Ana Catarina Simões - 22 April 2024*

Nuclear Power - The Comeback of Nuclear Energy in the Global Energy Landscape

Recognition of Nuclear Energy's Vital Role in the Global Energy Transition

The surge in international cooperation, driven by pressing needs, has underscored nuclear energy's importance as a crucial investment. This shift marks a departure from previous international events, where outdated energy policies often led to delays. There's a recognised need to accelerate regulatory and licensing processes and move away from anti-nuclear sentiments embedded in outdated energy policies. Both the COP 28 and the Nuclear Energy Summit, hosted by Belgium and IAEA, an important international entity that oversees nuclear activity globally, marked numerous unprecedented instances where governments, institutions, and key stakeholders collectively acknowledged nuclear energy's significance. Nuclear energy stands as a crucial linchpin in the overarching goal of transitioning to a sustainable and low-carbon energy future[1]. In the face of escalating climate change concerns and the imperative to mitigate greenhouse gas emissions, nuclear power offers a compelling solution that complements renewable energy sources such as wind and solar.

Amidst the urgent climate crisis, there is a glimmer of hope. The recent COP 28 witnessed an important milestone, placing the First Global Stocktake at the top of the agenda, with the Paris Agreement as its cornerstone. This initiative aims to ensure that limiting global warming to 1.5°C remains within reach, necessitating a substantial reduction in greenhouse gas emissions by 43% by 2030. Mention of coal phase-down and the imperative of transitioning from fossil fuels underscores the importance of nuclear and hydrogen, which have emerged for the first time in such discussions, highlighting the centrality of energy transition[2].

Importance of 'Renuclearisation'

The significance of 'renuclearisation' lies in nuclear energy's potential to contribute to energy transition efforts, given its positive impact on emissions reduction. During the summit, the contributions of nuclear energy were thoroughly discussed and extensively explored. This discourse highlighted the multifaceted benefits and challenges associated with integrating nuclear power into sustainable energy strategies.

One of the primary advantages of nuclear energy lies in its ability to provide reliable and consistent baseload power. Unlike intermittent renewable sources, such as solar and wind, nuclear reactors can operate continuously, providing a stable and predictable supply of electricity. This reliability is essential for maintaining grid stability and meeting the energy demands of modern societies[3].

Nuclear power boasts a remarkably low carbon footprint compared to traditional fossil fuels, Figure 1. By harnessing the process of nuclear fission to generate electricity, nuclear reactors produce virtually no greenhouse gas emissions during operation. This attribute makes nuclear energy a vital tool in the fight against climate change, as it enables the displacement of carbon-intensive coal and natural gas-fired power plants, thereby reducing overall emissions and mitigating the impact of global warming. The Nuclear Energy Institute affirms that annually, nuclear-generated electricity prevents the release of over 470 million metric tons of carbon dioxide emissions into the atmosphere, which would otherwise originate from fossil fuel sources.

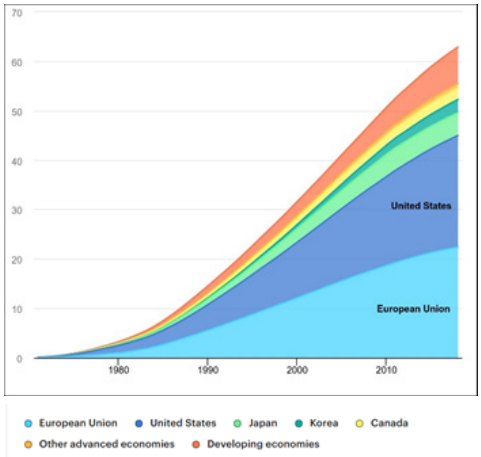

Figure 1 Cumulative CO2 emissions avoided by global nuclear power in selected countries, 1971-2018, IEA

* **Ana Catarina Simoes** *is CIFE Alumna of the Master in Global Energy Transition and Governance. She assists Corporate Sustainability activities and European & International reglementary analysis.*

Nuclear energy offers scalability and flexibility in energy production, so that it can be adapted to meet evolving energy needs and consumption patterns. Large-scale nuclear power plants can provide significant amounts of electricity to meet the demands of densely populated urban centres, industrial hubs, and critical infrastructure. Additionally, advancements in Small Modular Reactors (SMRs) hold promise for expanding nuclear energy's reach to remote or off-grid locations, as well as enhancing the resilience of energy systems in the face of natural disasters or grid disruptions[4]. The concept of SMRs involves the development of compact, modular nuclear reactors with a power capacity of up to 300 MWe per unit. These reactors are designed to be smaller in size compared to traditional nuclear power plants, allowing for easier installation in various locations and offering enhanced safety features. SMRs aim to provide a flexible and scalable solution for clean energy generation, catering to diverse energy needs while minimising environmental impact.

Global Hurdles and Anti-nuclear Sentiment

Despite its positive impacts, nuclear energy remains controversial due to various geopolitical and historical factors. The memories of disasters such as Chernobyl and Fukushima, coupled with the vulnerability to natural calamities, contribute to widespread discomfort in many countries and communities. Germany's anti-nuclear stance exemplifies this sentiment, as evidenced by their efforts to advocate for a European-wide denuclearisation plan. It is no coincidence that Germany was absent from the inaugural Nuclear Energy Summit, signalling their clear position on the matter[5, 6].

The global landscape of nuclear energy is characterised by a diverse array of trends and challenges that shape its role in the broader energy transition. While nuclear power continues to be a significant contributor to electricity generation in many regions, its growth and development are influenced by a variety of factors, including regulatory frameworks, public perception, and economic considerations. At the latest international events, several key topics took centre stage, notably financing, opposition, regulatory frameworks and licensing[7].

· *Regional Disparities in Nuclear Energy Utilisation*

Across different regions of the world, there exist significant disparities in the utilisation and adoption of nuclear energy. While countries like the United States, China, and Russia continue to invest in expanding their nuclear fleets, other regions, particularly in Europe, have witnessed stagnation or even decline in nuclear capacity. These disparities reflect varying policy priorities, public attitudes towards nuclear energy, and the availability of alternative energy sources.

Despite nuclear power playing a significant role, generating just over a fifth (21.8%) of the EU's electricity and 9.2% globally in 2022, Europe has witnessed a decrease in its usage. The Russian-Ukrainian war and ensuing energy security concerns have brought nuclear energy to the forefront, referenced in the REpowerEU plan aligned with the EU Green Deal[8]. As the USA, India, and China explore the possibility of expanding their nuclear energy fleet, the European Union presents a diverse approach. While countries like Slovakia, Hungary and France are advancing with Nuclear and SMRs for future energy strategies, others, such as Germany, are reverting to coal amidst energy crises[9]. This highlights the complexities in aligning budgetary allocations with nuclear energy initiatives and projects at both European and national levels.

Public perception plays a crucial role in shaping the future of nuclear energy, with safety concerns and misconceptions often influencing public attitudes and policy decisions[10]. Events such as the Fukushima Daiichi accident in 2011 have heightened public apprehension about nuclear safety and radiation risks, leading to increased scrutiny and opposition to nuclear projects[11].

· *Regulatory Hurdles and Licensing Delays*

One of the most significant challenges facing nuclear energy development is the complex regulatory environment and the associated licensing processes, explored in the Nuclear Summit. Obtaining permits for the construction and operation of nuclear power plants often involves lengthy and costly procedures, leading to delays and uncertainties that hinder investment and deployment. Streamlining regulatory frameworks and enhancing collaboration between regulatory bodies and industry stakeholders is

essential to address these challenges and expedite project approvals.

During the summit, countries showcased their project plans and targets, highlighting unprecedented international cooperation[12]. A key focus was extending licensing and educating younger generations in nuclear energy. China's nuclear energy expansion is notable, with construction averaging 5 new plants yearly and 8 to 10 permits issued annually. This positions China ahead, with its nuclear fleet expected to surpass 400 GW, surpassing the current global capacity[13]. In contrast, Europe lags behind in regulatory procedures and project development, relying on an aging nuclear fleet, primarily supported by France. This underscores the need for European nations to accelerate nuclear energy development to keep pace with global advancements.

- ***Economic Viability and Financing Uncertainties***

Even if we bypass the regulatory hurdles, we still have to deal with the economics of nuclear energy, which pose significant challenges due to high upfront capital costs and long project lead times, often deterring investors and developers[14, 15]. During the Summit costs took the centre stage, with the Inter-American Development Bank (IDB) and the European Investment Bank (EIB) putting forward their concerns and struggles regarding attracting investment and who would be the main stakeholders of future nuclear projects. During COP 28, finance and the lack of investment funds emerged as key topics in the agreement regarding the energy transition initiatives.

The USA affirmed that Congress had approved $2.7 billion to restart an enrichment programme[16], but this is still considered insufficient. In the EU the EIB there are plans to invest €1 trillion in climate and environmental projects, including clean energy, by 2030. Although EU nuclear projects are eligible for EIB financing and have received over €1 billion since 2000, renewable energy investments surpassed €10 billion in 2021. EIB Vice-President Thomas Östros underscored the ongoing priority for renewables.

In an era of rapidly evolving energy markets and growing competition from renewable energy sources, nuclear projects face uncertainties regarding their economic viability and long-term profitability. Securing financing for nuclear projects remains a formidable barrier, particularly in deregulated energy markets where nuclear power must compete with lower cost alternatives. This reality also challenges fusion and SMRs due to the limited economic prospects, impacting their marketability and profitability for private investors. The economics surrounding energy transition and investment in alternative sources remain ongoing and challenging topics. However, we have witnessed positive breakthroughs in recent years.

The Nuclear Fleet of the Future

While financing and other hurdles have been recurring topics in discussions surrounding nuclear power projects, recent international events have provided insights into the future. Discussions have focused on advanced reactor technologies such as SMRs, the potential of nuclear-renewable hybrid systems, including the exploration of nuclear hydrogen, and the growth of nuclear-related startups worldwide. Hybrid nuclear systems, as investigated by the IAEA, entail the integration of nuclear and renewable energy sources. These systems aim to boost energy production, enhance grid stability, and mitigate environmental impact. Leveraging the complementary strengths of both technologies, they tackle the intermittency and variability inherent in renewable energy generation while ensuring reliable electricity provision and facilitating various industrial applications[17].

In addition to technological advancements, there has been a growing emphasis on enhancing safety measures and waste management strategies within the nuclear industry. Collaborative efforts between governments, regulatory bodies, and industry stakeholders have aimed to address public concerns and ensure the safe and sustainable operation of nuclear power plants. Moreover, initiatives promoting international cooperation and knowledge sharing have paved the way for more standardised and streamlined approaches to nuclear energy deployment worldwide. That's why the term "Education" featured prominently during these events, as it serves as the primary strategy for overcoming the societal and political barriers that impede progress in nuclear energy. But it is recognised that such a strategy is only possible if we promote international collaboration and knowledge sharing, essential for driving innovation, reducing costs, and accelerating the deployment of nuclear energy technologies worldwide.

Some of the most talked about projects relate to Nuclear-Renewable Hybrid Systems. Convergence of nuclear and renewable energy technologies in hybrid energy systems holds significant potential for maximising energy output, optimising resource utilisation, and minimising environmental impacts. Hybrid systems offer the opportunity to capitalise on the complementary strengths of nuclear and renewables while addressing the challenges associated with intermittency and variability inherent in renewable energy generation.

But no less important, we also have hydrogen featuring in foreseeing future projects. This is because nuclear energy can serve as a reliable and cost-effective source of low-carbon hydrogen production, offering a promising pathway to decarbonise industrial processes, transportation, and energy storage. By leveraging high-temperature heat from nuclear reactors, such as High-Temperature Gas Reactors (HTGRs) or advanced thermal reactors, hydrogen can be produced through thermochemical or electrolytic processes with minimal greenhouse gas emissions.

Conclusion

Reflecting on the annual strides in nuclear energy, we find ourselves on the cusp of transformative change. Each breakthrough signifies not only technological progress but also the resilience of humanity in harnessing the power of the atom. From pioneering reactor designs to groundbreaking fusion research, our journey toward a sustainable energy future is illuminated by remarkable advancements in nuclear technology. These milestones serve as beacons, guiding us forward and inspiring further innovation. We undertake a collaborative journey propelled by the potential of nuclear energy—an indispensable factor in advancing toward a cleaner, brighter future.

References

1. *Nuclear energy: Between global electricity demand, worldwide. Bandoc, Remus Pravalie & Georgeta. s.l. : Elsevier, December 17, 2017, Journal of Environmental Management, Vol. 209, pp. 81-92.*
2. *Nuclear Energy Summit 2024. IAEA. March 21, 2024.*
3. *Nuclear energy: Between global electricity demand, worldwide. Bandoc, Remus Pravalie & Georgeta. s.l. : Elsevier, December 17, 2017, Journal of Environmental Management, Vol. 209, pp. 81-92.*
4. *'A Turning Point': First Ever Nuclear Energy Summit Concludes in Brussels. Fisher, Matt. s.l. : IAEA, March 25, 2024.*
5. *Nuclear energy finds support across EU Parliament groups. Waterfield, Emily. [ed.] Markham Watson. s.l. : S&P Global Commodity Insights, March 25, 2024.*
6. *First Ever Nuclear Energy Summit. Energy Industry Review. March 25, 2024, Energy Industry Review.*
7. *Nuclear energy: Between global electricity demand, worldwide. Bandoc, Remus Pravalie & Georgeta. s.l. : Elsevier, December 17, 2017, Journal of Environmental Management, Vol. 209, pp. 81-92.*
8. *Nuclear energy finds support across EU Parliament groups. Waterfield, Emily. [ed.] Markham Watson. s.l. : S&P Global Commodity Insights, March 25, 2024.*
9. *Ibid.*
10. *Ibid.*
11. *Nuclear energy: Between global electricity demand, worldwide. Bandoc, Remus Pravalie & Georgeta. s.l. : Elsevier, December 17, 2017, Journal of Environmental Management, Vol. 209, pp. 81-92.*
12. *First Ever Nuclear Energy Summit. Energy Industry Review. March 25, 2024, Energy Industry Review.*
13. *'A Turning Point': First Ever Nuclear Energy Summit Concludes in Brussels. Fisher, Matt. s.l. : IAEA, March 25, 2024.*
14. *Nuclear energy: Between global electricity demand, worldwide. Bandoc, Remus Pravalie & Georgeta. s.l. : Elsevier, December 17, 2017, Journal of Environmental Management, Vol. 209, pp. 81-92.*
15. *Challenges in nuclear energy adoption: Why nuclear energy newcomer countries put nuclear power programs on hold? Kim, Philseo, et al. s.l. : ScienceDirect, November 15, 2023, Nuclear Engineering and Technology.*
16. *Europe's pro-nuclear leaders seek atomic energy revival. Abnett, Julia Payne & Kate. s.l. : Reuters, March 22, 2024.*
17. *Nuclear-Renewable Hybrid Energy Systems. INTERNATIONAL ATOMIC ENERGY AGENCY. s.l. : IAEA, IAEA Nuclear Energy Series NR-T-1.24.*

Rédaction: Laurent Baechler et Aline Palige
Policy Paper / Note de recherche est publiée par le Centre international de formation européenne, association dont le siège est 81, rue de France, F-06000 Nice.

www.cife.eu

Ce projet a été financé avec le soutien de la Commission européenne. Cette publication (communication) n'engage que son auteur et la Commission n'est pas responsable de l'usage qui pourrait être fait des informations qui y sont contenues.

Avec le soutien du programme Erasmus+