



Readiness for Regulating Advanced Reactor Projects

**IFNEC - Infrastructure Development Working
Group workshop on “New Challenges Facing
Nuclear Regulators”**

May 28-29, 2018

Paris, France

Hugh Robertson

Director General – Directorate of Regulatory Improvement
and Major Projects Licencing
Canadian Nuclear Safety Commission



Canada (Ontario) ✕

February 16, 2018 12:40 PM

Carbon Intensity

29g

(gCO₂eq/kWh)

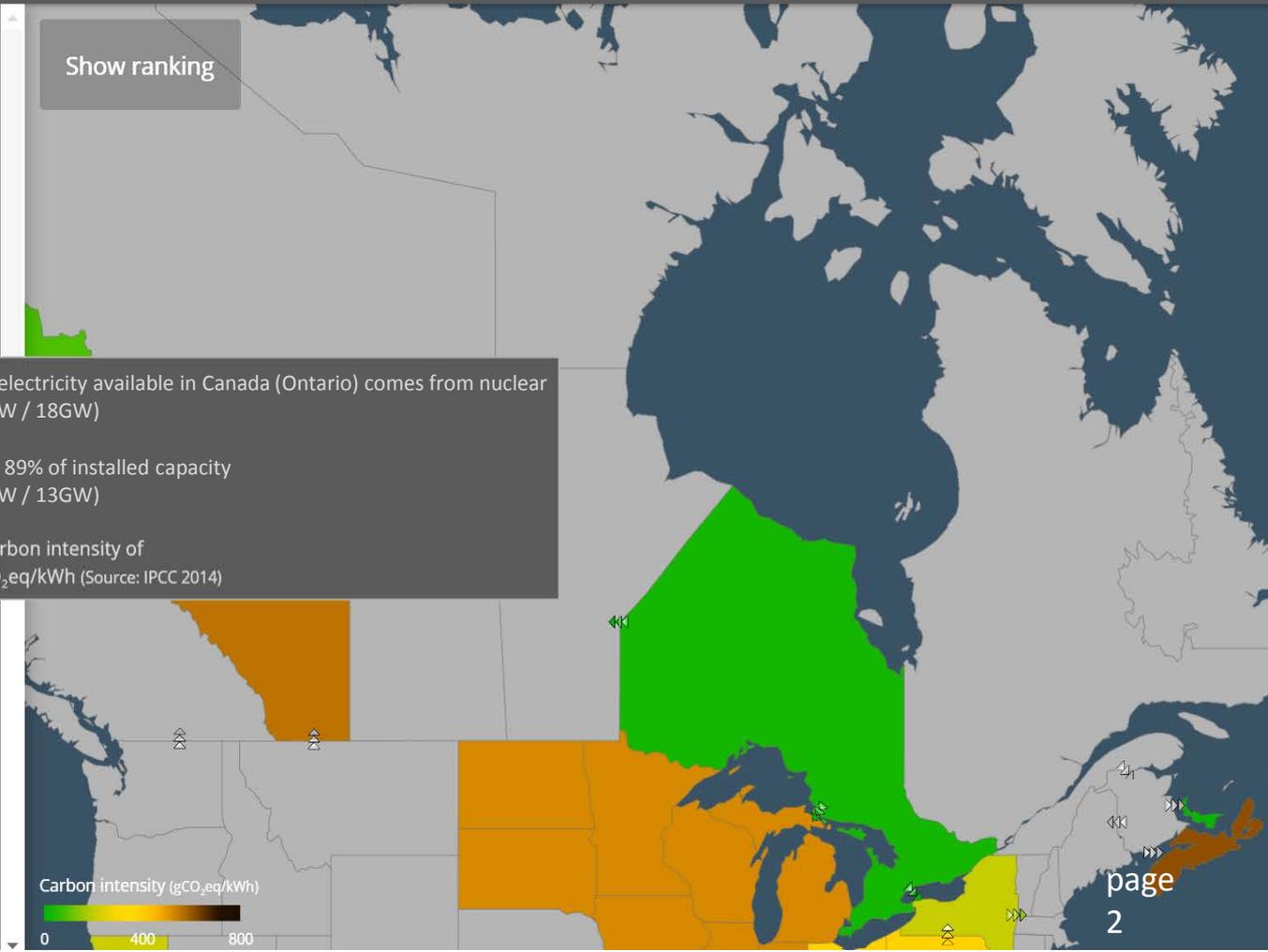
Low-carbon

97%

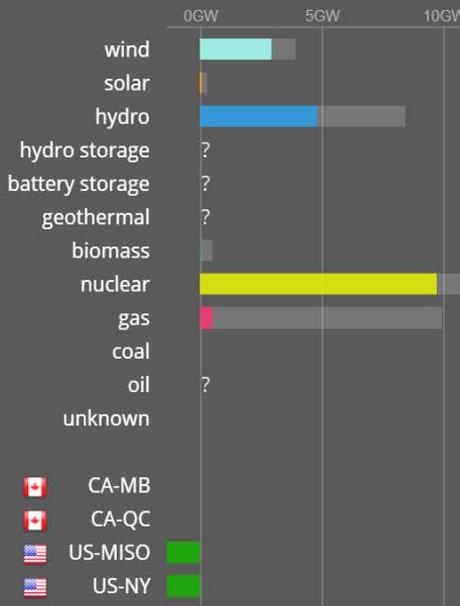
Renewable

43%

Show ranking



Electricity production | Carbon emissions by source



Germany

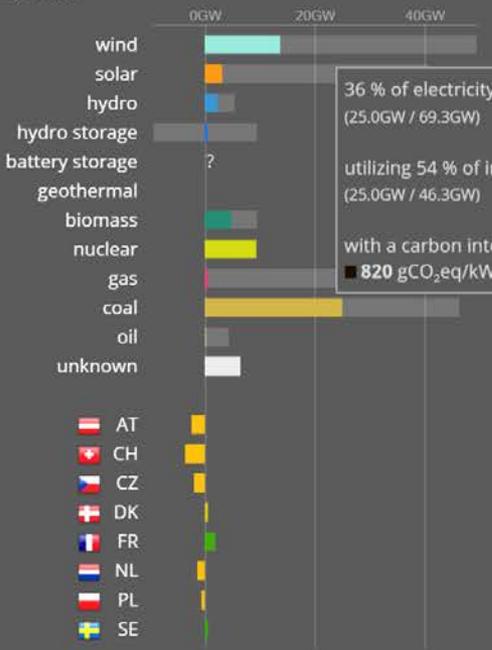
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Carbon Intensity **396g** (gCO₂eq/kWh)

Low-carbon **53%**

Renewable **37%**

Electricity production | Carbon emissions by source

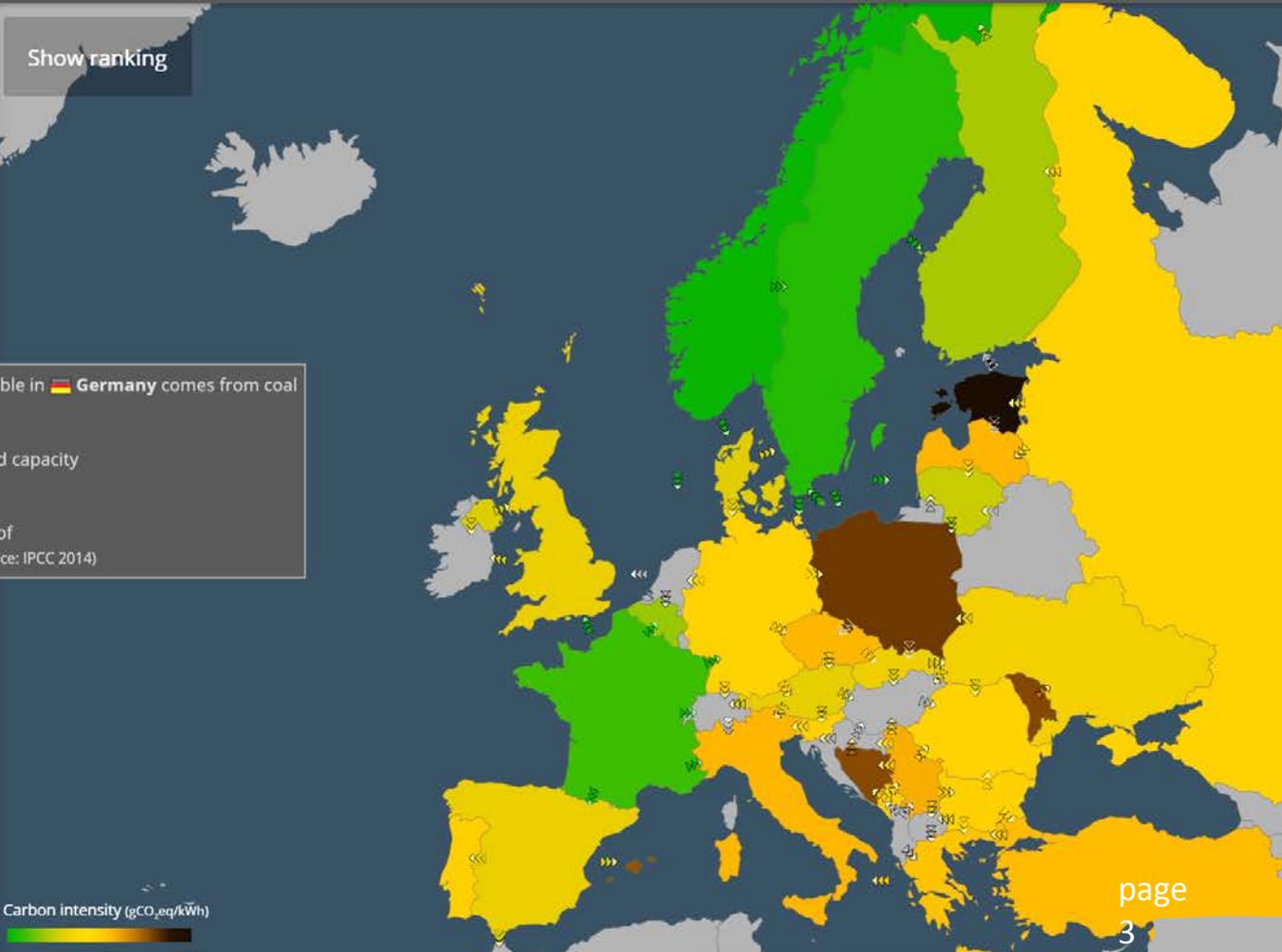


36 % of electricity available in **Germany** comes from coal (25.0GW / 69.3GW)

utilizing 54 % of installed capacity (25.0GW / 46.3GW)

with a carbon intensity of **820 gCO₂eq/kWh** (Source: IPCC 2014)

Carbon intensity in the last 24 hours



Show ranking

Current Situation

Significant interest in **potential deployment** of SMRs in Canada:

- 10 vendor design review (VDR) applications, and more to come
- Utility, federal and provincial government interest
- Canadian Nuclear Laboratories – Request for Expression of Interest for SMR demonstration project
- NRCAN led pan-Canadian SMR roadmap

Many reactor concepts claim to be **advanced reactor designs**

Pan-Canadian Roadmap

- In response to the October 2017 House of Commons Standing Committee report on Nuclear Energy
- Roadmap essential in view of potential benefits and to guide important decisions and reduce uncertainty
- Federal, provinces/territories, utilities and key stakeholders
- Three main applications:
 - On grid (150-300 MWe)
 - Heavy Industry (10-50 MWe)
 - Off-grid (< 2.5 MWe)



SMRs in Canada



Canadian Nuclear Laboratories

CNL Invitation for SMR Demonstration Projects on AECL sites

- April 17th, 2018 – Launch
- May 28th, 2018 – Closure of 1st intake (postponed to mid-June)
- Mid July, 2018 – Notification of results
- Staged application process

CNL stated long term strategy

- Siting an SMR on an AECL site by 2026

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)
- Location (remote location, close to industrial application, or closer to population)

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

Regulatory Challenges Identified in Discussion With Industry

Design review

- 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

EA and licence to prepare site

- Licensing of modular reactors
- Emergency planning zones

Licence to construct

- Licensing approach for demonstration reactor
- Transportable reactors

Licence to operate

- 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

CNSC response regarding regulatory challenges

Acknowledgement of key issues

Near Term Issues Being Resolved

- Nuclear Security Regulations being amended
 - Consideration for performance based criteria
- Graded Approach Workshop held late 2017
 - Alternatives to requirements can be proposed
 - Application of proportionality to manage risk
 - Fundamental Safety Objectives must be met
- CNSC pre-licensing engagement processes further documented and promoted
 - With Vendors on design reviews
 - With potential applicants early in project planning

Long Term issues being considered

- Gathering feedback of regulatory experience for future amendments to the regulatory framework
- Transportable factory fueled reactors
- Fleets of reactors

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



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

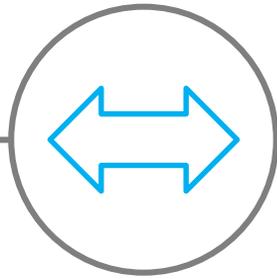
**Provide Leadership and
Coordination**

**Small Modular
Reactor Steering
Committee
(SMRSC)**

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

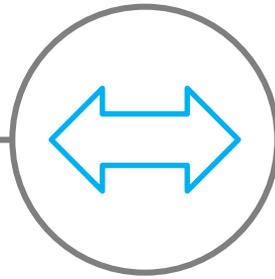
Elements of Strategy

Established processes for enabling management decisions regarding the regulation of SMRs



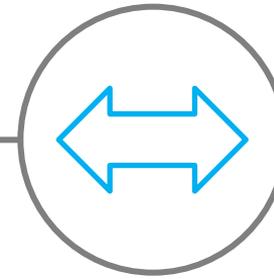
Regulatory framework

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



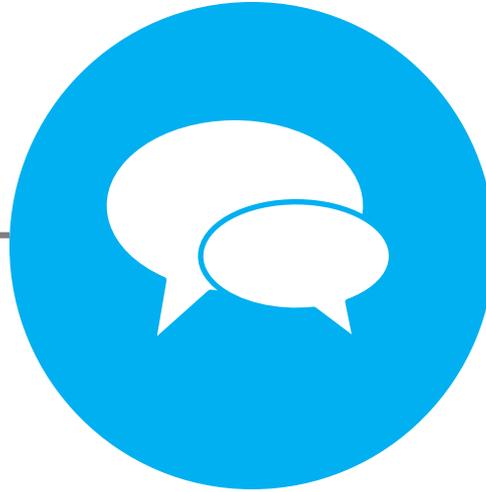
Risk-informed processes

Managed processes covering strategic decision making
Pre-licensing and licensing compliance



Capable and agile staff

Capacity/capability
Training
International cooperation



Communicate

Current Regulatory Framework

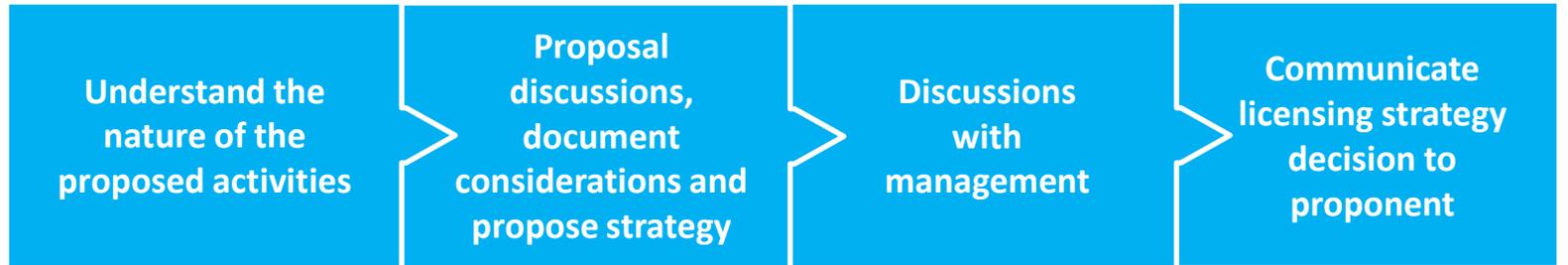
The NSCA, regulations and complete suite of regulatory documents ensure safety requirements in all aspects of design, construction, operation, etc.

All safety and control areas are covered

- developed based on decades of global operating experience principally from 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
 - requirements for each safety and control area are posted on the CNSC website (requirements can be applied using the graded approach)

Risk-Informed Licensing Strategy

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, regulatory documents and lead licensing service line

Recommendations for scope and depth of licensing review for each SCA

Applicants 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), Multinational Design Evaluation Programme (MDEP), Group on the Safety of Advanced Reactors (GSAR), bilateral with USNRC and UKONR
- 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

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

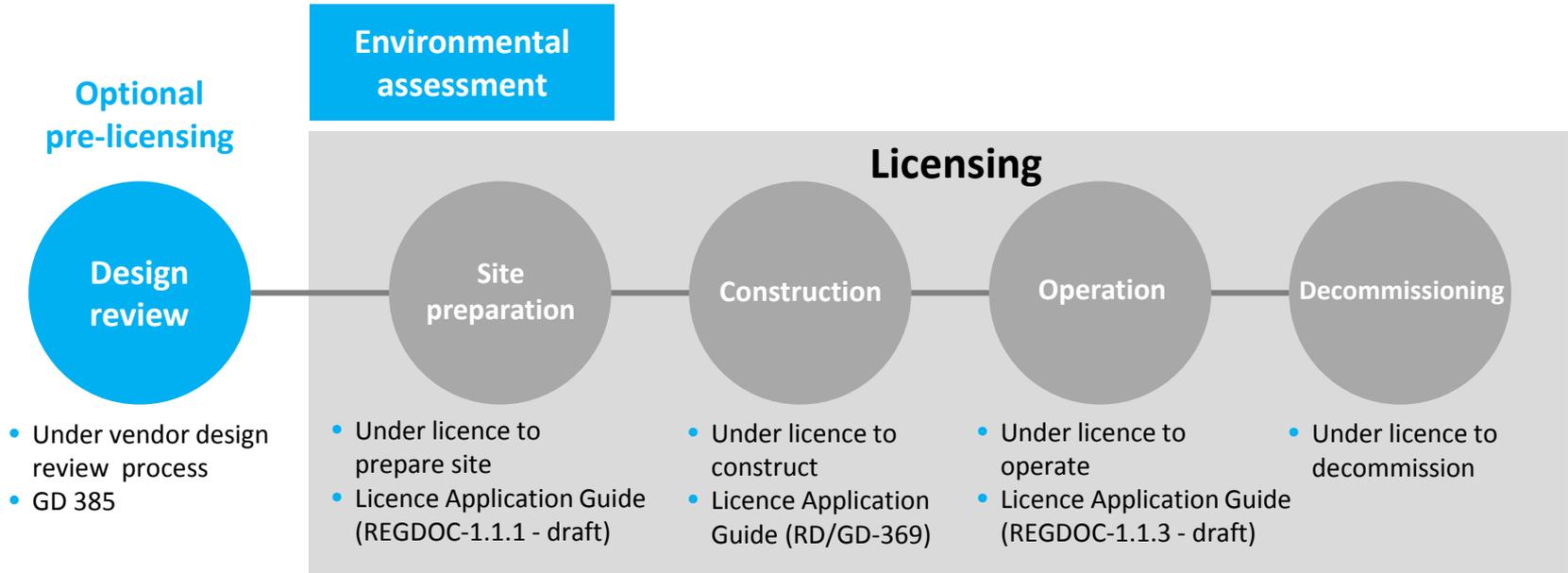
Phase 1: Conceptual design complete ~18 months

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



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!



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end

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