



Readiness For Regulating Small Modular Reactors

**Joint Meeting NRCAN-CNSC:
US Nuclear Infrastructure Council (USNIC)
Trade Mission to Canada**

August 28, 2017


Ottawa, Ontario, Canada

Ramzi Jammal

Executive Vice-President and Chief Regulatory Operations Officer
Canadian Nuclear Safety Commission

Significant interest in **potential deployment** of SMRs in Canada


- 7 VDRs applications, and more to come
- Utility, provincial governments interest
- CNL “Request for Expression of Interest” (RFEOI);




“The committee recommends that the Government of Canada continue to support the development of SMRs, recognizing the potential for SMRs to provide clean and reliable power to remote and northern communities and open new areas to economically valuable resource development.”

Federal Standing Committee on Natural Resources, June 2017 Report





**CNSC has developed a complete
framework to licence new
reactors ... but SMRs present
different challenges**



What Is Different With SMRs?

Novel Technologies

Can differ significantly from existing water based Generation II, III reactors

- Use of technologies common in other industries but novel to reactors
- Coolant (metal, sodium, molten fuel, gas)
- Different approaches to defence in depth (passive features, containment provisions)

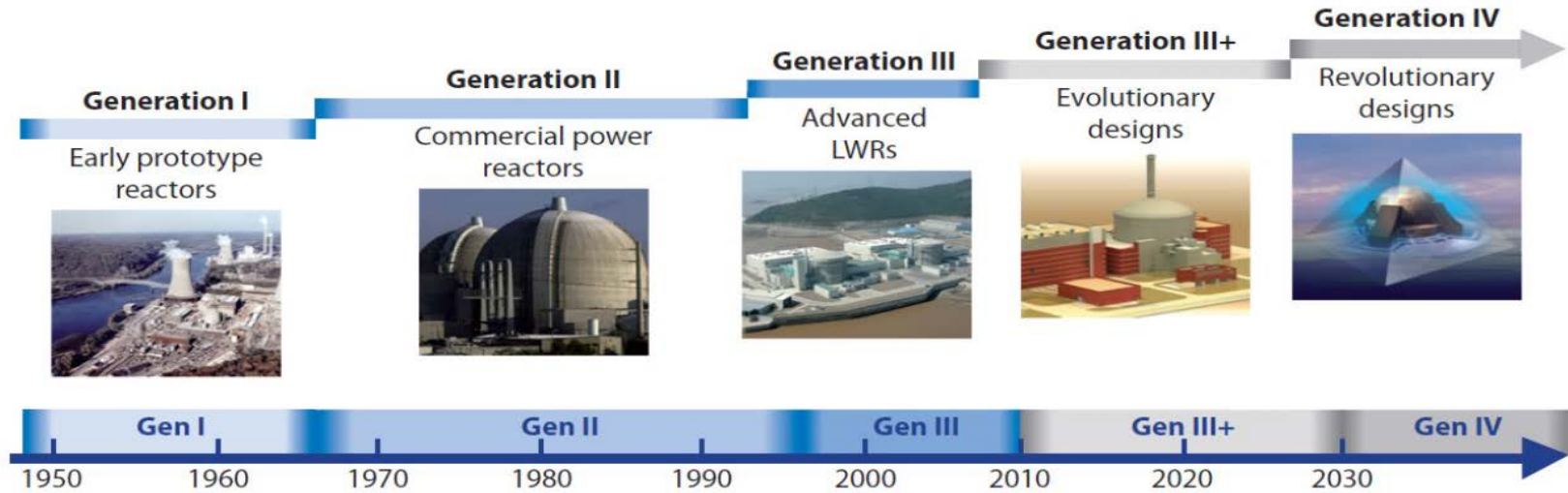
Novel Approaches to Deployment

Examples

- Operating model (reduced staffing / remote operation)
- Transportable reactors
- Security by design
- Fleets of reactors (EA, licensing, credit for prior reviews)

Key Regulatory Challenges Identified in Discussion Paper 16-04

Technology Evolution



Regulatory Framework



Current State of Readiness

Enhancing the existing regulatory framework developed during “Nuclear Renaissance”

Full Set of REGDOCs

- Developed for water cooled reactors but can be applied to SMRs and novel technologies
- <http://www.nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents/index.cfm>

Complete Set Management System Documents

- Assessment Plans and Work Instructions for EIS, LTPS and LTC phases
- Elements of application of graded approach are included in regulatory documents (not limited to design)

Tools are available and usable ... clarity on applying a risk informed approach and grading to be enhanced

Recent Readiness Activities

- Discussion Paper on SMRs
- Pre-licensing vendor design reviews (VDRs)
- International cooperation (NEA, IAEA) and bilateral (USNRC)
- International fora and working groups (MDEP, WGRNR, IAEA SMR forum)
- Gap analysis performed against USNRC vision and strategy for non-light water advanced reactors
 - Participation in USDOE and USNRC workshop
- Development of 4-step process for determination of licensing approach for novel technologies (e.g., prototypic facilities)

Strategy for Readiness



Increased **regulatory certainty**

Fairness, rigour, efficiency, transparency

Establishment of **technical readiness**

Knowledge and capacity, enabling processes

Establishment of **priorities**

What needs to be done and by when

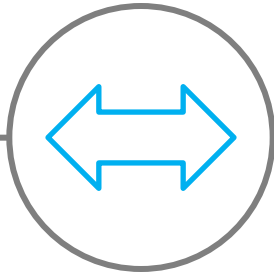
Increased **awareness**

Internally and with External Stakeholders

**Provide Leadership
and Coordination**

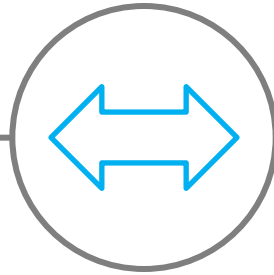
**Small Modular
Reactor Steering
Committee
(SMRSC)**

Elements of Strategy



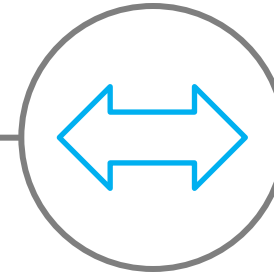
Regulatory Framework

NSCA, regulations, licences,
REGDOCs



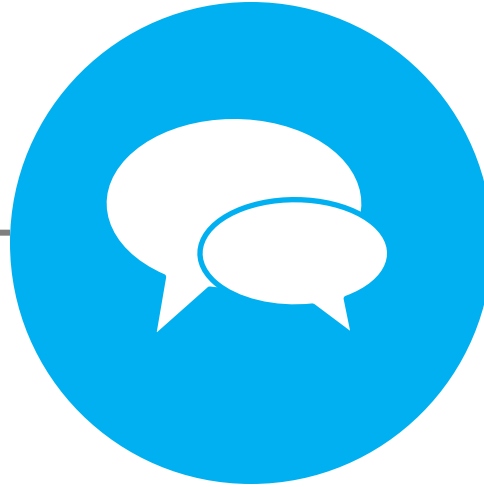
Risk Informed Processes

managed processes covering,
strategic decision making
pre-licensing and licensing
compliance



Capable and Agile Staff

capacity / capability
training
international cooperation



Communicate

Small Modular Reactor Steering Committee

- The small modular reactor steering committee (SMRSC) is to provide leadership to set the foundation for the regulation of SMRs
- To be chaired by the Executive Vice-president and Chief Regulatory Operations Officer
- The proposed mandate of the SMRSC is to:
 - Make high level decisions regarding the regulatory position for SMRs
 - Provide guidance and senior management support with respect to resource requirements
 - Monitor progress against planned activities and track other performance measures
 - Become aware of, and resolve issues as they arise



Current Regulatory Framework

Act, Regulations and complete suite of REGDOCS to ensure safety requirements in all aspect of design, construction, operation, etc.

All Safety and Control areas are covered

- Developed principally for water cooled reactors
 - Complete set of Licence Application Guides - Site preparation REGDOC 1.1.1 (nearing completion), Construction REGDOC 1.1.2 (being updated), and Operation REGDOC 1.1.3

“It is recognized that **specific technologies may use alternative approaches**. If a **design other than a water-cooled reactor is to be considered** for licensing in Canada, **the design is subject to the safety objectives, high-level safety concepts and safety management requirements** associated with this regulatory document. However, the CNSC’s review of such a design will be undertaken on a case-by-case basis.”

[REGDOC 2.5.2]

Enhancements Underway

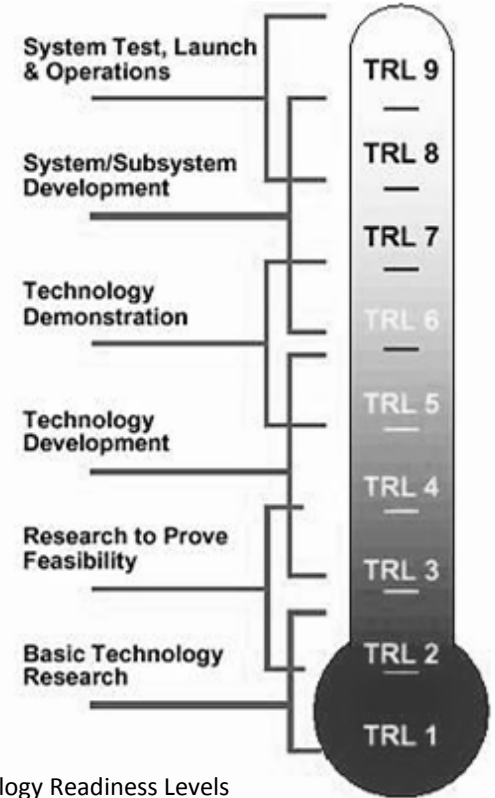
Enhance existing regulatory framework to become more objective based and **allow flexibility to address new types of reactors**

- Need to enhance clarity and provide processes on how to assess alternatives proposed by applicants
- Need formal mechanism to document regulatory OPEX as it is acquired for eventual updates to the regulatory framework

Process

Prototypic Facilities

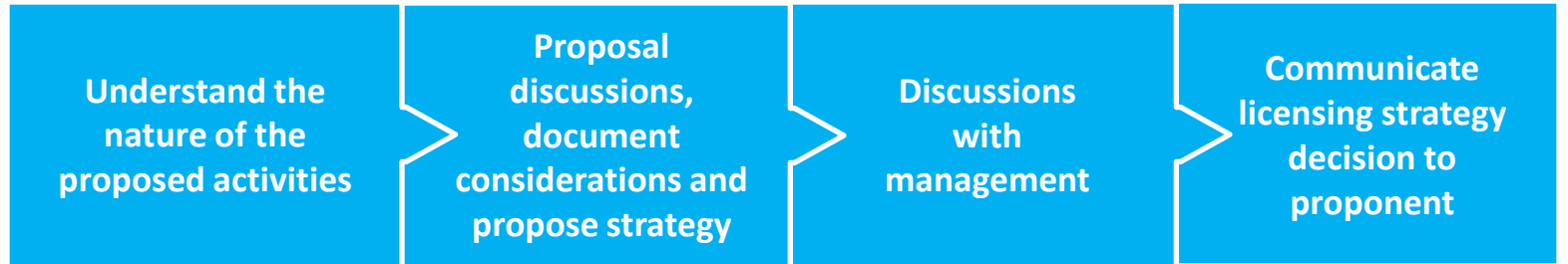
An applicant may want to use a prototypical facility as part of technology development for SMR reactor design



Based on USDOE Technology Readiness Levels

Risk Informed Licensing Strategy

Approach for determining the licensing strategy for novel applications



Proposal is evaluated on hazards, complexity and novelty aspects

Licensing strategy provides recommendation on the most appropriate regulations, application guides, REGDOCs and lead licensing service line

recommendations for scope and depth of licensing review for each SCA

SMR vendors are informed on expectations regarding information to be submitted in support of this process

Processes

What we Need to Improve

Review processes

To confirm they are commensurate with the challenge

- Risk-informed resource allocation for licensing and compliance

Assess need for new processes

Examples

- Readiness regarding workforce capacity and capability
 - Feedback from VDR experience as acquired
- Capacity and capability for vendor inspection
- Documenting lessons learned for future licensing stages

Capacity and Capability

Capability for Nuclear Safety Project

- Will help establishing baseline and knowledge gaps related to potential new build technologies

Contracting specialized training organizations to build up capacity

- Argonne National Labs: Molten Salt Reactor Technology
- Idaho National Labs: Sodium Cooled Reactors

International Cooperation

Benchmarking, Informing and Exchanging

With other countries facing similar challenges, in a number of forums

- IAEA SMR Forum, WGRNR, NEA working group on SMR, MDEP, GSAR, bilateral with USNRC
- USDOE bilateral agreements led to molten salt reactor training and sharing of information on gas cooled reactors

Flexibility

- Expert groups to review VDR (can be applied to future licensing phases)
- Expert project management skills (excellent project monitoring)
- Self learning time allocated for specialists

Establishment of Priorities

Early identification of challenges identified in Discussion Paper 16-04

- With time, other challenges will likely emerge
- Need for a prioritization process

Current focus

- Challenges arising from novelties in design (Pre-licensing)
- Establishment of readiness

Focus will change through deployment

- First units will be prototypes or demonstration facilities, likely on a “controlled” site
 - Focus on establishment of OPEX and economic demonstration
 - Will not initially be faced with deployment related issues
- Following units will face different challenges related to deployment
 - Location, deployment approach, security, operating models etc...

Regulatory Challenges Identified

Design Review

- R&D to support safety case
- Safeguards
- DSA/PSA
- DiD and Mitigation of Accident
- Site Security
- Waste and Decommissioning
- Subsurface Civil Structures
- Management System

EA and LTPS

- Licensing of Modular Reactors
- Emergency Planning Zones

License to Construct

- Licensing Approach for Demonstration Reactor
- Transportable Reactors

Licence to Operate

- Management System
- Minimum shift complement
 - Increased use of automation / human-machine interface
 - Financial guarantees

Regulatory challenges identified in Discussion Paper 16-04, Report to be published in late September 2017

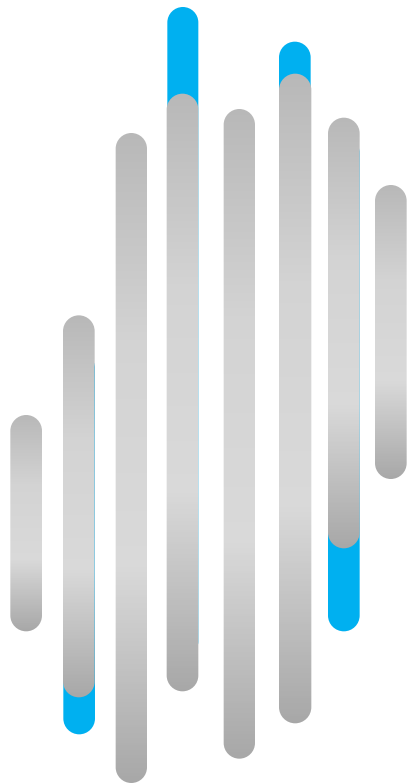
Current Activities

- Discussion Paper results
 - What We Heard Report being circulated
 - Comments disposition table being circulated
- Documenting strategy for readiness
- Consultation on amendments to Nuclear Security Regulations
- Graded approach workshop

Conclusions

- Current Regulatory Framework adequate for licensing of advanced technologies
 - Provide flexibility to adapt to new types of reactors
 - Need solid management system processes and capable workforce
- Development of a strategy to explain our approach and prioritize efforts will help provide regulatory clarity
- SMRSC to provide senior management leadership to set the foundation for the regulation of Small Modular Reactors

Vendor Design Reviews



Vendor Design Review

Pre-licensing

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 cannot fetter the Commission's decision-making in a future licensing process*

3 phases of review possible

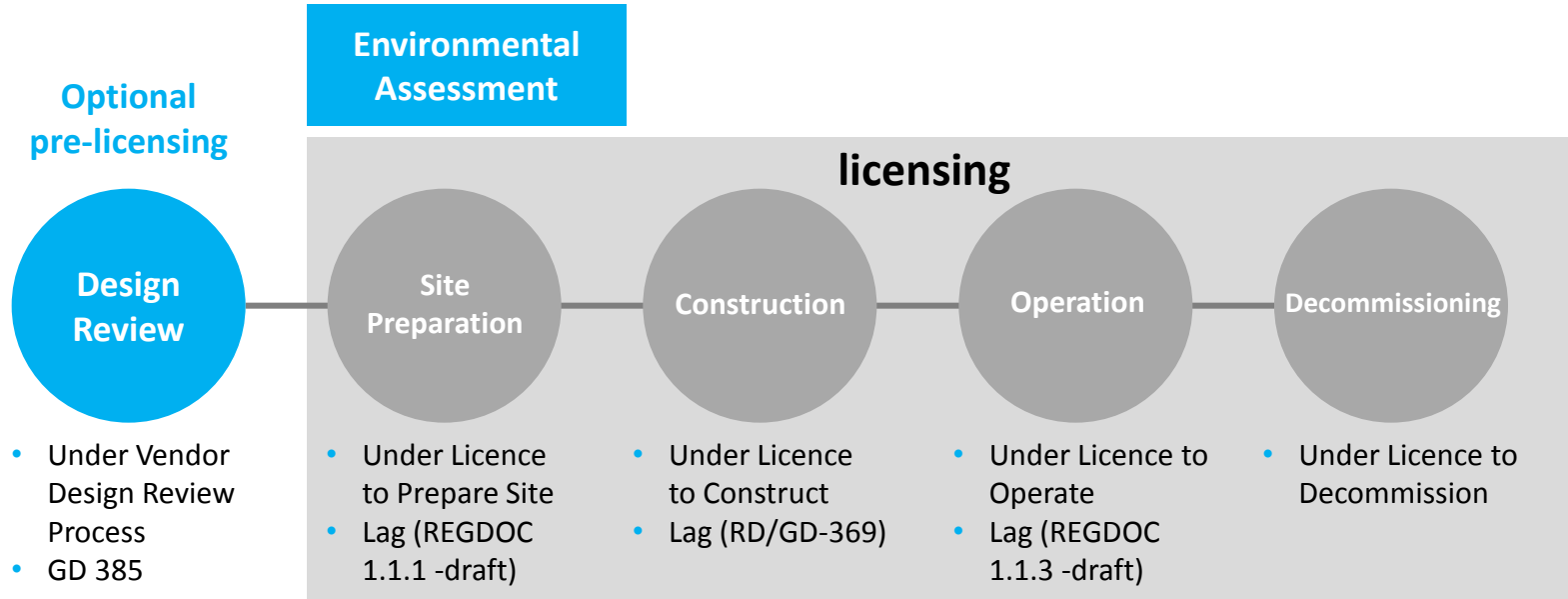
Phase 1 Conceptual design complete ~ 18 months

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

Licensing Stages of a New Reactor Facility



The VDR provides information that can be leveraged to inform licensing for a specific project – **It is not a design certification nor a licence**

Vendor Design Review

Benefits

Enables vendors and utilities to communicate

- Identify and address regulatory issues early enough so that delays in licensing and facility construction, can be minimized
- Higher-quality licence applications
- Efficient and effective licensing process
- Assists decision makers in quantifying project risks (informing cost and schedule estimates)

Vendor Design Review

Topic Areas

- 1 General plant description, defence in depth, safety goals and objectives, dose acceptance criteria
- 2 Classification of structures systems, and components
- 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
- 9 Beyond design basis accidents (BDBAs) and severe accidents (SA)
- 10 Safety analysis (PSA, DSA, 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

Vendor Design Review

Phase 1 CNSC VDRs in Progress

VDR No	Country of Origin	Company	Reactor Type / Output per unit
1	Canada/U.S.	Terrestrial Energy	Molten salt integral / 200 MWe
2	U.S./Korea/China	UltraSafe Nuclear/Global First Power	High temperature gas prismatic block / 5 MWe
3	Sweden/Canada	LeadCold	Molten lead pool fast spectrum / 3 – 10 MWe
4	U.S.	Advanced Reactor Concepts	Sodium pool fast spectrum /100 MWe
5	U.K.	U-Battery	High temperature gas prismatic block / 4 MWe
6	U.K.	Moltex Energy	Molten salt / ~1000 MWe
7	Canada/U.S.	StarCore Nuclear	High temperature gas prismatic block / 10 MWe

Thank you!