Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

Canada

Challenges in Regulation of Activities Involving New Reactor Technologies

DOE-NRC Advanced non-LWR Workshop

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Part 1: The Basics

The CNSC's role is regulatory oversight by:

- ☑ Ensuring regulatory requirements are clear
- ☑ Ensuring a balanced, efficient and transparent licensing process
- ☑ Confirming the licensee is meeting regulatory requirements and applying enforcement measures as necessary

Graded Approach in the Regulatory Framework – Reactor Facilities

- Methods used to establish stringency of the following commensurate with the level of risk posed by the reactor facility:

Design measures | **Safety analyses** | **Provisions for operation**

- 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: Safety will not be compromised

Use of Alternative Approaches

CNSC will consider alternative approaches to requirements where:

- the alternative approach would result in an equivalent or superior level of safety
- the application of the requirements conflicts with other rules or requirements
- the application of the requirements would not serve the underlying purpose, or is not necessary to achieve the underlying purpose

Alternative approaches must be explained and supported with suitable information

The Licensee Is Responsible for Safety and is Held Accountable Through Their Licence

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*

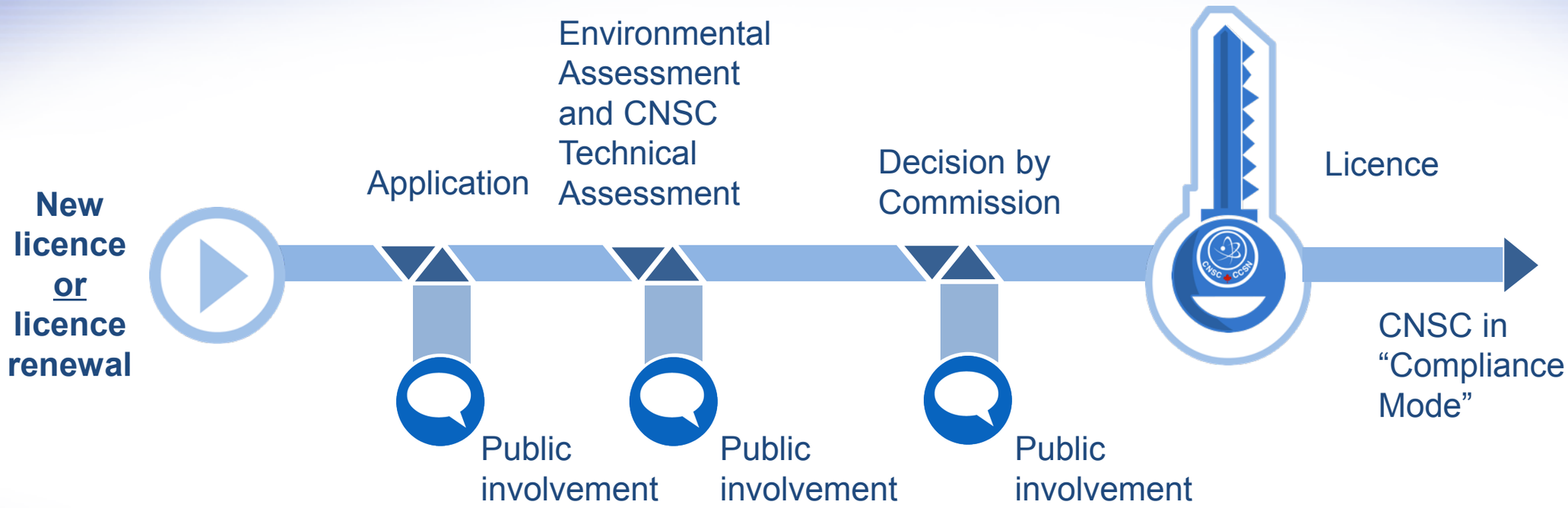
Five stages (types of activities) in the lifecycle of a nuclear facility

Site preparation under	Construction under	Operation under	Decommissioning under	Release from CNSC Regulatory Control under
Licence to Prepare Site	***Licence to Construct***	***Licence to Operate***	***Licence to Decommission***	***Licence to Abandon***

Combined licenses are possible

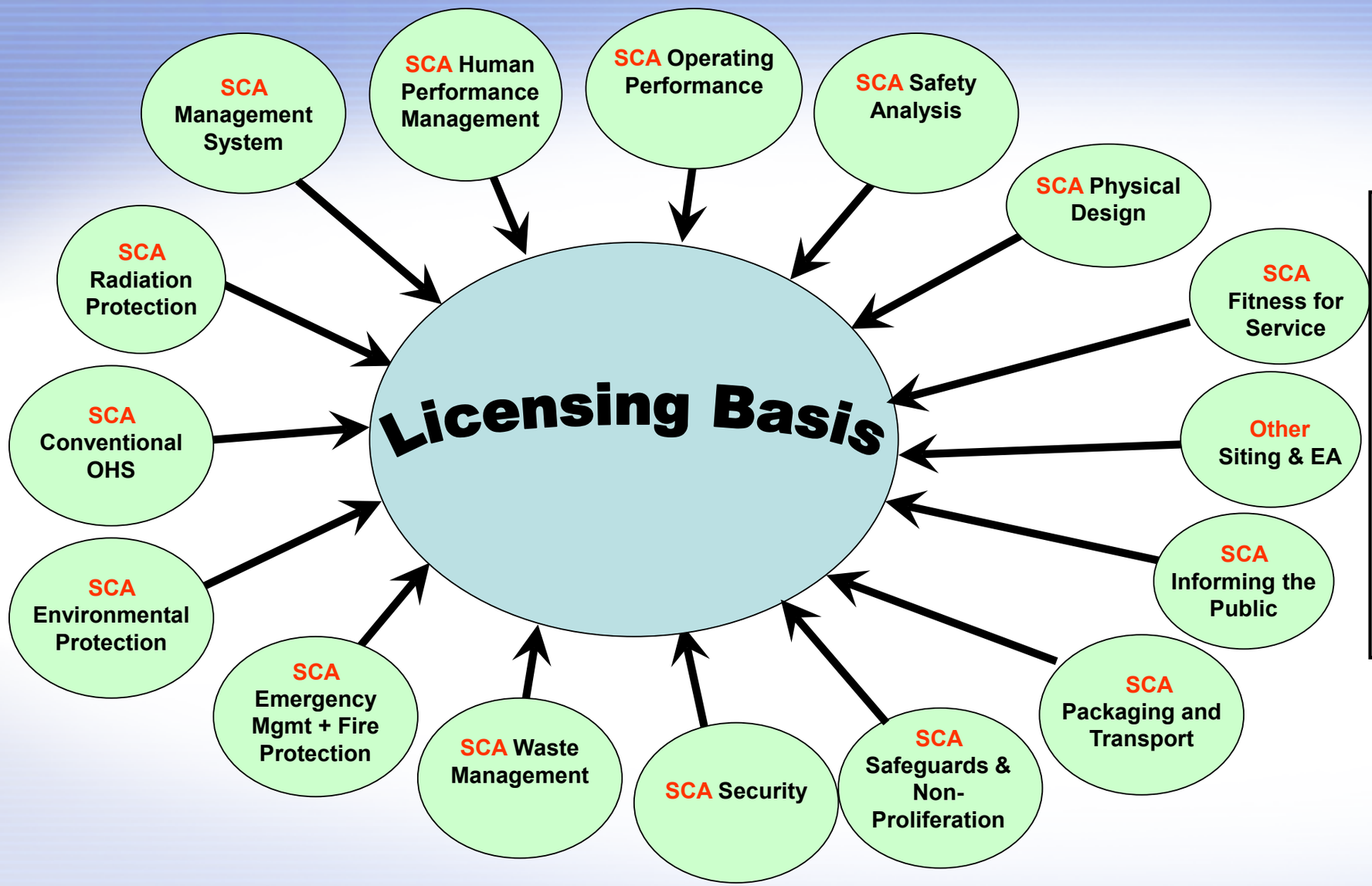
CNSC Licensing Process Overview

One process, regardless of facility size



Ongoing public involvement, Aboriginal consultation and environmental monitoring

Safety and Control Area (SCA) Framework



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

Regulatory Framework documents exist for each SCA.

Canadian Environmental Assessment Act 2012: Environmental Assessments are the responsibility of the CNSC

- 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 EA and first licence (generally a Licence to Prepare Site)
  - CNSC has service standards for subsequent licences
- 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 CEAA 2012 EAs

Part 2:
Challenges in Regulation of Activities Involving New Reactor Technologies

Challenges being presented to regulators

- New technologies can have just as many uncertainties as the first generation
  - Adding more new features over and above those tested in the past
  - How much of the original experimental evidence is valid/useful?
  - **Commercial power reactor operating cycle ≠ cycle of experimental facilities**
- Investors funding technology in smaller discrete steps
  - This influences the scope and depth of R&D at each phase of development, vendors looking for regulatory feedback
- Utilities under greater cost pressures
  - More aggressive plant performance including optimized maintenance and operation
  - Questioning rationales behind new regulatory requirements – regulator needs to explain why those requirements are necessary

Understanding What an "SMR" Represents Has Shaped Our Readiness Preparations

- We recognize that:
  - requirements must be 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)
  - supporting evidence needs to be based on sound science and engineering practices

Canadian regulatory framework is risk informed and independent of reactor size or technology

Work Well Underway

- CNSC is examining existing requirements and guidance:
  - To understand where clarifications need to be made
  - To communicate where requirements are sufficient (for now) given existing information on these emerging technologies
  - To provide input to standards committees where possible

- CNSC is gathering information on activities that may challenge existing licensing and operational models/approaches
  - Particularly for approaches that present policy questions
  - Will address implications in requirements and guidance if warranted

Lack of specific technical information on reactor technologies presents challenges

Pre-Licensing
Vendor Design Review Process

A tool for reactor vendors

- To determine whether the vendor is ready for potential deployment in Canada
- A proven and standardized process to evaluate, in principle, whether there are fundamental barriers to licensing the vendor's reactor design in Canada
- The process should not be triggered unless the vendor's 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

Process is optional and not a prerequisite to licensing

Benefits

- A VDR 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)

Identify and resolve key issues before build - reducing cost and time risks, and ensuring public safety

Optional, standardized and technology-neutral process

CNSC uses a managed process:

- To evaluate, in principle, whether there are fundamental barriers to licensing the vendor's reactor design in Canada
- To ensure each vendor receives a fair and consistent review
- to standardize review topics and drive the review using a combination of documented internal work instructions and specialist expert judgement
- With schedule flexibility, within reason, to take into account a vendor's desired submission schedule

The outcome of the review process is not a detailed review of the entire design – It is a broad sample of key safety related topics

Process is documented in GD-385

- GD-385 - *Pre-licensing Review of a Vendor's Reactor Design*, May 2012
  - Preserves vendor proprietary information while giving the public information through an Executive Summary
  - The review is solely intended to provide early feedback on the acceptability of selected aspects of a nuclear power plant design based on Canadian regulatory requirements and CNSC expectations
  - Is not certification of a design
  - Does not fetter the Commission in the licensing process

The CNSC will undertake a far more detailed review of the design at the time of review of a licence application for a specific site

Relationship between Pre-licensing VDR and an eventual specific site project

- The results from the VDR process can be used to inform licensing activities
- Assuming the vendor shares results with the interested utility, the utility can shape their own licensing submissions with information obtained from the VDR process (but that information would then become part of the public process)
- Understanding the results of the VDR process can help a utility understand where project risks can emerge, e.g.:
  - Where the design may need adjustment to meet requirements
  - Where extra utility scrutiny over the vendor may be needed

Remember: A VDR is a with the Vendor.
Licensing is with a Licensee (i.e. user of the vendor's technology)

Three-phases increasing review depth

- **Phase 1**: approximately 5,000 hours staff time (1 year to perform)
  - Does vendor design intent show an understanding of Canadian requirements? (examination of 19 Focus Areas)
    - does vendor understand regulatory language in Canada?
- **Phase 2**: approximately 10,000 hours staff time (18 months to 2 years to perform)
  - Phase 1 follow-up and assessment of the design for fundamental barriers to licensing in the 19 Focus Areas
    - is vendor addressing Canadian design and safety analysis requirements in specific aspects of the design?
- **Phase 3**: scope and depth requested by vendor (time varies)
  - Follow-up on review areas based on Phase 1 and 2 outcomes

Overview of Focus Areas used in Phases 1 and 2

1 General NPP description - defence-in-depth, safety goals and objectives, and dose acceptance criteria	**11** Pressure boundary design
2 Classification of systems, structures & components	**12** Fire protection
3 Reactor core nuclear design (e.g. core physics)	**13** Radiation protection
4 Fuel design and qualification	**14** Out-of-core criticality
5 Control system and facilities (main control systems, instrumentation and control, control facilities, emergency power systems)	**15A** Robustness **15B** Security and Cyber Security **15C** Safeguards
6 Means of reactor shutdown	**16** Vendor research and development program
7 Emergency core cooling and emergency heat removal systems	**17** Management system of design process and quality assurance in design and safety analysis
8 Containment and safety important civil structures	**18** Human factors
9 Beyond Design Basis Accidents (BDBA) and severe accident prevention and mitigation	**19** Incorporation of decommissioning into design considerations
10 Safety Analysis (Deterministic Safety Analysis, Probabilistic Safety Analysis, Internal and External Hazards)	

Entering the Pre-licensing VDR process

- The process should not be triggered by a vendor unless:
  - Phase 1: the conceptual design is essentially complete and the basic engineering program has begun (design requirements and safety specifications being established)
  - Phase 2: generic safety analysis report development is underway
  - Management system processes for design and safety analysis are documented and being used
  - Design quality assurance processes are established and being used

Examples of CNSC Requirements That Can Already Be Applied to SMRs

- REGDOC-2.4.1, *Deterministic Safety Analysis*
- REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants* (for larger SMRs)
- RD-367, *Design of Small Reactor Facilities* (for smaller SMRs)
- REGDOC-2.3.2, *Accident Management*, version 2
- REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*

All address the use of the graded approach and are written to permit use of (supported) judgement

"Point" to where your design requirements address each REGDOC clause

- If referring to a Design Certification Document (DCD) or similar document, this tells CNSC where the requirement is addressed
- Information should include references to applicable codes and standards
- Are there any Fukushima or OPEX lessons applicable to this Focus Area?
  - if so, how are they being addressed?

- If using codes and standards from outside Canada - the should vendor identify gaps between their adopted standard and those used in Canada.

Identify any "novel features" and outstanding R&D for the focus area

- Novel features, by nature, are not yet proven

  examples:
  - New core configuration / fuel type
  - passive behaviour of a preventive or mitigating system

- What is the path forward to show the novel feature will meet requirements?

- Give an overview of R&D being undertaken for the novel feature(s) and identify outstanding work to be done

Determination of "Proven" can be quite challenging

- All regulators looking at SMRs and Gen IV technologies are asking the question "what level of evidence is necessary to make the determination of 'proven enough' for:

Prototypical experiments	To collect specific scientific/ engineering information on (proof of concept)	Low state of proven-ness – risks and uncertainties are higher – additional safety & control measures needed
Demonstration reactor / First-of-a Kind	Demonstration of integrated components / systems and collection of OPEX to refine design for nth of a kind	Varying amounts of OPEX – proving in progress- varying risks and uncertainties to be addressed – some additional safety & control measures needed where uncertainties are high
"Nth"-of-a-Kind	Commercial operation – information used to improve operational performance	High state of proven-ness – uncertainties generally well understood and ongoing R&D supports management of uncertainties

'Proven' is both technical and process-driven (different technical specialist areas are involved in the assessment)

Summary

- There are challenges and pressures with regards to deployment of SMRs / advanced reactors
- Well established EA, licensing and VDR processes in Canada
- Regulatory framework is comprehensive
  - CNSC is reviewing their current regulatory framework and seeking feedback from stakeholders
- Vendor Design Reviews provide a framework for consideration of technologies, and in particular, novel approaches

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Additional Information

SMR Discussion Paper DIS-16-04

- Released for public consultation

- Different audiences being considered to maximize feedback:
  - Public at large – to explain SMR concepts and approaches to regulation
  - Existing licensees
  - Vendors and (build-own-operate) utilities originating from outside Canada but exploring Canadian deployment (i.e., no Canadian regulatory experience)
  - Government agencies (provincial, territorial and federal)
  - Educational and Science & Technology institutions
  - Foreign nuclear regulators are interested

SMR Discussion Paper (continued)

- Speaks to how we would address licensing (incl. technical assessment) should an application be submitted now

- Discusses key international issues and
  - Show how the issue is currently addressed in Canadian regulatory requirements
  - Identify challenges in a Canadian context
  - Ask for feedback (thoughts, concerns, proposals)

Topics Covered in the Discussion Paper

Technical information, including research and development activities used to support a safety case	Transportable reactor concepts
Licensing process for multiple module facilities on a single site	Increased use of automation for plant operation and maintenance
Licensing approach for a new demonstration reactor	Human/machine interfaces in facility operation
Licensing process and environmental assessments for fleets of small modular reactors	The impact of new technologies on human performance
Management system considerations: Licensees of activities involving small modular reactor (e.g. minimum complement)	Financial guarantees for operational continuity
Safeguards implementation and verification	Site security provisions
Deterministic/probabilistic safety analyses ...	Waste management and decommissioning
Defence in depth and mitigation of accidents	Subsurface civil structures important to safety
Emergency planning zones	Fusion technologies

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 **Example: Multiple unit control rooms**
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 (e.g., vendor design reviews) **Example: Safety analysis around use of specific passive and inherent safety features**
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 **Example: Licensing approach for a fleet of small reactor facilities by a single company over a widely distributed geographical area.**

What Will Feedback on the SMR Discussion Paper Be Used For?

- CNSC planning workshop with stakeholders this year to gather feedback – discussion based on the paper
- Commission meeting being planned for early 2017
  - Update being provided on SMR activities
- Inputs to be considered in regulatory framework
  - Impacts on regulatory requirements and guidance
  - Feed into development work on standards
- Inputs into CNSC regulatory research program