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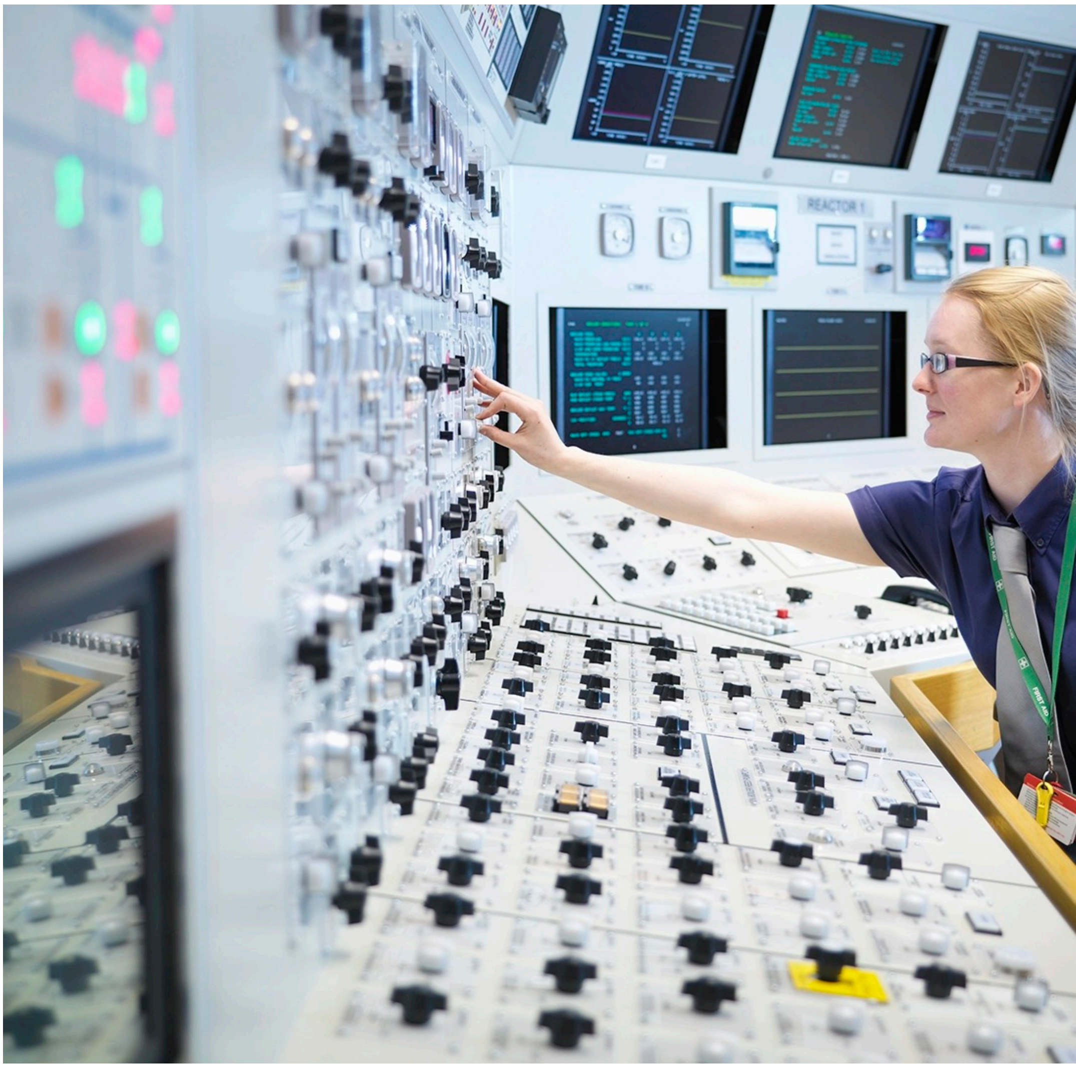

Revitalising Nuclear: The UK Can Power AI and Lead the Clean-Energy Transition

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Executive Summary

Artificial intelligence is ushering in a new era of infrastructure and energy.

As data centres and compute are built at scale, they are driving an unprecedented demand for energy. In turn, the world is witnessing a massive mobilisation of capital towards clean technology. Geothermal, solar, wind and new forms of ocean power are being developed. But one of the most significant implications is that nuclear is back. Countries such as the United States, South Korea, Canada, France and Japan have all committed to new nuclear programmes, while the US is moving at speed to fulfil its ambition to be the pre-eminent AI superpower. If the United Kingdom wants to remain competitive, it needs to build at pace.

On 20 September 2024, Microsoft announced it was paying to reopen the Three Mile Island Unit 1 nuclear reactor.[1] It was a symbolic announcement. The partial meltdown of the reactor's counterpart, Unit 2, in 1979 was the beginning of the decline of nuclear power. After the Chernobyl catastrophe that followed, the world witnessed a slowdown of nuclear. The price of this slowdown is now clear: if the world had not turned away from nuclear after Chernobyl, energy-related CO_2 emissions could have been 6 per cent lower in 2023, the same as taking 450 million passenger vehicles off the road for a year.

Renewed interest in nuclear is being driven by giant AI companies seeking to build vast data centres – using hundreds of megawatts of clean, firm power – in one place. However, in most geographies, connections are constrained and access to reliable power has become one of the primary bottlenecks to future AI growth. To resolve AI's energy problem, large hyperscalers are turning to nuclear energy. As a source of clean power with high energy density that is always available, nuclear power has the qualities that AI companies are looking for.

In addition to Microsoft's announcement, Google has committed to buying seven new small modular reactors (SMRs) from Kairos Power; Amazon[2] has signed three deals to deploy SMRs across the US; and Oracle has committed to building three SMRs to power a gigawatt-scale data centre.[3] These announcements come just weeks after White House officials met with leaders from AI and associated infrastructure companies to "ensure the United States continues to lead the world in AI"[4] and pushed to triple the country's nuclear-power capacity by the middle of the 21st century.[5]

This new dawn for nuclear energy represents a significant opportunity for the UK. The country was the first to split the atom, pioneered the development of civil nuclear technology and hosted the world's first commercial nuclear-power station. In 1965, there were 21 nuclear reactors within the country's borders, compared to 19 in the rest of the world combined.

But this is not a story of decline; the UK has maintained strong expertise that can provide hope for the future. Nuclear is the most cost-effective way for the country to deliver net zero and, with the right action, it can be a leader in the next era of the nuclear industry.

The UK can harness innovative nuclear technologies to power its AI future, help decarbonise its industries and deliver low-cost electricity for its grids. It could become a leader in nuclear technology and expertise, providing good jobs and economic growth across the country, and forming strategic geopolitical relationships with the US and beyond.

For the UK to benefit, it needs a bold new strategy – designed for the future of the nuclear industry – with action across three core areas.

First, the UK should create a modernised, streamlined and efficient planning and regulatory regime for new nuclear technologies. This would reduce delays and enhance the standardisation required to unlock new low-cost projects at scale.

Recommendations to achieve this include:

- Introducing new "AI growth zones" around the country, with simplified planning and environmental permitting applied to new nuclear plants for AI data centres.

- Recognising new design approvals for nuclear technology from trusted international regulators such as the US, Canada, France and South Korea, to enable faster approvals of new designs through the UK regulatory process.
- Requiring the Office of Nuclear Regulation (ONR) to regard approval of a single reactor as the basis for fleet approval as standard, to standardise design across deployment.[6]
- Introducing a two-year limit for the ONR, Environment Agency and Planning Inspectorate to approve nuclear-reactor construction if the proposed reactor is similar to previously licensed designs.

Second, the UK government should use the conclusion of its ongoing SMR competition to help kick-start the SMR pipeline. This would create options for government procurement of SMR capacity for the grid or public compute.

Recommendations to achieve this include:

- Having Great British Nuclear partner with AI hyperscalers to create a single entity that pools data-centre demand for a small fleet of Gen III and Gen IV reactors, and provides financing for their deployment.

Third, the government should deepen the UK-US partnership on SMR and the deployment of advanced modular reactors (AMRs), also known as Gen IV reactors, including cooperation on fuels, financing and supply-chain development.

Recommendations to achieve this include:

- Developing a co-financing partnership with the US to drive an international orderbook of a particular SMR or AMR design or set of designs, expanding the potential pool of offtakers and investors, and aggregating a broader suite of private and public financing tools. Such cooperation can mitigate risk, pool sufficient capital to drive an orderbook and stimulate private investment in supply chains and workforce skills.

- Establishing ways for the UK and US governments to work together to provide industry assurances of a robust transatlantic fuel supply chain, through trade agreements promoting procurement of fuel services.

02

A New Future for Nuclear

The world is yet again turning towards nuclear energy. At COP28 in 2023, 25 countries including the United Kingdom came together and committed to tripling global nuclear capacity by 2050. [7] This commitment has been backed up by pledges from the world's biggest banks and financial institutions to increase their support for nuclear energy.[8]

In both its high- and low-case scenarios, the International Atomic Energy Agency (IAEA) now sees a quarter more nuclear-energy capacity installed by 2050 than it did as recently as 2020;[9] this underscores how a growing number of countries are looking to nuclear to drive economic development, increase energy security and address climate change. In the high-case scenario of the IAEA outlook, nuclear capacity is projected to rise to 890 gigawatts electric (GWe) by 2050, compared with today's 369 GWe.[10]

These numbers could be adjusted even further upwards with increasing demand. Artificial-intelligence companies are pouring investment into new nuclear projects around the world. Recent agreements highlight this trend: Microsoft has partnered with Constellation Energy to restart the Three Mile Island nuclear plant, which would provide power for Microsoft's data centres in the 15 states in the north-east of the United States. Google announced its commitment to offtaking power from seven Kairos Power advanced modular reactors (AMRs),[11] while Oracle recently announced investments in four small modular reactors (SMRs) globally, further underscoring the growing interest in nuclear technology. Further increases in nuclear capacity and investment can be expected as AI companies continue to invest in nuclear projects worldwide, accelerating the development and deployment of new technologies such as SMRs and AMRs.

Over recent weeks, months and year, several countries have announced their intention to expand nuclear programmes, including specific interest in SMR and AMR technologies.[12] The US[13] and Japan[14] have both explicitly stated they are looking to nuclear to power the AI era and deliver clean, low-cost energy systems. China has plans to build 11 nuclear reactors in the next five years and is already operating Gen IV reactors, with plans for more.[15] In

September, Sweden announced a large new funding package for nuclear energy.[16] Poland has been showing increasing commitment to nuclear power, including designating a number of sites for new SMRs. India has a goal of tripling nuclear capacity to 22 gigawatts (GW) by 2032 and further growing capacity to 100 GW by 2047 as a part of its “Developed India” strategy.[17] Vietnam has recently amended its national energy plan to include nuclear energy. New advanced-reactor projects are also taking shape on the African continent in countries such as Ghana[18] and Rwanda.[19]

But for the world to be able to reap the benefits of nuclear power in the future, we must learn from the mistakes of the past. For the potential of nuclear power to be harnessed and costs to be low, countries must treat nuclear power in a way that is commensurate with the technology’s real, rather than perceived, risk and show sufficient commitment to a proper pipeline of projects.

03

A New Generation of Nuclear Power

Despite years of declining commitment to nuclear energy across the world, recent decades have witnessed a resurgence in innovative approaches to nuclear power and significant technological advancements.

New solutions could transform the trajectory of the nuclear industry. These innovative technologies have the potential to be lower cost and faster to construct, with characteristics such as improved safety, increased efficiency and enhanced sustainability compared to traditional large reactors. New models also have additional capabilities beyond those of traditional nuclear-power technologies, such as meeting additional load-following and flexibility needs, as well as providing high-temperature heat that could be used to decarbonise industrial processes or for the production of hydrogen or synthetic fuels.

Close to 80 new nuclear designs are currently in development. Some are smart, evolutionary changes to existing designs (often referred to as Gen III+ reactors), while others (known as Gen IV) are completely different to today's nuclear fleet.

The first main development is the introduction of SMRs. These Gen III+ reactors are smaller (according to IAEA definitions,[20] up to 300 megawatts (MW)) and of modular design, which allows for more factory-based manufacturing and limited assembly on sites. However, they come in a range of sizes, sometimes beyond 300 MW or even smaller (so-called "microreactors"), and levels of modularity, sometimes with limited factory-based manufacturing.

Historically, increasing the size was the most cost-efficient way of boosting energy production. From the 1960s to the 1980s, for example, the size of nuclear reactors increased by about 50 per cent while the energy capacity rose by 300 per cent to 400 per cent (from 200 MW in the 1960s to about 1,400 MW in the 1980s).

Recent advances in technology and reactor design, however, have reversed these economics, making it more efficient to build smaller reactors.

SMRs offer many potential advantages over classic reactors:

- They encourage a “product based” rather than “project based” approach, which can reduce the time and cost for construction and makes nuclear more scalable.
- Their smaller physical footprint open opportunities for deployment in small grids, direct use in industrial processes or powering data centres directly.
- Their smaller size reduces capital investment, which makes them easier to finance.
- Their size also makes it easier to remove decay heat without electrical power, meaning most SMRs have passive safety systems.
- They can be sited in a wider range of locations, creating potential for incremental power additions through adding units to the same site.
- They can operate more effectively alongside renewables, as many designs have the ability to ramp quickly up and down (for instance, through the ability to operate at low power levels).

The second main development is the emergence of Gen IV reactors, or AMRs. Where most traditional reactors are cooled and moderated using ordinary water – either in a pressurised water reactor (PWR) or boiling water reactor (BWR) – Gen IV reactors use different coolant materials to traditional reactors. This is not a new concept: different types of coolants have been used throughout the history of nuclear power. For instance, Britain has a long history of using gas-cooled reactors.

But AMR designs today are using different types of coolants to create reactors that can achieve higher-temperature process heat, increased efficiency and several other features beyond traditional nuclear. For instance, high-temperature gas-cooled reactors are cooled by flowing gas and designed to operate at high temperatures, making the reactor suitable for very efficient electricity generation, high-temperature industrial applications and synthetic-fuel production. Another example of an AMR type is molten-salt reactors, which use molten fluoride or chloride salts as a coolant, meaning they can operate at very high temperatures but run at low pressure, as salt does not expand when heated in the way that water does. This simplifies manufacturing and means the reactor can be far smaller and sited in a wider range of locations.

A number of advanced reactors are also “fast reactors” as opposed to traditional “thermal reactors”. While thermal reactors use a moderator to slow down the neutrons that are emitted when an atom is split, to increase the likelihood that each neutron will cause a fission reaction, so-called fast reactors allow neutrons to stay at the speed at which they emerge from the fission reactions. Fast reactors open opportunities to recycle waste from current nuclear reactors, reducing the amount of waste and enhancing the energy derived from nuclear fuels.

AMRs also use a different type of fuel, called high-assay low-enriched uranium (HALEU) fuel. HALEU contains between 5 per cent and 20 per cent of uranium-235 (U-235), higher than the 3 per cent to 5 per cent concentration in current commercial reactors but below weapons-grade levels. HALEU offers several advantages: it enables smaller reactor designs, longer core lifetimes, improved performance and efficiency, and potentially reduced waste generation.

FIGURE 1

The differences between Gen III+ and Gen IV reactors

	GEN III+	GEN IV		
COOLANT	Light water	Gas	Liquid metal	Molten salt
EXAMPLES	• Pressurised water reactor • Boiling water reactor	• High-temperature gas reactor • Gas fast reactor	• Sodium fast reactor • Lead fast reactor	• Fluoride high-temperature reactor • Molten chloride faster reactor
TYPICAL FUEL	LEU, LEU+	HALEU	HALEU	HALEU
OUTLET TEMPERATURE	~300°C	~750°C	~550°C	~750°C
POWER OUTPUT	Large, small	Small, micro	Small, micro	Small
EXAMPLE REACTOR DESIGNERS	• Westinghouse • Holtec • NuScale • Rolls-Royce	• BWXT • General Atomics • Radiant • X-energy	• ARC • TerraPower • Oklo • Newcleo	• Kairos • Terrestrial

Source: Adapted from US Department for Energy

These innovations in nuclear power represent a significant opportunity in a world increasingly hungry for clean electricity.

04

The Value of Nuclear Energy in the AI Era

This technological innovation in nuclear power represents a huge opportunity. There are broadly speaking three key strategic reasons why governments, businesses and investors are increasingly turning towards nuclear power: it can help accelerate low-cost grid decarbonisation, it can provide the baseload power AI data centres need, and it opens opportunities to provide power to a whole range of new industries and applications.

First, plentiful access to low-cost, decarbonised power will be a cornerstone of both the UK's aims for decarbonisation and growth. While it is unlikely that SMRs and AMRs will be online in time to support the government's mission to achieve clean power by 2030, they can be a cornerstone of the long-term, secure and low-cost decarbonised energy system that can power the future economy.

Nuclear power is a core component of a low-cost energy system. Renewable-generation technologies like solar and wind are intermittent in nature; they only produce power when the weather conditions are right. Nuclear energy, on the other hand, produces baseload power 24 hours a day.

While the development of batteries and other clean dispatchable sources of generation is continuing at pace, and will form the backbone of a decarbonised UK system, baseload nuclear energy will be an incredibly valuable component of the energy system to deliver a low-cost electricity mix. When more power on the grid comes from renewables, the value of firm power increases. Nuclear can help maintain grid stability through synchronous inertia, reactive power and other benefits. Nuclear power also limits grid-development needs, thereby lowering system costs.[21] Indeed, the International Energy Agency has set out that "achieving net zero globally will be harder without nuclear", highlighting that "less nuclear power would make net-zero ambitions harder and more expensive".[22]

Critics often point to levelised cost of energy (LCOE) as a measure where nuclear might seem more expensive. But LCOE alone fails to capture the full value of nuclear's contribution to the energy system over its full lifetime. For example, the US Department of Energy (DOE) has modelled that for California, the generational and transmission-system costs with nuclear are 37 per cent lower compared to a system with renewables and storage only.[23]

SMRs and AMRs can be a valuable part of the UK's baseload strategy. While SMRs and AMRs could have higher costs per MW compared to gigawatt-scale reactors, they could offer important advantages in expanding the range of potential siting locations and use cases. A number of models in development are also designed to operate in load-following mode, making them well-suited to effective integration with renewables. The reactors can also be built quickly and at lower absolute cost, providing shorter delivery timelines and easier financing, thus putting valuable power to the grid at a faster pace.

Second, AI-specific data centres will need larger amounts of power. While nearly all data centres used fewer than 10 MW of power a decade ago, today large data centres can use 100 MW of power or more. The computational power used to train the largest AI models has grown 100-million-fold since 2012.[24] Future chips are likely to be more computationally efficient – the energy efficiency of hardware has to date doubled every three years. However, they will still consume an increasing amount of power, with some projections suggesting global demand for data centres could almost double by 2026[25] or that data centres will use 4.5 per cent of global energy generation by 2030.[26]

AI data centres require significant upfront capital investment, and access to uninterrupted energy is essential for their operation. This means AI data centres, unlike most other forms of demand that can be flexible, will need grid connections with consistent access to power to limit interruptions in real-time operations and allow for continuous learning. While some operators such as Google are experimenting with shifting training across different data centres, the preferred method is continuous operation of data centres using clean baseload power. Google's projections for meeting decarbonisation targets for its global data centres indicate that including baseload power would reduce costs by approximately 40 per cent compared to only wind and solar with battery storage.[27]

SMRs and AMRs could be game-changing in this respect, as they provide consistent, reliable power output without fluctuations. A nuclear reactor directly connected to a data centre could offer continuous, uninterrupted power, ensuring the high availability needed for AI operations without the vulnerability to variable weather conditions. In contrast, solar power – while a renewable option – is intermittent. A solar farm providing 500 MW, for example, would require more than 2,000 acres of land. Moreover, solar's capacity factor in the UK is about 10 per cent to 12 per cent, meaning that on average it would only generate a fraction of its rated capacity throughout the year. To match the continuous output required by a data centre, extensive battery storage would be necessary to compensate for solar's variability. However, current battery technologies are not yet capable of providing long-duration energy storage at the scale required for continuous operations. While lithium-ion batteries can store energy for a few hours, they are insufficient for multi-day storage, particularly during extended periods of low solar output. This means that gas-fired back-up would be required. Using a combination of renewables, batteries and gas to power data centres would require more than 200 square kilometres of contiguous land area per gigawatt of power, and this area would need to be adjacent to a liquefied natural gas import terminal.[28]

This is why operators looking at large-scale data centres (500 MW and above) are generally not considering types of power other than baseload.

In comparison, an SMR producing 500 MW would occupy about 10 acres of land and deliver consistent baseload power 24/7. This makes nuclear a far more efficient and practical solution for AI data centres. The ability of nuclear power to deliver constant energy eliminates the need for massive grid investments, complex storage systems, or shifting workloads between different power sources, making it a superior option for maintaining the continuous operation that AI demands.

An ambitious agenda in this space will also help power the UK's AI aspirations and make the country an attractive place for AI investment. If the UK were to become one of the easiest countries in which to build AI data centres alongside clean power, it could attract investment in both AI and clean energy, as highlighted in the recent TBI paper *Greening AI: How the UK Can Power the Artificial-Intelligence Era*.

Third, the next generation of nuclear power offers opportunities for powering and decarbonising a range of other industries. Many AMRs can be constructed in varying geographies and optimised for different markets and grid conditions. Some Gen IV designs also incorporate storage and more flexible solutions, and can be suitable for the production of hydrogen, direct heat for industrial use and nuclear-waste management solutions, providing new opportunities for deep-decarbonisation challenges. New microreactors can also be valuable for specific applications where reliability and transportability are valued, such as for military bases, industrial operations, disaster relief and diesel-generator replacement. Nuclear propulsion may also be a viable solution in shipping.

Governments that understand the powerful opportunities that lie within the new generation of nuclear technology, and how it intersects with the requirements of the world of tomorrow, could power the future.

05

Britain's Opportunity in the Future Nuclear Economy

In the early years of nuclear power, the UK was a global leader. In 1965, it had 21 nuclear reactors, compared to 19 in the rest of the world combined.[29] This early leadership means that the UK has a strong legacy of nuclear expertise and industry experience. However, the UK's nuclear economy has been steadily dwindling. The most recent nuclear reactor, Sizewell B in Suffolk, was connected to the grid nearly 30 years ago; with a number of the currently operating reactors due to go offline in the next few years, it may be the only operational nuclear reactor in the country by 2028.[30] At present one more reactor, Hinkley Point C, is in development, with a second, Sizewell C, awaiting a formal decision to proceed.

Despite the lack of new nuclear projects coming online, the UK has maintained significant capabilities in the nuclear sector, particularly in specialised components and materials, precision engineering for reactor components, advanced materials development for nuclear applications, robotics and remote-handling technologies for nuclear environments, additive-manufacturing techniques for complex nuclear parts, and specialised welding and joining technologies for nuclear-grade materials. For instance, Sheffield Forgemasters' innovative local electron-beam welding technology has demonstrated the possibility of welding a nuclear-reactor vessel in less than 24 hours instead of the usual 12 months, enabling easier modular approaches and drastically reduced timelines for delivery.[31]

The UK is performing well in nuclear innovation. It ranks second in the top ten countries for nuclear-power patents and third for SMR and AMR patents. The UK accounted for 9.8 per cent of active patent families relating to nuclear power from 2001 to 2018.[32]

The UK's experience of developing and operating several non-traditional reactor designs in the past – such as Magnox gas-cooled graphite-moderated reactors, advanced gas-cooled reactors and prototype fast-breeder reactors – means the country has diverse nuclear-engineering experience. While the gap in new nuclear construction in the UK has led to a loss of some expertise, there could be advantages from some of this experience in AMR design and construction.

The UK also boasts a rich heritage in nuclear-fuel technology, centred around facilities like Springfields in Lancashire, which has been producing nuclear fuel since 1946, and Capenhurst in Cheshire, home to uranium enrichment since the 1950s. These historic capabilities have fostered a deep pool of knowledge and a skilled workforce in nuclear-fuel-cycle operations. Looking forward, this established foundation provides the UK with a significant advantage in developing advanced nuclear fuels for next-generation reactors. This existing infrastructure and expertise can be readily adapted and developed to produce HALEU and other innovative fuel types required for AMRs, making the UK a potential nuclear-fuels powerhouse that can support both domestic nuclear ambitions and the international market.

This expertise and experience represent a significant opportunity for the UK economy.

The nuclear industry is already valuable to the UK economy, generating £6.1 billion in GDP for the UK economy in 2021[33] and employing directly more than 64,000 people. Indeed, relative to other forms of clean energy, investments in nuclear energy may lead to greater employment of both high- and lower-skilled resources for the construction of nuclear reactors, with a multiplier of about four.[34,35] These jobs are well paid, long term and predominantly local to where construction takes place, helping to drive economic activity in a number of regions. Research comparing power-sector pay in the US in 2017 indicates that nuclear workers receive compensation that is one-third higher than that in the wind and solar sectors, and twice the average for power-sector workers.[36] Oxford Economics has found that in 2021 each nuclear worker in the UK contributed an average of £95,300 in gross value added (GVA) to the economy. Adjusting for full- and part-time work in the civil nuclear sector, this reached £102,300 in GVA per full-time equivalent worker. This is nearly twice as high as the median UK figure.[37]

In 2021, 46 per cent of the jobs in the civil nuclear industry were concentrated in areas deemed by the government to be in the highest need of investment.[38] This demonstrates the potential for the nuclear industry to drive economic development across the whole country and in specific areas in greater need of this development. For instance, the US nuclear-engineering group Holtec recently selected a north of England location as the site for its new SMR factory, representing a £1.5 billion investment and hundreds of skilled jobs. It will produce SMR components for use within the country and the wider region.[39] With a more favourable policy environment, the UK can continue to attract these types of opportunities.

Third Way and Energy for Growth Hub estimate that the global market for advanced nuclear technologies could triple by 2050,[40] and other factors, such as estimated projected growth of energy usage from demand centres, could increase the size of this international market even further.

There is already significant global interest in SMR and AMR designs from UK companies. Rolls-Royce SMR was recently named as the preferred supplier for SMRs in the Czech Republic[41] and has signed memorandums of understanding with a range of countries. Domestic deployment will open further doors, as many buyers will often be looking for deployment in home markets. UK firms can export materials and components for deployment overseas by utilising their knowledge of the design and existing relationships with the vendors.

06

Nuclear Energy as a Geopolitical Tool

The opportunity for the nuclear industry in driving growth and delivering good jobs across the country is significant. But there are also wider strategic geopolitical reasons for why the UK should revitalise its nuclear sector.

China and Russia have for years developed strong positions within the nuclear supply chain, and both actively use nuclear-energy exports to build alliances and extend their influence, shaping global energy politics for decades to come.

When Russian and Chinese state-owned nuclear companies export nuclear hardware and equipment, it empowers both Russia and China to establish standards on safety, security and non-proliferation practices. Over time, if the Russians and Chinese were to achieve an increasing share of the global civil nuclear market, it would enable them to more strongly influence international safety and security norms – ultimately to the detriment of the UK, US and other allies who have collectively built and shaped existing civil nuclear regimes and conventions. Also, Russia and China generally include long-term financing and fuel-supply provisions with their nuclear-export deals, thereby opening avenues to cement enduring diplomatic and strategic ties with their client countries.[42]

Russia and China utilise different approaches. Russia has long been a dominant player in the global nuclear-energy market, primarily through its state-owned enterprise, Rosatom. By exporting nuclear technology and constructing reactors in countries across Europe, Africa and Asia, Russia not only boosts its economic ties but also creates long-term dependencies with countries around the world. The operational lifespans of reactors often exceed 60 years, strengthening Moscow's political leverage by ensuring recipient countries remain reliant on Russian expertise, fuel supplies and maintenance services. The scale of Russia's exports in the nuclear sector has been significant – the country was the supplier in around half of all international agreements on nuclear power between 2000 and 2015.[43] One recent example is Hungary's Paks II project, where Russia provides both construction and financing, increasing Hungary's dependence on Russian energy and, by extension, augmenting Moscow's political influence. In late May 2024, The Uzbek and Russian governments signed an agreement for Rosatom to build a nuclear-power plant in Uzbekistan. Additionally, Russia's involvement in nuclear projects in Turkey and Slovakia, both NATO members, indicates a calculated effort to extend its influence even within Western-aligned regions.[44]

China, by contrast, has more recently emerged as a significant competitor in the global nuclear-energy market. Through its Belt and Road Initiative, China offers government-backed financing and technology packages, particularly to developing countries in need of affordable energy solutions. By exporting its nuclear reactors, China positions itself as a provider of clean energy, while simultaneously deepening its strategic relationships and expanding its global economic footprint. For instance, China has begun construction on the Chashma-5 nuclear-power plant in Pakistan, which will use Chinese-designed Hualong One reactors.[45]

As the only two countries that are now commercially operating SMRs and AMRs,[46] there is significant concern that China and Russia will similarly be looking to exploit their technological advantage in the next generation of reactors too.[47] Despite significant progress in SMR and AMR development and commercialisation in North America and Europe, both China and Russia lead in terms of completing construction and operating SMR and AMR plants.[48] Russia is reported to have 17 SMR designs in development[49] and is the only available commercial supplier of HALEU,[50] which is an essential input for many AMR designs. China is reported to have ten SMR designs in development, and the country's share of nuclear patents increased from 1.3 per cent to 13.4 per cent between 2008 and 2023, indicating substantial progress in nuclear-technology innovation.[51]

These developments create an urgent and strategic imperative for other countries to develop their nuclear sectors, diversify their supply chains and compete for influence in a world that is increasingly turning towards nuclear power.

The US is the global leader in SMR-technology development, with 22 designs in development,[52] including many of the global front-runners. Given the potentially strategic role of innovative reactor technologies, other countries such as France, Canada,[53] India,[54] Finland,[55] Sweden[56] and South Korea are also looking to capture segments of the future SMR value chain.

The UK could develop a strategic position within the future global supply chain, working with other countries to create a strong alternative to Chinese and Russian reactors. Furthermore, the ability of the UK to deploy SMR and AMR technologies will critically affect the provision of clean, firm, reliable and resilient power for key and strategic industries (data centres and semiconductor plants, among others). Therefore, the geopolitical ramifications of a robust UK civil nuclear industry extend beyond global influence in nuclear-energy technologies – the strength of the UK nuclear sector will ultimately impact the UK's capacity to shape international norms and standards around the use of other transformative technologies, such as AI.

Hence, mutual geopolitical interests around global leadership in strategic technologies may strongly encourage the UK to seek enhanced cooperation in the deployment of SMR and AMR technologies with like-minded countries, such as the US.

07

A New Policy Agenda for the Future of Nuclear

The revival of the nuclear industry represents significant opportunities for Britain: clean, cheap and secure power, inward investment from AI companies, and the emergence of a thriving British industry with good-quality jobs. But to harness these opportunities, the country will need a new, strengthened approach. If it fails to act now, the opportunities will go elsewhere.

The policy environment that today makes nuclear reactors expensive and slow must be revamped for the future. Nuclear-plant construction cost has increased massively in Britain over the past few decades. Plants built before 1995 in Britain cost an average of £4.79 million per MW to build. That's approximately half of the estimated costs for Hinkley Point C and Sizewell C, which are under construction now.[57] This problem has not been confined to Britain – projects such as Flamanville 3 in France and the Vogtle plant in the US have experienced significant cost overruns and delays, further illustrating the challenges faced worldwide. Any policy agenda needs to grapple with the root causes of these problems – an outdated regulatory system that means every reactor is a "first of its kind" and the lack of a reliable pipeline of domestic projects – to create the conditions for building new nuclear in an era when speed and scale are vital. SMR and AMR development are in early stages, and scaled build-out is required to unleash the benefits and advantages of these reactors.

Moreover, changes in both the nuclear technology itself and in the demands from modern power consumers and a decentralised energy system completely transform the way governments must approach nuclear policy. Up until now, nuclear represented a large, centralised asset in the energy system, commissioned by the government to serve the electricity grid and built in only a handful of places. But emerging SMR and AMR technologies can be deployed across a broader range of potential sites and are therefore capable of forming part of a decentralised system and serving specific industries or consumers directly rather than being commissioned by the government. Furthermore, SMRs and AMRs are designed to be mass deployed through higher degrees of modularity and manufactured content as opposed to bespoke construction for specific projects and locations.

Shifting geopolitical trends and a renewed interest in nuclear power around the world also call for deepened collaboration between the UK and its trusted partners, including the US. Nuclear energy could represent a key component of US-UK collaboration in the 21st century.

Unless government strategy and policy change to reflect the current challenges and the shifting nature of nuclear technology's role in the energy system, the opportunities will be lost.

The UK has made a good start. In 2023, the previous government published a Civil Nuclear Roadmap, setting out its plan for delivering 24 GW of nuclear by 2050. This was a forward-leaning strategy, identifying key barriers and enablers for the UK to lead in nuclear. The UK government also launched the SMR competition in 2023 and a £385 million Advanced Nuclear Fund, including £215 million for SMR development.

This and the ongoing SMR competition have positioned the UK as a country willing to lead in SMR deployment. But further work is needed to transform this commitment into action and grasp the opportunities the technology represents.

To harness the opportunities of new nuclear technologies for powering the AI era through a comprehensive SMR and AMR strategy, the UK government should take action in three areas:

1. **Continue to modernise the nuclear regulatory system** to make it possible to quickly, cheaply and safely build new nuclear reactors at scale by streamlining the regulatory process, creating a route for fleet approvals and establishing new "AI growth zones" with simplified site-level planning processes.
2. **Finalise the government-led procurement of SMRs** through a new pooled-demand vehicle for a small fleet of reactors, inviting AI hyperscalers to contribute.

3. **Deepen UK-US cooperation and coordination on SMR and AMR deployment** through co-financing partnerships to drive an international orderbook of a particular SMR or AMR design (or set of designs) and partnering on the development of a holistic nuclear-fuel supply chain, including HALEU.

A Modernised, Streamlined and Efficient Regulatory Regime for New Nuclear Technologies

In order for SMRs and AMRs to be deployed efficiently, safely and cheaply, it is crucial that the UK creates an environment where companies can reliably and quickly get consent to build reactors with a large degree of standardisation to get the economies of scale and learning-rate benefits of modular design.

To build a new nuclear reactor in the UK, there are three types of approvals that are required:

- **Generic Design Assessment (GDA):** This is a voluntary but heavily advised process nuclear developers can go through in which the Office for Nuclear Regulation (ONR) and the Environment Agency (EA) assess new nuclear designs before site-specific applications are made. The GDA process is usually designed to take four to five years, but a two-year option is also offered.
- **Regulatory consent:** This is the process for confirming that the regulator and the government are content with the safety of a nuclear reactor. This includes two components:
    - **Nuclear-site licence:** Issued by the ONR to the operator of the project. This licence contains site-specific information, defines permitted installations, and attaches standard conditions covering design, construction, operation and decommissioning. The licence puts the holder under strict legal obligations and gives ONR broader regulatory powers to ensure safety throughout the site's life cycle. While the licence is granted for an indefinite period, it does not itself permit nuclear-related construction, which requires separate regulatory

permission from ONR at the planning stage. With the required organisational maturity, a licence assessment could be completed in approximately one year, but could also take longer.
  - **Regulatory justification (about two years):** The reactor design must meet the Justification of Practices Involving Ionising Radiation Regulations 2004 (JoPIIRR), which assesses whether the benefits of the reactor outweigh the potential health risks. This step usually focuses on ensuring that the introduction of the technology serves a public benefit and minimises radiation exposure to the public and workers. This is led by the Department for Environment, Food and Rural Affairs (DEFRA).
- **Environmental permit:** This site-specific permit is granted by the EA or Natural Resources Wales, depending on the location. It assesses the environmental impact of construction and operation, covering issues like emissions, water use and waste management. The permit includes conditions for monitoring environmental impact, and non-compliance can result in severe penalties. This approval is also subject to the public-consultation process and may be affected by the level of public concern over environmental risks. Permits for nuclear projects often require extensive environmental monitoring and ongoing mitigation plans for the lifecycle of the project.
- **Planning consent:** This is typically issued through a Development Consent Order (DCO), granted by the Planning Inspectorate, or a Development of National Significance consent in Wales (below 350 MW). The process requires an Environmental Impact Assessment (EIA) and public consultations to assess the reactor's effect on the local area. For large nuclear-power plants, the stipulations for where planning permissions can be granted are set out in the National Policy Statement (NPS) for energy infrastructure, the current iteration of which is known as EN-6. However, with the growing interest in SMRs, the forthcoming EN-7 is expected to outline more specific planning criteria for SMR and AMR designs. The DCO process can take several years, depending on public opposition, environmental concerns and local-government input.

The UK regulatory system for nuclear power is considered safe, robust and flexible, with the outcome-focused nature of the system in theory leaving it open to innovation and new designs. The regulators are also active in making early engagement easy and creating an iterative process that guides nuclear developers through each stage.

However, there are several inefficiencies in how the system operates that slow down its pace and scale and drive up costs of nuclear buildout, without resulting in additional safety benefits. The result is fewer good outcomes for the public.

There are three broad problems with the way the system currently works, all of which will be particularly problematic in the context of new nuclear.

First, the number of steps and the volume of paperwork to achieve the consents required to get a nuclear project approved in the UK are prohibitive.

The process outlined above is slow and cumbersome for new nuclear projects, with additional steps that assess the same things without adding additional safety benefits. To illustrate, the regulatory justification alone can take two years. The site licence for Sizewell C took four years; the planning process took four to five years for Hinkley Point C and just over two years for Sizewell C. In the case of Sizewell C, this followed a pre-application process that took seven-and-a-half years. These timescales are defined, in part, by the applicant and their readiness to proceed.

The process is made even slower by additional risk of judicial review to the planning decisions, which can add years after approval is granted. The risk of judicial review has also resulted in over-the-top EIAs, with Sizewell C having a 44,000-page EIA that was still challenged in the courts.

The process will be slower and more cumbersome for new entrants, requiring further investigation of the design and the company to achieve approvals. Approval will depend on whether the entrant is only a technology vendor or also a developer and operator.

Second, the UK regulatory system is not built for the standardisation needed to deliver new nuclear at scale and cost.

The current regulatory system in the UK is site-specific rather than being based on specified and set standards, which is common in many countries around the world. This means that the UK regulator does not care how the reactor is made safe as long as it can be proven that it is safe. This differs from countries like South Korea or France where nuclear reactors are approved based upon standards and where the government will commission a number of reactors, all built to the same design to achieve economies of scale with limited changes.

While the outcomes-based approach means the UK system is, in theory, flexible and open to innovative methods, it is not designed in a way that can harness the benefits of economies of scale, and can result in a lack of appropriate consideration of risk and reward. Whether a reactor is made safe is based upon the principle of "as low as reasonably practicable" (ALARP), which means the regulator will ask for designs to be changed to mitigate safety or environmental concerns as far as it is practicable. In practice, ONR publishes its policy on how it judges the adequacy of ALARP demonstrations, and the supporting framework that sits behind the principles.[58] This starts with meeting relevant good practice – such as IAEA, or other international regulatory positions if relevant – and there are a range of numerical targets in place to support consistent regulatory judgements. ALARP demonstrations are sometimes supported by cost-benefit analysis, as was the case with Sizewell B, where safety measures were considered justified as long as their cost was less than ten times their benefit.[59] This is rare and would never form the whole argument justifying an ALARP decision.

The introduction of the GDA has largely enabled fleet build from a regulatory perspective, even if there are limited examples of how this has been applied in practice to date. The more significant problem is the changes required to the design through the planning process.[60]

The consequence is that a number of specific design changes are being requested when reactors go through the planning process. The practical effect of this approach can be seen with Hinkley Point C. Even though

Hinkley Point C is based on a French reactor design, meeting the requirements of UK regulations and planning processes led to a staggering 7,000 design modifications, including expensive modifications to save a relatively small number of fish (less than a small fishing vessel takes in per year).[61], [62] The result is that Hinkley Point C will use 25 per cent more concrete and 35 per cent more steel than it would otherwise.[63] These types of bespoke changes drive up project costs, increase the time and resources required to get approval and build the reactors, and limit the potential safety improvements and cost and time savings associated with learning from similar projects. The outcome is that Hinkley Point C has become one of the world's most expensive reactors.

This impact will be even more significant for SMRs and AMRs where the economics are based upon standardised modular design for several reactors at once, making the case-by-case bespoke modifications needed to get nuclear-site approvals a core issue that stands in the way of harnessing the full potential of low-cost new nuclear in the UK.

Finally, the number of sites where new nuclear-power stations can be built is limited. NPS EN-6 as currently drafted sets out that new nuclear power can only be built on a small handful of existing nuclear sites unless an onerous process of showing the site is suitable is followed, limiting the potential places for new nuclear-power stations to just eight sites around the country. The previous government consulted on a new NPS, EN-7, for nuclear energy that will supersede EN-6 and has broadened to include new nuclear, which will move to a larger set of sites to be applicable. However, some suitable sites are likely to be excluded because of population-density requirements.

Even this expansion in available sites will ultimately not be enough. For most SMR companies, eight to ten units is the minimum number needed to be deployed for the economics to work. For AMR companies the number will vary, but several projects will also be required. Housing several reactors on one site is one option to achieve scale and reduce the number of site regulatory hurdles, but to fully reach scale and impact, more sites must be made available.

Resolving these three barriers will be essential to delivering new nuclear safely at scale, speed and lower cost. The regulatory system needs to be updated to introduce increased standardisation as one of the regulatory outcomes, reducing the lengthy and complex regulatory barriers and creating a more proportionate regime.

A MORE PROPORTIONATE APPROACH TO REGULATORY JUSTIFICATION

The first thing that should happen is that the consenting steps should be simplified and reduced in number.

One step that could easily be streamlined is regulatory justification. This is a requirement in the UK under the JoPIIRR, which was amended in 2018, and requires regulatory justification on “a new class or type of practice”. This piece of legislation was enacted to transpose the EU Council Directive 96/29/Euratom, and involves the secretary of state secretary of state for environment, food and rural affairs granting a justification.

The principal intention of the legislation is to ensure that the benefits of certain types or classes of use of “ionising radiation” outweigh the costs. For example, the use of X-rays in prisons, or DEXA scanners for sports performance assessments. In the case of nuclear-power generation this has come to be interpreted to mean that every new design of nuclear reactor must undergo a new regulatory justification, meaning every single SMR developer needs to make a separate application. The process for getting this approval can take two years, cost developers millions and lead to further uncertainty around the path to deployment.

Regulatory justification is an expensive and time-consuming tick-box exercise, and not really in line with the intention of the original regulation. The output of any regulatory justification decision is just confirmation that the use of ionising radiation in the particular product or process is justified on a cost-benefit analysis. It does not set out any conditions or duties on operators. For nuclear-power stations all such controls are adequately covered in the GDA, DCOs, environmental permits and nuclear-site licences.

It is in fact on the basis of the robustness of those regimes that the secretary of state can feel confident that the cost-benefit analysis justifies the generation of electricity from nuclear power for the purpose of JoPIIRR.

To address this, the government should move to a system where regulatory justification is quickly and simply approved for a suite of reactors under Regulation 12 of JoPIIRR. For Gen III+ SMRs, the most effective option is that the secretary of state for DEFRA should issue a Regulation 12 statement of regulatory justification that the following is an existing practice: "the use of ionising radiation for the generation of electricity from nuclear energy using oxide fuel of low enrichment in fissile content in light water-cooled, water-moderated thermal reactors."[64] This would cover all the designs currently going through the SMR competition, as well as other Gen III SMR designs, removing the need for individual applications. This could in due course be done for Gen IV designs too, applying to reactors with non-light water-based coolants and moderators.

Recommendation: The secretary of state for DEFRA should issue a Regulation 12 statement for regulatory justification for all new nuclear designs. This would remove regulatory replication and save regulators and government both time and capacity, without any reduction in safety, security and safeguarding of the environment.

ENABLING FASTER APPROVALS OF NEW DESIGNS

The number of new nuclear designs around the world is increasing at pace. The current regulatory system for approving these new designs is slow, and there is no explicit way to approve new nuclear designs on a fleet rather than site-by-site basis.

UK regulators should leverage international experience and best practice to minimise design variations and facilitate replicability in construction.

One step that the UK could take would be to move towards a system of recognition of reactor designs that are approved in other trusted jurisdictions. This principle has already been implemented in UK life sciences on the back of the review by Sir Patrick Vallance.[65]

The opportunity to apply similar concepts to the nuclear-energy space has already been proposed by the previous government in the Civil Nuclear Roadmap from January 2024, in which it outlined the intention to be "using trusted relationships with mature international regulators to collaborate on and share assessment of reactor designs to minimise burden and timescales where possible".[66]

There are a number of regulators around the world, such as those in the US, Canada, France and South Korea, that the UK deems trusted. When a new reactor design has been approved by these regulators, there should be a significantly expedited process for approval in the UK based upon the work of these other regulators. Several SMR and AMR designs are currently going through the regulatory process in other trusted jurisdictions; if these could be approved mutually by the UK it would open the opportunity for greater scale internationally and free up UK regulatory capacity to deal with new designs.

Under this model, UK regulators should still review the specific design approvals of other regulators to ensure adequate rigour and to discharge their responsibilities under international conventions as sovereign regulators of nuclear installations. However, the burden should be on the ONR and EA to suggest and justify changes to existing approved design, as is standard through the "backfit" rule in the US.

Recommendation: Recognise safety and design approvals from regulators in the International Nuclear Regulators Association for UK justifications, with burden on the regulator to demonstrate the need for design alterations.

In the US, the Accelerating Deployment of Versatile, Advanced Nuclear for Clean Energy (ADVANCE) Act[67] sets out that the US Nuclear Regulatory Commission (NRC) must establish a new expedited review procedure that allows for licensing within 25 months for applicants that are referencing a certified design or a substantially similar design to one already licensed, or one that is on or next to a currently or previously licensed site.

These principles should also be adopted in the UK. The government should require the ONR and EA to provide site licences and planning approval to nuclear reactors that have been approved in the UK or trusted jurisdictions within a two-year period.

Recommendation: Introduce a two-year limit for the ONR, EA Agency and Planning Inspectorate to approve nuclear-reactor construction if the proposed reactor is similar to previously licensed designs.

MOVING TOWARDS "FLEET APPROVALS"

To further improve the system, once the ONR has approved one design (either through the GDA, as a part of the site-licence process or by mutual recognition), there should be a process through which the technology effectively receives an enabling "licence to operate" on a fleet basis.

This could be achieved if ONR, as part of its investigation of the technology, identifies those design elements that may need to be tweaked for site-specific consideration, with a high bar for what these site-specific elements could be, given sites that are being determined as appropriate for nuclear will be sites often of lower environmental concerns. The burden of proof should also, in line with the "backfit" principle, be on the regulator to demonstrate the design elements that could justifiably be tweaked.

Under this model, the principle would then be that the technology is considered approved from a safety perspective – shifting towards standardisation across a number of potential sites, away from creating bespoke arrangements for different sites.

It will also be essential for the ONR and Nuclear Decommissioning Authority to continue to develop effective procedures for waste management, tailoring the regime to a larger number of (smaller) reactors in a wider range of locations, including new fuel types. This should form part of the upfront assessment of the technology, as part of the first site licence, the GDA or assessment of mutual recognition.

Approvals should then also be granted at faster pace, in line with the US ADVANCE Act, mandating a two-year limit for approvals to be granted for “fleets”.

Recommendation: The government should instruct ONR to consider approval of a single reactor the basis for fleet approval, identifying a limited list of changes in line with what is proportionate for the site.

Moving to a system of increased standardisation would bring many benefits without compromising on the UK nuclear industry’s excellent safety standards. First, it would enable the UK to harness cost reductions from the economies of scale and modularity of SMRs, avoiding cost increases such as those seen with Hinkley. Second, it would improve safety and economic performance of the reactors through operational excellence. If increased standardisation could be achieved globally, this would only help make nuclear safer. The adoption of more standard designs around the world would enable lessons to be learned, embedded and transferred across the global fleet. Finally, this approach would also allow for faster decision-making and increased regulatory capacity as less work would be required on a site-by-site basis, allowing the regulator to focus on assessing entirely new designs.

EXPANDING THE NUMBER OF SITES

One of the key barriers to expanding nuclear power in the UK is the limited number of sites suitable for new nuclear developments. EN-6, while designed with safety in mind, overly restricts the locations where nuclear projects can be developed, particularly with regard to population density. SMRs and AMRs, given their smaller footprint and enhanced safety features, present an opportunity to rethink these regulations. For the UK to realise the full potential of these technologies, it is essential that the geographic limitations imposed by exclusionary zones be reconsidered.

The consultation on the new NPS EN-7 for nuclear power begins to address this issue by opening the door to new potential sites for nuclear developments. However, the government’s previous consultation still maintains restrictive exclusionary zones, which prevent nuclear projects from being located in areas with higher population densities. While these zones were historically important for traditional large-scale reactors, the smaller and more secure nature of SMRs and AMRs makes it possible to safely site them closer to populated areas.

These restrictions, if not adjusted, will limit the expansion of new nuclear sites where they can be most useful, such as for certain data-centre hubs or for industrial sites, as they would not comply with population-density requirements. This includes areas around London, such as Slough, which are currently the main areas where new data centres are being sited. While there are opportunities to find new sites for new data centres around the country further away from population centres, these exclusionary zones will unnecessarily limit potential sites and could hinder, for instance, existing industrial firms (which cannot easily move) from utilising new nuclear to decarbonise their operations.

Recommendation: The government should prioritise finalising the new EN-7, including exclusionary-zone action. This will also require an update to the 2008 Planning Act to expand the scope of Nationally Significant Infrastructure Projects (NSIPs) to include all new nuclear projects.

CREATING A FAST-TRACK ROUTE FOR AI GROWTH ZONES

To help accelerate new nuclear build, a new, alternative route for approval should be designed for new nuclear associated with data-centre investments that enables robust safety assessment but also speed and scale.

This could be achieved through a new act of Parliament, where the secretary of state is given powers to designate new AI growth zones across the country, possibly in addition to a range of types of zones designated in the act itself, such as sites of former or existing nuclear plants, ports and former steel plants. For these zones, the Environmental Permitting and Habitats Regulations process could be done on a larger site level ahead of specific projects, and would therefore not be re-done as part of the planning-consent process, enabling fast-track delivery of projects. This would be similar to the model adopted in Spain, where “renewables zones” have been identified. The sites could be chosen based on being less sensitive in terms of nature and biodiversity, such as old brownfield sites or old nuclear sites such as Harwell and Sellafield.

Within these zones, any design that has been approved for fleet design by the ONR could be deployed quickly, with only minor tweaks in line with a limited number of pre-defined parameters based on the properties of the zone and the technology.

For pre-approved designs, nuclear-site approvals and planning approvals should be presumed. This means that the ONR and Planning Inspectorate must grant consent within three months; if not, consent is assumed. To further de-risk the planning process and ensure projects are not stuck in a lengthy judicial-review process, the act should also set out the parameters for when judicial review is possible, limiting this to a narrow set of possible objections.

Such an act should be delivered by Parliament in the next few months, to unleash the investment in nuclear and the compute the country requires. Future expansion could also be considered for industrial zones, with new nuclear providing high-grade heat or power to heavy industry or new green industries such as hydrogen production.

Recommendation: Introduce new AI growth zones throughout the country, with simplified permitting for new nuclear, in a new act of Parliament.

To further ensure the success of these zones, the government should also consider accelerating and improving the methods for obtaining small grid connections for these projects. With behind-the-metre nuclear powering data centres, the current model of using diesel as a back-up can become a thing of the past, enabling lower-emission compute. However, data centres will require some sort of back-up capacity in case of an outage in the form of a grid connection. This grid connection could potentially be smaller than for traditional data centres, as the power would only be required as a backup, but it would enable the projects to be considered feasible from the perspective of the data-centre developer.

Creating a Framework for Government Procurement of SMRs and AMRs

In the UK, nuclear has traditionally only been state commissioned, but developed and operated by private companies. This is changing, opening opportunities for new models for funding and ownership.

For AI companies, energy cost is a relatively small cost of data-centre development – the focus is increasingly on speed of access and low emissions rather than cost. This opens new opportunities for investment. By developing effective partnerships with AI hyperscalers, governments can harness the power of customers willing to pay a premium for the power from new nuclear plants.

With an enabling regulatory environment, and in particular new AI growth zones, it is possible that AI companies will invest in new nuclear, similar to how Amazon, Google and Microsoft are doing so in the US, through corporate power-purchase agreements or direct investments.

However, the UK government has the chance to use the conclusion of the ongoing SMR competition as a way to help kick-start the SMR pipeline and create options for government procurement of SMR capacity for the grid or public compute.

The previous government launched an SMR competition through Great British Nuclear in July 2023, which was designed to support a number of SMR designs towards development, providing government support along the way. The government's objective has been "to select technologies which offer the greatest confidence in being able to make a final investment decision in 2029 and be operational in the mid-2030s".[68] The competition has gone through several phases. In October 2023, the number of designs was whittled down to six. In early July 2024, five designs – GE-Hitachi, Holtec Britain, NuScale Power, Rolls-Royce SMR and Westinghouse Electric Co – successfully submitted their documents for the next phase of the competition. Most recently, the number of designs has been whittled down to four, with NuScale dropping out.

This competition is now ready to conclude, as indicated by the previous government, with the government selecting winning designs and providing the necessary sites and financial framework to begin the projects. This will require the government to identify a practical approach to financing these projects.

Currently, the Nuclear Energy (Financing) Act 2022 provides a route to fund nuclear-energy projects through a Regulated Asset Base (RAB) model. This is the model used to finance Hinkley Point C. The government has stated that the RAB model could apply to small and advanced modular reactor projects; however, consideration would be given to how advanced technologies could be deployed.

The traditional discussion about financing new nuclear-power stations centres on how best to mitigate the development and construction risks, and whether the developer, the consumer or the taxpayer bears the costs of any such risks. Given that SMRs are a relatively new technology, one core question is how to avoid passing the costs of new nuclear, in particular at a first-of-a-kind stage, to households.

The RAB model puts a large amount of the development risk on consumers as they start paying for the project before it generates electricity, including additional cost overruns. While SMRs could have a valuable role in the UK electricity grid, this will not be their primary use, especially at this early, first-of-a-kind stage. The primary need for SMRs will be for specific applications, such as directly powering data centres or industrial facilities. This means development costs and risks should not be borne primarily by UK bill payers as with gigawatt-scale nuclear, but rather by end users such as data-centre developers. An alternative approach to a standard RAB approach should therefore be considered.

Another core consideration that the government needs to account for when developing a nuclear-financing route is the need for a robust pipeline of projects. To make the economics of new nuclear viable, especially SMRs and AMRs, it will be essential to have a strong pipeline of projects to unlock the economies-of-scale benefits. However, the government's fiscal headroom is currently restricted, and it will be unlikely to finance a whole pipeline of SMRs. This speaks to the need for innovative ways to pool demand from several users to create the pipeline necessary.

A group of companies, including utilities and large offtakers, could enter a cost-sharing agreement to pool demand for several units of one or more reactor designs. This would help drive the necessary fleet certainty and its associated benefits, and would de-risk the initial builds by sharing the costs and potential overruns across the pool as well as the learn-by-doing lessons and workforce from the initial build to future construction, and providing a substantial signal to scale the supply chain.

A potential model for doing this would be to use the principle behind a "Mankala", a model used in the Finnish electricity sector. It involves industrial companies, municipalities and energy firms coming together to create a limited liability company that invests in energy projects. The shareholders do not receive profits but instead have the right to purchase at cost electricity produced by the company's projects, in accordance with their respective share in the company. Shareholders are responsible for the fixed costs of the power company, including servicing of any debt.

Under this model, a hyperscaler would partner with the government, likely through GB Energy, to create a cooperative that would invest in building SMRs. The Mankala company could use debt financing to build the SMR orderbook. Both the hyperscaler and GB Energy would then be able to purchase the energy produced at cost. GB Energy could either sell its share of the energy to the grid or it could sell the energy on to the hyperscaler at a pre-agreed price (via a power-purchase agreement). This means that the development risk would be borne by all the shareholders of the Mankala company. While the hyperscaler would technically own the SMR plant, the day-to-day ownership and operations are managed via GB Energy.

Recommendation: Conclude the SMR competition by creating a pooled-demand vehicle for a small fleet of reactors, inviting AI hyperscalers to contribute.

The SMR competition only included Gen III reactors, which means that this would not include any Gen IV reactor designs. The government should consider whether there are alternatives for expanding this model to Gen IV reactors, without going through a lengthy competition process.

Deepening UK-US Cooperation and Coordination on SMR and AMR Deployment

The increasing demand for nuclear energy on both sides of the Atlantic creates an imperative for enhanced US-UK civil nuclear cooperation.

The growing competition from China and Russia in nuclear energy – including aggressive Chinese and Russian actions to accelerate SMR and AMR deployment and expand civil nuclear ties internationally – is a powerful incentive for the UK and US to cooperate in strengthening their collective standing and influence in the future global nuclear market. Moreover, to the extent that nuclear deployment ultimately affects global leadership in other strategic sectors (such as AI and semiconductors) through provision of firm and reliable energy to those industries, there are additional geopolitical drivers to help catalyse a deeper civil nuclear partnership between the UK and US (and possibly other like-minded states).

The geopolitical implications of an enhanced US-UK civil nuclear partnership on SMRs and AMRs, potentially involving other friends and allies, could drive impetus for broader international cooperation reminiscent of the UK, US and Australian trilateral security partnership AUKUS. An enhanced SMR and AMR international partnership could also derive models and lessons learned from the AUKUS initiative, such as joint pursuit of common and aligned technologies, as well as mutual support in workforce and supply-chain development around those technologies.

Pursuing deployment of a common and aligned set of technologies ultimately advances the prospects and viability of these SMR and AMR designs by increasing the theoretical size of orderbooks (thereby affording more "runway" for achieving economies of learning and cost reductions). Indeed, building upon existing UK-US cooperation on SMRs and AMRs can significantly amplify the UK's own investments into its nuclear sector, particularly investment directed at SMR and AMR development and commercialisation.

There are already strong foundations in place for collaboration between the UK and the US on SMRs and AMRs, with both countries having put government resources towards enhancing nuclear-energy opportunities. But further actions could be taken to strengthen this collaboration.

CONSIDERING UK-US COOPERATION IN SMR AND AMR PROCUREMENT

Through the SMR competition, the UK is considering the procurement of four designs: one based in the UK (Rolls-Royce SMR) and three based in the US. The decision about which designs are chosen will ultimately depend on the progress of the technologies, but there are some wider strategic considerations for the UK.

First, the UK needs to decide whether it wishes to have strategic nuclear-development capabilities. Foreign technology companies will certainly invest in a UK supply chain, but a UK company will also involve domestic capabilities to design nuclear plants and this creates potential to access export opportunities. As deployment in the national market is important to unlock international demand (with Rolls-Royce SMR's recent Czech announcement[69] being an important exception), deployment in the UK will become key for a domestic company to be successful at a global scale.

Second, procuring at least one additional design could expand the diversity of the UK's advanced nuclear market and supply chain – and could encourage deepened collaboration with the US.

Selecting and procuring designs with significant potential for commercial deployment and supply-chain development in the US, whether through the SMR competition or elsewhere, will ultimately enhance the prospects for commercial viability for that particular technology by increasing the theoretical market and diversifying the supply chain.

Ongoing regulatory cooperation between the NRC and ONR further enhances the outlook for commercial deployment of SMRs and AMRs in both the US and UK markets. Selecting and procuring technologies around which both national regulators are engaging in design-specific information sharing and coordination can act as a “force multiplier” for procurement decisions.

Recommendation: In both current and future procurement plans, aim to procure at least one SMR and one AMR design with prospects for deployment and supply-chain development in the US (and potentially other international markets), with longer-term goals of international co-financing and build-out of selected designs across country markets so the technologies can rapidly get to scale.

EXPANDING REGULATORY COOPERATION BETWEEN THE US AND UK

In March 2024, the ONR, NRC and Canadian Nuclear Safety Commission (CNSC) signed a memorandum of cooperation (MOC) “to increase collaboration on the technical reviews of advanced reactor and small modular reactor technologies”.[70] This trilateral MOC builds upon existing bilateral agreements, including the NRC-ONR bilateral memorandum of understanding executed in October 2024.[71]

Although there are limits to achieving full and unconditional regulatory “harmonisation” given the broadly accepted principle that nuclear-licensing evaluations and approvals are ultimately sovereign decisions, design-specific cooperation on new reactor technologies has been constructive in advancing the efficient review of those designs. This has been achieved through collaboration on pre-application activities, development of shared review approaches to resolve common technical questions, avoiding duplicative efforts, collaborative verification activities, joint utilisation of third-party verification, and general information sharing among participating regulators.

Leveraging existing avenues of regulatory cooperation can thus streamline and facilitate the efficient review of SMR and AMR designs that the US and UK are seeking to deploy. Utilising the charter[72] between NRC and CNSC on collaborative information sharing on the GE-Hitachi BWRX-300 as a model or template, the NRC and ONR can also pursue similar agreements to cooperate on reviews of specific designs, such as the Rolls-Royce SMR or other SMR and AMR designs of mutual interest. ONR can also derive lessons learned from and leverage work that NRC has already done on SMRs/AMRs more generally.

Decisions to pursue regulatory cooperation between the US and UK on specific designs can be done in accordance with procurement decisions pursuant to a strategy of alignment around a particular SMR and AMR design or set of designs.

According to the trilateral MOC,[73] the participating regulators' cooperation "may expand to facilitate a joint technical review of an advanced reactor or SMR design for which a governance body and structure will be established prior to the commencement of any joint technical review".

Recommendation: Building upon and leveraging existing regulatory cooperation; pursue enhanced UK-US design-specific collaboration around SMR and AMR technologies of mutual interest. Such partnerships can be expanded through the establishment of a joint technical review body, modifications of existing agreements and/or inclusion of additional international regulators.

FACILITATING CO-FINANCING OF SMR AND AMR DESIGNS OF MUTUAL INTEREST

Based on input from industry and other expert stakeholders, the US DOE released its liftoff report for advanced nuclear,[74] generally prescribing an approach of end-user and demand aggregation, committed investments into building a significant orderbook of a single technology, and the provision of a public and/or private backstop to mitigate cost escalations caused by construction or project risk. This report has been influential in shaping the currently accepted strategy towards derisking innovative nuclear-reactor technologies in the US: creating a critical mass of investment towards a large pipeline of new builds by which a particular design can reach cost maturity, while providing mechanisms to mitigate cost and schedule risks (which would be heightened in the initial projects of a series of new builds). This approach could help cross "the bridge of death" of risk aversion caused by the history of project delays and cost overruns in the US, more firmly committing investors and partners to an orderbook build and driving an SMR or AMR design towards commercial maturity.

Building out an international orderbook and facilitating co-financing arrangements for a series of new-build SMR and AMR projects could present a number of additional advantages by increasing the theoretical pool of offtakers and investors, and expanding access to a broader set of private and public capital and financial tools, further spreading the considerable financial risk and stakes associated with a large pipeline of projects.

An international SMR and AMR orderbook would enable access to a wider suite of private and public capital and financing, including new and proposed initiatives in both the UK and US. The government's National Wealth Fund seeks to attract and mobilise private capital and investment into key industries and infrastructure across the UK. In the US, there have been proposals[75] to establish a Clean Energy Finance Authority that would be empowered with a broad and flexible financial toolkit, including issuance of grants, equity and debt. There could be strong synergies between these capabilities in the US and UK, amplifying the intended effect of driving private and public investment into major infrastructure projects (including an orderbook of SMRs and AMRs).

Likewise, an international orderbook and co-financing approach also opens up the possibility of a significant role for export credit agencies to bring their unique and powerful capabilities to bear in driving serial build of SMR and AMR projects. These benefits include:

- **Greater risk tolerance and mandates to drive national-interest objectives:** Many export credit agencies, including the US Export-Import Bank (EXIM), are capable of providing preferential rates, terms and longer loan tenors, often prioritising national-interest objectives over bankability considerations. For example, EXIM's China and Transformational Exports

Program[76] affords US exporters access to enhanced loan terms when they are in direct competition with entities and enterprises associated with the People's Republic of China.

  - **United financing and national security accounts:** Many export credit agencies possess untied financing accounts and products, enabling them to offer direct financing that is not contingent upon procurement of goods and services from the home country on the basis that the transaction is in the strategic national interests of that country.[77] These accounts enable the agencies to finance projects and take on greater risk when it is in the national interest of the home country, again subsuming bankability concerns. Such accounts could be particularly useful to address financing gaps and needed pre-Final Investment Decision investments (for example, feasibility studies) required to get projects to a debt-financing stage.

- **Significant balance sheets to support large transactions:** Export credit agencies generally possess large balance sheets and significant loan authority, enabling them to engage in large transaction sizes that private capital markets cannot support. EXIM's total loan-exposure cap is $135 billion; as of December 2023, EXIM's total exposure stood at only $33.7 billion.[78]
- **Risk-mitigation tools and capabilities:** Export credit agencies have traditionally offered risk-insurance products, generally covering political risk and a range of commercial risks. Such products and tools could be adapted (or new solutions developed) to address cost and construction risks associated with early builds in an orderbook.
- **Tools to facilitate private investment:** Many export credit agencies offer indirect financing products by which loans or financing are offered to an intermediary (generally a commercial bank or private investor) which in turn offers finance at a lower interest rate. The agency may assume the responsibility for the difference between the lower interest rate and the commercial reference rate.[79] Such tools can help encourage and facilitate private investment and the involvement of private capital markets in a pipeline of SMR or AMR projects.

Export credit agencies have the potential to move the needle forward on SMR and AMR orderbook financing through flexible tools that can advance projects towards a debt-financing stage, providing the bulk of debt financing for orderbooks, and incentivising and encouraging private and other public investment. These co-financing partnerships can be extended to other like-minded states as well where there is an interest or demand for common SMR and AMR design, such as Canada and its export credit agency, Export Development Canada (EDC).

Recommendation: Develop a co-financing partnership with the US to drive an international orderbook of a particular SMR or AMR design or set of designs, expanding the potential pool of offtakers and investors, and aggregating a broader suite of private and public financial products, incentives and tools (including export credit agencies and development finance institutions). Such cooperation can mitigate risk, pool sufficient capital to drive an orderbook and further spread the financial risks of the new-build projects.

REDUCING POLICY BARRIERS TO EXPORT CREDIT AGENCY CO-FINANCING

Various statutory hurdles impede expanded cooperation between EXIM and UK Export Finance (UKEF) to engage in expanded co-financing of SMR and AMR orderbooks. On the US side, EXIM is currently constrained by a 2 per cent default rate cap: essentially, if 2 per cent of EXIM's total outstanding loan portfolio is in default (90 days overdue), then EXIM cannot authorise any further transactions.[80] This is a statutory constraint that no other export credit agency in the world is bound by, and severely restrains EXIM's risk appetite and ability to support larger nuclear-related transactions.

EXIM also has relatively stringent domestic content requirements compared to other export credit agencies, as well as accounting policies on co-financing arrangements that inhibit its ability to partner with UKEF. Currently, if EXIM co-finances a transaction with another export credit agency, the entire transaction amount counts towards EXIM's default rate calculation, not just the portion that EXIM financed.[81]

Bilateral coordination, including better policy alignment among the export credit agencies involved, can address many of these challenges. If statutory changes are required, then on the US side, authorisations and fixes could potentially be addressed legislatively in a new EXIM reauthorisation bill before the current charter expires at the end of 2026. Legislative changes through a new act of Parliament could similarly enhance UKEF's ability to co-finance SMR and AMR orderbooks across international markets with other export credit agencies, if required.

Recommendation: Facilitate coordination between UKEF and EXIM (and potentially other export credit agencies) and address any statutory barriers and hurdles to co-financing arrangements through acts of Parliament.

DEEPENING COLLABORATION ON A SECURE GLOBAL NUCLEAR-FUEL SUPPLY CHAIN

HALEU is a critical component in the future of nuclear energy, particularly for Gen IV nuclear designs. This nuclear fuel, enriched to between 5 per cent and 20 per cent U-235, offers several key advantages over traditional low-enriched uranium used in most current reactors.[82] HALEU enables smaller reactor designs, longer operating cycles and increased efficiencies, making it essential for the next generation of nuclear technologies.

Currently, the only country that produces HALEU fuels commercially is Russia. This dangerous dominance necessitates the creation of alternative supply chains for uranium enrichment.

The need for creating a secure pipeline of HALEU production is increasing with rising demand for advanced nuclear solutions. Two of the nuclear companies that received investment from hyperscalers last month (X-energy and Kairos) use HALEU as the fuel material.

Increasing Western recognition of the danger of relying on Russia or other unreliable nuclear-fuel suppliers is driving significant efforts to establish a secure, resilient and diversified global nuclear-energy supply chain.[83] The US and UK, along with Canada, France and Japan, formed the "Sapporo 5" initiative, which aims to strengthen international cooperation on nuclear-fuel supply and reduce dependency on external sources. This partnership is crucial for ensuring reliable access to the materials needed for both SMRs and AMRs. Originally, this initiative included a pledge to invest a total of $4.2 billion into fuel-supply infrastructure. In September 2024, the Sapporo 5 countries announced they had collectively surpassed that goal, already investing more than $5 billion into different parts of the fuel supply chain.[84]

As a part of this commitment, the previous UK government announced a $245 million award to Urenco to build a uranium-enrichment facility capable of producing up to 10 tonnes of HALEU annually, starting in 2031.[85] The previous government also awarded Westinghouse, in collaboration with Urenco, a grant to study the production of advanced TRISO fuels (needed for several leading AMR developers) at its Springfields facility in Lancashire.[86]

Meanwhile, the US has taken significant steps to bolster its own nuclear-fuel capabilities. Congress has approved more than $3 billion in funding for the DOE to award contracts to enrichment and deconversion companies, aimed at scaling up domestic production of HALEU and low-enriched uranium while reducing reliance on foreign suppliers. This includes investments in both enrichment facilities and the broader infrastructure needed to support the entire fuel cycle, from mining and conversion to fuel fabrication. Most critically, the DOE announced it awarded contracts to four companies – Louisiana Energy Services, Orano Federal Services, General Matter and American Centrifuge Operating – to enrich HALEU under the department's HALEU Availability Program.[87] DOE also awarded contracts to six companies to provide deconversion services.

The US and UK can position themselves as leaders in the development of a globally secure nuclear-fuel supply chain as they and their allies invest in infrastructure to support fuel supply.

The level of investment announced by the Sapporo 5 group is a notable and much-needed commitment to strengthening Western fuel supply. However, there remain opportunities for the US and UK to build on those commitments and operationalise a more integrated enrichment capacity.

To ensure swift deployment of a robust nuclear-fuel supply chain, national efforts must be conducted in coordination, not just in parallel. Building on the foundations within the Sapporo 5 initiative, the US and UK governments can send a strong assurance signal to industry by negotiating nuclear-fuel-supply-specific agreements that ease the procurement of transatlantic fuel services between the two countries, as well as their other allies with significant fuel supply resources.

Recommendation: The UK and US governments should negotiate a trade agreement specific to nuclear-fuel supply to ease the process of procuring fuel services, including enrichment, conversion and fabrication. Doing so would foster development of a shared fuel-supply-chain strategy, signal intent to continue committing to nuclear-fuel development and create easier paths for industry partners to procure and provide fuel services across the Atlantic.

08

Conclusion

Leading in the AI revolution and harnessing the benefits of modern industry will all depend on access to clean, cheap and plentiful low-carbon energy. As a source of low-cost, “baseload” energy, nuclear energy is emerging as one of the most strategic energy technologies of today. National governments and large-scale private companies alike are investing heavily in nuclear energy. To harness these opportunities the UK needs to act quickly and decisively. Nuclear-energy technology could present significant strategic value for the country. It is an opportunity for inward investment, good jobs across the country, enhanced geopolitical influence and – of course – powering the AI revolution. With a bold plan of action, tailored to the needs of the current wave of nuclear innovation, the UK can power the future.

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