KEY MESSAGES for CNSC-NRC Joint Report on Technology-Inclusive, Risk-Informed Reviews for Advanced Reactors (ADAMS Accession No. ML21225A101):

- Both the Canadian and U.S. regulatory approaches effectively protect the health and safety of the public and the environment during nuclear power plant operation.

- Both the Canadian and U.S. regulatory approaches include some degree of technology-inclusive, risk-informed, performance-based review.

- Comparing the Canadian and U.S. regulatory approaches is a first step in enhancing understanding of each regulator's framework to enable greater cooperation and collaboration on advanced reactor designs that are contemplated for deployment in both countries

- The existing common ground between the Canadian and U.S. regulatory approaches can be leveraged to pursue joint technical reviews of advanced reactor applications in the future

- Ongoing work plans under the CNSC-NRC Memorandum of Cooperation (MOC) involve joint reviews of limited technical topics for specific advanced reactor designs that will further develop our capabilities to perform joint technical reviews

FREQUENTLY ASKED QUESTIONS

Q1: What is the purpose of comparing the LMP process with the Canadian approach?

In August 2019, the Canadian Nuclear Safety Commission (CNSC) and the U.S. Nuclear Regulatory Commission (NRC), signed a Memorandum of Cooperation (MOC) to increase collaboration on technical reviews of advanced reactor and small modular reactor technologies. This increased collaboration aims to enable joint technical reviews on future advanced reactor applications submitted to both regulators or to leverage reviews performed by each regulator. Since advanced reactor applicants will likely use a more risk-informed, performance-based approach than previous LWR applications, the comparison of the technology-neutral, risk-informed, performance-based approaches in each country's regulatory framework is a logical first step. Identifying similarities and differences in these approaches and understanding the potential regulatory implications can enable more efficient technical reviews and perhaps even joint technical reviews of these applications, particularly if an applicant submits the same application simultaneously to both regulators.

Q2: Are you aware of any potential applicants for advanced reactors in the US that plan on using the LMP process?

The NRC is currently conducting application reviews or pre-application engagement with several advanced reactor designers/applicants. The NRC endorsed LMP in RG 1.233 as one acceptable method developing a risk-informed, performance-based application and applicants may propose other methodologies along with suitable justification for their approach. Several applicants have indicated an interest in the LMP process but have chosen to protect business confidential information about their specific plans at this time.

Q3: Has anyone actually submitted an application using the LMP process? What is the experience basis for using the LMP process for advanced reactors?

The NRC endorsed the risk-informed, performance-based LMP process described in NEI 18-04 in RG 1.233 in June 2020 but has not yet received any applications using the LMP process. There have been several applications in the past for new reactors (e.g., AP1000, ESBWR, etc.) that have included use of risk-informed and performance-based approaches in specific areas, however, no applications have been received yet that include the use of LMP. The LMP process is a structured and comprehensive process for designing a facility that focuses on safety significance and risk significance. It uses risk insights, deterministic analysis, and defense-in-depth adequacy assessments to identify licensing basis events, determine safety classifications of SSCs, and determine special treatments for structures, systems, and components to ensure capabilities and reliabilities and the safety of the facility.

The experience basis for elements of the LMP process goes back decades years and includes use of a precursor process to LMP for the Modular High Temperature Gas-Cooled Reactor (MHTGR), the Pebble Bed Modular Reactor (PBMR) and the Next Generation Nuclear Plant (NGNP). In addition, several advanced reactor designers piloted the NRC's draft guidance DG-1353 on endorsement of the LMP process in NEI 18-04 during 2018 and 2019: X-Energy high temperature gas-cooled pebble bed reactor, OKLO heat pipe reactor, PRISM Sodium Fast Reactor, Westinghouse eVinci micro-reactor, Kairos Power fluoride-cooled high temperature reactor, and the Molten Salt Reactor Test Reactor. Reports of these LMP pilot exercises may be found in the section on Industry-Led Licensing Modernization Project on the NRCs public webpage at: https://www.nrc.gov/reactors/new-reactors/advanced/details.html#flexLearn

In addition, during final development of the LMP process under NEI 18-04, several DOE-funded and industry developed reports associated with the LMP were issued that served as the basis for developing the final NEI 18-04 document. These reports can also be found in the table referenced above.

Q4: Are any of these applicants also engaging in regulatory activities in Canada?

The following vendors have also begun regulatory engagements with the CNSC in Canada: GEH for their BWRX-300 design, and X-Energy for their Xe-100 design. Both vendors are currently engaged in the Vendor Design Review process. In addition, there are collaborative work plans currently in progress under the Memorandum of Cooperation between CNSC and NRC for joint review of specific technical topics associated with these designs.

Q5: There are some differences associated with the categorization of licensing basis events between the approaches. What are the practical implications of these differences in implementing the two approaches and ensuring facility safety?

As nuclear regulators, both the NRC and CNSC will ensure that as part of their licensing reviews and follow-on inspection and oversight that nuclear power plants will be operated safety. There is no practical difference between the regulatory approaches in reaching outcomes that ensure facility safety. Although there may be differences in defining categories of licensing basis events and the resultant safety-classifications of structures, systems, and components relied upon to prevent and/or mitigate potential events, the reliabilities and capabilities of these SSCs as well as adequate layers of defense in depth are ensured through both approaches.

Q6: There are also some differences associated with the regulatory limits on dose to the public which are highlighted by the comparison of the Frequency-Consequences target curve. What are the practical implications of these differences in implementing the two approaches and ensuring facility safety?

The Frequency-Consequences target curve draws insights from various regulatory criteria some of which are limits, such as the requirements of 10 CFR Part 20, and others that are criteria or guides for action. There are no practical implications in the differences in the curves for ensuring facility safety. Of primary importance to safety, both agencies have established regulatory dose limits based on widely accepted recommendations of the International Commission on Radiological Protection (ICRP). The ICRP is an independent, international, non-governmental organization with the mission to protect people, animals, and the environment from the harmful effects of ionizing radiation

Other dose criteria, such as the siting criteria in 10 CFR Part 100, which are also reflected in 10 CFR 50.34, are used as reference values in evaluating plant design features with respect to postulated reactor accidents. This is done in order to ensure that such designs provide assurance of low risk of public exposure to radiation, in the event of such accidents. These dose criteria are not intended to imply an acceptable limit for an emergency dose to the public under accident conditions.

The Environmental Protection Agency Protective Action Guides (PAGs) help officials select protective actions under emergency conditions. The PAGs are not limits, are not legally binding and do not represent the boundary between safe and unsafe conditions.

Q7: The NRC determined in their regulatory guide RG 1.233 which endorsed the LMP process that the single failure criterion was no longer necessary if an applicant is using the LMP process to design their facility. Why is the NRC allowing relaxation of the SFC for advanced reactors that don't have a lot of operating experience when using a new process such as LMP?

As noted in RG 1.233, the single failure criterion was applied to deterministic evaluations of licensing basis events for light water reactors (LWRs). Advanced non-LWRs will employ a diverse combination of inherent, passive, and active design features to perform the required safety functions. The LMP process focuses instead on a holistic and comprehensive "layers of defense" approach that includes reliability and availability of SSCs and combinations of SSCs to prevent and/or mitigate events and inherently includes single criterion in its approach rather than a relaxation of it. The LMP process includes a detailed evaluation of defense-in-depth adequacy that includes use of both risk insights from a comprehensive PRA as well as deterministic analysis of event sequences over a wide range of frequencies and establishment of risk and safety function reliability targets. The approach described in NEI 18-04 is consistent with the Commission's SRM approving the recommendation in SECY-03-0047 to replace the single-failure criterion with a probabilistic (reliability) criterion. The staff found that the integrated methodology in NEI 18-04, including assessments of event sequences and defense-in-defense obviated the need to use the single-failure criterion as it was formerly applied.

Non-LWR developers that construct a licensing basis for a design using an alternative to the NEI 18-04 methodology would need to maintain or justify not applying the single failure criterion to those LBEs analyzed in a deterministic or stylized approach, such as DBAs. The NRC provided guidance related to assumptions on passive failures and the application of the single-failure criterion in SECY-94-0084, "Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs," dated March 28, 1994 (Ref. 34), and the related SRM dated June 30, 1994.

The portion of the question referring to lack of operating experience for advanced non-LWRs was one that was addressed as a part of the LMP Lessons Learned Report in PRAQ1 and PRAQ2 (see table referred to in Q3).

PRA is an integral part of the LMP process. Early use of PRAs for investigating nuclear power plant risks (e.g., WASH-1400 completed in 1975) were completed before there had been a significant accumulation of large LWR service experience. The risk models and risk analyses employed in this study did not use any statistical analysis of LWR service experience, but rather the estimates of initiating event frequencies, component failure rates, and human error rates were based exclusively on information from non-nuclear industries and augmented using engineering judgment. The results of the Rasmussen study and associated risk insights had a major impact on the understanding of nuclear safety issues despite not having benefitted in any appreciable way from the accumulation of service experience. Such insights include the large risk significance of small break loss of coolant accidents (LOCAs), very low risk significance of large break LOCAs, importance of dependent failures including common cause failures and support system faults, and the important role of human errors.

For PRAs on advanced non-light water reactors today there are a variety of information sources and approaches to develop and quantify the PRA models. Progress has been made to varying degrees to develop PRA models and supporting databases for the four major categories of advanced non-LWRs being considered: high temperature gas cooled reactors, sodium cooled fast reactors, molten salt reactors, and microreactors using heat pipes. These advanced reactor PRAs benefit from using many components and systems that are common to LWRs and therefore benefit from the LWR service experience which has been responsible for reducing uncertainties in estimating most of the PRA component-level data. For components unique to each advanced reactor, there is evidence to support the estimation of failure data from research and test reactors, non-reactor facilities that have service conditions similar to those in the reactors, and engineering judgements to compare the new components to those for which service data is available.

A very important aspect of developing data for any PRA, including those on advanced non-LWRs, is the treatment of uncertainty in the estimation of the data parameters on initiating event frequencies, component failure rates and maintenance unavailability's, common cause failure parameters, and human error rates. The PRA standard requires that uncertainties be addressed in all the technical elements of the PRA, including the treatment of data. There are structured processes for developing PRA data based on expert elicitation that have been applied to estimating LOCA initiating event frequencies for LWRs for which statistical analysis of service data is insufficient because the events are so rare. Such approaches may be employed to augment the data for future non-LWR PRAs as well. The PRA standard includes requirements for the use of expert opinion in support of PRA database development and other PRA inputs.

Q8: Would use of the LMP process result in any differences in the responses for Emergency Preparedness in the US vs. Canada?

The LMP process will not impact emergency preparedness (EP). While the LMP process can be used to support the licensing of non-light water reactors, the requirements for emergency planning for these types of facilities will be established by the Commission through the agency's rulemaking process. The NRC is currently working on the regulatory framework for an alternative performance-based, technology-inclusive, risk-informed, and consequence-oriented approach to EP for small modular reactors and other new technologies. The LMP process can provide part of the information needed to demonstrate compliance with emergency planning requirements, but the requirements themselves are part of a robust defense-in-depth strategy in which EP provides an independent final layer of defense to protect public health and safety.