Task Force 4
Refuelling Growth: Clean Energy and Green Transitions

THE ROLE OF NUCLEAR POWER IN CLEAN ENERGY AND GREEN TRANSITIONS

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Abstract

Nuclear power is an important energy source to help limit global warming to 1.5 °C. It is reliable, clean, safe, and secure. However, its role in dealing with climate change is not explicitly recognised in the G20 and Conference of the Parties (COP) meetings. This Policy Brief calls on G20 governments and the global community to acknowledge the significance of nuclear power in achieving a reliable and clean energy transition. This includes supporting existing nuclear plants, constructing new ones, and developing advanced nuclear technologies. G20 countries should promote research, pilot projects, and provide education to raise public awareness of the positive contributions of nuclear power towards climate change mitigation. Sharing best practices and ensuring adherence to nuclear safety, security, and non-proliferation standards are essential.

The Challenge

1

In order to address the pressing global challenge of climate change and ensure a just, reliable, and clean energy transition, it is crucial to prioritise certain policy measures. The Intergovernmental Panel on Climate Change (IPCC) emphasises limiting global warming to approximately 1.5 °C, which requires peaking global greenhouse gas emissions before 2025 and reducing them by 43 percent by 2030 (UNFCCC, 2023).

Achieving the goal of limiting global warming to 1.5 °C necessitates a reduction in carbon emissions. To accomplish this, low-carbon energy sources must be adopted and carbon capture and storage technologies implemented, at scale. However, transitioning away from fossil fuels and ensuring stable electricity supply (24/7) poses significant challenges that cannot be met by relying only on fluctuating renewables. Nuclear energy must be part of the solution. Nuclear power plants offer high reliability, safety, and low GHG emissions per unit of electricity generated (IPCC, 2021; Rogner et al., 2022). The challenge for G20 countries is to ensure that conditions are created that allow the expansion of safe nuclear energy in their own territories, in other states with peaceful nuclear energy, and also in newcomer countries.

While nuclear energy is a climate-friendly option, expanding its supply systems to the required scale in nearly all "net zero emission" scenarios presents significant challenges to the nuclear community. These challenges, which have been addressed in previous studies (see Rogner et al., 2022), include radiological safety concerns in the event of rare but potentially catastrophic accidents, nuclear security risks involving cybersecurity and terrorist activities, the economic viability of nuclear power, and the safe disposal of spent nuclear fuel (SNF), which has experienced delays in many national plans and projects (Dalton, 2023). It is important to recognise that many of these challenges are rooted in socio-political factors and public perceptions, often influenced by misconceptions or misinformation.

It is worth noting that none of these challenges pose technical barriers to expanding nuclear power. Public awareness of this fact is increasing, as evidenced by the growing support for nuclear energy in many countries (Dalton, 2023). The safety track record of current nuclear power plants (NPPs)

is unparalleled, and the enhanced safety features of new advanced reactors, including small modular reactors (SMRs), will further improve safety (Reyes et al., 2020). Additionally, the operational history of existing NPPs demonstrates a lack of significant security issues, and the economics of nuclear power are becoming increasingly favourable, particularly in a world facing geopolitical tension and energy security concerns. It is also essential to acknowledge and communicate the widespread consensus on the safety of geological disposal and the advanced progress of leading SNF disposal projects.

The overarching challenge is thus to promote and support national policies and international cooperation that facilitate the safe, secure, well-regulated, and economically viable expansion of nuclear power globally, including in countries where substantial nuclear power expansion is yet to occur. Therefore, it is of utmost importance to raise this discussion at high-level conferences, including in the T20 India Summit and COP28 UAE.

- ## The environmental benefits of nuclear energy

The environmental advantages of nuclear energy primarily revolve around its low carbon emissions and its potential to effectively address climate change. According to estimates from the International Atomic Energy Agency (IAEA), nuclear power has prevented the release of 74 gigatons of CO_2 between 1971 and 2018. This reduction is equivalent to the cumulative emissions generated by the entire power sector from 2013 to 2016 (IAEA, 2021). These emission reductions have been made possible by displacing fossil fuels in power generation. Furthermore, nuclear power plants do not emit air pollutants like sulphur dioxide, nitrogen oxides, and particulate matter, which have detrimental effects on public health and the environment.

- ## The economics of nuclear power plants are favourable

The economic advantages of nuclear power extend beyond its costs of generating electricity or heat. While wind and solar power may offer the cheapest electricity supply when the

conditions are favourable, the 24/7 dispatchability of nuclear power can make it a more economically viable option compared to intermittent renewables, even with the presence of daily and seasonal storage infrastructure for those renewables. Nuclear power can provide baseload power as well as load-following capabilities, ensuring 24-hour grid stability, which becomes a challenge when relying heavily on intermittent renewable sources.

- ## Today's nuclear power is a safe and secure form of energy

Nuclear power plants demonstrate a safety record that is among the highest in the energy industry. When measured in deaths per kilowatt-hour (kWh), nuclear power is on par with solar and wind power, ten times lower than hydro, and hundreds of times lower than fossil fuels (Ritchie et al., 2022). However, ensuring the security of nuclear power systems remains crucial for their successful development and deployment, with a particular focus on material and personnel security. Given the rapid changes in technology, economics, and demographics, it is imperative to maintain a stable security architecture. Therefore, a comprehensive analysis of the security of nuclear power systems is necessary, which should encompass solutions to non-proliferation and nuclear terrorism concerns.

Furthermore, comparing the security features of advanced technologies and SMRs with those of traditional light-water reactors (LWRs) is essential. By ensuring the safety and security of nuclear power systems, nuclear energy can become an even more reliable and secure form of energy. Achieving this goal is technically feasible if appropriate institutional arrangements are implemented and maintained.

- ## New advanced reactor designs are even safer

With the introduction of new advanced reactor designs, such as SMRs as well as next-generation, larger designs, safety improvements are expected to be significant based on a combination of design, operational experience, tests, and analyses. One notable feature of these new designs is the reduced reliance on active safety systems, which are replaced by passive safety features that are easier to understand and operate. Furthermore,

in case of a shutdown, most new designs can manage residual decay heat without external power or operator actions. For smaller new designs, there is less radioactivity to handle, and even for larger advanced designs, improved approaches to radioactive waste management will reduce the likelihood and consequences of accidents or off-normal events. Additionally, factory fabrication techniques ensure better-quality manufacturing, improved quality control, and less variability. Overall, these new advanced reactor designs incorporate several decades of experience with hundreds of operating nuclear power reactors, resulting in significant safety enhancements.

- ## Safe nuclear waste disposal technology is available

Contrary to criticisms, the so-called "unsolved waste disposal problem" is, in fact, a manageable concern. The IAEA and numerous national policies recognise that deep, stable geological formations provide a safe and permanent solution for nuclear waste management. Several nuclear programs have already planned, licensed, or constructed repositories of this kind. These facilities have undergone rigorous safety assessments and adhere to international standards. Recent advancements in drilling techniques suggest that simple deep borehole solutions may also be feasible. Furthermore, the growing interest in SMRs could foster international cooperation to simplify nuclear waste disposal, particularly for countries new to nuclear power. A global network of SMRs could potentially lead to the establishment of a multinational nuclear repository (MNR).

- ## Nuclear regulations are effective but should be harmonised

A robust and well-established regulatory framework is in place for operating nuclear reactors. National regulatory systems, guided by the nuclear standards set by the IAEA, effectively ensure the safe operation of nuclear facilities. The regulatory procedures for new advanced reactor designs, including both larger reactors and SMRs, must adhere to the same nuclear safety and security standards applied to existing reactors. As a result, a comprehensive regulatory framework explicitly tailored to these advanced designs (including regulations, guidance, inspection

protocols, operator qualifications) is still under development. Safety protocols must undergo validation, certification, and thorough evaluation in the country where the design was created to ensure adherence to IAEA standards. This process allows for the verification of safety norms worldwide. Such a rigorous and harmonised global regulatory system would facilitate and expedite the deployment of advanced reactors, leading to significant reductions in CO_2 emissions within a short timeframe.

- **SMR designs present new opportunities and challenges**

Small modular reactors offer numerous benefits and can help mitigate risks associated with large-scale reactors. These compact reactors offer improved affordability, shorter construction timelines, versatile applications, and seamless integration with renewable energy sources. They hold particular promise for newcomer countries and those with smaller grids or less developed infrastructure. Additionally, SMRs can be invaluable in powering remote off-grid areas and catering to non-power applications. However, developed countries can also benefit from their deployment.

Recent advancements in SMR design can potentially address economic risks associated with larger reactors. With capital exposure per unit reduced to less than 20 percent compared to large reactors, SMRs are easier to finance. They can be built and delivered quickly and cost-effectively, with minimised completion risks. These reactors can be predominantly manufactured in controlled factory conditions and transported for installation at the customer's location. Sites can be prepared to accommodate multiple units, allowing for modular expansion as needed. Furthermore, the economies of multiples of manufacturing multiple units in a factory setting can help lower the specific capital costs per kilowatt-electric (kWe), offsetting the economies of scale seen in traditional large reactors.

Government support in G20 and other countries, in terms of policy, financing and market regulation, for initial SMR projects can be instrumental. Greater worldwide acceptance and use of nuclear energy can be achieved by demonstrating these factors effectively.

The G20's Role

2

G20 countries can help accelerate energy transitions and meet climate change targets, as they collectively account for approximately 75 percent of global GDP (IMF, 2022), 80 percent of global greenhouse gas emissions (WRI, 2022), and 60 percent of the world's population (UN, 2023). The G20 also accounts for around 84 percent of the world's nuclear power capacity (IAEA, 2021).

Amidst the global shift towards clean energy and sustainable development, nuclear power is increasingly acknowledged as crucial for the green transition and climate change mitigation. Geopolitical tensions, exemplified by the Russia–Ukraine conflict, have further fuelled interest in nuclear power. Europe's energy security apprehensions and the need to diversify energy portfolios have led countries to reconsider nuclear energy. Major players like the UK, the USA, France, China, India, and Japan, and smaller countries like Sweden, the Netherlands, Slovenia, and Belgium are expanding their nuclear power capabilities. Non-nuclear countries like Poland, Saudi Arabia, and some African states are also considering nuclear power options.

Despite these developments, nuclear power has been at the periphery of discussions at the G20 and COP meetings. Despite its potential, it has not yet been appropriately acknowledged as an energy technology for tackling climate change. By recognising the necessity of nuclear power expansion if climate goals are to be met, the G20 States can play a key role in enhancing the prospects of achieving a net-zero carbon goal in the targeted timeframes.

Recommendations to the G20

3

Building on previous recommendations (Shihab-Eldin et al., 2020), and G20 Energy Transition Working Group deliberations to keep energy options open (G20, 2023), and efforts of IAEA to integrate nuclear energy in G20's agenda (Donovan and Watson, 2022), this Policy Brief calls on G20 countries to:

1. Adopt national policies that advance the deployment of nuclear reactor technologies by supporting specific technical, economic, and regulatory measures that accelerate the adoption and commercialisation of advanced nuclear reactor technologies. National policies that provide regulatory and financial support for advanced nuclear technologies are necessary to accelerate their deployment and commercialisation. This can include measures such as funding for research and development, streamlined licensing procedures, and loan guarantees for constructing advanced nuclear reactors. By adopting such policies, countries can encourage private sector investment and innovation in nuclear technology, which can help reduce the costs of nuclear power and increase its competitiveness with other energy sources.

2. Support newcomers in planning safe deployment of nuclear power plants (in particular SMRs) to increase their energy security and decrease the environmental effects of their current electricity generation systems. This includes encouraging long-term interaction between the buyer and the supplier to cover the operation and final decommissioning of reactors. This will also ensure safe and effective operations of these nuclear plants over their entire lifespan. Developing countries may lack the experience and resources to safely deploy nuclear technologies, including SMRs. By providing technical assistance and support to these countries, developed countries can help them improve their energy security and reduce their reliance on fossil fuels.

3. Establish a harmonised international regulatory system coordinated by the IAEA to simplify the introduction of new nuclear technologies in the global effort to produce more electricity and, at the same time, obtain significantly reduced CO_2 emissions. This would involve collaboration between countries and organisations to develop and implement regulations and guidelines for the safe and effective use of advanced

nuclear technologies, including SMRs. Establishing a harmonised international regulatory system would enable countries to work together to ensure that nuclear technologies are used safely and securely, while also allowing for more efficient deployment of advanced nuclear reactors.

4. Encourage multinational cooperation on permanent disposal of spent fuel to ensure that national repositories are sited and constructed with state-of-the-art technologies and that progress is made with multinational repositories that can limit the numbers of individual repositories around the world that require long-term maintenance and surveillance. The safe disposal of spent nuclear fuel is crucial for the sustainable use of nuclear power. By fostering international cooperation in this area, countries can mitigate the expenses and hazards associated with maintaining their own repositories, while simultaneously enhancing global nuclear safety and security. This could entail exchanging technology, knowledge, and financial resources to facilitate the creation of reliable and secure solutions for the disposal of spent nuclear fuel.

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