UPDATE ON CNSC's READINESS TO REGULATE PROJECTS PROPOSING THE USE OF SMALL MODULAR REACTORS (SMR)

M. de Vos[1], K. Lee[2]
[1]New Major Facilities Licensing Division
[2]Regulatory Policy Analysis Division
Canadian Nuclear Safety Commission, Ottawa, Ontario, Canada
marcel.devos@cnsc-ccsn.gc.ca
kevin.lee@cnsc-ccsn.gc.ca

Abstract

Over the past few years, Canadian Nuclear Security Commission (CNSC)staff have been working to identify and understand key regulatory and technical issues that may be encountered in Small Modular Reactor (SMR) deployment scenarios in Canada. This work is considered necessary not only to be ready to engage with vendors and utilities in technical and licensing discussions, but also to prepare to disseminate objective scientific, technical and regulatory information to the public.

Beyond size differences, SMRs are reactor-based facilities. The main finding from CNSC's work-to-date is that most, if not all, of the regulatory issues to be addressed from a Canadian perspective are due to thealternate or novel approaches that proponents of SMRs are proposing and that present uncertainties from the perspective of proven technology or public acceptance. These uncertainties represent risks that need to be mitigated by proponents before the environmental assessment and licensing processes are initiated.Examples of alternate or novel approaches include, but are not limited to:

- non-traditional siting scenarios (remote regions, near industrial facilities, in urban areas)
- increased use of physical design measures to reduce the need for security personnel
- fleet-based regional emergency planning and response
- design specific passive design features
- remote operation of the facility

This paper covers two main themes:

1. CNSC staff have made significant progress in the ongoing characterization of key regulatory and licensing issues that may emergein deployment of both large and / or small SMRs in Canada. This work informs CNSC's regulatory framework activities.
2. Many regulatory framework development activities (e.g. REGDOCs) have either already accounted for SMR concepts in the development of requirements and guidance or are planning to do so. This includes taking into account the ability to use a graded approach.

1. Introduction

Over the past several years, a large number of established and new reactor vendorsaround the world have indicated that they are developing technologies to address a potential need for smaller and more flexible nuclear reactor based facilities. These facilities are meant to address power generation and process steam needs in regions where a traditional large nuclear power plant (NPP) would not normally be consideredor even be possible. For example, some regions may have smaller grids, desire increased energy supply diversity (mix with renewables etc.) or be in remote areas where there is no grid at all and power must be generated locally under challenging conditions. These potential designs have been dubbed 'Small Modular Reactors','Small Medium Reactors' or'SMRs'.

Although many conceptual SMR designs exist, only a very small fraction of these designs are currently being considered for construction and operation. Of this small group, the majority are progressing through the early stages of licensing or certification. A smaller subset of this group is either certified or undergoing construction such as:

- CAREM – Argentina (25 MWe integrated light water reactor prototype) – under construction
- SMART– Korea (100 MWe integrated light water reactor) – certified but not under construction
- HTR-PM – China (210 MWe high temperature gas reactor) – under construction

What has become readily apparent in discussions at various nuclear energy forums is that there is a lack of consensus about what exactly an SMR is (or is not).

In some cases, such as the International Atomic Energy Agency (IAEA), specific definitions have been adopted based on size and electrical output:

- Small Reactor is less than 300 MW electric or MWe
- Medium Reactor is between 300 MWe and 700 MWe
- Nuclear Power Plant (NPP) is greater than 700 MWe

It is important to note, however, that the IAEA does not formally recognize SMRs as a separate class of reactor facilitiesin their published safety standards and guidance. While the IAEA has published documents specific to activities related toresearch reactor facilities, it generally has no hard power threshold demarcation line between research reactors and NPPs. In part this is because the difference in thermal output between both groups has traditionally been so large as to make the demarcation obvious. As a group of reactor designs that span a wide range of power outputs, SMRs appear to be bridging the gap between NPPs and research reactor facilities. As well, vendors are attempting to incorporate various safety improvements into their designs that promise[1] significantly higher levels of overall safety. These previous two points have led to differing views around the world on how activities utilizing these new technologies should be regulated. Some proponents have indicated that separate regulatory requirements and licensing processes need to be developed from those used for traditional NPPs. The main thrust of their viewis that that existing requirements will place undue regulatory and cost burden on future

[1] These safety features, in many cases have not yet been proven in regulatory licensing assessments.

licensees without any added safety benefits. The main counter-argument is that none of the proponents have adequately justified, from a safety perspective, the need for separate rules to regulate activities using SMR technologies.

In Canada, all facilities utilizing a nuclear reactor are subject to the same requirements under the *Class I Nuclear Facilities Regulations*. The Class 1A Facilities category encompass facilities that possess, process or use large quantities of radioactive material within a common range of risk[7]. Class IB facilities; on the other hand, tend to be higher power particle accelerators and fuel cycle facilities but not facilities that utilize a nuclear reactor. The concept of a "SMR" as a unique category is not possible in Canada because it is, by definition in regulations, a Class 1A Facility.

Rather than discuss what SMRs are, it is more important to understand what SMRs represent.

The fundamental fact is that an SMR, regardless of size, still uses a high energy fission process and an operator must safely manage the risks associated with it. In an overall effort to significantly improve operational, safety and economic performance, proponents of SMR technologies are introducing features and concepts that challenge the current nuclear industry knowledge-base and accepted practices including existing industry codes and standards.

Some examples include:

- Significant use of modular manufacturing and construction techniques – this practice is typical in many other industries such as shipbuilding and aerospace, however is relatively new to the nuclear sector where skill-of-craft has long been highly valued on a plant-by-plant basis.Some NPP vendors are implementing these techniques for major portions of the plant design.

- Greater use of physical features and automation to reduce the need for on-site staffing (whether operators, maintainers or security). This has been an overall trend across the nuclear industry for decades in many countries.

- Passive engineered features which promise enhanced safety by mitigating plant events with minimal human intervention thereby significantly reducing the need for both onsite and offsite emergency response. Again, this is typical of any new reactor design.

Although these features and concepts are being implemented in larger NPP designs, for SMRs, the use of these features are likely to be more pronounced. For example, generally the smaller the SMR the more the modules will consist of entire facility systems (e.g. entire reactor module with integrated coolant loop, steam generators, control systems etc.) This is the case because there is a greater need to make SMRs economically viable in the face of the loss of scale in power production found in traditional large power plants, nuclear or not.

In many cases, these features and concepts still require a history of experience in order to be able to convince stakeholders such as operators, the CNSC and the public that these features are proven and safe. This generally means these features and conceptswill need to be supported bystrong research and development evidence including data from both physical experiments and simulations using validated computer codes.

This paper discusses Canadian perspectives on the SMR phenomenaincluding:

- How the regulatory framework is continuing to evolve to address new technologies such as those being used for SMRs.
- CNSC's progress in ongoing characterization of key regulatory and licensing issues that may emerge in deployment of both large and small SMRs in Canada.
- How an understanding of these issues will feed back into the Canadian regulatory framework over time.

2. The Ongoing Evolution of the CNSC's Regulatory Framework

Below is a diagram illustrating the most common elements of the CNSC's regulatory framework. It should be noted that this paper focusses mostly on regulations, REGDOCs and discussion papers. For more detail on the CNSC's regulatory framework please go to the following link: http://www.nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-framework/index.cfm

Table 1: Table Illustrating the Most Common Elements of the CNSC's Regulatory Framework

	REGULATORY INSTRUMENTS						REGULATORY TOOLS	
	Act	**Regulation**	**Order**	**Licence Condition**	**Licence Condition Handbook**	**REGDOC**	**Discussion Paper**	**Work Instruction/ Inspection Procedures**
Purpose	Enabling legislation that establishes the Commission	Sets out statutory requirements	Legally compels timely action on the part of licensees or persons	Places legally enforceable restriction or condition upon a specific licensee. May point to CNSC document or outside standard	Specific guidance for licensees aligned with their licence and licence conditions. content used to judge compliance with licence conditions	Explains to licensees, applicants or certified persons what they must do (requirement) or should do (guidance) to achieve the regulatory requirements of the Commission	Used to solicit early public feedback on CNSC policies or approaches.	Internal working documents used by staff in conduct of technical assessments and compliance activities
Enforceable	Yes	Yes	Yes	Yes	Yes	Yes, when referenced in licence conditions	No	No
Approval	Parliament	Commission with Government In Council	Commission or Designated Officer	Commission or Designated Officer	Commission or Designated Officer	Commission	Senior Management	Director General/ Director
Applicable to	Commission	Licensees, Any Person	Group, Class or Individual Licensees, Any Person	Individual Licensees	Individual Licensees	Group, Class or Individual Licensees, Any Person	N/A	Staff

2.1 Periodic Detailed Review of Regulations under the *Nuclear Safety and Control Act*

The CNSC is committed to keeping its suite of regulations made under the NSCA evergreen. The CNSC has always reviewed and revised its regulations to address an external event or to modernize the regulatory framework, however, these revisions have generally resulted in only amendments being made to a few of the CNSC regulations at any given time. Over the course of the next two years, the CNSC is adopting a new approach in that it will be undertaking a review of all of its regulations in a holistic manner. Staff will be conducting a horizontal analysis to examine issues such as facility definitions as well as differences in requirements for items such as license applications, record keeping, reporting, whether some regulations should be consolidated, etc.

Part of the goal of this is review will be to ensure that the various regulations are as technology neutral as possible. As well, the existing regulations will be examined to consider whether there should be a new regulation to address decommissioning, waste and waste repositories.This project is described in the CNSC Forward Regulatory Plan 2014-16 at http://www.nuclearsafety.gc.ca/eng/acts-and-regulations/regulatoryplan/forward-regulatory-plan-details/index.cfm .

Currently the CNSC has on its web-site a discussion paper that invites interested stakeholders to provide their feedback on its regulations.Members of the SMR community are strongly encouraged to review the CNSC's regulations and to provide their comments as to any improvements they think could be made. Of particular note for the SMR community would be the following regulations:

- *General Nuclear Safety and Control Regulations*
- *Class I Nuclear Facilities Regulations*
- *Radiation Protection Regulations*
- *Nuclear Security Regulations*
- *Packaging and Transport of Nuclear Substances Regulations*
- *Nuclear Non-Proliferation Import and Export Control Regulations*
- *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations*

To access the CNSC's Act and associated regulations, and for a brief explanation of each, please use the following link:
http://www.nuclearsafety.gc.ca/eng/acts-and-regulations/regulations/index.cfm

2.1.1 Example for this paper: Brief discussion about the*Class I Nuclear Facilities Regulations*

The *Class I Nuclear Facilities Regulations*allow an applicant for a licence to propose and defend the approaches they will use to address the regulations. Because these regulations are written to address high level principles, requirements and guidance regulatory documents are used to further elaborate on the regulations to help an applicant understand what is needed to meet them. In the Canadian regulatory approach, an applicant is expected to use these tools to develop the necessary programs, processes and measures to safely conduct their proposed licensed activities.The licensee then uses key information from their programs, processes and measures to

support their application for a licence which is submitted to the Commission[2] for a decision (this information forms part of the licensing basis for the activities). CNSC staff's role is to assess the applicant's application and to recommend licensing actions to the Commission. CNSC staff usespublished requirements and guidance (such as REGDOCs, codes and standards) as a basis for their assessment work and discussions with all stakeholders during the licensing process.

2.2 CNSC Requirements and Guidance in REGDOCS

Regulatory documents, or REGDOCs, are a key part of the CNSC's regulatory framework for nuclear activities in Canada. They explain to licensees and applicants what they must achieve in order to meet the requirements set out in the NSCA and the regulations made under the NSCA.

Regulatory documents may contain practical guidance and suggestions to licensees and applicants on how to meet the CNSC's regulatory requirements. Such guidance may include, but is not limited to, information on possible approaches to the design of nuclear facilities, the design and implementation of required management and operational programs, and forms for applying for licenses or reporting information to the Commission. All REGDOCS, including historic CNSC published regulatory documents, are being reviewed, revised and organized within a Safety and Control Area framework. The CNSC is committed to review, and if required to revise, each regulatory document at least once every five years. To view the suite of REGDOCs use the following link: http://www.nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents/index.cfm.

Historically, the CNSC has recognized that risks posed by different reactor-based facilities can vary depending on factors such as reactor core characteristics, facility end-use, etc. In 2008, CNSC documented its design and safety analysis requirements (RD-337 [1], RD-310 [2]) for nuclear power plants. This was done in anticipation of multiple applications for new build NPPs in Canada. At the time, there was minimal interest in building new small reactors; however a few years later, CNSC staff noted that there was a level of interest in understanding how design and safety analysis requirements should be interpreted for new research reactors.

Through analysis, CNSC recognized that not all of the requirements in RD-337 and RD-310 were suitable, as-written for small research reactors; that is, the requirements did not allow for sufficient use of risk-informed insights in some key technical areas. Consequently, CNSC staff established parallel design and safety analysis requirements (RD-367 [3], RD-308 [4]) for reactor facilities below a threshold of approximately 200 MWth . The 200 MWththresholdwas, and still is considered to be a guideline only to be used with an understanding of the reactor's core inventory, operating characteristics and other potential risks that could arise from operation. CNSC staff, in discussion with the applicant/vendor, will ultimately decide which requirements will ultimately apply in a specific case based on the risks the activities will present. In most cases, requirements remain unchanged from those applied to NPPs because the nuclear safety principles are the same; however, some requirements were written to allow for some additional risk-informed flexibility in developing safety approaches. The various methods used by either the regulator or an applicant/licensee to risk-inform decisions is generally called a *Graded Approach*. This term is described further in Section 2.4.

[2] The licensing basis is described in more detail in INFO-0795 *Licensing Basis Objective and Definition* [5]

Over the past seven years, CNSC has been updating all of its requirements and guidance, in part, to address the need fora technology-neutral approach. In the past few years, these efforts have also focused on becoming size-neutral as well; that is, requirements and guidance focus on nuclear safety principles that need to be addressed in all safety cases. To do this, clarifications on the use of the graded approach are being introduced. As a result, a large number of existing REGDOCs already contain the right mix of nuclear safety principles that if applied to SMR activities, will ensure safe operation.

On the immediate horizon:

- REGDOC-1.1.1: *Site Suitability* is being prepared for public consultation. It will integrate the requirements of RD-346 *Site Evaluation for New Nuclear Power Plants*(in consideration of small reactor needs) with a License Application Guide (LAG) for a *License to Prepare Site*. In addition, it will also reflect Fukushima lessons learned.

- REGDOC 2.5.2:*Design of Reactor Facilities: Nuclear Power Plants* was published earlier this year and can be applied to most SMRs. REGDOC 2.5.3: *Design of Reactor Facilities: Small Reactors*is currently under development and will be applicable to new small SMRs, Transportable NPPs, and Research Reactors. This document will integrate the requirements found in RD-367 *Design of Small Reactor Facilities* and include applicable guidance. The principles used in REGDOC 2.5.2 and REGDOC 2.5.3 will the same.

- RD/GD-369, *Licence Application Guide: Licence to Construct a Nuclear Power Plant* is scheduled to be revised in the near future to integrate into the safety and control area framework structure and to revise its content to match recently updated REGDOCs.

SMR proponentsshouldreview the key subject area REGDOCs described in Table 2 and, where posted on the CNSC's web-site for public consultation, provide comments. These areas play a very significant role in licensing regardless of the facility size and purpose.

Table 2: List of High Level Topics Covered in Section 3.0 Category of the CNSC Regulatory Documents Suite

Area	Document	Status
3.1 Reporting Requirements	REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*	Published May 2014
3.2 Public & Aboriginal Engagement	REGDOC-3.2.2, *Aboriginal Engagement*	Consultation expected 2015

3.3 Financial Guarantees	REGDOC-3.3.1, *Financial Guarantees for Licensed Activities* (Revision of G-206)	Consultation expected 2015
3.4 Commission Proceedings	GD-379 *Guide for Applicants and Intervenors: Writing CNSC Commission Member Documents*	Published March 2012
3.5 Information Dissemination	REGDOC-3.5.2,*CNSC Compliance and Enforcement – Administrative and Monetary Penalties*	Published March 2014

2.3 Third-party Codes and Standards

The CNSC uses standards from various third-party standard-setting organizations, such as the IAEA, IEEE, ASME, etc. In Canada, Canadian Standards Association (CSA) standards are of particular relevance. The Nuclear Standards Program of the Canadian Standards Association has had a comprehensive nuclear program in place since the mid-70s. Although initially focused on supporting the existing CANDU fleet, the principles in most CSA standards would still apply to projects utilizing SMR technologies. Although proponents are permitted to propose the use of alternate standards, they are expected to identify and address gaps against Canadian standards. One CSA standard that any licensee must address is N-286-12*ManagementSystem Requirements for Nuclear Facilities.*

Because industry plays theleading role in the setting of industry standards, proponents of SMR technologies may wish to consider being active on CSA committees such that their needs are reflected in requirements and guidance.

With regards to international standards that proponents of SMRs may wish to use in Canada, they would need to demonstrate how these standards meet or exceed the Canadian requirements. To access the CSA standards use the following link:
http://www.csagroup.org/ca/en/services/codes-and-standards

2.4 Clarifying the meaning of the term “Graded Approach” in REGDOCs

The concept behind the term Graded Approach is not new or unique to Canada but the term itself did not officially appear in a regulatory document until RD-367 *Design of Small Reactor Facilities*was published in 2011. This raised a number of questions from industry, particularly from the SMR vendors who were seeking to understand the similarities and differences between Canadian regulatory approaches and other regulatory regimes.

Prior to 2011, the use of risk-informed approaches was an understood and accepted philosophy documented in many key CNSC documents ranging from the *Nuclear Safety and Control Act*itself to CNSC Policy Document P-299*Regulatory Fundamentals*[6].For example, Section 4.2 of P-299, Basing Regulatory Action on Levels of Risk states:

> *The CNSC:*

> *1) Regulates persons, organizations, and activities that are subject to the act and regulations in a manner that is consistent with the risk posed by the regulated activity;*
>
> *2) Recognises that risk must be considered in the context of the CNSC's mandate under the act; and,*
>
> *3) Makes regulatory decisions and allocates resources in a risk informed manner.*

In 2013, in response to these questions from industry regarding the meaning of Graded Approach, CNSC staff recognized that further clarification of the term was needed in regulatory documents to assist with the interpretation of requirements and guidance. CNSC staff developed both a formal definition of the term and context information around the term to be placed in the preface of future regulatory documents.

The definition of Graded Approach is:

> *A method or process by which elements such as the level of analysis, the depth of documentation and the scope of actions necessary to comply with requirements are commensurate with:*
>
> - *the relative risks to health, safety, security, the environment, and the implementation of international obligations to which Canada has agreed*
> - *the particular characteristics of a facility or activity*

Beginning with REGDOC 2.4.1*Deterministic Safety Analysis*, preface text has been enhanced with the following clarification:

> *A graded approach, commensurate with risk, may be defined and used when applying the requirements and guidance contained in this regulatory document. The use of a graded approach is not a relaxation of requirements. With a graded approach, the application of requirements is commensurate with the risks and particular characteristics of the facility or activity.*
>
> *An applicant or licensee may put forward a case to demonstrate that the intent of a requirement is addressed by other means and demonstrated with supportable evidence.*

These additions to relevant regulatory documents further reinforce that requirements and guidance are to be interpreted with their underlying safety principles in mind.

For SMR proponents usingsafety claimsof novel features as the bases for their application of the graded approach, those features will need to be well supported with evidence obtained from research and development activities. This evidence will play an important role in the public licensing discussion.

3. CNSC's Progress in the Ongoing Characterization of Key Regulatory and Licensing Issues

CNSC staff have been following and participating in the SMR regulatory and licensing issues discussion around the world for a number of years. Much of the early SMR discussions began in the US and as a result much of the discussion of issues to date has revolved around 'licensability' in the US and overcoming specific issues that would impact licensing of SMRs there.CNSC staff recognized that some electricity markets in Canada might take interest in some of these smaller designs and decided to understand whether some of the issues raised in the US were the same in Canada. In 2011, in an effort to begin understanding what the key SMR policy and regulatory issues are, CNSC reviewed two key US papers:

1. USNRC Document SECY-10-0034: Potential Policy, Licensing and Key Technical Issues for Small Modular Reactor Designs [8]

2. The American Nuclear Society's View: Interim Report of the ANS President's Special Committee on SMR Generic Licensing Issues [9]

The conclusion at the time was that a large number of the SMR issues discussed appeared to revolve around the need, under the US'srule-based regulatory regime, to amend or develop specific rules that are currently designed for conventional commercial light water reactors. Canada's nuclear regulatory philosophy was expressly designed to permit a measure of flexibility to applicants so long as the applicant can demonstrate that they have met regulatory requirements. This analysis did however drive CNSC Stafftocontinue focusing on technology-neutral requirements and guidance in ongoing development of regulatory framework documents to maximize readiness for potential new build projects in Canada.

In late 2012, potential proponents of different types of SMRs began to approach CNSC to understand the Canadian licensing regime and processes. In some cases, vendors were indicating interest in engaging with CNSC to perform Pre-Licensing Vendor Design Reviews[3] (VDR) to understand how their designs would stand up to Canadian requirements. Potential site licensing discussions (with a utility) are not part of a VDR because a VDR is a generic technology review (for a vendor) that does not consider site inputs or the potential licensee's role in construction and operation of the vendor's product.

Early site-licensing questions from interested companies indicated a need by both industry and the CNSC to delve more deeply into the kinds of technical and regulatory issues that an SMR proponent would encounter if siting certain types of SMRs whose characteristics differ from the traditional norm[4].Particularly important was the fact that the way SMRs might be used in Canada might differ significantly from the ways SMRs might be utilized in the US or Europe. Although much of the Canadian population resides in the south of the country on more traditional electrical grids, there are two cases where large power or process heat might be used in places where the grid was either severely limited or non-existent:

[3] The vendor design review process in discussed in GD-385 *Pre-licensing Review of a Vendor's Reactor Design* [10]
[4] As described in Section 1.

- Large resource projects – for example mines located in regions where grid supply is limited or unreliable.

- Remote northern projects and communities – where power is typically generated locally using fossil fuel sets (i.e. diesel generators) and conventional renewables may not be practical.

In mid-2013, CNSC staff began an internal project to develop a stronger understanding of how different types of SMRs might be used in Canada. This background information helped give an indication of the types of siting scenarios that might be encountered in order to help CNSC characterise and analyse some of the key regulatory issues that might emerge. The aim is for staff to characteriseall key issues by the end of 2014 in preparation to engage with industry who should be doing the same analysis independently. Characterising regulatory and policy issues involve the following:

- A clear articulation of a problem statement – for example: some vendors are proposing very small designs which would be autonomously operated (fully automatic with limited on-site staff) but with the ability to monitor and intervene from a centralized but remotely located control centre.

- An analysis of the existing regulatory documents to understand whether the issue can be resolved with the existing requirements and guidance

- The development of a proposed path forward for resolving the issue including a priority and resource estimate

CNSC expects industry, as the proponent, to take a lead role in proposing how these issues should be resolved. Each issue will likely involve some form of analysis against existing regulatory requirements.

In work completed to-date, CNSC staff have noted that typical SMR issues identified around the world appear to fall into three broad groups in the Canadian regulatory context:

First Group: The identified issue is not likely an issue in Canada - Existing Canadian requirements and guidance already address the issue in a clear enough way that vendors and applicants should be able to use them to meet requirements.Proponents will need to analyse and interpret requirements against their specific case and provide the necessary evidence that the requirements have been met.

Second Group: The identified issue requires some clarification to existing requirements and guidance. Here, clarification may be needed around application of the graded approach in certain cases or the basis of the requirements needs to be more clearly expressed. As discussed above, proponents will need to presentsufficient evidence to support their safety case.

Third Group: The identified issue requires significant regulatory analysis to understand potential risks and mitigation approaches. Public acceptance may also be an issue. In this

case, CNSC is expecting industry to initiate the discussion with fairly detailed proposals. CNSC staff will consider these proposals in developing a fulsome regulatory position. Public consultations, through processes such as CNSC Discussion Papers, will help to further establish regulatory positions prior to developing or modifying requirements and guidance. These issues may also benefit from international discussion through regulatory cooperative arrangements.

For the first and second groups of issues, CNSC staff are already attempting to address them in draft requirements and guidance as they are being developed.

CNSC expects to complete the first pass of the characterisation work by the end of 2014. Staff is prepared to engage in discussions with industry.

The following three subsections outline results compiled to-date by CNSC efforts.

3.1 Examples of Issuesthat fall into the First Group:

Table 3 lists examplesof common identified SMR issues where CNSC can confirm that existing Canadian requirements and guidance are adequate. Where regulatory documents are either being updated or written and influence discussion on the issue, CNSC staff continues to consider various SMR technical and siting scenarios in the writing work.

Table 3: Some First Group Issues

Issue Identified By Stakeholders	Comment
Non-water cooled technologies (case-by-case)	Despite being officially developed for water cooled reactors, the majority of existing CNSC requirements and guidance are based on principles that can, theoretically, be applied to most technologies regardless of coolant type. Case-by-case exceptions may emerge but these can be addressed within existing principles.
Extent of proposed Exclusion Zone	Described in RD-346*Site Evaluation for New Nuclear Power Plants*- Exclusion zone extent is proposed by applicant based on design and site specific factors including: - Dose considerations under normal operation and accident conditions - Security needs (assessment of Design Basis Threat and response) - Emergency Planning considerations presented by the site
Multiple unit/module operation	Construction and operation of multiple unit facilities has been licensed in Canada since the early 1970s. A single licence would encompass all activities associated with construction and operation of a multiple unit facility. Existing requirements and guidance do not preclude future licensing of activities for such facilities however proponents need to consider impacts of “whole of plant” events rather than on per-module/unit basis.

Issue Identified By Stakeholders	Comment
Shared Main Control Rooms	All current multiple unit facilities in Canada utilize Main Control Rooms from which operation of multiple units is managed. Existing requirements and guidance are suitable as-written.
Main Control Room located at a significant distance from the facility	Being proposed by some proponents of very small SMRs (e.g. ~2 to 25 MWe) along with the concept of autonomous local operation of the facility (limited on-site staff) – Existing requirements and guidance do not specify where a control room is to be located but rather focus on MCR capabilities. CNSC recognizes that full-automation is technically possible. Issuesaround novel communication links between the MCR and the facility falls into the second group of issues in Section 3.2. Unattended operation of a facility falls into the third group of issues in Section 3.3.
Modular construction techniques	Existing requirements and guidance do not preclude use of modular construction techniques.Industry needs to propose which codes and standards it will use.Existing import and export regulations encompass modules not fabricated in Canada. Most facilities manufacturing modules would not require a facility licence however other authorizations may be required from CNSC regarding Prescribed Information or Prescribed Equipment. If a manufacturing facility will produce fully fuelled and sealed reactor modules, that facility can be assessed under Small Reactor requirements and guidance with appropriate use of the graded approach for the activities to be conducted at the facility.
Radiation Protection requirements	Existing requirements and guidance are independent of facility size and technology.
Environmental Protection requirements	Existing requirements and guidance are independent of facility size and technology.
Emergency Management and Fire Protection	Existing requirements and guidance are independent of facility size and technology.
Waste Management	Existing requirements and guidance are independent of facility size and technology.
Foreign ownership of facilities	There are currently no rules in Canada regarding foreign ownership of nuclear facilities. The operator of the facility is the licensee in Canada.Safe operation of a nuclear facility must be adequately funded by secure funding models over the lifecycle of the activities. The Commission has statutory powers under the *Nuclear Safety and Control Act* to impose a financial guarantee to mitigatepotential safety risks presented by funding interruptions from the owner.

3.2 Examples of Issues that fall into in the Second Group:

Table 4 lists examples ofissues that likely require some clarification to existing requirements and guidance. Here, clarification may be needed around application of the graded approach in certain cases or the basis of the requirements needs to be more clearly expressed. In many cases, industry is expected to start the conversation with applicable codes and standards development organisations.

Where regulatory documents are either being updated or written and influence discussion on the issue, CNSC staff continues to consider various SMR technical and siting scenarios in the writing work.

Table 4: Some Second Group Issues

Issue Identified By Stakeholders	Comment
Safety Analysis	More guidance is needed in existing regulatory framework documents around approaches to balance the use of Probabilistic Safety Assessment against Deterministic Safety Assessment. This is needed to address the fact that many SMR designs being proposed fall into a region of risk that is between traditional NPPs and existing small research reactors. This additional guidance would also need to address transportable (factory fuelled) reactor facilities. Guidance will need to take into account site-based safety goals and dose acceptance criteria.
Multiple module operation by a single certified operator	This approach is not yet proven. Existing requirements and guidance do not preclude its use because a proponent is required to demonstrate the minimum complement for the facility's safe operation for all plant states. It isimportant to note that detailed human-factors related evidence supporting this method of operation would need to be reviewed by CNSC staff as part of a detailed technical review of a specific design.
Main Control Room located at a significant distance from the facility – novel communication links	The technical implications stemming from the use of long distance wireless communication technologies is not addressed in existing requirements and guidance.
Fitness for Duty – operations in remote regions	Work in remote (i.e., isolated) regions presents unique challenges to human performance, particularly in safety sensitive activities. The implications of isolation on existing fitness for duty requirements need to be studied.
Accident and Severe Accident Management and Recovery for Remotely Supported Sites	The implications of using distantly located emergency response resources (which supports a fleet of SMRs) needs to be better understood. (for example: response might arrive by aircraft from a central response location)
Requirements around Aging Management of Sub-Surface Civil	Where SMR proponents are planning to use deep sub-surface civil structures,understanding aging management related phenomena and detecting physical degradation will be important to the safety

Issue Identified By Stakeholders	Comment
Structures	case of the facility over its service life.(which could be as long as up to 100 years). Knowledge of degradation mechanisms is important not only to understand the state of structural integrity, but is also needed to understand and mitigate against liquid or gaseous emissions that may escape into the environment around the facility.A stronger understanding of the state of the art in this area is needed.
Security Provisions at Remote Sites	The existing security requirements need to be reviewed against a realistic remote site case to understand where grading might be appropriate.

3.3 Examples of Issues that fall into in the Third Group:

Table 5 lists examples ofissues that will require significant regulatory analysis to understand potential risks and mitigation approaches. Public acceptance is likely to be problematic. In this case, CNSC is expecting industry to initiate the discussion with fairly detailed proposals that CNSC can use to develop a fulsome regulatory position. Resolution of these issues may need consultation with the public through processes such as CNSC Discussion Papers prior to developing or modifying requirements and guidance. These issues may also benefit from international discussion through regulatory cooperative arrangements.

Table 5: Some Third Group Issues

Issue Identified By Stakeholders	Comment
Codes and Standards for water-cooled technologies	Although many existing codes and standards are likely applicable, there are specific applications where further interpretation of rules is needed. For example: • Proponents will seek longer intervals for pressure vessel inspection work because of longer periods between refuelling outages • Crane codes and standards may need to be modified for cases where a crane will lift a fully-fuelled reactor module.
Codes and Standards for non-water cooled Technologies	In some cases, codes and standards may already exist for materials that come in contact with alternative coolants (from conventional industrial sectors) but they need to be reviewed and amended as needed to take into account nuclear applications.
Unattended operation	Although the concept of a fully automated, remotely monitored facility is technologically feasible the nuclear safety implications of this are not clear. It should be recognized, however, that precedent does exist for licensed unattended SLOWPOKE research reactor facilities based on inherent core characteristics.
Handling and long term	Fuels from different SMR facilities will have different

Issue Identified By Stakeholders	Comment
storage of irradiated fuel	characteristics and enrichment levels. The long term implications on handling and storage in Canada need to be addressed.
Transport of fuelled reactor vessels	Whether transported with fresh fuel or irradiated fuel, the transport of a fuelled reactor core presents technical and regulatory challenges across a large number of technical areas ranging from safety analysis to materials sciences.

3.4 A Brief Word on Discussion Papers

Over the course of the last few years the CNSC has adopted the use of discussion papers as a way of seeking input as part of the policy analysis and project planning phase of document development. Discussion papers are increasingly being used by the CNSC to formally solicit early feedback from stakeholders on amendments or new regulations, when the CNSC is considering new areas of oversight or significantly different approaches to regulating to meet the mandate of the CNSC than have been used in the past. The expected outcome from discussion papers is a better understanding of stakeholder positions and concerns prior to the CNSC putting pen to paper on requirements or the final determination as to its regulatory direction on a given issue.

To ensure transparency, all comments received from stakeholders are published on the CNSC web-site. The CNSC also publishes, in a "What We Heard" report, an interpretation of the comments received as well as the CNSC proposed way forward on the issue, taking into account the feedback received. The CNSC also strives to be as flexible and responsive with regards to the consultative processes for discussion papers. While the usual period for consultation is 120 days, the CNSC has frequently extended this period at the request of stakeholders.

Current or planned discussion papers for the remainder of this year include:

DIS 14-01, *Design Extension Conditions for Nuclear Power Plants*
DIS XX-XX, Integrated Review of Regulations Made under the Nuclear Safety and Control Act
DIS 14-XX, Regulatory Approach for Waste and Decommissioning

Discussion papers may also form a good starting point to address broader and far reaching SMR issues such as those discussed in Section 3.3.

To access all previously published and current discussion papers please use the following link:
http://www.nuclearsafety.gc.ca/eng/acts-and-regulations/consultation/history/index.cfm

4. Conclusions

Canada has a robust regulatory framework in place that provides a good foundation for potential SMR projects without compromising the high level of safety expected by Canadians.The provision of innovation andflexibility in safety approaches based on modern nuclear safety principles was intentionally designed into the Canadian regulatory framework when the *Nuclear Safety and Control Act* was introduced in 2000. This was, in part, a carry-over from regulatory principles that have been in place since the birth of the nuclear industry in Canada.

CNSC has been updating all of its requirements and guidance, in part, to address the need for a technology-neutral approach. In the past few years, these efforts have also focused on becoming size-neutral as well in that requirements and guidance focus on nuclear safety principles that need to be addressed in all safety cases. To do this, clarifications on the use of the graded approach are being introduced. As a result, a large number of existing REGDOCs already contain the right mix of nuclear safety principles that if applied to SMR activities by a proponent, will ensure safe operation.

Many features being proposed for SMRs, such as modularity, passive safety mitigation and increased use of automationare also being implemented in larger Nuclear Power Plant designs. It is, however, important to understand that in quite a number of cases, the use of these features in SMRs is likely to be more pronounced and may challenge the existing nuclear safety knowledge base.Safety claims for such features and concepts will still require a history of experience to be developed in order to be able to convince stakeholders such as the operators, CNSC and the public that these features are proven. This means these features and concepts will need to be supported by strong research and development evidence including data from both physical experiments and simulations using validated computer codes.

In some cases, proposed approaches raise important and sometimes fundamental questions around how existing requirements and guidance might be applied. CNSC staff are independently trying to develop an understanding of these questions, related regulatory issues and their implications. CNSC expects to complete the first pass of itscharacterization work by the end of 2014 and some of the issues are introduced in this paper.

Industry, as the proponent, needs to take the lead role not only in proposing how these issues should be resolved, but in determining their priority based on which technologies are likely to be deployed in the near and long term. It is, however, very important to consider what role the public and other key stakeholders could play in this work. For some of the broader policy type issues discussed in Section 3.3, the CNSC has various processes in place to facilitate public participation in discussions. By having these discussions in an open and transparent way proposed solutions

5. References

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