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

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Scope of TEI's Review

Terrestrial Energy Inc. (TEI) is pleased to offer comments on the above discussion paper on Small Modular Reactors (SMRs). We respond to those areas whereof we have some experience or knowledge; hence we do not respond to topics such as regulation of fusion facilities or transportation of pre-fuelled reactors.

We quote the CNSC summary question(s) for each topic verbatim, and then provide a response.

The responses address each topic at an overview level. We have not provided line-by-line review of the applicability of each CNSC regulatory document to SMRs.

Our comments represent the views of TEI and we do not purport to speak for other vendors or utilities. We understand, however, that many of the themes in this assessment are shared by other stakeholders.

Overall Comment

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. 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.

[1] "Regulatory Fundamentals", CNSC Regulatory Policy Document P-299, April 2005. See e.g. Section 4.2.

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. We suggest that the regulatory challenges are not primarily because the reactor might be small or modular, but because its safety characteristics differ fundamentally from currently operating reactors.

Section 2.2 - Technical information, including research and development activities used to support a safety case - Question

For the topic of "technical information, including research and development activities used to support a safety case", 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*).

TEI Response

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 experiments to be performed, and implied expectations for the results) become a *de facto* 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.

Section 2.3 - Licensing process for multiple module facilities on a single site -Question

For the topic of "Licensing process for multiple module facilities on a single site", are clarifications 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.

TEI Response

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 in a common Main Control Room being less than the number of reactors, 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 as for the first module. 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 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 fuelled. This may require expansion of the regulatory requirements for transportation.

Section 2.4 - Licensing approach for a new demonstration reactor - Question

For the topic of "Licensing approach for a new demonstration reactor", is there a need for 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?

TEI Response

The licensing case for any reactor has to demonstrate that the plant is safe to operate. 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.

Section 2.5 - Licensing process and environmental assessments for fleets of small modular reactors - Question

For the topic of "licensing process and environmental assessments for fleets of SMRs", 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?

TEI Response

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 include confirmation that the operating organization has the knowledge, authority and resources to operate one or more plants.

Section 2.6 - Management system considerations: Licensees of activities involving small modular reactors - Question

For the topic of “Management system considerations: Licensees of activities involving SMRs”, to help the CNSC prepare for alternative ownership and operating models that would be used in SMR deployment, more details (such as case studies) are sought regarding areas including:

- how deployment of different SMR concepts (e.g., factory fueled transportable concepts) would proceed
- how oversight for such deployments would be conducted
- 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

The CNSC will use this information for future, more detailed workshops to discuss regulatory implication of different deployment approaches. See section B.6 of appendix B for additional background information.

TEI Response

TEI has no comments on these questions.

Section 2.6.1 - Management system: Minimum complement in small modular reactor facilities - Question

For the topic of “Management system: minimum complement in SMR facilities”, 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?

TEI Response

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[2] provides sufficient flexibility for this case to be made.

Section 2.7 - Safeguards implementation and verification - Question

For the topic of "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.

TEI Response

Application of safeguards is highly reactor-design-specific – for example the safeguarding of a core with at-power fuelling 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[3]. 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 - Question

For the topic of "deterministic/probabilistic safety analyses", 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?

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2 "Ensuring the Presence of Sufficient Qualified Staff at Class I Nuclear Facilities – Minimum Staff Complement", CNSC document G-323, July 2007.

3 However even a "sealed" reactor may have penetrations for sampling, instruments etc.

Does enough information currently exist to apply probabilistic safety analysis to novel designs?

TEI Response

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.

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 his 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, he 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 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.

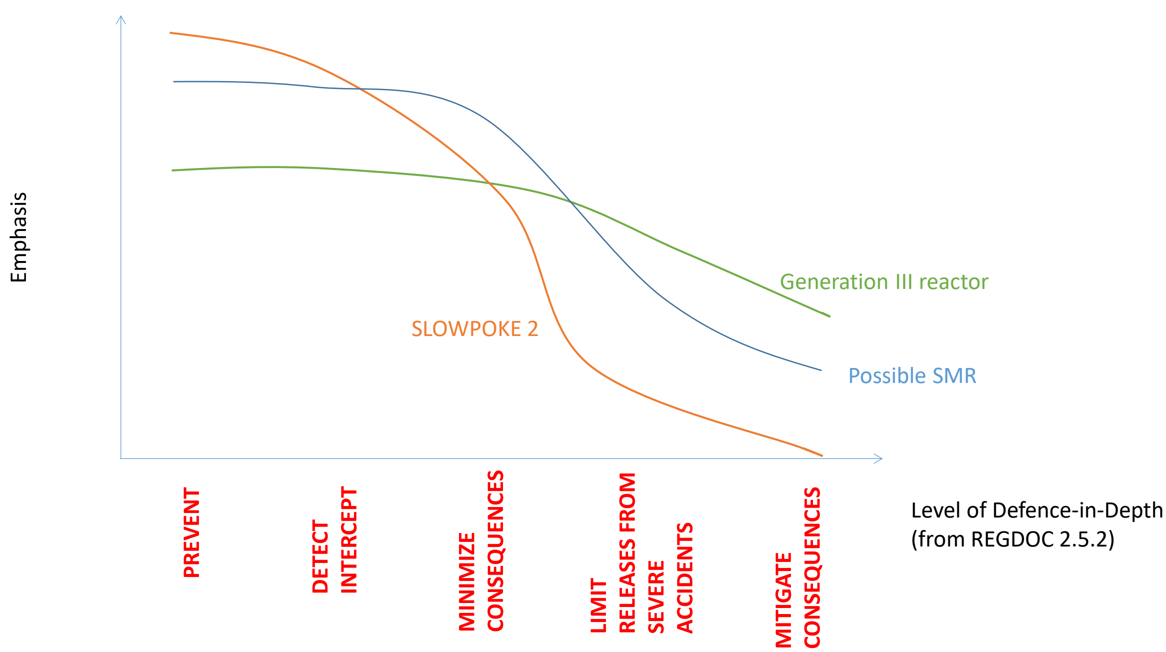
Section 2.9 - Defence in depth and mitigation of accidents - Question

For the topic of "defence in depth and mitigation of accidents", 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 fueled SMRs (see section 2.11)
- facilities proposed to be located in highly remote regions

TEI Response

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:



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 with a combination of a risk-informed and a graded 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 connexion changes from wired (as in Pickering) to wireless. It would be up to the proponent to demonstrate the adequacy of the connexion, along with a demonstrably safe fallback if the connexion 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 fuelled SMRs.

Section 2.10 - Emergency planning zones - Question

For the topic of "emergency planning zones", are the requirements and guidance related to EPZs sufficiently clear to enable an organization to submit a licence 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?

TEI Response

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 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 - Question

For the topic of "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?

TEI Response

TEI has no comments on this aspect.

Section 2.12 - Increased use of automation for plant operation and maintenance - Question

For the topic of "increased use of automation for plant operation and maintenance", 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?

TEI Response

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 industry standards (e.g. CSA Standards) on reliability and performance requirements of remote control/monitoring, as a precursor to regulatory prescription. The design 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 - Question

For the topic of "human/machine interfaces in facility operation", the CNSC is seeking comments from technology developers who are proposing new HMI technologies approaches/architectures for use in SMRs.

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?

TEI Response

We agree that the existing requirements cover most of the design aspects required to design 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 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 may need to define new models of human automation collaboration, 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 discrete controls, indicators, systems or SSCs, but also as an integrated whole".

Section 2.14 - The impact of new technologies on human performance - Question

The CNSC is currently working on a separate discussion paper on human performance and will request feedback on this specific topic in the near future.

For the topic of "The impact of new technologies on human performance" is additional clarity needed in existing requirements and guidance for human performance in an SMR environment?

TEI Response

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).

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 an HFE program, and as a result managed accordingly.

Section 2.15 - Financial guarantees for operational continuity - Question

For the topic of "financial guarantees for operational continuity", is additional clarity needed in existing requirements and guidance related to the implementation of financial guarantees for operational continuity to ensure safe conduct of licensed activities?

Are there other financial instruments not listed in G-206 that would be useful in helping put financial guarantees in place?

TEI Response

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.

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 - Question

For the topic of "site security provisions", what regulatory issues may present challenges to deployment scenarios for SMR facilities? For example:

- 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?

TEI Response

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 - Question

For the topic of "waste management and decommissioning", 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?

TEI Response

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 UO_2 – 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 - Question

For the topic of "subsurface civil structures important to safety", to complement the CNSC's investigation into ageing management of civil structures, where is 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?

TEI Response

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 considerations for concrete containments, seismic and safety-related structures. These standards can be expanded to provide more details for subsurface civil structures. Several 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 3 - Fusion technologies - Question

For the topic of “fusion technologies”, 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?

TEI Response

TEI does not have any comments on this issue.

Additional Comment (not in CNSC Question list)

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.