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CMD 24-H3.1C

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Supplementary Information

Written submission from Ontario Power Generation Inc.

In the Matter of the

Ontario Power Generation Inc.

Application for a licence to construct one BWRX-300 reactor at the Darlington New Nuclear Project Site (DNNP)

Commission Public Hearing Part-2

January 8-10 and 13-14, 2025

Renseignements supplémentaires

Mémoire d'Ontario Power Generation Inc.

À l'égard d'

Ontario Power Generation Inc.

Demande visant à construire 1 réacteur BWRX-300 sur le site du projet de nouvelle centrale nucléaire de Darlington (PNCND)

Audience publique de la Commission Partie-2

8-10 et 13-14 janvier 2025

OPG

Written Supplemental Submission

In support of the Darlington New Nuclear Project's

Power Reactor Construction Licence

ONTARIO POWER GENERATION

Electrifying life in one generation.

CMD 24-H3.1C PUBLIC HEARING December 12, 2024

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Table of Contents

Table of Figures

LAND ACKNOWLEDGMENT

The lands and waters on which the Darlington Nuclear Generating Station (DNGS) and Darlington New Nuclear Project (DNNP) are situated on are the Treaty and traditional territory of the Michi Saagiig and Chippewa Nations, collectively known as the Williams Treaties First Nations.

DNGS and DNNP are within the territory of the Gunshot Treaty and the Williams Treaties of 1923. These Rights were affirmed in 2018 in a settlement with Canada and the Province of Ontario.

To acknowledge traditional territories is to recognize their history, predating the establishment of the earliest European colonies. It is also to acknowledge the significance for the Indigenous people who lived and continue to live upon the land, to acknowledge the people whose practices and spiritualties were tied to the land and water and continue to develop in relation to the territory and its other inhabitants today.

As a company, Ontario Power Generation remains committed to fostering positive and mutually beneficial relationships with Indigenous people and communities across Ontario.

ALDERVILLE FIRST NATION | BEAUSOLEIL FIRST NATION | CURVE LAKE FIRST NATION | GEORGINA ISLAND FIRST NATION | HIAWATHA FIRST NATION | SCUGOG ISLAND FIRST NATION | RAMA FIRST NATION

Executive Summary

Ontario Power Generation Inc. has applied to the Canadian Nuclear Safety Commission for a Licence to Construct (LTC) the first of four BWRX-300 units at the Darlington Nuclear site under the Darlington New Nuclear Project [R-1]. In advance of Part 1 of the LTC Hearing, OPG submitted a Commission Member Document (CMD) 24-H3.1 [R-2] and CMD 24-H3.1A[R-3] and a presentation (CMD 24-H3.1B)[R-4] , which summarized the evidence demonstrating that OPG meets all the legal requirements of the Nuclear Safety and Control Act (NSCA) and the applicable Regulations for a LTC. In this CMD, OPG builds upon those previous submissions, with supplemental information to support a Commission decision.

At the Part 1 Hearing and in correspondence that followed [R-5], Commissioners requested additional information in a series of areas pursuant to the current LTC application and the design of the reactor OPG has proposed to construct. This CMD contains responses to those Commission questions. The Commission also directed OPG to submit the Predictive Environmental Risk Assessment already planned for submission to CNSC staff to the Commission Registry to be included on the record for Part 2 Hearing. The Predictive Environmental Risk Assessment is included as part of CMD 24-H3.1E.

CNSC staff in their Commission Member Documents (CMDs)[R-5] [R-6] and presentation [R-7] provided their review of OPG's LTC application [R-1]. In this CMD, OPG provides its perspective on some of the topic areas raised.

This supplemental CMD also provides information on other areas of interest raised in public interventions for the Part 2 Hearing. The intent of this material is to provide OPG's latest information and perspective on these topics, to support the Hearing and enable a Commission decision.

Benefits of this project and licence

In alignment with OPG's Climate Change Action Plan. OPG has committed to be a net-zero carbon company by 2040, in support of Canada's commitment to be a net-zero carbon economy by 2050. According to the Independent Electricity System Operator (IESO) Pathways to Decarbonization Report [R-09], demand for energy is projected to increase across Ontario and clean energy solutions that do not release significant greenhouse gases are required in attaining greenhouse gases emission reduction targets. For nuclear power to play a significant role in helping decarbonization efforts, it must be deployed safely, efficiently, cost effectively and with the appropriate nuclear regulatory and safety oversight. Canadian Nuclear

Safety Commission (CNSC) approval to construct a reactor facility would support OPG's mandate to add nuclear generation capacity at the Darlington site and would help to ensure reliable nuclear energy remains an important part of Ontario's low-carbon energy mix in the future.

Small Modular Reactors (SMRs), like the BWRX-300, support the decarbonization objective using technology that is safe, developed from proven existing reactors, and designed for ease of operation and efficient construction. OPG undertook an extensive and rigorous process and selected the General Electric Hitachi (GEH) BWRX-300 as the Darlington New Nuclear Project (DNNP) technology for deployment at OPG's existing Darlington Nuclear (DN) site.

Nuclear Safety

The BWRX-300 is an inherently safe reactor, as defined by REGDOC 2.4.1, due to its design and passive safety features. It has leveraged experience from the 9 previous generations of BWRs to create a design, and safety strategy, that exceeds regulatory requirements as demonstrated by a comprehensive safety analysis. The BWRX-300 employs multiple layers of defensive in depth to ensure the reactor remains safe even during an extremely unlikely beyond design basis event. OPG has been recognized as a world leader in how it has integrated Beyond Design Basis Event response. The passive safety features, leveraged in the BWRX-300 safety strategy (and described in this CMD), allow for the BWRX-300 reactor to remain cooled for seven days without external power or significant operator action, and for that to be extended indefinitely by utilizing connections for external water.

Project, Construction, and Operating Excellence

OPG has a history of excellent project management success. With the expertise and commitment of qualified partners and vendors, OPG has demonstrated world-class project performance with the successful and safe refurbishment of Darlington units 1, 2 and 3. Success in large projects such as the Darlington Refurbishment, as well as completion of the Lower Mattagami Hydroelectric Project and the Hydro Tunnel at Sir Adam Beck, demonstrate OPG's readiness and capability to undertake the construction of a BWRX-300 unit at the Darlington Site. OPG will continue to bring the same level of leadership in safety, protection of the environment, and quality in project management to the construction of a reactor under this licence, if granted.

Through organizations such as the World Association of Nuclear Operators, the Institute of Nuclear Power Operators, the Nuclear Energy Institute and the Electric

Power Research Institute, OPG maintains vigilance about staying on top. As active members and leaders within these organizations, we have access to significant experience and knowledge, leveraging reports such as NEI 20-08 Strategic Project Management Lessons Learned & Best Practices for New Nuclear Power Construction to inform our strategies, including things like collaborative contracting models, which have been demonstrated to improve project performance in safety, cost, and schedule.

OPG leverages our well-established processes of internal and external review boards which have been instrumental in the station and refurbishment project to achieve sustained excellence.

As a world leader in nuclear operations, OPG is well positioned to lead a skilled workforce in the future operation of new nuclear technology. OPG has a 50-year history of strong safety and operational performance at its two nuclear generating stations and OPG continues to be recognized for exceptional performance in nuclear operations within the nuclear industry.

Indigenous Relations

OPG acknowledges the Aboriginal and Treaty Rights of Indigenous People as recognized in the Constitution Act, 1982. OPG is committed to its relationship with Indigenous Nations and Communities. OPG's Indigenous Relations policy provides a framework for engagement with Indigenous peoples and communities to advance its reconciliation efforts. OPG's Reconciliation Action Plan is our road map for how we intend to work in partnership with Indigenous communities, businesses and organizations to advance reconciliation. It's also about how we intend to grow and continue learning as an organization. OPG regularly reports on the company's activities and progress in achieving the goals found in its Reconciliation Action Plan.

OPG looks forward to presentations from Indigenous Nations and Communities at the Part 2 Hearing, and to responding to Commissioner questions on these important matters.

Public Engagement and Communication

Since 2006, OPG has kept the public and stakeholders informed about DNNP as part of the existing engagement and communications activities for the existing Darlington Nuclear Generating Station. Topics such as station operations, environmental performance, and the status of projects (including DNNP) are communicated through various methods and forums with the goal of ensuring transparent disclosure of our activities. Specific to DNNP, OPG has kept the public and stakeholders updated on the status of the project since its inception and continues to make publicly available the relevant documents associated with the DNNP licensing process. We trust that the information contained within this submission will likewise support open and transparent communications about this project and the requested licence.

In summary, OPG's application for a Licence to Construct the DNNP facility, supplemented by the Part 1 and 2 CMDs and the presentations in front of the Commission, demonstrate that OPG has met or exceeded the applicable regulatory requirements for an LTC and is further substantiated by a history of safe and successful operations and project management. Ontario Power Generation has demonstrated that it is qualified to perform the requested licensed activities and that it will make adequate provision for the protection of the environment, the health and safety of persons and the maintenance of national security and measures required to implement international obligations to which Canada has agreed.

OPG respectfully requests the Commission approve OPG's Darlington New Nuclear Project Power Reactor Construction Licence for one BWRX-300 unit. OPG also requests that the Commission accepts OPG's proposed Financial Guarantee for DNNP as part of the requested Power Reactor Construction Licence.

The Licence Application, CMDs, and supplementary information to the Application are available to the public on OPG's website, www.opg.com/newnuclear.

1.0 INTRODUCTION – SUPPLEMENTAL INFORMATION

1.1 Introduction

Ontario Power Generation Inc. is the leading supplier of electricity to the power grid in the province of Ontario. We provide safe, reliable, and low-cost power through our nuclear stations at Pickering and Darlington; our hydro-electric facilities; a solar generating station; a biomass generating station; and several natural gas plants. We have safely provided for the electricity needs of the people of Ontario for decades and look forward to doing so for many decades to come. Building on OPG's extensive experience and in partnership with its key contract partners, OPG is proposing to construct the first of four General Electric Hitachi (GEH) BWRX-300 units and ancillary facilities at the DNNP site.

OPG's capabilities as an industry leader in safe nuclear operations at both its Darlington and Pickering Nuclear Generating Stations continue to be demonstrated by achievements and recognition both at home and internationally.

OPG has demonstrated its ability to deliver on large scale nuclear projects. In June 2020, after more than three years of safe, quality work, OPG completed the Darlington Unit 2 refurbishment and successfully returned the unit to the grid. The successes and learnings of Unit 2 were further demonstrated in July 2023 and November 2024, when Units 3 and 1 were safely returned to the grid, five months ahead of schedule. OPG remains on track and committed to return all four Darlington units to the grid, safely and on time. This world-class project performance is a testament to the detailed preparations and planning, as well as the expertise and commitment of OPG and its partners to deliver projects on time. The OPG Project Management Office was the recipient of the PMO of the Year: The Americas award in 2023. OPG continues to demonstrate that with detailed planning and preparation, large nuclear projects can be completed safely, on time and budget, and with quality.

2.0 RESPONSES TO QUESTIONS FROM THE COMMISSION CMD 24-H3-Q

2.1 Description

On October 2, 2024, the Commission held Part 1 of the public hearing to consider Ontario Power Generation's (OPG) application to construct one BWRX-300 reactor at the Darlington New Nuclear Project (DNNP) Site. In conducting the Part 1 hearing, the Commission considered written submissions provided by CNSC staff in CMD 24-H3 [R-6], CMD 24-H3.B [R-8], CMD 24-H3.C, and CMD 24-H3.D and OPG in its application and supporting submissions, CMD 24-H3.1 [R-2] and CMD 24-H3.1B [R-4]. The Commission also considered oral submissions from CNSC staff in CMD 24-H3.A [R-7] and OPG in CMD 24-H3.1A [R-3] at the Part 1 hearing. Following the hearing, the Commission directed OPG to provide additional information to seven questions based on the oral and written submissions as documented in CMD 24-H3-Q [R-8] and set out in Table 1 below.

Table 1: CMD 24-H3-Q Questions from the Commission

#	**Commission Questions**
1	How has the Transient Reactor Analysis Code "GE Hitachi" (TRACG) computer code been validated for use on the BWRX-300 reactor design? The Commission notes that the BWRX-300 design has a smaller reactor core than traditional boiling water reactors.
2	What instabilities may occur in the reactor core and chimney during start-up and how does the BWRX-300 design mitigate these potential instabilities?
3	How was the TRACG code used to model instability within the BWRX-300 reactor core during start-up? The Commission is seeking specific information on what assumptions were used in that modelling and how the void distribution within the "Global Nuclear Fuel Mk. 2" (GNF2) fuel assembly was considered.
4	Has the GNF2 fuel assembly been optimized for use in a reactor core with natural circulation, and if so, how? The Commission notes that the GNF2 fuel assembly was designed for reactors with forced circulation of coolant through the reactor core and that the proposed BWRX-300 design would employ natural circulation.
5	How was the onset of the boiling transition modelled for the GNF2 fuel assembly? What ability would OPG have to detect boiling conditions along the fuel assembly during reactor operation and what risk exists for fuel dry-out?
6	The Commission is seeking additional information on the power coefficient of reactivity during different reactor power levels. How would reactor power control be maintained for conditions where the power coefficient of reactivity may be positive?
7	The Commission is seeking specific information on the design and validation of the Distributed Control and Information System (DCIS), including detailed information on: • software certification and verification • fail-over from System A to back-up System B • transfer of control from the main control room to the secondary control room

2.2 Commission Question 1

How has the Transient Reactor Analysis Code "GE Hitachi" (TRACG) computer code been validated for use on the BWRX-300 reactor design? The Commission notes that the BWRX-300 design has a smaller reactor core than traditional boiling water reactors.

<u>OPG Response</u>

TRACG Qualification:

OPG has audited GEH's quality assurance process and has deemed it compliant with CSA N286 and N286.7. The TRACG qualification process used by GEH is equivalent to the process used in Canada and internationally. TRACG code has been developed in compliance with the NQA-1 quality code in the US, and in compliance with the key elements of the Code, Scaling, Applicability and Uncertainty methodology (CSAU) process developed in the US and used by GEH internationally. Qualification of TRACG has been carried out by a systematic and comprehensive process, which has been assessed by OPG and determined to be compliant with REGDOC-2.4.1 and CSA N286.7 requirements. Compliance with the Canadian regulatory requirements provided in REGDOC 2.4.1 and CSA N286.7 has been ensured through compliance with CSAU [R-10].

TRACG Validation:

TRACG's validity and accuracy are established through a systematic and comprehensive qualification process, where the key parameters calculated by TRACG are compared with relevant data from scaled and full-scale experiments and full-scale reactor transient data that were determined to be representative of BWRX-300 conditions. This validation approach ensures that TRACG models are qualified for BWRX-300 safety analysis and that calculated parameters are obtained with required accuracy and quantified uncertainty. By comparing TRACG's calculations to experimental data and full-scale data from the current fleet of BWRs, the code qualification process confirms that TRACG can adequately simulate reactor behaviour during all reactor states as described above. For the BWRX-300, TRACG's validation builds on years of successful validation and application in previous BWR designs. Qualification of TRACG for BWRX-300 is based on two key principles: (1) equivalence of BWRX-300 phenomena with phenomena present in previous BWR designs for which validation has been successfully completed, and (2) selection of validation results and conclusions from validation for previous BWR designs that were determined to be applicable to BWRX-300, which are explained further, below.

BWR Designs Determined to Be Applicable to BWRX-300:

The BWRX-300 shares many of the same features and components with existing BWRs. There are differences in the importance of some phenomena, between the BWRX-300 and operating BWRs, that have been identified in a BWRX-300 specific Phenomena Identification Ranking Table (PIRT). The BWRX-300 shares many of the same features and components with existing BWRs. TRACG's models, which were already validated for existing BWRs, including natural circulation BWRs (e.g. Dodewaard), are determined to be applicable to the BWRX-300 design. Note that the BWRX-300 core size and fuel design is the same as Kernkraftwerk Mühleberg, (KKM) plant which was a jet-pump BWR/4 that also operated with Global Nuclear Fuel 2 (GNF2) in natural circulation when the recirculation pumps were tripped. Validation of natural circulation phenomena is based on comparisons with integral effects test data and plant data from jet-pump BWRs operating at natural circulation conditions (due to the jet pumps not operating) with core and bundle flows lower than (therefore, bounding) what BWRX-300 would experience. Applicable documentation produced for TRACG validation for previous BWR designs appended with new validation documentation produced specifically for BWRX-300 design confirm the applicability of TRACG's models for BWRX-300 safety analysis [R-10] [R-11]. The PIRT demonstrated that the key BWRX-300 phenomena are not different from key phenomena in operating BWRs, while specific unique aspects are discussed below.

Unique Aspects of BWRX-300 Validation:

While the BWRX-300 design is similar to previous BWRs, the PIRT identified that one unique feature of the BWRX-300 is the partitionless chimney. In a BWR reactor, the chimney is part of the system that circulates steam and water within the reactor pressure vessel (RPV), determining core flow, thereby impacting core power levels and cooling. The partitionless design means there are no internal separators, which influences the flow dynamics within the chimney. In order to attain the required data to validate TRACG for the BWRX-300's partitionless chimney, a series of experiments were performed at the Hitachi-GE Nuclear Energy (HGNE)'s Hitachi Utility Steam Test Leading (HUSTLE) facility, an internationally recognized facility capable of creating high-pressure conditions and steam qualities that match those of the BWRX-300. GEH performed two series of HUSTLE tests which are applicable to BWRX-300 and that provided void fraction data that were used in the validation program to ensure that TRACG can accurately model the chimney's behavior. Accurate modeling of chimney void fractions (fluid density) is important because the density difference between fluid in the chimney and core versus the downcomer is what determines core flow. TRACG's model of the BWRX-300 chimney was validated by comparing its predictions with the HUSTLE test data and detailed Computational Fluid Dynamics (CFD) simulations of both the HUSTLE facility and the BWRX-300 chimney design. Results showed a very good match, confirming that TRACG can predict chimney performance accurately [R-11].

Summary of TRACG's Validation:

In summary, TRACG is qualified for use in BWRX-300 deterministic safety analysis. TRACG validation is based on scaled and full-scale experimental data and data from operating BWRs including natural circulation BWRs. TRACG uses proven and qualified models that have been used in previous BWR licensing applications. TRACG was subjected to additional validation focused on new BWRX-300 features (e.g., partitionless chimney). OPG provides technical reviews, input and oversight to GEH for TRACG validation and verification documentation.

2.3 Commission Question 2

What instabilities may occur in the reactor core and chimney during start-up and how does the BWRX-300 design mitigate these potential instabilities?

<u>OPG Response</u>

During startup, instabilities known as Type 1 oscillations may occur in the BWRX-300 reactor core and chimney. These oscillations are characteristic of natural circulation reactors and arise from flow-pressure dynamics as the reactor moves through startup conditions to establish a steady, two-phase voided state in the chimney. In Type 1 oscillations, initial vapor production in the chimney can lower hydrostatic pressure, which temporarily increases core flow. This flow increase can cause vapor voids to collapse in the chimney, leading to small flow oscillations. However, because these oscillations have an insignificant impact on core moderator density during startup, they have an insignificant impact on core power output, ensuring that all fuel performance requirements are satisfied. The BWRX-300 design incorporates several key features to mitigate these oscillations and enhance stability during startup:

1. Controlled Low Power Levels: To minimize Type 1 instabilities, the reactor power is kept below approximately 3% until system pressure reaches about 5 MPa. This approach reduces the intensity of any flow surges that may arise due to chimney dynamics.

2. Forced Circulation: During startup, the BWRX-300 utilizes forced circulation (about 2% of the rated flow rate) as the reactor pressure vessel (RPV) heats up and pressurizes. This forced flow helps to further stabilize the system.

3. Anticipatory SCRAM via Period Monitoring: Wide-Range Neutron Monitors (WRNM) continuously track the reactor's "Period," which is the time it takes for power to increase by a factor of 2.71828. If the period becomes too short, the WRNM monitors can trigger a proactive SCRAM, adding an additional safety layer [R-10].

Due to these design features, Type 1 oscillations remain minor, monitored and controlled, and safety margins are maintained throughout startup. Furthermore, Type 2 oscillations, which can develop at higher power levels, are precluded in the BWRX-300 design due to its compact core, balanced feedwater temperature, natural circulation, and tall chimney which enhances stability across operational conditions.

2.4 Commission Question 3

How was the TRACG code used to model instability within the BWRX-300 reactor core during start-up? The Commission is seeking specific information on what assumptions were used in that modelling and how the void distribution within the "Global Nuclear Fuel Mk. 2" (GNF2) fuel assembly was considered.

OPG Response

TRACG's ability to model Type 1 instabilities is supported by comparisons with test data. TRACG models are qualified to analyze Type 1 instabilities, specifically the hydrostatic oscillations that can occur during startup. In this low-pressure, low-power phase, the natural circulation flow loop experiences fluid property variations along its path. TRACG addresses this by calculating fluid properties specific to the thermodynamic state in each cell in the system including detailed nodalization for the fuel channels in the core. This ensures accurate representation of the transient behavior of the system and the core. During startup, core voiding is minimal or non-existent. Thus, voiding within the GNF2 fuel assembly (which would be critical to reactivity at higher power conditions) has minimal relevance during startup as there is very little core void or density feedback. Startup simulations of BWRX-300 with TRACG will be used to confirm (as they did for ESBWR) that the reactor can be safely operated during startup as well as at power [R-12].

2.5 Commission Question 4

Has the GNF2 fuel assembly been optimized for use in a reactor core with natural circulation, and if so, how? The Commission notes that the GNF2 fuel assembly was designed for reactors with forced circulation of coolant through the reactor core and that the proposed BWRX-300 design would employ natural circulation.

OPG Response

The BWRX-300 design evolved to utilize existing contemporary boiling water reactor (BWR) fuel as there are multiple industrial benefits to reactor owners associated with standardization (e.g., completed fuel qualification, operating experience applicability, supply chain maturity, compatibility with future BWR fuel technology, etc.). This approach influenced aspects of the reactor design, such as the chimney height, core configuration and power density to result in a self-consistent set of reactor design and core conditions that support compliance with regulatory requirements and performance targets with high confidence. There are a number of critical parameters that must be validated in order to demonstrate that the natural circulation conditions of the BWRX-300 are suitable for a given fuel design. These include parameters such as hydraulic resistance, critical power ratio, linear heat generation rate, and reactivity characteristics. Determination of these parameters and limits is based on well-established methodology and has been confirmed through modelling, analysis, and experiment.

GNF2 is evaluated to be an excellent and the optimal choice for the BWRX-300 within the catalogue of industrially available fuel designs as it has: 1) the lowest hydraulic resistance of GNF's product lines that results in the highest core flow, 2) excellent critical power performance for operating thermal margins (e.g. maintaining nucleate boiling and precluding boiling transition), 3) very large linear heat generation rate margins that support agile core power maneuvering, 4) excellent nuclear efficiency and reactivity characteristics, 5) broad familiarity with GNF2 throughout the BWR industry, and 6) fifteen (15) years of operating experience and utilized by approximately 70% of the BWR fleet. Pertaining to application engineering, BWRX-300 thermal hydraulic conditions are enveloped by the forced circulation fleet such that the engineering tests, hydraulic correlations and engineering models are applicable. As demonstrated in the DNNP Preliminary Safety Analysis Report, the fuel conditions are met with significant margins for safe operations during steady state and transient conditions [R-10].

2.6 Commission Question 5

How was the onset of the boiling transition modelled for the GNF2 fuel assembly? What ability would OPG have to detect boiling conditions along the fuel assembly during reactor operation and what risk exists for fuel dry-out?

<u>OPG Response</u>

The onset of boiling transition is determined in the same fashion for all GNF fuel designs through the use of a product specific critical power correlation, GEXL17 for GNF2 as described in NEDO-33292 GEXL17 Correlation for GNF2 Fuel [R-13]. The form of the GEXL correlation is the same for all GNF fuel bundle types and has been demonstrated to be effective for all BWR fuel designs as applied to all BWR types through a combination of analysis and experiment.

Once the mechanical design of a BWR fuel bundle is established, full scale testing is performed using prototypical spacers and electrically heated fuel rod simulators that are highly instrumented to detect the onset of boiling transition. Testing is performed throughout the range of fluid conditions (e.g., coolant mass flux, pressure and inlet temperature) and all characteristic rod locations for multiple axial power shapes. A large critical power database is then established from which the correlation coefficients in the generalized GEXL correlation are determined. The correlation coefficients then represent the product specific GEXL correlation that is used to compute the critical power for any set of hydraulic conditions within its application range and axial power shape that a fuel assembly may experience. The GEXL method is used to determine the critical power in core design, deterministic safety analysis and core monitoring.

The onset of boiling transition is characterized by an oscillatory cladding temperature transient of moderate magnitude that is not considered a threat to fuel rod integrity during an Anticipated Operational Occurrence (AOO). In the full- scale testing of a fuel design, the onset of boiling transition is detected by thermocouples installed in the electrically heated fuel rod simulators. In fuel for boiling water reactors, no such instruments exist to detect the onset of boiling transition. Instead, the GEXL correlation is embedded in the online Core Monitoring System to determine the critical power ratio for every fuel assembly in the core based on the operating conditions that exist at the time of calculation (e.g., fuel bundle power, bundle flow rate, inlet enthalpy and axial power shape). Note, the critical power ratio (CPR) is the ratio of bundle power at which the onset of boiling transition occurs to the operating bundle power. A CPR of 1.0 is the best estimate value for the onset of boiling transition as calculated by GEXL17.

There are no known instances in which the overall boiling transition prevention system has failed to protect the fuel as the signature of sustained operation in boiling transition is known and has not been observed in poolside examination of fuel assemblies (it would present as localized corrosion where boiling transition occurred). The risk of experiencing boiling transition in the BWRX-300 is considered to be the same as forced circulation BWRs as the same criteria for defining operating limits is used. Boiling transition is rigorously precluded by establishing cycle-specific operating limits that carry various conservatisms in addition to operating margins. Operating limits for GNF2 are calculated to confirm safe operations during normal operation and AOOs (i.e., the fuel may be returned to service following an AOO). More specifically, operating limits are established to preclude the onset of boiling transition resulting in no appreciable cladding temperature rise. The process for establishing operating limits for the fuel is applicable to all BWR types in which established uncertainties are combined with the plant-type dependent and cycle-specific transient response that results in precluding boiling transition should the most limiting AOO occur during the most limiting point in the cycle with the most limiting fuel assembly operating on its operating limit with no margin. The application range for the GEXL17 correlation currently used within the fleet envelopes the hydraulic conditions the BWRX-300 experiences during normal operation and AOOs which provides confidence that fuel thermal limits are not be exceeded. More information on this topic can be found in Section 4.4 Thermal and Hydraulic Design Basis of the Preliminary Safety Analysis Report submitted in support of the Licence to Construct Application [R-10].

2.7 Commission Question 6

The Commission is seeking additional information on the power coefficient of reactivity during different reactor power levels. How would reactor power control be maintained for conditions where the power coefficient of reactivity may be positive?

<u>OPG Response</u>

The power coefficient is a combination of the Doppler, moderator temperature and void reactivity coefficients in the power operating range and is no longer explicitly evaluated for BWRs as contemporary analysis methodologies employ 3D kinetics. Also, during power operation, a perturbation to the reactor power does not materially affect the moderator temperature nor the fuel temperature, but rather the void fraction is the key parameter that is affected such that the power response is essentially just a reflection of the void reactivity coefficient.

The fuel reactivity acceptance criteria are established in General Electric Standard Application for Reactor Fuel (GESTAR) [R-14] and serves as the generic fuel qualification requirements that govern nuclear dynamic parameters for all GEH BWRs. These requirements are also documented in the Preliminary Safety Analysis Report [R-10] submitted as part of the Darlington New Nuclear Project Licence to Construct application. It is desirable for each of the following fuel parameters to be negative throughout the life of the core:

- Doppler reactivity coefficient for all operating conditions;
- Core moderator void reactivity coefficient resulting from boiling in the active flow channels for any operating conditions;
- Moderator temperature coefficient for temperatures equal to or greater than hot standby. Hot standby refers to a reactor state in which the temperature of the coolant and fuel is near operating temperatures and represents the end of the startup region;
- Power coefficient, as determined by calculating the reactivity change resulting from an incremental power change from a steady–state base power level for all operating power levels above hot standby; and

- Net prompt reactivity feedback originating from prompt heating of the moderator and fuel for a super prompt critical reactivity insertion event (e.g., control rod removal from core event).

The Doppler reactivity coefficient, the moderator void reactivity coefficient and the moderator temperature coefficient of reactivity are negative for power operating conditions, thereby assuring negative reactivity feedback characteristics [R-10].

BWRs have a tendency to exhibit a positive moderator temperature coefficient (MTC) during the startup temperature range (20°C to 260°C). It is required that the MTC be negative at operating temperatures and pressures, and this requirement is motivated by operational considerations as opposed to safety. The temperature at which the MTC becomes negative, referred to as the cross-over temperature, varies by point in the cycle in which a reactor startup occurs. The positive nature of the MTC is lowest at the beginning of cycle when normal startups occur.

During a startup that originates at low temperature, a positive MTC manifests itself as a slow increase in reactor power and a shortening of the reactor period. The transient evolves slowly as the coolant must recirculate to achieve a new equilibrium temperature. The in-core nuclear instrumentation, specifically Wide-Range Neutron Monitors (WRNMs), continuously monitors the reactor period and control rods are used to maintain the reactor period within specified values and control reactor power. The Reactor Protection System will issue a SCRAM should the reactor period reduce to its trip setpoint. It should be noted that once boiling is initiated that the power coefficient becomes negative as void feedback is dominant. Startups can also be performed by increasing the reactor temperature to the MTC cross-over temperature prior to withdrawing control rods and bringing the reactor to a critical state via decay heat and auxiliary heat addition, if required.

2.8 Commission Question 7

The Commission is seeking specific information on the design and validation of the Distributed Control and Information System (DCIS), including detailed information on:

- software certification and verification
- fail-over from System A to back-up System B
- transfer of control from the main control room to the secondary control room

<u>OPG Response</u>

Software certification and validation

As previously stated, OPG has audited the GEH quality assurance process against CSA N286-12 and N286.7 requirements and has deemed the process as acceptable. GEH uses vendor supplied certificates for digital instrumentation and control (I&C) equipment in accordance with CSA N290.14-15 (R20), "Qualification of digital hardware and software for use in instrumentation and control applications for Nuclear Power Plants," Section 6.4.3.4. The certificates are used as supporting evidence in a safety demonstration for the BWRX-300 I&C systems. GEH performs verification and validation of safety classified software in accordance with the following industry standards [R-10]:

IEC 61513, "Nuclear power plants – Instrumentation and control important to safety – General requirements for systems," is used for safety classified systems.

IEC 60880, "Nuclear power plants - Instrumentation and control systems important to safety - Software aspects for computer-based systems performing category A functions," is used for Safety Class 1 systems.

IEC 62138, "Nuclear power plants - Instrumentation and control systems important to safety - Software aspects for computer-based systems performing category B or C functions," is used for Safety Class 2 and Safety Class 3 systems.

For devices programmed in Hardware Description Language (HDL), the following industry standards are utilized:

IEC 62566: 2012, "Nuclear power plants – Instrumentation and control systems important to safety – Development of HDL-programmed integrated circuits for systems performing category A functions" is used for Safety Class 1 systems.

IEC 62566-2: 2020, "Nuclear power plants – Instrumentation and control systems important to safety – Development of HDL-programmed integrated circuits – Part 2: HDL programmed integrated circuits for systems performing category B or functions" is used for Safety Class 2 and Safety Class 3 systems.

CSA N290.14-15 recognizes the industry standards as an acceptable method for safety classified software development [R-10] [R-15].

Failover from System A to B

The BWRX -300 I&C systems do not use failover schemes (e.g., failover from system A to B) for system fault management. Instead, the BWRX-300 I&C systems use several system redundancy arrangements for system fault management, as described below.

The Safety Class 1 system (i.e., Primary Protection System) uses an architecture that has three independent divisions from sensor to voting logic. The single failure criterion is met using a two-out-of-three voting logic. The failure of a single division to actuate does not prevent the system safety function from being performed. The spurious operation of a single division does not result in an unwanted system safety function being actuated. [R-10]

The Safety Class 2 system (i.e., Diverse Protection System) uses a triple modular redundant (TMR) architecture. Three redundant channels of sensors and controllers are used to acquire signals that are voted on using a two-out-of-three voting logic. The failure of a single hardware component does not prevent the system safety function from being performed or cause an unwanted system safety function actuation. [R-10] The Safety Class 3 protection system (i.e., Anticipatory Protection System) uses a TMR architecture. Three redundant channels of sensors and controllers are used to acquire signals that are voted on using a two-out-of-three voting logic. The failure of a single hardware component does not prevent the system safety function from being performed or cause an unwanted system safety function actuation[R-10].

Safety Class 3 control systems that support redundant mechanical systems can be arranged in an A/B arrangement. These controllers do not fail over; instead, they independently control independent mechanical systems. [R-10]

The Safety Class 3 control rod block functions use a simple redundant architecture. The redundant controllers are monitored for disagreement. A detected disagreement or a loss of communication between the redundant controller results in the rod block being inserted. The rod block prevents control rods from being withdrawn but does not prevent control rod insertion. [R-10]

The use of independent divisions is a common arrangement for the highest safety classified nuclear safety systems. The use of a TMR architecture is common for the high reliability industrial protection and control systems.

The robust safety class system design reflects the use of design methods and adherence to engineering best practices to ensure its functions are achieved for all operational states and abnormal conditions. The software employed in safety class systems perform automatic self-diagnostics which check for inconsistencies between the redundant signals and watchdog timers; perform sensor range checks; and monitor actuators, communication, and power supply status. If a diagnostic failure is detected during plant operation, the systems take an appropriate and timely response. [R-10]

Transfer of Control Room

The Secondary Control Room (SCR), located in the Reactor Building, is the assured shutdown location for the plant, if habitability and control from the Main Control Room (MCR) is lost. The operators in the SCR perform the following functions when the MCR is uninhabitable [R-10]:

- Initiate shutdown of the reactor and maintain the plant in a safe shutdown condition
- Monitor Fundamental Safety Functions (FSFs)

The necessary MCR to SCR control transfer functions are suitably located in a qualified and physically protected location determined through Human Factors Engineering analysis. Access to the SCR is indicated by alarms in the MCR to ensure unauthorized access is detected. The SCR includes all the Human-System Interface (HSI) inventory required to maintain the plant in a safe state for scenarios requiring MCR evacuation. [R-10] The necessary MCR to SCR control transfer provisions ensure the availability of necessary HSI after MCR evacuation and access control when the SCR is not activated [R-10].

2.9 Direction from the Commission CMD 24-H3-Q

In the Part 1 Hearing, OPG indicated that it would be submitting a predictive environmental risk assessment (PERA) to CNSC staff by December 15, 2024. As stated in Table 2 below, the Commission directed that OPG submit its Predictive Environmental Risk Assessment to the Commission Registry to be included on the record for this hearing.

Table 2: CMD 24-H3-Q Questions from the Commission

#	Commission Direction
1	OPG indicated that it would be submitting a predictive environmental risk assessment (ERA) to CNSC staff by December 15, 2024. The Commission directs that OPG submit its predictive ERA to the Commission Registry to be included on the record for this hearing. OPG shall file its predictive ERA with the Commission Registry at the same time as it submits the assessment to CNSC staff.

The Predictive Environmental Risk Assessment (PERA) is submitted along with this supplemental CMD as CMD 24-H3.1E.

The DNNP PERA was conducted to meet the requirements of CSA N288.6:22 "Environmental Risk Assessments at Nuclear Facilities and Uranium Mines and Mills" (CSA, 2022a) [R-18], and meets the requirements for an Environmental Risk Assessment outlined in Section 4.1 of REGDOC-2.9.1 "Environmental Protection: Environmental Principles, Assessments and Protection Measures" (CNSC, 2020) [R-19]. The objectives of the PERA are to:

- Predict and assess the risk to representative human and ecological receptors resulting from exposure to radiological and non-radiological substances and physical stressors expected to be released throughout the project phases;
- Inform prioritization of monitoring and mitigation measures; and
- Meet follow-up program commitments (specifically D-P-12.9 in the DNNP Commitments Report) to verify no significant residual adverse effects from the DNNP and confirm the effectiveness of mitigation measures.

As a result of having no radiological materials on site during license to construct activities, there are no radiological releases expected to air and water during construction of the DNNP. During the site preparation and construction phases, air pollutants expected to be released into the local atmosphere include fugitive dusts generated as part of typical construction activities (e.g., excavation, land clearing) and engine exhaust emissions from heavy construction vehicles, on-site personnel vehicles, and other motorized pieces of equipment. DNNP air emissions generated during the operation phase will also include emissions from the standby generators. Activities are also expected to generate additional noise levels.

The results of the predictive human health risk assessment show that the incremental radiation dose from the DNNP to all human receptors during the operation phase is predicted to be well below the regulatory public dose limit of 1 mSv/year. The maximum predicted cumulative dose to members of the public has been assessed to be less than 1% of the regulatory public dose limit. Since the dose estimates are a small fraction of the public dose limit, no discernable health effects are anticipated due to exposure of these receptors to radioactive releases from the DNNP. A new human receptor, the Harvester, was added to the DNNP PERA. The Harvester aims to better represent the lifestyle characteristics of an Indigenous person who may work and/or live near the DN site and harvests traditional foods in the local area.

The characteristics of this receptor may be further refined as more site-specific information is gathered through site specific surveys and ongoing engagement activities with local Indigenous Nations and communities.

Predicted non-radiological air concentrations during all Project phases were compared against ambient air quality criteria at human receptor locations. The results of that assessment indicated that both cancer and non-cancer risk were below levels that would cause adverse impacts for human health.

The assessment for the Predictive Ecological Risk Assessment focused on the DNNP site and surrounding areas. The assessment was divided into five distinct assessment areas. A new receptor location was introduced within the existing assessment area for this PERA to assess ecological receptors within closer proximity to the location of the future SMRs. There were no predicted exceedances of the radiation dose benchmark for the aquatic biota nor the radiation dose benchmark for terrestrial and riparian biota; therefore, aquatic and terrestrial receptors at the DNNP are considered protected. The PERA indicated that the maximum predicted cumulative dose to members of the public is well below the regulatory public dose limit and the maximum predicted cumulative dose to ecological receptors is a small fraction of the terrestrial dose benchmark. Since there were no predicted exceedances of the respective dose benchmarks for any of the aquatic or terrestrial receptors, individual species at risk are also considered protected. Overall, it is unlikely that there would be adverse effects on terrestrial or aquatic populations or communities as a result of radionuclide releases from the DNNP.

Based on the results of the PERA, the DNNP is not predicted to result in any adverse effects to human or ecological receptors groups evaluated.

OPG recognizes that the DNNP PERA, while it satisfies assessment of environmental impacts from the Western science perspective, may not fully address the impact of the Project on Aboriginal, Inherent and Treaty rights as they are understood today.

This is particularly true in light of the 2018 settlement agreement between the seven members of the Williams Treaties First Nations (WTFN) with the Governments of Canada and Ontario. The Settlement (Government of Canada, 2018) pertains to the lands of the DN site and reaffirms the rights of WTFN citizens, which has fundamentally shifted how WTFN is engaged and consulted on site development. OPG recognizes the importance of furthering our knowledge and understanding, in ongoing meaningful engagement with the WTFN. OPG endeavors to continue to work with the WTFN to appropriately identify the rights impacted by the DNNP and to achieve feasible mitigation measures and/or accommodation.

3.0 BWRX-300 DESIGN AND FEATURES

3.1 BWRX-300 Design

The BWRX-300 is a boiling water reactor. There are over 60 Boiling Water Reactors currently operating in the world today. Boiling Water Reactors generate steam in a simple way to produce electricity.

Boiling water reactors use a direct cycle system. Steam is generated in the reactor pressure vessel and does not require a steam generator to ultimately produce the necessary steam. Similar to the ESBWR, the BWRX-300 uses a large pressure vessel to produce steam that flows directly through a series of turbines, sending power to the grid through the generator. Main condensers turn steam from the turbines into condensate, which is then pumped back into the reactor pressure vessel by the feedwater pump. A conceptual cutaway of BWR-300 Reactor Building is shown in Figure 1.

To generate the steam, water in the reactor vessel flows over the fuel, acting as both a coolant and a moderator, slowing down the neutrons sufficiently so that they can be captured by the Uranium-235 uranium isotope. When U235 captures a neutron, fission occurs and releases energy. The energy boils the water, creating steam under pressure, sending the steam to the turbine generator. This means of producing power has been demonstrated through over 60 years of safe BWR operating history. During these 60 years, there have been 10 generations of GE Hitachi BWRs, each evolving over the previous to improve safety margins through simplifications and passive features, that have eliminated a number of potential component failures and their subsequent consequences.

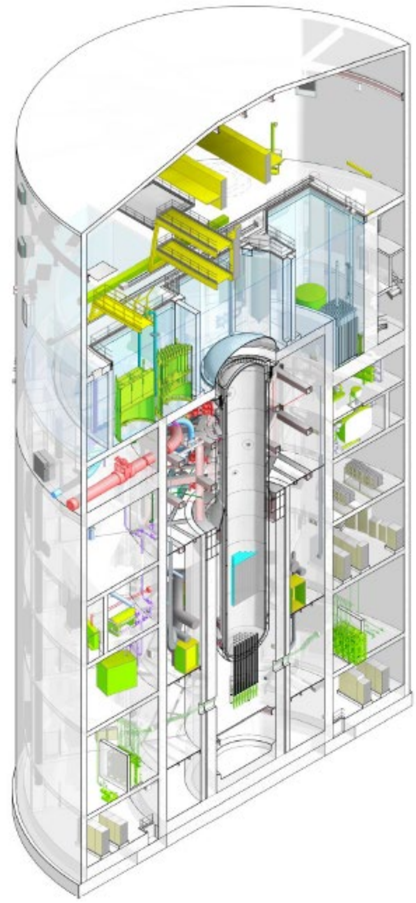


Figure 1: BWRX-300 Reactor Building and Containment Design

3.2 Design and Safety Features

The BWRX-300 is an inherently safe reactor, as defined by REGDOC 2.4.1, that utilizes a number of passive safety systems that rely on natural phenomena (such as gravity) to reduce the need for human intervention, reliance on off-site power, and improve reliability. As an example, the BWRX-300 reactor is designed with negative coefficients of reactivity and thermal hydraulic stability as inherent safety features. If a BWRX-300 experiences a loss of cooling water, the result is an increase in voids in the moderator. These voids work to decrease reactivity and reduce reactor power without human intervention. To supplement this, the BWRX-300 employs a coolant preservation strategy that includes maximizing coolant above the fuel to extend fuel cooling during potential events. An overview of the BWRX-300 systems is shown in figure 2, with specific systems elaborated on below.

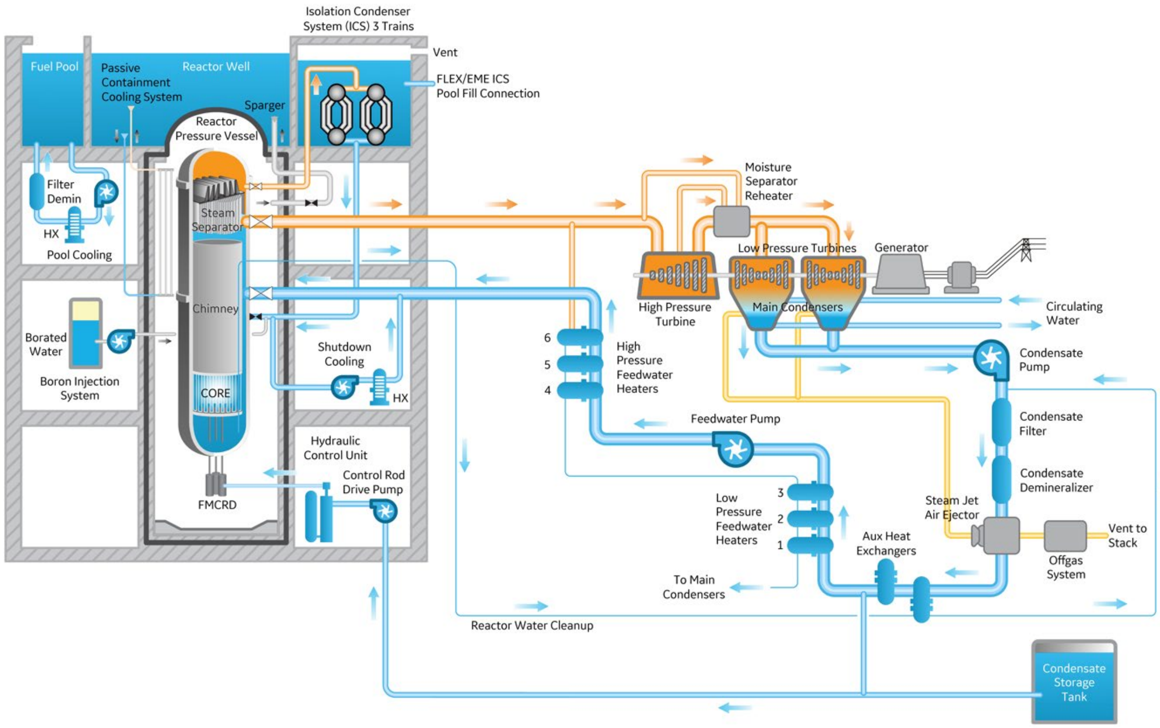


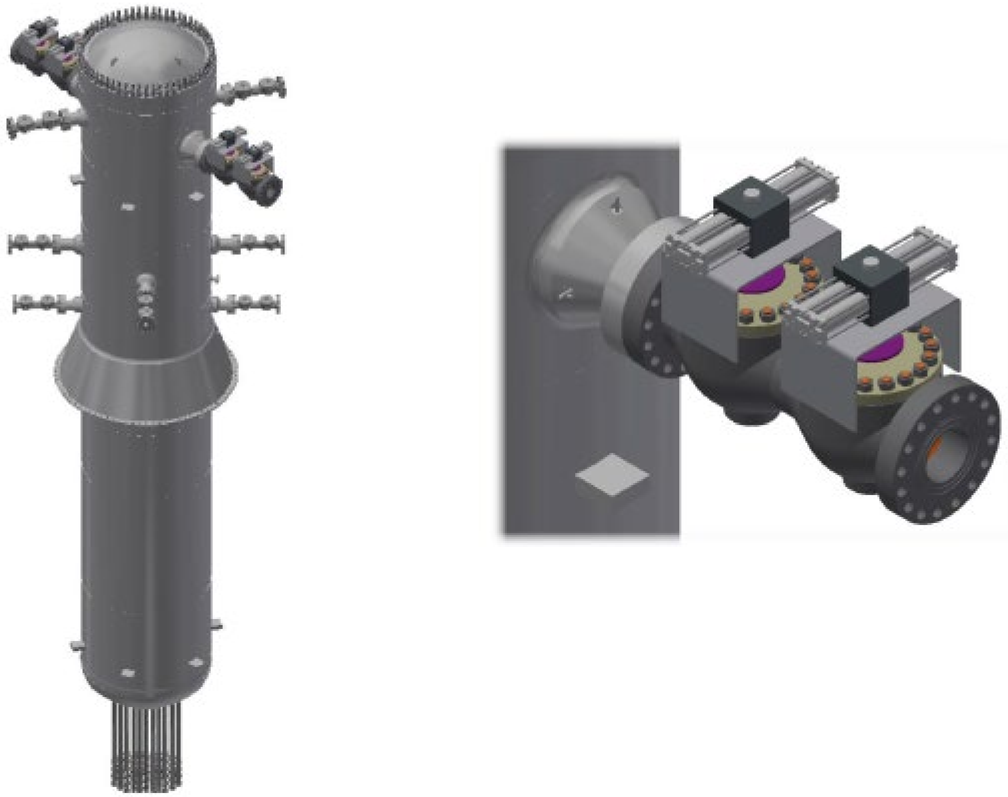
Figure 2: BWRX-300 Systems Overview

Reactor Pressure Vessel and Components

The BWRX-300 Reactor Pressure Vessel (RPV) is equipped with integral reactor isolation valves (as shown in Figure 3). In case of a transient, these fail-safe valves rapidly close to maintain coolant inventory in the core. The addition of the isolation valves significantly reduces the likelihood of a large loss of coolant accident, constituting a major safety improvement from previous BWR generations. Like the RPV, the forged integrated nozzles and flanges are being designed and will be fabricated to comply with ASME BPVC design and fabrication requirements as Code Class 1 components. All large fluid pipes with RPV penetrations are equipped with double isolation valves that are installed directly on the reactor pressure vessel nozzles to prevent pipe breaks between the Reactor Isolation Valves (RIVs) and RPV.

OPG has provided information on the RIVs as part of the design and safety analysis documents.

To further reduce the consequence of a pipe break, all large piping penetrations on the reactor pressure vessel are well above the top of the



core.

Figure 3: Conceptual Rendition of Reactor Isolation Valves

For high and moderate energy piping penetrating containment, OPG intends to apply the Break Exclusion Zone (BEZ) concept. Through the application of BEZ concept, piping is design to higher standards and requirements than those required by the American Society of Mechanical Engineers (ASME) Boiler and Pressure Section III. This includes:

- High quality materials: pipes are constructed from materials that resist corrosion, fatigue and thermal stresses.
- Stringent Quality Control: Manufacturing processes are subject to high standards, including non destructive testing methods to detect flaws, welding inspections and quality assurance protocols.

- Rigorous inspections: periodic thorough inspections on all pipe welds, beyond those required by code, ensure that any signs of wear, corrosion or damage are detected and addressed long before they can compromise pipe integrity.

- Robust design standards: design minimizes stresses on the pipe thus increasing safety margin beyond those required by applicable codes.

As demonstrated through years of implementation of BEZ methodology in nuclear stations in the United States, pipes within the BEZ are considered to have an extremely low probability of failure due to the high confidence in their design, materials, and maintenance. This confidence is rooted in enhanced requirements from existing codes and standards and safety analysis. BEZ is a proactive and layered strategy that focuses on preventative and mitigative measures to ensure safe and reliable operation.

For CANDU plants, these pressure retaining components are typically governed by CSA N285.0 "General requirements for pressure-retaining systems and components in CANDU nuclear power plants/Material Standards for reactor components for CANDU nuclear power plants." The existing CSA N285.0 standard, is focused on CANDU reactors and does not adequately address BWR designs. The main difference between CANDU and BWRX-300 designs is the ability to isolate the Reactor Pressure Vessel during a loss of coolant accident. To bridge this gap, OPG submitted a variance application to the CNSC for the BWRX-300, aligning its Structures System and Component (SSC) classification approach with USNRC Regulatory Guide 1.26, demonstrating equivalent safety, and meeting the intent of the Canadian standard.

The BWRX-300 will comply with unique CSA requirements, such as pressure boundary system registration, which are documented in the associated implementation procedure that OPG has submitted to CNSC along with the CSA N285 variance. Efforts are ongoing in the industry to update CSA N285.0 to be technology neutral.

Independent Means of Shutdown

Similar to existing BWRs, BWRX-300 has two independent means of shutdown, a fast-acting shutdown by hydraulic force stored in the Hydraulic Control Units Scrams (HCUs) and a second means of shutdown by electric fast motor run-in of the Fine Motion Control Rod Drives (FMCRDs). The control rods inside the core are common to both means of shutdown. However, the sensing, logic, and actuation in different Defense Lines (DLs) are independent and diverse for the two means of shutdown. Both means of shutdown are, or can be, initiated by the Anticipatory Trip System (ATS), Preferred Protection System (PPS) and Diverse Protection System (DPS), allowing for safe shutdown through control rod insertion during Anticipated Operational Occurrences, Design Basis Conditions and Design Extension Conditions. The BWRX-300 design meets the safety objectives of the CNSC requirements and guidance with respect to independent and diverse means of shutdown for an inherently safe reactor core, consistent with the guidance in REGDOC-2.4.1 and requirements of REGDOC-2.5.2. Specifically, the probability of failure to shutdown on demand and contribution of failure to shutdown to the Large Release Frequency are below the values in REGDOC-2.4.1. REGDOC-2.4.1 guidance defines reactors with inherent safety as those that do not lead to severe core damage in case of failure to shutdown on demand. CNSC staff have conditionally accepted OPG's alternate approach to meeting REGDOC 2.5.2, and the conditions will be satisfied through provision of detailed design information.

As part of the defence-in-depth strategy for BWRX-300, a boron injection system is available as a complimentary design feature which can be actuated in the extremely unlikely scenario where a beyond design basis event occurs that prevents shutdown of the reactor through rod insertion.

Isolation Condenser System

The BWRX-300 uses natural circulation and passive cooling systems. Steam condensation and gravity allow it to cool itself passively for at least seven days, using the inventory of the Isolation Condenser System, during abnormal events without external power or significant operator action.

The large capacity Isolation Condenser System, in conjunction with the large steam volume in the pressure vessel, provides overpressure protection. This has eliminated the need for some vessel pressure relief valves from this design that could otherwise be a point of vulnerability.

The isolation condenser system is normally in standby, ready to activate to provide cooling to the reactor instantly by opening its return line valves, which are normally closed. There are three independent trains of isolation condensers, and only one train is needed to mitigate most unusual events such as station blackout and turbine trip. Under extreme, beyond design basis events, connections are also available to provide additional external water for fuel cooling providing indefinite cooling exceeding the seven day pool capacity.

The BWRX-300's coolant conservation system, involving closed-loop heat removal between the RPV and the isolation condenser, sets it apart from previous BWR generations. Under most design basis accidents, almost no heat would be transferred to the containment and coolant levels would remain stable. This reduces the need for large containment volumes.

BWRX-300 Dry Containment

The BWRX-300 has a dry containment that encompasses the reactor pressure vessel called the Steel Plate Composite Containment Vessel (SCCV). Dry containment has been proven to effectively contain steam, water, and fission products in the unlikely event of a loss of coolant water. The primary containment design uses a nitrogen inerted- containment atmosphere during most operating modes. The atmosphere provides dilution of hydrogen and oxygen gases that could be released during an extremely unlikely severe accident condition. The containment also has a passive containment cooling system (PCCS) that does not require any pumps or support systems, working on the principles of density and gravity. The PCCS condensers are closed loop and the fluid inside does not contact the containment atmosphere. Since there are no containment isolation valves between the PCCS heat exchangers and the containment, the mode is always in "ready standby".

The BWRX-300 containment, as well as reactor building, uses Steel Composite (SC) structural modules, specifically the Diaphragm Plate Steel Composite (DPSC) system, to enhance modularity, strength, and construction efficiency. This design meets nuclear safety and performance standards, as demonstrated in the Licensing Topical Report in joint review by CNSC and USNRC. The DPSC containment design meets the intent of nuclear codes and standards and is supported by extensive research, development and testing. The National Reactor Innovation Center (NRIC) prototype testing confirmed the structural performance and technical readiness of the DPSC technology for nuclear applications.

3.3 Design Progression

The BWRX-300 design follows a systematic, structured, and phased process ensuring a robust and reliable outcome by validating that requirements are met at every phase of design. This is consistent with industry design approaches to risk-informed design management.

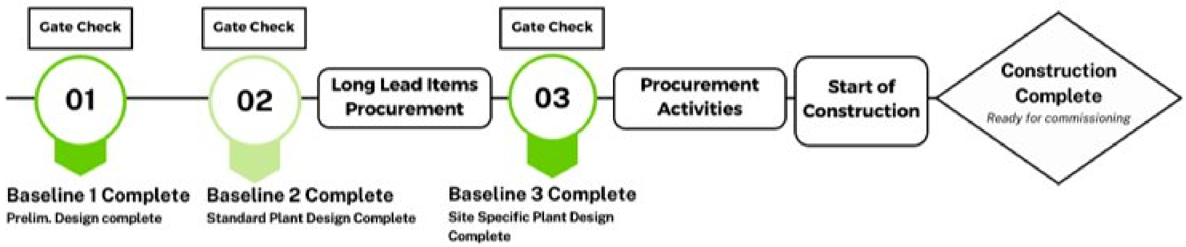


Figure 4: System Design Process

The approach consists of three design phases, applied to each system, with the design undergoing safety analyses at the overall design completion of each phase, ensuring that safety margins are managed, and key parameters are optimized. A robust and mature design control process is in place. Design control activities include technical reviews, special purpose reviews, design verification, and design review and acceptance.

The phases are defined by the maturity of, and level of detail for, each of the requirement levels and design output documents such as specifications, drawings and instructions.

The process began when design requirements were established from regulatory requirements, owner input, and product needs. A high-level conceptual design was developed, building on nine previous generations of BWR designs, proven operating performance and inclusion of operational experience, as well as research and development. Safety evaluations, both deterministic and probabilistic provided crucial guidance, shaping the design and ensuring alignment with safety standards.

The second phase of design focuses on developing detailed designs for key structures, systems, and components. Design continues to be refined using updated inputs, some bounding, some site-specific Integrated system models in the deterministic and probabilistic safety analysis and interfaces are created, ensuring a cohesive plant operation. Rigorous technical reviews confirm the design meets high standards of performance, reliability, and safety, with attention to constructability and human factors. In this phase the design is bounding and is considered the standard plant design.

In the third and final phase design and analysis are completed using site-specific inputs to confirm all local requirements are met. Procurement vendor feedback is incorporated, ensuring all components are optimized for performance and compliance. Design is finalized for all systems and components for construction readiness. Continual updates and reviews following robust established design change management processes ensure configuration control, and that the design meets and exceeds regulatory requirements.

At the end of each phase for a specific system, there is a gate check where it is ensured that the system has met the defined success criteria, and level of detail, for the corresponding phase. At the end of the third phase, this gate check allows the specific system to progress to construction.

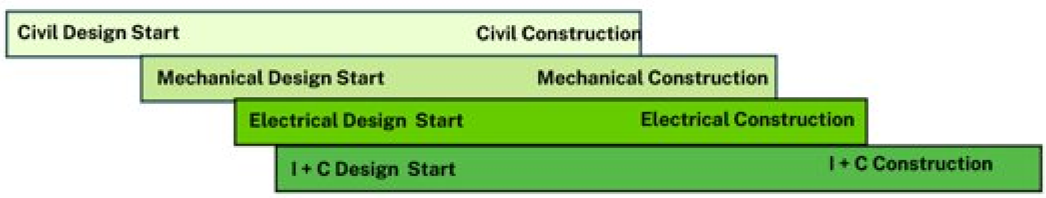


Figure 5: Design and Construction Sequence

Systems are released to construction in a logical sequencing that is typical to major construction projects. Design typically starts with civil/structural first as it establishes the foundation and sets the groundwork for all subsequent installations. Mechanical design follows, as close coordination is needed as systems are large and require space and load considerations. Electrical design starts next as it supports both civil and mechanical designs, ensuring power availability for systems and construction. Instrumentation and Controls design is the last discipline to be completed as it depends on the finalized mechanical and electrical designs for integration and alignment with operational requirements.

By following this sequence, the design process ensures a logical flow, reduces the need for rework and supports efficient construction. The design process being used for the BWRX-300 is consistent with industry design approaches to risk-informed design management and has incorporated best industry practice in design evolution. Through the implementation of this process, OPG is confident in the safety and robustness of the BWRX-300 design, and its readiness for construction.

3.4 Safety Analysis and Robustness of Design

The BWRX-300 employs a safety strategy based in industry best practices and guidelines to achieve a safety analysis that demonstrates that regulatory safety goals are exceeded by orders of magnitude.

The safety strategy's approach to classifying Systems, Structures and Components (SSCs) is based primarily on deterministic methods and is directly traceable to their respective safety functions. This approach is based on principles in IAEA SSR-2/1 and IAEA SSG 30 and in alignment with CNSC REGDOC-2.5.2, Section 7.1 by considering:

- The consequences of the SSC's failure to perform its safety functions.
- The expected frequency of the SSC being called upon to perform its safety functions.
- The time following a postulated initial event at which, or the period for which, the SSC may be called upon to perform a safety function.

A fundamental element of the BWRX-300 SSC classification approach is the direct correlation between the Defense Line (DLs) in which an SSC performs a function, and the relative safety importance of that function. DL functions are classified into three safety categories, Safety Category 1, Safety Category 2, and Safety Category 3, with Safety Category 1 correlated to the most important DL functions. Components are assigned a Safety Class (Safety Class 1, 2, or 3) based on the Safety Category of the functions they perform and when that function is required after an event.

The safety analysis, which considers the implementation of the safety strategy, has demonstrated that the BWRX-300 is capable of cooling itself passively for at least seven days, in case of an abnormal event, without external power or significant operator action.

Current probabilistic safety analysis results, which cover all hazards and operating conditions, show that the BWRX-300 is below the Regulatory Document 2.5.2 safety goals by more than one order of magnitude, as per the results reported in CMD 24-H3.1.

As an example, current results show that the most significant contributor to the Large Release Frequency (LRF) for the BWRX-300 has a frequency that is 5 percent of the regulatory safety goal for LRF for new facilities.

3.5 Consideration for External Hazards

Safety is OPG's number one priority, and OPG would not consider deploying any nuclear technology that was not able to demonstrate class-leading levels of safety. Operating experience from industry events, such as that at the Fukushima Nuclear station, are extensively analyzed and lessons learned have been incorporated into the design from first principles.

The design process for the BWRX-300 considers external hazards such as a Fukushima-type event and is designed to withstand the effects of those hazards. This is a requirement by the Canadian Nuclear Safety Commission. Specifically, the BWRX-300 incorporates passive safety features such that it does not rely on external power sources or cooling water to reach a safe state. The probability of a beyond-design basis event like Fukushima is greatly reduced by these design features.

The primary cause of the accident at Fukushima was not reactor design, but availability of support services, water, and power to mitigate the effects of the tsunami. This vulnerability has been both addressed for BWRX-300, as the reactor design does not rely on external power sources or cooling water to reach a safe state. The reactor relies on passive features such as natural circulation, passive ICS for heat removal. For defense in depth reasons, BWRX-300 also has back-up power supplies (such as Standby Diesel Generators), make-up water and Emergency Mitigating Equipment strategies for very unlikely Beyond Design Basis Event (BDBE) scenarios requiring external support services.

The next generation of nuclear technologies have all been designed after Fukushima and take those learnings completely into their design from first principles. Hazards such as flooding and seismic events were assessed for the DNNP site. Tsunami flooding is very unlikely due to the location and geological stability of the Darlington New Nuclear site. Flooding from seiche (lakewater sloshing back and forth due to a disturbance) and storm surge would cause maximum water levels lower than DNNP breakwater works. Flooding from extreme precipitation is the bounding case. The impact of climate change has been assessed and is being used to inform the design. Seismic design parameters have been developed based on site response analyses. Structures and equipment are assigned a seismic category to reflect requirements during and after a seismic event.

Fukushima lessons learned are being incorporated into the siting, design, and equipment. The BWRX-300 design includes key passive safety features such as the Isolation Condenser System and tall reactor vessel design to enable the reactor to maintain cooling for at least seven days with external water and power or significant operator action. Emergency plans and procedures for the operational phase of the BWRX-300 will be created prior to fuel-in commissioning.

OPG is confident that the safe and robust design of the BWRX-300, demonstrated through the safety analysis, the many years of operating experience from BWRs and OPG's history of safe, reliable nuclear generation means the construction of a BWRX-300 SMR on the Darlington New Nuclear Site will not cause unreasonable risk.

4.0 COMMITMENTS

OPG has continued to meet its commitments with respect to DNNP and reports on the status of the project as part of the DNNP annual report. OPG has closed 74 commitments associated with the Licence to Construct (LTC)LTC application review and has submitted information for 15 Joint Report Panel commitments in 2024. OPG regularly updates the DNNP Commitments Report [R-20] to show the status of OPG commitments and actions arising from the DNNP Environmental Assessment. These include activities, and deliverables associated with the site preparation and construction phases. OPG also continues to report on the status of the remaining 85-related commitments to CNSC staff.

In addition, any other formal regulatory commitments made by OPG as part of the CNSC Licence to Construct application review process are captured and tracked as regulatory actions and OPG reports on the status of these commitments regularly to CNSC staff.

5.0 INDIGENOUS ENGAGEMENT

5.1 Status Update

OPG engages with Indigenous Nations and communities on the DNNP project. Key to this engagement are the ongoing collaborative efforts with the Treaty rights-holding Michi Saagiig Nations pertaining to the Indigenous Knowledge Study (IKS), which is Indigenous-led and funded by OPG. The IKS will run parallel to DNNP project phases and into the operational phase as part of OPGs long-term relationship with the Nations. The IKS will encompass and inform the following elements:

- Rights Impact Assessment;
- Cumulative Effects Study;
- Enhanced Environmental Monitoring (EA follow-up) to bridge the 2009 EA to today's standards; and
- Aquatic offsetting and terrestrial restoration planning and execution

OPG will continue to provide the Michi Saagiig Nations and other Indigenous Nations and Communities with relevant project information.

Since the conclusion of Hearing Part 1, commercial participation discussions with the four Michi Saagiig Nations (Mississauga of Scugog Island, Hiawatha, Curve Lake and Alderville) have continued to progress. At the same time, a new internal model and escalation process within OPG's Nuclear team has been established. This model will support OPG to enhance the overall relationship by enabling faster response times to questions and concerns raised by the Michi Saagiig Nations, improving communication and co-ordination between various OPG projects and the Michi Saagiig Nations, and ensuring Nation to Corporation leadership meeting take place on a regularized schedule.

Over the course of the 2024 calendar year, eighteen (18) permits were approved by federal and provincial regulators. These permits were discussed with the Michi Saagiig Nations as rights-holders and adjustments made to reflect the Nations' rights and interests. Permit discussions have included discussion regarding aquatic offsetting and terrestrial restoration at the DNNP site and will continue into 2025.

Key to these discussions have been accommodations to Michi Saagiig Nations rights, interests and concerns. For example:

On site seed collection

In June 2024, recommendations were made to collect seeds on-site prior to vegetation removals. While most of the areas permitted for clearing under the site preparation ESA (Endangered Species Act) permits had already been cleared, there were areas on site identified where clearing had not yet occurred. OPG is currently collecting seeds and salvaging plants in these locations.

Butternut replacement ratio

OPG agreed that if it were to remove one healthy (Category #2) butternut tree, it would compensate by planting 40 butternut trees. The plantings will form part of post-project restoration on site or may involve offsite plantings in collaboration with the Michi Saagiig Nations.

Design changes to CCW

Design changes to the Condenser Cooling Water (CCW) system came as a result of environmental impact concerns expressed by the Michi Saagiig Nations regarding key species e.g., salmon and walleye. This was tied to concerns that the habitat alteration, disruption, and destruction (HADD) be minimized, and that thermal effects be reduced. This was achieved by utilizing computational fluid dynamics, resulting in a reduction in the number of risers that the diffuser needed.

Additional examples include:

- Spills reporting
- Tritium sampling during dewatering activities
- Bluebird boxes
- Bat boxes
- Milkweed data collection
- Inclusion of Sugar Maple in planting plans
- Tree replacement ratio for ESA habitat cleared under ESA permits

Waste is a key subject of concern expressed by Indigenous Nations and Communities. OPG and the Michi Saagiig Nations launched a waste table in August 2024 to complement the existing twice monthly meeting schedule to ensure that waste management strategies will be discussed beyond project waste management; a Terms of Reference is currently under discussion. In addition, OPG funded an independent consultant at the suggestion of the Mississaugas of Scugog

Island to review international waste management best practices; this review was recently concluded, and a subsequent report will be issued.

OPG has also developed a curriculum on the energy sector called "Generation for Generations" which covers everything from the players in the energy industry (e.g., IESO, Ontario Energy Board, CNSC, IAEA, and HydroOne), renewable generation, nuclear power and waste and is designed to fill the gaps in information Indigenous Nations and communities may have as a result of being historically excluded from the energy sector. This curriculum will be rolled out in early 2025.

OPG and the Michi Saagiig Nations have agreed to two Letters of Intent (LOI) with the purpose of clarifying many aspects of our ongoing relationship. One LOI is related to the specific DNNP project and will address the ongoing relationship at a project level; the other LOI relates to the borader relationship between the Michi Saagiig Nations and OPG. The proposed DNNP specific agreement, which will be negotiated through 2025, will cover various subjects, including environmental monitoring participation, economic development opportunities, the ongoing incorporation of Indigenous Knowledge into all project phases of DNNP and unit operations, as well as some commercially sensitive information and includes confidentiality clauses which prevents the public sharing of information.

5.2 Interim Storage of Low and Intermediate Level Waste

On November 13, 2024, OPG submitted a correspondence to notify the Commission Registry of OPG's decision regarding the storage of DNNP Low and Intermediate Level Waste (L&ILW). OPG previously considered the two options described in the Environmental Assessment and is not actively pursuing the option of interim storage of L&ILW from DNNP at OPG's Western Waste Management Facility located within the traditional territory of the Saugeen Ojibway Nation.

6.0 KEY TOPICS OF INTEREST

6.1 Preparing for a Large Project

The DNNP lessons learned program incorporates the various activities undertaken in order to help prepare for this project. There have been extensive lessons learned and incorporated directly from the Darlington Nuclear Generating Station (DNGS) Refurbishment project. OPG has carried out extensive benchmarking with various international nuclear and non-nuclear projects. These included the Windsor-Detroit Bridge, Hinkley Point C, Vogtle, Kajima Corp and others. This also included the use of a shared database through GEH with input from the Tennessee Valley Authority (TVA).

The key learning brought into the project from these benchmarkings and lessons learned include training on intrusive oversight, implementation of a common corrective action program, development of an issues management policy and the use of high impact teams to tackle critical and emergent issues. A quality oversight program has also been put in place to assess how procedures, processes and tools are being utilized and adjust where needed.

OPG has engaged internationally with other organizations involved in construction of nuclear power plants to obtain experience and lessons learned for constructability, layout spacing, weather proofing and other aspects. Other items incorporated in the project include the integration of technology into the project set up and delivery processes as well as the integration of the schedule and work breakdown structure. OPG also engaged with Kajima Corp who have ABWR steel composite experience through a visit to the DNNP site to incorporate lessons learned. There has been onboarding of external resources with key experience to support planning, construction and commissioning. Roles supporting design, construction and commissioning are occupied by resources with expertise in new build design, greenfield construction and commissioning of BWRs.

OPG is utilizing construction best practice references such as “Design Completion and Reliability of Schedule and Cost Estimations to Support Construction Decisions” by Nuclear Energy Institute [R-X] as well as “Strategic Project Management Lessons Learned & Best Practices for New Nuclear Power Construction” by the Nuclear Energy Institute.

6.2 Conventional Health & Safety

At the Part 1 Hearing, Commissioners had requested information about OPG’s approach and plans regarding the health and safety of personnel on the DNNP construction site. OPG would like to take this opportunity to provide a supplemental response to the information provided in Part 1 Hearing.

OPG and its vendor partners will use qualified experienced and competent personnel to perform the construction phase work, similar to the approach for the current site preparation activities. Site training and onboarding is governed by the AECON Onboarding and Training plan. OPG will maintain oversight to confirm compliance with legislative and regulatory standards as well as compliance with site-specific implementation plans. Qualification criteria is determined for the positions and roles based on the work to be performed. The scope of the training and onboarding for personnel includes:

- DNNP site safety orientation;
- WHIMIS & Environment Health and Safety Training;
- Task Specific Training; and
- Quality Overview Training.

  The site-specific health and safety plan, which was created for the start of site preparation activities has been updated to address the scope of the construction activities and the identification and mitigation of potential risks arising from these activities.

There is a protocol in place at DNNP to ensure that any safety incidents are reported. OPG and its vendor partners maintain a detailed set of safety metrics on this project, similar to OPG existing fleet, with industry leading targets to manage performance. These metrics are used to monitor safety performance and allow OPG and its vendor partners to manage merging trends and make adjustments as needed to ensure personnel safety is maintained throughout the project. The project leadership meets on a regular basis to review the report. To date, OPG has demonstrated the safe conduct of the site preparation activities, with quality and on schedule.

A site-specific non-radioactive hazardous waste management plan will be in place for the construction phase to address the management and mitigation of hazardous materials and waste, including storage, handling, disposal and minimization.

There are unique features to the DNNP construction project, such as blasting, underwater tunneling, and deep foundation trenching. OPG has retained the services of a constructor that has experience in completing this type of work. They have a proven track record for safely completing this type of work on major projects around the world. OPG has ensured AECON and their subcontractors have developed detailed procedures for these tasks that are based on industry best practices and all regulatory requirements. OPG has reviewed these procedures and is providing oversight in the field to ensure work is being executed in accordance with these robust plans.

In addition to these unique hazards, we recognize that activities like material handling and heavy equipment movement are present on this project and there are plans in place to manage these hazards and oversight is provided by OPG to ensure safe execution.

6.3 Management of Waste

There will be no radioactive waste generated during the construction phase of the DNNP. OPG has been safely handling, processing and storing radioactive waste for over 50 years and the radioactive waste from the BWRX-300 is fundamentally no different.

Under the Nuclear Fuel Waste Act, the Nuclear Waste Management Organization (NWMO) has responsibility for long-term management for all of Canada's used fuel – including that which is created using new technologies like SMRs. All disposal planning will follow consent-based siting processes.

6.4 Decommissioning

As part of the DNNP Licence to Construct Application, OPG submitted both as-built and end-of-life preliminary decommissioning plans (PDPs). As stated in the As-Built PDP, a prompt decommissioning strategy for the DNNP as-built facility was selected based on a high-level review of the factors and strategy considerations provided as guidance in REGDOC-2.11.2.

As stated in the End-of-Life PDP, OPG has, for financial planning purposes preliminarily, chosen to assume a prompt decommissioning strategy primarily because the DNNP is a smaller reactor that can be easily isolated from the other units on the site and this strategy will allow the licence to terminate sooner than with deferred decommissioning.

Consistent with international practices, sub-surface structures will be dismantled to a 'nominal removal depth' of one meter below grade, backfilled with concrete rubble and/or soil and graded over. OPG has reviewed experience and obtained lessons learned from other decommissioned nuclear facilities as part of the preparation of its preliminary decommissioning plans and cost estimates. Humbolt

Bay was one such example of a below grade reactor that was successfully decommissioned. In

As per regulatory requirements in REGDOCs 2.11.2 preliminary decommissioning plans are updated every five years or as requested by CNSC. OPG has maintained the decommissioning plan for DNNP and will maintain and submit it as per regulatory requirements.

The decommissioning cost estimate was developed based on industry guidelines for decommissioning planning, and incorporated experience gained from other decommissioning projects and the latest available design information for BWRX-300. OPG submitted a financial guarantee for the site preparation activities and to close Joint Review Pane commitment D-P-13, which was accepted by the Commission in June 2022. OPG submitted an updated financial guarantee for the scope of construction activities as part of the Licence to Construct Application in March 2023. The decommissioning plans and associate cost estimate will be reviewed every five years as per REGDOC-2.11.2 and 3.3.1 and updated as necessary.

6.5 DNNP Adjacent to Darlington Nuclear Generating Station

Multi-unit interactions are not unique to the BWRX-300 and were addressed as part of the Environmental Assessment when other larger non-CANDU reactor designs were considered. The BWRX-300 does not introduce any new feature that would alter the conclusions. All human-induced external hazards for DNNP-BWRX-300, which also includes hazards originating from DNGS, have been thoroughly examined and addressed as part of the safety case.

The potential scenario involving an event at the Darlington Nuclear Generating Station was also investigated and screened out quantitatively via frequency in the DNNP BWRX-300 hazards analysis documentation. The calculated frequency of a core damage in such a scenario, assuming no operator actions at DNNP, has a frequency of 2.7E-11/yr, which is significantly below the screening criteria of 1E-7/yr from international standards. Further, this hazard was also combined with other quantitatively screened out hazards for DNNP, and the sum is less than 1% of the cumulative risk target.

6.6 Industry Experience

The BWRX-300 design leverages lessons learned from over 100 previous in Boiling Water Reactors (BWRs) that have been built, operate, and in some cases decommissioned. The BWRX-300 design is based on proven concepts from the Economic Simplified Boiling Water Reactor (ESBWR) and addressing issues like Intergranular Stress Corrosion Cracking (IGSCC) with advanced materials and water chemistry control. Finally, incorporating OPEX reviews is proceduralized into the design and decision-making process for the BWRX-300 and DNNP facility.

The nuclear industry pools resources through groups like the BWR Owners Group and the BWR Vessel and Internals Project to enhance plant reliability, safety, and cost-efficiency. Additional operating experience is sourced from organizations such as Institute of Nuclear Power Operations (INPO), World Association of Nuclear Operators (WANO), and Electric Power Research Institute (EPRI). OPG is a member of all of these organizations and has joined the BWR Owners Group in order to gain from the industry knowledge and shared experience.

7.0 CONCLUSION

OPG's history of safe operations and project management success, in particular large nuclear projects such as the Darlington Nuclear Refurbishment Project, demonstrates OPG's readiness to undertake the construction of a BWRX-300 unit at the Darlington New Nuclear Site. The BWRX-300 leverages operating experience from generations of previous BWRs, providing enhanced safety features that are demonstrated through the Licence to Construct Application.

OPG is committed to delivering the project in an environmentally sustainable manner. The Darlington New Nuclear Project will be a significant step for OPG towards net-zero carbon company by 2040 so that we can act as a catalyst for a net-zero carbon economy by 2050. OPG is committed to continuing to build partnership with Indigenous Nations and local communities as it works towards achieving these goals.

Under the existing site preparation licence, in its application for a licence to construct, and in response to the information requests by CNSC staff, OPG has demonstrated that it:

- is qualified and ready to carry on the proposed licensed activities, and
- will make adequate provisions for the protection of the environment, the health and safety of persons and the maintenance of national security and measures required to implement international obligations to which Canada has agreed.

As such, OPG respectfully requests the Commission approve OPG's Darlington New Nuclear Project Power Reactor Construction Licence for one BWRX-300 unit. OPG also requests that the Commission accepts OPG's proposed Financial Guarantee for DNNP as part of the requested Power Reactor Construction Licence.

REFERENCES

[R-1] OPG Letter, M. Knutson to D. Saumure, "Darlington New Nuclear Project Application for Licence to Construct A Reactor Facility", CD# NK054-CORR-00531-10738, Oct. 31, 2022.

[R-2] CMD 24-H3.1, Submission from Ontario Power Generation – Application for a Licence to Construct One BWRX-300 Reactor for the Darlington New Nuclear Project, June 27, 2024.

[R-3] CMD 24-H3.1A OPG Indigenous Engagement Report, September 25, 2024.

[R-4] CMD 24-H3.1B Presentation by Ontario Power Generation - Application for a Licence to Construct One BWRX-300 Reactor for the Darlington New Nuclear Project, September 25, 2024.

[R-5] CMD 24-H3 Submission from CNSC - Application for a Licence to Construct One BWRX-300 Reactor for the Darlington New Nuclear Project, June 27, 2024.

[R-6] CMD 24-H3.A Presentation by CNSC Staff - Application for a Licence to Construct One BWRX-300 Reactor for the Darlington New Nuclear Project, September 25, 2024

[R-7] CMD 24-H3.B Supplementary Submission by CNSC Staff – Application for a Licence to Construct One BWRX-300 Reactor for the Darlington New Nuclear Project, September 25, 2024.

[R-8] CMD 24-H3 Q Questions from the Commission Following DNNP Part 1 Hearing, October 11, 2024.

[R-9] IESO Report "Pathways to Decarbonization", December 15, 2022.

[R-10] OPG Report - NK054-SR-01210-00001 R001, "DNNP BWRX-300 Preliminary Safety Analysis Report", March 2023.

[R-11] GEH Report - NEDO-33987P, Rev 1, BWRX-300 Darlington New Nuclear Project (DNNP) TRACG Application.

[R-12] GEH Report - NEDO-33083 Supplement 1-A Rev2, "TRACG Application for ESBWR Stability Analysis".

[R-13] GEH Report – NEDO 33292 GEXL17 Correlation for GNF2 Fuel.

[R-14] GEH Report - NEDO-24011-P-A-32, "General Electric Standard Application for Reactor Fuel (GESTAR II)", August 2024

[R-15] CSA N290.14-15, "Qualification of Digital Hardware and Software for use in Instrumentation and Control Applications for Nuclear Power Plants"

GLOSSARY

ALARA A principle of radiation protection that holds that exposures to radiation are kept as low as reasonably achievable, social and economic factors taken into account.

Best Practice An industry-accepted approach (for example, toward a design, process or procedure) that is acknowledged as consistently producing superior results.

Beyond-Design-Basis Event (BDBE) An event less frequent and potentially more severe than a design-basis accident.

Boiling Water Reactor (BWR) A common type of light-water reactor, where water is allowed to boil in the core, generating steam directly in the reactor vessel to generate electrical power.

Canadian Nuclear Safety Commission (CNSC) Canada's nuclear regulator, established under the Nuclear Safety and Control Act to regulate the use of nuclear energy and materials to protect health, safety, security, and the environment; to implement Canada's international commitments on the peaceful use of nuclear energy; and to disseminate objective scientific, technical and regulatory information to the public.

Commissioning With respect to a reactor facility, a process intended to demonstrate that installed Structures, Systems and Components (SSCs) perform in accordance with their specifications before the facility is placed in service or before the SSCs are returned or placed in service.

Complementary Design Feature A design feature added to the design as a standalone structure, system or component or added capability to an existing SSC to cope with design extension conditions.

Construction The process of procuring, manufacturing, and assembling the components, carrying out civil work, installing and maintaining components and systems, and performing associated tests.

Core Damage Accident leading to significant fuel degradation. For CANDU reactors, core degradation is defined as extensive physical damage of the multiple fuel channels due to overheating leading to loss of core structural integrity.

Core Damage Frequency An expression of the likelihood that an event could cause core damage.

CSA Group A standard-setting body that works with the regulator, industry, and stakeholders to produce consensus-based Canadian industry standards that may be used by the regulator or industry. Formerly called Canadian Standards Association.

Decommissioning Administrative and technical actions taken to allow the removal of some or all of the regulatory controls from a facility, location or site where nuclear substances are managed, used, possessed or stored.

Defence In Depth A hierarchical deployment of different levels of diverse equipment and procedures to prevent the escalation of anticipated operational occurrences and to maintain the effectiveness of physical barriers placed between a radiation source or radioactive material and workers, members of the public or the environment, in operational states and, for some barriers, in accident conditions.

Design Authority The entity that has overall responsibility for the design process, or the responsibility for approving design changes and for ensuring that the requisite knowledge is maintained.

Design Basis The range of conditions and events taken explicitly into account in the design of a nuclear facility, according to established criteria, such that the facility can withstand this range without exceeding authorized limits. Note: Design extension conditions are not part of the design basis.

Design-Basis Accident (DBA) Accident conditions for which a nuclear facility is designed according to established design criteria and for which damage to the fuel and the release of radioactive material are kept within authorized limits. DBA is a plant state.

Design Extension Conditions (DEC) A subset of beyond-design-basis accidents that are considered in the design process of the facility in accordance with best-estimate methodology to keep releases of radioactive material within acceptable limits. Design extension conditions could include severe accident conditions. DEC is a plant state.

Deterministic Safety Analysis An analysis of a nuclear facility's responses to an event, performed using predetermined rules and assumptions (such as those concerning the initial facility operational state, availability and performance of the facility systems and operator actions).

Equipment Pool A pool located at the opposite end of the Reactor Building Cavity from the RB Pool that holds the dryer and separator during the refueling outage.

Environmental Risk Assessment (ERA) A process that identifies, quantifies and characterizes the risk posed by contaminants (nuclear or hazardous substances) and physical stressors in the environment. An ERA is a practice or methodology primarily developed by regulatory agencies to provide scientific input to decision makers. In this way, ERAs commonly serve as a supportive tool providing technical information in a manageable form to a larger EA.

Heat Sink A system or component that provides a path for heat transfer from a source, such as heat generated in the fuel, to a large heat-absorbing medium, such as water.

Licensee An individual or organization that is licensed to carry on a Licensed Activity.

Loss-Of-Coolant Accident (LOCA) A type of reactor accident that results from a loss of coolant due to a break in the primary heat transport system.

Nuclear Facility (in the context of DNNP) a nuclear fission or fusion reactor or subcritical nuclear assembly.

Nuclear Power Plant A nuclear facility consisting of any fission- reactor installation that has been constructed to generate electricity on a commercial scale.

Offsite Power alternating current (AC) power supplied from the transmission system (grid), to the plant electrical power distribution systems.

Operating Experience (OPEX) Pertinent internal and external information, gained through practical experience, used to learn about and improve the safety and reliability of nuclear facilities.

Owner OPG is the Darlington Nuclear Site Owner where the future DNNP Facility will be located. OPG is the current licence holder for the DNNP Site Preparation Licence and will be the licence holder for the proposed Power Reactor Construction License.

Pressure Boundary A boundary of a pressure-retaining structure, system or component of a nuclear or non-nuclear system. Note: This definition applies to components subject to registration under applicable boiler and pressure vessel legislation.

Probabilistic Safety Assessment (PSA) A comprehensive and integrated assessment of the safety of a facility. The safety assessment considers the probability, progression and consequences of equipment failures or transient conditions to derive numerical estimates that provide a consistent measure of the safety of the facility.

Sievert (Sv) The International System of Units (SI) unit of equivalent dose and effective dose, equal to 1 joule/kilogram.

ACRONYMS

AC	Alternating Current
ALARA	As Low As Reasonably Achievable
AOO	Anticipated Operational Occurrences
ASME	American Society of Mechanical Engineers
BDBA	Beyond Design Basis Accident
BEZ	Break Exclusion Zone
BIS	Boron Injection System
BWR	Boiling Water Reactor
CCS	Containment Cooling System
CDF	Core Damage Frequency
CEAA	Canadian Environmental Assessment Agency
CFD	Condensate Filters and Demineralizers System
CMD	Commission Member Document
CNSC	Canadian Nuclear Safety Commission
CRDH	Control Rod Drive Hydraulic
CWS	Circulating Water System
DBA	Design Basis Accident
DC	Direct Current
DCIS	Distributed Control and Information System
DEC	Design Extension Condition
DFO	Department of Fisheries and Oceans Canada
DGR	Deep Geological Repository
DIQ	Design Information Questionnaire
DL	Defence Line
DN	Darlington Nuclear

DNGS	Darlington Nuclear Generating Station
DNNP	Darlington New Nuclear Project
DPSC	Diaphragm Plate Steel Composite
DSA	Deterministic Safety Analysis
EA	Environmental Assessment
ECA	Environmental Compliance Approval
ECCC	Environment and Climate Change Canada
EcoRA	Ecological Risk Assessment
EDS	Electrical Distribution System
EIS	Environmental Impact Statement
EMEAF	Environmental Monitoring and Environmental Assessment Follow-Up
EMPP	Environmental Management and Protection Plan
EMS	Environmental Management System
ERA	Environmental Risk Assessment
ESA	Endangered Species Act
ESBWR	Economic Simplified Boiling Water Reactor
FFEE	Fixed Face Earthen Embankment
FFHE	Functional Failure Hazards Evaluation
FLEX/EME	Flexible Mitigation Strategies or Emergency Mitigating Equipment
FMCRD	Fine Motion Control Rod Drive
FMEA	Failure Modes and Effects Analysis
FPC	Fuel Pool Cooling and Cleanup System
FSF	Fundamental Safety Function
GEH	General Electric Hitachi
GT	Gamma Thermometer
HFE	Human Factors Engineering

HHRA	Human Health Risk Assessment
HSI	Human-System Interface
HX	Heat Exchanger
IAEA	International Atomic Energy Agency
ICS	Isolation Condenser System
INPO	Institute of Nuclear Power Operations
ION	Indigenous Opportunities Network
IPD	Integrated Project Delivery
ISO	International Organization for Standardization
ISRW	Integrated Strategy for Radioactive Waste
JRP	Joint Review Panel
L&ILW	Low and Intermediate Level Waste
LOCA	Loss of Coolant Accident
LPRM	Local Power Range Monitor
LRF	Large Release Frequency
LTC	Licence to Construct
masl	meters above sea level
MCA	Main Condenser and Auxiliaries
MCR	Main Control Room
MECP	Ministry of Environment, Conservation and Parks
MNRF	Ministry of Natural Resources and Forestry
MW	megawatts
MWe	megawatts electric
MWth	megawatts thermal
NBS	Nuclear Boiler System
NMS	Nuclear Management System

NRC	Nuclear Regulatory Commission
NSCA	Nuclear Safety and Control Act
NWMO	Nuclear Waste Management Organization
OHSA	Occupational Health and Safety Act
OLCs	Operating Limits and Conditions
OPG	Ontario Power Generation
PCCS	Passive Containment Cooling System
PCS	Primary Containment System
PDP	Preliminary Decommissioning Plan
PEP	Project Execution Plan
PERA	Predictive Environmental Risk Assessment
PIE	Postulated Initiating Event
PIT	Project Integration Team
PLT	Project Leadership Team
PMT	Program Management Team
PPE	Plant Parameter Envelope
PRSL	Power Reactor Site Preparation Licence
PSA	Probabilistic Safety Assessment
PSAR	Preliminary Safety Analysis Report
RB	Reactor Building
REGDOC	Regulatory Document
RIV	Reactor Isolation Valves
RPV	Reactor Pressure Vessel
RWB	Radwaste Building
SA	Severe Accident
SARA	Species at Risk Act

SAT	Systematic Approach to Training
SCA	Safety and Control Area
SCCV	Steel-Plate Composite Containment Vessel
SCR	Secondary Control Room
SMR	Small Modular Reactors
SRF	Small Release Frequency
SSCs	Structures, Systems and Components
SSEMP	Site-Specific Environmental Management Plan
Sv	Sievert
TQD	Training and Qualification Description
WRNM	Wide Range Neutron Monitor
WTFN	Williams Treaty First Nations