point C Socio Economic Report: Proving The Wider Benefits Of Nuclear New Build. https://www.edfenergy.com/energy/nuclear-new-build-projects/hinkley-point-c/realising-socio-economic-benefits

44 Sizewell C Employment and Training Prospectus 2023-2024. https://www.sizewellc.com/wp-content/uploads/2023/06/SZC_Employment-Prospectus-2023_V2.pdf

45 Green Jobs Delivery Group https://www.gov.uk/government/groups/green-jobs-delivery-group

The nuclear workforce of tomorrow – our commitments in summary

1. We will continue to work with colleagues across nuclear and other sectors, as well as within defence and education, to develop the nuclear skills pipeline.
2. The government will work in collaboration with key stakeholders to prioritise:
   - **a** Increasing the number of people entering the workforce and developing future leaders.
   - **b** Communication and collaboration to raise the profile of the nuclear sector while promoting nuclear sector jobs and opportunities.
   - **c** The diversity of our workforce, and enhancing the benefits of nuclear sector careers, especially in lower socio-economic level areas.

11. Developing the nuclear supply chain

Due to being one of the first countries in the world to establish a nuclear power programme, the UK has built a strong nuclear industrial base. The UK is a pioneer in nuclear technology, with various domestic companies developing small and advanced modular reactor designs; has extensive nuclear fuel capability; is a leader in waste management and decommissioning; and has a mature supply chain across professional services, technical consultancy and specialist manufacturing.

As a result, our supply chain is renowned across the world and many countries view the UK as a key partner as they develop their own civil nuclear programmes. To meet our future nuclear ambitions, we need to ensure the UK has a resilient supply chain with the required capabilities and capacity to meet the demands of ramping up our nuclear deployment and delivering our existing decommissioning requirements.

Setting out our wider nuclear ambitions in this Roadmap is a crucial step in providing the nuclear industry with the certainty it needs to invest in the supply chain. But we are going further. Recognising that companies in the supply chain do not solely operate in the civil space, we are working towards optimal alignment on supply chain management with the nuclear defence sector and wider infrastructure projects.

We are also aiming to address wider barriers, such as accessibility for Small and medium-sized enterprises (SMEs), the different requirements for standards across nuclear sites and competitiveness of UK companies. Through our policy interventions we are aiming to support the nuclear sector to develop a supply chain that is resilient, accessible to business of all sizes (including SMEs), capable and competitive both domestically and internationally.

Our actions to date

Civil-defence interdependencies

To address the commonalties across the civil and defence supply chains and the potential risk to our respective nuclear programmes due to competing demand for the supply chain, DESNZ is working closely with MoD and the defence nuclear sector.

DESNZ and MoD have established a formal nuclear supply chain working group for government and our delivery partners to tackle shared challenges and identify further opportunities to collaborate. The overarching aim of this group will be to build the resilience of our shared nuclear supply chains by, for example:

- sharing supply chain intelligence
- working with industry to build upon existing initiatives to address supply/demand mismatches
- identifying and managing shared critical and fragile suppliers; and
- aligning internal demand signals.

Inward investment and exports

Working with UK companies and international partners, the Department for Business and Trade (DBT) also supports the building of capacity and capabilities to meet the needs of our domestic nuclear programmes, as well as maximising inward investment and the export potential of the UK's civil nuclear supply chain.

To encourage inward investment into the supply chain, DBT assists foreign companies with establishing a UK presence and manages relationships with key existing investors, facilitating connections and providing guidance to help companies diversify and grow their operations in the UK. This was the case at HPC, where DBT worked closely with regional organisations, such as Nuclear South West, to raise awareness of the project, promote opportunities and connect investors with local businesses.

Additionally, the Office for Investment, a joint No.10 and DBT unit, ensures that the most strategically important investors, including in the nuclear sector, get the targeted practical, policy, legal, and commercial support they need from the government.[46]

Similarly, DBT has supported UK companies to export their products and services across the world and form partnerships with international counterparts by providing tailored support and signposting opportunities. A notable example is DBT's facilitation of the partnership between the civil nuclear sectors in the UK and Japan. There are several UK companies who are active in the clean-up mission of the Fukushima Dai-ichi plant in Japan. Through the challenging and often novel work that has taken place in Japan, the UK supply chain has developed expertise and innovative ways of working which can be utilised to tackle the UK's domestic waste management and decommissioning objectives.

46 https://www.gov.uk/government/organisations/office-for-investment

Case study: LongOps and UK/Japan research collaboration

Long Term Operations Long Reach Manipulators (LongOps) is a joint UK/Japan Nuclear Robotics research collaboration that commenced in 2020 and is worth £12m over 3.5 years. It brings together 3 international nuclear operations use cases: decommissioning in the UK (NDA/Sellafield), fusion remote operations (UKAEA) decommissioning at Culham, and decommissioning of the Fukushima Dai-ichi reactors in Japan (TEPCO), which were damaged during the Fukushima earthquake and tsunami of 11 March 2011.

Each of these nuclear end users has a need to develop solutions to conduct work over many decades inside large, shielded spaces which contain hazardous material using remotely controlled 'long reach' slender robotics. LongOps represents an opportunity for the nuclear end users to explore the potential of this new robotic technology, enabling the completion of their missions quicker on a more cost-effective level.

In recent years, advances in robotics have progressed to the point where remote operations are both increasingly feasible and cost effective. This is dependent on the availability of reliable equipment, suitably qualified and experienced operators, organisational infrastructure and leadership strategy. LongOps will address these needs with the goal of increasing the competence and capacity of nuclear end users to the level required to deliver long term remote operations.

Good progress has been made on LongOps over the last 2 years, with excellent collaboration between the organisations. TEPCO has sent a team of 6 secondees on a rolling basis to work at Culham who have fully integrated into the LongOps team. Discussions are ongoing to agree the next phase of LongOps.

The LongOps robotic arm at Sellafield, Cumbria

Advanced manufacturing

Encouraging innovation across the supply chain, and in particular within manufacturing practices, is a key step to delivering the UK's civil new nuclear programme. As set out in the government's Advanced Manufacturing Plan, published in November 2023, the government's ambition is for the UK to be the best place in the world to start and grow a manufacturing business.[47] Adoption of advanced manufacturing techniques in the civil nuclear sector will help reduce time and cost of projects, free up resources for elsewhere in the sector, and improve the competitiveness of the companies deploying them.

The government will work closely with the nuclear industry to support the development and deployment of advanced manufacturing processes. This includes supporting the University of Sheffield Nuclear Advanced Manufacturing Research Centre (Nuclear AMRC) which is part of the UK's High Value Manufacturing Catapult, a national network of industry-focused research centres supported by Innovate UK.[48]

The Nuclear AMRC operates across nuclear new build, operations, decommissioning and technology development, and brings together supply chain development with manufacturing innovation. The centre helps UK companies compete for opportunities in the UK and compete worldwide by raising quality and productivity, reducing costs, and developing new capabilities and skills.

Additional support is offered through the Nuclear AMRC's Fit For Nuclear (F4N) programme which helps UK manufacturers get ready to bid for work in the civil nuclear supply chain by engaging with potential suppliers and helping them meet the specific requirements of the sector. As of November 2023, the 107 companies that have been granted F4N status have reported to the Nuclear AMRC that the programme has helped them win c.£2.1 billion of new contracts, with over 2,900 jobs created or safeguarded and £42 million of private investment unlocked.

F4N
Fit For Nuclear

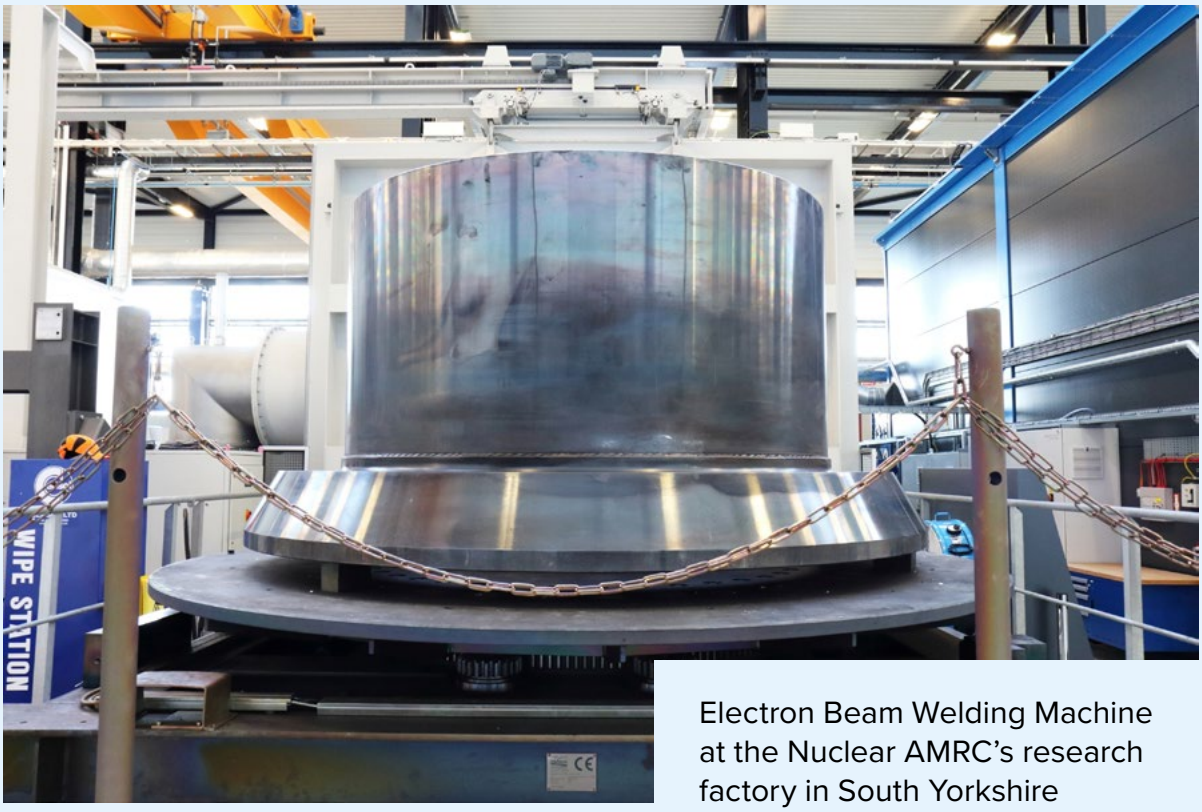
47 https://www.gov.uk/government/publications/advanced-manufacturing-plan
48 https://namrc.co.uk/

Case Study: Nuclear AMRC electron beam welding

The Nuclear AMRC's research factory in South Yorkshire is home to a variety of state-of-the-art manufacturing equipment, including what is believed to be the largest electron beam welding chamber available for collaborative R&D anywhere in the world.

Electron beam welding has the potential to revolutionise the production of reactor pressure vessels, and the Nuclear AMRC is part of an international collaboration to reduce the lead time for SMR pressure vessels from 2 and a half years to less than one year. The centre's researchers have demonstrated that electron beam welding can join thick-walled steel sections of a pressure vessel in a single pass – completing a circumferential weld within an hour, compared with around 60 hours using traditional arc welding methods. As well as radically increasing productivity, electron beam welding can reduce failure rates and in-service inspection requirements – and save more than 1,800kg of CO_2 emissions during the fabrication of each vessel.

Widespread adoption and uptake of electron beam welding would also increase the productivity of nuclear-trained welders, helping mitigate some of the recruitment and skills challenges facing the industry.



Electron Beam Welding Machine at the Nuclear AMRC's research factory in South Yorkshire

Next steps

As the UK's civil nuclear programme develops, new challenges and opportunities for the supply chain will arise, such as modular manufacturing. We will continue to engage with industry to identify and tackle further barriers faced by companies, monitor the effectiveness of existing policies and develop new support measures, where appropriate. Our intention is to help the supply chain develop world-leading expertise across a range of civil nuclear activities from manufacturing to decommissioning.

While DESNZ will retain the responsibility for developing nuclear supply chain policy, we will work closely with GBN as the organisation progresses the SMR programme. As GBN develops its advisory role, we will use the organisation's expertise to identify additional supply chain barriers and gaps in the existing policy to help inform future policy development.

Alongside this, we will continue to work with our arm's-length bodies, MoD and DBT to identify further opportunities for cooperation and, where appropriate, support the implementation of cross-sector ambitions.

Other initiatives we will support includes the NDA's creation of a decommissioning standards database to standardise common engineering designs used by the nuclear industry. This will help reduce procurement costs, facilitate the export of UK products, improve the accessibility of contracts for SME's, and help nuclear projects be completed more quickly and at a lower cost. The initial database is expected to launch in April 2024.

Developing the nuclear supply chain – our commitments in summary

1. We will work jointly with the MoD and key delivery partners to identify and tackle common supply chain challenges to ensure that we have a resilient nuclear supply chain.
2. We will continue to engage with industry to identify barriers to entry and develop the necessary polices to help create more accessible opportunities for the supply chain.
3. We will support the industry develop and deploy innovate ways of working, such as advanced manufacturing practices, to help UK business compete for more opportunities domestically and internationally.

12. Conclusion: Delivering the Roadmap

Working together

The publication of this Roadmap does not mark an end point. We will continue to develop our policies, working closely with our partner organisations and the nuclear sector. Our partner organisations, GBN, NNL and the NDA, are key to delivering our policies. We will also continue to engage with the ONR and the relevant national environmental regulators as the Roadmap commitments, the role of GBN, and our policies evolve.

DESNZ will continue to work jointly with MoD to seek alignment across civil and defence. We will also work with MoD and the NIA[49] to recast a Nuclear Industry Council.[50] A refreshed Council will be tasked with providing strategic direction to the nuclear sector, including overseeing the delivery of a programme of work aligned to key commitments set out in the Roadmap. As part of the work to recast the Council, we will also engage with the Next Generation Nuclear Industry Council.[51]

We will continue to engage with local government and communities already hosting or exploring nuclear opportunities. This engagement will primarily take place through existing regional fora, but we will establish new regional fora where needed. To ensure that insights from these fora are reflected in our policy making and objectives, we will review our regional community engagement strategy and continue to engage with non-governmental organisations through the Nuclear NGO Forum.[52]

Monitoring progress

Building and operating new nuclear power stations is a complex process taking many years. It consists of several different phases including designing, planning, commissioning, construction, operations, and decommissioning. To ensure the objectives of the different phases and the projects are met, the projects will be monitored by the organisations responsible for implementing them, using a range of indicators. Other nuclear projects have encountered similar Monitoring and Evaluation (M&E) challenges, albeit under different government responsibilities, and have produced credible M&E plans accordingly which capture key metrics. One example is HPC, which publishes an annual socio-economic report featuring high-level reporting indicators.[53]

49 Nuclear Industry Association (https://niauk.org). Trade Association for the UK's civil nuclear industry. NIA supports over 280 member companies across the supply chain.

50 Nuclear Industry Council (https://www.gov.uk/government/groups/nuclear-industry-council). Joint Forum between the nuclear industry and government. The Council's primary role is to provide strategic leadership to the nuclear industry. The Council, which has not met since 2019, was responsible for overseeing the delivery of the 2018 Nuclear Sector Deal

51 Next Generation Nuclear Industry Council (https://niauk.org/next-generation-nuclear-industry-council). Group of early- to mid-career professionals which shadows the NIC, and focuses on enabling the future of the UK nuclear industry and its role in decarbonisation and net zero.

52 Nuclear NGO Forum (https://www.gov.uk/government/groups/non-governmental-organisation-forum). Organises stakeholder meetings with NGOs, government, and nuclear regulatory stakeholders to address issues of NGOs regarding new build nuclear and nuclear waste management.

53 EDF Energy (2023) Socio-economic impact report 2023. (https://www.edfenergy.com/energy/nuclear-new-build-projects/hinkley-point-c/realising-socio-economic-benefits)

For government, it is essential to monitor the impact of the enabling policies to determine whether progress is on track to meet the overall ambition. Given the different policies outlined in this document, along with different nuclear technologies, deployment routes and enabling areas, and organisational practices, the indicators and frequency of monitoring required for each area will differ. Some indicators, for example, will require real-time monitoring, whereas others will require less frequent reporting.

Broadly, we will keep a track of electricity generation statistics, economic metrics such as the number of jobs and apprenticeships created, the percentage of UK-supplied construction material used in new nuclear projects, other socio-economic metrics, and environmental aspects such as the amount of carbon saved across a project's lifetime and changes to biodiversity in the areas where they are situated.

These M&E components will work in tandem with one another, building on the learning from previous nuclear projects where appropriate and exploring a range of high-level questions. We will make use of a mix of different methodologies, potentially including baseline studies, process evaluation, outcome monitoring/impact evaluation, and/or value for money assessments. More detail on our approach to evaluation will be developed over the coming months and years.

Roadmap update

We have just launched two major consultations to inform our future nuclear policy. The coming years are also expected to bring further clarity on the costs and effectiveness of new nuclear technology. This may require us to re-evaluate some of our strategies and policies for the long term. To take account of these developments, we therefore intend to publish a Roadmap 'update' by the end of 2025.

After the Roadmap – our commitments in summary

1. We will work jointly with the MoD and the NIA to recast and refresh the NIC, including developing a programme of work aligned to the Roadmap for the Council to deliver.
2. We will review our engagement strategy with local governments and communities that are hosting or exploring nuclear opportunities to ensure that insights from these fora are reflected in the evolution of the Roadmap, our policy making, and objectives.
3. We will monitor the impact of our enabling policies, alongside whether progress is on track to meet the overall ambition.
4. To reflect evolving policy we will publish a Roadmap 'update' by the end of 2025.

GLOSSARY

ACPPNM	Amended Convention for the Physical Protection of Nuclear Material
AFP	Advanced Fuel Programme
AI	Artificial Intelligence
Am-241	Americium-241
AMR	Advanced Modular Reactor
ANF	Advanced Nuclear Fund
BEIS	Department for Business, Energy and Industrial Strategy. In February 2023 it was split to form the Department for Business and Trade (DBT), the Department for Energy Security and Net Zero (DESNZ) and the Department for Science, Innovation and Technology (DSIT).
Capenhurst	Location of the URENCO UK Ltd operated enrichment plants in the UK
CfD	Contracts for Difference
CPF	Coated Particle Fuel
CSC	Convention on Supplementary Compensation for Nuclear Damage
CSNP	Centralised Strategic Network Plan
DBT	Department for Business and Trade
DCO	Development Consent Order
DESNZ	Department for Energy Security and Net Zero.
DevCo	Development Company
DfE	Department for Education
DSUS	Defence Nuclear Enterprise STEM Undergraduate Sponsorship Scheme
EDF	Électricité de France. In this context usually refers to EDF Energy, which is the British subsidiary of French state owned EDF company.
EIA	Environmental Impact Assessment
EOR	Environmental Outcome Report
EPR	European Pressurised Water Reactor
F4N	Fit For Nuclear
FE	Further Education
FID	Final Investment Decision
FNEF	Future Nuclear Enabling Fund
FOAK	First-of-a-kind. The first reactor of a certain design built
GBN	Great British Nuclear
GDA	Generic Design Assessment
GDF	Geological Disposal Facility

GW	Gigawatts
HALEU	High Assay Low Enriched Uranium
HMT	His Majesty's Treasury
HPC	Hinkley Point C
HTGR	High Temperature Gas Reactors
IAEA	International Atomic Energy Agency
IRR	Integrated Review Refresh
LEU	Low Enriched Uranium
LongOps	Long Term Operations Long Reach Manipulators
M&E	Monitoring and Evaluation
MoD	Ministry of Defence
MoU	Memorandum of Understanding
MRIP	Medical Radionuclide Innovation Programme
MWh	Megawatt hour
NDA	Nuclear Decommissioning Authority
NDPB	Non-departmental public body
NFF	Nuclear Fuel Fund
NIRAB	Nuclear Innovation and Research Advisory Board
NIU	Non-Irradiated Uranium
NNL	National Nuclear Laboratory
NPS (nuclear)	National Policy Statement – Document which sets out the planning policy framework for potential new nuclear power stations
NPT	Treaty on the Non-Proliferation of Nuclear Weapons – International treaty ratified in 1968 to prevent the spread of nuclear weapons and nuclear weapons technology
NSF	Nuclear Standards Forum
NSIP	Nationally Significant Infrastructure Project
NSSB	Nuclear Skills Strategy Board
NSSG	Nuclear Skills Strategy Group
NSTF	Nuclear Skills Taskforce
NTPL	Nuclear Third Party Liability
Nuclear AMRC	Nuclear Advanced Manufacturing Research Centre at the University of Sheffield
NWA	Nuclear Workforces Assessment
NWS	Nuclear Waste Services

ONR	Office for Nuclear Regulation
PINS	Planning Inspectorate
RAB	Regulated Asset Base
RD&D	Research, Development and Demonstration
RepU	Reprocessed Uranium
RHU	Radioisotope Heater Units
RPS	Radioisotope Power Sources
RPV	Reactor Pressure Vessel
RTG	Radioisotope Thermo-electric Generators
SEA	Strategic Environmental Assessment
Sellafield	NDA owned nuclear licenced site in Cumbria
SMEs	Small and medium-sized enterprises
SMR	Small Modular Reactor
SoS	Secretary of State
Springfields	Westinghouse Electric owned fuel production plant in Lancashire.
SSEP	Strategic Spatial Energy Plan
STEM	Science, technology, engineering, and mathematics
SZC	Sizewell C
TAT	Targeted Alpha Therapy
THETIS	Thorium Extraction Technology Ion Separation
UKRI	UK Research and Innovation
VfM	Value for Money
WiNUK	Women in Nuclear UK

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