



Working Group on Manufacturing, Construction, Commissioning and Operation

Phase 4 Report

Fleet-Wide Deployment

March 2026



The content of this SMRRegulators' Forum report is protected by copyright. To use information contained in this publication, in part or in its entirety, in printed or electronic form, for their own purposes, the SMR Regulators' Forum requires the parties to seek authorization from the Scientific Secretary at: SMR-Reg-Contact-Point.Team@iaea.org with the details of the excerpt extension and the purposes. Once permitted, it is requested to give credit to the SMR RF for the reproduction of its material in your publication. Proposals for non-commercial reproductions and translations are welcomed and considered on a case-by-case basis.

TABLE OF CONTENTS

EXECUTIVE SUMMARY.....	1
1. INTRODUCTION	3
1.1. IAEA CONTEXT.....	4
2. CONCEPT OF THE FLEET-WIDE APPROACH.....	5
3. ENVELOPE DESIGN STRATEGY	9
3.1. ENVELOPE DESIGN STRATEGY AND ASSOCIATED APPROACHES.....	9
3.2. REGULATORY BODY'S ACCEPTANCE OF A MEMBER STATE REVIEW.....	10
3.2.1. EXAMPLES OF REGULATORY COOPERATION	12
4. CONCLUSION.....	15
REFERENCES.....	16
ABBREVIATIONS.....	18
CONTRIBUTORS TO DRAFTING AND REVIEW.....	19

EXECUTIVE SUMMARY

There continues to be sustained global interest in small modular reactors (SMRs), which have the potential to play an important role in globally sustainable energy development as part of an energy mix. In particular, SMRs may enhance energy availability and security of supply in countries expanding their nuclear energy programs and those embarking on a nuclear energy program for the first time.

As the interest in SMRs continues to grow, so does the importance of international collaboration. Given that its main purpose is to bring together experienced regulatory bodies to identify and address key SMR-related challenges, the SMR Regulators' Forum (SMR RF) has an increasingly important role to play in making such collaboration possible.

The SMR RF <https://www.iaea.org/topics/small-modular-reactors/smr-regulators-forum> was formed in 2014 as a regulator-to-regulator entity to consider key issues that could emerge in future SMR regulatory discussions and propose common positions regarding the way in which these could be addressed. The Forum's work is expected to help enhance safety as well as efficiency in SMR regulation, including licensing, and to enable regulatory bodies to inform changes, if necessary, to their requirements and regulatory practices. Since then, the Forum has completed three phases of work. For more details about the Forum, please visit: <https://gnssn.iaea.org/regnet/SMR-Forum/Pages/default.aspx>

This report has been produced by the Manufacturing, Construction, Commissioning and Operation Working Group (MCCO WG) of the Forum during its Phase 4 of work (2024 to 2026). The report explores the conditions, strategies, and regulatory practices needed to enable fleet-wide deployment of SMRs across multiple countries and sites. It focuses on how standardized designs, harmonized regulatory approaches, and coordinated manufacturing practices can reduce deployment barriers and support safe, efficient expansion of SMR fleets worldwide.

This report was developed based on information, insights, and experience gained from the regulatory activities of the SMR RF Members. It is generally consistent with existing IAEA documents but may deviate in some cases. This report is intended to provide useful information in the development, deployment, and oversight of SMRs.

The text presents 'common positions', i.e. agreements reached within the WG, on issues such as how vendors are advised to implement envelope design strategies, the level of standardization expected for SMR components and modules, the conditions under which regulatory bodies could rely on third-party assurance of manufacturing quality, and the methods for assessing or accepting foreign codes and standards in support of multinational deployment.

While this report contains no specific recommendation for the IAEA, the common positions agreed upon by the MCCO WG are presented below.

COMMON POSITIONS FOR THIS REPORT

Common Position 1

Regulatory bodies should look at the conditions under which they are willing to accept third party assurance of the required level of manufacturing process and component quality.

Common Position 2

Vendors should consider using the envelope design strategy that involves developing either a design that adheres to the regulatory requirements of multiple countries or a design that complies with various site-specific requirements.

Common Position 3

Manufacturers of SMRs and microreactors should pursue a greater level of standardization for components and modules, because of mass serial production of components and their off-site assembly compared to traditional reactors. Standardization, especially when coupled with serial production, can lead to improved regulatory efficiency.

Common Position 4

Regulatory bodies need more experience working together on SMR designs to develop a better understanding of the envelope design strategy. The NUWARD Joint Early Review and the Trilateral Memorandum of Cooperation between the U.S. Nuclear Regulatory Commission (U.S. NRC), the Canadian Nuclear Safety Commission (CNSC) and the United Kingdom Office for Nuclear Regulation (UK ONR) have yielded substantive, tangible results on SMR and advanced reactor licensing and can serve as models for multilateral regulatory collaboration on new reactors.

Common Position 5

Regulatory bodies acknowledge that creating an envelope design approach will be challenging for the vendors given different standards and regulations in different jurisdictions. However, broadly used pressure boundary codes, such as those by the American Society of Mechanical Engineers (ASME) give vendors a starting point when initiating the envelope design approach.

Common Position 6

Regulatory bodies may consider formulating requirements for the comparison or even acceptance of codes and standards between different jurisdictions to effectively assess nuclear technologies of diverse origin.

1. INTRODUCTION

This report explores the concept of fleet-wide deployment. The business cases for SMRs often envisage wide deployment of a standardized design across multiple countries and potentially involving many different manufacturers. Vendors and potential new licensees will need to consider what codes and standards are applied in each country. There should be mutual efforts among vendors, manufacturers and licensees to find a suitable cooperation model if multiple fleets are to be built. The vendor must ensure that manufacturers produce components in line with the targeted deployment country's codes and standards. When a vendor seeks to use an international supply chain for the manufacture of its components, it is expected that its chosen partners will work to a common set of codes and standards that are accepted in the target market.

Some of these concepts below are explored in this report:

1. **Envelope Design Approach:** A single design meeting multiple national regulatory requirements with minimal adaptations, enabling fleet-wide standardization and efficient manufacturing. However, it requires complex upfront regulatory alignment and broad safety margins to cover diverse frameworks.
2. **Generic Site Envelope:** A regulatory approach that defines a broad range of external risks allowing a design to be deployed at multiple locations generally within a country. This simplifies fleet-wide deployment domestically but does not address cross-border licensing challenges.
3. **Cross-Border Acceptance of pre-licensing efforts:** Using pre-licensing approvals from one country, supported by gap analyses, to adapt to another's regulations.
4. **Recognition of Site-Specific Licenses:** Accepting licenses from other countries for specific sites, allowing faster deployment where conditions align. However, local infrastructure, environmental conditions, and regulatory differences often require modifications.
5. **International Harmonization Efforts:** Initiatives like the IAEA Nuclear Harmonization and Standardization Initiative (NHSI) and the SMR RF aim to streamline licensing and regulatory recognition, but detailed technical requirements remain country-specific, limiting full harmonization.

1.1. IAEA CONTEXT

At the highest level, the *IAEA Fundamental Safety Principles* [1] specify in section 3.4 that “[a]uthorization to operate a facility or conduct an activity may be granted to an operating organization or to an individual, known as the licensee.” In addition, the *IAEA Safety Standard on Governmental, Legal and Regulatory Framework for Safety* [2] requirement 23 states that “[a]uthorization by the regulatory body, including specification of the conditions necessary for safety, shall be a prerequisite for all those facilities and activities that are not either explicitly exempted or approved by means of a notification process.” Section 4.29 of this document states that “[d]ifferent types of authorization shall be obtained for the different stages in the lifetime of a facility or the duration of an activity. The regulatory body shall be able to modify authorizations for safety related purposes.”

More specific guidance for licensing is found in the *IAEA Safety Standard on the Licensing Process for Nuclear Installations* [3]. The following guidance is helpful in understanding the issues associated with fleet-wide deployment:

- The regulatory body holds the licensee responsible for safety regardless of commercial arrangements. The licensee must have the capability to demonstrate effective oversight and control of the activities being carried out under the license.
- The licensee needs to be able to exercise its responsibilities, giving priority to safety, without undue interference from its stakeholders.
- The applicant or licensee need to be able to demonstrate that contractual arrangements do not compromise the independence or safety of its decision making and effective oversight processes.

IAEA Safety Report No. 123 [4] identifies gaps in GSR-Part 1 [2], GSG-12 [5], SSG-12 [3], GS-G-3.1 [6], GS-G-3.5 [7], SSG-71 [8], SSG-72 [9], SSG-74 [10] and SSG-75 [11], in relation to the consideration of new ownership and operating models for fleets of geographically dispersed SMRs. Some of these issues will be addressed, at a high level, in the revised version of SSG-12. However, additional information would be helpful to support Member States in considering new SMR deployment models. This is particularly important for embarking member states that will rely on regulatory reviews done in other member states. The discussion of the envelope design approach and generic site envelope in this report are helpful to regulatory bodies and licensees to understand the approach that vendors will take to implement a fleet wide approach. In addition, the idea of cross-border acceptance of pre-licensing efforts, site-specific licenses, and third-party design assessments present new challenges to licensees and regulatory bodies.

2. CONCEPT OF THE FLEET-WIDE APPROACH

Common Position 1

Regulatory bodies should look at the conditions under which they are willing to accept third party assurance of the required level of manufacturing process and component quality.

As stated in the MCCO Phase 3 report [12], “[f]leet-wide concept is a broad concept and could apply to different stages of SMR lifecycles. For the purpose of manufacturing the concept can be described as follows: a first-of-a-kind (FOAK) design is taken and is used to create a fleet of the same design.” A ‘fleet’ of SMRs may be owned/operated by more than one organization, or one organization may own many of the SMRs. Location is not limited to a specific Member State, and the same design could be deployed in multiple Member States.

A fleet of SMRs in this report is understood as a deployment of the same design SMRs at more than one site to achieve cost-effectiveness in serial production. It is closely connected to off-the-shelf manufacturing, because it would be necessary to have related components ready in minimum time. It can be assumed that a typical SMR fleet will consist of more than two units to fulfil the economic benefits. According to a study prepared for the UK Department of Energy & Climate Change [13], cost parity between SMRs and large-scale NPPs (the economic criterion of the fleet) can be reached within 5-8 GWe deployment of a specific SMR design (i.e. at least 10 units depending on its power output).

Fleet-wide approach is strongly dependent on the SMR design characteristics. The main differentiating criteria may include:

- a. Reactor type (pressurized water reactor, boiling water reactor, very high temperature gas reactor, gas-cooled fast reactor, lead-cooled fast reactor, sodium-cooled fast reactor, molten salt fast reactor, etc.);
- b. SMR power and size (in line with the MCCO Phase 2 report [14] definition of micro, small reactors, i.e. typically <300 MWe);
- c. Degree of modularity (modular components, modular or integral reactor etc. - see the MCCO Phase 2 report [14]).

The market potential for lower-output nuclear reactors could significantly exceed that of traditional large-scale designs and promises benefits of standardization, serial manufacturing and off-site assembly, if massively produced. Under high demand scenarios, we might see fleet deployment of tens or hundreds of SMRs to hundreds or thousands of compact microreactors. This shift would likely drive manufacturing

approaches resembling aviation industry practices (see blue box below¹), favouring standardized serial production over custom-built components. As reactor power levels decrease, key trends, like increased standardization (smaller designs enable modular architectures and repeatable manufacturing processes) and supply chain evolution (off-the-shelf procurement rather than bespoke fabrication), emerge. This can impact both manufacturing and regulation in innovative, more efficient aviation-like manner.

¹ Sources: Aviation Suppliers Association: <https://www.aviationsuppliers.org>, European Union Aviation Safety Agency: <https://www.easa.europa.eu/en>, Federal Aviation Administration: <https://www.faa.gov>, Global certification body: <https://www.nga.com/en-cy/certification/sectors/aerospace>.

Manufacturing and certification in aviation industry

Aviation manufacturing is all about safety and precision. This requires meeting the challenges of using and integrating product purchased from suppliers throughout the world, while delivering product for multiple customers to their varying expectations and specifications.

The drive towards unified quality processes in the aviation industry arose from the need to ensure consistent, high-quality standards across a complex global supply chain. Historically, individual aerospace companies had their own proprietary quality management standards, which created challenges in coordinating suppliers and verifying compliance. To address this, the industry collaborated to develop the AS9100 family of standards as a comprehensive, globally recognized framework.

To maintain the highest standards, regulatory bodies have played a key role in influencing this congruence. Aviation regulators, such as the Federal Aviation Administration and the European Union Aviation Safety Agency, mandate that manufacturers adhere to approved quality management standards like AS9100. These regulatory bodies expect manufacturers to have well-documented and rigorously implemented processes in place to minimize risks and ensure that components meet the most stringent safety requirements.

The core set of Standards is AS9100 series, which focuses on Quality Management Systems (QMS) specific to Aviation, Space & Defense. The AS9100 series is one of the most recognized in the global aerospace industry. AS9100 actually incorporates the entirety of the current ISO 9001 standard, which is a generic QMS standard applicable to various industries but includes additional industry requirements specific to the aerospace industry.

The AS9100 series covers a wide range of areas, including product safety, configuration management, raw material testing, post-delivery support, managing the risk of counterfeit parts and more.

Based on AS9100, the manufacturers build a QMS that integrates processes for quality control, documentation, and continuous improvement. Third-party auditors then assess the manufacturer's QMS for compliance with the standards. Achieving certification demonstrates adherence to the standards for the regulatory bodies.

Regulators expect manufacturers to have robust processes in place to minimize risks and ensure components meet stringent safety requirements, to have a documented QMS that ensures parts are manufactured to exact specifications and every component to be traceable throughout the manufacturing process.

Sources:

Aviation Suppliers Association: <https://www.aviationsuppliers.org/>

European Union Aviation Safety Agency: <https://www.easa.europa.eu/en>

Federal Aviation Administration: <https://www.faa.gov/>

Global certification body: <https://www.nqa.com/en-cy/certification/sectors/aerospace>

Considering the above, serial manufacturing is likely for reactors of small power or micro-reactors, which can be similar to aviation industry with its processes. However, with this, greater level of standardization and harmonization is expected. In particular, it is expected that the regulatory bodies will find efficiencies and standardize the licensing processes for high volume licensing requests which could streamline and potentially shorten the licensing times, due to experience gained from domestic and international licence applications. Regulatory bodies can also work together, even though the quality standards and expectations among the Member States differ. The aviation industry, where safety is of utmost importance, is a good example of standardization and harmonization.

3. ENVELOPE DESIGN STRATEGY

Common Position 2

Vendors should consider using the Envelope Design Strategy that involves developing either a design that adheres to the regulatory requirements of multiple countries or a design that complies with various site-specific requirements.

Common Position 3

Manufacturers of SMRs and microreactors should pursue a greater level of standardization for components and modules, because of mass serial production of components and their off-site assembly compared to traditional reactors. Standardization, especially when coupled with serial production, can lead to improved regulatory efficiency.

3.1. ENVELOPE DESIGN STRATEGY AND ASSOCIATED APPROACHES

The Envelope Design Strategy enables standardized designs to be licensed and deployed across multiple sites and jurisdictions. While there is no strict formal definition universally adopted in nuclear engineering, the concept is commonly used in reactor design, licensing strategies, and component qualification. By developing a reactor system that complies with a broad range of regulatory, environmental, and operational requirements, vendors can reduce the complexity of site-specific adaptations and facilitate efficient manufacturing and deployment. This approach is particularly relevant for SMRs, where the economic case depends on fleet-wide standardization and the ability to deploy multiple units with minimal design changes.

Within this strategy, two primary approaches can be distinguished: the Envelope Design Approach (EDA) and the Generic Site Envelope (GSE).

The EDA focuses on ensuring that a single design – or a small set of standardized variations – meets the regulatory requirements of multiple countries. This makes it an attractive option for fleet-wide deployment, as it allows vendors to streamline international licensing while minimizing redesign efforts. It is particularly valuable in regions like Europe, where diverse regulations have been developed independently within a relatively small area. However, this approach is inherently complex, as it requires extensive regulatory harmonization efforts, addressing differences in safety classification, siting criteria, and licensing frameworks across various countries. It requires efforts from the vendor to clearly understand the different regulatory frameworks and expectations. Successfully implementing this approach demands early engagement with regulatory bodies and a design that incorporates common safety standards to ensure broad acceptance.

On a more localized scale, the GSE approach is used within a single or similar regulatory framework to assess how a reactor design can accommodate varying external site conditions. This approach is commonly applied in Generic Design Assessments (GDA), such as those conducted for Rolls-Royce SMR (RR-SMR) in the

UK. Instead of adapting a design for each specific location, sensitivity analyses are performed on multiple potential sites to define an envelope of conditions for external risks within which the reactor can be deployed and safely operated. This method primarily focuses on cliff-edge effects, analyzing how external hazards could push the design beyond its safety margins. Since it deals only with variations in external site parameters, the GSE is a simpler and more targeted process than the broader EDA, making it a practical tool for fleet-wide deployment within a single country.

By integrating both approaches, vendors can optimize their fleet-wide deployment strategies, using the EDA where international deployment is planned, and the GSE where reactors are expected to be deployed in multiple locations within a single regulatory environment. This combination ensures faster licensing, reduced project risks, and cost-efficient serial production, making SMRs more viable as a scalable energy solution.

However, the scope of regulatory focus can differ. For example, some Member States emphasize only the reactor pressure boundary, while others extend their review to systems important to safety. Initially, the design can focus on common safety standards with adaptations for individual national regulations later to minimize the need for costly and time-consuming design modifications. While some regulatory-specific adaptations may be necessary, the broader applicability of the envelope design significantly reduces overall project complexity and facilitates economies of volume associated with fleet-wide production and deployment. This approach fosters enhanced cooperation between nuclear regulatory bodies by promoting a common understanding of the design and its safety features, contributing to more efficient and harmonized regulatory processes. As a result, this approach puts more responsibility on vendors.

Within the Envelope Design Strategy, different approaches are better suited to different stages of the NPP life cycle. For example, during the early design phase, a more standardized approach that incorporates the most stringent common safety standards is critical for ensuring broad acceptance and facilitating licensing. As construction progresses, the focus may shift to localized assessments of site-specific risks, ensuring the design can adapt to varying external site conditions. By adjusting the approach to each phase, the design remains flexible and continues to meet regulatory and operational needs throughout the life cycle.

3.2. REGULATORY BODY'S ACCEPTANCE OF A MEMBER STATE REVIEW

Common Position 4

Regulatory bodies need more experience working together on SMR designs to develop a better understanding of envelope design strategy. The NUWARD Joint Early Review and the Trilateral Memorandum of Cooperation between the U.S. Nuclear Regulatory Commission (U.S. NRC), the Canadian Nuclear Safety Commission (CNSC) and the United Kingdom Office for Nuclear Regulation (UK ONR) have yielded substantive, tangible results on SMR and advanced reactor

licensing and can serve as models for multilateral regulatory collaboration on new reactors.

Common Position 5

Regulatory bodies acknowledge that creating an envelope design approach will be challenging for the vendors given different standards and regulations in different jurisdictions. However, broadly used pressure boundary codes, such as ASME, give vendors a starting point when initiating the envelope design approach.

Common Position 6

Regulatory bodies may consider formulating requirements for the comparison or even acceptance of codes and standards between different jurisdictions to effectively assess nuclear technologies of diverse origin.

An alternative scenario involves countries leveraging licensing work conducted elsewhere, such as a GDA or pre-licensing process completed in another country. The SMR RF has led the development of a methodology for a regulatory body to leverage the reviews completed by other regulatory bodies [15] within the framework of the IAEA NHSI. Leveraging regulatory reviews can save considerable time and resources, but it does not automatically enable fleet-wide deployment. Before being able to leverage another regulatory review, a divergence analysis is necessary to evaluate differences in national regulations, as well as site-specific or design-specific requirements that could impact manufacturing, construction, commissioning and operation. Divergences could include differences in safety standards, safety categorization and classification, reporting obligations, or environmental considerations, while site-specific issues might relate to external risks or infrastructural differences. Although such evaluations may require input from vendors, they are essential for ensuring compliance without redundant licensing efforts that could delay fleet-wide deployment.

Another approach focuses on leveraging site-specific reactor licenses granted by other countries. While this framework builds on already-approved designs for specific sites, it similarly requires a careful assessment of divergences between the original licensed conditions and the requirements of the receiving country. Such evaluations could focus on both regulatory compatibility and technical adaptations necessary for the new deployment location. Although this strategy simplifies the process, site-specific differences often prevent direct deployment without additional review.

Efforts to align global regulatory frameworks are also underway through international initiatives, such as the IAEA NHSI or such entities as the SMR RF. These initiatives and entities aim to harmonize safety goals, promote mutual recognition, and reduce duplication of regulatory efforts. While such initiatives hold promise, full harmonization remains challenging, particularly at the level of detailed technical requirements, which tend to remain jurisdiction specific. In some cases, other technically competent organizations could assess SMR designs to provide neutral reviews for regulators, but national bodies would still retain authority over the final

approval. In addition, the Organisation for Economic Cooperation and Development Nuclear Energy Agency's (OECD NEA) working groups focus on nuclear safety, sharing of knowledge and development of best practices, which can lead to enhanced harmonization and increased regulatory efficiency.

While these strategies partially focus on licensing, without an efficient and predictable licensing framework, standardized production, site preparation, and deployment cannot move forward. A fragmented process creates bottlenecks that delay manufacturing readiness and infrastructure development, undermining fleet-wide efficiency.

3.2.1. EXAMPLES OF REGULATORY COOPERATION

Regulatory bodies are beginning to work together to review specific designs (e. g. NUWARD Joint Early Review initiative, Rolls-Royce GDA observation process, etc.).

For the EDF NUWARD SMR design, developed by a consortium led by the French utility Électricité de France (EDF), the French nuclear regulatory body ASN² worked with other European regulatory bodies (France, Czechia, Finland) through a 'joint early review' process. This collaborative assessment aimed to align requirements and facilitate the potential deployment of the NUWARD design across Europe. As of July 2024, the EDF announced major modification to the NUWARD design, which halted the current cooperation³. In January 2025, NUWARD announced relaunching the development of SMR⁴ [16].

Similarly, the Rolls-Royce SMR, a 470 MWe pressurized water reactor design from the UK, is undergoing evaluation by the UK ONR through the GDA process. Czech, Finnish, Dutch, Polish and Swedish nuclear regulatory bodies participated as observers to this process.

The GE-Hitachi BWRX-300 SMR, a 300 MWe boiling water reactor, is currently being reviewed by the CNSC and the U.S. NRC as part of licensing reviews, and it is also in review by the ONR under their GDA process. The U.S. NRC has signed a Memorandum of Co-operation (MoC)⁵ with the CNSC and ONR for the coordinated assessment of the GE-Hitachi design and its potential deployment in multiple jurisdictions. It is more than likely that these collaborations will continue among the Member States.

² ASN and IRSN merged to form ASNR from 1 January 2025.

³ https://www.linkedin.com/posts/nuward_smr-activity-7215987924771684352-dlc6?utm_source=share&utm_medium=member_desktop; also at <https://www.nuward.com/en/what-s-new>.

⁴ https://www.linkedin.com/posts/nuward_nuward-relaunches-the-development-of-its-activity-7282013908419186689-m4PU?utm_source=share&utm_medium=member_desktop; also at <https://www.nuward.com/en/what-s-new>.

⁵ MoC On Advanced Reactor and SMR Technologies Among NRC, CNSC And ONR, <https://www.onr.org.uk/media/2wofjcp3/moc-on-advanced-reactor-and-small-modular-reactor-technologies-among-the-usnrc-cnsc-and-onr.pdf>

This growing trend of multinational regulatory cooperation is crucial for the streamlined deployment of SMRs worldwide. By aligning on safety standards, design requirements, and review processes, regulatory bodies can ensure a more efficient and consistent approach to evaluating these advanced nuclear technologies, regardless of their country of origin. This collaboration helps to eliminate unnecessary duplication of effort and facilitates the global commercialization of SMRs.

While these are examples of cooperation in the licensing of SMRs, manufacturing of SMRs has not proceeded to more than one item at a time. It is expected that further cooperation and oversight of manufacturing and construction of SMR can be achieved through the OECD/NEA Committee on Nuclear Regulatory Activities (CNRA) Working Group on Supply Chain (WGSUP) and other MoCs between Member States (see also the blue box below). The international deployment of SMRs will require more intensive cooperation among regulatory bodies compared to traditional NPPs. Sharing of information, experiences and lessons learned will play a more important role and enable more effective assessment of different technologies. The final responsibility will be with the national regulatory bodies of the licensee's country themselves.

Focus area: Committee on Nuclear Regulatory Activities - Working Group on Supply Chain (CNRA WGSUP)

Extract of document NEA/SEN/NRA (2022)7 [17]:

“The WGSUP provides a mechanism for nuclear safety regulators and Technical Support Organisations to share their knowledge in making policy and licensing decisions, as well as oversight practices related to the supply chain. WGSUP focuses on supply-chain-related issues of operating nuclear power reactors and those progressing towards nuclear licence application or are under construction in NEA member and partner countries. The WGSUP aims to facilitate an active and timely exchange of commendable practices, information on specific challenges and emerging risks like Counterfeit, Fraudulent, and Suspect Items (CFSI), as well as lessons learned to help regulators perform these functions more effectively and efficiently.

The WGSUP collects and analyses information to:

- leverage national regulatory resources, and share vendor inspection information and experience to support and enable regulators to verify the quality of the supply chain and its products and services;
- share vendor inspection practices among regulators;
- facilitate the adoption of good vendor oversight practices by national regulators;
- focus the attention of regulators, licensees and vendors on areas of emerging risk;
- focus licensee and vendor oversight on effective supply chain performance;
- focus licensees’ and vendors’ attention on positive nuclear safety culture expected within the supply chain;
- maximise the use of the results obtained from other regulators’ efforts; and
- continue to learn from the similarities and differences between national regulators’ quality management system requirements and utilise the information to improve regulators’ own requirement.”

4. CONCLUSION

The fleet-wide deployment of SMRs is an essential part of the business case for many SMR vendors. To realize fleet wide deployment, this report emphasizes the need for greater standardization, third-party quality assurance, and regulatory cooperation to streamline licensing and manufacturing processes. A central strategy is to use an envelope design strategy, and associated approaches, that aim to create reactor designs that meet a broad range of regulatory requirements with minimal modifications. All the options proposed in this report are suggestions for industry that can serve as a risk reduction strategy and can prove beneficial during their procurement process. Ultimate responsibility for fleet-wide deployment is on the industry to ensure that they meet the regulatory requirements. The vendor must ensure that manufacturers produce components in line with the targeted deployment country's codes and standards. There should be mutual interaction and effort to find suitable cooperation model among vendors, manufacturers and licensees if multiple fleets are to be built.

It is hoped that the common positions in the report will be helpful to regulatory bodies and the industry involved in the development, deployment and oversight of SMRs. These concepts introduced here are expected to be further discussed by various working groups of the IAEA NHSI.

REFERENCES

- [1] EUROPEAN ATOMIC ENERGY COMMUNITY, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, INTERNATIONAL MARITIME ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, WORLD HEALTH ORGANIZATION, Fundamental Safety Principles, IAEA Safety Standards Series No. SF-1, IAEA, Vienna (2006),
<https://doi.org/10.61092/iaea.hmxn-vw0a>
- [2] INTERNATIONAL ATOMIC ENERGY AGENCY, Governmental, Legal and Regulatory Framework for Safety, IAEA Safety Standards Series No. GSR Part 1 (Rev. 1), IAEA, Vienna (2016).
- [3] INTERNATIONAL ATOMIC ENERGY AGENCY, Licensing Process for Nuclear Installations, IAEA Safety Standards Series No. SSG-12, IAEA, Vienna (2010).
- [4] INTERNATIONAL ATOMIC ENERGY AGENCY, Applicability of IAEA Safety Standards to Non-Water-Cooled Reactors and Small Modular Reactors, IAEA Safety Reports Series No. 123, IAEA, Vienna (2023).
- [5] INTERNATIONAL ATOMIC ENERGY AGENCY, Organization, Management and Staffing of the Regulatory Body for Safety, IAEA Safety Standards Series No. GSG-12, IAEA, Vienna (2018).
- [6] INTERNATIONAL ATOMIC ENERGY AGENCY, Application of the Management System for Facilities and Activities, IAEA Safety Standards Series No. GS-G-3.1, IAEA, Vienna (2006).
- [7] INTERNATIONAL ATOMIC ENERGY AGENCY, The Management System for Nuclear Installations, IAEA Safety Standards Series No. GS-G-3.5, IAEA, Vienna (2009).
- [8] INTERNATIONAL ATOMIC ENERGY AGENCY, Modifications to Nuclear Power Plants, IAEA Safety Standards Series No. SSG-71, IAEA, Vienna (2022).
- [9] INTERNATIONAL ATOMIC ENERGY AGENCY, The Operating Organization for Nuclear Power Plants, IAEA Safety Standards Series No. SSG-72, IAEA, Vienna (2022).
- [10] INTERNATIONAL ATOMIC ENERGY AGENCY, Maintenance, Testing, Surveillance and Inspection in Nuclear Power Plants, IAEA Safety Standards Series No. SSG-74, IAEA, Vienna (2022).
- [11] INTERNATIONAL ATOMIC ENERGY AGENCY, Recruitment, Qualification and Training of Personnel for Nuclear Power Plants, IAEA Safety Standards Series No. SSG-75, IAEA, Vienna (2022).

- [12] SMALL MODULAR REACTORS REGULATORS' FORUM, Regulatory Considerations in Pre-Licensing Engagement for Long-Lead Item Requests, Working Group on Manufacturing, Construction, Commissioning and Operation, Phase 3 Report (2023).
- [13] ATKINS LIMITED, ERNST & YOUNG LLP, SMR Techno-Economic Assessment, Project 1: Comprehensive Analysis and Assessment, Techno-Economic Assessment Final Report, Volume 1 (2016).
- [14] SMALL MODULAR REACTORS REGULATORS' FORUM, Working Group on Manufacturing, Construction, Commissioning and Operation, Phase 2 Report (2021).
- [15] INTERNATIONAL ATOMIC ENERGY AGENCY, Collaborative Reviews and Effective Leveraging – The IAEA's Nuclear Harmonization and Standardization Initiative, IAEA-TECDOC-2098, IAEA, Vienna (2025),
<https://doi.org/10.61092/iaea.psrj-fkjj>
- [16] NUWARD EDF GROUP, NUWARD SMR, NUWARD SMR Joint Early Review Phase 2 Summary Report (2025),
<https://www.nuward.com/sites/nuward/files/2025-12/NUWARDJERPhase2publicreport.pdf>
- [17] NUCLEAR ENERGY AGENCY, ORGANISATION FOR ECONOMIC COOPERATION AND DEVELOPMENT, Mandate of the Working Group on Supply Chain (WGSUP), [NEA/SEN/NRA (2022)7], (2022).

ABBREVIATIONS

ASME	American Society of Mechanical Engineers
CFSI	Counterfeit, Fraudulent and Suspect Items
CNSC	Canadian Nuclear Safety Commission
EDA	Envelope Design Approach
EDF	Électricité de France
FOAK	First-Of-A-Kind
GDA	Generic Design Assessment
GSE	Generic Site Envelope
MoC	Memorandum of Co-operation
MCCO	Manufacturing, Construction, Commissioning and Operation
NHSI	Nuclear Harmonization and Standardization Initiative
NPP	Nuclear Power Plant
OECD/NEA	Organisation of Economic Co-operation and Development/Nuclear Energy Agency
QMS	Quality Management System
SMR RF	Small Modular Reactor Regulators' Forum
SMR	Small Modular Reactor
UK ONR	The United Kingdom Office for Nuclear Regulation
U.S. NRC	The U.S. Nuclear Regulatory Commission
WG	Working Group
WGSUP	Working Group on Supply Chain

CONTRIBUTORS TO DRAFTING AND REVIEW

This report was produced and/or reviewed by the following experts of the MCCO WG of the SMR RF and of the IAEA Secretariat and was subsequently approved by the SMR RF Steering Committee:

Baig, A.	Canadian Nuclear Safety Commission, Canada
Botelho, I. J.	International Atomic Energy Agency
Broeders, M.	Canadian Nuclear Safety Commission, Canada
Calle Vives, P.	International Atomic Energy Agency
Kasagawa, Y.	Nuclear Regulation Authority, Japan
Kavanagh, K. (Chair)	Nuclear Regulatory Commission, United States of America
Lee, S.	Nuclear Regulatory Commission, United States of America
Liu, R.	Nuclear and Radiation Safety Center, People's Republic of China
Magruder, S.	Consultant, International Atomic Energy Agency, United States of America
Nonyane, M. D.	National Nuclear Regulator, South Africa
Ondruška, J.	Ministry of Industry and Trade, Czech Republic
Piotukh, V.	International Atomic Energy Agency
Raunio, V. A. J.	Radiation and Nuclear Safety Authority, Finland
Shi, J.	International Atomic Energy Agency
Stenhoff, P.	Office for Nuclear Regulation, United Kingdom
Tolud, W. J.	Authority for Nuclear Safety and Radiation Protection, Kingdom of the Netherlands
Vlček, D.	State Office for Nuclear Safety, Czech Republic