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Mr. Brian Torrie
Director General, Regulatory Policy Directorate
Canadian Nuclear Safety Commission
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OTTAWA, Ontario K1P 5S9

COMPLIANCE
Regulatory Affairs
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REFERRED TO REFÉRÉ À Torrie, B.

Dear Mr. Torrie:

Canadian Nuclear Laboratories Comments on Draft Discussion Paper DIS-16-04 Small Modular Reactors: Regulatory Strategy, Approaches and Challenges

Canadian Nuclear Laboratories (CNL) has reviewed the Discussion Paper DIS-16-04 *Small Modular Reactors: Regulatory Strategy, Approaches and Challenges* and has consulted with industry partners to produce a set of consolidated comments, which are presented in Attachment A.

The discussion paper was found to be well written and thus allowed industry to provide effective input during the review. The major themes of the consolidated comments are:

1. Industry supports the application of a graded approach to all elements in the discussion.
2. There is no need for significant changes to the regulatory framework.
3. The licensing process should be streamlined to take into account production of repeat SMR units.
4. There are no insurmountable roadblocks to licensing SMR units in Canada under the existing regulatory framework.

If you require further information or have any questions regarding this submission, please contact me as indicated below.

Yours sincerely,

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SK/cvdw/mj

Attachments (1)

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	J.D. Garrick	K. Kehler	H. Khartabil	W.S. Pilkington
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Attachment A

Industry Comments on Draft Discussion Paper DIS-16-04 Small Modular Reactors – Regulatory Strategy, Approaches and Challenges

#	Comments/ Responses to CNSC Questions	Major Comment/ Request for Clarification	Impact on Industry, *if major comment*
	General Comments and Observations		
1.	An SMR in and of itself does not inherently pose any particular challenge to regulatory requirements in Canada. For example, an SMR which is just a smaller version of an existing water-cooled NPP, with all the safety characteristics of such Generation III reactors, should be able to be licensed using all existing CNSC regulatory documents and guides. The difference arises if an SMR uses novel technology to achieve greater inherent and/or passive safety than existing NPPs – the question then is how can the regulatory process be aligned to permit offsets in regulatory requirements for such aspects (i.e. a graded approach), while acknowledging the burden of proof on the proponent to establish the effectiveness of the novel technology. Note that part of the issue is the use of the term SMR, which can encompass a broad range of reactor technology, from conventional to highly innovative.	**MAJOR**	The Discussion Paper does not really deal with this aspect. While we do not believe that new regulations are needed, guidance on application of the graded approach (which is already acknowledged at a Policy 1 level by the CNSC) could be useful.
2.	The discussion in the introduction on "alternative uses" may deserve more elaboration to include the required characteristics of these uses and the potential for SMRs to co-exist with other types of generation such as renewables. SMRs will typically be base loaded to be competitive and this will limit compatibility with other generation sources that are base load or require	**MAJOR**	It is unlikely that SMR vendors, at this time, would have the resources and local presence to develop a relationship with alternative energy users. This would be an appropriate role for local developers or governmental agencies.

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	priority (such as renewables). Similarly, compatible alternative uses will need to be flexible and have low enough capital costs to be economic with reduced capacity factors or be able to economically use alternative energy sources when the SMR is fully dedicated to the electrical grid. SMRs do have the advantage of being more likely to match alternative uses in scale than traditional large nuclear units.		
	Section 2.2: Technical Information, Including Research and Development Activities used to Support a Safety Case The CNSC would like to know are requirements regarding the scope and adequacy of supporting information sufficiently clear. Of particular interest are whether existing R&D requirements are clear in key regulatory documents such as REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants*, RD-367, *Design of Small Reactor Facilities*, REGDOC-2.4.1, *Deterministic Safety Analysis*, and other documents related to facility lifecycle (e.g., REGDOC-2.6.3, *Fitness for Service: Aging Management*).		
3.	**Graded Approach to Licencing**: An important aspect of licensing SMRs in Canada is CNSC's Graded Approach, where the regulatory requirements are commensurate with the risks. Hence, it is important to articulate how Graded Approach is applied and how it can benefit very small modular reactors. • CNSC's Graded Approach is based partly on IAEA's Safety Requirements document NS-R-4 "Safety of Research Reactors". NS-R-4 seems to limit the applicability of the Graded approach to "several tens of megawatts" and excludes nuclear reactors used for the production of electricity. This is different than CNSC's definition of "Small Reactor Facilities" with power levels <200 MWt and may produce electricity. What are, if any, the implications of the difference in the scopes on the application of the Graded Approach?		

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	• Is there any past experience where graded approach has been used and facilitated the licensing process?		
4.	**Applicable Standards**: CSA standards form a key part of the CNSC's regulatory framework. Unlike CNSC documents, which attempt technology neutrality, most CSA standards are very CANDU-Specific. For non-CANDU SMR technologies, these standards may have to be updated. The whitepaper should address this issue		
5.	For components of some innovative SMRs, existing Canadian industry codes and standards may not be applicable (e.g. CSA Standards), especially for non-water-cooled designs. If there are applicable international codes and standards, the vendor / licensee will need to make the case to use them, to the CNSC. However even international codes and standards may not be applicable, and development of an applicable Canadian Standard can take a very long time. It is important that the CNSC is willing and able to licence an SMR based on the case made by the applicant, in the absence of any existing and/or applicable (Canadian or international) standard.		
6.	**1. Design Codes**: What codes and standards can be used for non-water cooled systems? **2. Licensing of Production Built Reactors (Economy-of-scale in licensing cost)**: SMRs will be factory-manufactured in a production setting to be economically competitive. After the licensing of the first unit, the identical units should be easier (cheaper) to licence. Addressing the licencing requirements for the repeat units would be a useful addition.	*Clarification*	

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7.	**Definitions (Section 1):** Although it is defined in some of the references, definitions of Class 1 and Class 2 facilities and material categories would be helpful in the whitepaper.		
8.	How will "*risk-informed*" and "*graded approach*" concepts be applied to SMR designs that will make extensive use of passive engineered design features (e.g., use of passive cooling) and/or strongly inherent safety features (e.g., self-limiting nuclear reactions). Additional discussion on application of the "*risk-informed*" and "graded approach" concepts would be useful Employing passive engineered design features and/or strongly inherent safety features, may not need some of the current regulatory requirements to be imposed (e.g., requirement for redundancy, separation, meeting the single failure criterion, requirement for complementary design features, requirement for the reactor to be shut-down and kept shut-down rather than kept sub-critical, etc.). In addition, it is very likely that some passive design features would have sufficient reliability to be credited for both preventive and protective/mitigating safety functions. Does any CNSC requirement prevent that today?	*Clarification*	
9.	CNSC requirements appear to allow for flexibility in meeting safety objectives. This should be viewed positively but does have the potential for requiring additional interpretation of requirements.		

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	SMR viability will depend on the ability to produce a large number of identical reactor modules. In practical terms this will require that multiple countries accept an essentially identical design. This is particularly important for a country like Canada. Although the potential Canadian market for SMRs is large, it may not develop in a short enough period to support the development of a "Canadian SMR". To support SMR vendors from other countries interested in the Canadian market, the CNSC should closely monitor the SMR licensing progress in other countries and clarify the applicability of CNSC requirements to these SMRs. The overall goal should be to provide guidance relative to which specific licensing approaches accepted in other countries will be considered in Canada.		
10.	The secret of success for the majority of SMR business models is that they are produced, installed and operated in a standardized, reproducible manner. The same notion needs to apply to how SMRs are sited, licensed and regulated. This could mean, in effect, that if one SMR facility is licensed under a given set of boundary conditions, it can be licensed elsewhere (perhaps simultaneously) provided it can be demonstrated that the boundary conditions are the same. Barring unique local environmental conditions the approach should be to licence a fleet. This general principle is our input for sections 2.3, 2.5, and 2.6.1.	**MAJOR**	The current CNSC process requires that the industry and licensees take a financial risk on licensing identical SMR plants. The CNSC needs to take steps to help the licensee manage this risk including the risk involved in licensing identical SMRs. This includes the risk of having to complete environment assessments for multiple reactors using the same process used for the first of a kind reactor.
11.	The CNSC expectations for the scope and adequacy of supporting information for a safety case require integrating the expectations in REGDOC-2.5.2 Section 5.4 or RD-357 Section 6.4, REGDOC-2.4.1 Section 4.4.3, and REGDOC-2.6.3 Section 3.1.	**MAJOR**	If the CNSC expectation is that new supporting research and development programs are always required for the safety cases for SMR designs, this expectation could become a significant barrier for SMR designers.

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	In particular, REGDOC-2.5.2 Section 5.4 and RD-357 Section 6.4 both state: *"When a new SSC design, feature or engineering practice is introduced, adequate safety shall be demonstrated by a combination of supporting research and development programs and by examination of relevant experience from similar applications."* The expectation that a new SSC design, feature or engineering practice requires a combination of supporting research and development and examination of relevant experience from similar applications needs some clarification. The CNSC expectations should be made clearer regarding the expectations for the quality of operational historical recorded data from previously operated plants of similar design that could be used on a case-by-case basis to justify not needing some new supporting research and development programs. For example, to support the design of SSCs for new SMRs that are based on previously operated plants of similar design, the operational data could include: • Data from the operation and maintenance of components and systems in previous plants of similar design, including the effects of aging and wear of SSCs, and the effectiveness of aging management experience, and failure rates for components, • Data on the performance of components and systems in plants of similar design during tests under transient conditions and postulated initiating event conditions, and		

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	• Evaluations of the effects and interactions between mechanical, thermal, chemical, electrical, physical, biological and radiation stressors on materials properties, materials aging and degradation processes.		
12.	With respect to application of the requirements in REGDOC-2.5.2 and RD-367 to non-water-cooled reactors, the CNSC should ensure that there is flexibility and guidance in the existing REGDOCs . The work done by the US NRC for their Draft Advanced Reactor Criteria Table and the work being done by the Generation IV Forum on safety design criteria are sources of information for developing the CNSC guidance.	**MAJOR**	Gas-cooled, sodium-cooled, lead-cooled and molten salt SMRs need safety design requirements that are not the same as those for water-cooled reactors. While the SMRs designers are developing their own criteria, guidance is needed from the CNSC on the CNSC's expectations.
13.	Generally the requirements regarding the scope and adequacy of supporting information are sufficiently clear. There should be some recognition in the licensing review that since many SMRs employ novel technology, the level of completeness will not be the same as for existing NPPs, leading to more emphasis on the R&D program and on commissioning of the first plant. Specifically, the referenced CNSC documents focus more on incorporating information from a mature R&D program than on initiating an R&D program. Since in most cases any requirement for a prototype (non-commercial) reactor will be a major barrier to deployment of a new technology, there has to be a pathway whereby the safety of a novel SMR can be established through an R&D program while the design and licensing are ongoing (i.e. the R&D program may not be complete until the first plant is commissioned). In that sense early regulatory review of the R&D program is important for novel SMRs. Commitments made in the vendor's R&D program (both in terms of		

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	experiments to be performed, and implied expectations for the results) become part of the plant licensing. It might be useful for CNSC to consider practical guidance on use of R&D acceptance criteria in plant licensing, as is done in the US in design certification (Design Acceptance Criteria (DACs); and, particularly, Inspections, Tests, Analyses, and Acceptance Criteria (ITAACs)).		
	Section 2.3: Licensing Process for Multiple Module Facilities on a Single Site The CNSC would like comments on: • Whether or not clarifications are needed to REGDOC-3.5.1, *Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills*? • In order to be better prepared for the use of replaceable reactor core modules or relocatable facilities, the CNSC is seeking information on facility deployment strategies being considered by developers, including impacts of such an approach on areas such as worker and public safety, environmental assessment and decommissioning. • The CNSC will use this information for future more-detailed workshops to discuss regulatory implication of different deployment approaches.		
14.	**Non-Permanent SMRs** – Special consideration is needed for non-permanent sites (VSMR that are small enough to fit onto one or a few trucks and moved to where the power is required. i.e. to provide steam for the oil sands)		
15.	Canada has extensive experience licensing multiple power reactors on one site, as well as sharing facilities among them (e.g. control rooms, containment, emergency core cooling, turbine hall). Apart from a few special topics which are still under discussion (i.e. how to apply CNSC numerical safety goals to a multi-unit site), and some items listed below, we believe that the licensing of multi-unit sites for SMRs does not require further overall guidance. Some aspects unique to some SMRs such as the number of operators being less than the number of reactors in the Main Control Room,		

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	can be dealt with under the CNSC's normal review of human factors. There is one major and a few special considerations. *Major Item* - For a site initially licensed with one or more identical modules, it should be relatively straightforward to *add* further modules at a later time – i.e. environmental and licensing decisions made on the first set of modules should apply for the most part to additional modules added later on. However the processes and in particular the timelines in REGDOC-3.5.1 imply that modules added after the initial licence is granted are treated just as the first reactor . Adding more modules could be done by licence amendment (increasing the number of modules in the original licence). A similar comment applies to decommissioning individual modules. *Other Items* - The safety of the operating modules while a module is being constructed / commissioned / replaced / decommissioned will have to be evaluated. This is not new but may be more extensive with SMRs. - Internationally it is generally accepted that reactors should not share safety systems with one another, e.g. from IAEA SSR-2/1: "Safety systems shall not be shared between multiple units unless this contributes to enhanced safety." Some SMRs may challenge this assumption, and regulatory guidance on what can be shared, and how, might be useful. - There is an international expectation now that a Periodic Safety Review (PSR) should occur every 10 years for an NPP. In Canada large-scale pressure-tube replacement for CANDU reactors has also triggered a PSR. A similar concept could apply to module replacement – i.e. module		

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	replacement provides an opportunity for a PSR. However the frequency of a PSR for modular SMRs should be consistent with the frequency of module replacement, or some multiple thereof if a module is replaced more frequently than once a decade. For a First-Of-A-Kind (FOAK) module, the first module change should trigger a PSR. Where there are multiple identical modules, a PSR should be done only for representative modules, not each one. Similar comments apply to periodic inspection. - In some designs the module is brought to site already fueled. This may require expansion of the regulatory requirements for transportation.		
16.	Licensing multiple reactor units on a single site is not new and has been done in Canada and internationally. Canadian examples are Pickering A (4 units), Pickering B (4 units), Bruce A (4 units), Bruce B (4 units) and Darlington (4 units). In each of these examples, the licences were granted for each group of four units at a time. For the Pickering and Bruce sites, the entire licensing process from environmental assessment and licence to prepare site to operating licence was executed for the A reactor units and subsequently for the B reactor units. Note that the installation of the multiple reactor units all occurred during the respective construction licences. Furthermore, the original construction licensing of the Pickering A and B units and of the Bruce A and B units could be viewed as a large scale version of deployment of multiple reactors on a site. The licensing process considered each 4 unit facility at a time. However, the concepts for deploying multiple modules for SMRs on a single site will need to be considered with a different approach than has been used in the past, because the installation of multiple reactor core modules could	**MAJOR**	A regulatory approach for controlling changes to an SMR facility under an operating licence is needed to enable a licensee to deploy additional or replacement reactor core modules. This regulatory approach should strive to minimize the administrative burden.

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	occur during the operating licence period with the first units in full operation for some time before deploying addition units. Hence, the deployment of multiple SMR modules may not occur in the same way as the deployment of the multi-unit CANDU station, which all occurred during the construction licence. An approach could be considered where the environmental assessment accounts for all expected SMR modules, and provisions made in the licences to facilitate addition of SMR modules at later dates. One approach for deployment of multiple modules for SMRs on a single site, where the deployment takes place in multiple deployment phases, can be to follow the example of a licence condition in the operating licences for the existing nuclear power plants: "The licensee shall not load any fuel bundle or fuel assembly into a reactor unless the use of the design of the fuel bundle or fuel assembly has received prior written approval of the Commission, or consent of a person authorized by the Commission." A licence condition for an SMR module could state: "The licensee shall not install a reactor module unless the use of the design of the reactor module has received prior written approval of the Commission, or consent of a person authorized by the Commission."		

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	REGDOC-3.5.1 should be revised to include guidance to licence applicants for deploying multiple reactor core modules in multiple deployment phases and on replacing a reactor core module under the operating licence. However, this approach to licensing the SMR reactor module would not alleviate the requirement to address the safety concerns associated with common cause failures that affect all SMR modules simultaneously.		
17.	When the SMR module design and manufacture are taking place in one or multiple jurisdictions, and the target market is multinational, it would be desirable to establish a licensing basis that allows the SMR module to be more readily accepted by regulatory jurisdictions in Canada and internationally. This would enable the regulators in each country to decide on whether the modules can be used with or without additional review. There is a precedent for this approach. The Packaging and Transport of Nuclear Substances Regulations under the Nuclear Safety and Control Act incorporates the requirements of the Regulations for the Safe Transport of Radioactive Material, published by the IAEA, as amended from time to time. CNSC regulatory document RD-364, Joint Canada-United States Guide for Approval of Type B(U) and Fissile Material Transportation Packages, provides the example on regulatory guidance to enable licence applicants to prepare that thoroughly and completely demonstrate the ability of the given package to meet either Canadian or U.S. regulations, as applicable.	**MAJOR**	Establishing a regulatory approach that increases the harmonization of regulatory requirements between Canada and international jurisdictions would implement a common-sense regulatory approach that meets the expectations in the Government of Canada's Red Tape Reduction Action Plan. This suggested regulatory approach would continue to enable the CNSC to perform all licence applications for SMR facilities, and would provide a more efficient regulatory approach for regulatory review of replacement modules or additional modules after the initial construction of the SMR facility.

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	While licensing the complete SMR facility is unlikely to be amenable to this type of licensing approach, the fuel and reactor core modules should be amenable to this type of licensing approach.		
18.	REG DOC 3.5.1 allows under Section 6. Licensing Process for Class I Nuclear Facilities, to apply for *"A single licence may also be issued for multiple facilities, each at a different stage in their lifecycle"*.	**MAJOR**	Under this process, is there a potential impact on streamlining the regulatory process and its timelines? As per Appendix B.1 Class IA nuclear facilities (reactor facilities) the licensing timeframe is typically 9 years – could that be shortened for individual SMR modules or sites under a single licence, or does CNSC expect that each installation would take a 9 year licensing process?
19.	Replacement of core modules should not be seen as an issue in the context of multi-module facilities. It is a technical issue and, depending on the choice of SMR technology, an aspect related to transportation and packaging, safeguards, security, waste management, but not a particular multi module facility issue. Some of the related regulations (e.g., transport) probably need to be augmented to address fueled modules.	**MAJOR**	Review and, if needed, revise the packaging and transport Regulations to specifically allow for replacement of fueled core modules which is in industries best interest
20.	Relocation of transportable reactors between sites is not clearly addressed by existing Canadian Regulations	**MAJOR**	Review for how best to incorporate requirements in the regulatory framework
21	It is noteworthy that in the current regulatory framework the safety goals are defined on a per unit basis, whereas there is an expectation to demonstrate adequate safety for multi-unit facilities. Discussions on this topic between the industry and the CNSC staff are ongoing and any outcome from the discussions will affect the licensing on a single site of multiple module SMRs	*Clarification*	.
	Section 2.4: Licensing Approach for a New Demonstration Reactor		

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	The CNSC would like comments on: • Whether or not additional clarification or information beyond that found in RD/GD-369, *Licence Application Guide: Licence to Construct a Nuclear Power Plant*? If yes, what needs to be clarified or added? • With respect to addressing uncertainties introduced by the application of integrated multiple novel features in a demonstration facility, are requirements regarding the scope and adequacy of supporting information sufficiently clear? • What, if any, requirements need to be revisited to address activities involving demonstration reactors? For example, are additional requirements or guidance needed to address operational restrictions if the facility is being used to gather operating experience that would be normally be needed for commercial facility licences?		
21.	FOAK reactors should have different inspection and surveillance programs than established designs. Requirements for the "maintenance, surveillance, inspection and testing" program are given in section 9.7 of RD/GD-369. Operating experience is stated to play a large part in defining these activities, so the program for a demonstration unit having novel features with no OPEX will require additional justification and will contain additional or more frequent inspection and maintenance activities. If a demonstration reactor can provide operating experience for future identical units, less conservative inspection and maintenance regimes for identical future units should be justified by a more comprehensive testing program in the demonstration reactor. In particular, pre-service and baseline inspections are needed as a reference point to assess degradation rates of critical components.		
22.	Vendors/proponents may want to employ a range of R&D options, e.g., facilities (demonstration or prototype), experimental rigs, test assemblies, etc., in support of the safety case. These could make use of radioactive sources and/or be subcritical facilities, etc. Currently, there seems to be no	**MAJOR**	Owners / investors / operators need to know if proposed demonstration and/or prototype facilities would take same time to licence and need to know upfront what are the applicable regulations, requirements, and CNSC expectations for such facilities.

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	clear guidance or mapping of the licensing framework, regulations and requirements that are expected to apply for such options.		Would all such options be considered Class 1A, or would a graded approach apply to test facilities which are sufficiently small scale demonstration reactors? Otherwise, regulatory burden may be excessive for the risk.
23.	We do not believe that any special licensing approach needs to be put in place for a Demonstration Reactor – many of these will become commercial plants in any case, after an initial period of operation. The licensing case for any reactor has to demonstrate that the plant is safe to operate. Given that each SMR design will be different, it is unlikely that general requirements can be written on "the scope and adequacy of supporting information" beyond those that exist for current NPPs. CNSC has had considerable experience licensing first-of-a-kind designs, such as research reactors. Some SMRs will use the commissioning phase of the first commercial plant to confirm behaviour that can only be done on a real reactor, given that building a prototype or test reactor may not be feasible. Effectively the R&D program for each design may extend into the commissioning phase of the first commercial plant. This first plant will have a longer and more extensive commissioning phase, likely more instrumented than subsequent plants or cores, to validate integral behaviour. CNSC may wish to place more hold points in the Commissioning program to make sure results are as expected. As discussed earlier, it would be useful for the licensee to propose acceptance criteria in advance for such commissioning tests. Exceptionally, novel commissioning tests might require CNSC approval in advance on an		

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	individual basis. However none of these activities in our view require further regulations.		
24.	RD/GD-369 allows utilization of licensing bases documents and guidance not normally used in Canada with an appropriate assessment such as a gap analysis. Because SMRs are expected to be international designs applicable to multiple countries, implementation of this process is critical.		The gap analysis would typically be the responsibility of the applicant.
25.	It is not clear that SMRs should be considered demonstration facilities, even for the first of a kind. The elements of the designs have long histories and are being addressed in detail. Currently the SMR designs are not anticipated to require additional special considerations after the required startup testing.		
26.	With respect to addressing uncertainties introduced by the application of integrated multiple novel features in a demonstration facility, the requirements regarding the scope and adequacy of supporting information are not sufficiently clear. A demonstration reactor facility can be considered as a full-scale, fully integrated demonstration of the collection of novel features. A purpose for the demonstration reactor facility would be to obtain operating experience on the integrated performance of the novel features. With this idea in mind, the degree of confidence in the design of the demonstration reactor facility would be less than that for a replication of the production version of the reactor facility. In light of the greater degree of uncertainty, RD/GD-369 should provide guidance regarding the CNSC's expectations for the adequacy and quality of the supporting research and development information that would be acceptable for a demonstration reactor facility.	**MAJOR**	By its very nature, a demonstration reactor is expected that the degree of confidence in the performance of the integrated novel features in the demonstration reactor facility would be less than that for a replication of the production version of the reactor facility. The licence application process can be improved by providing guidance on the CNSC's expectations for risk control measures that the licence applicant should consider including in the operation of a demonstration SMR.

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	Guidance is also needed on how best to meet the CNSC expectations in the application of a risk-informed approach for new demonstration reactors for each of the safety and control areas. The discussion paper does not mention the use of any risk-informed decision making process and benefit-cost analysis process. The CNSC expectations for a risk-informed decision making process and a benefit-cost analysis process is needed as guidance for the licence applicants of new demonstration SMRs since not only novel features may be used in the design, but novel approaches may be used to justify the minimum staff complement and operational programs for each safety and control area.		
27.	With the expectation that the supporting operational experience for a demonstration SMR is less than what is expected for a production SMR, the additional activities to acquire the operating experience from the demonstration SMR should be discussed with the CNSC.	**MAJOR**	The licence application process can be improved by providing guidance on the CNSC's expectations for risk control measures that the licence applicant should consider including in the operation of a demonstration SMR.
28.	With respect to operational restrictions for demonstration SMRs while accumulating operational experience, the CNSC should make available information on the typical types of licence conditions that may be used while accumulating the operational experience.	**MAJOR**	Providing guidance on the licence conditions and the expectations for verification criteria will help licence applicants to a priori develop their programs for each safety and control area.
29.	The existing CNSC document, RD/GD-98, defines requirements for identifying systems important to safety for the licensee's reliability program. The guidance in RD/GD-98 recommends making use of the PSA for a nuclear power plant as a systematic method for identifying the systems important to safety. The components and equipment in SMR designs may be sufficiently unique that their failure rates are not well quantified or have very large	**MAJOR**	Consider whether further guidance is needed in RD/GD-98 for SMR designs.

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	uncertainties. This introduces greater uncertainty into the PSA results. Hence, alternative approaches to the traditional PSA may be used for SMRs. Since alternative methods to the traditional PSA may be used by SMRs, further discussions will be needed to agree on alternative approaches to establish a reliability program for an SMR.		
30.	For non-water-cooled SMRs, the applicable set of codes and standards will have many differences from the set of codes and standards that have been used to design water-cooled reactors. Section 2.2 of RD/GD-369 provides guidance on the CNSC's expectations for the licence applicant to evaluate the codes and standards used for the physical design for applicability and to provide assurance that any deviations from CNSC requirements and expectations will not adversely affect the facility's overall level of safety. In this regard, the CNSC expectations are clear. However, for some non-water-cooled SMR designs, the conventional health and safety hazards are greater in magnitude and different in nature from the conventional health and safety hazards for water-cooled reactors. The CNSC may want to clarify that the safety significance when evaluating codes and standards for applicability to an SMR design needs to consider both nuclear and conventional safety.	*Clarification*	
	Section 2.5: Licensing Process and Environmental Assessments for Fleets of SMRs The CNSC would like comments on: • How do you envision proposals for such fleets across large geographical territories proceeding through licensing and environmental assessments? • How would the principles discussed in REGDOC-3.5.1, *Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills* be applied and where might challenges exist?		
31.	Many characteristics of SMRs designs (some mentioned in the Introduction section of DIS-16-04) make the SMRs suitable to expect a graded approach in regulatory requirements application. However, there are two issues to note:	**MAJOR**	Industry (owners / licensees) may be less interested in SMRs if licensing timelines are same (long durations) as for classic CANDU/PWR/BWR reactors. The CNSC should review the licensing timelines (and potentially

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	i) First, it is not known how the "*graded approach*" concept will be concretely applied by the CNSC staff in their review, as the concept is subjective and open to interpretation. ii) Second, although noting the willingness of CNSC to apply a risk informed and "*graded approach*" application of regulatory requirements, there is no clear acknowledgement that the licensing timeline for Class 1A nuclear facilities can be reduced below the 9 years' duration as provided by REGDOC 3.5.1. There is thus no indication what that duration may be for SMRs (and other facilities, including prototypes and demonstration) that would make significant use of the risk-informed and "*graded approach*" concepts. This is a significant item of interest for stakeholders such as vendors, applicants, owners/investors and warrants addressing.		adjust some processes) that are published in REGDOC-3.5.1, taking into account the features of SMRs. Could the Licence Conditions Handbook process (14 SCA) be used to manage EA for a fleet of SMRs?
32.	Allowing a single licence on multiple sites, especially for the same or similar SMR designs and for same licensee should be encouraged and streamlined. It may be the case that the only differences could be in EA factors if sites are significantly different. The regulatory process to allow single licence but different EAs (if significantly different site characteristics) should certainly be a focus point for the CNSC. In addition, formal credit should be given for CNSC staff technical assessment under a licence application for a facility (unit) on one site to the licence application of same or similar type of facility (unit) on a different site,	**MAJOR**	Having a single licence for multiple sites, and taking credit for regulatory reviews (including EA) of other licensees' same/similar SMRs facilities, would be expected to result in streamlined and shorter licensing timelines.

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	taking into account site-specific differences. This would be useful when two different licensees would seek licences of same/similar SMRs on different sites.		
33.	Fleet licensing raises similar challenges for REGDOC-3.5.1 as a previous question: it is not an effective use of regulatory or licensee resources to independently grant licenses for a large number of identical small reactors. A model such as the following could be helpful): - Prior regulatory *detailed* design approval for a modular design on a generic site characterized by some sort of "envelope" of site conditions. This would require that a licensee submit an essentially complete design. That may be more practical once the (first) demonstration plant has actually been licensed. - Prior approval of the same generic site envelope for environmental assessment purposes - A combined EA/licensing site-specific process which would simply confirm that the actual site is enveloped by the "generic" site for the approved design. This would be accomplished in a differential-scope EA which would focus only on aspects which might not be covered by the above two processes – e.g. local community or aboriginal factors, design changes forced by site features. - A combined construction and operating licence granted at the conclusion of the differential-scope EA - Parallel prior regulatory approval of a fleet operator as an organization (and licensing its operating staff, as appropriate) to operate the approved design at any site within the generic envelope. Organizational approval would		

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	include confirmation that the operating organization has the knowledge, authority and resources to operate one or more plants.		
34.	To support a program establishing a fleet of SMRs at different sites, a clear division of approval for the plant design and separate approval for the site is required.. It is critical that plant design issues not be revisited for each site if established interface requirements are met.		
35.	An alternative approach to licensing for deploying SMRs across large geographical territories would be to consider using the first SMR site as the lead plant for the construction and operating licence, and basing the licensing for subsequent deployment of SMRs on the licensing approvals granted for the first facility.	**MAJOR**	A licensing approach to licence a generic design would help to reduce the commercial risks on costs and timescales for a fleet of one SMR design across large geographical territories.
36.	Most of the technical information for the environmental assessment can be provided in a generic environmental impact statement with a Plant Parameter Envelope that effectively brackets the range of variables to be assessed. This generic environmental impact statement would then need to be assessed against the site specific conditions to confirm that the Plant Parameter Envelope does bracket the site specific conditions. This approach could reduce the cost and timescales for completing site specific environmental assessments.	**MAJOR**	A regulatory approach to completing environmental assessments where generic Plant Parameter Envelopes are used would help to reduce the commercial risks on costs and timescales for a fleet of one SMR design across large geographical territories.
	Section 2.6: Management System Considerations: Licensees of Activities Involving SMRs The CNSC would like comments on: • Preparing for alternative ownership and operating models that would be used in SMR deployment, more details (such as case studies) are sought including. • How deployment of different SMR concepts (e.g., factory fueled transportable concepts)would proceed • How oversight for such deployments would be conducted		

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	• How issues such as licensee performs inspections of key components (e.g., a reactor module)when received from a vendor • How alternative ownership models will address requirements in CSA Group's standard N286-12, *Management system requirements for nuclear* facilities and in CNSC regulatory requirements		
37.	**Sealed Cores:** Sealed cores/modules pose a number of licence and operational issues. A licensee would be responsible for the condition of a module received (and that it is not damaged during transportation). One of many options might be to have the core sealed at the factory for transportation and non-proliferation purposes, and then, can be unsealed at the site under observation (by the regulator and/or the IAEA) for inspection and acceptance and sealed again for operation. While *pre-service* inspection may benefit from access to subsequently sealed components, a *baseline* inspection, conducted with the same access limitations as periodic or in-service inspections is still needed as reference for aging management programs.		
38.	Regarding procurement of sealed core SMR modules, such long lead items (including integral vessel designs) could be designed and manufactured outside Canada under different nuclear jurisdiction requirements, codes and standards, before a decision to site and operate them in Canada. It is not clear in the regulatory framework how management system requirements will be used for such designs.	**MAJOR**	
39.	Extensive and retroactive standard-to-standard comparisons may not be feasible nor useful to demonstrate equivalency to Canadian codes and standards and regulations. We encourage the CNSC to develop some efficiencies for the process	*Clarification*	
	Section 2.6.1: Management System: Minimum Complement in SMR Facilities		

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	The CNSC would like to know are the regulatory requirements and guidance related to minimum complement sufficient and clear as applied to activities involving SMRs? What, if any, proposed changes should be considered for the existing regulatory requirements? For example, in conjunction with the question in section 2.12, is additional guidance needed to address human coverage for failure of automated systems?		
40.	**Minimum On-Site Staffing Level**: As the CNSC develops changes to G-323 , they may want to consider innovative approaches to defining minimum shift complement that takes into account new designs and technology		
41.	The requirements for minimum complement should not be solely related to the use of automation for plant operation and maintenance, but also to the level of safety conferred by the use of inherent and passive safety features in the design.	*Clarification*	
42.	Security may require a significantly different staffing approach from existing large units. A traditional size of security staff might pose a significant burden on small plants. The inherent SMR design could result in a reduced need for security staff. This may require a review and revision of the nuclear security regulations.		
43.	Clarification should be provided regarding G-323 and the on-site nuclear response force complement as part of the minimum staff complement at a nuclear facility. G-323 does not make any reference to Nuclear Security Regulations article 32: *"Every licensee shall at all times maintain an on-site nuclear response force that is capable of making an effective intervention, taking into account the design basis threat and any other credible threat identified by a threat and risk assessment."* However, G-323 does define emergency to mean *"an abnormal situations that may increase the risk of harm to the health and safety of persons, the*	*Clarification*	

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	environment, or national security, and that requires immediate attention of the licensee". It is expected that more specific guidance on the minimum staff complement for the nuclear response force is available in REGDOC-2.12.1		
44.	This issue arose some decades ago in Canada. For example, the SLOWPOKE 20 kW research reactors licensed in Canada can operate unattended and remotely monitored for up to 24 hours. The basis for this permission was the inherent / passive safety of the facility. Later on, during pre-licensing discussions on the SLOWPOKE Energy Systems 10MW(th) reactor (SES-10), it was proposed that due to the inherent and passive characteristics of the design, a licensed operator was not required to be present in the control room. In case of external events such as fire or security, a local attendant could shut the reactor down manually. Startup or restart had to be done by a licensed operator.		
	We posit that staffing levels should be tied intimately to the level of inherent / passive safety of the machine (not as much to automation of the control and safety systems). However no new regulations are needed: CNSC document G-323 provides sufficient flexibility for this case to be made.		
	Section 2.7: Safeguards Implementation and Verification The CNSC would like to hear if its current framework provides enough clarity to effectively ensure safeguards verification of novel fuels and new designs.		
45.	This section covers all the main points and is consistent with CNL's position in References [J. Whitlock and J. Sprinkle, "*Proliferation Resistance Considerations for Remote Small Modular Reactors*", The 2nd International Technical Meeting on Small Reactors, Ottawa, Canada, 2012 November] and [J. Whitlock and J. Sprinkle, *"Proliferation Resistance Considerations for*		

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	Remote Small Modular Reactors", CNL Nuclear Review, vol 1, no 2, Dec. 2012] in that "Safeguards by Design" – i.e. engagement of safeguards experts (including CNSC, IAEA, and could include SbD expertise at CNL) should be engaged as early as possible in the design/siting process.		
46.	In general the safeguards arrangements, as they are defined by the IAEA with the CNSC's additional requirements of RD-336, should be accepted as they are. However, some designs remove/replace/transport the entire core, which will no doubt require special techniques to verify fuel being added and removed from the core off-site (and possibly outside of Canada). There may be some technical challenges with safeguards for SMRs, as outlined in the regulations and licences e.g. remote location with limited access of IAEA inspectors, long-life sealed core, high initial excess reactivity, etc. Some of these challenges are also potential benefits; i.e., a remote location makes it more difficult for diversion; the same is true of a sealed long-life core.	*Clarification*	
47.	The current framework for safeguards, as described in RD-336 and GD-336 relies on an item (e.g., individual fuel assembly) and inventory accounting approach for maintaining Continuity of Knowledge of containment and surveillance (C/S) data of the nuclear fuel throughout the operational life of the reactor. Water cooled reactors have been amenable for using item and inventory accountancy and periodic independent verification of the	**MAJOR**	Since the licence applicant is required to demonstrate that the facility design meets Canada's international obligations for nuclear non-proliferation, it is unclear how a safeguards program can be developed by the licence applicant for non-water cooled SMRs. It is also unclear what features the SMR designers need to include in their designs to facilitate the implementation of safeguards.

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	accountancy and C/S data by visually inspections and scanning of the fuel assemblies. • However, the nuclear material accountancy requirements in RD-336 and GD-336 may not be appropriate for many SMRs that are not water-cooled reactors. Further discussions will be needed to agree on appropriate approaches to fulfilling Canada's international obligations for nuclear non-proliferation for each type of SMR.		
48.	Application of safeguards is highly reactor-design-specific – for example the safeguarding of a core with at-power fueling is quite different from one that is (truly) sealed during the entire core lifetime and then removed as a unit. For the former, the concern would be unauthorized introduction or removal of material into/out of the core; for the latter, the concern would be diversion of material during spent core removal or transportation. Additional regulatory guidance does not appear to be necessary. One common thread may be the increased use of automation to reduce the number of site visits required by the IAEA/CNSC – i.e. real-time automatic monitoring of movements of material, with the data transmitted to the IAEA. Guidance on the standards for such monitoring might be useful (measurement parameters, reliability, protection against tampering, communications requirements etc.) but could be developed by industry (or the proponent).		
	Section 2.8: Deterministic/Probabilistic Safety Analyses		

#	Comments/ Responses to CNSC Questions	Major Comment/ Request for Clarification	Impact on Industry, *if major comment*
	The CNSC would like to know are the regulatory requirements and guidance clear for the kinds of alternatives that might be proposed for Deterministic/probabilistic safety analyses for SMR facilities. Do the existing requirements permit the establishment of a suitable level of probabilistic safety analysis for different novel designs? Does enough information currently exist to apply probabilistic safety analysis to novel designs?		
49.	The regulatory framework for SMRs has to take into account designs that include (extensive) use of passive features that render some or most of the traditional PIEs and scenarios to have no effect on core damage or on releases of radioactive materials in the environment. Traditional PSAs may be difficult to be employed, and alternate techniques should be recognized as applicable or acceptable for safety cases..	**MAJOR**	Use of alternate (simpler) methods in lieu of traditional PSAs should be acknowledged by and be acceptable to the CNSC.
50.	Approaches to and requirements for probabilistic safety analysis continue to be in a state of development for both large reactors and SMRs. To avoid overly detailed and expensive PSA efforts, the scope should be limited to feasible events. The SMR passive designs will typically eliminate many of the accident scenarios used in the past. Level 1 and Level 2 PSA should be adequate to indicate level of safety.		
51.	The requirements and guidance offered by CNSC documents (REGDOC-2.4.1, “Deterministic Safety Analysis”, and REGDOC-2.4.2, “Safety Analysis: Probabilistic Safety Assessment (PSA) for Nuclear Power Plants”) are a good starting point for SMRs. The extent of applicability depends on three aspects: 1. the documents are aimed mainly at water-cooled reactors 2. the documents do not deal with passive systems and inherent safety to a significant degree 3. the documents do not really cover the issue of identifying potential accidents on a design which has little operating experience.		

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	The first issue can be addressed by the vendor of a non-water-cooled reactor design by systematically reviewing the CNSC safety analysis requirements and excluding those that are not applicable, and/or identifying the underlying requirement (safety intent) and applying that instead. The vendor would also have to add any requirements for phenomena in the design that are not addressed by the REGDOCs. Given the range of coolants for SMRs (molten salt, gas, molten metal, organic liquid, water etc.) it may be difficult to give guidance beyond this basic principle. The second aspect is more fundamental. If a vendor provides a design with a high degree of passive/inherent safety, the vender will likely make the case that inherent safety can always be credited, and that failure of truly passive systems or structures (including the reactor vessel, if applicable) can be "practically eliminated". As a consequence, there would be no need to provide safety-grade backup to safety functions which are covered inherently or passively, nor to include reactor vessel failure as part of the Design Basis. As per our overall comment, while new regulatory requirements are not needed, acknowledgement of this principle and guidance on demonstrating it as part of the application of a graded approach to safety would be useful. The third issue applies to any new design. Much of our experience on identifying initiating events comes from real operating experience. There are various techniques to get a "complete" list of initiating events (e.g. PSA, top-down approach, master logic diagram, Systems Engineering Process). These techniques are fairly well-established and no further regulatory guidance is needed. However conventional PSA does not fit well with passive systems, especially those that have no moving parts and/or for which there is no		

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	operating history. There is a need for some development in PSA methods for such systems: we propose that the development be initiated by the vendors and once some good examples have been accumulated, CNSC could use them as an input to regulatory guidance.		
	Section 2.9: Defense In-Depth and Mitigation of Accidents The CNSC would like comments on: • Given some of the novel safety approaches that vendors are proposing, are the existing requirements and guidance around defence in depth adequately clear for prevention and mitigation of accidents? • Consider this question with particular attention to the following topics and combinations thereof: • Application of inherent and/or passive safety features • Application of alternative instrumentation and control strategies (e.g., remote monitoring and intervention of a fully-automated facility) • Non-water cooled technologies • Transportable sealed and factory fuelled SMRs (see section 2.11) • Facilities proposed to be located in highly remote regions		
52.	The five levels of defence in depth have obvious relevance to traditional water-cooled reactors. It must be recognized that this is at least partly because the entire notion of "defence in depth" itself has evolved with experience from operating LWRs and HWRs. The basic principles of these reactors have not substantially changed since their genesis in the first decades of nuclear technology, but just as the technology has become more mature and refined, so have the safety and regulatory concepts. When taking in to account the novel and passive safety features in the proposed SMR designs, however, the distinction between some of the levels of defence in depth becomes unclear. The description of a "beyond design basis" accident, necessary to distinguish between levels three and four, is		

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	replete with examples of containment challenges in water-cooled reactors. This reflects how experience with water-cooled reactors has shaped the regulatory framework. When bringing novel technologies up for licensing, a vendor then has to consider: • What inherent or passive features of the design should be credited in the analysis of a design basis accident (level three)? Should some be withheld so that they can be applied beyond design basis (level four)? • If the design basis covers a significant range of events up to and including those which would be considered beyond design basis in contemporary water-cooled reactors, does that mean that extremely extraordinary events need to be considered to fulfill the requirements for defense in depth?		
53.	The innovative safety features of SMRs (passive/inherent safety characteristics that will account for the safety benefits) can constitute the basis for a change in traditional safety design practices. This may lead to a change in the relative importance of the 5 different levels of defence in depth.	**MAJOR**	Existing framework used for evaluating defense-in-depth for conventional NPP should be adapted for SMRs. Oversimplifying a bit, advanced SMRs typically put much more emphasis on Levels 1 and 2 of defence-in-depth in the design than do conventional power reactors, and require less on Levels 3, 4 and 5. Example: For example, if a large Reactor Coolant System (RCS) pipe break is not possible because of the absence of large RCS pipes, and if spontaneous pressure-vessel failure (e.g. at a nozzle) is practically eliminated, and if there are no accident scenarios such as un-terminated loss of reactivity control or loss of heat sink which would induce vessel failure, then the Emergency

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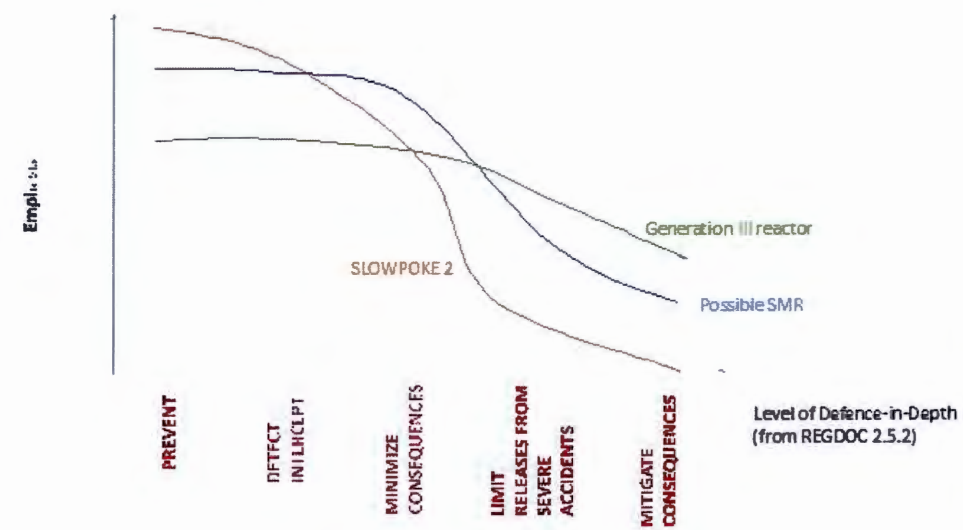
			Core Cooling system and the containment need not be designed for LBLOCA – i.e. Level 3 defence-in-depth is less important for LBLOCA.
54.	Those SMRs which are just smaller versions of conventional NPPs can and should match conventional defence-in-depth philosophy. However many SMRs will have more emphasis on the "front-end" aspects of defence-in-depth, as shown *conceptually* in the figure below: (*to your right ->*) An increased emphasis on the first level – prevention - implies an increased emphasis on *inherent* safety characteristics. An increased emphasis on the second and third levels - control and protection - implies an increase in either inherent safety characteristics or passive safety systems. An SMR which places more emphasis on the front-end of defence-in-depth will not need to place as much emphasis on the back-end (accident management and off-site measures). Vendors of such SMRs may justify, for example, a smaller Exclusion Area Boundary, and reduced scope for on-site and off-site measures for severe accidents, based on the "practical elimination" of the latter. In short (as with the SLOWPOKE 2 reactor example given earlier) application of defence-in-depth to innovative SMRs should be handled within a combination of a graded approach and risk informed approach to regulation. We do not see a need for further detailed guidance on remote monitoring and intervention *per se*. The control room in existing multi-unit plants such as Pickering can already be a long distance from the reactor that it is monitoring and controlling. Reliability is a concern as the distance increases, especially if the connection changes from wired (as in Pickering) to wireless. It would be up to the proponent to demonstrate the adequacy of the	**MAJOR**	

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	connection, along with a demonstrably safe fallback if the connection failed or was corrupted. A more challenging situation arises when no local action is possible. We would expect the vendor to make the case that any accident (including BDBAs) would not lead to releases for a considerable time, regardless of success or failure of all control and monitoring (remote or local). The case would presumably be based on inherent or passive characteristics plus robust protection against external and malevolent events. In general, traditional defence-in-depth concepts will apply regardless of reactor coolant. Water-cooled, gas-cooled and metal-cooled reactors can meet the traditional "five barriers" concept of defence-in-depth. Some interpretation would be required for molten salt reactors, where the fuel "boundary" does not exist as such, but is offset by the ability of the molten salt to retain fission products. We suggest that the proposed interpretation of defence-in-depth for non-water-cooled reactors is best left up to the vendor of each type. We have no comments on transportable sealed and factory fueled SMRs.		
55.	The general approach of defence-in-depth is applicable to SMRs. The difference will be in the array of events that must be defended against. It is expected that this scope will be reduced by the inherent design features. This will require a review to determine which events are addressed with Level 1 and Level 2 defences without adding mitigation features.		
56.	The implementation of practical elimination should be further clarified in discussions between the nuclear industry and the CNSC. The nuclear industry and the CNSC should achieve mutual understanding of the	*Clarification*	Since SMR designs are relying on being able to make safety cases for greater safety by the use of passive safety features and novel design features, clarity on the extent of demonstration of these features is needed.

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	expectations for the degree of substantiation and degree of confidence when implementing practical elimination. It is recognized that probabilistic estimates of accident sequences for SMRs may have larger uncertainties, and alternative methods for risk assessment may be used. Hence, practical elimination of an accident sequence should include consideration of features in SMR designs such as multiple layers of protection, enhanced safety margins, and passive safety features.		
	Section 2.10: Emergency Planning Zones The CNSC would like to know are the requirements and guidance related to EPZs sufficiently clear to enable an organization to submit a license application for a facility-specific EPZ while still meeting the CNSC's expectations regarding the environment and worker health and safety? Are there specific considerations that need to be incorporated into requirements and guidance for specific siting cases like remote regions?		
57.	Safety analysis informing EPZ is not just probabilistic safety analysis, contrary to first para of page 16.	*Clarification*	
58.	The guidance and requirements related to EPZs are sufficiently clear.		
59.	We believe the CNSC discussion paper covers the issue well, namely that there is already sufficient flexibility in the requirements for emergency planning zones so that no further regulatory guidance is needed. Again we expect the case for a smaller EPZ to be based not only on projected releases in accidents, but also in the confidence that the calculated releases are bounding, such confidence being related to the degree of passive/inherent safety of the plant. Remote regions represent a special case of the above, in that short-term off-site emergency measures are difficult to implement, making it even more		

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	imperative that they are not needed (unless they can be done in a timely and reliable fashion by local personnel such as police).		
	Section 2.11: Transportable Reactor Concepts The CNSC is seeking information about deployment scenarios for further discussion. Examples of questions to inform future discussions include: • How might deployment of such concepts proceed? (The CNSC seeks examples such as case studies.) • What nature of activities will occur at the factory or service facility versus the site and how will those activities interface with one another from a management-system perspective? • What would environmental impact statements look like? • What would the relationship between the manufacturing facility, the facility fuelling the reactor modules, the carrier transporting the modules and the site operator entail? • How would post-shipment inspections be conducted and addressed by the licensee of the deployment site facility? • How would these scenarios be impacted if major components or modules were imported or exported? • How would transport be conducted such that transport requirements would be met throughout the deployment journey? • What is the strategy for performing safety analysis for all deployment activities? • How would these scenarios be impacted if major components or modules were imported or exported? • How would transport be conducted such that transport requirements would be met throughout the deployment journey? • What is the strategy for performing safety analysis for all deployment activities?		
60.	While Canada has Certified Packages for used nuclear fuel, the packages for new and used reactor cores could possibly be developed by the vendor, approved in a foreign country, and then certified in Canada. A cursory review of the PTNSR Regs does not indicate any show-stoppers for SMRs however this needs to be confirmed. However, for the area of nuclear materials transportation, an import/export licence can complicate the whole process. Since the used and new cores both contain fissile material,	**MAJOR**	

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	prevention of both tampering / diversion during transit and criticality will be areas of detailed review.		
61.	With respect to the relationship between the manufacturing facilities, the facility fuelling the reactor modules, the transport of the modules and installation at the site, this type of approach will need to consider a safeguards verification approach that starts at the manufacturing facility and maintains a continuity of knowledge through the installation at the site. For SMR designs where conventional safeguards verification methods for water-cooled reactors cannot be used, alternative safeguards verification methods will need to be developed.	**MAJOR**	The safeguards verification methods for MSRs could impose new requirements on the design, manufacturing, transport and installation of SMR modules. The SMR designers need guidance.
	Section 2.12: Increased use of Automation for Plant Operation and Maintenance The CNSC would like to know is additional clarity needed in existing requirements and guidance related to the implementation of automation strategies for SMRs. Specific to autonomous operation with remote monitoring and intervention, what safety and control measures could be taken to help prevent/mitigate communication loss between the SMR and the monitoring facility?		
62.	One aspect that may deserve attention is the increased automation of maintenance through computerized aids (e.g. virtualization). Generally this should increase the reliability, efficiency, safety and effectiveness of maintenance. However it also introduces the possibility of errors in the maintenance software or underlying data, and the effect thereof on plant safety. This needs to be considered in the plant safety case, and perhaps follow similar graded qualification and development approaches as used for computerized control and monitoring equipment for the plant systems as covered by CSA-N290.14. With respect to autonomous operation, it may be useful to first develop CSA standards on reliability and performance requirements of remote control/monitoring, as a precursor to regulatory prescription. The design		

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	would have to cater to a long operator response time (possibly through inherently safe design features) and also to the fact that the communication link extends outside the plant boundary and hence is subject to additional hazards and reduced reliability. Dedicated communication links may be an option to improve reliability and additional measures may be necessary to address cyber security. There may also be lessons learned from satellite control. We have already noted that there would need to be a safe "fallback" of plant behaviour in case remote communication / monitoring all fail, giving enough time to allow an operator`s return to the site for corrective actions using the local facilities.		
	Section 2.13: Human/Machine Interfaces in Facility Operation The CNSC would like to know is additional clarity needed in existing requirements and guidance for HMIs used for facility operation and maintenance. If so, what areas could benefit from additional clarity?		
63.	CNSC has recognized the potential for some clarifications to be needed. It is suggested that updates be made to regulatory documents, if and as needed, based upon questions from technology developers.	*Clarification*	
64.	We agree that the existing requirements cover most of the design aspects required to design Human/Machine Interfaces (HMIs) capable to support oversight and control of SMRs. One prospective area that could benefit from additional clarity would be guidance for HMI technology selection. This is area is not specific for SMRs but for new NPPs in general. The regulatory guidance should encourage approaches that permit the selection of the best available technologies that can be qualified for system operation and maintenance. Human performance and operational safety and effectiveness should be major deciding factors in choosing technologies. Designers need to consider		

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	various trade-offs associated with alternative perceptual and interaction modalities such as touch, voice, and gesture interaction. Technology selection will require accounting for mental and physical demands (by the characteristics of the device, physical workspace, and collaboration among personnel). This in turn means that there is a need for guidance for levels of automation, computational intelligence, operator support systems, and other methods of reducing complexity, to optimize human automation interaction (building further to our response to question in Section 2.12 regarding autonomous operation). New HMI technologies such as tablets or handheld devices, large and high-resolution displays, wearable devices, and augmented reality systems have been introduced into other industries and can be expected to become predominant options for the nuclear industry, particularly for new builds. Most new reactor designs will employ first of a kind (FOAK) technology in this industry (i.e. having not been used in the older generation of NPPs). FOAK designs need to define new models of human automation collaboration, the need for integrated system validation, and new concepts of operation. This can be achieved through use of simulation, test beds, and prototypes, for example, as methods to provide proof-of-concept evidence of the appropriate use of new HMIs prior to acceptance. Through following verification and validation activities in the existing guidance (e.g. G-278), these new designs should fit the existing requirements and guidance for HMIs used for facility operation and maintenance. Furthermore, CSA N290.12-14, "Human factors in design for nuclear power plants", addresses the challenge of integration by the requirement, "HSIs [Human System Interfaces] and functionality shall be treated not only as an assembly of		

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	discrete controls, indicators, systems or SSCs, but also as an integrated whole".		
	Section 2.14: The impact of New Technologies on Human Performance The CNSC would like to know is additional clarity needed in existing requirements and guidance for human performance in an SMR environment.		
65.	The existing human performance requirements and guidance are sufficiently clear with respect to new technologies. Perhaps greater emphasis should be placed on system knowledge in the personnel training requirements documents, due to the potential increase in system complexity that may accompany the introduction of new technologies. Essentially advanced technology may reduce the workload of personnel but knowledge of how the system works is required to properly respond in the event of malfunction.		
66.	With more passive design features likely to be included in SMR designs, it is expected the focus of HF will shift even more onto the design aspects and phases of the SMRs. CNSC regulatory documents should be reviewed to ensure that they are not too closely structured to older (and especially CANDU) designs, and that they allow for flexibility in approach (e.g. to more passive safety features).	*Clarification*	
67.	Additional clarity is not needed in the existing requirements and guidance for human performance in an SMR environment. The existing guidance encourages the production of a human performance monitoring program to provide reasonable assurance that completing a thorough HFE program achieves a verification and validation of the control room, and integrated systems design, that is maintained over time (from NUREG-0711, referenced in G-276).		

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	Under the topic of "The impact of new technologies on human performance", interesting areas to note are: 1) The use of computerized operating procedures – Operating procedures are essential in the day-to-day management of NPP operations. Using computerized operating procedures is a major shift from current operating NPPs for normal and emergency operations (many HMIs use analog I&C, hardwired controls such as switches, knobs, handles; and walk-up control panels are arranged to be used with paper procedures). Design, format, representation, and the contents of computerized operating procedures are a few factors that will impact the effectiveness and human performance. The human performance monitoring program should be able to trend human performance including interaction with computerized operating procedures. 2) Digital I&C – The use of digital I&C (versus analog) will impact physical workspaces, operator tasks, procedures and personnel communication and collaboration. For example, during operators' primary tasks (e.g. monitor and control) in a new digital based system, operators may be burdened with a secondary task such as retrieving information or interface configuration tasks. On the other hand, with the increased automation provided by the system, the operator could potentially suffer from low workload and boredom. The requirements and guidance documents listed in Section 2.14 do not explicitly address these types of human factors challenges; however, they should be realized by following a HFE program, and as a result managed accordingly.		
	Section 2.15: Financial Guarantees for Operational Continuity		

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	The CNSC would like to know is additional clarity needed in existing requirements and guidance related to the implementation of financial guarantees for operational continuity to ensure safe termination of licensed activities? Are there other financial instruments not listed in G-206 that would be useful in helping put financial guarantees in place?		
68.	In fact, Financial Guarantees are now required for all licences in Canada, to our knowledge, not just for major nuclear facilities, mines and mills.	**MAJOR**	It would be useful to know which financial guarantee regime would apply for small prototype facilities – similar to that for existing nuclear reactors, or more aligned to those for licensees of sources and labs.
69.	REGDOC-3.5.1 section 2.1 states that applicants must be aware of and comply with the Nuclear Liability and Compensation Act (formerly the Nuclear Liability Act). The discussion paper does not mention the financial requirements in the Nuclear Liability and Compensation Act. Since the CNSC has acted in an advisory role to the Minister of Natural Resources on the designation of non-power reactor facilities under the Regulations, the CNSC should provide information how they will advise the Minister of Natural Resources on the need for a Regulation that is applied to SMRs to account for the range of nuclear liabilities associated with increasing the number of SMR modules deployed at a site.	**MAJOR**	The owner and operator would need to know the financial commitments for nuclear liability insurance before making the decision to build an SMR facility. These financial commitments would affect the operating costs for the SMR facility.
70.	As TEI is not a licensee or owner of an SMR, we have limited comments on this aspect. G-206 is broadly applicable to SMRs and we do not see the need for major changes. One aspect that should be considered is that the owner and the operator of an SMR may be different, especially with a fleet model, where the owners could be local and the operator could be national or even international. Since the operator is the licensee, it is important that the provisions of G-206 can be implemented on the operator – i.e. that they do not depend on the resources of the owner, who may be a local business or small municipality, and that they are enforceable for a foreign operator.		

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	There have been some Canadian precedents where the owner and the operator differ (Douglas Point, part of Pickering A (historical), Bruce A/B (current)) but these have always involved large Canadian organizations; SMRs represent a potential broadening of this situation.		
	Section 2.16: Site Security Provisions The CNSC would like to know: • What regulatory issues may present challenges to deployment scenarios for SMR facilities? • How could subsurface or civil structures be implemented as part of the security by design approach? • How might security provisions differ for SMRs with a very limited onsite staff and located in a remote region? • How would possibly lengthy offsite response times be addressed? • How would security provisions be addressed for offsite monitoring/control of facilities if used?		
71.	One would expect a SMR operator to argue that in view of enhanced inherent/passive safety characteristics, a smaller security force per MW can be justified than for a conventional NPP. The Threat-Risk-Assessment could be used to justify a smaller security force. Nuclear Security Regulations or supporting Regulatory Documents may need to be revised to account for SMR design including the off-site monitoring issue noted in the discussion paper	*Clarification*	
72.	SMRs will require a completely fresh look at site security because the credible threats will potentially be completely different. If nuclear material is not stored on site other than in the reactor that significantly reduces the vulnerability. Use of passive systems may eliminate most of the systems vulnerable to sabotage. While the regulatory framework may be applicable, the operating plant experience may not be applicable.		

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73.	We agree that the *Nuclear Security Regulations* enable a graded approach to security. The Regulations specifically require on-site security officers and an on-site nuclear response force. This may be problematical for small and/or remotely located reactors. As previously discussed for safety, the trade-off for on-site staff has to be *inherent* security resistance for design-basis and beyond-design-basis threats, sufficient to prevent release of radioactive material for the time that is required to detect a security violation, and to travel to, gain control of, and safely stabilize the facility. Regulatory guidance on this trade-off would be useful. Experience to date with security at unmanned hydro-generating stations may be instructive.		
	Section 2.17: Waste Management and Decommissioning The CNSC would like to know • What are some of the key strategies for waste management, spent fuel management and decommissioning that the CNSC and licensees need to consider for various SMR deployment scenarios? • For example, for companies considering a fleet of SMRs across a wide geographical area, how would waste and decommissioning be addressed? • In implementing these strategies, where are the challenges that exist in interpretation of current requirements and guidance?		
74.	SMRs with factory fueled cores within a lower range of operating life (e.g., 5-10 years) need to address storing of the used cores, as the size and/or layout of the sites may not allow storage of too many of the cores (assuming they are not exported back to the country of origin). Industry now stores used fuel in wet storage (fuel bays), before moving it to dry storage containers, until a disposal facility is available.	*Clarification*	

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	CNSC regulatory framework will need to be flexible enough to adapt to various scenarios, not just on-site dry storage.		
75.	REGDOC-3.5.1 section 2.1 states that applicants must be aware of and comply with the Nuclear Waste Act. The discussion paper does not mention the financial requirements in the Nuclear Fuel Waste Act The current Nuclear Fuel Waste Act would need to be revised if the operator of an SMR does not meet the definition of a nuclear energy corporation in article 2 of the Nuclear Fuel Waste Act. Furthermore, articles 10(1) and 10(2) would need to be revised to having a funding formula to account for increasing the amount of nuclear fuel waste as a function of the number of SMR modules that would be deployed at a site.	**MAJOR**	The owner and operator would need to know the financial commitments for nuclear fuel waste before making the decision to build an SMR facility. These financial commitments would affect the operating costs for the SMR facility.
76.	We believe that in general the existing regulatory documents cover waste management and decommissioning for SMRs. There are differences – for example the use of fuels other than zircaloy-clad UO2 – which may require different strategies for interim storage and long-term disposal. However these can be dealt with technically using the existing regulatory framework. In addition, for some SMR designs it may be advantageous from a waste minimization and fuel utilization point of view to reprocess the used fuel. This has no precedent in Canada for power reactors, and will need regulatory guidance when and if it occurs.		
	Section 2.18: Subsurface Civil Structures Important to Safety The CNSC would like to know • Where SMR industry work is being performed in this area to address aging management issues in codes and standards? • Of particular interest is ongoing work being done on technologies necessary to reliably demonstrate that such structures remain fit for service over the life of the facility including provisions for safe storage and decommissioning plans?		

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77.	Existing plants have significant embedment of safety related structures and are often located in areas with relatively high groundwater tables. In many cases there are areas of these structures that are difficult or impossible to monitor for degradation. The embedded designs of SMRs should not be considered unique.		
78.	Subsequent Licence Renewal efforts are looking at the issue of structural degradation, specifically for areas that cannot be directly inspected. It is expected that these efforts will develop a criteria based on some combination of testing, inspection and evaluation of experience.		
79.	As noted in the discussion paper, this is not a new issue and for some modern pool-type reactors, CANDU spent fuel bays, etc. underground location is an essential part of defence-in-depth. Given the lack of experience on underground SMRs, however, it might be useful for industry to lead in writing a "best practices" summary of engineering underground reactors, before the CNSC steps in with regulatory guidance. There are already a number of CSA standards dealing with some of these aspects, with CNSC specialists participating actively in the development of these standards. As an example CSA N287.8-15, which was issued recently, deals with "Aging management for concrete containment structures for nuclear power plants"; it builds on REGDOC 2.6.3 and IAEA NS-G-2.12. This specific standard can be expanded to provide the necessary details by the industry and CNSC. Another example is the CSA N287, CSA N289 and CSA N291 series of standards, which already cover the design consideration for concrete containments, seismic and safety-related structures. These standards can be expanded to provide more details for subsurface civil structures. Several		

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	aspects of the design such as loads, load combinations, analysis, acceptance criteria for stresses and strains, reinforcement covers, documentation etc. are already covered by these standards and the additional details required by the industry and CNSC can be provided in these series of standards. It should be stressed that subsurface civil structures design, analysis and construction are considered well established in civil engineering practice. There are several ASCE (American Society of Civil Engineers) publications and standards dealing with these areas. The role of the industry and CSA, with CNSC participation, is to build on this practice by accounting for the unique additional requirements of the nuclear industry.		
	Section 2.19: From Section Three: Fusion Technologies The CNSC would like to know: • What are the types and magnitudes of risks and hazards that would be posed by different fusion technologies (conventional and radiation hazards)? • With this in mind, how would the risks posed by activities involving fusion reactors differ from current nuclear fission reactors? • Should fusion reactors be regulated differently than fission reactors?		
80.	Fusion and fission technologies are not necessarily discrete. Since most practicable fusion interactions release free neutrons, a novel reactor concept could incorporate both fusion and fission as a source of energy. A single regulatory framework could be applicable to both fusion and fission reactors and any combination thereof. If the risk of operating a fusion reactor is quantifiable, then a fission reactor with the same quantifiable risk should be regulated identically.		
81.	Industry suggests that these are all excellent questions for which a thorough review of the regulatory framework would be required. Without more information on fusion reactor designs, we cannot comment further.	*Clarification*	

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82.	In our view fusion reactors should be regulated the same way as fission reactors. The hazards are different but the mechanisms for quantifying and managing those risks are the same. • The most significant difference between fusion and fission is fusion's dependency on a source of external energy to initiate and sustain the reaction – principally electricity to heat plasmas, generate magnetic fields for containment, inject fuel, power lasers, etc. • Fuel handling is a potential issue given the challenges with handling tritium • A waste stream still exists as components become activated over the course of operations.		