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Nuclear Energy

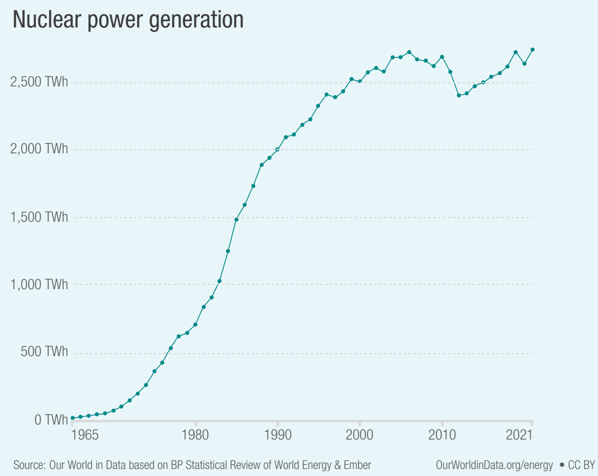
Nuclear energy continues to be one of the most controversial and heavily debated aspects of the low carbon transition. In this RI Expert Briefing, we explore the issues that make it so contentious, and set out our House view on whether there is a case for including nuclear energy as part of the energy mix within a responsible investment strategy.

What is nuclear energy?

Nuclear energy is the energy in the nucleus of an atom. In a process called nuclear fission, atoms are split to release that energy. Each splitting nucleus induces its neighbours to split in turn, creating a controlled chain reaction that generates heat and produces steam. The steam drives a turbine generator which creates electricity[1].

Uranium is the fuel most widely used for nuclear fission. Nuclear plants use a specific type of uranium called U-235 as its atoms split apart relatively easily. Though uranium is quite common, U-235 is much rarer, constituting just 1% of the world's uranium. Before it can be used for nuclear fission, uranium must be mined, extracted from other minerals and processed. The countries with the largest uranium reserves include Kazakhstan, Canada, Australia, Namibia, Niger and Russia[2].

What is the current use of nuclear energy worldwide?



Global generation of nuclear energy. (Source: Our World in Data)

Nuclear energy has been part of the energy mix since 1956. Since then, it has been harnessed by 32 countries and currently accounts for 10%[3] of the world's total electricity production. National attitudes towards nuclear power are mixed, with some countries utilising it more than others.

1 Nuclear Energy (nationalgeographic.org)
2 World Uranium Mining - World Nuclear Association (world-nuclear.org)
3 Nuclear Power Today | Nuclear Energy - World Nuclear Association (world-nuclear.org)

The UK opened the world's first nuclear power station, Calder Hall in 1956, and has viewed nuclear power as a crucial part of its energy mix since then. In 2022, nuclear power delivered 20% of the country's energy, down from a peak of 28% in 1997[4]. The UK government's ambition is for 24GW of nuclear power to be produced by 2050, representing 25% of projected electricity demand[5]. There are currently six generating stations in the UK, with Hinkley Point C under construction, which is projected to provide electricity for six million homes. Britain highlights that its nuclear energy programme is driven by its net zero targets paired with the desire to have a secure domestic energy supply.

France, with 70% of its electricity met by nuclear power has the largest share of national electricity generated by nuclear power worldwide[6]. France's pro-nuclear stance has been cemented by the current administration which announced "the renaissance of the French nuclear industry" in 2022[7], firmly reiterating France's pro-nuclear approach.

In contrast, Germany has traditionally been a centre of anti-nuclear sentiment, with consistent campaigns across the nation following widely publicised nuclear accidents in other countries. In 2011, the then Chancellor, Angela Merkel, announced an eleven-year process to phase-out the country's nuclear power stations, due to be complete in April 2023.

What are the drawbacks of nuclear energy?

A key barrier to nuclear power is safety concerns, as the radioactivity (half-life) of uranium fuel can last anywhere between 700m and 4.5bn years, meaning it remains dangerous almost indefinitely. There have been three sizeable nuclear disasters in the past 50 years; Three Mile Island in 1979, Chernobyl in 1986 and Fukushima in 2011, all three of which saw radioactive matter released into the local environment. Particularly damaging effects occurred in the case of Chernobyl, where the radiation the local population was exposed to was 37,000 times the strength of a chest X ray, and as such it has been labelled the "largest anthropogenic disaster in the history of humankind."

Although long-term effects of Chernobyl are difficult to quantify, approximately five million people are estimated to have been affected by the nuclear meltdown, with 1.8m Ukrainians carrying the status of victims of Chernobyl according to the National Research Centre for Radiation Medicine due to the high number of associated disabilities and cancers[8].

Environmentally these nuclear disasters have been significantly damaging. All three saw hundreds of square kilometres formed into exclusion zones with the land deemed untenable. Chernobyl saw meat, milk and wool reclassified as unsuitable across Europe due to the strong winds that blew radioactive material across the continent – lamb from Wales was only reclassified as 'safe' in 2012. The financial remediation was also significant. The clean-up from Fukushima cost over $142bn, whilst the total cost from Chernobyl is estimated to be over $700bn, making it the most expensive disaster in human history[9].

A further safety risk is proliferation, which is the risk that civilian nuclear fuel could be weaponised by the state. The Treaty of the Non-Proliferation of Nuclear Weapons came into force in 1970 with 191 State signatories (not including India, Israel or Pakistan), all committing to fostering the peaceful use of nuclear energy and preventing it from being weaponised. There have been some concerns over the recent Russian capture of the Chernobyl and Zaporizhzhia plants with regards to proliferation and safety, and ongoing sanctions against Iran for its potential conversion of its civil nuclear energy program into weapon grade material. There is also the risk that nuclear plants could be the target of terrorist activities.

Expense is another considerable drawback of nuclear energy. Nuclear power plants are characterised by high costs throughout their lifetime, with billions spent on construction, decommissioning and waste storage. There are also few examples of nuclear power plants being constructed within both budget and timeframe. The ongoing construction of Hinkley Point C was estimated to cost £16bn in 2021[10]; it has now risen to £26bn. Similarly, the Olkiluoto-3 reactor in Finland was estimated to open in 2009 with a cost of €3bn; it didn't launch until 2022 and cost €11bn[11].

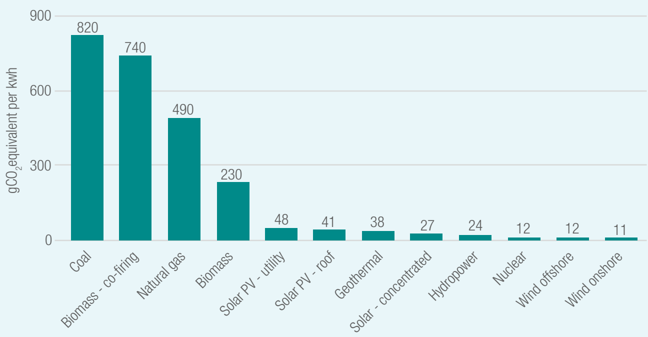
4 The UK's nuclear history - GOV.UK (www.gov.uk)
5 Nuclear energy: What you need to know - GOV.UK (www.gov.uk)
6 Nuclear Power in France | French Nuclear Energy - World Nuclear Association (world-nuclear.org)
7 Macron is committing to nuclear energy while Britain dithers | The Spectator
8 Microsoft Word - Chernobyl Report-Final-240102.doc (iaea.org)
9 2016_chernobyl_costs_report.pdf (wordpress.com)
10 Hinkley Point C delayed by a year as cost goes up by £3bn - BBC News
11 Finland's much-delayed nuclear plant launches – DW – 03/12/2022

Decommissioning adds another layer of expense. The operating lifespan of a nuclear reactor is typically 20-40 years, after which it must be decommissioned to ensure that the spent fuel is safely removed and stored, and the site is rehabilitated. The decommissioning process takes between 20-30 years, roughly equivalent to the operating lifespan, which is a costly process for a site which no longer produces energy. It has been estimated that it will cost UK taxpayers £132bn to decommission the existing fleet of UK nuclear power plants once they reach the end of their working lives[12].

Finally, storing the spent radioactive fuel is also a lengthy and costly process. Fuel must be stored for its potent radioactive period, which is estimated at one million years. Spent nuclear fuel is stored either in pools or caskets on the site of the decommissioned plant or in a specialist geological deposit facility (GDF). Storage makes up a considerable portion of a power plant's decommissioning budget. In the UK the 700,000m³ of radioactive waste produced from the 20th century nuclear sites is to be stored in a new £54bn GDF, a figure which has doubled twice since the GDF was initially tabled.

What are the benefits of nuclear energy?

Nuclear reactors have one of the lowest CO_2 emission rates of all energy sources. The Intergovernmental Panel on Climate Change (IPCC) has estimated that the carbon footprint for nuclear is as low as 12 gCO_2 per KWh, making it four times more efficient than solar, 40 times more efficient than natural gas, and 68 times more efficient than coal[13]. In the past 50 years, the use of nuclear power has prevented over 60 gigatonnes of CO_2 from entering the atmosphere, equivalent to almost two years' worth of global emissions.



Average life-cycle carbon dioxide-equivalent emissions for different electricity generators (Source: IPCC)

12 UK nuclear power stations' decommissioning cost soars to £23.5bn | Nuclear power | The Guardian

13 ipcc_wg3_ar5_annex-iii.pdf

Fossil fuels emit nitrogen dioxide, sulphur dioxide, fine particles, nitrates and phosphates into the atmosphere, whereas nuclear solely emits water vapour, a substance harmless to both society and the environment. By displacing hazardous emissions, nuclear energy has already averted around two million pollution-related deaths[14].

One of the biggest misconceptions surrounding nuclear energy is safety. High profile accidents such as Chernobyl and Fukushima have seared a narrative of danger and fear into the public consciousness. However, in reality nuclear is one of the safest energy sources in the world. Studies show that the death rate associated with nuclear (from both accidents and pollution) is 0.03 per TWh of electricity produced, compared to 18.43 for oil and 24.62 for coal[15]. Not to mention that most new nuclear plants built today are 3rd generation reactors, which are physically unable to meltdown in the same way as the traditional reactors involved in the Fukushima and Chernobyl disasters. The same misconceptions surround nuclear waste which, contrary to popular belief, is dense and relatively small. The World Nuclear Association (WNA) has estimated that, on average, the waste from a reactor supplying a person's energy needs for a year would be equivalent to the size of a brick. Furthermore, only 3% of the total volume is high-level radioactive waste. The majority, 90%, is low level waste[16].

This presents a positive case for nuclear power over fossil fuels, however it holds several advantages over renewable energy as well. One example is its land use efficiency. According to the UN, nuclear energy has the lowest land use and ecosystem impact of all electricity generation technologies[17]. Based on lifecycle assessments, per unit of electricity it needs 50x less space than coal, 46x less space than hydropower, and 27x less space than solar[18], leaving more undisturbed room for natural habitats, and easing the pressure on land to meet competing interests from food, energy, and housing.

Nuclear energy is equally as efficient in terms of inputs. The number of critical[19] raw materials required for a nuclear power station is significantly lower than what is needed for many other renewable technologies. Respectively, the mineral intensity of nuclear is 10x lower than solar PVs and 17x lower than wind power[20]. In turn, this supports a 'Just Transition' as heightened demand for rare minerals in the race to decarbonise the Global North potentially risks a wave of resource extraction, land grabbing, human rights abuses, and local environmental destruction across the Global South[21].

Arguably, the biggest advantage of nuclear energy is it provides baseload electricity. Nuclear power plants consistently operate at over 90% of their maximum capacity average, meaning they provide energy on a highly reliable basis. In contrast, renewable energy is inherently intermittent and cannot provide constant electricity. This means a complementary baseload supply is needed to step in and meet demand when the sun doesn't shine, or the wind doesn't blow. Nuclear energy, with its proven technology, is well-positioned to displace fossil fuels as the primary provider of global baseload electricity.

[14] Prevented Mortality and Greenhouse Gas Emissions from Historical and Projected Nuclear Power | Environmental Science & Technology (acs.org)

[15] What are the safest and cleanest sources of energy? - Our World in Data

[16] Radioactive Waste Management | Nuclear Waste Disposal - World Nuclear Association (world-nuclear.org)

[17] https://unece.org/sites/default/files/2022-04/LCA_3_FINAL March 2022.pdf

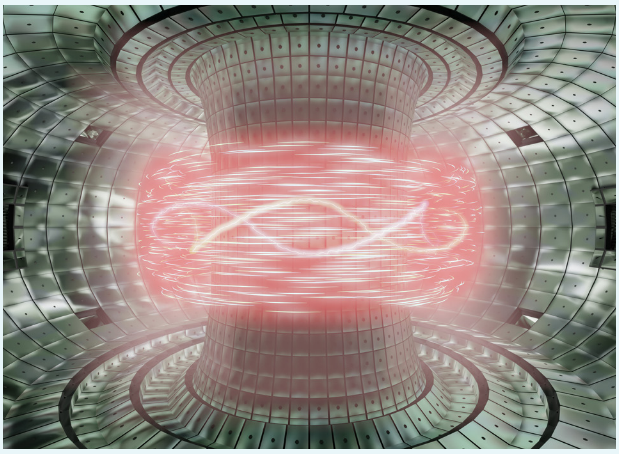
[18] Energy: How much land do energy sources use? | World Economic Forum (weforum.org)

[19] The IEA has defined copper, cobalt, nickel, lithium, REEs, chromium, zinc, PGMs and aluminium as the essential minerals for a low-carbon future.

[20] Mineral Requirements for Electricity Generation - World Nuclear Association - World Nuclear Association (world-nuclear.org)

[21] We have written elsewhere about the need to promote a Just Transition. https://www.edentreeim.com/docs/default-source/amity-hub-documents/ri-expert-briefings/c00734-expert-brief---just-transition-v5.pdf?sfvrsn=345ef3ce_3

Does nuclear energy have a role in the low carbon transition?



Yes. Energy consumption is by far the greatest source of CO_2 emissions meaning that the decarbonisation of power is essential to securing the pathway to net zero. The first step must be the rapid elimination of the dirtiest fossil fuels – coal and oil. However, as renewable capacity is not yet large enough to meet global demand, the question is which alternative energy source, gas or nuclear, can step in to provide the baseload supply. The crucial difference is that nuclear is low carbon, whereas gas not only would continue to add to global CO_2 emissions, but also has a higher land footprint and a higher associated mortality rate. This suggests nuclear is well-placed to enable the transition, a view reinforced by the IEA's Net Zero Scenario (NZE) which prioritises the role of nuclear energy over gas. Under the NZE, nuclear power doubles from a capacity of 413GW in 2022 to 812GW in 2050[22].

The IEA go so far to claim that achieving net zero globally will be "much harder" without nuclear energy. Their Low Nuclear Case Variant of the NZE considers the impact of such a reality[23]. In this scenario, gas plays a bigger role than nuclear, whose share of total generation declines from 10% in 2020 to 3% in 2040. Greater capacity from solar and wind is needed to fill the gap, as well as more fossil fuel plants fitted with carbon capture and storage. This requires $500bn more investment, raising consumer bills by $20bn a year to 2050, as well as significantly increasing the pressure on critical mineral supplies. The Low Nuclear Case Variant has the effect of making net zero ambitions harder and more expensive, therefore strengthening nuclear's position as the energy source best-placed to enable the transition.

Can nuclear innovation drive decarbonisation?

Innovations in the nuclear energy space promise lower cost, increased energy generation and safer production. Two of the most promising developments are Small Modular Reactors and nuclear fusion.

Small Modular Reactors (SMRs) are on average 1/10th of the size of conventional nuclear reactors with a power capacity of 1/5th-1/3rd. The reduction in size allows for components to be factory assembled and transported rather than built on site. This enables higher safety specifications, and also makes SMRs more cost- and time-efficient, and therefore more scalable than conventional nuclear plants. Additionally, physically occupying less land ensures that a wider variety of sites are appropriate for nuclear power plants. SMRs are favoured by the UK as part of its future energy mix with the government providing £210m for Rolls-Royce to develop UK manufactured SMRs.

Nuclear Fusion is the energy that powers the sun, and if replicated on earth could provide near limitless energy with no radioactive waste or greenhouse gas emissions. Fusion occurs by taking pairs of light atoms and forcing them together, which produces significantly more energy than traditional fission, which occurs by forcing atoms apart. Although seemingly more science fiction than fact, at the Culham Centre in the UK 59 megajoules of sustained fusion over a five second period was produced, proving that it is technically possible to generate fusion on Earth[24]. Despite the vast cost of fusion experiments the payoff of a near endless supply of clean energy is enticing – often quoted as the 'Holy Grail' of energy. The UK, for example, has funded billions in the UKAEA's fusion programme, demonstrating the appetite for this seemingly perfect solution.

Innovation in the nuclear power space is vast and exciting, and will no doubt contribute to future clean energy security. However, due to stringent regulation the timeline for their deployment is decades away. SMRs are still unknown in terms of timing and cost, with most predictions suggesting they won't be available until at least 2030. Similarly, the timeline for nuclear fusion's deployment is estimated at best to be 2050 with sceptics saying that since the first fusion experiments in the 1930s it has forever been "just 30 years away". This therefore puts nuclear Innovation at odds with the immediate decarbonisation that is needed to prevent global temperatures rising above 1.5°C and suggests we cannot rely on them to enable the transition. Focus must remain on whether existing nuclear energy sources have a role in the energy mix, rather than hoping for an innovative breakthrough.

[22] Net Zero by 2050 - A Roadmap for the Global Energy Sector (windows.net)
[23] Nuclear Power and Secure Energy Transitions (windows.net)
[24] Fusion in brief - Culham Centre for Fusion Energy (ukaea.uk)

What is the investment case?

Regardless of whether it has a role in facilitating the low carbon transition, a project must be economically viable to attract finance. As previously mentioned, nuclear power plants are characterised by high upfront capital costs, long construction periods, and a history of significant cost-time overruns. This results in a lengthy period before a return on investment can be secured. There are also external costs to consider, such as the environmental, health and financial consequences of a nuclear disaster, which would not appear in the project's accounts. Further, decommissioning liabilities can be considerable if a government does not assume responsibility for end-of-life management. These factors make nuclear power a high-risk investment, and therefore more challenging for investors to embrace.

This view may be affected by future changes in the 'green' status of nuclear power. For example, in the UK, nuclear is likely to become classified as "environmentally sustainable" under the upcoming Taxonomy which may afford it with the same investment incentives that are currently associated with renewable energy. This could make nuclear energy more financially viable for private investors.

An alternative and perhaps more opportunistic investment avenue lies in processes associated with nuclear energy. For instance, storing spent radioactive fuel. Any technology which could remediate the effects of nuclear waste in a faster and more cost-efficient manner could be an attractive investment opportunity due to the solution it provides to one of nuclear power's main challenges.

What is EdenTree's view on nuclear energy?

Nuclear energy remains one of the most controversial sources of energy generation, and one that potentially divides clients. Since inception, its status has been in constant flux, sometimes hailed as the nexus for a greener world, other times overshadowed by the 'apocalyptic' aftermath of nuclear disasters. Events such as the Russia-Ukraine war, the OPEC oil crisis, Fukushima and Chernobyl have all driven voters and governments to either disavow or rush to fund nuclear energy, depending on whether it is energy security, climate change or safety concerns dominating headlines and psyches.

EdenTree views climate change as one of the principal challenges of the 21st century and therefore believes there is a role for nuclear power's inclusion within the global energy mix. We believe that renewable energy must lead the transition but argue that nuclear power may also be needed to provide a complementary baseload, enhance energy security, and to reduce the environmental burden on land and critical minerals. This is not to downplay the associated risks – the consequences when nuclear goes wrong are undoubtedly severe. However, the cost of a failed climate transition should equally be borne in mind.

As to whether nuclear energy is currently investible for our Responsible and Sustainable Funds, the case is weaker. As investors with a fiduciary duty to our clients, we tend to favour investment in less capital-intensive and risky forms of low carbon energy. Therefore, whilst we believe there is a case to be made for the environmental and social value of nuclear energy, it must be matched by an equally attractive investment opportunity for us to consider allocating capital.

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Our Responsible Investment Team

We have a specialist in-house Responsible Investment (RI) team who carry out thematic and stock-specific research to identify ethically responsible investment ideas for our range of screened Funds. Headed up by Neville White, Head of RI Policy & Research, and supported by Senior Responsible Investment Analysts Carlota Esguevillas and Rita Wyshelesky and Responsible Investment Analysts Amelia Gaston and Cordelia Dower-Tylee, the team is also responsible for creating an on-going dialogue with companies, allowing us to engage on a wide variety of ethical and socially responsible investment concerns. For investors, it's an added layer of assurance that our client's money is being invested in companies that are operating in a responsible and sustainable way. Our ethical and responsible investment process is overseen by an independent Advisory Panel that meets three times a year, and comprises industry and business experts, appointed for their specialist knowledge.

Neville White
Head of RI Policy and Research

Rita Wyshelesky
Senior RI Analyst

Carlota Esguevillas
Senior RI Analyst

Amelia Gaston
RI Analyst

Cordelia Dower-Tylee
RI Analyst

We hope you enjoy this RI Expert Brief and find it useful and informative.
For any further information please contact us on:

0800 011 3821
or at **ifa@edentreeim.com**
or visit **edentreeim.com**

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