Article

Alternative Law Journal
2024, Vol. 49(2) 149–157

DOI: 10.1177/1037969X241249569
journals.sagepub.com/home/alj

Demonised energy: Could nuclear power help Australia achieve net zero emissions by 2050?

Evgeny Guglyuvatyy
Department of Business Law and Taxation, Monash University, Malaysia

Abstract
Nuclear energy is probably the most controversial source of energy praised by some and demonised by others. Although several countries acknowledge the benefits of nuclear power and continue to support its use, there are some nations such as Australia that reject nuclear energy. The implementation of the nuclear moratorium by the Australian federal government in 1998, coupled with the shared net zero ambition of the country, has the potential to reinvigorate a crucial debate on nuclear power. Revaluating the nuclear moratorium could foster public debate and private sector involvement, potentially enabling financially viable, safe, and environmentally sustainable nuclear power in the future.

Keywords
Atomic energy, climate change, net zero by 2050, Australia

Many nations have pledged to achieve net zero emissions by the year 2050. The swift progress of renewable energy sources, particularly the decreasing costs of electricity that they generate, is prompting countries to establish more ambitious targets to decrease greenhouse gas (GHG) emissions. The rapid advancement of electric vehicle technologies, backed by many car manufacturers and governments, is also contributing to this optimistic outlook. However, the challenge of intermittency inherent in renewable energy sources, particularly wind and solar energy, as well as the costly electricity storage systems, raise some doubts about the future phasing-out of coal and gas-fired power plants currently used to compensate for the intermittency issues of renewables.[1]

Nuclear energy is probably the most controversial source of energy. Negative perceptions towards nuclear power, especially around the safety of waste and the possibility that an accident could release radiation into the environment, persist in many countries including the United States of America (US/America), Australia, Germany and several other countries. Meanwhile, South Korea, China, Russia and India have continued to develop nuclear power generation. For example, South Korea has developed the necessary competencies and has continued to build nuclear power plants.[2] Several countries, including China, India and Russia, have already pledged to promote the advancement of nuclear power generation.[3]

However, there are other developed countries, such as Australia, that have moved away from nuclear power. The Australian government's nuclear moratorium implemented in 1998, along with the net zero ambition, may serve as a driving force to revive the crucial debate on nuclear power. Australia is responsible for about 1 per cent of global GHG emissions; however, Australia's role as a significant coal and gas producer means, when accounting for emissions from its exported fossil fuels, that its contribution to global emissions increases to around 4 per cent.[4] Despite the increasing shift towards renewable energy sources for the

[1]Anne Sjoerd Brouwer et al, 'Impacts of large-scale Intermittent Renewable Energy Sources on electricity systems, and how these can be modeled' (2014) 33 *Renewable and Sustainable Energy Reviews* 443–66.
[2]Jessica R Lovering, Arthur Yip and Ted Nordhaus, 'Historical construction costs of global nuclear power reactors' (2016) 91 (April) *Energy Policy* 371–82.
[3]World Nuclear News, *China and Russia sign fast-neutron reactors cooperation agreement* (22 March 2023).
[4]Tom Swann, 'High Carbon from a Land Down Under: Quantifying CO2 from Australia's fossil fuel mining and exports', *The Australia Institute* (2019).

Corresponding author:
Associate Professor Evgeny Guglyuvatyy, Department of Business Law and Taxation, School of Business, Monash University Malaysia, Jalan Lagoon Selatan, 46150, Bandar Sunway, Selangor Darul Ehsan, Malaysia.
Email: Evgeny.Guglyuvatyy@monash.edu

nation's power supply, the extraction and export of fossil fuels will likely remain a vital part of Australia's economy for some years to come.

Australia has committed to achieving net zero emissions by 2050. The majority of emissions cuts in the government's plan for the power sector are expected to come from renewable energy. The Australian government is prioritising the reduction of GHG emissions and the promotion of renewable energy sources, while not considering nuclear power as an option.[5] The Opposition party, on the other hand, is arguing that nuclear power can provide Australia with the emission-free electricity it needs.[6] Recently, with renewed interest in nuclear power in the US and Europe, the debate on the necessity and acceptability of nuclear power in Australia has gained attention.[7] This article contributes to the ongoing debate regarding the crucial role of nuclear energy in addressing climate change, emphasising its significance for both Australia and the global community.

Historical background of nuclear energy and its opposition

Nuclear fission made significant progress after World War 2, following its initial development in the early 19th century.[8] Both the US and the Union of Soviet Socialist Republics (USSR/Soviet Union), which had become rivals, made significant strides in their nuclear weapons programs, and also began exploring the potential of nuclear energy for electricity generation. In the 1960s, other countries, particularly the United Kingdom (UK) and France, joined the nuclear 'club' and initiated their own nuclear energy generation projects.

Even prior to the development of nuclear weapons and extensive testing in both the US and Soviet Union, popular culture in America featured the concept in books and movies.[9] X-rays were embraced in the early 20th century as a fascinating idea of invisible rays capable of revealing internal structures of the human body. This laid the groundwork for the public to anticipate the potential hazards of nuclear fission, as portrayed in pop culture, books and movies. Subsequently, issues related to radiation and radioactive fallout were frequently discussed in scientific journals and various other media. As a result, the public in the US and some other Western European countries opposed the idea of building nuclear power plants nearby.

In 1971, the US experienced a significant turning point, marked by a historic ruling from the US Court of Appeals, which pertained to the Calvert Cliffs Nuclear Power Plant.[10] This decision served as the basis for a major upgrade of the Atomic Energy Commission (AEC) licensing procedures. The court declared that the AEC's regulations for enforcing the *National Environmental Policy Act of 1969* did not meet the requirements of the law in several ways.[11] This opened the option for civil lawsuits to interfere with the licensing and construction process, sometimes resulting in additional delays.

Business interest in nuclear plant projects in the US has declined since the Calvert Cliffs ruling. By 1978, the expenses associated with building reactors that commenced following the 1971 court decision had escalated by 50 to 200 per cent.[12] Additionally, in 1979, an incident occurred at the Three Mile Island nuclear power plant. Approximately 150,000 people were forced to evacuate from the area around the nuclear power plant.[13] The response to evacuate was clearly excessive, given that not a single person was found to have health issues, even at the plant. In contrast, coal power plants generally operated without incident, yet caused numerous deaths, and this did not cause much alarm, let alone trigger evacuations. The cost per kilowatt of electricity generated by nuclear plants that were constructed before this event was 2.8 times lower than those built afterward.[14] The increase in prices was caused by the average construction duration of such nuclear plants in the US increasing by 2.2 times. Subsequently, from 1978 to 2012, no additional licences were issued for nuclear power plant construction in the US.[15]

In 2012, a permit was granted to build two 1.1 gigawatt reactors in the US state of South Carolina, marking the first such construction in decades.[16] Nevertheless, stringent regulations and the loss of necessary competencies by the American nuclear industry led to significant construction delays. As a result, Westinghouse Electric Company, which had led the construction, announced on 24 March 2017 that they were filing for Chapter 11 bankruptcy due to losses of US$9 billion from nuclear reactor construction projects in the US.[17]

Unfortunately, the American experience of negative public attitude towards nuclear energy was repeated in

[5]Australian government, *Powering Australia* (Web Page) https://www.dcceew.gov.au/energy/strategies-and-frameworks/powering-australia.
[6]Tamsin Rose, Catie McLeod and Tory Shepherd, 'Peter Dutton in standoff with state Liberal leaders over federal Coalition's nuclear plan', *The Guardian* (online, 23 March 2024) https://www.theguardian.com/australia-news/2024/mar/24/peter-dutton-liberal-leaders-nuclear-power-ban.
[7]Ibid.
[8]Spencer R Weart, *Nuclear Fear* (Harvard University Press, 1988).
[9]Ibid.
[10]*Calvert Cliffs' Coordinating Committee Inc v US Atomic Energy Commission*, 449 F 2d 1109 (DC Cir, 1971).
[11]Ibid.
[12]Lovering, Yip and Nordhaus (n 2).
[13]'Backgrounder on the Three Mile Island Accident', *US Nuclear Regulatory Commission* (Web Page) https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html.
[14]Lovering, Yip and Nordhaus (n 2) 375.
[15]David Biello, 'Nuclear Reactor Approved in US for First Time Since 1978', *Scientific American* (online, 9 February 2012) https://www.scientificamerican.com/article/first-new-nuclear-reactor-in-us-since-1978-approved/#:~:text=YearsofshiftingandsmoothingnuclearpowerstationnearAugusta.
[16]Ibid.
[17]Makiko Yamazaki and Tim Kelly, 'Toshiba's Westinghouse files for bankruptcy as charges jump', *BNN Bloomberg* (Web page, 29 March 2017) https://www.bnnbloomberg.ca/toshiba-s-westinghouse-files-for-bankruptcy-as-charges-jump-1.709134.

other countries. For example, France, the world's second-largest producer of nuclear energy, generated about 70 percent of its total energy output from its nuclear power plants in 2022.[18] However, after Japan's Fukushima disaster in 2011, 57 per cent of French citizens polled expressed opposition to nuclear energy being produced in their country.[19]

Nuclear regulation in Australia

In Australia, the first Commonwealth legislation was the *Atomic Energy (Control of Materials) Act 1946* (Cth). At that time, uranium was classified as a strategic material and the government reserved its production in Australia. Between the 1980s and '90s, opposition to nuclear power in Australia increased as a result of the UK's nuclear tests at the Maralinga site in South Australia, French nuclear testing in the Pacific, the *Rainbow Warrior* incident,[20] proposals for a medical and industrial nuclear waste dump, as well as secret plans to use Australia as a site for the global commercial nuclear waste disposal.[21]

A comprehensive regulatory regime for nuclear activities was not established until the Australian government acted on the recommendations of the Fox Inquiry regarding the Ranger uranium mine and commercial uranium exports.[22] In 1978, several legislative measures related to uranium mining were introduced. Also, the *Environment Protection (Nuclear Codes) Act 1978* established a coordination mechanism to enable the Commonwealth to collaborate with the states and territories in developing national codes of practice for nuclear activities.

At present, Australia's nuclear sector is limited to the OPAL nuclear reactor at Lucas Heights, and well as uranium mining, as it does not have a substantial nuclear industry. The Australian Nuclear Science and Technology Organisation (ANSTO) runs the country's lone nuclear fuel cycle facility. The private sector's nuclear ventures are restricted to two active uranium mines – Ranger in the Northern Territory and Olympic Dam in South Australia.[23] The states and territories have primary constitutional responsibility for regulating uranium mining, and any environmental impacts would generally be localised within the relevant jurisdiction. While it may appear that nuclear regulation in Australia is split between the Commonwealth and the states and territories, the structure has been designed to fit the circumstances and is generally appropriate given Australia's nuclear moratorium.[24]

Net zero and nuclear power

Back in 1988, nuclear energy accounted for 17.08 per cent of the world's energy but, by 2018, it had dropped to 10.21 per cent, resulting in a 1.6-fold decline in its overall share.[25] This trend of reducing the use of nuclear energy may appear paradoxical since global warming has become of unanimous concern among many nations. Nuclear energy development has decreased significantly since the 1980s, often attributed to accidents such as those previously mentioned at Three Mile Island and Fukushima, as well as the Chernobyl accident.[26] Despite past incidents, proponents of nuclear energy argue that nuclear plants are generally safer than other types of power plant.[27]

Energy sources have varying carbon footprints, with coal emitting the most CO2 at 900 grams per kilowatt hour (kWh) produced.[28] In contrast, nuclear energy has a relatively small carbon footprint, primarily from the production of concrete, steel and uranium mining.[29] Coal alone accounts for about 15 billion tons of carbon dioxide per year.[30] If nuclear power had been used instead of coal in the past, the scale of global warming would be significantly different today. Nuclear power emits only a few grams of CO2 equivalent per kWh of electricity produced during its lifecycle. Although estimates vary, studies by the United Nations (UN) Intergovernmental Panel on Climate Change

[18]'Nuclear Power in France', *World Nuclear Association* (Web Page, August 2023) https://world-nuclear.org/information-library/country-profiles/countries-a-f/france.aspx.

[19]Sylvain Brouard and Isabelle Guinaudeau, 'Policy beyond Politics? Public opinion, party politics and the French pro-nuclear energy policy' (2015) 35(1) *Journal of Public Policy*.

[20]David Robie, 'The Rainbow Warrior, Secrecy and State Terrorism: A Pacific journalism case study' (2016) 22(1) *Pacific Journalism Review* 187–213.

[21]Clarence Hardy, *Atomic Rise and Fall: The Australian Atomic Energy Commission, 1953–1987* (Glen Haven Publishing, 1999).

[22]Les Dalton, 'The Fox Inquiry: Public Policy Making in Open Forum' (2006) 90 *Labour History* 137–154; Senate Select Committee on Uranium Mining and Milling, Parliament of Australia, *The Fox Report* (c01-1) https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Former_Committees/uranium/report/c01-1; Commission, *Ranger Environmental Uranium Inquiry* (Report, 17 May 1977) https://www.dcceew.gov.au/sites/default/files/documents/ranger-uranium-environmental-inquiry-fox-report-2.pdf.

[23]Paul Kay, 'Australia's Uranium Mines: Past and present' (Report, Science, Technology, Environment and Resource Group, Parliamentary Library, Parliament of Australia) https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Former_Committees/uranium/report/c07.

[24]John Carlson and John Bardsley, 'Nuclear Regulation in Australia: Future Possibilities' (Conference Paper, Second Conference on Nuclear Science & Engineering in Australia, 16–17 October 1997).

[25]'Electricity production from fossil fuels, nuclear and renewables, World', *Our World in Data* (Web Page, 2022) https://ourworldindata.org/grapher/elec-fossil-nuclear-renewables.

[26]Sigvard Eklund, 'Nuclear power development: The challenge of the 1980s' (1981) 23(3) *IAEA Bulletin* 8–18; 'Chernobyl Accident 1986', *World Nuclear Association* (Web Page, April 2022) https://world-nuclear.org/information-library/safety-and-security/safety-of-plants/chernobyl-accident.aspx.

[27]Richard Rhodes, 'Why Nuclear Power Must Be Part of the Energy Solution', *YaleEnvironment360* (Web Page, 19 July 2018); Valérie Masson-Delmotte et al (eds), *Global Warming of 1.5°C: An IPCC Special Report on the Impacts of Global Warming of 1.5°C above Pre-industrial levels and Related Global Greenhouse Gas Emission Pathways* (Intergovernmental Panel on Climate Change, 2019).

[28]National Academy of Science, *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use* (National Research Council, 2010); Aaron J Cohen et al, 'The Global Burden of Disease due to Outdoor Air Pollution' (2005) 68(13-14) *Journal of Toxicology and Environmental Health*, Part A, 68, 1301–7; 1 kilowatt hour (kWh) is the energy consumed by a 1,000-watt or 1-kilowatt electrical appliance operating for 1 hour.

[29]Ibid.

[30]'Global CO2 emissions rebounded to their highest level in history in 2021', *International Energy Agency* (Press release, 8 March 2022) https://www.iea.org/news/global-co2-emissions-rebounded-to-their-highest-level-in-history-in-2021.

(IPCC) demonstrate a median value of 12g CO2 equivalent/kWh for nuclear energy, which is comparable to wind energy and lower than all types of solar energy.[31]

The term 'deathprint', which refers to the number of deaths caused by different energy sources per kWh produced, is often overlooked in discussions about energy.[32] Coal has the worst deathprint, while wind and nuclear have the best.[33] Despite worst-case scenarios like Chernobyl, Fukushima, and uranium mining deaths, nuclear energy has the lowest deathprint and is considered very safe.[34] Consistent with estimates, the total number of accidental deaths caused by nuclear power plant accidents throughout history is less than 90 deaths per trillion kilowatt-hours.[35]

According to some academics, nuclear power has been a slow, expensive and dangerous source of energy, and the problem of nuclear waste disposal remains unresolved.[36] However, this statement only holds partially true. Modern nuclear power plants have evolved and differ from earlier versions. There are novel technologies being developed, such as TerraPower, a nuclear company established by Bill Gates, that is innovating fast sodium reactor technology.[37] A technologically similar Russian BN-800 fast neutron reactor at the Beloyarsk[38] nuclear power plant, which employs MOX (mixed oxide) fuel, is already in operation.[39] There is renewed interest in fast reactors due to their ability to fission actinides, including those recovered from ordinary reactor used fuel.

There are also some critics who claim that nuclear power plants are unsuitable for Australia, both at present and in the future.[40] Critics also argue that the idea of safe and affordable nuclear power is unrealistic and has never been achieved.[41] They suggest that investing in nuclear power may hinder investment in the safer alternatives of renewable energy. Conversely, a number of international experts and organisations claim that renewable energy sources may not be a viable solution to replace nuclear power plants in the near future, and that it will be very difficult to achieve the goal of the *Paris Agreement*[42] without nuclear power.[43]

It is worth noting that, since the inception of nuclear power production in 1954, roughly 400,000 tonnes of used fuel has been discharged from commercial power reactors, with approximately 30 per cent having been reprocessed.[44] The push for higher production of wind and solar energy and the increased usage of batteries come with a significant environmental cost. These technologies require vast resources and, to meet the escalating demand for renewable energy, electric vehicles, and battery storage, there is a need for a significant increase in mining operations. However, experience demonstrates that mining can cause substantial harm to the environment.[45] Moreover, the challenge of recycling wind turbines, batteries and solar panels is becoming increasingly complex. As the production of renewables continues to surge, pollution levels are inevitably increasing, exacerbating environmental concerns.[46] For example, currently most used solar panels go to landfill – in Australia alone, more than a quarter of a million tons of panel material may end up in landfill by 2030 if an efficient recycling method is not found.[47]

In recent years, the cost of renewable energy sources has been declining, while the price of nuclear power has risen. As a result, opponents of nuclear power have shifted their focus to renewable energy sources as a less expensive solution to combat climate change. The cost of building wind turbines in the US grew by 10 per cent annually during the 2000s, a trend that is now common in nuclear power in

[31]Steffen Schlömer (ed), 'Technology-specific Cost and Performance Parameters: Annex III' in Edenhofer et al, *Climate Change 2014: Mitigation of Climate Change – Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press, 2014).
[32]James Conca, 'How Deadly Is Your Kilowatt? We Rank the Killer Energy Sources', *Forbes* (10 June 2012).
[33]Peter Bickel and Rainer Friedrich, 'ExternE: Externalities of Energy', *Directorate-General for Research Sustainable Energy Systems* (European Union Report EUR 21951, 2005).
[34]Christopher Helman, 'Fukushima's Refugees Are Victims of Irrational Fear, Not Radiation', *Forbes* (10 March 2012).
[35]Hannah Ritchie, 'What are the safest and cleanest sources of energy?', *Our World in Data* (Web Page, 10 February 2020) https://ourworldindata.org/safest-sources-of-energy.
[36]Catherine Clifford, 'How Bill Gates' company TerraPower is building next-generation nuclear power', *CNBC: Make it* (Web Page, 8 April 2021) https://www.cnbc.com/2021/04/08/bill-gates-terrapower-is-building-next-generation-nuclear-power.html.
[37]'Natrium Reactor and Integrated Energy Storage', TerraPower (Web Page) https://www.terrapower.com/our-work/natriumpower/.
[38]'Beloyarsk NPP prepares for construction of BN-1200', *Nuclear Engineering International* (Web Page, 3 January 2023) https://www.neimagazine.com/news/newsbeloyarsk-npp-prepares-for-construction-of-bn-1200-10486479.
[39]Unlike enriched uranium, which is traditional in the nuclear industry, MOX fuel pellets are produced using plutonium oxide obtained from the reprocessing of spent nuclear fuel from a traditional water-water energetic reactor (WWER), and depleted uranium oxide (obtained through defluorination of depleted uranium hexafluoride (DUHF), also known as secondary 'tails' of the enrichment industry). 'Mixed Oxide (MOX) Fuel', *World Nuclear Association* (Web Page, October 2017) https://world-nuclear.org/information-library/nuclear-fuel-cycle/fuel-recycling/mixed-oxide-fuel-mox.aspx.
[40]'Nuclear Power Stations are not Appropriate for Australia – and Probably Never will be', *Climate Council* (Web Page, 18 January 2022) https://www.climatecouncil.org.au/nuclear-power-stations-are-not-appropriate-for-australia-and-probably-never-will-be/.
[41]Clifford (n 36).
[42]The Paris Agreement is an international climate change treaty adopted by 196 countries in Paris, France, on 12 December 2015 (Web page) https://unfccc.int/process-and-meetings/the-paris-agreement.
[43]UN News, 'Global climate objectives fall short without nuclear power in the mix: UNECE', *United Nations* (Web Page, 11 August 2021) https://news.un.org/en/story/2021/08/1097572; Nico Bauer, Robert J Brecha and Gunnar Luderer, 'Economics of nuclear power and climate change mitigation policies' (2012) 109(42) *PNAS*.
[44]'Nuclear Technology Review 2020', *International Atomic Energy Agency* (Report No GC(64)/INF/2, September 2020).
[45]Elsa Dominish, Sven Teske and Nick Florin, *Responsible Minerals Sourcing for Renewable Energy* (Report prepared for Earthworks by the Institute for Sustainable Futures, University of Technology Sydney, 2019).
[46]Javier Chiquillo Molano et al, 'A holistic reverse logistics planning framework for end-of-life PV panel collection system design' (2022) 317 *Journal of Environmental Management* 1–16.
[47]Charlotte Elton, 'Recycling dead solar panels isn't easy. These Australian scientists might have found a solution', *EuroNews: Green* (6 March 2023) https://www.euronews.com/green/2023/03/06/recycling-dead-solar-panels-isnt-easy-these-australian-scientists-might-have-found-a-solut.

some countries.[48] Despite this, wind energy was not abandoned; rather, efforts have been made to understand the causes of rising costs and identify potential solutions to counteract them. These efforts have had the desired effect, as the cost of wind energy has dropped significantly. Similarly, the cost of solar panels is declining as manufacturers become more experienced in their production. Nuclear power could experience similar cost reductions. For example, the cost of nuclear power in South Korea has dropped markedly over time.[49]

According to a report from CSIRO in Australia, nuclear energy costs are estimated to be 50 to 100 per cent higher than wind and solar energy.[50] The International Energy Agency (IEA) and Nuclear Energy Agency has calculated that the overnight cost for constructing a nuclear power plant in OECD countries increased from around $1900/kWe in the late 1990s to $3850/kWe in 2009.[51] The OECD report shows that the overnight costs ranged from $2157/kWe in South Korea to $6920/kWe in Slovakia. The report also suggests that, in certain countries, the cost of nuclear energy may be comparable to that of wind and solar energy.

The high cost of nuclear energy reinforces the scepticism of some European politicians . However, advocates of nuclear energy argue that, despite Europe's move away from fossil fuel, the fluctuations in oil and gas prices do not affect the cost of nuclear energy.[52] Nevertheless, some analysts remain sceptical about nuclear power's ability to serve as an effective carbon-free option to address the ongoing energy crisis.[53] Nuclear energy remains a topic of contention, with Europe divided into two opposing camps.[54] The majority of European countries endorse the use of nuclear power. However, several EU member states, including Germany, Austria, Denmark, Portugal and Luxembourg, express opposition to nuclear energy and advocate against its inclusion in the EU taxonomy system.[55]

Germany – where The Green party, a current ruling coalition member, strongly opposes the EU's reliance on nuclear energy – has permanently closed its last three nuclear plants[56] but there are still voices in favour of reinstating the closed plants. A recent poll revealed that more than 60 per cent of German citizens consider nuclear power plants are necessary in the face of the ongoing conflict in Eastern Europe.[57] However, according to Germany-based nuclear physicist Thomas O'Donnell, the Green Party is reluctant to change its position on nuclear power, stating that '[i]t would be suicide for the Greens to say we were wrong about nuclear power … so they're forced to continue with the old battle plan'.[58]

The EU countries that are proponents of nuclear power, headed by France, have jointly appealed to the EU Commission to classify nuclear plants and waste storage as environmentally friendly economic activities.[59] France is taking a leading role in this effort, with its 56 nuclear reactors making it the EU's foremost atomic power.[60] France is continuing to invest in nuclear power stations and has plans to construct at least six more reactors. Currently, nuclear reactors provide 25 per cent of the EU's electricity, making it a challenging task to replace this significant energy source with alternative carbon-free options.[61] Among the leading EU economies, France has the most exceptional record for emissions. When compared to France, Germany generates six times more per-capita emissions from electricity generation.[62] Countries such as Germany and Austria, which are against nuclear power, advocate for renewable energy sources as the solution to meet the EU's energy demands. However, despite technological advances, there are still no low-cost storage solutions for intermittent energy sources. And nuclear plants can produce energy continuously, unlike intermittent renewable energy such as solar and wind.

Nuclear energy stands out with the highest capacity factor among all energy sources, producing dependable and carbon-free power at a rate surpassing 92 per cent in the US in 2021.[63] Despite nuclear power plants accounting for only 8 per cent of the total US generation capacity in 2021, they produced 19 per cent of the country's electricity due

[48]Brad Plumer, 'Why America abandoned nuclear power (and what we can learn from South Korea)', *Vox* (Web Page, 2016) https://www.vox.com/2016/2/29/11132930/nuclear-power-costs-us-france-korea.
[49]Lovering, Yip and Nordhaus (n 2).
[50]Paul Graham et al, 'GenCost 2021–22', *CSIRO* (Final report, July 2022).
[51]International Energy Agency/Nuclear Energy Agency/OECD, *Projected Costs of Generating Electricity* (2020). Note that kWe refers to one thousand watts of electric capacity; see US Energy Information Administration, *Glossary* https://www.eia.gov/tools/glossary/index.php.
[52]Marco Sonnberger et al, 'Climate concerned but anti-nuclear: Exploring (dis)approval of nuclear energy in four European countries' (2021) 75 102008 *Energy Research & Social Science*.
[53]Ibid.
[54]Rosie Frost, 'Europe is divided on nuclear power: Which countries are for and against it?' *EuroNews: Green* (Web Page, 1 April 2024) https://www.euronews.com/green/2023/03/13/europe-is-divided-on-nuclear-power-which-countries-are-for-and-against-it.
[55]Ibid; the EU taxonomy is a system providing a list of environmentally sustainable activities. European Commission, *EU taxonomy for sustainable activities* (Web Page) https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en.
[56]'Nuclear Power in Germany', *World Nuclear Association* (Web Page, April 2023) https://world-nuclear.org/information-library/country-profiles/countries-g-n/germany.aspx.
[57]Melanie Amann et al, 'Germany Sees Tidal Shift in Sentiment Toward Atomic Energy', *Spiegel* (online, 12 August 2022).
[58]Guy Chazan, 'Why Germany is resisting calls to ease energy crunch by restarting nuclear power', *Financial Times* (online, 20 April 2022) https://www.ft.com/content/229c21c7-991c-4b44-a2f9-20991670a4ba.
[59]'Nuclear Power in the European Union', *World Nuclear Association* (Web Page, January 2024) https://world-nuclear.org/information-library/country-profiles/others/european-union.aspx.
[60]'Nuclear Power in France' (n 18).
[61]'Nuclear Power in the European Union' (n 59).
[62]'France 2021: Energy Policy Review', *International Energy Agency* (November 2021) https://www.iea.org/reports/france-2021; German Environment Agency/Umwelt Bundesamt, *Indicator: Greenhouse gas emissions* (Web Page, 2023) https://www.umweltbundesamt.de/en/data/environmental-indicators/indicator-greenhouse-gas-emissions#at-a-glance.
[63]US Energy Information Administration, *Total Energy Data: Monthly Energy Review* (Web Page, 26 March 2024) https://www.eia.gov/totalenergy/data/monthly/.

to their high capacity factor.[64] This makes nuclear energy much more reliable than most other alternatives to fossil fuels, presenting nuclear plants as a dependable backup source of energy. Also, when calculating energy costs, the installed capacity utilisation factor – that is, what percentage of energy is generated from the declared capacity – is often not taken into account. However, allowing for the installed capacity utilisation factor, the cost of building wind and solar power plants will become comparable to the cost of building a nuclear power plant.[65] Another important advantage of nuclear power is its ability to sustain a consistent level of power output for up to 60 years, with the potential to enhance output through thermal optimisation after the commencement of plant operation.[66] By comparison, wind turbines must be replaced after 25 years of service due to wear and tear, and solar batteries degrade at a rate of 0.5 per cent of their capacity per year, resulting in a 25 per cent decrease in output over the course of half a century.[67]

An important argument against nuclear energy is that the construction time of a nuclear power plant is significant, ranging from six to eight years and in some cases more. However, South Korea, Japan and China could build such plants in three to five years, and new small modular reactors, which are actively being developed in the US and other countries, can be built in three years. In particular, during the US President's visit to Canada in March 2023, the leaders issued a joint statement reaffirming their commitment to accelerating the transition to clean energy in both countries.[68] The statement also declared that Canada will join the Foundational Infrastructure for Responsible Use of Small Modular Reactor Technology (FIRST) program.[69] Russian Rosatom[70] and the China Atomic Energy Authority (CAEA) signed a Comprehensive Program for Long-Term Cooperation in the field of fast neutron reactors and closing the nuclear fuel cycle in March 2023.[71] And, in the same month, the UK's Chancellor declared that nuclear energy will be considered 'environmentally sustainable' in the country's green taxonomy after consultation.[72]

The discussion on whether the world requires nuclear power is highly polarising. Some believe that it is too risky and costly, while others argue that it is a dependable source of clean energy and essential to meeting ambitious climate targets. The IEA report highlights the additional challenges of pursuing CO2 reduction with reduced dependence on nuclear energy.[73] It suggests various potential government actions, such as extending the operation of existing nuclear power plants, supporting new nuclear construction, and fostering the development of novel nuclear technologies, in order to address these challenges. The IPCC incorporated nuclear-generated electricity into each of its four proposed paths to net zero carbon emissions in its 2021 report.[74] The current reality, confirmed by major intergovernmental bodies and leading experts, is that nuclear power is essential, and that it will be much more difficult to reach net zero by 2050 if nuclear power is phased out – a consideration that needs to be taken into account by those who advocate against nuclear energy.[75]

Australian nuclear debate in light of the net zero ambition

Australia's newly implemented *Climate Change Act 2022* (Cth) and *Climate Change (Consequential Amendments) Act 2022* (Cth) incorporate emissions reduction targets of 43 per cent below 2005 levels by 2030, as well as confirm the plan to achieve net zero emissions by 2050.[76] This represents a substantial increase from the previous government's GHG reduction target of 26 to 28 per cent by 2030.[77] Australia's strategy for addressing climate change has evolved, with the government implementing reforms to various existing policies, including the Safeguard Mechanism.[78]

Despite the present government staying away from a nuclear debate, the Liberal Opposition leader, Peter Dutton, has committed to bringing nuclear energy policy into focus for the next election.[79] He believes that nuclear power is a viable option to reduce emissions and lower electricity prices, citing the examples of France and the UK. Dutton has appointed Ted O'Brien as the shadow minister for climate change and energy, who has previously

[64]Ibid.
[65]Nuclear Energy Agency/OECD, *The Costs of Decarbonisation: System Costs with High Shares of Nuclear and Renewables* (2019).
[66]World Nuclear News, *NRA approves use of Japanese reactors beyond 60 years* (14 February 2023).
[67]'Renewable Energy and Electricity', *World Nuclear Association* (Web Page, August 2021) https://world-nuclear.org/information-library/energy-and-the-environment/renewable-energy-and-electricity.aspx.
[68]Justin Trudeau, Prime Minister of Canada, 'Joint Statement with President Biden' (News Release, 24 March 2023) https://www.pm.gc.ca/en/news/statements/2023/03/24/prime-minister-trudeau-and-president-biden-joint-statement.
[69]World Nuclear News, *Canada, USA pledge to bolster nuclear supply chains, SMR development* (27 March 2023).
[70]At present, the Russian state corporation Rosatom is the global leading constructor of nuclear power plants.
[71]World Nuclear News, *China and Russia sign fast-neutron reactors cooperation agreement* (22 March 2023).
[72]Jeremy Hunt, UK Chancellor, 'Spring Budget 2023 Speech', *Gov.uk* (Web Page, 15 March 2023) https://www.gov.uk/government/speeches/spring-budget-2023-speech; World Nuclear News, *UK 'to class nuclear as environmentally sustainable'* (15 March 2023).
[73]'Nuclear Power in a Clean Energy System', *International Energy Agency* (Final report, May 2019).
[74]Joeri Rogelj et al, 'Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development' in Valérie Masson-Delmotte et al (eds), *Global Warming of 1.5°C* (Intergovernmental Panel on Climate Change, 2019) https://www.ipcc.ch/sr15/.
[75]Nuclear Power in a Clean Energy System (n 73); ibid.
[76]*Climate Change Act 2022* (Cth) s 10.
[77]Emily Hanna and Elizabeth Smith, 'Climate change and emissions reduction' (Briefing Book, Parliamentary Library, Parliament of Australia) https://www.aph.gov.au/About_Parliament/Parliamentary_departments/Parliamentary_Library/pubs/BriefingBook47p/ClimateChangeEmissionsReduction.
[78]The Safeguard Mechanism mandates Australia's top GHG emitting facilities to align their emissions with the country's reduction targets. See, Evgeny Guglyuvatyy, *Climate Change, Forests and Federalism: Australian experience* (Springer, 2022) Ch 4; Clean Energy Regulator, 'Safeguard Mechanism' (Web Page, 9 April 2024) https://cer.gov.au/home/schemes.
[79]Rose, McLeod and Shepherd (n 6).

advocated for Australia to incorporate nuclear power into its energy mix.[80] O'Brien chaired a parliamentary committee in 2019 that recommended the government consider lifting the current moratorium on nuclear energy for new and emerging technologies, including small modular reactors.[81] Additionally, some commentators attribute to O'Brien the development of the Coalition's proposal to construct large-scale nuclear reactors nationwide, ostensibly aimed at impeding the transition from coal.[82]

The current government's stance on nuclear power can be explained by the supposed negative public perception of nuclear power, as well as the influence of its political allies, the Australian Greens, who, similar to The Greens in Germany, do not see nuclear power as a viable option for Australia and argue that nuclear power generation must be stopped.[83] Negative perceptions towards nuclear power, especially around the safety of waste and the possibility of an accident, persist to some extent in Australia.[84] However, a June 2022 survey, commissioned by the Institute of Public Affairs, demonstrated significant support for the construction of nuclear power plants in the country. Specifically, 53 per cent of participants agreed with the assertion that 'Australia should build nuclear power plants to supply electricity and reduce carbon emissions'.[85] Of those surveyed, 24 per cent neither agreed nor disagreed, and 23 per cent disagreed with the statement. The survey also showed that there is widespread support for nuclear power across all political parties, with a higher percentage of supporters than opposers in each party grouping. Even among Greens voters, 44 per cent of respondents supported the building of nuclear plants, while 30 per cent opposed it. Additionally, the poll found that there is more support for nuclear power than opposition across all age and income groups.[86]

Over the past few years, three distinct enquiries have examined various potential opportunities related to nuclear power in Australia.[87] The House of Representatives' Standing Committee on Environment and Energy carried out an inquiry into the prerequisites for nuclear energy in Australia, and a report was submitted on 13 December 2019.[88] The New South Wales (NSW) Parliament conducted an investigation into uranium mining and the potential for nuclear power in that state, with a report being tabled in March 2020.[89] In addition, in 2020 the Legislative Council's Environment and Planning Committee of Victoria's Parliament held an inquiry into nuclear prohibition in that state.[90] South Australia also held a Royal Commission between 2015 and 2016 to examine the expansion of its nuclear industry.[91] It is important to recognise that Australian authoritative reports generally support the assertion that nuclear power does not present a timely or cost-effective solution to Australia's imperative for decarbonising its electricity supply. However, these inquiries indicate that the moratorium on nuclear power impedes Australia from conducting a balanced assessment of the costs and commercial potential of nuclear power within the country. Additionally, the current moratorium hinders the initiation of public policy dialogues essential for determining the viability of nuclear power in Australia.

Removing the moratorium is a crucial step that would allow the governments, businesses, and the Australian public to gather the information required to make informed decisions about the advantages and disadvantages of nuclear power. Although two Acts of Parliament currently prohibit nuclear power in Australia, the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) ('EPBC Act') is the only one that requires immediate reform to allow for the potential development of a nuclear industry. The *Australian Radiation Protection and Nuclear Safety Act 1998* (Cth) also includes a prohibition, but this restriction pertains only to Commonwealth entities and is therefore not an immediate obstacle for state government entities or private sector developers who wish to consider nuclear power. Section 140A of the EPBC Act states that the Minister is not permitted to approve any action involving the construction or operation of the following nuclear installations: a) a nuclear fuel fabrication plant; b) a nuclear power plant; c) an enrichment plant; d) a reprocessing facility.

The primary initial action needed would be to repeal s 140A of the EPBC Act. This would allow global entrepreneurs to introduce and commercialise their nuclear designs and technologies in Australia, with the potential for eventual deployment across the country's extensive range of energy applications. It is important to note that removings 140A would not necessarily imply that a nuclear power plant will be constructed in Australia. For a nuclear power plant to be considered, it would need to be

[80]Ted O'Brien, House Standing Committee on the Environment and Energy, 'Nuclear Energy: Not without your approval' (Media Release, 13 December 2019).
[81]Ibid.
[82]Mike Seccombe, '"The most beige person": The man behind the Coalition's nuclear plans', *The Saturday Paper* (online, 16 March 2024) https://www.thesaturdaypaper.com.au/news/environment/2024/03/16/the-most-beige-person-the-man-behind-the-coalitions-nuclear-plans#hrd.
[83]The Greens, 'Nuclear and Uranium' (Web Page, 2020) https://greens.org.au/policies/nuclear-and-uranium.
[84]Deanne K Bird et al, 'Nuclear power in Australia: A comparative analysis of public opinion regarding climate change and the Fukushima disaster' (2014) 65 *Energy Policy* 644–53.
[85]Institute of Public Affairs, *Nuclear Power Poll* (April 2022).
[86]Ibid.
[87]Ian Cronshaw, 'Australian electricity options: Nuclear' (Research Paper, Parliamentary Library, Parliament of Australia, 20 July 2022) https://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/pubs/rp/rp2021/AustralianElectricityOptionsNuclear.
[88]House of Representatives Standing Committee on the Environment and Energy, Parliament of Australia, *Not Without your Approval: A Way Forward for Nuclear Technology in Australia* (Report, December 2019) https://www.aph.gov.au/nuclearpower.
[89]Legislative Council Standing Committee on State Development, Parliament of NSW, *Uranium Mining and Nuclear Facilities (Prohibitions) Repeal Bill 2019* (Report 46, March 2020).
[90]Legislative Council Environment and Planning Committee, Parliament of Victoria, *Inquiry into nuclear prohibition* (Final Report, 26 November 2020).
[91]*Nuclear Fuel Cycle Royal Commission* (Report, May 2016).

economically feasible and would also require environmental approval from the Commonwealth government. However, eliminating the prohibition in the Act would promote private sector engagement, with the expectation that an economically viable, safe and ecologically sustainable development may be established in the future.

Australia is home to nearly a third of the world's confirmed uranium reserves, and from which we have been exporting roughly 7000 tonnes per year.[92] This accounts for approximately 10 per cent of global supply and positions Australia as the fourth-largest uranium producer worldwide. Numerous nations are currently interested in and committed to nuclear power. China and India, the world's two most populous countries, are actively developing nuclear power and expanding their nuclear power generation substantially. China alone is planning to build up to 400 gigawatts of nuclear capacity by 2050.[93] Nuclear power plants in India produce about 3 per cent of the country's electricity, but India is aiming to increase its nuclear power capacity to generate about 9 per cent of the country's electricity by 2047.[94] With a number of countries committed to developing nuclear power generation, Australia has the potential not only to remain a major uranium exporter, but also to make progress in developing a large nuclear industry that would be much more economically viable than just focusing on uranium mining.

Commonwealth government leadership is needed to reform the regulatory framework for environmental approval of specific proposals related to nuclear power generation, and to explore potential opportunities in the nuclear sector. While Australia continues to mine and export uranium, its self-imposed ban on nuclear power prevents the development of a high-value, high-tech nuclear industry similar to Canada's.[95] The Canadian government has demonstrated support for the essential role of nuclear power in the clean energy transition having included it in the clean energy investment tax credit and made it eligible for various other tax incentives in the 2023 budget.[96]

Despite the Australian government-funded CSIRO's conclusion that domestic nuclear projects in the current decade are unlikely due to the technology's lack of commercial maturity and high costs, there are numerous independent experts and international organisations that emphasise the importance of nuclear power.[97] Many countries recognise nuclear energy as a valuable tool in combatting climate change. The Executive Secretary of the UN Economic Commission for Europe (UNECE) has noted that nuclear power is a crucial source of low-carbon electricity and heat, contributing to carbon neutrality and mitigating climate change.[98] Furthermore, the IPCC has released a report underscoring the significance of nuclear power in reducing global temperature increases.[99] The report projects a substantial increase in nuclear power usage, ranging from 60 per cent to 106 per cent by 2030.

With the current goal of achieving net zero emissions by 2050, there is an opportunity to reopen this crucial discussion, which could bring significant benefits to Australia and the world. It is essential for the Commonwealth government to take proactive steps towards regulatory reform and exploration of nuclear opportunities to align with the nation's emissions reduction goals and economic potential. Meeting the carbon emissions reduction targets outlined in the *Paris Agreement* is already an immense undertaking. It necessitates substantial investment in renewables and a greater reliance on nuclear power.

Conclusion

The world is striving to reduce GHG emissions and stop climate change. The goal of achieving zero emissions by 2050, supported by many countries, is an ambitious but necessary step in the fight against climate change. This is an enormous challenge for many countries, especially developing nations trying to meet the ever-increasing demand for electricity and at the same time reduce carbon emissions. To transition to clean energy in a limited timeframe, it is necessary to use all available sources of carbon-free energy, including nuclear power. Although a number of countries acknowledge the benefits of nuclear power and continue to support its use, there are some nations such as Australia and Germany that reject nuclear energy.

The growing use of renewable energy exacerbates pollution concerns stemming from the intensified mining required for constructing renewable energy plants, as well as the waste generated from decommissioned wind and solar facilities. While nuclear power generation is currently helping to address climate change through carbon-free energy production, further progress is needed to reduce the cost of building nuclear power plants and improve nuclear waste processing technologies. Potentially, this could lead to nuclear energy becoming more affordable, similar to wind and solar technologies. This endeavour will stimulate a balanced debate on the cost of nuclear energy and its necessity.

Within the Australian context, the initial crucial measure involves the recission of the moratorium on nuclear power. This will allow the instigation of a thorough evaluation of the viability of nuclear energy, thereby fostering a well-informed and balanced public

[92]Cronshaw (n 87).
[93]'Nuclear Power in China', *World Nuclear Association* (Web Page, January 2023).
[94]World Nuclear News, *Indian minister eyes 9% nuclear share by 2047* (April 2023).
[95]Mineral Council of Australia, *It's time to rethink Australia's ban on nuclear power* (September 2017).
[96]World Nuclear News, *Canadian budget underlines government support for nuclear* (March 2023).
[97]Paul Graham et al, 'GenCost 2021–22', *CSIRO* (Final Report, July 2022).
[98]United Nations Economic Commission for Europe, 'International climate objectives will not be met if nuclear power is excluded' (Press release, 11 August 2021).
[99]Valérie Masson-Delmotte et al (eds), *Climate Change 2021: The Physical Science Basis – Working Group I Contribution to the Sixth Assessment Report of the IPCC* (Intergovernmental Panel on Climate Change, 2021).

dialogue, ultimately leading to comprehensive and equitable resolutions on this matter. Advancements in nuclear energy could facilitate the transition to clean energy and potentially foster a progressive and economically viable industry that would be advantageous for both Australia and the global community.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iD

Evgeny Guglyuvatyy https://orcid.org/0000-0003-0888-2709

Evgeny Guglyuvatyy is an Associate Professor in the Department of Business Law and Taxation, School of Business, Monash University Malaysia.