WG1 – Nuclear Safety and Regulation Inter Jura Congress 2024 Paper

By Roopa Mathews, Maroof Mittha, Colleen Spapens
21 October 2024

Title of session: Navigating the Evolving Landscape: Safety and Regulation in the Nuclear Industry

Introduction paper for the panel discussion on **'***What, if any, are the main opportunities and challenges for streamlining regulation around the world to allow more efficient and cost-effective licensing of new nuclear projects in multiple jurisdictions while maintaining high standards of safety, security and environmental protection, and ensuring public confidence?*'

Content

1. Introduction

In recent years, a global shift in attitudes towards nuclear energy has sparked a new nuclear renaissance. The urgency of addressing the climate crisis and achieving carbon neutrality has positioned nuclear power as a crucial 'green' or transitional energy source. In addition, the geopolitical landscape, highlighted by the war in Ukraine and resulting sanctions against Russia, has demonstrated the risks of overreliance on Russian gas. In search of greater energy independence and security, nuclear energy has been identified as a strategic alternative. At the same time, growing global energy demands and the ageing of existing nuclear power plants have driven countries to consider, plan or initiate nuclear power programs.

According to the World Nuclear Association, approximately 60 reactors are currently under construction globally, with a further 110 planned.[1] This surge in nuclear activity reflects a diverse range of economies, from developed nations to emerging markets, all recognizing the value of nuclear energy in their energy portfolios.

After a time of uncertainty regarding the future of nuclear energy following the Chernobyl and Fukushima disasters, this global shift in mindset towards nuclear energy is welcomed by the nuclear industry. However, this evolving nuclear landscape is not without its challenges. Time- and cost-efficiency combined with high levels of safety are of considerable importance to meet energy demands, counteract climate change and build trust amongst the public to change the often negative public perception of nuclear energy.

Streamlining regulation is an important factor in achieving these goals, which includes efficient cooperation between regulatory bodies and industry stakeholders, and the development of suitable

[1] 'Plans for New Reactors Worldwide' (*World Nuclear Association*, 29 July 2024) <https://world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors-worldwide> accessed 21 August 2024.

regulation. Initiatives from the International Atomic Energy Agency (IAEA), such as the Nuclear Harmonization and Standardization Initiative (NHSI), and specific new-build projects, like the NUWARD Small Modular Reactor (SMR), exemplify the collaborative efforts aimed at enhancing nuclear safety, technological innovation, regulatory compliance, and effectiveness and efficiency in the licensing process within the new nuclear landscape by streamlining regulation.

This paper provides an overview of the work of these initiatives and projects, and serves as a basis for a wider discussion regarding the main opportunities and challenges for streamlining regulation around the world.

2. Streamlining Regulation

Before diving into ongoing global efforts in streamlining regulation, it is important to understand that 'streamlining regulation' in this paper refers to efforts in harmonizing regulatory approaches internationally. This can take many forms, from regulatory convergence to harmonization, from bilateral or multilateral collaborations to global efforts. While the IAEA Safety Standards Series arguably creates a convergence of regulation by setting minimum safety standards for nuclear safety, this is not seen to be enough. Many experts wish a deeper form of harmonization of regulations between countries on a global scale, such as in the aircraft industry, including the adoption of the same technical requirements and standards. This, however, is widely seen as a very difficult, and potentially unachievable, task.

The overall goal of streamlining regulation is to allow for more efficient and cost-effective licensing of new nuclear projects in multiple jurisdictions, while maintaining high standards of safety, security and environmental protection. Historically, conventional nuclear power plants have been criticized (among other reasons) for costs and time overruns. For instance, The Guardian reported in February 2024 that EDF would take a near €13bn hit after delays and cost overruns (largely due to civil works) to Hinkley Point C.[2]

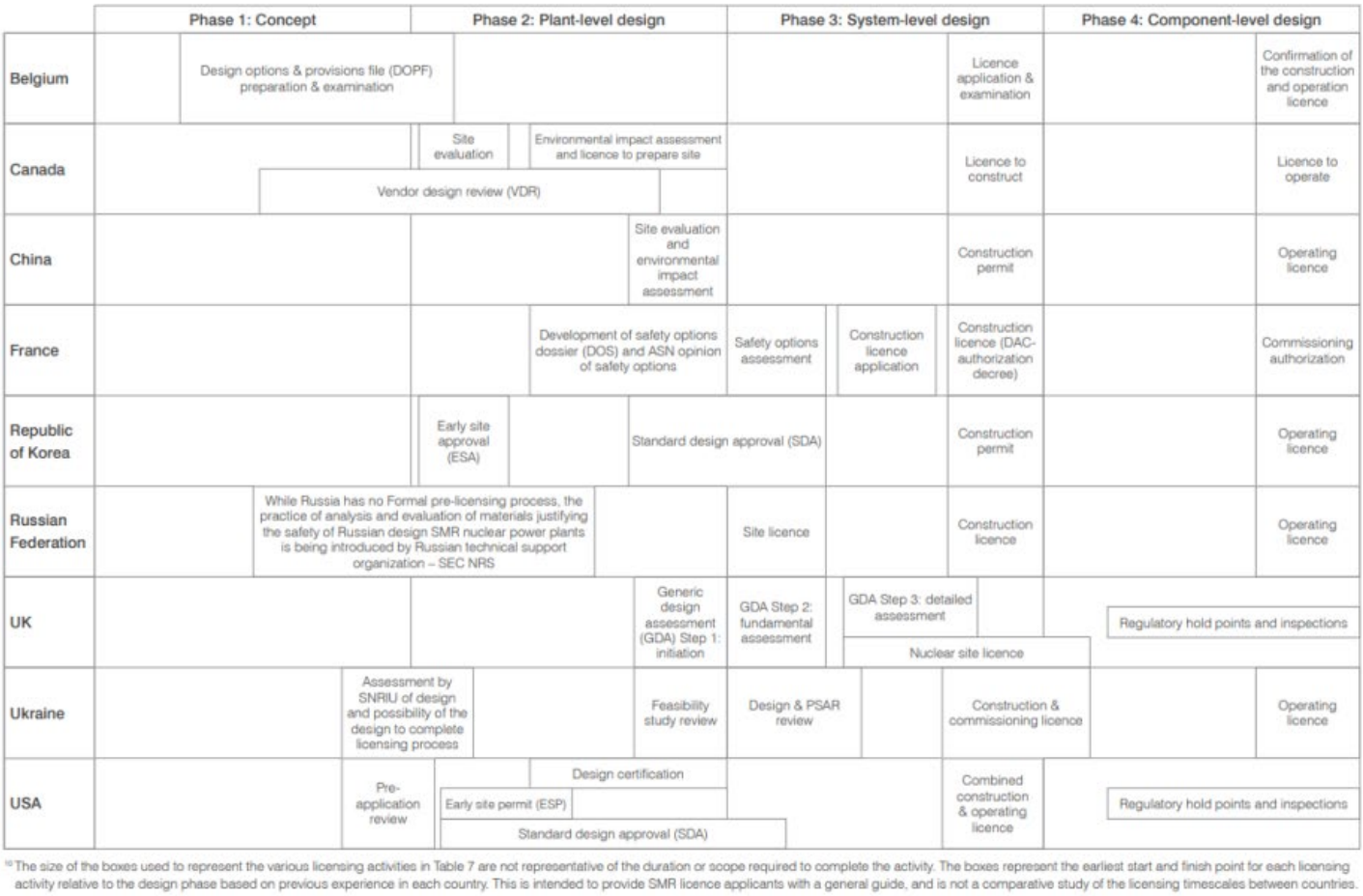
Several factors contribute to high construction costs for large Gigawatt-scale (GW-scale) reactors, including the safety requirements set by the regulatory framework in each nuclear jurisdiction. The Organization for Economic Co-operation and Development (OECD) Nuclear Energy Agency's (NEA) Practical Guide for Stakeholders, commenting on the cost increases during the construction of nuclear plants in the United States (US), indicated that "changes during construction" (though necessary for safety), typically imposed by the regulator, can have significant implications on time and cost.[3] These factors are encountered every time a reactor undergoes regulatory approvals and processes in a new jurisdiction. The costs and times incurred in the construction phase for a nuclear reactor imposed by the regulator are separate and in addition to the regulatory approvals and licensing processes for reactor designs, which may also vary in every jurisdiction.

The World Nuclear Association's Report on the 'Design Maturity and Regulatory Expectations for Small Modular Reactors' provides an outline of the diverse steps in the licensing process in various jurisdictions:

---

[2] Alex Lawson, 'EDF takes €12.9bn hit after Hinkley Point C delays and cost overruns' (*The Guardian*, 16 February 2024) <https://www.theguardian.com/uk-news/2024/feb/16/edf-hinkley-point-c-delays-cost-overruns#:~:text=The%20owner%20of%20the%20Hinkley,have%20triggered%20international%20political%20tensions> accessed 21 August 2024.

[3] 'Unlocking Reductions in the Construction Costs of Nuclear: A Practical Guide for Stakeholders' (*Nuclear Technology Development and Economics*, 2020) <https://www.oecd-nea.org/upload/docs/application/pdf/2020-07/7530-reducing-cost-nuclear-construction.pdf> accessed 21 August 2024.



[a] The size of the boxes used to represent the various licensing activities in Table 7 are not representative of the duration or scope required to complete the activity. The boxes represent the earliest start and finish point for each licensing activity relative to the design phase based on previous experience in each country. This is intended to provide SMR licence applicants with a general guide, and is not a comparative study of the licensing timescales between countries.

Figure 1: Licensing steps in surveyed countries[4]

As shown in Figure 1 above, most countries' regulatory frameworks have evolved independently to meet jurisdictional requirements, leading to persistent differences. The Nuclear Innovation and Research Advisory Board (NIRAB), United Kingdom (UK), recently provided an overview of the timescales of the new nuclear builds (which include both large conventional reactors and SMRs) in the UK. An estimated pre-construction and final investment decision (FID) regulatory approval process, including design assessment can take up to six years.

The NIRAB Report also estimated that the construction and commissioning phase of large GW-scale reactors and SMRs in the UK could take more than seven years in total.

At the industry level, the time and cost overruns for on-site construction of conventional power plants with large GW-scale output have also spurred interest in advanced reactors or SMRs (Gen III+, Gen IV reactors). These reactors, capable of standardized factory off-site production, offer a potential solution to the industry's challenges by mitigating the risks of time and cost overruns attributable to the civil works carried out for large-GW-scale reactors on-site.

From a regulatory perspective, regulatory disparities, combined with the concept of state responsibility for the safety, safeguards, and security of civil nuclear power, have paved the way for

[4] 'Design Maturity and Regulatory Expectations for Small Modular Reactors' (*World Nuclear Association*, June 2021) <https://world-nuclear.org/images/articles/smr-design-maturity-report-FINAL.pdf> accessed 21 August 2024.

initiatives such as regulatory harmonization for SMRs and advanced reactors. Several initiatives and projects have been launched for regulatory harmonization at multilateral and bilateral levels, which are discussed in Section 3.

These initiatives and projects aim to achieve a consistent set of applicable standards and regulations for efficient and cost-effective licensing of new nuclear projects in multiple jurisdictions. According to the NEA, in one of its reports on Nuclear Safety Technology and Regulation, harmonization seeks functional equivalency in the regulations promulgated by sovereign authorities.[5]

The goals and objectives of harmonization seem to present a unique opportunity for the industry and regulators to fully capitalise on the potential of SMRs and advanced reactors in net-zero objectives; however, jurisdictional sovereignty is likely to remain a continuing obstacle and challenge in the path towards the harmonization of regulations.

The need for more efficient and cost-effective licensing of new nuclear projects across multiple jurisdictions has sparked the launch of projects and initiatives with different strategies for harmonization to achieve this goal. Some focus on developing a general strategy for harmonizing licensing regulations on a large scale, while others are bilateral or multilateral efforts in concrete licensing projects. International organizations, such as the Western European Nuclear Regulators Association (WENRA)[6] and the International Nuclear Regulators' Association (INRA)[7], are supporting such collaboration efforts. The following section provides an overview of some of these global efforts, both in connection with SMRs and large-scale reactors.

3. Ongoing Projects and Initiatives

Much can be learned from ongoing international cooperation initiatives and projects, such as the Nuclear Harmonization and Standardization Initiative (NHSI), the NUWARD SMR project and the Memorandum of Cooperation (MoC) between the US Nuclear Regulatory Commission (NRC) and the Canadian Nuclear Safety Commission (CNCS). These are described in turn below.

3.1. *Nuclear Harmonization and Standardization Initiative (NHSI)*

In light of the growing interest in SMRs in the international community, the IAEA Director General established the NHSI in 2022. This initiative brings together governments, regulators, designers, technology holders, operators and other international organizations, and seeks to promote the harmonization and standardization of SMR design, construction, regulatory, and industrial practices. It consists of two complementary parts: the NHSI Regulatory Track and the NHSI Industry Track.[8]

The NHSI Regulatory Track aims to enhance collaboration among regulatory bodies in different countries, reduce repetitive efforts, improve efficiency, and foster the development of unified regulatory standards while maintaining nuclear safety and respecting national sovereignty. To achieve

[5] 'Harmonising the Nuclear Licensing Process for Emerging Technologies: A Global Path Forward' (*Nuclear Safety Technology and Regulation*, 2022) <https://www.oecd-nea.org/upload/docs/application/pdf/2022-04/7616_harmonising_licensing_process_2022-04-06_17-14-45_681.pdf> accessed 21 August 2024.
[6] 'WENRA's statement on the challenges related to the development of Small Modular Reactors (SMR)' (*WENRA*, 2023) <WENRA's statement on the challenges related to the development of Small Modular Reactors (SMR) | WENRA> accessed 4 October 2024.
[7] 'INRA Statement on Small Modular Reactors and International Collaboration' (CNSC, 2023) <INRA Statement on Small Modular Reactors and International Collaboration - Canada.ca> accessed 4 October 2024.
[8] 'The SMR Platform and Nuclear Harmonization and Standardization Initiative (NHSI)' (*IAEA*, 2024) <https://www.iaea.org/services/key-programmes/smr-platforms-nhsi> accessed 21 August 2024.

this, the Regulatory Track has devised ambitious, yet achievable, work programs that build on previous efforts and steadily advance the harmonization of regulatory practices.[9]

The NHSI Regulatory Track is divided in three Working Groups (WGs): [10]

- WG1 – Established a framework for pre-licensing/licensing information sharing for collaborative reviews[11], joint reviews[12] and the leveraging of regulatory reviews.[13] This includes a proposed Memorandum of Cooperation.
- WG2 – Established a multinational pre-licensing joint review process.
- WG3 – Established a process for collaborative reviews and a separate process for performing due diligence when leveraging regulatory reviews.

Meanwhile, the NHSI Industry Track focuses on creating more standardized industrial methods for the development, manufacturing, construction, and operation of SMRs. By setting common standards and best practices, this track aims to reduce licensing timelines, costs, and overall deployment times for SMRs.[14]

3.2. *The NUWARD SMR Project*

The NUWARD SMR is a 340 MWe SMR plant, which has been in development since 2019 by a consortium composed of EDF, Naval Group, TechnicAtome, the French Alternative Energies and Atomic Energy Commission (CEA), Framatome and Tractebel.[15] Construction was initially scheduled to begin in 2030 in France.[16]

The NUWARD design was used as a case study for a European early joint regulatory review led by France's Nuclear Safety Authority (ASN) with the participation of Finland's Radiation and Nuclear Safety Authority (STUK) and the Czech State Office for Nuclear Safety (SUJB).[17] This joint early review aims "to identify the key issues for the hypothetical licensing of a NUWARD SMR in the involved countries, and to identify divergences and convergences between the regulatory frameworks in these countries".[18] From June 2022 to June 2023, ASN, STUK and SUJB conducted a joint early review of the

[9] 'The SMR Platform and Nuclear Harmonization and Standardization Initiative (NHSI)' (*IAEA*, 2024) <https://www.iaea.org/services/key-programmes/smr-platforms-nhsi> accessed 21 August 2024.
[10] 'NHSI Regulatory Track' (*IAEA*, 2023) < NHSI Regulatory Track (iaea.org)> accessed 4 October 2024.
[11] Collaborative reviews: participating regulatory bodies review all the information against national requirements or against other agreed requirements, conferring with other participants, and reaching their own decisions.
[12] Joint reviews: a team drawn from participating regulatory bodies jointly reviews all the information against agreed requirements and comes to a joint decision.
[13] Leveraging of regulatory reviews: A regulatory bodies undertake a review against its own requirements and seeks to leverage existing reviews made by other regulatory bodies against their own requirements.
[14] 'The SMR Platform and Nuclear Harmonization and Standardization Initiative (NHSI)' (*IAEA*, 2024) <https://www.iaea.org/services/key-programmes/smr-platforms-nhsi> accessed 21 August 2024.
[15] 'NUWARD SMR: Leading the way to a carbon-free world' (*EDF*, September 2023) <https://www.nuward.com/sites/nuward/files/2023-11/NUWARDSMR.pdf> accessed 16 August 2023, pp. 5, 16 and 17.
[16] Ibid, p. 5.
[17] 'NUWARD SMR Joint Early Review: Pilot Phase Closure Report' (*ASN, STUK and SUJB*, September 2023) <https://www.nuward.com/sites/nuward/files/2023-09/NUWARDSMR_JointearlyReview_ASNSUJBSTUK.pdf> accessed 21 August 2024.
[18] Ibid, p. 4.

NUWARD SMR design and issued a report presenting the initiative and the lessons learned.[19] In 2023, three additional European safety authorities – Poland's National Atomic Energy Agency, the Swedish Radiation Safety Authority and the Netherlands' Authority for Nuclear Safety and Radiation Protection – joined the review process.[20] This type of joint early review of an SMR project was a global first.

In July 2024, following the joint review by the six nuclear safety authorities and feedback from initial prospective customers and an international advisory committee, EDF announced that it now plans to revise the NUWARD design.[21]

3.3. *Memorandum of Cooperation Between US NRC and CNCS*

In August 2019, pursuant to a pre-existing MoU on Exchange of Technical Information and Cooperation in Nuclear Safety Matters (signed in 2017), the US NRC and the CNSC entered another Memorandum of Cooperation (MoC) to further expand their cooperation on activities associated with advanced reactor and SMR technologies. The Steering Committee, already set up under another Charter signed in August 2017, would function for the cooperation agreed under the MoC. The MoC indicated cooperation in the following areas:

> "1. Development of shared advanced reactor and SMR technical review approaches that facilitate resolution of common technical questions to facilitate regulatory reviews that address each Participant's national regulations;
> 2. Collaboration on pre-application activities to ensure mutual preparedness to efficiently review advanced reactor and SMR designs; and
> 3. Collaboration on research, training, and in the development of regulatory approaches to address unique and novel technical considerations for ensuring the safety of advanced reactors and SMRs"[22]

Since the MoC, the two regulatory bodies have carried out joint activities and reports for vendors and technology developers, i.e., GE Hitachi (GEH), X-Energy, and Terrestrial Energy.

In September 2022, the regulatory bodies entered a collaboration charter in relation to GEH's BWRX-300 Design. The regulators were already engaged in pre-application activities with the Tennessee Valley Authority (TVA) and Ontario Power Generation (OPG) in their respective jurisdictions to prepare for pending license applications in Canada and the US. GEH was also engaged in pre-application activities with both CNSC and US NRC with respect to GEH-led design activities.

---

[19] 'NUWARD SMR Joint Early Review: Pilot Phase Closure Report' (*ASN, STUK and SUJB*, September 2023) <https://www.nuward.com/sites/nuward/files/2023-09/NUWARDSMR_JointearlyReview_ASNSUJBSTUK.pdf> accessed 21 August 2024, p. 4.

[20] 'NUWARD and EDF are proud to start the second phase of the Joint Early Review of the NUWARD SMR design with an extended group of European nuclear safety authorities' (*EDF Press Release*, 19 December 2023) <https://www.edf.fr/en/the-edf-group/dedicated-sections/journalists/all-press-releases/nuward-and-edf-are-proud-to-start-the-second-phase-of-the-joint-early-review-of-the-nuward-smr-design-with-an-extended-group-of-european-nuclear-safety-authorities> accessed 16 August 2023.

[21] 'EDF to modify Nuward design to aid commercialisation' (*World Nuclear News*, 3 July 2024) <https://www.world-nuclear-news.org/Articles/EDF-to-modify-Nuward-design-to-aid-commercialisati> accessed 16 August 2024; 'Nuward: EDF to Revise Design of Its European SMR' (*Sfen in English*, 3 July 2024) <https://sfeninenglish.org/nuward-edf-to-revise-design-of-its-european-smr/> accessed 16 August 2024.

[22] Rumina Velshi & Kristine L. Svinicki, 'Memorandum of Cooperation on Advanced Reactor and Small Modular Reactor Technologies between the Canadian Nuclear Safety Commission and the United States Nuclear Regulatory Commission' (*Government of Canada*, August 2019) <https://www.cnsc-ccsn.gc.ca/eng/resources/international-cooperation/international-agreements/cnsc-usnrc-smr-advanced-reactor-moc/> accessed 21 August 2024.

The Charter reflected the intention of the two regulators to enhance their cooperative framework under MoC by working on regulatory and safety issues in the licensing review of the BWRX-300 design.[23]

By July 2023, the regulatory bodies, among other reports, have jointly undertaken activities and reviews and issued a report concerning the structural design for the BWRX-300 for feedback on its steel-plate composite containment vessel and reactor building structural design. This report is one among many of the reports, white papers, technical reviews and a joint report on technology-inclusive, risk-informed reviews for advanced reactors.[24]

3.4. *Summary of Other Projects and Initiatives*

Other projects and initiatives for streamlining regulation around the world to allow for more efficient and cost-effective licensing of new nuclear projects include the following:

- **The Multinational Design Evaluation Programme (MDEP)** was established in 2006 by the OECD NEA as a multilateral initiative by national safety authorities to combine resources and knowledge for the review of new reactor nuclear power designs.[25] MDEP's activities include (i) enhancing multilateral cooperation within existing regulatory frameworks, with a view to harmonization of regulatory requirements and practices, (ii) facilitating multinational convergence of international and inter-governmental safety standards and safety goals and (iii) facilitating the licensing of new reactors as well as oversight of their construction and commissioning activities.[26] MDEP members currently include the nuclear regulatory authorities of six countries: Argentina, China, Hungary, Russia, South Africa and Turkey.[27] MDEP carries out its work through design-specific working groups that share information and co-operate on specific reactor design evaluations, construction, commissioning, and early phase operation.[28] The currently active design-specific working groups are the VVER Working Group and the HPR1000 Working Group.[29] Between 2006 and 2021, MDEP published 39 common positions reflecting a variety of technical topics that were identified during design reviews and 41 technical reports to enable member countries to better understand similarities and differences in national requirements and practices.[30]

- In 2007, the World Nuclear Association created the **Cooperation in Reactor Design Evaluation and Licensing (CORDEL)** working group to promote the standardization of nuclear reactor designs through the harmonization of regulatory requirements in order to address the challenge of significant efforts and modifications needed for a reactor design to be licensable

[23] Daniel H. Dorman & Ramzi Jammal, 'Charter: Collaboration on GE Hitachi's BWRX-300 Design' (*Government of Canada*, September 2022) <https://www.cnsc-ccsn.gc.ca/eng/reources/international-cooperation/international-agreements/cnsc-usnrc-smr-advanced-reactor-charter/> accessed 21 August 2024.
[24] 'Joint Reports of the Canadian Nuclear Safety Commission (CNSC) and the NRC' (*U.S.NRC*, 9 October 2023) <https://www.nrc.gov/reactors/new-reactors/advanced/who-were-working-with/international-cooperation/nrc-cnsc-moc/joint-reports.html> accessed 21 August 2024.
[25] 'Multinational Design Evaluation Programme (MDEP)', (*Nuclear Energy Agency*, 16 May 2024) <https://www.oecd-nea.org/mdep/> accessed 16 August 2024.
[26] Ibid.
[27] Ibid.
[28] Ibid.
[29] Ibid.
[30] 'Phase 1 Summary Report 2006-2021' (*Multinational Design Evaluation Programme*) <https://www.oecd-nea.org/mdep/annual-reports/MDEP_Phase1_SummaryReport7613.pdf> accessed 20 August 2024.

in several countries.[31] The CORDEL working group was established as the industry counterpart to the OECD NEA's MDEP.[32] The CORDEL working group has six task forces that cover a range of technical areas including mechanical codes and standards, design change management, licensing and permitting, the IAEA Nuclear Safety Standards, instrumentation and control and SMRs.[33]

- In 2022, the European Union began the **HARMONISE project** ("Towards harmonisation in licensing of future nuclear power technologies in Europe") in the framework of the Euratom Research and Training Programme to study and formulate a comprehensive approach to the harmonization and standardization of methodologies, codes and standards and the assessment of nuclear reactor components.[34] HARMONISE will examine issues related to qualification, standardization, verification and validation, and licensing of fission and fusion installations.[35] The HARMONISE project aims to (i) analyse preliminary safety assessments of innovative fission and fusion installations, (ii) examine licensing needs for innovative nuclear installations, (iii) examine risk-informed, performance-based approaches in licensing reviews and regulatory decision-making, (iv) delimit harmonization and standardization on component assessments, methodologies, codes and standards and (v) learn from earlier harmonization efforts.[36]

4. Conclusion

The global resurgence of nuclear energy, driven by the need for carbon neutrality, energy security, and growing demand, presents significant opportunities for the industry. However, to fully realize the benefits of nuclear energy, collaborative efforts – like those of the IAEA and new-build projects – aiming to streamlining regulation are of high importance. While harmonization efforts in recent years have tended to focus on the licensing of SMRs, significant efforts have also been made to streamline regulation for large-scale reactor projects. The information set out in this paper serves as a foundation for further discussions regarding the main opportunities and challenges for streamlining regulation around the world, while maintaining high standards of safety, security and environmental protection, and ensuring public confidence.

[31] 'Cooperation in Reactor Design Evaluation and Licensing (CORDEL) Working Groups' (*World Nuclear Association*) <https://world-nuclear.org/our-association/working-groups?workinggroup=cordel#NuclearDeploymentValueChain> accessed 16 August 2024; 'CORDEL Strategic Plan 2019-2023' (*World Nuclear Association*, March 2019) <https://wna.origindigital.co/images/articles/CORDEL-Strategic-Plan-2019.pdf> accessed 21 August 2024, p. 3.

[32] 'CORDEL Strategic Plan 2019-2023' (*World Nuclear Association*, March 2019) <https://wna.origindigital.co/images/articles/CORDEL-Strategic-Plan-2019.pdf> accessed 21 August 2024, p. 5.

[33] Ibid.

[34] 'Towards harmonisation in licensing of future nuclear power technologies in Europe' (*European Commission*, 28 October 2022) <https://cordis.europa.eu/project/id/101061643> accessed 16 August 2024. See also 'Welcome to HARMONISE' <https://harmonise-project.eu/> accessed 16 October 2024.

[35] Ibid.

[36] Ibid.