Readiness for Regulating Advanced Reactor Projects

Advanced Reactors Technical Summit V
& Technology Trailblazers Showcase

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Texas A&M University, College Station, Texas, U.S.

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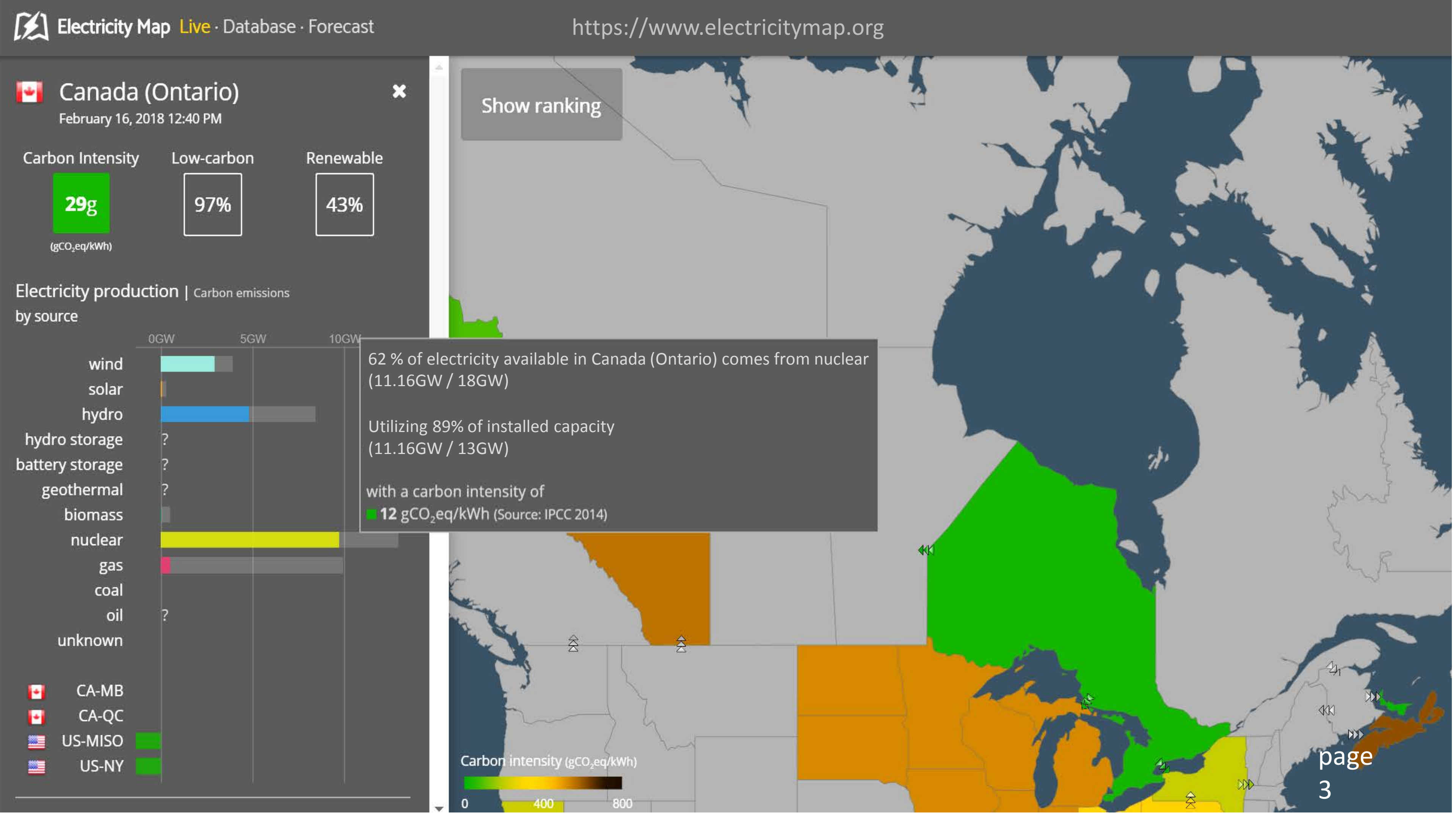
Canadian Nuclear Safety Commission

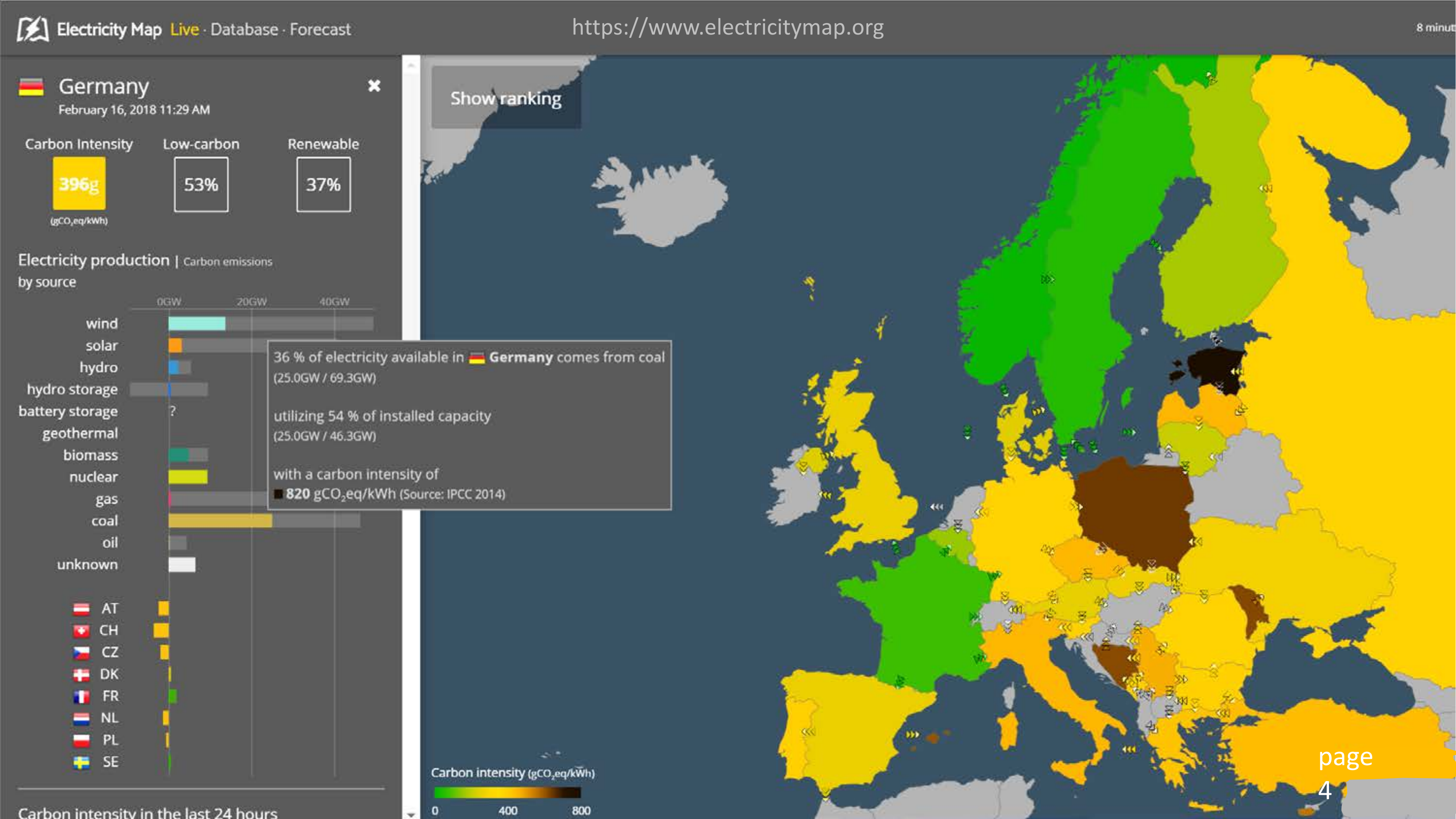
“The committee recommends that the Government of Canada continue to support the development of small modular reactors (SMRs), recognizing the potential for SMRs to provide clean and reliable power to remote and northern communities and open new areas to economically valuable resource development.”

– Federal Standing Committee on Natural Resources, June 2017 report



Electricity Map Live · Database · Forecast
https://www.electricitymap.org
Canada (Ontario)
February 16, 2018 12:40 PM
Carbon Intensity
29g
(gCO2eq/kWh)
Low-carbon
97%
Renewable
43%
Electricity production | Carbon emissions
by source
0GW
5GW
10GW
wind
solar
hydro
hydro storage
battery storage
geothermal
biomass
nuclear
gas
coal
oil
unknown
CA-MB
CA-QC
US-MISO
US-NY
Show ranking
62 % of electricity available in Canada (Ontario) comes from nuclear
(11.16GW / 18GW)
Utilizing 89% of installed capacity
(11.16GW / 13GW)
with a carbon intensity of
12 gCO2eq/kWh (Source: IPCC 2014)
Carbon intensity (gCO2eq/kWh)
0
400
800

https://www.electricitymap.org



Current Situation

Significant interest in potential deployment of SMRs in Canada:

- 10 vendor design review (VDR) applications, and more to come
- Utility, provincial government interest
- Canadian Nuclear Laboratories – Request for Expression of Interest

Many reactor concepts claim to be advanced reactor designs

Vendor Design Reviews
CNSC VDRs in Progress

VDR no.	Country of origin	Company	Reactor type / output per unit	VDR status
1	Canada/U.S.	Terrestrial Energy	Molten salt integral / 200 MWe	PHASE 1 COMPLETED, PHASE 2 PENDING
2	U.S./Korea/China	UltraSafe Nuclear/Global First Power	High-temperature gas prismatic block / 5 MWe	PHASE 1 IN PROGRESS completion date 2018 PHASE 2 Service Agreement under development
3	Sweden/Canada	LeadCold	Molten lead pool fast spectrum / 3 – 10 MWe	PHASE 1 ON HOLD AT VENDOR REQUEST
4	U.S.	Advanced Reactor Concepts	Sodium pool fast spectrum /100 MWe	PHASE 1 IN PROGRESS
5	U.K.	U-Battery	High temperature gas prismatic block / 4 MWe	PHASE 1 Service Agreement under development
6	U.K.	Moltex Energy	Molten salt fast spectrum / ~300 MWe	PHASE 1 IN PROGRESS
7	Canada/U.S.	StarCore Nuclear	High-temperature gas prismatic block / 10 MWe	PHASE 1 and 2 Service Agreement under development
8	U.S.	SMR, LLC. (A Holtec International Company)	Pressurized Water / 160 MWe	PHASE 1 Service Agreement under development
9	U.S.	NuScale Power	Integral Pressurized Water / 50 MWe	PHASE 2* Service Agreement under development
10	U.S.	Westinghouse Electric Co.	eVinci Micro Reactor / < 25 MWe	PHASE 2* Service Agreement under development

* Phase 1 objectives will be addressed within the Phase 2 scope of work

What Is Different
With SMRs/Advanced Reactors?

Novel technologies

Can differ significantly from existing water-based Generation II and III reactors

- 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 (EA), licensing, credit for prior reviews)

Key regulatory challenges presented to industry in discussion paper DIS-16-04

Regulatory Challenges
Identified in Discussion With Industry

Design review	EA and licence to prepare site	Licence to construct	Licence to operate
• R&D to support safety case • Safeguards • Deterministic safety assessment /probabilistic safety assessment • Defence in depth and mitigation of accidents • Site security • Waste and decommissioning • Subsurface civil structures • Management system	• Licensing of modular reactors • Emergency planning zones	• Licensing approach for demonstration reactor • Transportable reactors	Management system • Minimum shift complement • Increased use of automation / human-machine interface • Financial guarantees

CNSC discussion paper DIS-16-04,

Small Modular Reactors: Regulatory Strategy, Approaches and Challenges

Next Steps

CNSC Discussion Paper DIS-16-04, *Small Modular Reactors: Regulatory Strategy, Approaches and Challenges*

- Next steps and follow-up actions identified in the *What We Heard Report* (published September 2017)
- With time, other challenges will likely emerge
- Near-term challenges will be addressed first

Strategy for Readiness

Objectives

Increased regulatory certainty

- fairness, rigour, 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 and with external stakeholders

Elements of Strategy

Provide Leadership and Coordination

Small Modular Reactor Steering Committee (SMRSC)

Chaired by:
Executive Vice-President and Chief Regulatory Operations Officer

Elements of Strategy

Established processes for enabling management decisions regarding the regulation of SMRs

Regulatory framework

Nuclear Safety and Control Act (NSCA), regulations, licences, regulatory documents

Risk-informed processes

Managed processes covering strategic decision making

Pre-licensing and licensing compliance

Capable and agile staff

Capacity/capability

Training

International cooperation

Elements of Strategy

Communicate

Current Regulatory Framework

The NSCA, regulations and complete suite of regulatory documents ensure safety requirements in all aspects 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 (nearing completion), construction REGDOC-1.1.2 (being updated), and operation REGDOC-1.1.3

Risk-Informed Licensing Strategy

Approach for determining the licensing strategy for novel applications

Understand the nature of the proposed activities	Proposal discussions, document considerations and propose strategy	Discussions with management	Communicate licensing strategy decision to proponent

Proposal is evaluated on hazards, complexity and novelty aspects

Licensing strategy provides recommendation on the most appropriate regulations, application guides, regulatory documents and lead licensing service line

Recommendations for scope and depth of licensing review for each SCA

SMR vendors are informed of expectations regarding information to be submitted in support of this process

Enhancements Underway

Review processes

To confirm they are commensurate with the challenge

- Risk-informed resource allocation for licensing and compliance

Assess need for new processes

Examples:

- Readiness regarding workforce capacity and capability
  - feedback from VDR experience as acquired
- Capacity and capability for vendor inspection
- Documenting lessons learned for future licensing stages
- Establish formal mechanism to document regulatory operating experience (OPEX) for eventual updates to the regulatory framework

International Cooperation

Benchmarking, informing and exchanging with other countries facing similar challenges, in a number of forums

- IAEA SMR Forum, Working Group on the Regulation of New Reactors (WGRNR), NEA working group on SMR, Multinational Design Evaluation Programme (MDEP), Group on the Safety of Advanced Reactors (GSAR), bilateral with USNRC
- USDOE bilateral agreements led to molten salt reactor training and sharing of information on gas cooled reactors

CNSC technical review can be informed by other regulators' assessments

- 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

Development of SMR Licence Application Guide

- Taking into consideration different SMR technologies
- Consideration of application of graded approach and alternative to requirements

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
  - may not initially be faced with deployment-related issues
- Deployment of "standardized" units will face different challenges related to location, deployment approach, security, operating models, social acceptance, etc.

“Disruptive Technologies”: Are Regulators Ready?

Disruptive Technologies

Smart glasses

Nuclear industry experimenting with smart glasses that display real time radiation levels

3D printing

Westinghouse chose binder jetting (additive manufacturing) to produce its passive hydrogen igniter prototypes for testing. The parts could not be produced with the same performance benefits using traditional manufacturing.

Disruptive Technologies

Wireless sensors

Comanche Peak Nuclear Power Plant is the site of a pilot program using a wireless, automated, remote diagnostic system

Drones

Ontario Power Generation first used unmanned aerial vehicles to inspect Darlington’s vacuum building

Disruptive
Technologies

Autonomous vehicles

Rio Tinto has at least 54 autonomous trucks currently operating handling various transportation-related tasks.

New energy systems

"Next-generation nuclear has the potential to disrupt the global energy mix"

"Fusion power has massive disruptive potential"

Conclusions

- Current regulatory framework adequate for licensing of projects using advanced technologies
  - provides flexibility to adapt to new types of reactors
  - needs solid management system processes and capable workforce
- Publication of a strategy to explain the CNSC's approach and prioritize efforts will help provide regulatory clarity
- CNSC senior management are providing leadership to set the foundation for the regulation of SMRs
- Regulatory objectives to deal with disruptive technologies

Vendor Design Reviews

Vendor Design Review
Pre-licensing

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

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

Licensing Stages of a New Reactor Facility

Environmental assessment

Optional pre-licensing

Design review

- Under vendor design review process
- GD 385

Licensing

Site preparation

- Under licence to prepare site
- Licence Application Guide (REGDOC-1.1.1 - draft)

Construction

- Under licence to construct
- Licence Application Guide (RD/GD-369)

Operation

- Under licence to operate
- Licence Application Guide (REGDOC-1.1.3 - draft)

Decommissioning

- Under licence to decommission

The VDR provides information that can be leveraged to inform licensing for a specific project – it is neither a design certification nor a licence

Vendor Design Review
Benefits

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)

Vendor Design Review
Topic Areas

1	General plant description, defence in depth, safety goals and objectives, dose acceptance criteria
2	Classification of structures, systems and components
3	Reactor core nuclear design
4	Fuel design and qualification
5	Control system and facilities
6	Means of reactor shutdown
7	Emergency core cooling and emergency heat removal systems
8	Containment/confinement and safety-important civil structures
9	Beyond design basis accidents (BDBAs) and severe accidents (SA)
10	Safety analysis (PSA, DSA, hazards)

11	Pressure boundary design
12	Fire protection
13	Radiation protection
14	Out-of-core criticality
15	Robustness, safeguards and security
16	Vendor research and development program
17	Management system of design process and quality assurance in design and safety analysis
18	Human factors
19	Incorporation of decommissioning in design considerations

Thank you!

Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire

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