Review on Regulatory Framework and Licensing Process for SMR Deployment in Canada

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***Keywords : SMR, Regulatory Framework, Licensing, VDR**

1. Introduction

Small Modular Reactors (SMRs) are increasingly regarded as a critical option for decarbonization and reliable energy supply in the global energy transition. Canada, with its strong nuclear industry and clear commitment to achieving Net Zero by 2050, is emerging as one of the most active markets for SMR deployment. The Government of Canada has published the *SMR Roadmap* (2018)[1] and the *SMR Action Plan* (2020)[2], highlighting its strategic vision for next-generation nuclear technologies. Under this policy, the Canadian Nuclear Safety Commission (CNSC) granted a construction licence for the BWRX-300 small modular reactor at the Darlington site in Ontario in 2025, marking a significant step toward SMR deployment in Canada. Moreover, New Brunswick is advancing the ARC-100 sodium-cooled fast reactor project in partnership with ARC Clean Technology, further demonstrating Canada's role as a leading market for diverse SMR technologies.

To successfully participate in this growing SMR market, however, it is essential to understand Canada's regulatory framework and licensing procedures for new nuclear facilities. Accordingly, this paper reviews the Canadian regulatory system, including the regulatory framework, licensing stages, and the Vendor Design Review (VDR) process, to provide insights for prospective SMR deployment in Canada.

2. Canadian Nuclear Regulatory Framework

The Canadian Nuclear Safety Commission (CNSC) administers a comprehensive regulatory framework that governs all nuclear activities in Canada. The CNSC's regulatory framework (see Fig. 1) is founded on the Nuclear Safety and Control Act (NSCA) and other parliamentary statutes, and is implemented through regulations, licences, and regulatory document that provide clarity and enforceability for applicants and licensees[3].

At the highest level is the Nuclear Safety and Control Act (NSCA), which establishes the authority of the CNSC and defines its mandate to regulate the development, production, and use of nuclear energy and materials in Canada[4].

Under the NSCA, several regulations specify detailed requirements. For nuclear facilities, the General Nuclear Safety and Control Regulations and the Class I Nuclear Facilities Regulations are particularly important, as they govern licensing requirements, operational safety, and worker protection [5][6].

Licences are binding legal instruments issued by the CNSC for distinct stages: site preparation, construction, operation, decommissioning, and abandonment. Certificates apply to activities such as radiation devices or transport packages.

CNSC publishes regulatory documents that elaborate on expectations for safety, analysis, and operations. For instance, REGDOC-2.4.1, Deterministic Safety Analysis specifies safety analysis methodologies, while REGDOC-2.10.1, Nuclear Emergency Preparedness and Response sets requirements for emergency planning zones and response frameworks [7][8].

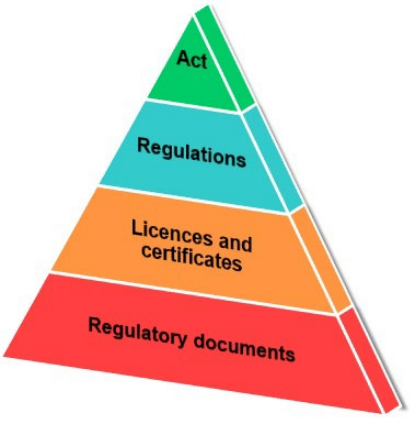

Fig. 1. Key elements of the CNSC's regulatory framework

In addition to these key elements, the CNSC also makes use of external forms of guidance to provide greater clarity for applicants and licensees. Such guidance may include information on best practices and the application of domestic and international standards. In particular, standards developed by the Canadian Standards Association (CSA) form an important component of the regulatory environment. While not legally binding in the same way as the Act or regulations, CSA standards complement CNSC regulatory documents by offering technical specifications and practical approaches that help demonstrate compliance with regulatory requirements.

These standards, together with CNSC regulatory documents, provide applicants with both flexibility and transparency in meeting safety objectives under the Canadian nuclear regulatory framework.

3. Licensing Process for New Nuclear Facilities

The licensing process in Canada is a five-step lifecycle: (1) site preparation, (2) construction, (3) operation, (4) decommissioning, and (5) abandonment. At each stage, a licence is required and issued by the CNSC following a detailed review of technical submissions. Each licence application must demonstrate compliance with the NSCA and its regulations, supported by deterministic and probabilistic safety assessments, environmental impact evaluations, and operational programs. Importantly, the process integrates mandatory public and Indigenous engagement.

Before a project can proceed to the licensing stage, it must first undergo a federal Impact Assessment to evaluate potential environmental and socio-economic effects. Under the Impact Assessment Act (IAA, 2019), designated projects such as nuclear reactors require an Impact Assessment that includes consultation with Indigenous peoples and opportunities for public comment [9]. Additionally, CNSC public hearings are held at each licensing stage, enabling participation from Indigenous communities, local residents, NGOs, and other stakeholders. This reflects Canada's constitutional duty to consult Indigenous peoples and its commitment to transparent, participatory regulation. The Impact Assessment further considers socio-economic factors, such as impacts on the regional economy, employment generation, social well-being, and the cultural and social sustainability of Indigenous communities. These broad considerations ensure that nuclear projects are evaluated not only for technical safety and environmental protection but also for their overall societal impact.

In parallel with the licensing process, vendors may seek a Vendor Design Review (VDR), a voluntary pre-licensing technical review service offered by the CNSC under REGDOC-3.5.4[10]. While the VDR does not result in the granting of a licence, it plays a vital role in providing early regulatory feedback, reducing project risks, and increasing the confidence of potential Canadian operators. The VDR is conducted in three phases;

- Phase 1 :
  focuses on high-level safety concepts and design philosophy

- Phase 2 :
  examines technical details such as reactor physics, thermal-hydraulics, probabilistic safety assessment, instrumentation and control, and severe accident management

- Phase 3:
  reviews how the vendor has addressed previous findings

A central element of the VDR is its review of 19 Focus Areas, which include reactor physics, fuel design, thermal-hydraulic behavior, severe accident management, radiation protection, safeguards, fire and external hazards, commissioning and operations planning, as well as organizational aspects such as management systems and quality assurance. For SMRs, these focus areas are particularly important because they allow early discussion of innovative features such as integral primary systems, natural circulation, modular construction, and digital instrumentation and control. Although not legally binding, a successful Phase 2 review often serves as a strong signal of regulatory feasibility, which can also strengthen the vendor's position in other international markets.

4. Key Regulatory Issues for SMRs

While Canada's regulatory framework is technology-neutral, SMRs introduce challenges that extend beyond conventional reactor licensing. One major issue is the validation of passive safety systems, such as natural circulation or gravity-driven injection, which require experimental data and advanced code validation. Another is the licensing of multi-module facilities, where shared systems must be evaluated to ensure that risks do not propagate across units. Digital instrumentation and control systems also present regulatory challenges, as their reliance on software introduces cybersecurity considerations. In addition, some SMR designs propose the use of advanced fuels, such as TRISO or metallic fuels, which have not yet been licensed in Canada and therefore demand new qualification programs. Waste management and decommissioning strategies also need to be clarified, particularly for novel fuel cycles. Finally, SMR projects proposed for deployment in remote or Indigenous territories will face heightened expectations for community engagement and socio-economic benefits.

5. Discussion

Canada's regulatory framework balances rigor with flexibility, making it an attractive environment for SMR deployment. The licensing process ensures that projects meet stringent safety and environmental standards, while the VDR process allows vendors to proactively align with Canadian expectations.

However, the dual requirement of technical excellence and social licence to operate cannot be overstated. Indigenous engagement, transparent communication, and proactive resolution of public concerns will be as critical as resolving technical issues.

For international vendors, success in Canada may depend as much on social legitimacy as on engineering innovation.

6. Conclusion

The Canadian regulatory framework for new nuclear facilities provides a comprehensive pathway for SMR deployment, consisting of a stepwise licensing process and an optional but highly influential VDR. Together, these mechanisms allow early identification of technical and social challenges while maintaining Canada's high standards for safety and environmental protection.

For international vendors, Canada represents both a promising market and a proving ground. Mastery of the CNSC's regulatory expectations—including the 19 VDR Focus Areas, Indigenous engagement requirements, and advanced fuel qualification—will be essential for successful entry.

Acknowledgement

This study was conducted with the support of the National Research Foundation of Korea with the funding of the government (Ministry of Science and ICT). (No. NRF-2020M2D7A1063205)

REFERENCES

[1] Canadian CSMR Roadmap Steering Committee. A Call to Action: A Canadian Roadmap for Small Modular Reactors. Ottawa, 2018.
[2] Natural Resources Canada, Canada's SMR Action Plan. Launched December 18, 2020.
[3] CNSC, REGDOC-3.5.3, Regulatory Fundamentals, version 2.1, 2021.
[4] CNSC, Nuclear Safety and Control Act, 2000.
[5] CNSC, General Nuclear Safety and Control Regulations. SOR/2000-202, 2000.
[6] CNSC, Class I Nuclear Facilities Regulations. SOR/2000-204, 2000.
[7] CNSC, REGDOC-2.4.1, Deterministic Safety Analysis., 2014.
[8] CNSC, REGDOC-2.10.1, Nuclear Emergency Preparedness and Response, 2017.
[9] Impact Assessment Agency of Canada (IAAC). Impact Assessment Act., 2019.
[10] CNSC, REGDOC-3.5.4, Pre-Licensing Review of a Vendor's Reactor Design, 2021.