SAFETY AND SECURITY OF SMALL MODULAR REACTORS IN CANADA

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Pan-Canadian SMR Roadmap

SMR Roadmap is charting a national path forward for SMRs

- One year, multi-stakeholder effort
- Canada, 4 Provinces, 2 northern Territories, 5 electric power utilities

SaskPower Powering the future
Bruce Power Innovation at work
Qulliq Energy Corporation / Société d'énergie Qulliq / Qulliq Alruyaktuqtunik Ikumatjutiit
Natural Resources Canada / Ressources naturelles Canada
CNSC CCSN
nwmo Nuclear Waste Management Organization / Société de gestion des déchets nucléaires
Ontario Power Generation
Alberta Energy
Ontario Ministry of Energy
cna canadian nuclear association
Énergie NB Power
Alberta Innovates
Canadian Nuclear Laboratories / Laboratoires Nucléaires Canadiens
Organization of Canadian Nuclear Industries OCNI Clean Energy for a Low Carbon Economy
COG
New Brunswick Canada
Government of Northwest Territories Department of Infrastructure
AECL

Ontario, Saskatchewan, N.B. premiers to announce nuclear reactor deal

Posted November 30, 2019 4:42 pm
Updated December 1, 2019 7:26 pm

SMRs being considered for Canada …

Latest news on CNL's invitation to demonstrate SMR technology

STAGE 1: Prequalification	STAGE 2: Due Diligence	STAGE 3: Negotiation	STAGE 4: Project Execution
STARCORE NUCLEAR TERRESTRIAL ENERGY UBATTERY Local Modular Energy		GLOBAL FIRST POWER	

Partners in New Brunswick Power's SMR Project

ARC NUCLEAR CANADA, INC.
SUBSIDIARY OF ADVANCED REACTOR CONCEPTS, LLC

moltex energy
cheap, clean, safe

Énergie NB Power

SMRs in Canada

Potential End-Users of SMRs

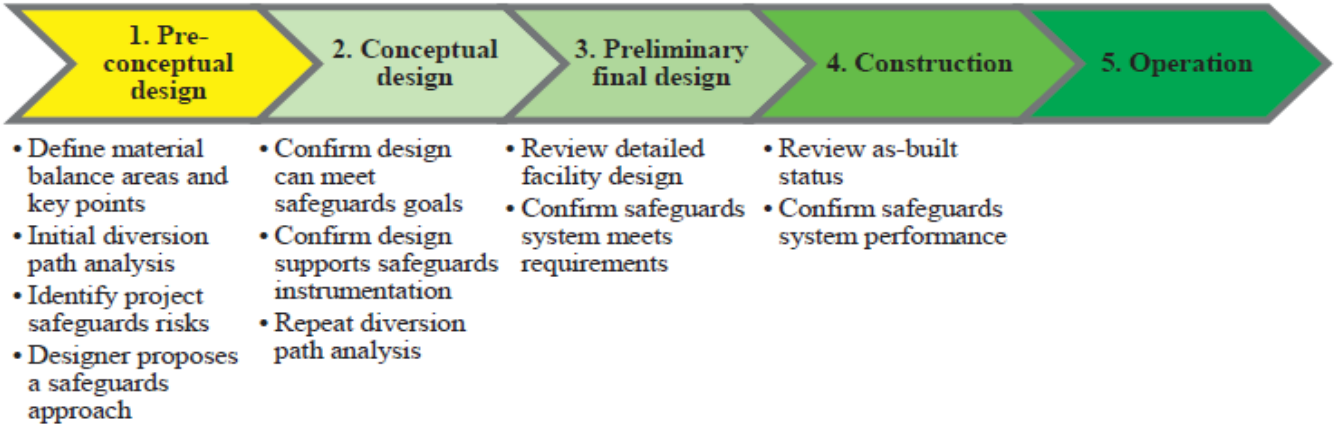
- Small northern communities
- Remote mining establishments
- Remote military facilities
- Dedicated facility power

vSMR Designs in Review in Canada

- 6 out of 10 SMR designs in pre-licensing vendor design review with the Canadian Nuclear Safety Commission are vSMRs
- Core types: IPWRs, high-T gas reactors, molten lead reactors, molten salt – thermal and fast reactors, solid core reactors

Challenges for SMRs

- SMRs present unique characteristics with benefits and challenges
- Nuclear safety, security, and safeguards have strongly overlapping regimes and must be optimally integrated
- Security and Safeguards by Design is desirable and necessary for development of SMR technology
- The adopted safety requirements, security recommendations, and safeguards approaches must be chosen in an integrated manner, using a balanced, graded approach.



SMRs in Remote Locations with Limited Access

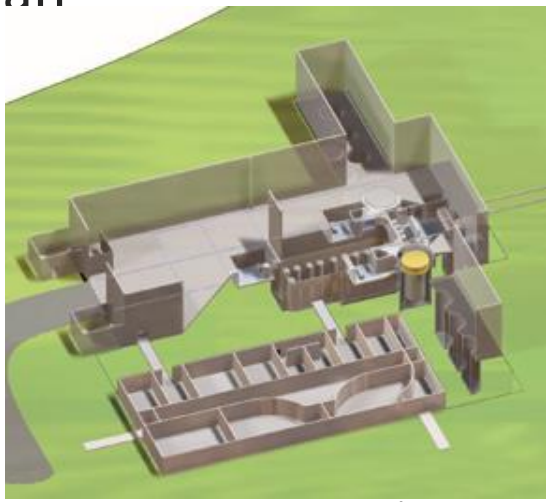
Impact on Security:

- Benefit: limited access mitigates likelihood of attack
- Challenge: may be difficult to have enough manpower to ensure full protection against attacks

Impact on Safety:

- Benefit: remote location mitigates impact on populated areas in case of radiological release, further mitigated when the core is a subterranean installation.
- Challenge: may be difficult to have external emergency services present in a timely fashion when needed.

http://terrestrialenergy.com/imsr-technology/



Potential Large Number of SMR Sites

Safety/Security/Safeguards & Cyber Security

- Distributed generation/operation: power generation at point of consumption
- SMRs lend themselves to distributed operation: many sites over a large geographic area, all requiring safeguards inspections, all requiring safety and security infrastructure.
- Capitalize on 3S safe and cyber secure remote monitoring mated with centralized 3S cross functional response capable of responding within a required time period.

http://www.bloomenergy.com/fuel-cell/distributed-generation/

SMRs with Long-life Reactor Cores, Possibly Sealed

Impact on Security:

- Benefit: reduced core access mitigates success of attack on the core.
- Challenge: maintaining vigilance against attack during the lifetime of the core.

Impact on Safety:

- Benefit: where the core seal provides containment against radiological release.
- Challenge: maintaining safety across the entire range of plant states of the core

http://terrestrialenergy.com/imsr-technology/

SMRs with Smaller Fissile Inventory

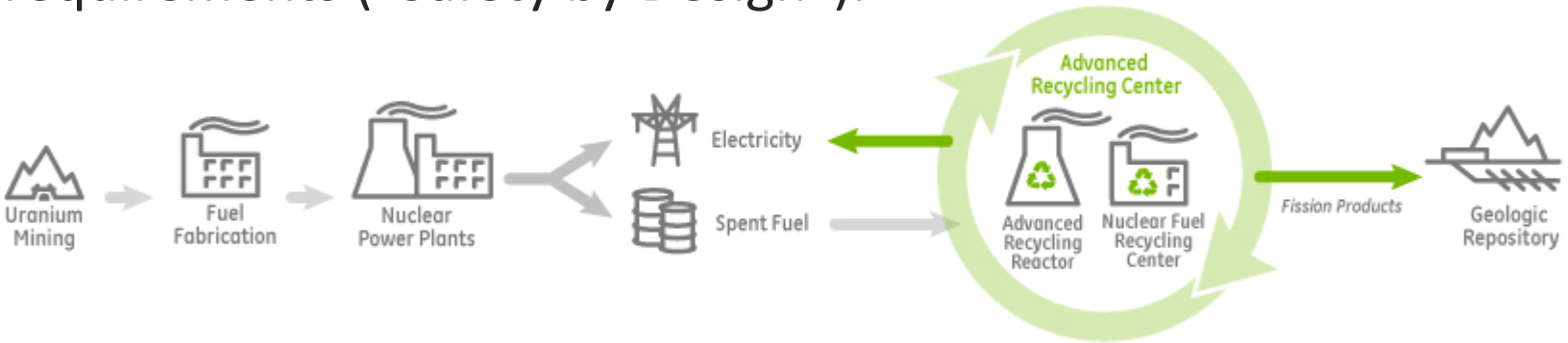
Safety/Security/Safeguards:

- Core loads are small compared to conventional power reactors, reducing source material in accident scenarios, and providing an additional barrier to diversion/misuse.
- However, nuclear devices using supporting materials such as neutron reflectors can achieve critical mass significantly below standard Significant Quantity (52 kg U, or 10 kg Pu)
- It is tempting to reduce security infrastructure and safeguards approaches in a graded approach to individual sites.
- The number of SMR sites deployed over time must be considered.

SMRs with Advanced Fuel Cycles

Safety/Security/Safeguards:

- Requires significant analysis to determine best safety requirements, security recommendations, and safeguards approach
- Important to employ “Safeguards by Design” and “Security by Design” at the earliest design stages, while complying with safety requirements (“Safety by Design”).



http://gehitachiprism.com/what-is-prism/how-prism-works/

Challenges for Transporting Sealed Cores

Safety and Security Issues:

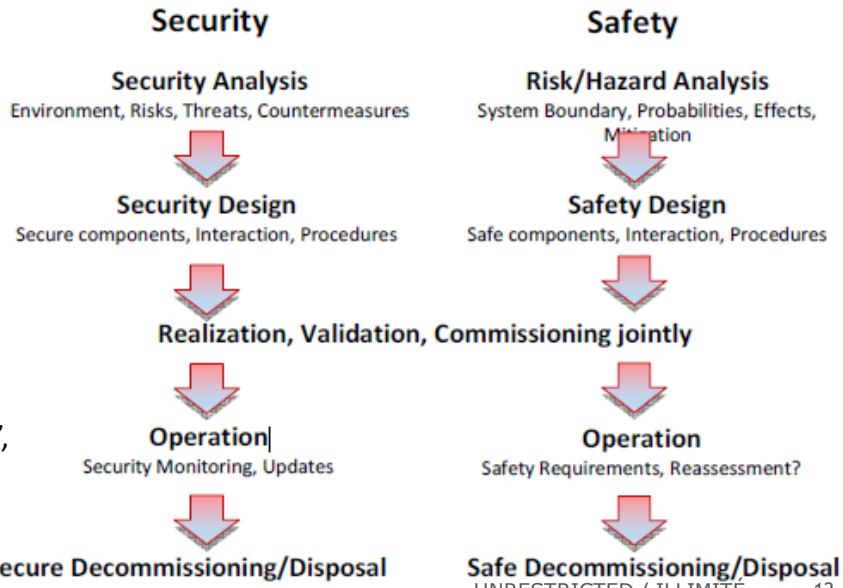
SMR design must maintain the integrity of core in transport

Other challenges:

- Inspection/evaluation of fitness for transport/service
- Maintaining sub-critical arrangement during transport
- Payload size/weight, encumbered by shielding requirements
- Limitations of local transportation infrastructure
- Maintaining robust security monitoring during transport

The Interface between Nuclear Safety and Nuclear Security

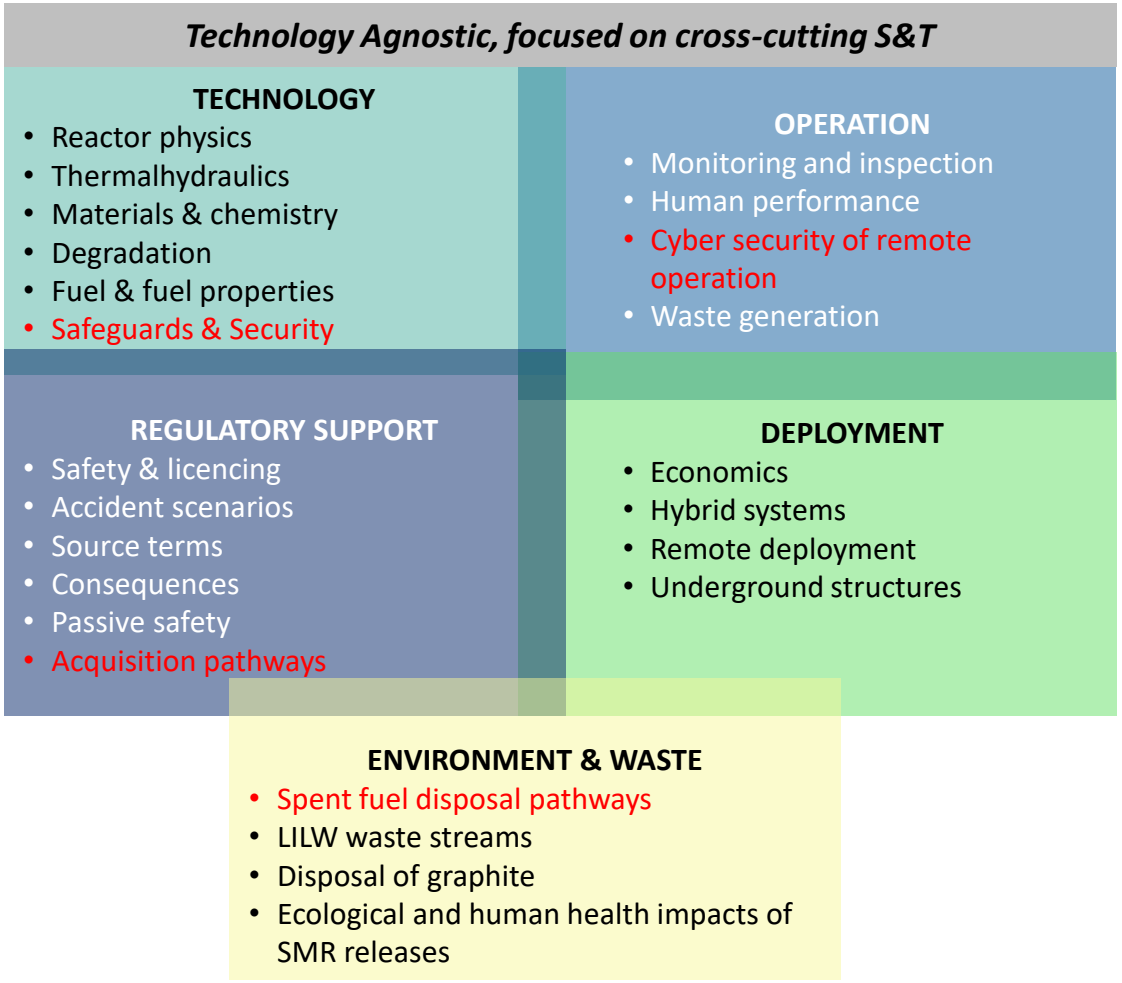
1. Safety is necessary, but not adequate to protect nuclear or other radioactive material from theft, sabotage, or other malicious acts.
2. Security is necessary, but not sufficient to protect people or the environment from a radioactive release caused by malicious acts.
3. In most cases, safety and security are not mutually exclusive, and have to be managed in an integrated manner.
4. The acceptable risk to workers, the public, and the environment cannot be different, irrespective of the cause of the initiating event of a radiological release.



One possible unified approach to nuclear safety and security
B. Heinz-Peter, S. Freddy, "Interface between nuclear safety and security", Journal of Polish Safety and Reliability Association, 5 (1) 9-20 (2014)

SMR R&D

CNL Capabilities and Research Areas



Canadian Nuclear Research Initiative (CNRI)

- CNL's Canadian Nuclear Research Initiative (CNRI) is a program to support collaborative small modular reactors (SMR) research projects with third-party proponents in Canada. The goal of the program is to accelerate the deployment of safe, secure, clean, and cost effective SMRs in Canada.
- CNRI first in-take launched in July 2019. Seven submissions were received from five SMR industry partners
- The seven Canadian Nuclear Research Initiative proposals were received in the following areas:


Feasibility Study


Safety, Security and Licensing


Reactor Physics


Economics


SMR Component Degradation


Thermalhydraulics

- CNRI will launch a new intake to the program in early 2020!

Why Canada? Why now?

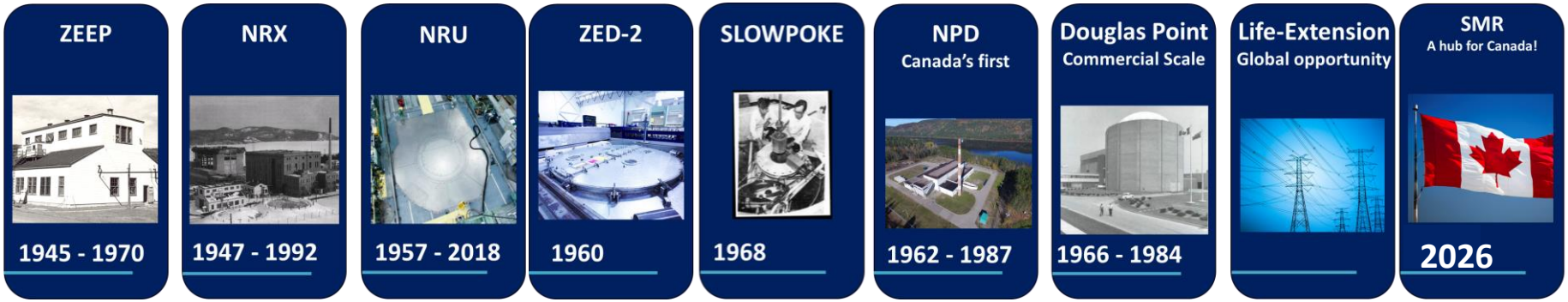
World class regulatory framework

Efficient gateway to North American market

Pressing domestic need for the technology

Capable, established supply chain

Government committed to action on climate change



A record of innovation.

A vision for the future.

www.cnl.ca/SMR