Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

Canada

Regulation of Small Modular Reactors (SMRs) in Canada: Progress and Challenges

Dr. Douglass Miller, Director
New Major Facilities Licensing Division

Technical Session T4, Improving the Way We Do Business – for Large Lights and Small Modulars

March 10, 2015

E-Docs#-4620406

Canadian Nuclear Safety Commission

- Established May 2000, under the *Nuclear Safety and Control Act*
- Replaced the *AECB,* established in 1946, under the *Atomic Energy Control Act*
- The CNSC regulates all nuclear-related facilities and activities

Over 66 years of experience

Our Mission

To protect the **health, safety** and **security** of persons and the **environment**; and to implement Canada's **international commitments** on the peaceful use of nuclear energy

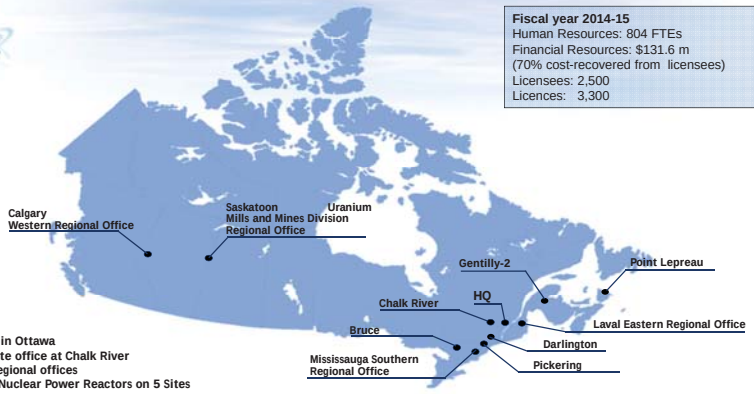
To disseminate objective scientific, technical and regulatory information to the public concerning the activities of the Commission and the effects on the environment and on the health and safety of persons

Independent Commission

- Quasi-judicial administrative tribunal
- Independent Commission members
- Public hearings
- Supported by Secretariat and independent legal services
- Decision can only be reviewed by Federal Court

Transparent, science-based decision-making

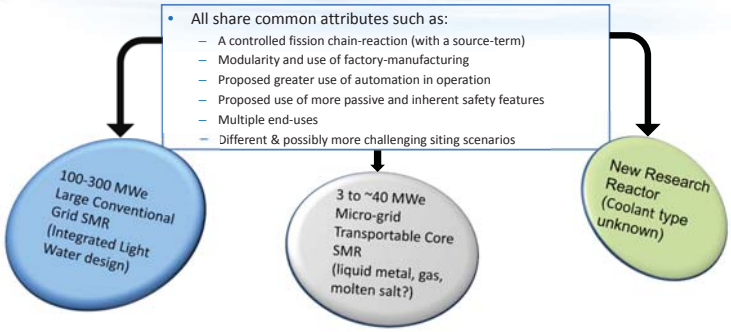
Fiscal year 2014-15
Human Resources: 804 FTEs
Financial Resources: $131.6 m
(70% cost-recovered from licensees)
Licensees: 2,500
Licences: 3,300



- HQ in Ottawa
- 1 site office at Chalk River
- 4 regional offices
- 22 Nuclear Power Reactors on 5 Sites
- 6 active uranium mines/mills in northern Saskatchewan

Meaning of "SMR" in Canada is very broad

- All share common attributes such as:
  - A controlled fission chain-reaction (with a source-term)
  - Modularity and use of factory-manufacturing
  - Proposed greater use of automation in operation
  - Proposed use of more passive and inherent safety features
  - Multiple end-uses
  - Different & possibly more challenging siting scenarios



Different safety approaches need to be supported by R&D and proven design methodologies

What makes SMRs different from the technologies/activities we are familiar with

- At the root of the discussion is: **Novel approaches**
  - Need to clarify how existing requirements and guidance address these
  - Understanding where clarifications need to be made
- New technologies
- Activities that challenge existing licensing and operational models/approaches
- Approaches that present policy questions

Understanding what a "SMR" represents has shaped our readiness preparations

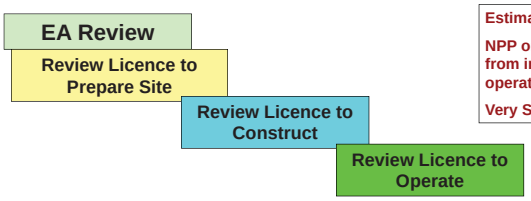
- We recognize that:
  - Requirements should based on well-understood nuclear safety principles that are technology neutral
  - Guidance should speak to a graded application of those requirements under different circumstances and risk scenarios (i.e., use of risk-informed insights)
  - Both of the above need to reinforce the need for supporting evidence based on sound science and engineering practices

Safety will not be compromised

Licensing process is risk-informed and independent of reactor size or technology

Parallel Environmental Assessment (EA) and Licence to Prepare Site

[First of a Kind (FOAK)]

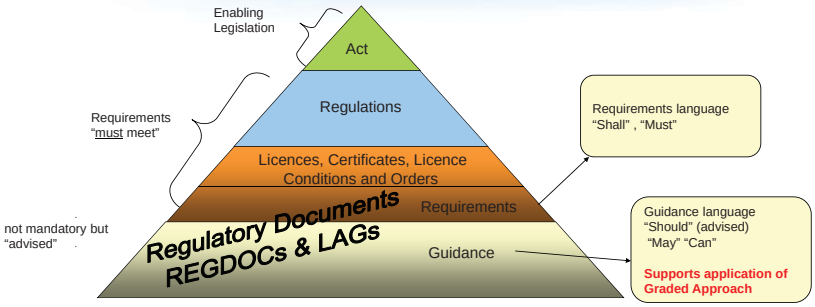


Estimated Timeline

NPP or large SMR: 9 years from initial trigger to operating licence granted

Very Small SMR: 6-7 years

Regulatory framework is risk-informed and independent of reactor size or technology



Examples of SMR applicable REGDOCs

- REGDOC 2.4.1: *Deterministic Safety Analysis* (published)
- REGDOC 2.5.3: *Design Requirements for Small Reactors* (under development – revision of RD-367) – twin of REGDOC 2.5.2 *Design Requirements for Nuclear Power Plants* (published)

- An example of an SMR applicable industry standard is:
  - CSA N286-12 - *Management System Requirements for Nuclear Facilities*

Licence Application Guides (LAGs)

- Suggest application format and submission information

Graded Approach

- The graded approach is a method in which the stringency of the design measures and analyses applied are commensurate with the level of risk posed by the reactor facility

- Factors to be considered include:
  - reactor power, reactor safety characteristics, fuel design, source term
  - amount and enrichment of fissile and fissionable material
  - what the reactor is being utilized for
  - presence of high-energy sources and other radioactive and hazardous sources
  - safety design features
  - siting, proximity to populated areas

Requirements are not relaxed

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Example of Application of Graded Approach

- REGDOC 2.5.2, 8.4 Means of shutdown: "The design shall provide means of reactor shutdown capable of reducing reactor power to a low value, and maintaining that power for the required duration…."
- The design shall include two separate, independent, and diverse means of shutting down the reactor:
  - Reactors with inherent safety: One fast-acting shutdown means, and a 2nd shutdown means
  - Reactors with engineered safety: Two fast-acting shutdown means

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Ongoing efforts of the CNSC SMR working group

- Multidisciplinary group representing management systems, safety analysis, policy analysis, licensing, technical issues and environmental assessment
- Categorizing topics against topics in the CNSC safety framework
- Goals:
  - understand what the issues are, who they affect, and whether, how and when they might need to be addressed
  - Prioritize and plan future work
  - Feed information into REGDOC development
  - Prepare to engage with industry, the public, and government stakeholders to answer questions

Drive Readiness Preparations

Conventional Grid SMRs

Vendor	Output MWe / MWth per module	Reactor Type
KAERI – SMART (Republic of Korea)	100 / 330	Integrated PWR
CNNC ACP-100 (China)	100 / 310	Integrated PWR
Generation mPower (USA)	180 / 530	Integrated PWR
NuScale Power Inc. (USA)	45 / 160	Integrated PWR
Westinghouse SMR (USA)	225 / 800	Integrated PWR
Hitachi-GE DMS (Japan)	300 / 840	Boiling Water Reactor
Terrestrial Energy IMSR (Canada/USA) 2 designs	120 / 300 288 / 600	Molten Salt Reactor

- Activities using these technologies would be licensed under existing NPP requirements and guidance such as:
  - REGDOC 2.5.2 *"Design of Reactor Facilities: Nuclear Power Plants"*
  - REGDOC 2.4.1 *"Deterministic Safety Analysis"* & 2.4.2 *"Probabilistic Safety Assessment" (PSA) for Nuclear Power Plants*
  - RD-346 *Site Evaluation for New Nuclear Plants*

Off-grid/edge of grid SMRs (1)

Vendor	Output MWe / MWth per module	Reactor Type
NIKIET UNITHERM (Russian Federation)	2.5 / 20	Integrated PWR - Sealed transportable core
Global First Power/Ultra Safe Nuclear	5/(12?)	High Temperature Gas / Triso fuel - Sealed transportable core
StarCore Nuclear Inc. (Canada)	10/35	High Temperature Gas / Triso fuel - Sealed transportable core
Gen4 Energy G4M Module (USA)	25 / 70	lead-bismuth eutectic fast reactor - Sealed transportable core
Swedish Advanced Lead Reactor (SEALER)	10 / 35	Lead fast reactor - Sealed transportable core
Thorenco Electron Beam Driven Subcritical Reactor (EBDSR) - (USA + MEVEX Canada)	5 MWth (pilot) 10 / 35	lead-bismuth eutectic - Electron Beam Driven Subcritical Reactor - Sealed transportable core
Terrestrial Energy IMSR (Canada/USA)	29 / 80	Molten Salt Reactor - Sealed transportable core
Northern Nuclear Industries Inc. (Canada) -LEADIR-PS	38/100	Lead fast reactor (integral pool)– TRISO fuel pebble bed - On-line refuelling, batch fuelled on-site

Regulatory / licensing issues appear to fall into 3 broad groups:

First Group - Issue not likely a problem	Existing requirements and guidance already address the issue
Second Group - Issue requires some clarification (Short to medium lead time to resolve)	Clarification may be needed around application of the graded approach or the basis of the requirements needs to be more clearly expressed For now, can be addressed in pre-licensing engagement discussions
Third Group - Issue requires significant regulatory analysis to understand potential risks and mitigation approaches Long lead time to resolve Challenges: • We are not sure if or when the issue might be proposed in an application • May be technology dependent	CNSC staff will consider proposals in developing regulatory positions based on science and engineering practices Public consultations, through processes such as CNSC Discussion Papers, will help to further establish regulatory positions prior to developing or modifying requirements and guidance Issues may also benefit from international discussion through regulatory cooperative arrangements

First Group: Topics not likely to be an issue

- Multiple modules in one facility
  - Multiple unit stations already operating
  - Station licence covers multiple units
- Shared control room facilities
  - Existing stations already licensed under this configuration
- Risk informed Exclusion Zones and Emergency Planning Zones
  - Addressed in RD-346 *Site Evaluation for New Nuclear Plants*

Operating experience exists in Canada

Second & Third Group Issues of Interest

Area where potential issue might exist	For example:
New technical approach	• One certified operator overseeing multiple units • Autonomous operation with remote monitoring • New types of passive safety technologies • Liquid Fuel (Molten Salt Reactors)
Activities that challenge existing licensing models/approaches	• One central operator training centre and simulator to support many sites
Approaches that present policy questions	• Multiple Unit PSA and Site Based Safety Goals

International efforts: SMR Regulators' Forum

- Formation in progress – Terms of Reference developed for 2 Year Pilot
- IAEA acting as facilitator
- Technology neutral but considering modularity and possibly transportable designs
- Three interconnected topical Working Groups:
  - Emergency Planning Zones (EPZ)
  - Defence in Depth for SMRs
  - Graded Approaches

Share Regulatory Information, Develop Common Position Statements and Inform IAEA Document Development

In Conclusion…

- CNSC 's regulatory framework is robust, flexible and technology neutral:
  - We are committed to setting the right level of requirements and guidance to enable flexibility without compromising safety
  - Positions are informed by engineering judgement and scientific data
- Applicant / licensee needs to be prepared to demonstrate their proposals will meet or exceed requirements
- To help define and resolve issues, active and more public involvement on the part of non-governmental stakeholders is needed

We Will Never Compromise Safety…

… It's In Our DNA!

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