U.S. NUCLEAR REGULATORY COMMISSION SUMMARY OF THE DECEMBER 14, 2022, PUBLIC OBSERVATION MEETING TO DISCUSS PRE-APPLICATION LICENSING WHITE PAPER AND TOPICAL REPORT ON SAFETY STRATEGY FOR THE BWRX-300 SMALL MODULAR REACTOR

Meeting Summary and Staff Feedback

The meeting commenced on December 14, 2022, at 10:00 a.m. with the NRC staff's opening remarks that described the pre-application "White Paper," process as a means for the NRC staff to gain understanding of the objectives and provide early feedback on the approach the applicant will propose in a future submittal of a Licensing Topical Report (LTR) on the topic of "Safety Strategy" for the BWRX-300 small modular reactor (SMR). After the introduction of the NRC and Canadian Nuclear Safety Commission (CNSC) principal staff and review team, GE Hitachi Nuclear Energy Americas, LLC (GEH) used the "White Paper," submitted to the NRC and CNSC on December 7, 2022 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML22341A058), as a pre-submittal overview of its planned LTR, "Safety Strategy (NEDC-33934)" that is expected to be submitted for NRC staff review in early calendar year 2023.

GEH used the publicly available "White Paper," for its presentation to the NRC and CNSC staff, who participated in the meeting as part of a 2019 memo of cooperation with the NRC on advanced reactor and SMR technologies and as outlined in the September 2022, "Collaborative Information Sharing Charter," on the review of the BWRX-300 (ML22284A024). The presentation began with GEH clarifying its intent and goals associated with submitting the "White Paper" as a prelude to a possible future LTR. GEH further outlined their needed alignment aspects as they relate to their design's overall safety philosophy and design process used in development of the BWRX-300 that utilizes principles of layered defense-in-depth (DID) for the design of safety systems consistent with International Atomic Energy Agency (IAEA), SSR-2/1, "Safety of Nuclear Power Plants: Design." However, GEH specifically stated during a previous public meeting dated June 29, 2022 (ML22215A081), that after implementation of its final design and submitting it for staff's review under Title 10 of the *Code of Federal Regulations* (CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," or Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants," the BWRX-300 would expect to meet all the applicable NRC regulations and guidance as well as meet the design requirements in CNSC REGDOC-2.5.2.

Throughout the meeting, NRC and CNSC staff asked clarifying questions in addition to providing constructive feedback to GEH on their Safety Strategy design framework. There were no questions or concerns from the public. The presentation from GEH did not contain any proprietary information so a closed portion of this meeting was not necessary. As a result, the meeting was adjourned at 12:45 pm.

Staff feedback and Comments on the "White Paper"

NRC and CNSC staff provided verbal feedback to GEH regarding the details and information that could be provided to enhance their proposed future LTR regarding the BWRX-300 "Safety Strategy."

- **BWRX-300 Safety Strategy Design Process and Philosophy**

GEH presented the design process and philosophy for its BWRX-300 small modular reactor (SMR) referred to as the "Safety Strategy." The objective of this process is to establish a design with a high-level of safety using a layered defense-in-depth (DID) concept using an iterative risk informed process aligned with design requirements using selected guidance of the IAEA's Specific Safety Requirements SSR-2/1, "Safety of Nuclear Power Plants Design." During past public meetings with the NRC staff, GEH has specifically stated that for licensing the BWRX-300 in the United States; GEH would meet the regulations prescribed in 10 CFR Part 50, or 10 CFR Part 52 with no exemptions expected and satisfy all applicable guidance including "NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants" (SRP), and other applicable regulatory guides as well as Commission Policy statements specifically for advanced passive nuclear power plant designs.

CNSC staff listened to the discussions during the meeting and asked clarifying questions. At that time, CNSC assessment of GEH's proposed Safety Strategy (as described in the White Paper) consisted of feedback to GEH that the proposed strategy appeared to be generally consistent with CNSC's regulations and processes; and that they would give a more detailed assessment at the scheduled follow-up meeting

However, the NRC staff's assessment of the BWRX-300 Safety Strategy (as described in the White Paper) consisted of feedback that GEH should provide additional information to adequately address all elements of the NRC's regulatory framework including risk informed performance-based decision making which is based on regulatory compliance, maintenance of safety margin, and treatment of uncertainties. The NRC staff also reiterated that while this novel approach by GEH could be successful, NRC approval of the safety strategy will be based on an applicant showing conformance to NRC regulations or justifying applicable exemptions.

For example, GEH in its White Paper describes a risk-informed and performance-based approach using line of defense concepts supported by probabilistic risk assessment (PRA) fault sequence frequency to identify different categories of events which may not align with the requirements for structures systems and components (SSCs) under 10 CFR Part 50 or 52. This proposed approach has the potential to result in the final BWRX-300 design which is not in compliance with NRC regulations. In addition, consistent with staff requirements to SECY-98-144, on risk-informed and performance-based regulation, the identification and quantification of uncertainties needs to be addressed in a risk informed performance-based application. The treatment of uncertainties is not discussed in the White Paper. Also, the BWRX-300 Safety Strategy would need to demonstrate consistency with the Commission's policy statements on the use of PRA in regulatory activities (60 FR 42622; August 16, 1995), severe accidents regarding future designs and existing plants (50 FR 32138; August 8, 1985), and the several staff requirements memoranda for advanced light-water designs. Potential inconsistencies or deviations will result in additional NRC resources to ensure regulations are met, exemptions are justified, and Commission's expectations are addressed.

Further, GEH identified the fundamental safety functions for Defense Line 3 with a fault sequence frequency between 1.E-2/year and 1.E-5/year. The NRC staff commented that this approach of providing numerical cutoff frequencies to delineate event categories may exclude consideration of some hypothetical design basis events required by 10 CFR Part 50. For example, if the final design is determined to have a reactor coolant pressure boundary break frequency less than 1.E-5/year, the proposed strategy could result in a loss-of-coolant accident (LOCA) being defined as a beyond-design-basis accident which would not comply with 10 CFR 50.46. A LOCA is a postulated accident that is required to be analyzed regardless of frequency of occurrence. The NRC staff also provided the postulated accidents of steam-line rupture and a rod drop accident as additional examples of non-mechanistic events that are required to be analyzed as design basis accidents. The NRC then summarized this portion of the meeting by recommending that the proposed Safety Strategy concept must comply with the NRC regulations, or if not, exemptions to specific NRC regulations should be identified.

Next during the meeting, the NRC staff noted that the proposed BWRX-300 Safety Strategy may also need to align better with the NRC regulations and NRC guidance on the characterization of the safety-related SSCs needed for the mitigation of anticipated operational occurrences (AOOs) as defined in 10 CFR 50.2 and as implemented in accordance with the guidance from SRP Chapter 15, “Transient and Accident Analysis.” Specifically, in Section 3.2, “Defense Line 2,” on page 18, of the White Paper, GEH states that, “there is no regulatory basis for asserting that AOOs must be mitigated by safety-related SSCs.” However, 10 CFR 50.2 states that safety-related SSCs are those that are relied on during or following a design basis event to assure, in part: (1) The integrity of the reactor coolant pressure boundary, and (2) The capability to shut down the reactor and maintain it in a safe shutdown condition. AOOs are considered design basis events and are defined in Appendix A to 10 CFR Part 50, as those conditions of normal operation that are expected to occur one or more times during the life of the nuclear power unit.

The NRC staff additionally commented that the general design criteria (GDC) in 10 CFR Part 50, Appendix A provides the minimum requirements and criteria for maintaining the integrity of the reactor coolant pressure boundary, and for shutting down the reactor and maintaining it in a safe condition for AOOs and postulated accidents such that there is reasonable assurance that the facility can be operated without undue risk to the health and safety of the public. For AOOs, the GDCs prescribe a safe shutdown condition to be one where decay heat is being sufficiently removed and the fuel integrity barrier is maintained by demonstration of appropriate margin to the specified acceptable fuel design limits. SRP, Section 15.0, states that “*the reviewer verifies that the applicant has specified only safety-related systems or components for use in mitigating AOO and postulated accident conditions and has included the effects of single active failures in those systems and components.*” This statement was specifically added in 2007 to align with the minimum requirements in the GDC discussed above.

GEH stated during the meeting that the BWRX-300 Safety Strategy is a holistic approach to classifying SSCs. Upon assessment of the proposed information, the NRC staff noted that 10 CFR Part 50, Appendix A, GDC 1, “Quality Standards and Records,” require SSCs important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. Further, 10 CFR 50.55a, “Codes and Standards,” provides the specific requirements for design, fabrication, erection, and testing standards for certain systems and components of boiling- and pressurized-water reactors. NRC RG 1.26, “Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste-Containing Components of Nuclear Power Plants,” describes the quality standards for SSCs acceptable to the NRC staff for satisfying the requirements of GDC 1. In the NRC staff’s

opinion, the White Paper neither defines the various safety classes included in the strategy, nor describes the corresponding regulatory treatment of SSCs. The proposed holistic approach to classifying SSCs for the BWRX-300 may cause inconsistency with NRC regulations and does not specifically address the Commission policy regarding advanced passive light-water reactors SSCs designated for special regulatory treatment (RTNSS).

Further, IAEA SSR-2/1, which provides the foundation for GEH's safety strategy for BWRX-300, focuses both on safety and the environment. The NRC staff commented that the White Paper did not discuss how GEH's Safety Strategy addresses the environmental aspects to conform with NRC requirements. The NRC's licensing process requires an applicant to evaluate Severe Accident Mitigation Design Alternatives (SAMDAs), which provides a systematic assessment using established guidance to examine the residual risk and if incorporation of additional mitigation is practicable to implement. It is unclear to the NRC staff if and/or how the proposed Safety Strategy considers SAMDAs to address environmental aspects identified in SSR-2/1.

- **Additional specific issues raised by the NRC staff from information presented in the Safety Strategy White Paper, include:**

    a. The White Paper describes the ultimate design goal to control the radiation exposures and restrict the likelihood of a loss of control over a nuclear reactor core, etc. However, it does not provide details on how to address the Commissions quantitative safety goals such as core damage frequency and/or large dose release frequency and their connection to the safety strategy ultimate design goal.

    b. The detailed technical basis for the numerical threshold demarcating the boundary between design basis events (Defense Line 3) and design extension conditions (Defense Line 4) as described under White Paper Section 3.3, "Defense Line 3" is not provided.

    c. The technical basis for how design basis hurricanes, hurricane missiles, and tornadoes (which are assessed at 1E-7 annual exceedance frequency) should be better aligned with the NRC regulations in addition to how GEH evaluated them using the numerical thresholds demarcating the Safety Strategy defense lines.

    d. The Safety Strategy did not seem to include provisions for or references to meeting the mitigating strategies rule under 10 CFR 50.155, "Mitigation of beyond-design-basis events." This includes the provisions related to the Spent Fuel Pool level monitoring and cooling makeup capabilities.

    e. GEH's use of numerical screening thresholds for Defense Line 5 and the concept of "practical elimination of large releases" should be reevaluated and enhanced because these thresholds could be unnecessary for the purposes of the Safety Strategy review for the NRC and, if included, could lead to a significantly expanded scope of review.

    f. A detailed roadmap explaining how the proposed safety strategy addresses NRC regulations would be valuable.

g. CNSC staff raised the comment about potential lack of independence between the defense lines due to sharing of SSCs between Defense Line 2 and Defense Line 4a, which was identified during the BWRX-300 Vendor Design Review.

- **Additional specific issues identified by the CNSC staff will be provided at the scheduled follow-up meeting.**

In summary, CNSC staff listened to the discussions during the meeting and asked clarifying questions. At that time, CNSC's assessment of GEH's proposed Safety Strategy (as described in the White Paper) consisted of feedback to GEH that the proposed Safety Strategy appears to be generally consistent with CNSC's regulations and processes. However, based on the available information, the NRC staff noted that the Safety Strategy concept, as currently proposed, could result in potential inconsistencies with Part 50 and Part 52 regulations in terms of event categorization, mitigation, and safety analyses acceptance criteria. The NRC staff additionally noted that a detailed roadmap explaining how the proposed safety strategy addresses NRC regulations could be valuable as a roadmap could help to identify any potential gaps/differences and areas that would need exemptions from the current NRC regulatory requirements. Furthermore, the NRC staff commented that it could be beneficial to see examples of implementation of various aspects of the Safety Strategy and a summary of how the proposed BWRX-300 Safety Strategy is similar to or different from (i.e., as comparison) the strategies implemented by GEH for the NRC approved Economic Simplified Boiling-Water Reactor design.