Strategic Preparation of the Canadian VDR Application for SMART

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1. Introduction

Small Modular Reactors (SMRs) are emerging as a practical and powerful solution for energy security in the global energy transition. SMRs are increasingly regarded as a next-generation nuclear technology capable of supporting both decarbonization and reliable electricity supply.

To secure competitiveness in the global SMR market, it is essential to undergo internationally recognized licensing processes such as the U.S. Nuclear Regulatory Commission (NRC) Design Certification (DC), the Canadian Nuclear Safety Commission (CNSC) Vendor Design Review (VDR), and the United Kingdom's Office for Nuclear Regulation (ONR) Generic Design Assessment (GDA). These procedures not only verify the safety and feasibility of reactor designs but also function as important mechanisms for securing stakeholder confidence.

Canada has recently emerged as a leading market for SMRs, supported by strong governmental policies and active deployment initiatives. The CNSC's approval of the BWRX-300 at Ontario's Darlington site, along with the ARC-100 fast reactor project in New Brunswick, demonstrates Canada's role as both a proving ground for next-generation nuclear technologies and a leading market for global SMR deployment. In this context, many reactor vendors are actively utilizing the VDR process either to pursue entry into the Canadian SMR market or to enhance their international recognition.

The SMART reactor, developed in Korea, has already obtained Standard Design Approval twice in Korea, demonstrating its technological readiness. Through collaboration with the province of Alberta and joint feasibility studies with several interested countries, Korea has explored opportunities to expand SMART deployment abroad. Applying for a VDR is therefore regarded as a practical and strategic step to increase the feasibility of SMART's entry into the Canadian SMR market while also enhancing its global recognition.

This paper examines the key considerations and the current status of preparations for a SMART VDR application, with the aim of providing insights into international deployment strategies for Korean SMRs.

2. Overview of Canadian Vendor Design Review

2.1 Purpose

The VDR is a voluntary pre-licensing process conducted by the CNSC upon request by a vendor. Its purpose is to assess whether a new design meets Canadian regulatory expectations, identify potential licensing barriers, and mitigate uncertainties in subsequent licensing stages. Importantly, VDR is not a regulatory approval but a process that highlights the adequacy and gaps of the design, thereby fostering constructive dialogue between vendors and the regulator.

2.2 VDR Process

The Vendor Design Review (VDR) begins when the vendor formally expresses its intent to participate through pre-engagement discussions with the Canadian Nuclear Safety Commission (CNSC). During this stage, the scope of the review (Phase 1, 2, or 3), schedule, and associated costs are negotiated. The process is officially initiated once a Service Agreement is signed between the vendor and the CNSC.

The VDR is structured as a Phased Review, consisting of three phases that may be pursued to the extent requested by the vendor:[1]

- Phase 1 (General Review):
  Examines the conceptual design, safety goals, defense-in-depth philosophy, and R&D status. The main purpose is to verify whether fundamental safety concepts align with international regulatory expectations.
- Phase 2 (Detailed Review):
  Involves in-depth analysis based on detailed technical documents, including system-level design, safety analyses, and compliance with regulatory requirements. While optional, Phase 2 is frequently undertaken to demonstrate the technical maturity of the design to the international community.
- Phase 3 (Specific Review):
  Conducted when additional clarifications or focused feedback are needed on specific topics identified during Phases 1 or 2. It is a supplementary and selective review process rather than an independent stage.

At the end of each phase, the CNSC provides technical questions, to which the vendor responds with

clarifications and supporting documents. The findings are consolidated in an Outcomes Report, which does not represent approval or a "pass/fail" decision, but documents identified gaps and required resolutions for future licensing.

2.3 Focus Areas

The VDR evaluates reactor designs across 19 Focus Areas (FAs), covering safety, performance, and regulatory alignment. These areas are based on CNSC regulatory documents (e.g., REGDOC-2.5.2, REGDOC-2.4.1) and include nuclear design, fuel qualification, safety analysis, containment, radiation protection, human factors, and decommissioning.

Table 1: 19 Focus Areas of VDR

FA	Title	Review Scope
FA1	General Design Information & Safety Goals	Overall safety goals of the design
FA2	Classification of SSCs	Classification of structures, systems, and components by safety importance
FA3	Reactor Core Nuclear Design	Core design, fuel cycle, and power distribution
FA4	Fuel Design and Qualification	Fuel type, physical/chemical properties, and qualification procedures
FA5	Control Systems & Electrical Systems	Main control, I&C systems, electrical design
FA6	Means of Reactor Shutdown	Provision of two diverse and independent shutdown systems
FA7	Emergency Core Cooling & Heat Removal	ECCS and residual heat removal functions
FA8	Containment & Safety Structures	Design of containment and safety-related buildings
FA9	Beyond Design Basis & Severe Accidents	Design features for extreme accident scenarios
FA10	Safety Analysis	Deterministic/Probabilistic analyses, hazards
FA11	Pressure Boundary Design	Pressure-retaining system design
FA12	Fire Protection	Fire prevention and mitigation measures
FA13	Radiation Protection	Measures to protect workers and the environment
FA14	Out-of-Core Criticality	Prevention of criticality outside the core
FA15	Robustness, Safeguards & Security	Structural robustness, physical/cybersecurity
FA16	R&D and Computer Code Validation	Verification of codes/models and supporting R&D
FA17	Design Management & QA	Design process, management, and quality assurance
FA18	Human Factors & Ergonomics	Human-system interface and ergonomic design
FA19	Decommissioning	Planning for decommissioning from the design stage

3. Preparation of VDR Application for SMART

SMART100 possesses a Standard Safety Analysis Report (SSAR) based on Korea's SDA, providing a foundation for VDR submission. Current preparation includes:

- Pre-engagement with CNSC**:** Defining the vendor's position and prioritizing Phase 1 application.
- Documentation: Preparing reports aligned with 19 Focus Areas, with phased (package-based) submission.
- Enhanced **r**eview readiness**:** Supplementary technical data (e.g., safety analyses, detailed designs) will be provided even at Phase 1, to ensure timely responses to CNSC questions.

4. Challenges and Response Strategies

SMART applies design standards consistent with U.S. standards under SDA, but potential gaps may exist with Canadian standards, notably the CSA(Canadian Standards Association) standards. While many CSA standards are harmonized with international frameworks, some are unique to Canadian nuclear operations (e.g., CSA N285.0/N285.6 for pressure-retaining systems in CANDU reactors)[2]. Therefore, a compliance matrix should be developed to map CSA standards, CNSC regulatory documents, and international standards (IAEA, ASME, U.S. NRC). This will strengthen regulatory alignment and facilitate clear communication with the CNSC. The strategy must go beyond technical compliance and emphasize harmonization with the Canadian regulatory framework.

5. Conclusion

This paper has examined the current status and challenges of SMART's preparation for the Canadian VDR. The analysis confirmed that the VDR can serve as a strategic instrument for both entering the Canadian market and enhancing global recognition. Furthermore, it identified key directions for further preparation toward the VDR application, including securing regulatory alignment through a Compliance Matrix, phased responses to the 19 focus areas, and strategic engagement with the CNSC during the pre-engagement stage. In this way, the study highlights the practical significance of SMART's preparation process and suggests that it provides a foundation for future VDR application and broader international deployment.

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