CNSC Update on Advanced Reactors/SMRs Activities in Canada

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Overview

Present the current activities related to licensing and deployment of new reactor technologies in Canada

- Government and industry initiatives
- Licensing and pre-licensing activities
- Preparedness activities

Government and Industry Initiatives

- SMR Deployment Feasibility in Ontario (Hatch Report)
- Canadian Nuclear Laboratories
  - Engaged by SMR technology developers for a wide range of activities
  - Ontario Ministry of Energy contract for recycling used fuel
- Natural Resources Canada
  - Promoting government expertise in clean technologies such as nuclear power and engaging with provincial governments
- Fedoruk Center in Saskatchewan
  - SaskPower readiness for new energy options
- Emission Free Energy Working Groups (EFE-WG)

Governments and Industry Initiatives
Ontario SMR Deployment Feasibility Study

- Hatch Report – June 2016
  - Funded by Ontario Ministry of Environment and Ministry of Natural Resources
- State of readiness and deployment readiness for Ontario northern mines and remote communities
  - SMR technical readiness
  - Vendor readiness
  - Technology compatibility
  - Lifecycle power costs (incl. licensing)
- 9 designs selected from initial list of 90
  - Integral Pressurized Water Reactors (2), Gas Cooled Reactors (3), LeadCooled Fast Reactor, Sodium Cooled Fast Reactors (2), Molten Salt Reactor

Government and Industry Initiatives
Sylvia Fedoruk Centre for Nuclear Innovation

- SaskPower SMR feasibility Study -2015
  - Small size of electricity grid. SMRs could be an economically feasible supply option for clean, reliable baseload power

- Report “Northern Indigenous Peoples & The Prospects for Nuclear Energy” – 2016
  - Reviews the receptiveness of northern Indigenous peoples (northern Saskatchewan, the Yukon, and Northwest Territories) to alternate energy sources, focusing on small nuclear

Government Initiatives

Environmental Assessment Process

Before a licence to prepare a site can be issued, the environmental impact of the project must be considered for the lifecycle of the project

- Legislated timelines apply to environmental assessments (EAs) and first licence (generally a licence to prepare site)
- EA process is independent of facility size
- The province / territory may have involvement in the EA process – jurisdiction dependent
- Other federal departments are involved in EAs under the *Canadian Environmental Assessment Act, 2012*

Federal EA process under review, suggestion that it becomes Impact Assessment

Pre-Licensing Engagement

Stakeholders encouraged to engage with CNSC early and often

- Used to understand options for performing licensed activities
  - Can be performed under a protocol arrangement
- Vendor design review (VDR) is one process used to engage with reactor technology vendors
  - Feedback mechanism that looks at vendors' efforts to address Canadian requirements in their design and safety analysis processes
  - Identify key issues as well as fundamental barriers to licensing
  - Identifies research activities in order to support design review and future licensing requirements

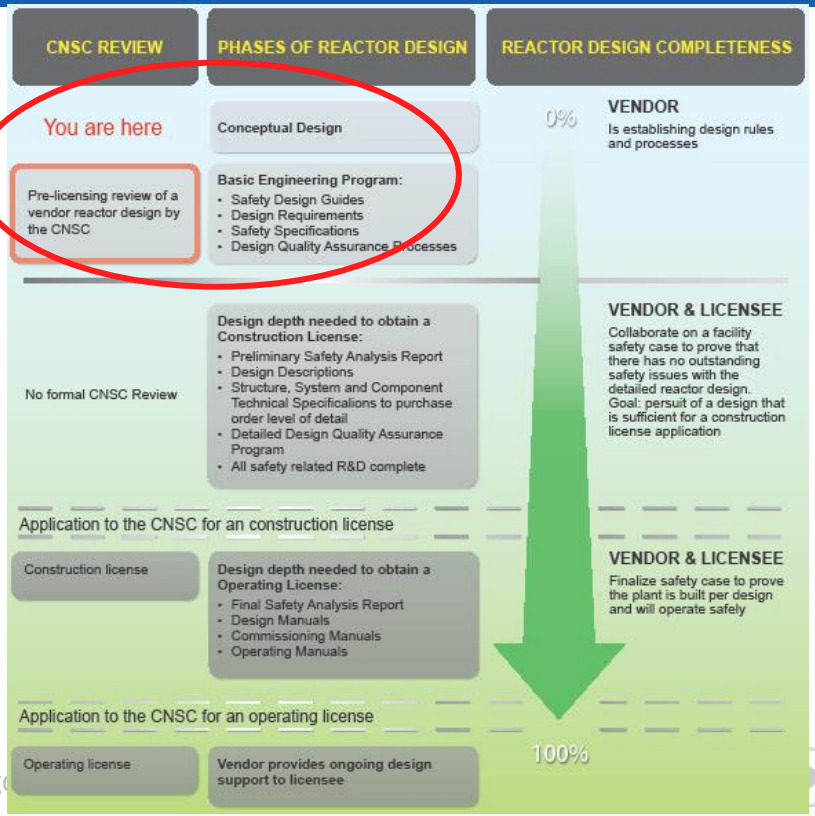
Enabling understanding of regulatory processes and requirements

Pre-Licensing Engagement
VDR in the Overall Licensing Context

A VDR should not be triggered unless the conceptual design is essentially complete and the basic engineering program has begun (design requirements being established)

Outcomes of the process helps the vendor have discussions with potential future licensees interested in their technology

A Pre-licensing VDR is not a licensing discussion, it is a technical conversation between the CNSC and the vendor. The process is optional and not a prerequisite to licensing



Pre-Licensing VDR follows a documented approach

Scope of VDR phases pre-defined

- Ensure fairness and predictability of results, timeliness and cost
- Some flexibility provided to vendor to add extra topics

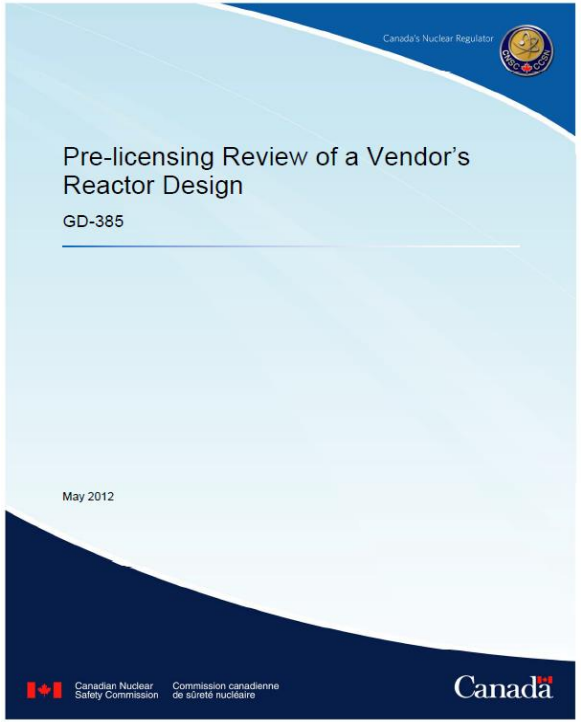
Outputs may never fetter the Commission's decision-making in a future licensing process

3 Phases of review possible

Phase 1: Conceptual design complete **~18 months**

Phase 2: System level design well underway **~ 24 months**

Phase 3: Normally for specific topics where advanced design is underway and Phase 2 completed



Vendor Design Review 19 Topic Areas

1. General plant description, defence in depth, safety goals and objectives, dose acceptance criteria
2. Classification of structures systems, and components (SSCs)
3. Reactor core nuclear design
4. Fuel design and qualification
5. Control system and facilities
6. Means of reactor shutdown
7. Emergency core cooling and emergency heat removal systems
8. Containment / confinement and safety-important civil structures
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. Robustness, safeguards and 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

Phase 1 CNSC VDRs in Progress

VDR No	Country of origin	Company	Reactor type / output per unit	Status
1	Canada / U.S.	Terrestrial Energy	Molten salt integral / 200 MWe	In progress – pending completion September 2017
2	U.S. / Korea/ China	UltraSafe Nuclear/Global First Power	High temperature gas prismatic block / 5 MWe	In progress – pending completion March 2018
3	Canada	LeadCold Nuclear	Molten lead pool fast spectrum / 3 – 10 MWe	In progress – pending completion June 2018
4	Canada / U.S.	StarCore Nuclear	High temperature gas prismatic block / 10 MWe	Pending start July 2017
5	U.S.	Advanced Reactor Concepts	Sodium pool fast spectrum /100 MWe	Pending start fall 2017
6	U.K.	URENCO	High temperature gas prismatic block / 4 MWe	Pending start fall 2017

Industry Has Approached the CNSC for Information on Licensing Process

- Less interest in prototype reactors – seen by industry as sending a message to potential utilities that technology is “less ready”
- Some interested in partial-to full-scale demonstration facilities
  - To complete R&D work
  - To demonstrate technical and commercial performance
- Some equate full-scale demonstration facility with the FOAK commercial plant
  - Confirmatory R&D work
  - To demonstrate technical and commercial performance

Industry Should set Utility Requirements

- Utility requirements rather than regulatory requirements should drive technology development
- Technology users (i.e. future licensees) need to establish the utility requirements that technology developers must meet taking into account:
  - Canadian regulatory requirements
  - Societal need (e.g. expectations for waste and decommissioning)
  - Acceptance criteria for vendor capacity / capabilities for product support
  - Technology deployment strategy
  - Requirements for demonstration of “proven-ness”
  - Economic performance

SMR Deployment Strategies - Licensee's Role

- Who will the licensee(s) be for different SMR projects?
- What is the R&D roadmap for each SMR concept?
- What is the role of the First-of-a-Kind (FOAK)/Demonstration facility in establishment of "proven-ness"?
  - Impacts the safety case for FOAK/Demonstration facility
    - Additional margins needed to address uncertainties?
    - Additional features needed to collect OPEX data for the future fleet?
  - Successive projects will learn and adapt from the FOAK
    - Design optimization will occur
    - Need to understand what "standardization" means and when it has been achieved

CNSC Licensing Background

Section 24(4) of the NSCA

No licence shall be issued, renewed, amended or replaced — and no authorization to transfer one given — unless, in the opinion of the Commission, the applicant:

a) ***is qualified to carry on the activity*** *that the licence will authorize the licensee to carry on*

b) ***will****, in carrying on that activity,* ***make adequate provision*** *for the protection of the environment, the health and safety of persons and the maintenance of national security and measures required to implement international obligations to which Canada has agreed*

Applicable for all licensed activities

Licensing a Prototype/Demonstration Facility

Novel facility and novel use

- Demonstration purposes initially
- Some prototypes may not clearly assigned to our current list of facilities/licences
  - Class 1, 1A, 1B, Class II
- Need an appropriate licensing strategy proposal
- Need for flexibility

Risk-Informed Approach for Determining an Appropriate Licensing Strategy – In Development

Understand the nature of the activities being proposed

Pre-licensing discussions with proponent

What are the risks?
Where is the work being done?
Complexity?
Novelties?

Regulatory operations stakeholders discuss proposal, document regulatory considerations and propose strategy (informed by past practice)

Select licensing process and specific requirements to address risks

Discuss recommendations with decision makers

Confirm process selected is appropriate and decision is documented

Communicate decision regarding strategy back to proponent

CNSC staff outline the licensing process and identify requirements applicable to the proposal

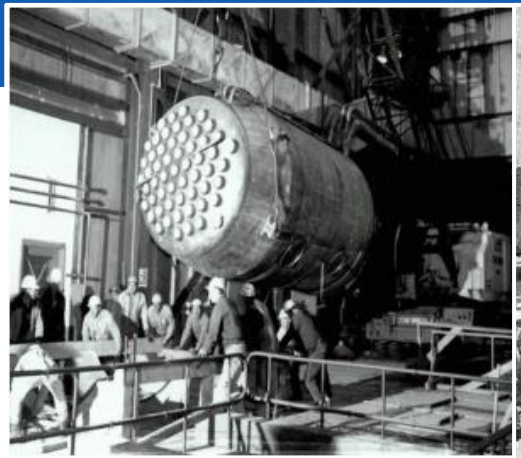
Example:
Conventionally Heated Thermalhydraulic Prototype

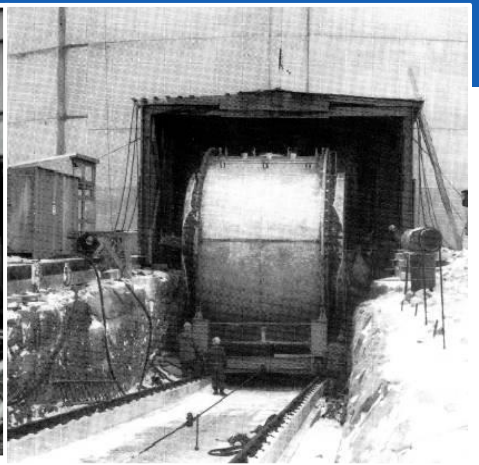
- If no nuclear substances used, no licence necessary
- If nuclear substances used for laboratory applications, may be as simple as a nuclear substances licence
- If fissionable material used for reactor physics experiments (e.g. subcritical assembly) requirements would be similar to nuclear substances licence with additional requirements applied based on sub-criticality margins

If activities are performed on already licensed site, proponent can incorporate activities into existing facility licence

Licensing of Activities Related to Prototype Reactors/Demonstration Reactor/First-of-a-Kind (FOAK) Reactor Facilities

Whiteshell WR-1 Prototype Organically Cooled Reactor (60 MWth)
Reactor being installed, 1964





Douglas Point Generating Station Demonstration CANDU (250 MWe)
Calandria being installed, 1962/1963

Prototype have been licensed in Canada in the past

Class 1A Nuclear Facilities Regulations

Encompasses activities for preparing a site, constructing and operating, decommissioning, release from regulatory control (abandon) of

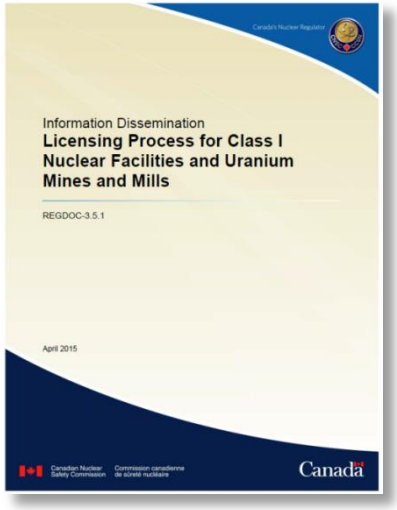
a) a nuclear fission or fusion reactor or subcritical nuclear assembly

b) a vehicle that is equipped with a nuclear reactor

Includes small modular reactors and advanced reactors whether Prototype Reactor, Demonstration, FOAK, or nth-of-a-kind

REGDOC- 3.5.1, *Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills*

- This regulatory document describes:
  - Licensing process for each phase of a project
  - Regulated timeline (less than 24 months) for EA and *Licence to Prepare Site* – for complete application
  - Expectations for involving stakeholders in the licensing process
- For subsequent licences, the CNSC has service standards for timelines, but applicant/licensee impacts the service standards
- Timelines primarily impacted by:
  - How well safety margins are supported in the safety case
  - Time to construct and commission new facility



Use of an existing licensed site can introduce benefits

What Are Safety and Control Areas (SCAs)?

Technical topics used by the CNSC to assess, review, verify and report on regulatory requirements and performance across all regulated facilities and activities

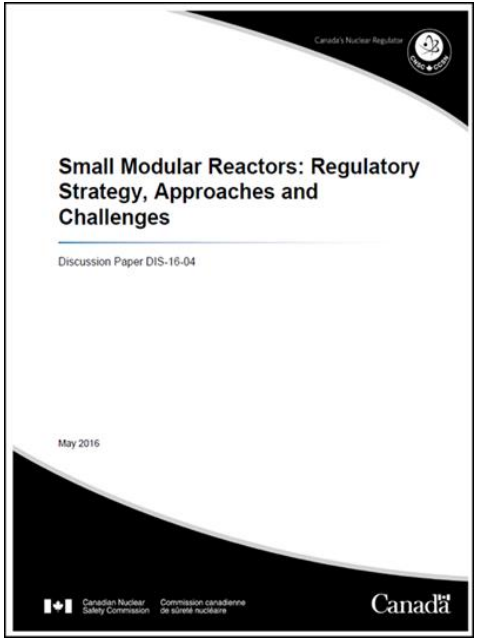
- Each SCA addresses an aspect of the overall safety profile of a proposed set of activities
- Regulatory framework documents exist for each SCA

SCA Framework

Licensing Basis	Safety and Control Areas	
	Management	Management system
		Human performance management
		Operating performance
	Facility and equipment	Safety analysis
		Physical design
		Fitness for service
	Core control processes	Radiation protection
		Conventional health and safety
		Environmental protection
		Emergency management and fire protection
		Waste management
		Security
		Safeguards and non-proliferation
		Packaging and transport

Discussion Paper DIS 16-04

- Address growing public interest in new reactor technologies, in particular SMR technologies
- Prepare the CNSC to evaluate an SMR application
- Further the CNSC's knowledge in areas where SMRs may present licensing challenges based on their unique characteristics
- Clarify where and how to augment the Regulatory Framework



Discussion Paper DIS 16-04
General Comments and Observations from Industry

Major themes of the consolidated comments

- Industry supports the application of a graded approach to all elements in the discussion paper, but …
- Licensing process should be streamlined to take into account production of repeat SMR units
- No insurmountable roadblocks to licensing SMRs under the existing regulatory framework

Consensus

- New regulations are not needed although amendments to some regulations, notably Security, should be considered
- Achieving common understanding on application of the graded approach is essential

Discussion Paper DIS 16-04
Other Comments and Observations

Other challenging areas:

- Technical information, including research and development activities used to support a safety case
- Licensing process for multiple module facilities on a single site
- Licensing approach for a new demonstration reactor
- Licensing process and environmental assessments for fleets of SMRs
- Minimum complement in SMR facilities
- Safeguards implementation and verification

Conclusion

- Many activities underway in Canada from government and industry
- CNSC staff involved in many parallel Vendor Design Reviews
- Major theme from the discussion paper is the need for a graded approach
  - Graded and adaptable
  - Both on licensing process and technical requirements
- CNSC is developing a readiness approach to encompass, licensing, technical and capability readiness for new novel reactor technologies

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