# ENERGY AND ENVIRONMENT

## An Investigation and Policy Recommendation into the Potential Development of Future Nuclear Energy Infrastructure in the UK

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# Abstract

The UK's transition towards a low-carbon energy system is accelerating in response to climate change and net-zero commitments. As renewable energy sources such as wind and solar become increasingly integrated into the national grid, their intermittent nature creates challenges for maintaining a stable and reliable electricity supply. This report evaluates the potential role of nuclear power—particularly Small Modular Reactors (SMRs)—in supporting this transition by providing consistent, low-carbon baseload energy. It explores the economic viability, environmental impact, and technological maturity of SMRs, as well as the policy and regulatory frameworks necessary for their deployment. The report also considers financing challenges and public perception as critical factors influencing the future of nuclear energy in the UK. Through a comprehensive assessment of these dimensions, the report aims to inform policymakers and industry stakeholders on the feasibility of nuclear energy as a strategic component of the UK's future energy mix.

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Leeds Policy Institute (LPI) is the first student-run policy unit and think tank based at the University of Leeds. Since its founding in April 2023, LPI has grown into a vibrant and inclusive platform for policy research and engagement, bringing together over 100 undergraduate and postgraduate students from a wide range of academic disciplines across the University. LPI is structured around seven dynamic policy divisions: Macro Policy, Social Policy, Urban Planning and Transport, Energy and Environment, Financial Regulation, Foreign Policy, and Labour Policy. Through these divisions, our members research both local and national challenges, generating evidence-based, data-driven policy proposals from a non-partisan starting point.
Our mission is twofold: to produce high-quality research that informs public debate and policymaking, and to create professional development opportunities for students by building academic, research, and interpersonal skills. All research outputs undergo a rigorous internal review and are evaluated by our Academic Advisory Council, which includes University of Leeds lecturers and researchers with expertise across various policy domains. This ensures that all published work meets the highest academic standards. In just our second year, LPI members have presented at The British Conference of Undergraduate Research (BCUR) in both London (LSE) and Newcastle, and have seen their work published in national platforms, including the Financial Times. These achievements reflect the innovative, resilient, and research-driven spirit of our community and the values that underpin the University of Leeds.

## About Leeds Policy Institute

The charts and data presented in this report would not have been possible without the generous support of Macrobond, the world's largest macroeconomic and financial data platform. We are incredibly grateful for their partnership, which has provided Leeds Policy Institute with full access to their integrated analytical software—an essential tool in enabling our members to carry out robust and sophisticated data-driven research. In addition, we extend our sincere thanks to the Leeds University Business School (LUBS) and the Economics Department for their continuous support. This includes their assistance in securing funding to attend the British Conference of Undergraduate Research (BCUR) at both LSE and Newcastle, and in promoting LPI opportunities across the wider University community.

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## Policy Recommendations:

1. **Accelerate SMR Deployment:** The government should continue to streamline the regulatory approval process for SMRs owned by private companies and stated developers, reducing bureaucratic hurdles and accelerating project timelines. This will lower the costs associated with establishing and operating nuclear energy, paving the way for a brighter, more sustainable future for the UK's energy sector. The government should also Provide targeted financial incentives, such as tax breaks, subsidies, and components and materials, to further reduce costs and ensure a reliable nuclear energy supply.
2. **Enhance International Collaboration:** Enhancing international collaboration is crucial in advancing nuclear technology. The UK should foster partnerships with countries actively pursuing nuclear energy, particularly CANZUK nations, to share knowledge, technology, uranium resources, and best practices. Joint Research and Development: Collaborate with other countries (like France and CANZUK) on joint research and development projects to advance nuclear technology and reduce costs. Through such collaboration, the potential exploitation of developing nations in operating nuclear energy could be reduced.
3. **Ensure Long-Term Waste Management:** Secure Storage Facilities: Develop safe and secure long-term storage solutions for nuclear waste in the UK, avoiding potential nuclear catastrophes. This could be achieved through increased investment in research and development to explore advanced waste management technologies, such as nuclear waste recycling and disposal.
4. **A Strong Vision of a Mission to the British Public:** Openly explain the mission's potential of nuclear power to British communities with a wartime-like consensus, like the post-war projects of the NHS and post-war council housing estates. With the vision that entire counties, cities, and towns could be powered by British-made SMR technology, providing a range of skilled long-term jobs, national energy security through low-carbon technology, and lower energy bills with little risk.

5. **Transparent communication:** Maintain open and transparent communication with the public regarding the benefits, risks, and safety measures of nuclear energy. This commitment to transparency will reassure the public and build confidence in the safety of nuclear energy, especially when SMRs are deployed on city/county scales.
6. **Community engagement:** Involve local communities in the planning and developing nuclear projects to address concerns and build trust, but do not allow local authorities to block the implementation of all SMRs.
7. **Education and outreach:** Invest in public education and outreach programs to raise awareness about the benefits of nuclear energy and dispel misconceptions portrayed on social media.

# 1 Introduction

## 1.1 Introduction

The UK's energy landscape is transforming significantly, driven by the imperative to reduce greenhouse gas emissions and achieve net-zero targets. The increasing integration of various renewable energy sources, such as wind and solar, is inherently intermittent with weather conditions. The threat of climate change and limitations of new alternative technologies necessitate reliable, low-carbon alternatives to ensure a stable energy supply. Nuclear power offers a compelling solution by providing a consistent baseload of electricity, effectively complementing the fluctuating output of renewables. While natural gas currently plays a significant role in bridging supply gaps caused by this intermittency, a greater contribution from nuclear power could substantially reduce this reliance, fostering a more secure and lower-carbon energy system. With its potential to provide consistent, low-carbon electricity, nuclear energy has emerged as a compelling option. However, the high start-up costs, complex regulatory processes, and public concerns associated with nuclear power have hindered its widespread adoption. This report aims to assess the feasibility of nuclear energy, particularly Small Modular Reactors (SMRs), as a viable solution to the UK's energy challenges.

It examines the economic, environmental, and technological aspects of nuclear energy to explore the potential benefits and risks associated with its deployment. It also explores the policy implications, including regulatory frameworks, financing mechanisms, and public acceptance. Ultimately, this report seeks to comprehensively analyse nuclear energy's role in the UK's energy mix and offer recommendations to policymakers and industry stakeholders to facilitate its successful implementation.

# 2 The Science of Nuclear Development

## 2.1 The Science Behind Nuclear Energy

Nuclear energy is produced from a nuclear fission reaction, a process involving the release of energy from the collision of a neutron with a uranium-235 atom. This collision splits the atom into smaller nuclei and more neutrons, triggering more collisions with the surrounding uranium-235 atoms. The process repeats, generating a chain reaction producing energy from heat. This chain reaction produces steam that drives turbines and manufactures electricity for companies and households across the UK (Galindo, 2022). A typical reactor can be dissected into several components; the fuel (most commonly uranium) is arranged in rods within a physical barrier (cladding) preventing the fuel from unwanted chemical reactions. Every reactor consists of adjustable control rods of boron or other materials that absorb neutrons to slow down or halt chain reactions. Additionally, there is a moderator placed at the reactor's core (made of graphite or water), which slows down the speed of neutrons to increase the likelihood of collisions. The coolant (gas or liquid) enters from the bottom of the reactor and travels through the hot reactor core to remove heat for energy transfers.

Liquid coolants (e.g. water) are boiled to produce steam and power the turbines, whilst a gas coolant is heated by the core and pumped into the steam generator (The Open University, 2024). Finally, reactors have a containment structure around the steam generators as a safety mechanism to prevent any leak of radioactive substances (World Nuclear Association, 2024a).

## 2.2 The UK's Current Nuclear Energy Infrastructure Production

The World Nuclear Association (2024b) states the UK currently generates 15% of national electricity from 6.5GW of nuclear capacity, equivalent to nine operational nuclear reactors scattered across the country. Eight of the operating reactors are Gas Cooled Reactors (GCR), all being Advanced Gas Cooled (AGR) reactors. The AGR design was developed from an earlier gas-cooled reactor design, the Magnox reactor. The Magnox was a graphite moderated reactor that used CO2 as a coolant and was fuelled by natural metallic uranium, which was a key limitation of this design (Shropshire, 2004). Its more enriched oxide fuel made from uranium dioxide is able to increase the reactor power density and its thermal efficiency to around 42% (Explore Nuclear, 2023). While both Magnox and AGR reactors are gas-cooled and graphite-moderated, they differ in fuel and other design aspects (Orhan et al., 2012).

The UK has only one operational Pressurised Water Reactor (PWR) reactor, the Sizewell B reactor in Suffolk. PWR reactors use water as both a coolant and moderator. This design consists of 200-300 uranium dioxide fuel rods in the core where fission occurs heating water to 325ºC. The primary cooling circuit running through the core keeps the water under a high pressure to prevent boiling. It is then transferred to the steam generator in the secondary circuit where the steam produced drives the turbines to generate electricity. Condensation reuses the steam to create water to pump back into the generator to be heated again, restarting the cycle (World Nuclear Association, 2024b). These reactors are the most common, making up 70% of the global nuclear fleet (World Nuclear Association, 2024c).

They have been widely adopted due to their enhanced safety system, as the separate circuits ensures no radioactive contaminants are leaked to the turbine and condenser as well as having the standard containment building around the primary circuit. Although PWR reactors have a lower thermal efficiency than AGR reactors of around 33% (Breeze, 2016), they have a much simpler, compact, and stable design, reaching lower temperatures which makes them more universally used (Belyakov et al., 2019).

EDF are currently constructing Hinkley Point C, consisting of two European Pressurised Reactors (EPR) that are 3rd generation PWRs (World Nuclear Association, 2024b). The EPR design has more advanced safety requirements against external hazards like earthquakes and has enhanced protection against a core meltdown. Furthermore, it has the highest thermal efficiency for water reactors at 36-37%, producing 1600MW of power using less uranium in the process (Leverenz and Gerhard, 2004). It also has a 20% lower power generation cost compared to gas plants (Leverenz and Gerhard, 2004).

## 2.3 Comparison with Other Countries' Legislation

Small Modular Reactors (SMRs) are a type of nuclear reactor that are significantly smaller than traditional nuclear power plants. They are designed to be modular, allowing for flexible deployment and scalability. SMRs can offer several advantages over traditional nuclear power plants, including a reduced construction time as SMRs are smaller and factory-made, lower upfront costs, and increased safety features (World Nuclear Association, 2024d). Additionally, SMRs can be deployed in remote locations, providing reliable and clean energy to areas with limited access to traditional power sources (Liou, 2023). SMRs are gaining traction globally, with numerous designs under development across approximately 18 countries, including Canada, China, Japan, the UK, the US, Russia, and South Korea.

While widespread deployment is still emerging, notable progress has been made in Russia and China, who have already connected SMRs to their grids. The International Atomic Energy Agency (IAEA, 2025) maintains the ARIS database with detailed information on various SMR designs and their developmental stages.

The economics of SMRs are projected to differ from traditional large-scale nuclear plants in positive ways. Their modular design allows for factory fabrication, aiming to achieve economies of scale that can reduce construction costs and timelines (Nuclear Energy Agency [NEA], 2021). This modularity also offers greater flexibility in siting, as SMRs require less space and cooling water, and can be deployed in locations unsuitable for larger plants (World Nuclear Association, 2024d). Moreover, SMRs offer a lower upfront capital investment than large-scale reactors (International Energy Agency [IEA], 2024). The global market potential for SMRs is substantial, with projections indicating significant capacity additions in the coming decades. The IEA (2024) projects that, with tailored policy support and streamlined regulations, SMR capacity could reach 120GW by 2050. The literature also suggests SMRs can match or even exceed the cost-efficiency of other energy sources, especially when considering the value of reliable, low-carbon energy. For example SMR Start (2021), an organisation dedicated to SMRs, indicate that they could be cost-competitive against natural gas plants and renewable generation sources by 2035.

In terms of operational advantages, SMRs are designed with enhanced safety features, including passive safety systems that rely on natural phenomena like convection for cooling. This design aims to simplify operation and reduce the risk of accidents, with some designs potentially operating for extended periods without refuelling (IAEA, 2024). SMRs can also be deployed incrementally to match increasing energy demand due to their modular design.

They are well-suited to replace retiring fossil fuel plants, potentially utilising existing infrastructure and supporting a transition to cleaner energy. Furthermore, SMRs offer advantages in terms of land-use efficiency, often requiring smaller land areas compared to traditional nuclear plants (Oğuz, 2024).

While promising, SMRs face potential challenges. Ramana et al. (2018a) suggest SMRs may produce more nuclear waste per unit of electricity generated compared to larger nuclear reactors due to higher neutron leakage and the need for more frequent refuelling. Economic uncertainties also persist, as the projected cost-savings associated with modularity and mass production have yet to be consistently demonstrated in real-world deployments (Lovering et al., 2020). Additionally, SMRs face regulatory challenges, including the need to develop new licensing frameworks and address potential proliferation risks associated with the increased number of smaller, more dispersed reactors as part of a SMR strategy (Krall et al., 2023). However, despite these challenges, the pursuit of SMRs, alongside traditional large-scale nuclear power plants, remains crucial in establishing a diversified nuclear energy portfolio. Nuclear energy, in general, offers a reliable, low-carbon source of electricity, essential for mitigating climate change (Intergovernmental Panel on Climate Change, 2022). The advantages of SMRs, especially their enhanced safety features, reduced upfront capital costs, and greater flexibility in deployment, make them suitable for a wider range of applications and locations (Carelli et al., 2010; Locatelli et al., 2014), and offer a promising contribution to achieving the UK's net-zero targets.

## 2.4 Freedom of Information (FOI) Request to Great British Nuclear

Great British Nuclear [GBN] is a UK government-owned company established to drive the development and deployment of nuclear energy in the UK. In 2023, it announced a competition shortlisting six companies, designed to develop SMR technology (Department for Energy Security and Net Zero [DESNZ], 2023a). Since then, it initiated negotiations with four of the shortlisted companies, including GE Hitachi, Holtec, Rolls-Royce SMR, and Westinghouse, with 'each company's design [being] assessed on various criteria, including safety, deliverability, and scalability' (DESNZ, 2023a). This initiative aligns with the government's plan to revitalise nuclear power and solidify the UK's global leadership in advanced nuclear technologies through delivering operational SMRs by the mid-2030s (DESNZ et al., 2023b).

Leeds Policy Institute submitted an FOI request to GBN on 11 November 2024, seeking information regarding its plans for developing nuclear energy in the UK. Specifically, the request inquired on GBN's overall strategy, safety protocols, financing mechanisms, and aims of integrating SMRs into the UK's energy grid. In its response, GBN indicated that it will work towards achieving the government's long-term vision of expanding SMRs, aligning with the UK's net-zero emissions targets. GBN stated it will do so through collaborating with various stakeholders to support the government's nuclear programme. It also affirmed its commitment to transparency, ensuring compliance with all reporting requirements and releasing information to the public.

On integrating SMRs into the UK's energy grid, GBN reported that it is in the early stages of planning grid connections for its sites, adhering to the protocols established by the National Grid and Ofgem. The National Energy System Operator (NESO) is responsible for overall grid strategy, and GBN states it will collaborate with and support NESO.

To further support integrating SMRs into the UK's energy grid, GBN stated it will collaborate with stakeholders to develop a UK-based supply chain, enhancing domestic manufacturing capabilities and securing a reliable supply of materials.

Regarding the licensing and regulation of SMRs, GBN clarified that the regulatory framework is established by the government and other official bodies, such as the Office for Nuclear Regulation [ONR] and Environment Agencies. GBN stated it will operate by these regulations whilst also advising the government on improving relevant regulations and processes. Its response also addressed nuclear waste management, stating that the Nuclear Decommissioning Authority and associated entities (e.g. the Nuclear Waste Services) are responsible for long-term waste management. GBN states it will collaborate with these bodies and develop existing regulations surrounding decommissioning and waste management further.

Concerning the financing of SMR projects, GBN indicated that the government is implementing various mechanisms to encourage private investment, such as grants. The Nuclear Energy (Financing) Act 2022 enacts a Regulated Asset Base (RAB) model, and GBN states it will work with the government and the private sector to ensure the RAB model is structured in a way that attracts investment into nuclear energy.

In summary, GBN states they will contribute towards delivering the government's nuclear energy strategy on SMRs. The organisation says they will ensure the safe, transparent, and efficient deployment of SMR technology, whilst collaborating with various stakeholders and adhering to regulatory standards set by other governmental bodies.

# 3 Nuclear Economics

## 3.1 The Relationship Between Nuclear Energy Consumption and Economic Growth

While some research suggests a positive long-term relationship between nuclear energy consumption and economic growth, this connection is far from straightforward and universally accepted. On one hand. Apergis and Payne (2010) identified a strong positive correlation between nuclear energy consumption and real GDP growth across several countries in the long term. Additionally, Bandyopadhyay and Rej (2021) examined data from India, finding that investment in nuclear energy could create a 'tunnelling effect' leading to sustained economic growth in the long-run. However, other studies identify the crucial nuances of this relationship. Kirikkaleli et al. (2021) argue the relationship may be bidirectional, meaning economic growth itself can influence nuclear energy consumption and vice versa, thereby making it difficult to identify causality between the two. Menya and Wolde-Rufael (2010) support this, finding that the relationship varies across countries, being unidirectional in some and bidirectional in others. This heterogeneity suggests it is challenging to design 'one-size-fits-all' policies around the application of nuclear power. Indeed, the literature suggests that the correlation between nuclear energy and economic growth is weaker in some countries compared to others. For instance, despite France's significant reliance on nuclear power and Germany's complete phase-out of nuclear energy by 2023 (Fisher, 2024), Germany's average economic growth over the past five years has surpassed France's (Georank, 2025). This suggests that the impact of nuclear energy on economic growth could be less significant than other factors. Therefore, while nuclear energy might play a role in a nation's energy strategy, its direct impact on economic growth, independent of other factors, remains unclear. The UK must therefore take a nuanced approach in designing its nuclear strategy, considering its wider economic context in identifying the potential benefits it could yield.

### 3.2 The Cost of Nuclear Energy

Key to evaluating the economics of nuclear energy is distinguishing between its significant upfront costs and relatively low operational expenses. Nuclear power plants require substantial initial investment, with construction, capital, and the plant load being the primary cost-drivers for nuclear energy (Thomas et al., 2020). Lévêque (2013) argues that a significant reduction in construction costs is crucial for nuclear energy to become a more viable energy source, highlighting the need for continuous improvement in the sector's research and development. Stewart and Shirvan (2023) reinforce this idea: in calculating expected cost variations among different nuclear plant types, they caution that cost overruns and delays could render even the most initially affordable plant considerably more expensive than its counterparts. Portugal-Pereira et al. (2018) further suggest that these 'time overruns' are symptomatic of a declining sector, a concern also shared by Gómez-Cabrera et al. (2023). However, once a nuclear plant is running, its operational costs are notably lower than those of other energy sources, including renewables (World Nuclear Association, 2023). As such, although nuclear power may be capital-intensive and thus expensive in the short-run, it can serve as a cost-competitive energy solution in the long-run.

## 4 The Environmental Impacts of Nuclear Energy

### 4.1 Environmental Benefits of Nuclear Energy

There is compelling evidence behind nuclear energy, particularly that generated by SMRs, being more environmentally friendly than other energy sources. A significant advantage of nuclear power is its high energy density, translating to a much smaller land footprint compared to other energy sources. Ritchie (2022) states, 'nuclear power is the most land-efficient source: per unit of electricity, it needs 27 times less land than coal; 18 times less than hydropower plants; and 34 times less than solar PV'.

This is corroborated by Lovering et al. (2022), who found that nuclear energy has a land use intensity of 7.1 ha/TWh/y, being considerably lower than that of other energy sources. This efficiency is especially relevant to SMRs: their smaller size and modularity means they can further minimise land use and be in areas unsuitable for larger power plants. This helps promote coexistence with local ecosystems and minimise environmental costs, as siting practices can be optimised to avoid sensitive areas such as critical habitats for endangered species or migration corridors (IAEA, 2002). Indeed, the United Nations Economic Commission for Europe (UNECE, 2021) indicates that nuclear energy generation has a low impact on biodiversity. The literature also explores the impact of nuclear energy production on aquatic environments, with the Electric Power Research Institute (2010) highlighting the effectiveness of technologies like fish diversion systems and management of thermal plumes in minimising the potential harm to marine life. Some SMR concepts also propose using air cooling, which reduces reliance on large volumes of water and further minimises potential impacts on aquatic ecosystems. Although Hassan et al. (2023) argue that the initial environmental costs of nuclear energy could be considerable, they acknowledge that its long-term integration into the energy mix can substantially improve overall ecological outcomes.

## 4.2 Environmental Benefits of Nuclear Energy

Although wind is a renewable energy source, it is not without significant negative consequences to wildlife. Wind turbines are a particular threat to birds, including endangered species, killing between 140,000 and 500,000 birds annually (Smallwood, 2007). They also cause substantial bat mortality, killing millions of bats annually in North America (Hayes et al., 2020). Bats are particularly vulnerable, as they are attracted to turbines and are susceptible to lung damage caused by rapid air pressure changes (barotrauma) (Hayes et al., 2020).

Beyond direct fatalities, wind farms can disrupt natural habitats. The construction of access roads, foundations of turbines, and power lines can damage ecosystems through negatively affecting migration patterns, breeding grounds, and overall biodiversity. Considering this alongside their extensive land requirements, wind turbines can cause significant ecological disruptions. In contrast, the land-efficiency of nuclear power plants, particularly SMRs, mitigates their disruptions to natural habitats. While there are concerns surrounding thermal discharge into aquatic ecosystems, as mentioned above, these impacts are generally localised and can be mitigated through proper management.

### 4.3 Environmental Challenges and Concerns of Nuclear Energy

Environmental concerns surrounding nuclear energy persist throughout society, government, and industry. Although some studies suggest transitioning from fossil fuels to nuclear power can reduce production-based carbon dioxide (CO2) emissions (e.g. Ceylan et al., 2021; Hassan et al., 2023; Saidi and Omri, 2020; Ulucak and Erdogan, 2022), Ulucak and Erdogan (2022) find that the impact of nuclear energy on consumption-based CO2 emissions is negligible. Indeed, there are differing perspectives on carbon emissions released during the full nuclear fuel cycle. Studies funded by nuclear energy companies tend to focus on the operational stage of reactors, suggesting minimal emissions (World Nuclear Association, 2024b). However, this potentially presents a biased view, as the wider literature indicates a more significant carbon footprint when considering all fuel cycle stages. As Shrader-Frechette (2013a) states, 'when accounting for all fourteen fuel cycle stages, some studies have found nuclear fission is five to forty times dirtier than wind, three to ten times dirtier than solar-PV, and roughly as dirty as natural gas'. This discrepancy stems from greenhouse gas emissions during uranium ore mining, ore milling, fuel fabrication, waste storage/cooling, waste transportation, and reactor decommissioning (Sovacool, 2008).

As such, despite nuclear energy generally emitting fewer greenhouse gases than fossil fuels, it is not completely clean. Therefore, it is crucial to critically assess sources of information surrounding nuclear energy, as studies funded and published by corporations on nuclear energy can generate a biased interpretation of its environmental impacts. Beyond concerns surrounding emissions, the literature also identifies wider environmental issues concerning nuclear energy production. The UNECE (2021) identifies the evaporation of water during the electricity generation process as a potential environmental issue. Moreover, the long-term management of nuclear waste poses a significant environmental and ethical dilemma, placing the responsibility for safe disposal on future generations (Tondel and Lindahl, 2019). While advancements in reactor technology aim to reduce the volume of waste produced compared to older designs, the challenge of secure long-term storage persists.

# 5 Ethics of Nuclear Energy Infrastructure

## 5.1 Social and Ethical Dynamics of Current Energy Sources

The issue of transitioning away from fossil fuels must be viewed as a collective action problem: that is, a situation whereby individual incentives lead people to the disbenefit of the overall group (Friederich and Boudry, 2022a). Fossil fuels are relatively cheap, are currently abundant, can be used on demand, have a high energy density, are easy to transport, and are versatile. These characteristics are especially important to developing and emerging economies, where cheap and efficient energy provision is crucial to lifting billions out of poverty and increasing their quality of life (Shrader-Frechette, 2013b). Despite this, the social and environmental costs associated with the continued use of fossil fuels, including climate change, air pollution, and ecological damage, are undeniable (Friederich and Boudry, 2022a).

Indeed, climate change will first impact those living in environments susceptible to increases in extreme weather and rising sea levels, which are primarily located in developing and emerging economies (Friederich and Boudry, 2022a). As such, it is those who would be most impacted that lack the financial ability to recover. Therefore, although the short-term use of fossil fuels can be used to propel the living standards of those living in developing economies, their long-term use will eventually reverse these to levels lower than ever before. Developed and emerging economies thus require an affordable and abundant energy source that can easily provide for the base load currently provided by fossil fuels (Friederich and Boudry, 2022b).

In theory, nuclear energy can provide such an alternative without dangerously high carbon emissions, thereby avoiding the negative consequences associated with excessive fossil fuel consumption. However, several limitations exist to this perspective, as the levelised cost of electricity from nuclear sources can be volatile and often exceed that of other renewable energy sources, particularly solar and wind (Kabeyi and Olanrewaju, 2023). This is because construction delays, regulatory hurdles, and potential decommissioning costs can escalate the final price of nuclear power significantly (NEA, 2020). Additionally, the literature understates the potential long-term issues of nuclear waste disposal and accidents, factors that can introduce substantial social costs and ethical concerns (Selimbegović et al., 2016; Ramana, 2018b). The claim that alternative renewable energy sources are not sufficiently cheap has also become increasingly outdated, as solar and wind energy costs have declined dramatically in recent years, making them even cheaper than fossil fuels and nuclear power at times (International Renewable Energy Agency, 2021). Although the reliability of solar and wind energy can suffer from weather intermittency issues, these can be addressed through technological advancements and policy measures in energy storage, grid management, and demand-side management (IEA, 2021).

Transitioning away from fossil fuels therefore requires a multifaceted approach considering the socioeconomic and ethical dimensions of energy production and consumption. While nuclear energy can be part of the solution, it is essential to address its limitations. Renewable energy sources should thus play an increasing role through continued technological innovation and policy support. A just and sustainable energy transition necessitates such a balanced approach that prioritises current and future generations, acknowledging different countries' diverse circumstances and needs. It is only through such a comprehensive approach that we can effectively address the ethical and environmental challenges of our energy transition.

### 5.2 Ethical Sourcing of Uranium

Low-income countries often export natural resources, such as uranium for nuclear energy, and rely on this for economic development. This leaves them vulnerable to foreign debt from the uranium market and liable to global fluctuations in the natural resource sector. They become disproportionately impacted by uranium mining as high-income countries exploit their resources whilst externalising the environmental consequences, generating energy for their benefit without enduring ecological damage (McKie, 2020). A prominent example of this is France's decades-long exploitation of Niger's abundance of uranium (Maad, 2023). The extraction is chiefly performed by the multinational corporation Orano (2025), of which the French government owns 90%. Such exploitative relationships between developed nations with nuclear energy capacity and emerging economies are a significant ethical issue associated with nuclear power. To overcome this, focus must be placed on equal and non-exploitative international relations.

The ethical and economic challenges associated with uranium extraction extend to numerous other resources crucial for global industries, including 'sustainable' and 'green' energy production methods like solar power. The production of solar panels relies heavily on rare earth minerals such as neodymium and dysprosium, essential for high-performance magnets. However, rare earth mineral extraction frequently occurs in developing nations, raising significant ethical and environmental concerns. For example, mining operations in the Democratic Republic of Congo have been widely reported to involve hazardous working conditions, including child labour, poor wages, and exploitative labour practices (Amnesty International, 2016; Kara, 2021). These activities also result in substantial environmental damage, including deforestation, soil erosion, and water contamination (Gwenzi et al., 2018; Lawson, 2021). These practices mirror the challenges seen in uranium mining, where demand from high-income countries can perpetuate exploitation in resource-rich, low-income nations. While critical for climate change mitigation, the reliance on rare earth minerals for solar power necessitates addressing these patterns of exploitation in resource extraction.

The UK can pursue a more ethical approach to sourcing nuclear materials by prioritising alliances with countries such as Australia and Canada. These nations boast stable economies and transparent governance, significantly reducing the risk of exploitation and corruption in developing countries. Furthermore, Australia and Canada are recognised for their robust regulatory frameworks that govern uranium mining, emphasising stringent environmental protection, safety, and fair labour practices (World Nuclear Association, 2024e). A report by the International Council on Mining and Metals supports this, highlighting principles that include upholding human rights and respecting cultures (Fox, 2023). Sourcing from these countries also means greater respect for indigenous rights, increasing recognition of land rights, the need for consultation, and benefit-sharing in resource development.

By sourcing uranium from allies with these high standards, the UK can minimise the ethical dilemmas associated with vulnerable populations and environmental degradation and foster a more sustainable and equitable supply chain.

Studies conducted in various countries provide evidence for the effectiveness of different interventions in developing media literacy in the digital space. For example, integrating media literacy into standard school subjects (history, art, culture, and Ukrainian language and literature) enabled Ukrainian students to better detect false information (IREX, 2019). Results from the Learn to Discern pilot programme, which reached 5,425 students in Year 8 and 9 across 50 schools, were generalisable and led to the programme's expansion to 650 schools across Ukraine.

However, this approach may be less effective in other countries. Hobbs (p.56, 2004) reviews media education campaigns in more than dozen countries and finds that: "what is institutionally appropriate in one setting may not be so in another". For instance, in Indonesia, a video-based media literacy campaign did not significantly enhance users' ability to distinguish between true and false information, even though participants were 64% less likely to share false headlines than the control group (Journal of Media Literacy Education, 2023, p.99-123). This suggests that the effectiveness depends on the design of the intervention. In Ukraine, media literacy initiatives were implemented in the secondary school setting, whereas in Indonesia, online delivery was used, which had less engagement from participants (only 72 out of 656 surveyed individuals accessed the Media Literacy education website) (Journal of Media Literacy Education, 2023, p.101). Therefore, the context of the country and campaign format should be considered to improve the impact of media literacy efforts.

## 5.3 Health and Safety of Nuclear Energy

While studies investigating cancer incidence in populations living near nuclear power plants have yielded various conclusions, the consensus within the literature suggests that no significant health impacts have been consistently linked to nuclear power plants operating under normal conditions (Baker and Hoel, 2007). It is imperative to distinguish this from the potential health consequences of nuclear accidents, which are a separate and significant concern often highlighted in public debates about nuclear energy. While the health impacts of routine operations appear minimal, the risks associated with potential accidents remain a critical aspect of the discussion surrounding nuclear power. The accidents at Three Mile Island, Chernobyl, and Fukushima tragically demonstrated the potential for significant health consequences from nuclear power plant malfunctions. The Three Mile Island accident in Pennsylvania, US, while resulting in no direct deaths, caused widespread fear and distrust and led to increased safety regulations. Chernobyl in Ukraine was far more severe, with immediate deaths and a substantial increase in thyroid cancer rates due to the release of radioactive iodine (United Nations Scientific Committee on the Effects of Atomic Radiation [UNSCEAR], 2008). The most significant increases in thyroid cancer after Chernobyl were observed in children, particularly those aged 0-4 at the time of the accident, in Ukraine and Belarus, the areas most contaminated by radioiodine releases (UNSCEAR, 2008). Ecological studies in these affected countries reported significantly elevated risks for thyroid cancer in children in the decade following the disaster, with more recent studies estimating excess relative risks per Gray (ERR/Gy) of 8.0 and 19 with 95% confidence (UNSCEAR, 2008). A large case-control study of Belarusian and Russian children younger than 15 at the time of the accident found an ERR/Gy of 5.6 among those with estimated doses less than 1 Gy (Cardis and Hatch, 2011).

The Fukushima disaster in Japan, triggered by a tsunami, released radioactive materials that resulted in evacuations and concerns about long-term health impacts, including potential increases in cancer incidence among affected populations (Lipton, 2012; Ozasa et al., 2012). These events underscore the importance of robust safety measures and highlight the potential for widespread and long-lasting health consequences in the event of a major nuclear accident. However, despite the severity of these isolated accidents, nuclear power has been statistically shown to cause the least deaths per unit of energy produced compared to other primary energy production methods. Fossil fuels (e.g., coal, gas, oil) are associated with significantly higher death rates due to air pollution causing respiratory illnesses, cardiovascular problems, and cancer (Lelieveld et al., 2015). Hydroelectric power, while renewable, carries risks of dam failures, which can lead to catastrophic floods and fatalities (Sovacool et al., 2016). Although much safer, even renewable sources like wind and solar have some associated risks during manufacturing, installation, and maintenance (Sayed et al., 2021). The literature consistently demonstrates that, when considering the entire lifecycle of energy production, from fuel extraction to waste disposal, nuclear power has a lower mortality rate than other energy sources, including rooftop wind and solar sources (Markandya and Wilkinson, 2007; Wang, 2008; Evans et al., 2021).

### 5.4 Public Perception of Nuclear Energy

There are discrepancies in demographic support for nuclear energy, but these are not as significant compared to the role of the media. Secure democracies emphasise the freedom of expression, and so the media has major significance in shaping their public opinion. Media coverage often emphasises the risk of nuclear energy, especially following accidents, whilst downplaying its potential benefits in mitigating global climate change (Kristiansen, 2017), despite a wealth of evidence supporting the safety of nuclear energy (Brook et al., 2014;

Wheatley et al., 2016; Rehm, 2023). Indeed, there is a 'risk perception gap' between experts and the public, with the latter perceiving nuclear risks much more likely than they actually are (Slovic, 1987; 1996). Vossen (2020) provides a potential explanation behind this, arguing that the media framing of nuclear energy is influenced by cultural and societal factors, often relying on familiar narratives of disaster rather than exploring the empirical evidence in its potential to mitigate climate change. For example, in countries with bigger technocratic cultures (e.g. France, China, India, etc.), scientists are more highly esteemed, hence their public perception of nuclear energy is more favourable to the public (Nguyen and Yim, 2018). It is therefore crucial for the media to provide balanced and accurate reporting on nuclear energy to ensure the public is well-informed. While there are challenges to public acceptance of nuclear energy, they can be overcome with educated media coverage. Negative portrayals in the media emphasise the dangers of rare nuclear catastrophes, resulting in a distrust of authority and shaping unfavourable perceptions, but this is not the case in countries where scientists are more esteemed and thus empirical findings are considered more prominently. Governments and independent media organisations must therefore provide balanced, factually grounded coverage of the risks and benefits of nuclear energy to foster a more informed public discourse. Such a shift in media presentation can potentially increase public acceptance, paving the way for greater development and utilisation of nuclear power (also see Ho et al., 2022).

# 6 Nuclear Policy

## 6.1 Commitments Towards Nuclear Development and Investment in the UK

Although previous UK governments have expressed their interest in nuclear development, no new sites have become operational since 1995 (Heffron, 2013). Out of all operational nuclear power plants in the UK, seven out of eight will be in the process of being, or be completely decommissioned over the upcoming six years (ONR, 2020).

Only one of these, Sizewell B, has an operational lifetime of ten or more years (ONR, 2024). Additionally, most proposed nuclear site projects and reactor developments have been suspended or experienced limited progress. All six proposals for new nuclear power stations by 2025 have been suspended (Nuclear AMRC, 2025), meanwhile the EDF's proposed partnership with China General Nuclear Power Corporation (CGN) to introduce the Chinese Hualong HPR1000 reactor in Bradwell has not progressed further (Nuclear AMRC, 2025). Despite this, both two major political parties, Conservative and Labour, have expressed their support for nuclear power. The previous Conservative government had clear plans, establishing commitments of bringing at least one large-scale nuclear project to the point of Final Investment Decision, and allocating £385 million towards an 'Advanced Nuclear Fund' for future development of SMRs and building an Advanced Modular Reactor (AMR) demonstrator (Department for Business, Energy and Industrial Strategy, 2021). Similarly, in their 2024 manifesto, Labour have expressed their commitment to finishing the construction of Hinkley Point C, extending the lifetime of existing plants, building new stations such as Sizewell C, and continuing the development of SMRs (Labour, 2024). However, no specific plans have been established formally by the recent Labour government at the time of writing. Nevertheless, further commitments need to be made. The nuclear market is valued at around £600 billion for new nuclear builds and £250 billion for decommissioning, waste treatment, and disposal, and critical opportunities over the next twenty years could arise through larger investment in builds and research (de Carvalho, 2018).

## 6.2 Regulatory Challenges Towards Revitalising the UK Nuclear Industry

It is important to consider the recent development of SMR reactors as an option for revitalising the UK's nuclear industry. As mentioned previously, SMRs can serve as highly beneficial complements to other renewable energy sources due to their greater flexibility and lower environmental impacts compared to traditional large-scale reactors (Amin et al., 2024). However, they face the same challenges present in the wider nuclear industry; regulatory processes are time-consuming, costly, and complex, discouraging investment in SMR technology (Amin et al., 2024). Considering this, changes to the current nuclear project planning system must be implemented. The current planning system and extensive government 'bureaucracy' are seen as major barriers to implementing new policies and developing new nuclear builds (Greenhalgh and Azapagic, 2009). Saunders and Townsend (2019) propose that adequate risk management should be central to these projects while still providing an effective period to tackle its complexity and cost. As such, a more cost- and time-effective regulatory process that companies can easily navigate is crucial towards making investment towards new nuclear builds and SMR technology more inviting.

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