



Canadian Nuclear
Safety Commission

Commission canadienne
de sûreté nucléaire

Canada

CNSC Activities in Support of Regulation of Activities Involving New Reactor Technologies

Technical and Regulatory Issues Facing Nuclear Power Plants: *Leveraging Global Experience*

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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

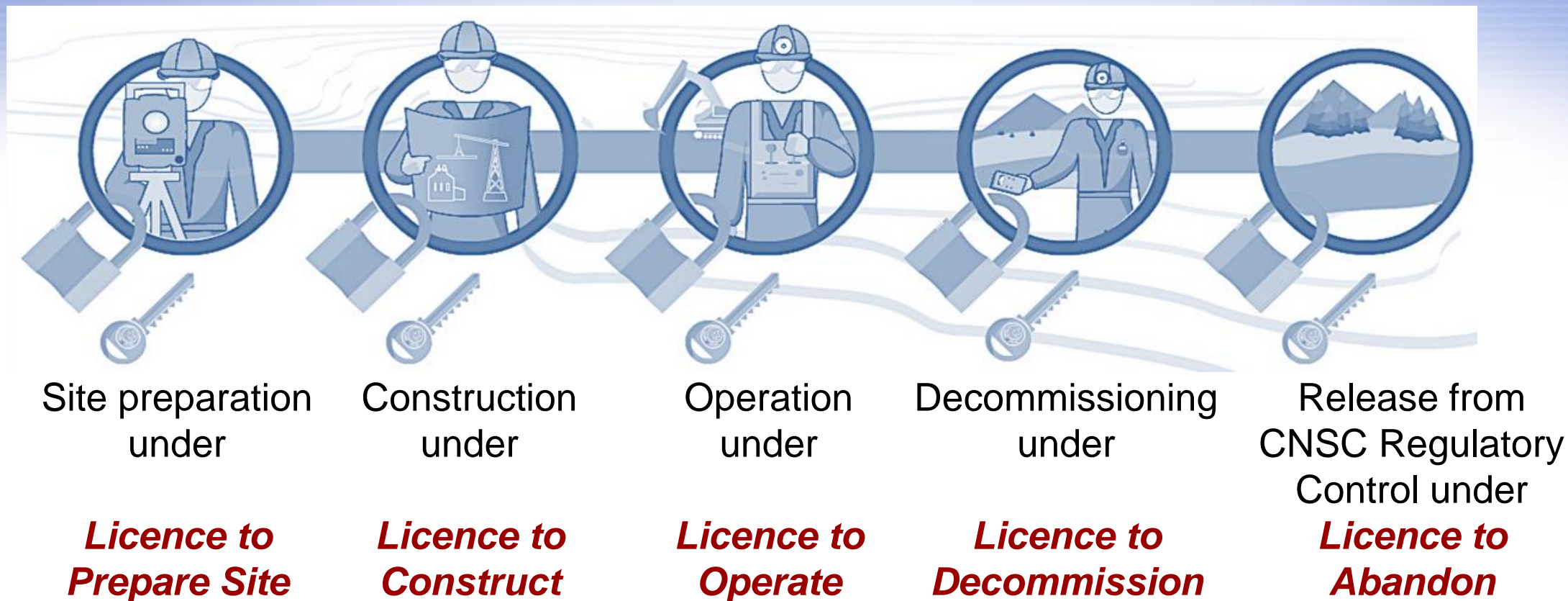
Section 24(4) of the NSCA

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

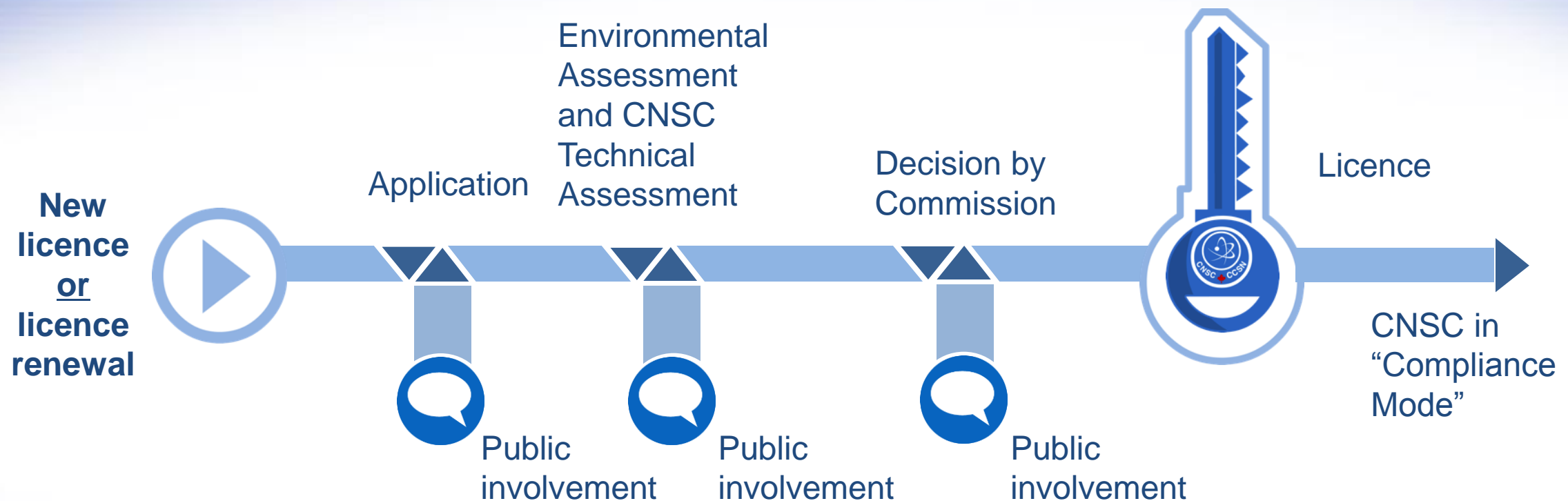


Combined licenses are possible



CNESC Licensing Process Overview

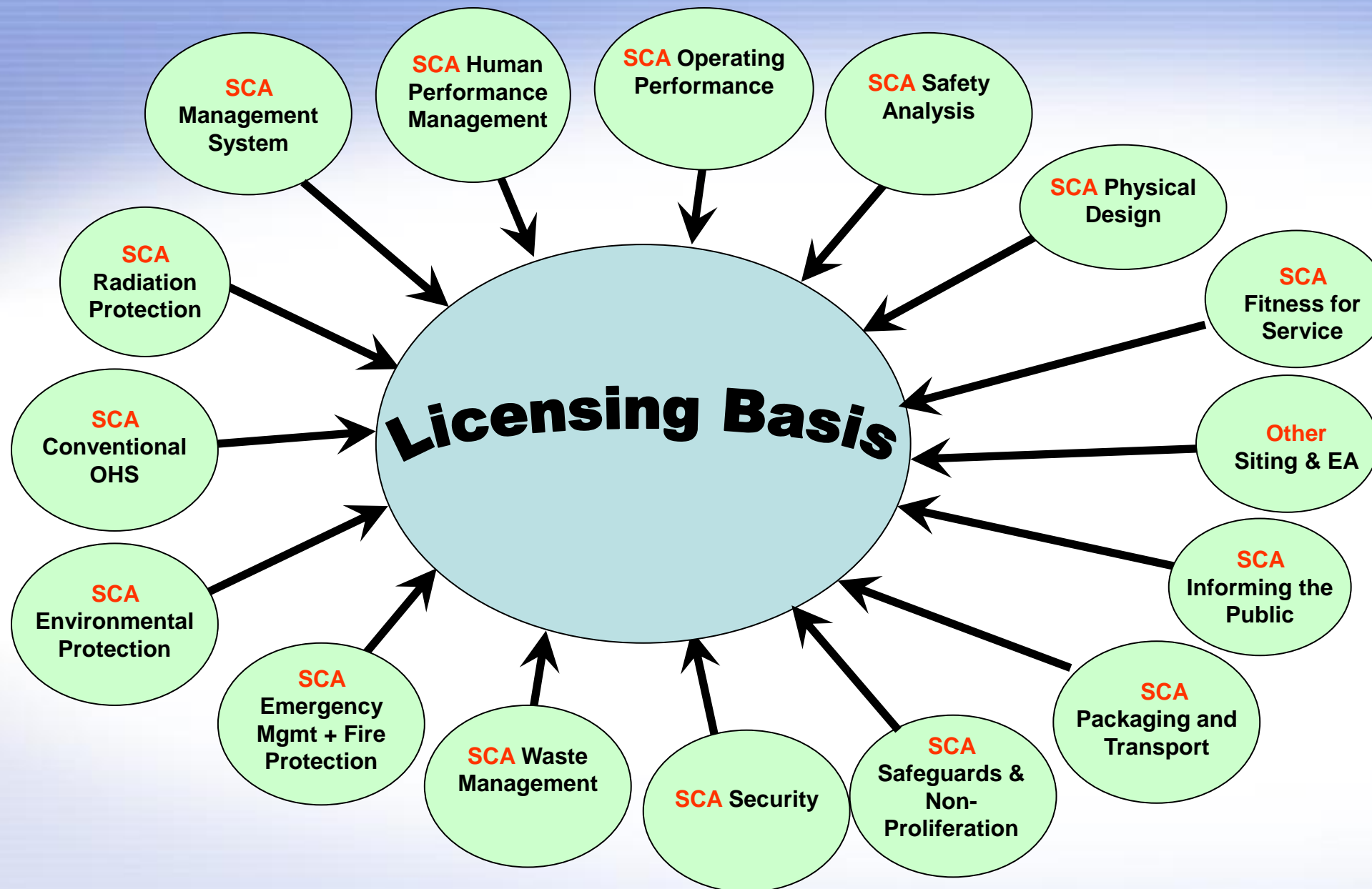
One process, regardless of facility size



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:

CNSC Activities in Support of Regulation of Activities
Involving New Reactor Technologies

Collaborative Efforts to Understand and Address SMR and Advanced Reactor Issues

CNSC SMR Working Group

- Multidisciplinary – licensing, technical, environmental
- Engage with proponents, other regulators and public to ensure requirements are understood
- Authored CNSC SMR Discussion Paper (DIS-16-04)

Canadian Nuclear Laboratories

- Conducting specific Science and Technology work to support CNSC

IAEA SMR Regulators' Forum

- Canada, USA, France, Russia, Finland, Korea, China
- Currently 3 Issue Specific Working Groups: Graded Approach, Defence-in-Depth, Emergency Planning Zone
- Understand SMR issues and our current approaches for addressing them & to find common positions
- Suggest enhancements to IAEA requirements

OECD-NEA-CNRA Advanced Reactor Task Force

- Looking at specific regulatory and safety issues pertaining to new Sodium Cooled Reactors

Generation IV International Forum

- Regulatory interest in ongoing R&D work

All information from these is considered in CNSC path forward



Conventional Grids – Larger SMRs / Advanced Reactors

Water cooled

- 2 integrated light water reactor companies
- 1 boiling water reactor company

Non-water cooled (i.e., advanced reactors)

- 3 molten salt reactor companies
- 1 sodium fast reactor company
- 1 lead-cooled reactor company
- 1 high temperature gas-cooled reactor company

**One Phase 1 Vendor Design Review is in progress:
Terrestrial Energy Molten Salt Reactor (195 MWe/unit)**

1 more VDR likely this year for this size range (sodium fast reactor)



Off-Grid, Edge-of-Grid – Smaller SMRs / Advanced Reactors

Non-water cooled (i.e., advanced reactors)

- 1 molten salt reactor company
- 1 sodium fast reactor company
- 2 lead / lead bismuth reactor companies
- 2 high temperature gas-cooled reactor companies

**One Phase 1 Vendor Design Review set to begin this summer:
[Vendor Name not releasable until agreement signed]
HTGR <25 MWe/unit**

2 more VDRs likely this year for this size range (lead-cooled, water-cooled designs)



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 \neq cycle of experimental facilities**
- Investors funding technology in smaller discrete steps – expecting concrete results with exit as an option
 - This influences the scope and depth of R&D at each phase of development
 - Vendors looking for regulatory feedback to help them manage what they need to do
- 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 (e.g. through guidance)



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**

- 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**



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 <u>integrated</u> 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)



SMR Discussion Paper DIS-16-04

- Is being 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: <ul style="list-style-type: none">• 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



Regulatory Cooperation / Collaboration?

- CNSC and other regulators share regulatory views in many areas
- Many other technical areas are being discussed through IAEA SMR Regulators' Forum



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Canada

We Will Never
Compromise Safety...

... It's In Our DNA!

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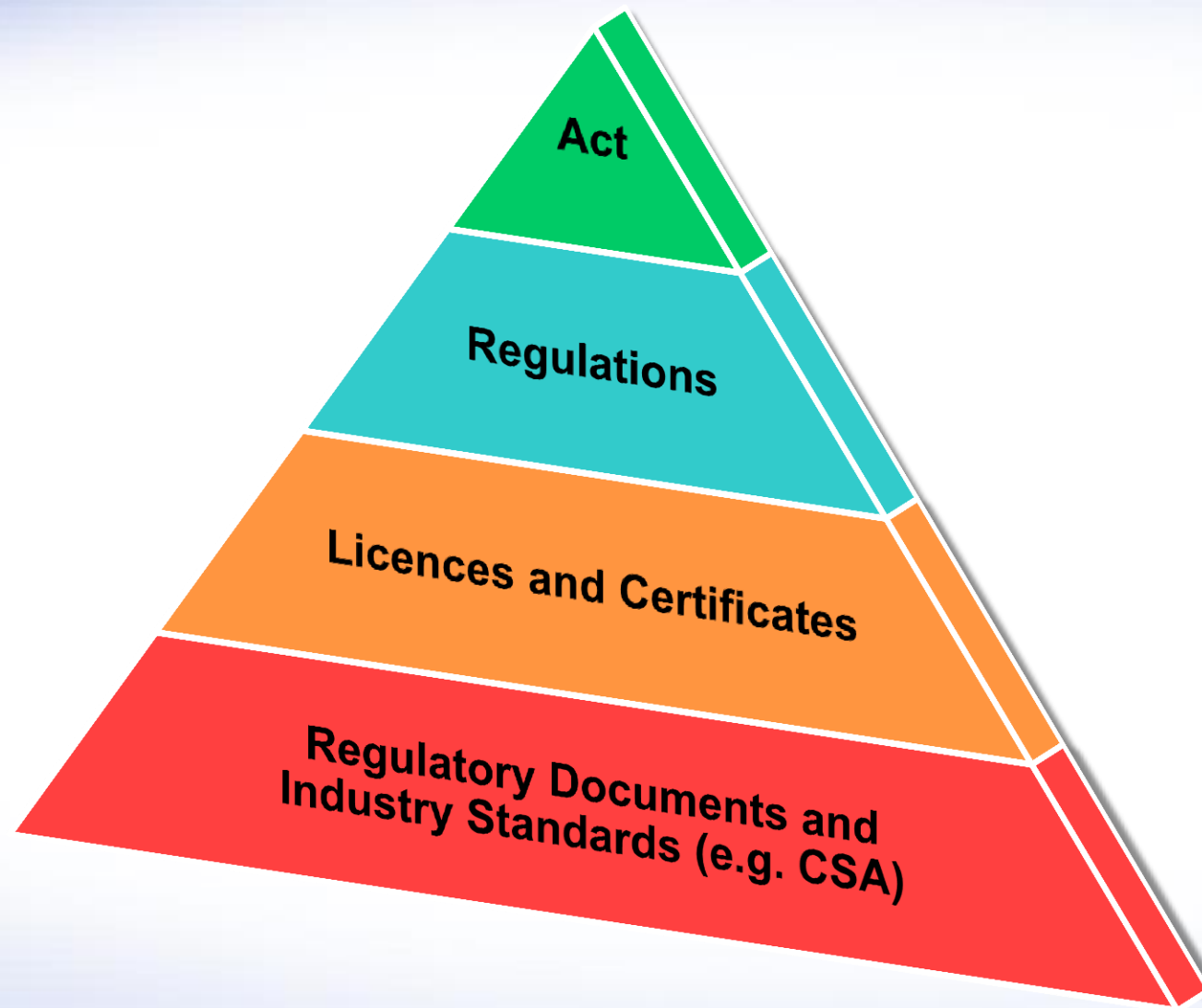
Background Information

Regulatory Framework

Fundamentals



The CNSC's Regulatory Framework





Nuclear Safety and Control Act (NSCA)

- Sets out the legal framework that established the Commission, its authority and responsibilities, and allows the CNSC to make regulations
- Establishes the power to licence, to inspect, and to enforce






Risk-Informed Regulation

§3. *The purpose of this Act is to provide for (a) the limitation, **to a reasonable level** and in a manner that is consistent with Canada's international obligations, of the risks to national security, the health and safety of persons and the environment that are associated with the development, production and use of nuclear energy and the production, possession and use of nuclear substances, pre-scribed equipment and prescribed information...*

The Commission makes informed, science-based decisions on the mitigation of risk **to a reasonable level**

 CANADA	
CONSOLIDATION	CODIFICATION
Nuclear Safety and Control Act	Loi sur la sûreté et la réglementation nucléaires
S.C. 1997, c. 9	L.C. 1997, ch. 9
Current to August 5, 2014	À jour au 5 août 2014
Last amended on July 3, 2013	Dernière modification le 3 juillet 2013
Published by the Minister of Justice at the following address: http://laws-lois.justice.gc.ca	Publié par le ministre de la Justice à l'adresse suivante : http://lois-laws.justice.gc.ca



Examples of other Federal Acts that Apply

- *Canadian Environmental Assessment Act, 2012*
- *Canadian Environmental Protection Act*
- *Canada Labour Code*
- *Fisheries Act*
- *Migratory Birds Convention Act*
- *Navigation Protection Act*
- *Species at Risk Act*
- *Transportation of Dangerous Goods Act*



Regulations

Regulations of General Application

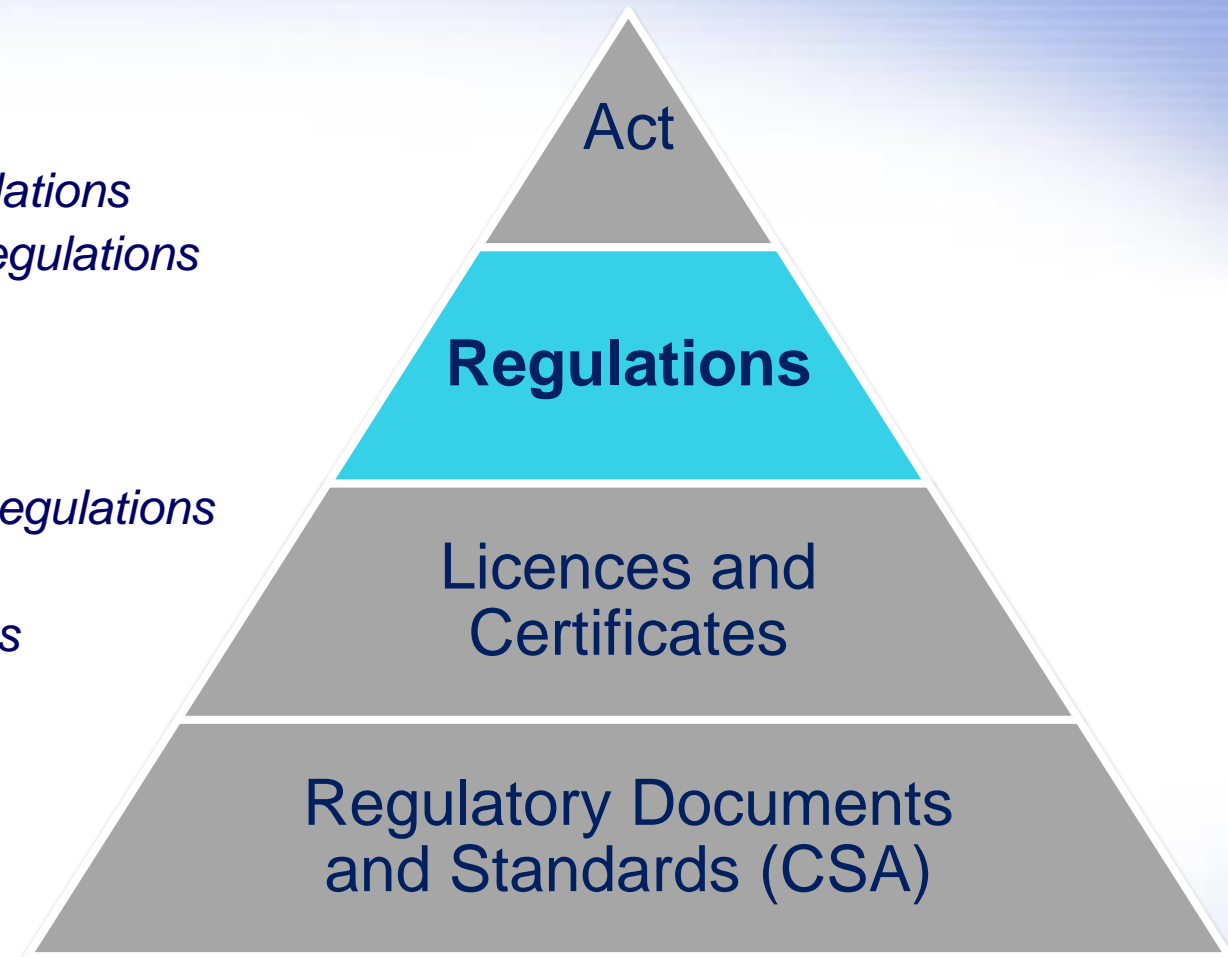
- *General Nuclear Safety and Control Regulations*
- *Radiation Protection Regulations*
- *Nuclear Security Regulations*
- *Packaging and Transport of Nuclear Substances Regulations*
- *Nuclear Non-Proliferation Import and Export Control Regulations*
- *Administrative Monetary Penalties Regulations*

Facilities and Uses

- *Class I Nuclear Facilities Regulations*
- *Class II Nuclear Facilities and Prescribed Equipment Regulations*
- *Uranium Mines and Mills Regulations*
- *Nuclear Substances and Radiation Devices Regulations*

Other

- *CNSC Cost-Recovery Fees Regulations*
- *Canadian Nuclear Safety Commission Rules of Procedure*
- *Canadian Nuclear Safety Commission By-laws*





Licences and Certification

- **Licences**

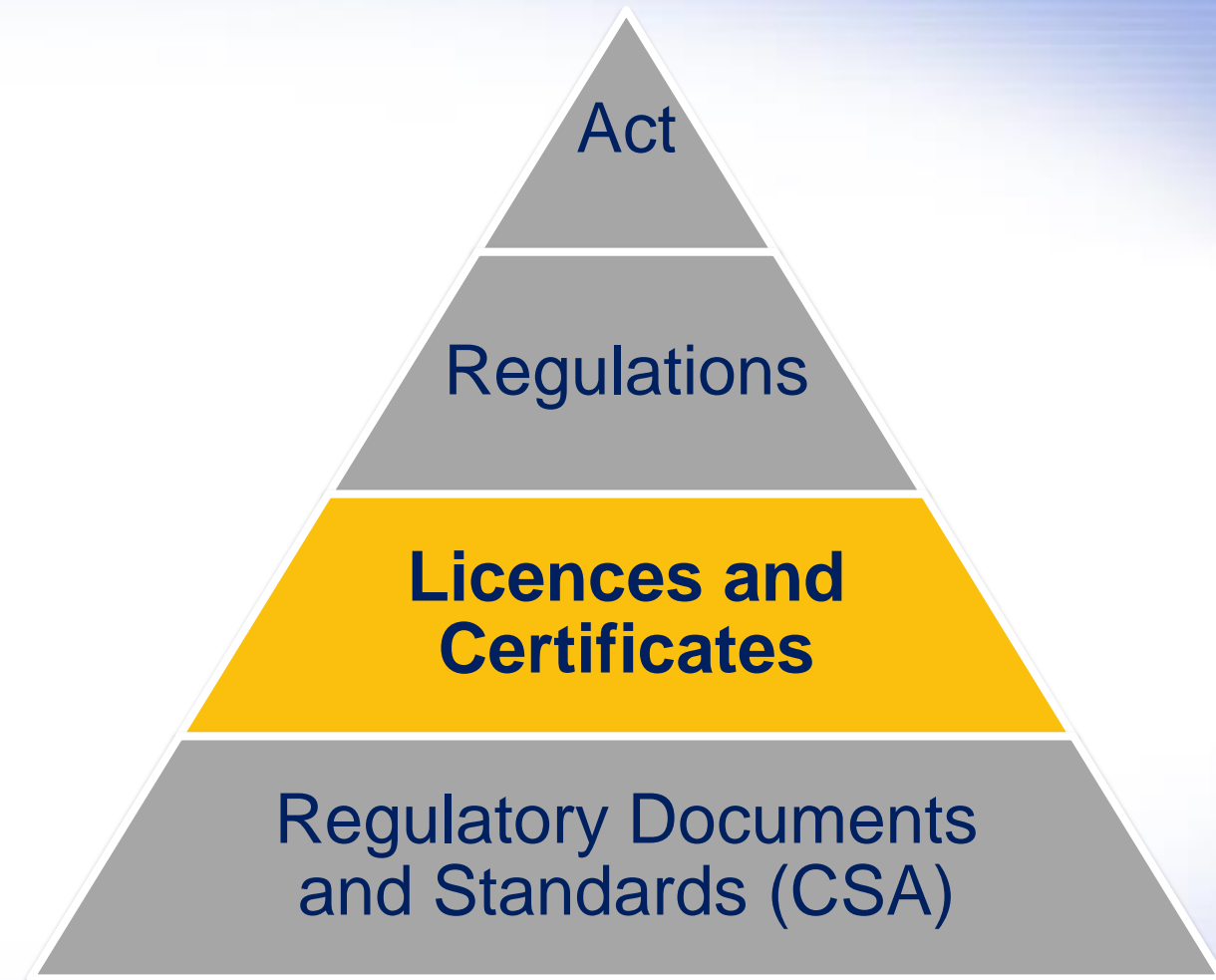
- *An authorization issued by the Commission (or Designated Officer) to conduct activities described in a licence application*
- *Once issued, the applicant becomes a CNSC licensee*

- **Licence conditions**

- *Most are standardized across facilities*
- *Can be licensee specific as well*
- *Licence condition handbooks accompany licence and provide further explanation of licence conditions and contain compliance verification criteria – LCH is not part of the regulatory framework.*

- **Certificates**

- *The CNSC issues certificates indicating that a nuclear device (e.g. transportation package) or person working in the nuclear sector (e.g. authorized nuclear operator) meets regulatory requirements*





Regulatory Documents and Industry Standards

Regulatory documents

- set outcomes (requirements) that must be achieved to meet the regulations
- contain guidance to provide clarity as to how requirements can be met
- are developed using extensive public consultation led by CNSC

Industry standards

- CNSC participates where appropriate
- set outcomes (requirements) that must be achieved to achieve safety/quality etc.
- contain guidance to provide clarity as to how requirements can be met
- are developed using extensive public consultation led by the standard development organization
- CNSC decides whether use of the standard is appropriate in specific situations





Licensing Process for New Power Plants

- REGDOC- 3.5.1, *Licensing Process for Class 1 Nuclear Facilities and Uranium Mines and Mills*

<http://www.nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents/published/html/regdoc3-5-1/index.cfm>

- CNSC does not have a design certification regime for reactors
 - future projects using the same technology see efficiencies from the technical reviews performed in the first project
 - Differences in design between the first plant and subsequent plants must be addressed

SMRs are Class 1 Nuclear facilities



Licence Application Guides (LAGs)

- Suggest application format and submission information
- Used in conjunction with REGDOCs and industry standards





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



Background Information

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

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



Identify which REGDOC 2.5.2/ RD-367 clauses apply to that focus area

- this exercise helps the vendor understand which requirements apply and why
- gives a point of reference for discussions between vendor and CNSC staff



“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