Readiness for Regulating Small Modular Reactors

Nuclear Energy Agency Workshop:

Multilateral Cooperation in the Regulatory Reviews of Small Modular Reactors
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CANADA 150

Current Situation

- Significant interest in potential deployment of advanced reactors or SMRs in Canada
  - 7 VDR applications, and more to come
  - Utility, provincial governments interest
  - CNL “Request for Expression of Interest” (RFEOI)
- Federal Standing Committee on Natural Resources (June 2017 report):
  - “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.”
- CNSC has developed a complete framework to licence new reactors
  - …but these new **advanced** reactors present different challenges

What is different with new generation of advanced reactors?

- **Novel technologies**

  Very different from water based Generation II, III reactors, e.g. :

  - 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)

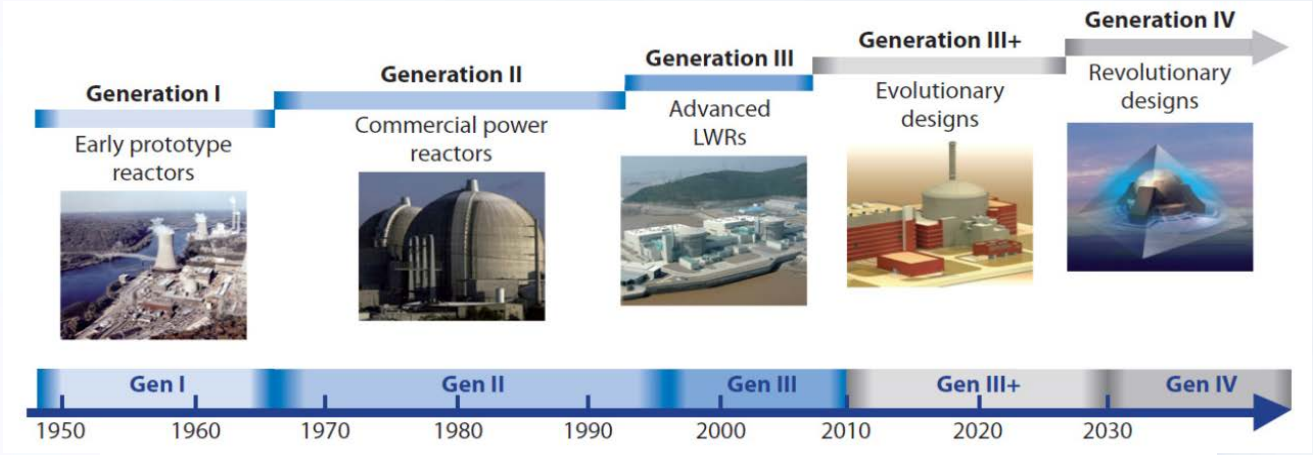
- **Novel approaches to deployment**

  Examples:

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

Key Regulatory Challenges identified in Discussion Paper 16-04

Technology evolution vs regulatory framework



Regulatory Framework

- Objective based with few prescriptive requirements. Limited OPEX, generous safety margins
- Adapted as OPEX grew – more regulatory certainty, but more prescriptive
- Limited OPEX to support safety claims or operating models
- Return to objective based?

Current state of readiness

- Enhancing existing the regulatory framework developed during “Nuclear Renaissance”
  - Full set of REGDOCs
    - Developed for water cooled reactors but can be applied to new/novel technologies
      http://www.nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents/index.cfm
  - Complete set of 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

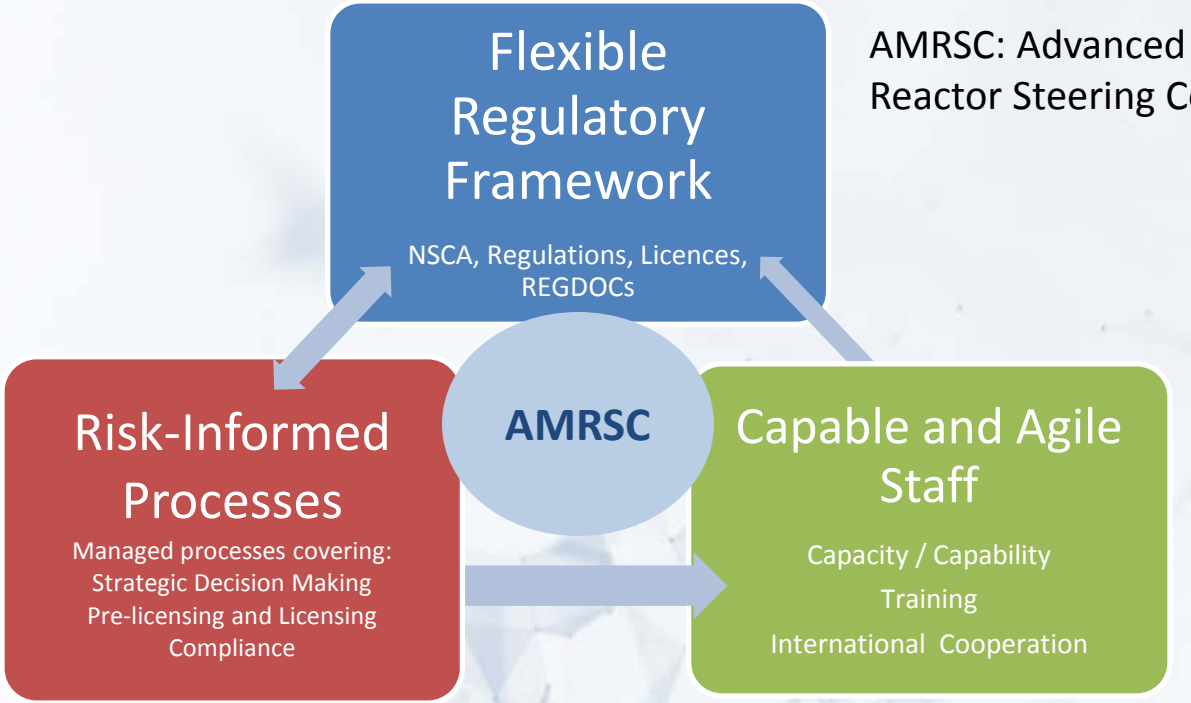
- Discussion Paper on SMRs
- Pre-licensing vendor design reviews (VDRs)
- International cooperation (NEA, IAEA) and bilateral (USNRC)
- International fora and working groups (MDEP, WGRNR, IAEA SMR forum)
- Gap analysis performed with USNRC vision and strategy for non-light water advanced reactors
  - 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: Objectives

- Increased regulatory certainty
  - Fairness, rigor, 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
  - External Stakeholders

CNSC Readiness – Elements of Strategy

Three Pillars



AMRSC: Advanced Modular Reactor Steering Committee

And communicate…

Advance Modular Reactor Steering Committee

- The Advanced Modular Reactor Steering Committee (AMRSC) is to provide leadership to set the foundation for the regulation of Advanced Modular Reactors
- To be chaired by the Executive Vice-President and Chief Regulatory Operations Officer
- The proposed mandate of the AMRSC is to:
  - Make high level decisions regarding the regulatory position for AMRs
  - 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

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 principally for water cooled reactors
    - Complete set of Licence Application Guides (Site preparation (REGDOC 1.1.1) and Operation (REGDOC-1.1.3 nearing completion))

"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]

Regulatory framework – Enhancements Underway

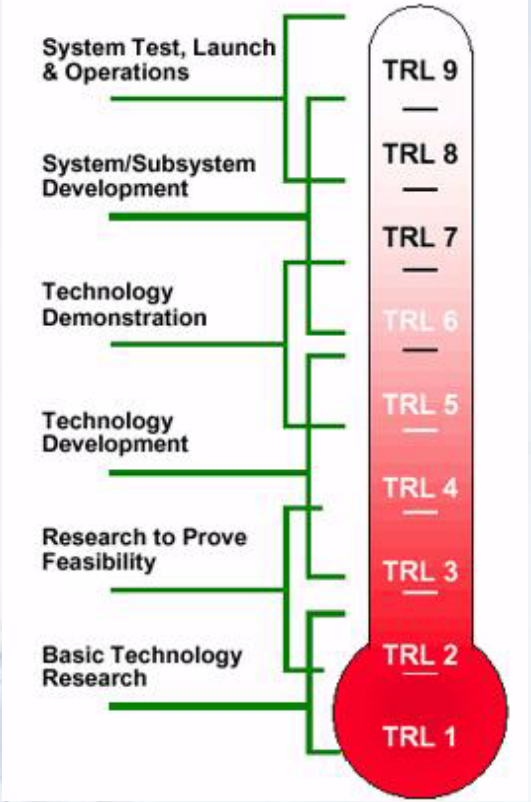
- Enhance existing regulatory framework to become objective based and allow flexibility to address new types of reactors
  - Need to enhance clarity and provide processes on how to assess alternatives proposed by applicants
  - Need formal mechanism to document regulatory OPEX as it is acquired for eventual updates to the regulatory framework

Framework – People – Processes

Process

What we have: Prototypic Facilities

- Risk-Informed Licensing Strategy
  - An applicant may want to use a prototypical facility as part of technology development for novel reactor

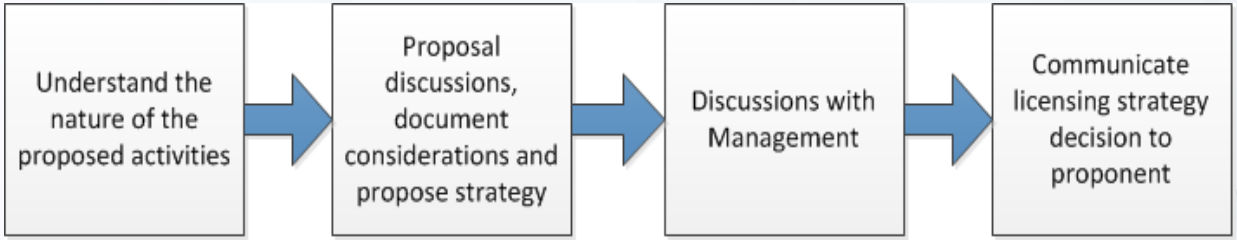


Based on USDOE Technology Readiness Levels

Process

What we have (cont'd)

- 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 were 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
- Assessment of need for new processes
  - Example:
    - Readiness regarding workforce capacity and capability
      - Feedback from VDR experience as acquired
    - Capacity and capability for vendor inspection
    - Documenting lessons learnt for future licensing stages

Framework – People – Processes

Staff

What we have

- Highly educated staff
- 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

Staff

What we have (cont'd)

- 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 gas reactor training
- 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 in Discussion Paper 16-04
Time relevance

Design Review	EA and LTPS	License to Construct	Licence to Operate
R&D to support safety case	Licensing of Modular Reactors	Licensing Approach for Demonstration Reactor	Management system: minimum shift complement
Safeguards	Emergency Planning Zones	Transportable Reactors	Increased use of automation / human-machine interface
DSA/PSA			Financial guarantees
DiD and Mitigation of Accident			
Site Security			
Waste and Decommissioning			
Subsurface Civil Structures			
Management System			
Human-machine interface			

What We heard 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
- AMRSC to provide senior management leadership to set the foundation for the regulation of Advanced Modular Reactors

APPENDIX

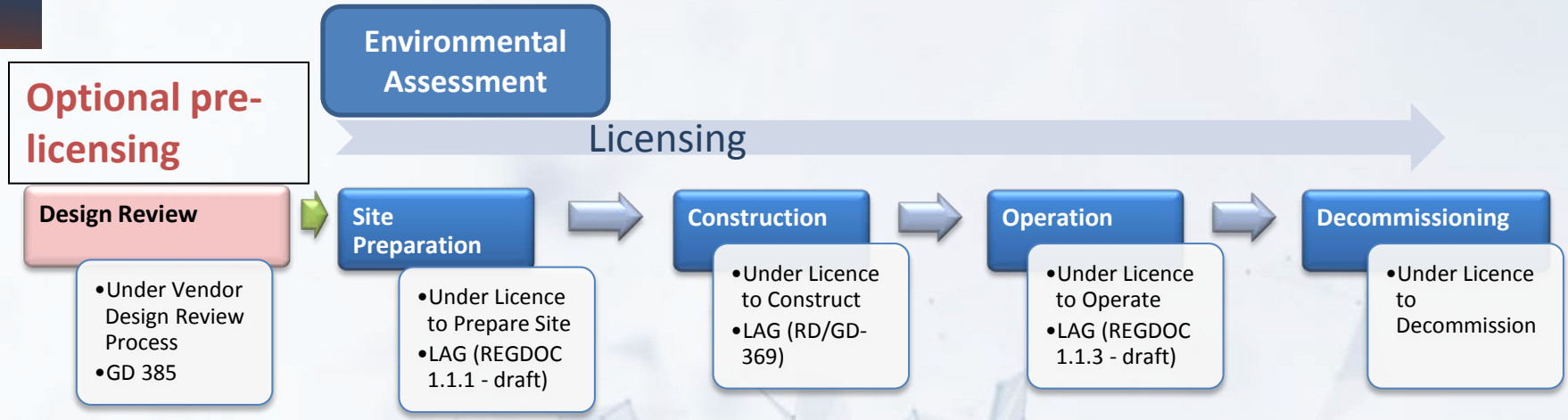
VENDOR DESIGN REVIEWS

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

Vendor Design Review and Licensing Stages of a New Reactor Facility



Above is an example of series licensing – Combined licences are possible

The VDR provides information that can be leveraged to inform licensing for a specific project

VDRs – 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)

VDRs – Benefits (2)

- 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

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)		

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	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!