# Perspectives on Technical Assessments of New Reactor Technologies

**Molten Salt Reactor Workshop 2017— Panel on MSR Safety & Regulatory Related Topics**

**Oak Ridge National Laboratory, USA**

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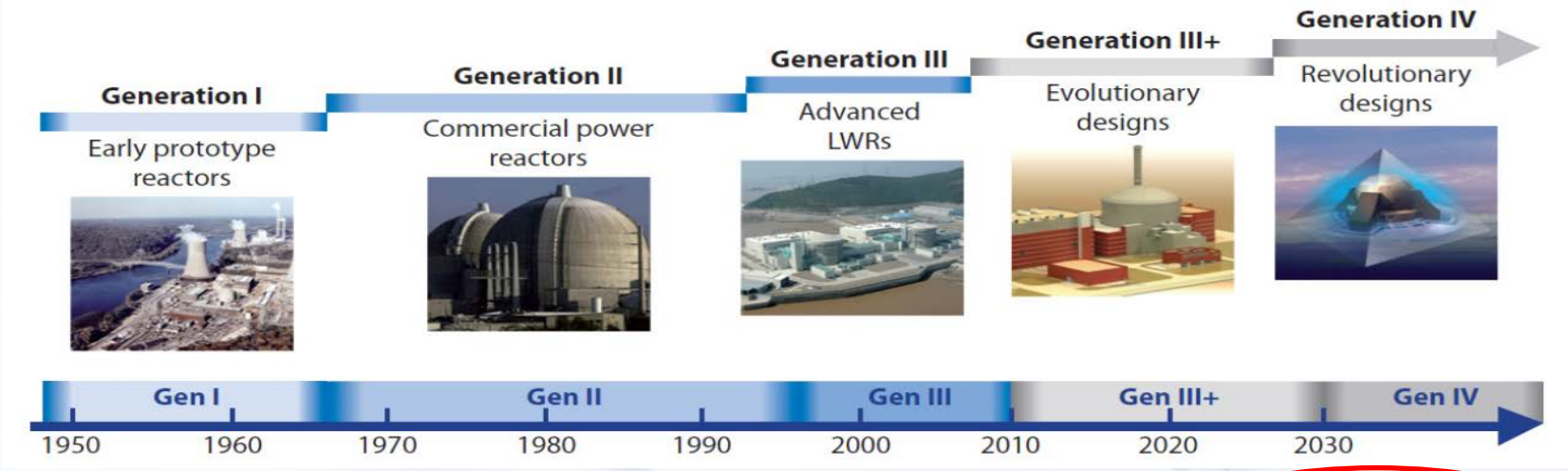
**New Major Facilities Licensing Division**

**Canadian Nuclear Safety Commission**

CANADA 150

# Technology Evolution vs Regulatory Approach




Objective based with few prescriptive requirements. Limited OPEX, generous safety margins – significant use of engineering judgement

Adapted as OPEX grew – more regulatory certainty, but more prescriptive & rule based – consistent with mature fleet

Limited OPEX to support safety claims or operating models

return to objective-based but leverage existing tools -significant use of engineering judgement

# Technical Challenges associated with SMRs and Advanced Reactor Designs

- All claim to be a step-change improvement in safety performance
  - Either evolutionary changes based on proven technologies already in use; or,
  - Concepts based on past development activities
- Some evolutionary changes such as passive safety systems require proof of concept
- Engineered safety features will have limitations and uncertainties that must be understood and addressed

# Regulatory framework : What we currently have

- 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 using extensive operating experience from water-cooled reactors, but…

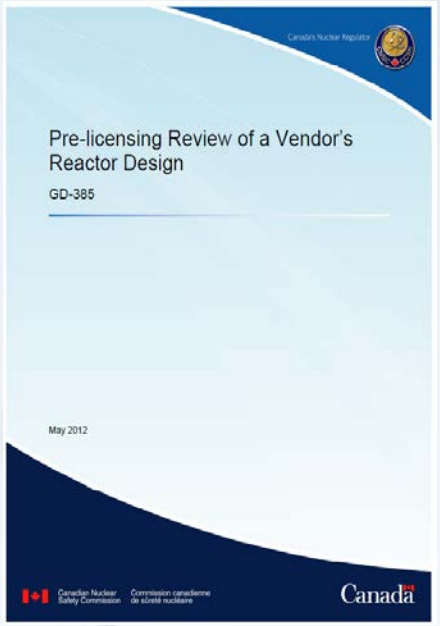
  *"It is recognized that specific technologies may use alternative approaches. If a design other than a water-cooled reactor is to be considered for licensing in Canada, the design is subject to the safety objectives, high-level safety concepts and safety management requirements associated with this regulatory document. However, the CNSC's review of such a design will be undertaken on a case-by-case basis."[REGDOC 2.5.2]*
- Existing requirements address fundamental safety objectives for design of I&C systems but clarifications may be necessary in more specific areas

Vendor Design Review projects and international cooperation are being used to understand where additional clarification to CNSC expectations may be needed

# Pre-licensing Vendor Design Review

- **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



# VDRs – Benefits

- 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. 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

The most important part of the VDR process is the conversation around safety objectives and what requirements mean in specific technical applications

# 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 October 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 |
| 4 | U.S. | Advanced reactor concepts | Liquid sodium pool fast spectrum /100 MWe | Start October 2017 |
| 5 | U.K. | U-Battery | High temperature gas prismatic block / 4 MWe | Service agreement under development |
| 6 | U.K. | Moltex Energy | Molten salt / ~1000 MWe | Pending start December 2017 |
| 7 | Canada / U.S. | StarCore Nuclear | High temperature gas prismatic block / 10 MWe | Service agreement under development |

# Vendor Design Review – Topic Areas

| | | | |
|---|---|---|---|
| **1** | General plant description, defence in depth, safety goals and objectives, dose acceptance criteria | **11** | Pressure boundary design |
| **2** | Classification of structures systems, and components | **12** | Fire Protection |
| **3** | Reactor core nuclear design | **13** | Radiation Protection |
| **4** | Fuel design and qualification | **14** | Out-of-Core Criticality |
| **5** | Control system and facilities | **15** | Robustness, safeguards and security |
| **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 /confinement and safety-important civil structures | **18** | Human factors |
| **9** | Beyond design basis accidents (BDBAs) and severe accidents (SA) | **19** | Incorporation of decommissioning in design considerations |
| **10** | Safety analysis (PSA, DSA, hazards) | | |

# Designs increasingly employing inherent and passive safety features

- In many cases, designers are making claims that a number of features are no longer needed to ensure plant safety
  - Safety can be achieved despite failure of control functions
  - Safety can be achieved despite failure of shutdown systems
  - Significant grace time following events reduces or eliminates need for operator action
- This raises discussions in technology reviews around application of safety classification, reliability expectations, and application of redundancy and diversity requirements
- Fundamental Safety Principles such as Defence-in-depth and how design addresses Control, Cool and Contain remain central to judging whether an approach meets requirements
- Claims must be supported by information from OPEX and R&D results

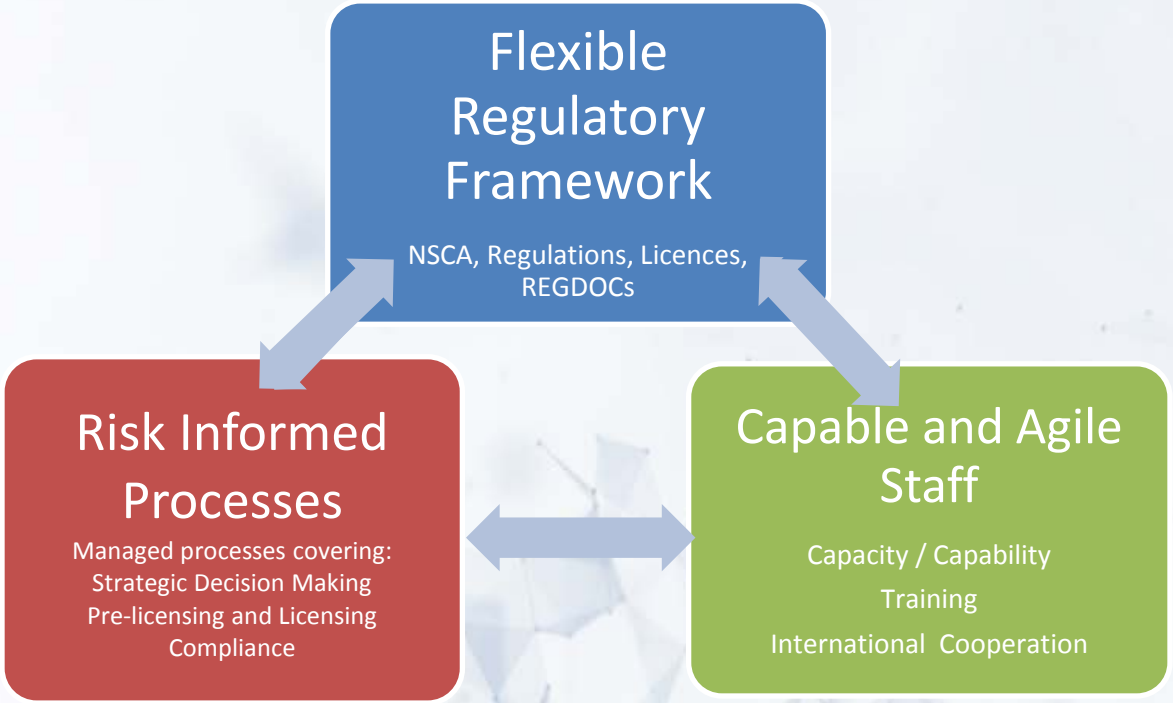
Margins are expected to address uncertainties

# Some Additional Insights from Past Vendor Design Reviews

- The vendor is expected to show how:
  - They are using their systematic engineering processes to make engineering decisions
  - Safety claims will be supported by appropriate evidence in a timely manner to support a project licence application
  - They are managing a quality-assured and systematic R&D program to support their design decisions.
- The five levels of Defence-in-Depth versus traditional five barriers to fission product releases
  - Vendors proposing alternative approaches with design features covering multiple levels of defence in depth
  - The vendor is expected to show that all five levels will be addressed and that sufficient barriers to fission product releases are in place
- Need for clear definitions of “Core damage” and “Severe Accident”

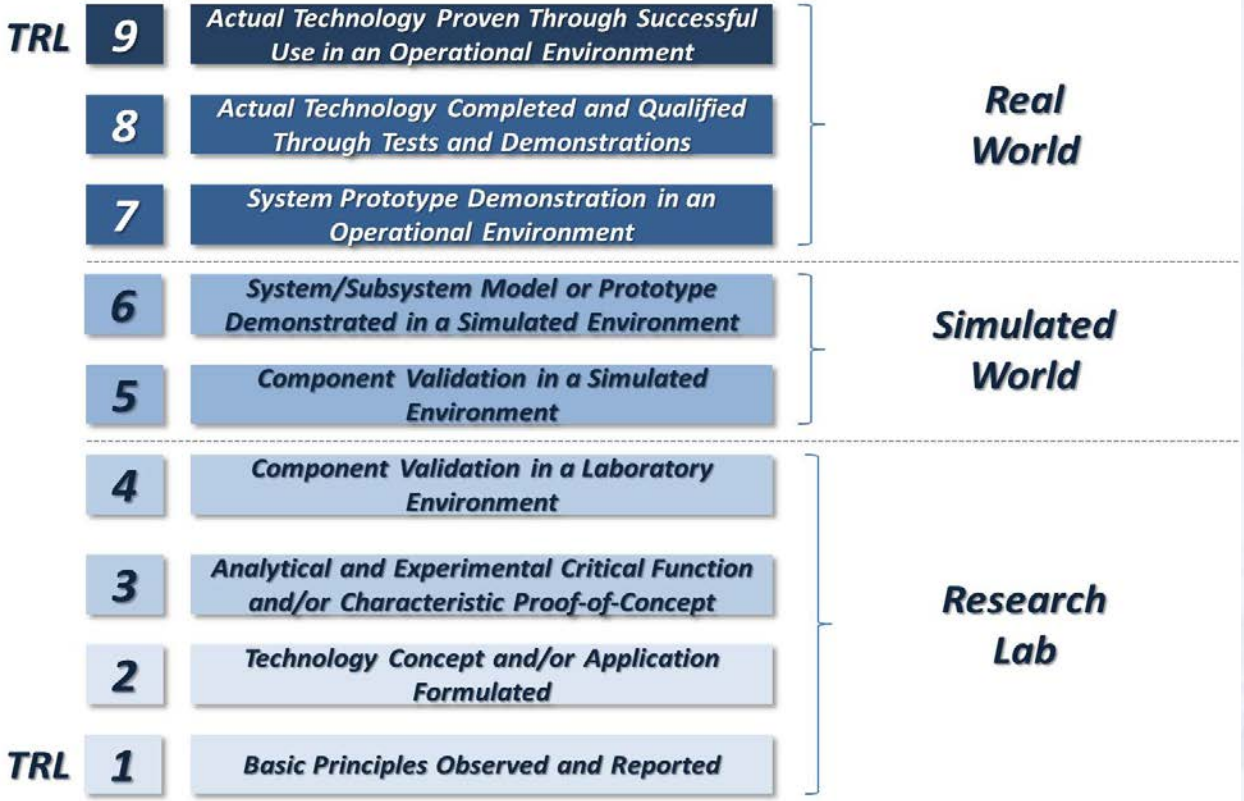
# CNSC Readiness – Elements of Strategy

## Three Pillars




**And communicate…**

# Different Types of Activities Support Achieving Technology Readiness Levels

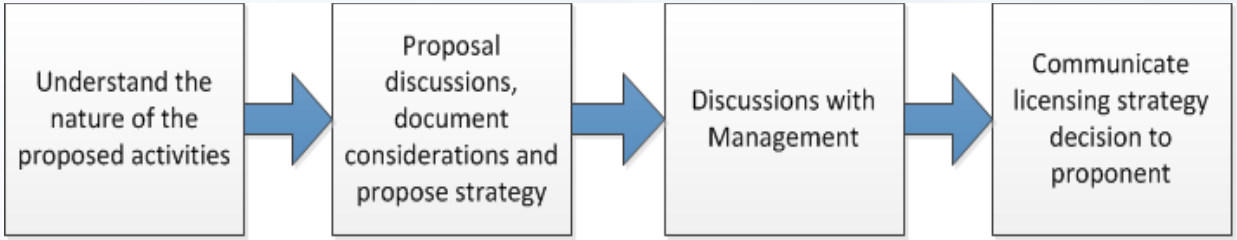



First of a Kind Facility – integrated (commercial?) demonstration

Large scale experiments (may have nuclear substances)

Small scale experiments (may have nuclear substances)

# CNSC 4-Step Process for determining the licensing strategy for novel applications




- A 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 Technical Area
- SMR vendors were informed on expectations regarding information to be submitted in support of this process

# Thank You!