Leading the Way to a Bright Energy Future

TEI's Experience with CNSC's Vendor Design Review of the IMSR400

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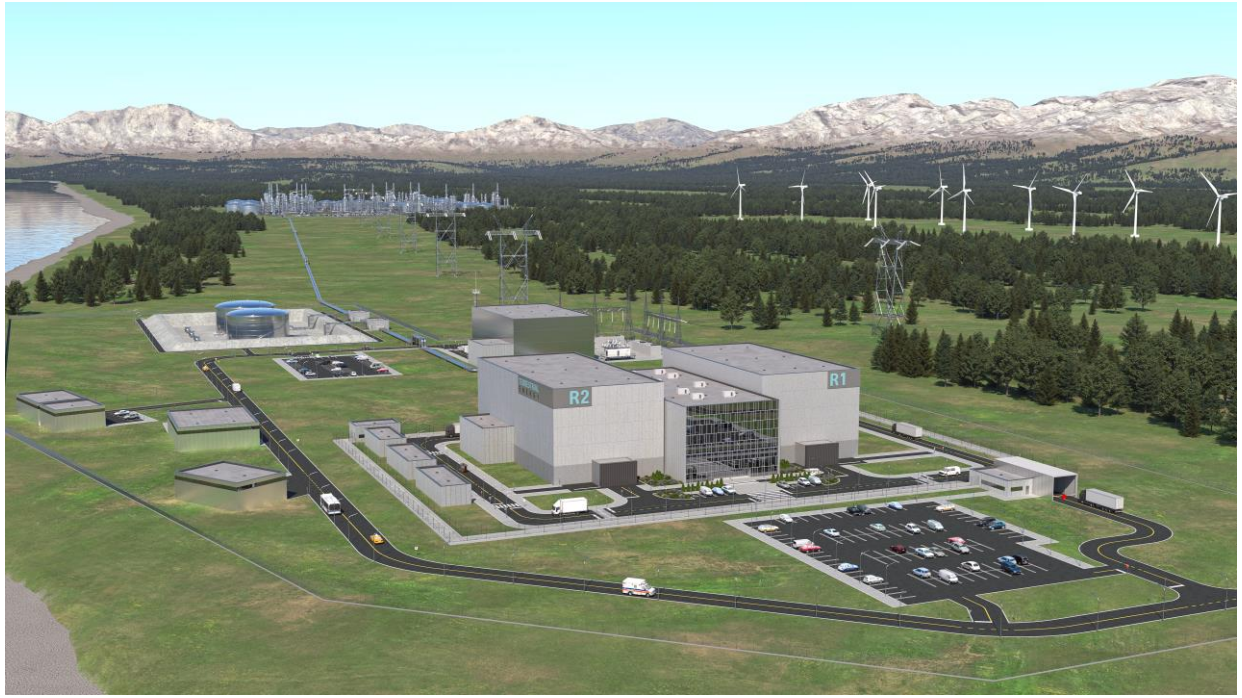
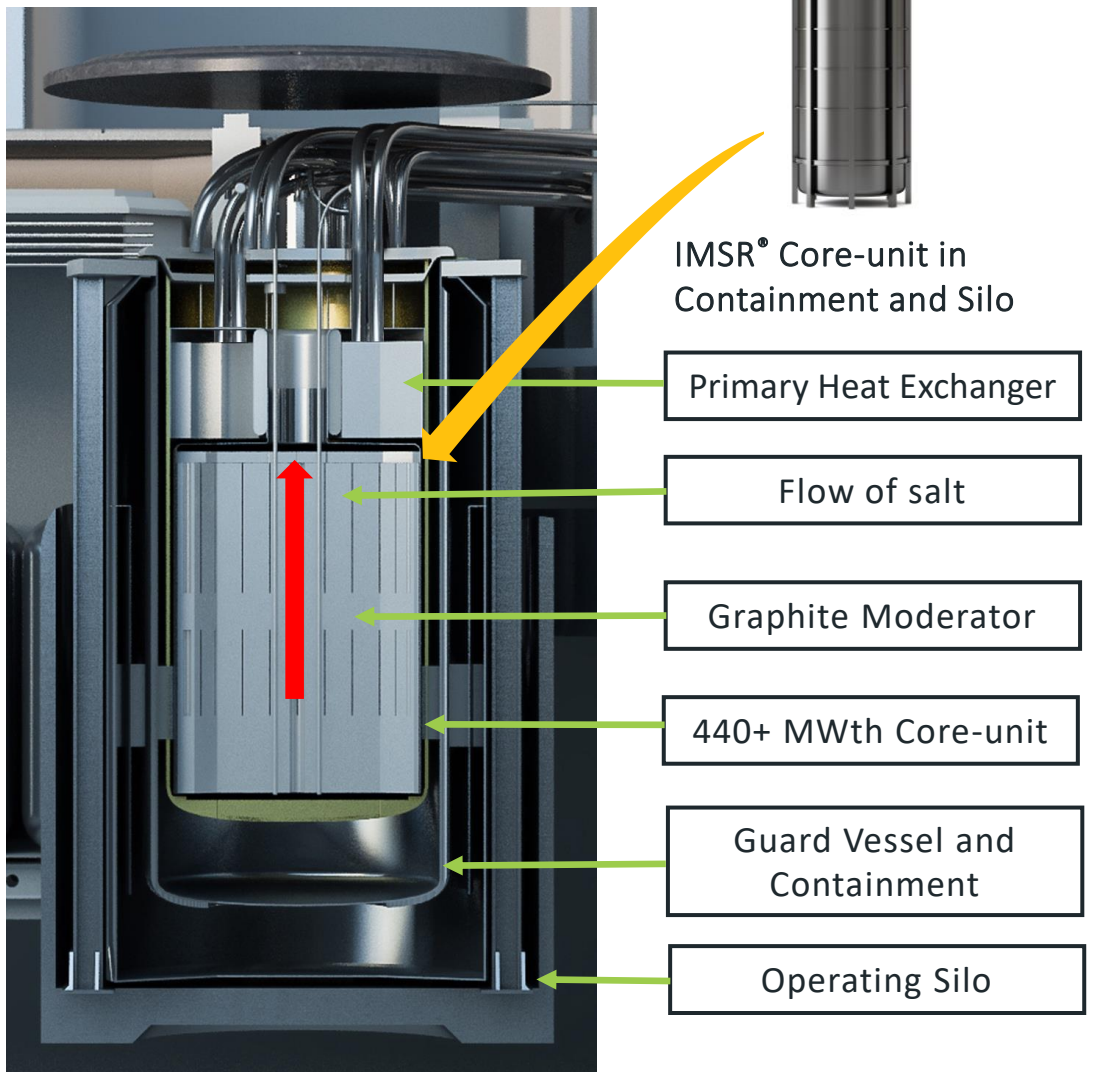
TEI's Experience with Vendor Design Review - Outline

- Pre-licensing VDR Benefits and Scope
- TEI's VDR Timeline
- Main benefits to design and analysis - mitigate licensing risk



IMSR400

- Technology: molten salt reactor
- Plant life: 60 years
- Core-unit cycle: 7 years
- Fuel salt: KF-NaF-UF4-UF3
- Moderator: graphite
- Heat to customer: 585 °C
- Fuel enrichment: <5%
- Electrical output: ~195 MWe
- Capacity factor: 95%



VDR Benefits – High-Level

- Pre-licensing review conducted by CNSC with NPPs vendors / reactor developers
- Main benefits:
  - *For vendors:*
    - VDR improves understanding of the CNSC's regulatory processes and requirements
    - VDR allows potential regulatory or technical issues to be identified early so they can be acted upon as early as possible before the start of the formal licensing process
    - Potential early influence on some design decisions and design processes
  - *For CNSC:*
    - Allows CNSC staff to familiarize with the design, for a more efficient review in subsequent licensing phases
  - *Overall: At the end of Phase 2, CNSC issues a statement of "licensability"; although not binding for the formal licensing process, the VDR outcome is a great licensing risk mitigation opportunity*
- VDR focusses on the design aspects of the facility (see next slide)
- VDR has 2 phases, with an optional 3rd phase

VDR Scope

- VDR Phases 1 and 2 include a set of 19 technical Focus Areas (FAs) established by the CNSC. The optional Phase 3 can continue on a select number of the 19 FAs, or on new topics per vendor's request.

Focus Area	Description
1	General Plant Description, Defence-in-Depth, Safety Goals and Objectives, Dose Acceptance Criteria
2	Classification of Systems, Structures & Components (SSCs)
3	Reactor Core Nuclear Design
4	Fuel Design and Qualification
5	Control System and Facilities: a) Main control systems, b) Instrumentation and control, c) Control facilities, and d) Emergency power system(s)
6	Means of Reactor Shutdown
7	Emergency Core Cooling and Emergency Heat Removal Systems
8	Containment /confinement and safety important civil structures
9	Mitigation of Design Extension Conditions (DECs)
10	Safety Analysis (Deterministic Safety Analysis, Probabilistic Safety Analysis) and Internal and External Hazards
11	Pressure Boundary Design
12	Fire Protection
13	Radiation Protection
14	Out-of-core Criticality
15	a) Robustness, b) Safeguards, and c) Security
16	Vendor Research and Development Program
17	Management System of Design Process and Quality Assurance in Design and Safety Analysis
18	Human Factors
19	Incorporation of Decommissioning in Design Considerations

Other regulatory jurisdictions pre-licensing

- UK Regulators (Office for Nuclear Regulation-ONR, and Environment Agency-EA) Generic Design Assessment (GDA):
  - *VDR is similar to ONR's GDA scope*
  - *VDR is not similar in final outcome (a GDA Step 3 positive outcome, i.e. a Design Acceptance Confirmation (DAC), can be taken formally into account in the licensing stage)*

- US NRC's Pre-Application Reviews:
  - *VDR can be similar in scope with Pre-Application Reviews; Pre-Application Review can have differently defined or more limited scope*
  - *VDR not similar (especially in outcome) with NRC's Design Certification*

TEI's IMSR400 VDR Timeline

- TEI is the first SMR/AR vendor that initiated the VDR process with the CNSC (2016)
- TEI is the first vendor to complete VDR Phase 1 (2017)
- TEI is the first vendor to initiate VDR Phase 2 (2018)
- TEI is likely to be the first vendor to complete VDR Phase 2 (end of 2022)

VDR Benefits – For Vendor's Design

- Clear benefit to Vendors' designs if intent to market, sell, licence and have an SMR built and operating in Canada. Specifically, if (examples):
  - Classification of SSCs does not follow CNSC's safety classification expectations or the IAEA's SSG-30 - VDR FA2 (Classification of SSCs)
  - Fuel, physics differ *significantly* from water cooled reactors - FA3 (reactor design), FA4 (Fuel), FA16 (R&D)
  - Claiming no *need* to shutdown to ensure safety – FA6 (Means of Shutdown)
  - Claiming no need for an ECCS – FA7 (EHRS/ECCS)
  - Claiming *functional* containment – FA8 (Containment and Safety Civil structures)
  - Employing non-traditional safety analysis methodologies or approaches (e.g., for analysis, for defence-in-depth) – FAs 9&10 (DECs and safety analysis)

VDR Benefits – For Vendor's Design (contd.)

- Computer codes are not validated, or not validated per *CSA N286.7*, or codes not (widely) used in North America – FA10 (safety analysis), FA16 (R&D)
- Not familiar with CNSC's expectations on *Management System (CSA N286-12)* and QA requirements – FA17 (Management System)
- Fuel cannot be *discretely* counted and tracked (e.g., molten salt, liquid metal, or pebble bed) – FA15 (Safeguards); also, opportunity to discuss with IAEA
- Have not started to use or *integrate into the design* the following concepts *as early as possible*: security-by-design and safeguards-by-design – FA15 (Robustness, Safeguards, Security), Human Factors Engineering (HFE) – FA18 (HF), decommissioning-by-design – FA19 (Decommissioning)

Vendor Design Review – Main Outcomes

- Upon completion of the VDR Phase 2, a potential nuclear operator/investor and future licence applicant (to build and operate the IMSR400) will:
  - Have a significant portion of the licensing risk mitigated (i.e., related to the design and analysis aspects)
  - Become aware of the areas for further focused attention, thus better supporting the vendor's detailed/site-specific design phase
  - Be able to assemble most of the elements of a Preliminary Safety Analysis Report (PSAR), and best support an applicant/operator to assemble a Licence to Construct (LTC) application

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