Disposition Table Appendix: Responses to key themes from the comments on REGDOC-1.1.5, *Supplemental Information for Small Modular Reactor Vendors and Proponents*

Contents

Theme #1 – Desire for SMR definition

The CNSC is not pursuing a formal definition for the term 'Small Modular Reactor' (SMR). For the purposes of REGDOC-1.1.5, the following text was added to provide a qualitative description of an SMR, and clarify the scope of the document:

> *The term 'SMR' can be used to describe a wide range of Class 1A reactor facilities. For the purposes of this document, the term Small Modular Reactor (SMR) includes:*
>
> - *smaller water cooled reactors*
> - *advanced reactors with alternative coolant technologies (i.e. non-water cooled)*
>
> *SMRs may produce energy in the range of a few megawatts to a few hundred megawatts per reactor and may not be confined to electricity generation. In some cases, an SMR facility may be composed of multiple reactor units whose combined power output could potentially be equivalent to a traditional nuclear power plant.*

Internationally, there is no universal agreement of what the definition of an SMR should be. The IAEA, for the purposes of enabling member state discussions on SMR Technologies established two categories that envelop the different types of SMR technologies being developed: <300 electrical MW per unit for small modular reactors and between 300 and 600 electrical MW for medium sized 'modular reactors'.

- In Canada, all reactor facilities are regulated in accordance with the *Class 1 Facilities Regulations*, which already encompass all reactor sizes from research reactors to large nuclear power plants (NPPs).
- Output of SMR concepts can vary from hundreds of kilowatts to hundreds of megawatts. Electrical MW output does not accurately coincide with the risk profile of a facility. The risk profile is informed by many factors such as fissile material inventory, operating model, presence of hazardous substances, adequacy of safety features, operability/maintainability.
- The degree of modular design and modular construction used in SMR designs varies considerably from none to highly modular. In fact, many Generation 3 and up NPP concepts utilize modularity.

Background on the term SMR

The term "small modular reactor" (SMR) generally refers to a nuclear reactor facility that is usually smaller than a traditional NPP. Like the majority of new nuclear power reactor technologies, SMR technology developers are seeking to employ multiple novel technological approaches, such as:

- next generation fuels
- passive/inherent safety features to reduce the need for operator intervention in plant events
- previously separate systems integrated into a single component or system (integral reactors)
- modular design to permit future facility expansion as demand for power grows (in some cases, modules are being designed to be mass produced and delivered to sites)
- modular construction approaches to improve predictability and quality of construction

- greater ability to leverage the heat produced by the reactor to produce multiple product streams under load following conditions (e.g., parallel production of electricity, process steam)
- factory fueled land or water transportable concepts (very small reactor concepts)

Other terminologies used internationally to describe such designs include:

- integral light water reactors
- non-water cooled concepts
- advanced reactor technologies
- advanced modular reactors
- SMRs/Nuclear Batteries (typically non-water cooled concepts that could be factory manufactured and fueled and can range from hundreds of kilowatts to <25 electrical MW)

SMRs being developed vary significantly in size, design features and cooling types. Examples of different SMR technologies include:

- integral and non-integral pressurized water reactors
- molten salt reactors
- high-temperature gas reactors
- liquid metal cooled reactors
- solid state or heat pipe reactors

SMRs may also be located on sites that differ from where traditional NPPs have been built. For example, SMRs may be established:

- on small grids where power generator needs allow usually less than 300 megawatt electric (MWe) per facility
- at edge-of-grid or off-grid locations where power needs are small – in the range of 2 to 30 MWe

Electrical utilities, industry groups and government agencies throughout the world are investigating alternative uses for SMRs beyond electricity generation for uses that include:

- producing steam supply for industrial applications and district heating systems
- making value-added products such as hydrogen fuel and desalinated drinking water

Theme #2 – The role of the vendor design review (VDR) process

The Canadian Nuclear Safety Commission regulates the use of nuclear energy and materials to protect health, safety, security and the environment; to implement Canada's international commitments on the peaceful use of nuclear energy; and to disseminate objective scientific, technical and regulatory information to the public.

Dissemination of information to vendors, potential applicants and the regulated community is meant to convey how they will be regulated and the requirements to be met when conducting activities in accordance with the *Nuclear Safety and Control Act* (NSCA). All licensed activities are expected to be conducted in a manner which prevents unreasonable risk to the environment, to the health and safety of persons, and to national security.

The difference between a reactor vendor and an applicant for a licence under the NSCA:

An applicant for a licence is a person or organization proposing to conduct activities that are regulated per Section 26 of the NSCA including:

> *"(a) possess, transfer, import, export, use or abandon a nuclear substance, prescribed equipment or prescribed information;*
> *(b) mine, produce, refine, convert, enrich, process, reprocess, package, transport, manage, store or dispose of a nuclear substance;*
> *(c) produce or service prescribed equipment;*
> *(d) operate a dosimetry service for the purposes of this Act;*
> *(e) prepare a site for, construct, operate, modify, decommission or abandon a nuclear facility; or*
> *(f) construct, operate, decommission or abandon a nuclear-powered vehicle or bring a nuclear-powered vehicle into Canada."*

An applicant applies to the Commission for a licence to conduct proposed activities. This application triggers an open and transparent licensing process which is described in detail in CNSC regulatory document REGDOC-3.5.1, *Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills*, Version 2. Public involvement is integrated throughout the licensing process to inform the Commission's decision making.

Conversely, a reactor vendor (i.e. vendor) is a technology designer who can supply goods and services to the applicant for a proposed project. Until requested by a potential applicant, a vendor is a stand-alone commercial organization with the objective to develop technologies that might be considered by potential customers. To do this successfully, a vendor needs to understand the regulatory environment in each country it operates in.

A vendor may engage with CNSC staff during design activities to develop an understanding of how regulatory expectations can be met. For example, a vendor could gain a better understanding of how to support safety claims using suitable evidence, commensurate with risk and uncertainties.

Purpose of a Vendor Design Review

A VDR is an **optional, standardized and cost-recovered** feedback process that the CNSC makes available to vendors to have a conversation about how Canadian requirements for design and safety analysis are being addressed in the vendor's activities as the vendor develops its design. Fees for VDR services are cost recovered as outlined in the *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations*. A VDR is a "Special Project" under these regulations.

A VDR, is **not** a licensing process. A VDR does not involve a potential applicant for a project, does not involve any decision making by the Commission and does not result in any decisions that could fetter the

Commission's decision making concerning a potential project. A VDR consists of reviews of a design as it evolves through a design process. A VDR is conducted under a service agreement which contains legal provisions to maintain separation between the VDR process and the Commission's authority to issue licences.

A VDR provides a vendor with the opportunity to better understand the CNSC's requirements and guidance in order to identify and resolve potential regulatory or technical issues early in the design process. In parallel, but separate from the CNSC's VDR process, a vendor would normally also be engaging with potential customers to ensure their needs are being addressed.

Because the vendor is seeking feedback on regulatory expectations during its design process, the level of design completion for a generic (e.g., non-site specific) reactor concept reviewed in a VDR is lower than the level of design completion necessary for a future applicant planning to apply for a construction or operating licence. The applicant for a licence may request the vendor to make design adaptations to take the specific project factors (e.g. site characteristics) into account. As a result, the VDR process does not contain any provisions to issue any binding statements of design acceptance such as design certification. It is the responsibility of a future applicant to accept and apply the vendor's information into an application for a licence.

Theme #3 Public availability of VDR information

Lack of Vendor design review information made available to the public

The CNSC is committed to ensure transparency to the extent practicable on the conduct of its activities, including VDRs. For VDRs, the CNSC approach is consistent with Canadian privacy and intellectual property laws and practices. Both the CNSC and licensees have a duty to consult with stakeholders on nuclear projects. Note that a VDR is not a licensing process, nor is it indicative of a physical nuclear project.

Within that context, the CNSC takes into account the following additional three key factors:

- The vendor's design is not completed and remains subject to change.
- The provision of feedback to the vendor by CNSC staff about regulatory expectations requires the CNSC to access to the vendor's commercially sensitive information. Release of this information, or comments on the substance could be detrimental to the vendor.
- No formal decision-making process is being conducted by the Commission or CNSC staff. All VDR results are non-binding on both parties.

The CNSC informs the public of:

- the status of all VDR projects
- high-level outcomes of VDR reviews by the posting of executive summaries of each review report
- regulatory issues / trends being seen across multiple VDR projects

The CNSC does this through its website as well as through its participation in conferences. Information can also be made available, by request, for stakeholders unable to access the CNSC website or attend conferences. A couple of examples of VDR executive summaries are as follows:

- Phase 1 Pre-Licensing Vendor Design Review Executive Summary: Ultra Safe Nuclear Corporation
- Phase 1 Executive Summary: Pre-Project Review of Terrestrial Energy's 400-thermal-megawatt integral molten salt reactor (IMSR400)

This approach balances the need to inform the public, while allowing CNSC to have sufficient access to commercially sensitive information in order to have a conversation with vendors around Canadian regulatory expectations.

As the VDR process is not part of a licensing activity (i.e., a VDR is not indicative of a physical project), input from the public is not sought. A vendor engages with the CNSC for advice on how its design, as it is evolving, would be capable of meeting CNSC requirements and guidance; this engagement is cost recovered and paid for by the vendor.

The above approach also helps CNSC readiness to review licence applications should an applicant choose to reference the vendor's technology. In such a case, supporting information would be made available and be subject to public input as part of any licensing activity.

For all activities, the CNSC is subject to the *Access to Information Act* and complies with all its requirements.

Theme #4 – The graded approach

Section 3 of the *Act* states that:

> "*The purpose of this Act is to provide for*
> *(a) the limitation, to a* ***reasonable*** *level and in a manner that is consistent with Canada's international obligations, of the* ***risks*** *to national security, the health and safety of persons and the environment that are associated with the development, production and use of nuclear energy and the production, possession and use of nuclear substances, prescribed equipment and prescribed information…*"

Canada's political and legal system has established the independent CNSC Commission Members as the final arbitrators of what represents reasonable risk when it comes to the development and use of nuclear energy and sources.

The CNSC licenses a wide range of activities under the NSCA using a systematic framework of risk-informed decision making tools. This framework of tools is otherwise known as a "graded approach". The concept of graded approach, as applied by both the CNSC and the regulated community, is described in CNSC regulatory document REGDOC-3.5.3, *Regulatory Fundamentals*. This concept is recognized internationally and is used in other regulated sectors. The notion of graded approach can also be referred to as the application of proportionality.

The CNSC's regulatory requirements and guidance have been formulated using globally accepted fundamental safety objectives and principles; however, the CNSC recognizes that these fundamental objectives can be met in many different acceptable ways, in a risk-informed manner, without compromising safety. It considers information from operational experience, licensee performance, safety assessments, and expert judgment when developing regulatory requirements and guidance, and in planning activities for licensing, certification and compliance. Risk insights are taken into account to prevent unreasonable risk to people and the environment.

Understanding risks, including associated uncertainties, and ensuring that these risks are mitigated, plays a significant role in the CNSC's activities to make regulatory recommendations and decisions. The pedigree and quality of supporting evidence is a significant factor in the credibility of safety claims, safety margins and the confidence that the applicant for a licence will conduct their licensed activities within sufficient margins of certainty. The risks and mitigation approaches need to be clearly described and well understood in order for the Commission to make an informed decision.

The CNSC applies proportionality to all safety and control areas (SCAs) in order to place an appropriate amount of regulatory scrutiny on activities, depending on the level of risk. Primary considerations for the extent and depth of application are the degree of novelty, complexity and potential harm posed by the proposed activity or facility. The degree of scrutiny (decision to apply more or less scrutiny) is further informed by:

- technical assessments of submissions
- safety performance history of the licensee (if applicable)
- relevant research
- information supplied by parties relevant to Commission proceedings
- national and international activities that advance knowledge in nuclear and environmental safety
- cooperation with other regulatory bodies

When the CNSC assesses applications, its primary consideration is to ensure that risk is demonstrated to be at a reasonable level. This includes ensuring that:

- regulatory requirements have been met
- fundamental safety functions have been met
- defence in depth is demonstrated
- safety margins are appropriate and in line with specific hazards over the facility's lifecycle

Simplified non-nuclear industry example

Whether in a passenger vehicle, or a professional race car, seat belts serve the same fundamental safety objectives in a collision event:

- They support other physical design features in the vehicle (defence in depth approach) that manage energy from the collision away from the human occupants to mitigate injuries (e.g. collision avoidance systems, anti-lock brakes, crumple-zone in the vehicle structures, air bags).
- They restrain the occupants into a specific seating position to predictably distribute remaining residual crash energy on parts of the body that can withstand those forces with thereby resulting in non-life threatening injury.

The seat belts (restraints) in the race car are specifically designed for higher risk crashes that occur at higher speed and more aggressive design and operating conditions.

Figure 1: Example of multi-point racing harness

For a passenger car, the seatbelt is of a simpler design because the vehicle is intended to be used in less aggressive operating conditions at lower speeds.

Figure 2: Example of standard passenger car seat belt

The fundamental safety objectives discussed above are met in both cases by different design approaches. Both are acceptable for the risk profile presented.

It is not intuitively obvious that race car restraints imposed into a passenger vehicle design would result in improvements in safety performance. In fact, such an approach might inadvertently present new conditions that result in lower safety performance.

The decision to accept one approach versus another considers the same fundamental safety objectives but also risks that might be presented in implementing an alternative approach. The tools used to perform these analyses are part of a risk informed approach (i.e., graded approach) and include reviews of operational experience, experimental data and other relevant information. As a result the regulatory authority has accepted the use of different belts under different intended driving conditions in different vehicle classes without compromising safety.

Theme #5 - CNSC's role in ensuring nuclear safety

When it comes to SMR technologies, or any other nuclear technology, the CNSC's primary role is to ensure that an applicant can demonstrate it will operate its reactor safely. The CNSC has no role in setting nuclear policy in Canada. This includes nuclear policy on electricity generation or on the use of nuclear materials.

The Government of Canada has determined that it is essential - in the national and international interests - to:

- regulate the development, production and use of nuclear energy and the production, possession and use of nuclear substances, prescribed equipment and prescribed information
- apply consistent national and international standards to the development, production and use of nuclear energy

Although hazards may exist, societal benefits can be gained from conducting these activities as long as assurances are provided that:

- the activities are being conducted by qualified persons
- they are making adequate provision for the protection of the environment
- the health and safety of persons and the maintenance of national security and measures required to implement international obligations to which Canada has agreed

As a result, the CNSC regulates the use of nuclear energy and materials to protect health, safety, security and the environment; to implement Canada's international commitments on the peaceful use of nuclear energy; and to disseminate objective scientific, technical and regulatory information to the public.

Part of the CNSC's information dissemination role includes:

- enabling the regulated community to understand their obligations to society under the NSCA and through the CNSC's expectations
- enabling all stakeholders to participate actively and in an informed manner in conversations around what constitutes reasonable risk in the conduct of regulated activities

Natural Resources Canada (NRCan) is the federal organization which has the mandate for sustainable development and use of natural resources: energy, minerals and metals, earth sciences and forestry. It is the organization which develops policies and programs that enhance the contribution of the natural resources sector to the economy.

An example of work that NRCan has undertaken as part of its mandate is the development of the Canadian Small Modular Reactor Roadmap (Roadmap) report in 2017-18. The development of this report included a 10-month public consultation. The CNSC participated as an observer in the development of the Roadmap, providing guidance on regulatory issues as they arose. Indigenous groups were consulted as a part of that process, in Indigenous and northern communities. The final report noted the need for ongoing engagement with civil society, northern and Indigenous communities and environmental organizations.

Another clarification of Canadian energy policy is that within the context of Section 92 of the *Constitution Act, 1867*, the provinces have exclusive jurisdiction concerning which energy technologies are to be pursued within a province. If a province were to choose a nuclear technology, the CNSC's role would be to ensure that the nuclear facility is safely constructed and operated. The CNSC does not decide on the type of technology that will be utilized in Canada.

Theme #6 - The safety of new technologies

As any new technology evolves from a design concept to a point where it is used in a physical facility, the first facility built which utilizes this this new technology can be thought of as a First of a Kind (FOAK) facility.

FOAK designs will differ in the type of evidence and operating experience available to support their safety case. In addition, there may not be specific standards in place to support an engineering approach for a technology. More unknowns in the design (which are needed to assure capability and safety) are expected for FOAK than for subsequent facilities using the same technology. The latter are referred to as N^{th} of a kind (NOAK) facilities.

In order to assure safety, FOAK facilities may be required to provide a safety case which implements more conservative measures than one for a NOAK reactor. To mitigate design uncertainties, FOAK facilities may be required to demonstrate:

- enhanced design margins (e.g., thicker concrete, more margins in reactivity control, more heat removal capacity, etc.)
- high fidelity of design accuracy (e.g., better computer modelling of material behaviour, the utilization multiple modelling/simulation approaches and then cross-referencing results, better comparison of simulation results to experimental data, etc.)
- enhanced safety features (e.g., supplementary shutdown means)
- stringent/conservative operational limits (e.g., limit operation to lower power)

Information supporting a licence application must always be of high quality and describe in sufficient detail how proposed approaches, in lieu of operating experience, will ensure safety.

The use of available codes and standards may be used, coupled with:

- experimental information
- supplementary safety analyses (including analyses of uncertainties)
- conservative approaches to design

In summary, additional safety features and increased use of conservative design may be used in FOAK facilities to address potential risks. The licensing process is designed to confirm that these risks are being addressed in all areas, to ensure that the activities conducted using the FOAK facilities are done so safely.

Theme #7 – Waste management

Used Fuel Disposal

In 2002, Parliament passed the *Nuclear Fuel Waste Act* (NWFA), which required nuclear energy corporations to establish a waste management organization as a separate legal entity to manage the full range of activities for the long-term management of used nuclear fuel. In response, Canada's nuclear electricity producers established the Nuclear Waste Management Organization (NWMO). The NWMO was given the responsibility for designing and implementing Canada's plan for the safe, long-term management of used nuclear fuel. The NWMO is implementing Adaptive Phase Management (APM), which at its end-point is safe isolation of used nuclear fuel in a deep geological repository in a willing host community.

The NFWA, and NWMO's development of APM, considered the potential for new waste forms through new technologies or new-nuclear projects. As such, fuel waste from SMRs would be within NWMO's mandate for long-term disposal.

For emerging technologies, the NWMO would provide a fee for service at fair and reasonable costs to determine the long-term management requirements and associated costs for the resulting fuel wastes. In Canada, waste owners are responsible for managing their radioactive waste. If a new technology is deployed and there is a new fuel waste owner, the NWMO would work with the fuel waste owners to determine the long-term costs and develop the appropriate funding mechanism for accommodating these wastes. This would also include the recovery of costs expended by NWMO for the implementation of APM up to the date of SMR fuel waste production, proportional to the volume of SMR waste, as well as any additional costs required to manage the new fuel waste form.

The CNSC's role is to ensure safety and security from any waste disposal facility proposed by the NWMO, or other proponents. Any waste disposal facility would be licensed by CNSC.

Interim Storage of Used Fuel

Currently, used nuclear fuel in Canada continues to be safely stored in both wet and dry storage configurations by the waste producers as it has been for decades. With the exception of research fuels, approximately 99% of the used fuel is CANDU fuel from nuclear reactors in Ontario, Quebec and New Brunswick. There is a robust regulatory and licensing framework for interim storage of used fuel.

Canada is a signatory to the *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management* (Joint Convention), an international agreement governing all aspects of the management of spent fuel and radioactive waste. The Joint Convention is a legally binding treaty that aims to ensure worldwide safe management of radioactive waste. It represents the participating countries' commitment to achieving and maintaining a consistent high level of safety in the management of spent fuel and radioactive waste as part of the global safety regime for ensuring the protection of people and the environment. The Joint Convention allows for the international peer review of a country's radioactive waste management programs. Prior to the peer review, Canada submits a national report demonstrating the measures taken to implement the agreement's obligations. Canada's national reports to the Joint Convention are published every three years.

Canada's waste solutions will comply with the Joint Convention.

Transportation of Fuel from Small Modular Reactors

Proponents wishing to transport fuel from SMRs would have to demonstrate to the Commission that provisions for the health, safety and security of Canadians, the environment and the respect of international obligations, are in place. In general, the transportation of any radioactive material in Canada needs to follow both: the *Transport of Dangerous Goods Regulations*; and, the *Packaging and Transport of Nuclear Substances Regulations, 2015*, which are overseen and enforced by Transport Canada and the CNSC respectively.

CSA N294, *Decommissioning of facilities containing nuclear substances* contains requirements regarding final end-state which is applicable to small modular reactors.

Theme #8 – Environmental assessment

The new *Impact Assessment Act* (IAA) has received Royal Assent. The Government has a number of proposals to make regulations pursuant to the IAA. In making these regulations, the Government provided opportunities for the public and Indigenous peoples to submit their comments on regulatory proposals, including proposed types of projects that would require an impact assessment.

Regardless of whether a project is designated under the proposed IAA as requiring an Impact Assessment, all projects will be subject to other regulatory instruments and regimes, including assessment and oversight by the CNSC.

The CNSC examines all project applications and considers whether an applicant will make adequate provision for the protection of the environment, health and safety of persons, as per its mandate under the NSCA. A licence under the NSCA can only be granted if the project is not likely to result in significant adverse environmental effects, taking mitigation measures into account.

The CNSC must adhere to the legislative framework of the day.

Further information concerning the CNSC's approach to environmental assessments, including the principles of sustainability, socio-economic considerations and the use of alternatives is available in REGDOC-2.9.1, *Environmental Protection: Environmental Principles, Assessments and Protection Measures*.

The Federal Court of Appeal ruled favorably on the CNSC's approach to environmental assessments in both 2015 and 2016:

- https://decisions.fca-caf.gc.ca/fca-caf/decisions/en/item/119796/index.do
- https://decisions.fca-caf.gc.ca/fca-caf/decisions/en/item/143472/index.do

Theme #9 – CNSC's input on impact assessment exemptions in Bill C-69 for small reactor facilities

The CNSC has a clear statutory mandate to regulate the nuclear industry. The CNSC's implementation of its robust regulatory framework ensures the ongoing protection of the environment and the health and safety of persons. The Commission is an independent administrative tribunal that operates at arm's length from government, and that is independent of the nuclear industry.

As Canada's nuclear regulator, the CNSC has the responsibility to regulate nuclear activities in Canada, and its regulatory framework would apply throughout the life of any nuclear project. Because of its technical expertise, the CNSC has provided analysis based on its regulatory experience to the Government on Bill C-69, including the concept of a threshold that is based on safety risk and alignment with international standards and best practices. It is of note that any nuclear project, regardless of its treatment under Bill C-69, will be subject to the requirements of the NSCA, including its environmental protection provisions.

The CNSC can confirm that its regulatory framework is ready to regulate new technologies such as SMRs and that the CNSC has the expertise and capacity to ensure that any authorization of the operation of such new technologies in Canada will be because they are safe and the environment is protected.