WHY SERIALLY MANUFACTURED INDUSTRIAL PRODUCTS ARE CRUCIAL FOR RELIABLE DEPLOYMENT OF SMALL MODULAR REACTORS

Working Paper produced by the Industry Track Topic Group 2
IAEA Nuclear Harmonization and Standardization Initiative (NHSI)[1]

1. Widespread SMR deployment is important for energy security

Small modular reactors (SMRs) represent a reliable, low-carbon energy source that can be easily integrated with existing grid infrastructure and in new locations. Their deployment is essential to achieving energy security and net-zero objectives while meeting the increasing electrification and heat demands of diverse economies worldwide.

2. Capable and experienced suppliers are challenged by unique nuclear requirements

Rigorous requirements and demanding equipment specifications can ensure quality when they are well established within a mature supply chain specialized to deliver them, such as the top tier nuclear suppliers familiar with a robust nuclear safety culture and quality assurance awareness. However, when such demands are first introduced to lower tier suppliers serving other industries, or requested infrequently, they may upset normally stable manufacturing processes and increase costs and complexity. Paradoxically, in such cases the increase of quality assurance and control may lead to less conformance and reliability. This is because of the changing manufacturing process settings and product design details to meet just the nuclear requirements.

As the manufacturers face the nuclear industry's requirements for the first time or only intermittently, they may have difficulties in predicting the exact means to meet those requirements and related timelines. The manufacturer's learning curve is largely the result of changes in the quality assurance process, and it may take time if there are resource constraints within the manufacturer's organization.

3. Serially manufactured products are reliable and proven solutions

Several SMR vendors are planning to use high volumes of serially manufactured items.[2] From systems and equipment to sub-components, there are intensions to use a wide array of industrial equipment such as commercial turbine sets, cooling equipment, electrical switchgear, pumps, valves, etc. Proven industrial items, well-integrated in other high-reliability industrial facilities and with considerable operating experience, are also often applicable to SMRs.

Serial manufacturing in the nuclear industry represents an opportunity to lessen some of the challenges associated with stringent procurement requirements on low-volume production orders. At the same time, it can capitalize on the benefits of proven manufactured product designs. By utilizing equipment with successful track record in industrial settings, nuclear power plant projects can leverage the accumulated knowledge and experience from their widespread use.

4. SMR supply chains need to be based mainly on serially manufactured equipment

SMR supply chains need to focus on dependable lead times, optimizing costs and consistently conforming to requirements. This may happen in a near-term market of high-volume demand for

[1] This working report is not an IAEA publication. It reflects the consensus opinion of the members of the NHSI Industry Track Topic Group 2. The views expressed do not necessarily reflect those of the IAEA or its Member States

[2] Lessons Learned in Regulating Small Modular Reactors, Challenges, Resolutions and Insights, IAEA-TECDOC-2003, 2023

equipment. The supply chain should thus be designed to be resilient to market shocks and to sustain long-term support throughout the plant lifetime estimated to be upwards of 80 years for some of today's light-water SMR designs.

A common approach of basing the design on proven industrial equipment greatly minimizes the risk of bespoke requirements for each jurisdiction or by each customer, and it will lead towards international standardization of SMR components.

5. Using industry standard items without compromising safety or performance

The high level of safety is paramount and is achieved through SMR plant and system design based on defense-in-depth, passive designs and coupled with application of principles of diversity and redundancy as necessary. The high level of safety is demonstrated via deterministic and probabilistic safety analyses. Graded approach to risk management with robust acceptance processes enable use of industrial equipment in safety systems[3].

The IAEA is publishing a new TECDOC entitled *Suitability Evaluation of Commercial-grade Products for Use in Nuclear Power Plant Safety Systems* to provide information on approaches to evaluating the suitability of commercial grade items. This includes both their design aspects and quality of their manufacturing. An often-used concept related to the latter is commercial grade dedication for which international[4], regional[5] and national guidance[6] and standards[7] already exist, but new related approaches are also emerging. There is an opportunity for new paradigms and a greater consensus on how to deliver the suitability of such items whilst still meeting national expectations.

6. "Design for supply chain" philosophy

To maximize the use of proven, commercially available products in SMRs, designers should be able to look for such equipment on the market. They can then design systems and sub-systems around these products, rather than develop unique specifications for products not readily available in industrial supply chains. In doing so, SMR developers can maximize the potential benefits of industrial products, such as consistent conformance with established product design, proven operating experience, safety and performance improvements, cost savings and accelerated deployment timelines.

Using existing industrial products support standardization and offer significant advantages in cost management, access to higher volume manufacture and time to market. Some SMR vendors have highlighted this "catalogue" approach to their near-term deployments by also designing SMR systems that can use multiple industrial equivalents available on the open market.

CONCLUSION

High quality is the outcome sought for any nuclear procurement. Thus, the importance of reaching a common understanding and vision for SMR supply chains in using serially manufactured industrial items needs to be recognized among all stakeholders. Specifically, that is, between operators, regulators, industry, and government bodies responsible for industrial strategy. The success of a large SMR market with its supply chain using extensively serially manufactured items represents an avenue to reduce three major risks: the obsolescence of items, bottlenecks in supplies, and the ability to use the most modern equipment and proven technologies. All stakeholders need to consider how to leverage serially manufactured items to support widening and resilience of the nuclear supply chain so that near-deployment SMRs will meet the challenge of being part of the answer to net-zero future.

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[3] *Ref IAEA TECDOC 2034 on Suitability Evaluation of Commercial Grade Products for Use in Nuclear Power Plant Safety Systems.*
[4] World Nuclear Supply Chain Outlook, 2023 edition, World Nuclear Association
[5] *Quality Assurance Guideline for Procuring High-Quality Industrial Grade Items Aimed at Supporting Safety Functions in Nuclear Facilities*, Foratom, 2022
[6] *Guideline for the Acceptance of Commercial-Grade Items in Nuclear Safety- Related Applications: Revision 1 to EPRI NP-5652 and TR-102260*. EPRI, Palo Alto, CA: 2014. 3002002982.
[7] *UNE 73403:1995 standard*