Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

CMD 24-H2.32

File / dossier : 6.01.07
Date: 2023-11-20
Edocs: 7170772

Oral presentation

Written submission from Northwatch

Exposé oral

Mémoire de Northwatch

In the Matter of the

À l'égard d'

Ontario Power Generation Inc.

Ontario Power Generation Inc.

Applicability of the Darlington New Nuclear Project environmental assessment and plant parameter envelope to selected reactor technology

Applicabilité de l'évaluation environnementale et de l'enveloppe des paramètres de la centrale à la technologie de réacteur sélectionnée pour le projet de nouvelle centrale nucléaire de Darlington

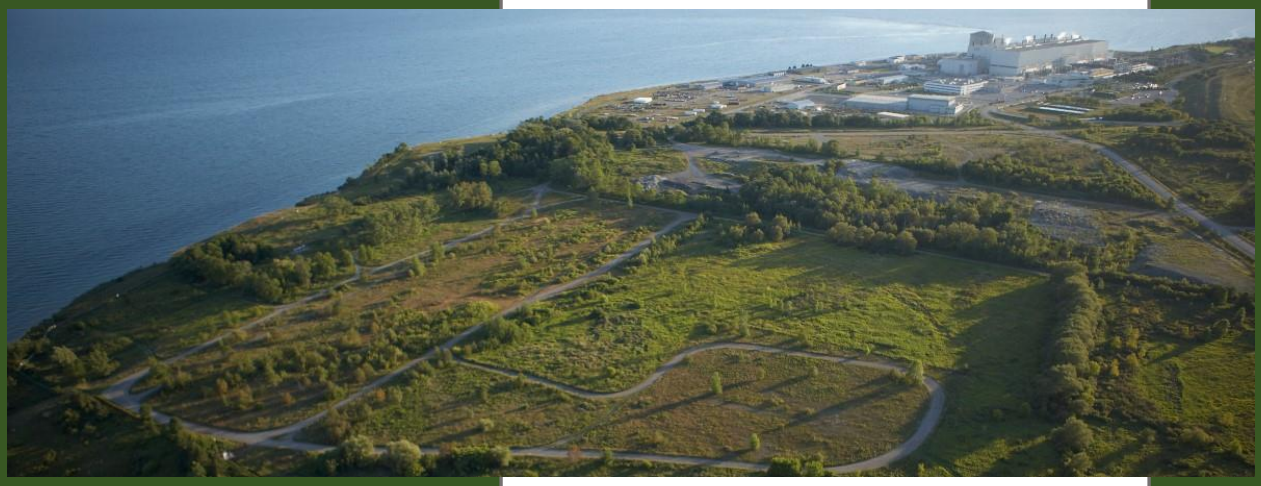
Commission Public Hearing

Audience publique de la Commission

January 2024

Janvier 2024

Canada



Northwatch Comments on Applicability of the Darlington New Nuclear Project Environmental Assessment and Plant Parameter Envelope to the BWRX-300

NORTHWATCH

November 20, 2023

24-H2

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Summary

Ontario Power Generation's proposal to construct four units of the BWRX-300 reactor at the site of the Darlington Nuclear Generating Station is anticipated to be the subject of a series of public hearings to be convened by the Canadian Nuclear Safety Commission. This submission is with respect to the first public hearing, to be held in January 2024.

The purpose of the first public hearing is, according to the public notice, for the Commission to consider and decide on the applicability of the Darlington New Nuclear Project (DNNP) 2009 environmental assessment (EA) with respect to OPG's selected BWRX-300 small modular reactor technology, as per the Government of Canada response to recommendation #1 of the Joint Review Panel's report.[1]

Ontario Power Generation submitted an Environmental Impact Statement and supporting documents in 2009 related to its proposal to construct four reactors at the Darlington Nuclear Generating Station. Following a 17-day hearing in 2011 a Joint Review Panel (JRP) appointed by Minister of the Environment released its report and 67 recommendations on August 25, 2011 including recommendation 1:

> *"The Panel understands that prior to construction, the Canadian Nuclear Safety Commission will determine whether this environmental assessment is applicable to the reactor technology selected by the Government of Ontario for the Project. Nevertheless, if the selected reactor technology is fundamentally different from the specific reactor technologies bounded by the plant parameter envelope, the Panel recommends that a new environmental assessment be conducted."*

Subsequently, in accepting JRP recommendation #1, the Government of Canada stated that:

> *"Any RA (Regulatory Authority) under the CEAA will need to determine whether the future proposal by the proponent is fundamentally different from the specific reactor technologies assessed by the JRP and if a new EA is required under the CEAA."*

In December 2021, OPG selected the General Electric Hitachi (GEH) BWRX-300 reactor technology for the Darlington site, and in October 2022, submitted an application for a Licence to Construct (LTC) to build the first BWRX-300 reactor.[2]

In their respective Commission Member Documents both the Canadian Nuclear Safety Commission staff and Ontario Power Generation have largely occupied themselves with considering their own end-products of exercises to compare the 2009 version of the Environmental Impact Statement with a 2022 summary (and a 2023 update of that summary) and

[1] Notice of Public Hearing, Ref. 2024-H-02, as found at https://www.cnsc-ccsn.gc.ca/eng/the-commission/pdf/NoticeHearingPFP-OPG-DNNP-EA-Jan2024-e.pdf
[2] CMD 2024-H2

to compare the 2009 Planning Parameter Envelope Report with a 2022 version of that report (and a 2023 update of the PPE report).

These comparisons are substantively different than what is directed by the Government of Canada's response or the JRP Recommendation #1. The JRP recommendation and the Government Response clearly direct that the responsibility authority must determine whether the "future proposal by the proponent", now identified by OPG as the BWRX-300, is fundamentally different from the specific reactor technologies assessed by the JRP, those being the ACR-1000, the EPR, the AP1000, and the EC6.

As noted above the purpose of this hearing is for the Commission to consider and decide on the applicability of the DNNP EA with respect to OPG's selected BWRX-300 small modular reactor technology, as per the Government of Canada response to recommendation #1 of the joint review panel's 2012 report, i.e. to determine whether the BWRX-300 reactor design is fundamentally different from the specific reactor technologies assessed by the JRP in 2009. If the Commission finds that the BWRX-300 is fundamentally different from the reactors which were included in the 2009 EIS then it must find that a new Environmental Assessment is required under the Canadian Environmental Assessment Act.

In this submission, Northwatch will outline for the Commission the multiple ways in which the BWRX-300 is fundamentally different from the reactors included in the 2009 Environmental Impact Statement, hence necessitating a finding by the Commission that a new environmental assessment is required in accordance with the Joint Panel Review's recommendation #1 and the Government of Canada Response.

In addition, Northwatch provides comments on the "Darlington New Nuclear Project Environmental Impact Statement Review Report for Small Modular Reactor BWRX-300 (2022)" [3]and update and the "Use of Plant Parameters Envelope to Encompass the Reactor Designs being considered for the Darlington Site (2022)" report[4] and update and related matters.

[3] Darlington New Nuclear Project Environmental Impact Statement Review Report for Small Modular Reactor BWRX-300, NK054-REP-07730-00055 R000, October 5, 2022,

[4] Use of Plant Parameters Envelope to Encompass the Reactor Designs being considered for the Darlington Site, N-REP-01200-10000 R005, October 4, 2022

Introduction

Overview

Ontario Power Generation is intending to construct four of the GE-Hitachi BWRX-300 boiling water reactors at the site of the Darlington Nuclear Generating Station on the north shore of Lake Ontario, 70 kilometres east of Toronto.

The BWRX – 300e is a small modular reactor designed by GE Hitachi. It is cooled and moderated by low-pressure, light-water with what the proponent describes as "distinctive safety feature of natural cooling of the core without reliance on electrical pumps to circulate water and remove decay-heat in the event of reactor shutdown".

The fuel is UO2, enriched to an average of 3.4% 235-U.

It is a tenth-generation version of the U.S. NRC-licensed, 1,520 MWe ESBWR. As such, many of the components, e.g., fuel and moderator/coolant, have already been in use for decades, which GE-Hitachi claims provides considerable operational experience and knowledge of materials properties and their response to intense radiation fields. However, the BWRX-300 reactor has not yet been constructed or operated anywhere, and it is unclear where this reactor lands on the continuum from idea to concept to design to deliverable. It must also be noted that its predecessor design by GE-Hitachi, the ESBWR[5] has never been constructed and is more than five times larger in electrical output. The BWRX-300 is also the only boiling water reactor under development in Canada or the United States.[6]

With the current plethora of SMR vendors or would-be vendors, it is difficult to differentiate between reactors with realistic designs and those which are simply power-point productions.

While some much earlier versions of this reactor type have been employed elsewhere, the only commercial reactors that have operated in Canada have been the heavy-water CANDU reactors, which use a different fuel, have a different operating system, and generate reactor fuel wastes which are very different in characteristics and in dimensions. As such, the selection of the BWRX-300 is a significant departure for Ontario Power Generation and for Canada more generally.

Ontario Power Generation announced the selection of the 300-megawatt (MWe) BWRX-300 reactor in December 2021. According to OPG, their preliminary schedule is to complete construction of the first reactor by 2028 with commercial operation in 2029.

[5] https://aris.iaea.org/PDF/BWRX-300_2020.pdf
[6] https://www.energy.gov/ne/articles/first-us-small-modular-boiling-water-reactor-under-development

On October 20th 2022 Northwatch received an email notification from the Canadian Nuclear Safety Commission that the CNSC would be holding "webinars on the upcoming licensing review of the Darlington New Nuclear Project". This was first notice received from CNSC with respect to the CNSC review of OPG's application to construct additional reactors at the Darlington Nuclear Generating Station. The email indicated:

> *Ontario Power Generation (OPG) is proposing to construct a small modular reactor of up to 300 megawatt electric as early as 2028 in the Municipality of Clarington, Ontario. In December 2021, OPG announced its selection of GE Hitachi's BWRX-300 technology. OPG currently holds a site preparation licence and intends to submit an application for a licence to construct in October 2022.*[7]

The email included a link to a web page that further described the purpose of the webinar as being to familiarize the public with the project and its activities; discuss the CNSC's licensing process; discuss OPG's licence application; and provide information on participant funding to review two reports: Use of Plant Parameters Envelope to Encompass the Reactor Designs Being Considered for the Darlington Site and Darlington New Nuclear Project Environmental Impact Statement Review Report for Small Modular Reactor BWRX-300[8]

On October 24th 2022 Northwatch received an email notification from the Canadian Nuclear Safety Commission that again described that "*Ontario Power Generation (OPG) is proposing to construct a small modular reactor as early as 2028 in the Municipality of Clarington, Ontario. OPG currently holds a site preparation licence for the project and intends to submit an application this month to the CNSC for a licence to construct* and that funding is available to assist Indigenous Nations and communities, members of the public and stakeholders in reviewing two OPG documents related to the Darlington New Nuclear Project, namely the "*Use of Plant Parameters Envelope to Encompass the Reactor Designs Being Considered for the Darlington Site*" and "*Darlington New Nuclear Project Environmental Impact Statement Review Report for Small Modular Reactor BWRX-300*" and to support the participation in workshops and/or meetings with CNSC staff regarding OPG's Darlington New Nuclear Project and the submission of comments to the CNSC. No dates or descriptions for the workshops and/or meetings were provided at that time.

The notice also stated that a "second stage of funding, to be announced at a later date, will assist with participation in the remainder of the regulatory process, including the review of

[7] Email subject line "Webinars on the upcoming licensing review of Ontario Power Generation's Darlington New Nuclear Project", dated Thu, 20 Oct 2022 10:02:45 -0400, received from cnsc.info.ccsn@cnsc-ccsn.gc.ca
[8] https://www.nuclearsafety.gc.ca/eng/stay-connected/get-involved/meet-the-nuclear-regulator/darlington-webinar.cfm

Commission member documents and documents related to OPG's application for a licence to construct, and participation at the Commission hearing."[9]

CNSC staff describe the purpose of the first consultation as being "to enable the Canadian Nuclear Safety Commission (CNSC) to gather feedback early in the licensing process for Ontario Power Generation's (OPG) Darlington New Nuclear Project (DNNP). Feedback received during this stage will help the CNSC to better understand this project."[10] Northwatch provided a written submission on March 20, 2023.

On April 3, 2023 the CNSC issued a notice that it would conduct a public hearing on applicability of the Darlington New Nuclear Project environmental assessment and plant parameter envelope to selected reactor technology. It further state that the Canadian Nuclear Safety Commission (CNSC) will hold 2 separate public hearings to consider the application from Ontario Power Generation (OPG) for a licence to construct a reactor facility for its Darlington New Nuclear Project (DNNP). The first hearing will be held during the week of January 22, 2024 and will focus on the applicability of the DNNP environmental assessment (EA) to Ontario Power Generation's selected reactor technology.[11] This written submission is with respect to that first public hearing.

[9] Email subject line "Funding available to review documents for Darlington New Nuclear Project", dated Mon, 24 Oct 2022 11:52:54 -0400, from cnsc.info.ccsn@cnsc-ccsn.gc.ca

[10] As found at https://www.letstalknuclearsafety.ca/dnnp-pre-licensing-consultation 19 March 2023

[11] Hearing notice Ref. 2024-H-02 as found at https://www.cnsc-ccsn.gc.ca/eng/the-commission/pdf/NoticeHearingPFP-OPG-DNNP-EA-Jan2024-e.pdf

Northwatch's Interest

Northwatch is a public interest organization concerned with environmental protection and social development in northeastern Ontario. Founded in 1988 to provide a representative regional voice in environmental decision-making and to address regional concerns with respect to energy, waste, mining and forestry related activities and initiatives, we have a long term and consistent interest in the nuclear chain, and its serial effects and potential effects with respect to northeastern Ontario, including issues related to uranium mining and refining, nuclear power generation, and various nuclear waste management initiatives and proposals as they may relate or have the potential to affect the lands, waters and/or people of northern Ontario.

Northwatch has a dual mandate that includes public interest research, education and advocacy to promote environmental awareness and protection of the environment, and the support and promotion of public participation in environment-related decision-making.

Northwatch is interested in Ontario Power Generation's proposed approach to nuclear waste management and containment over various time frames. Northwatch's issues and concerns relate to the generation and management of the nuclear wastes that will result from Ontario Power Generation's operations. The wastes of concern include those wastes which will result from continued and future reactor operation, including and particularly – in this case – the novel wastes from the BWRX-300 reactors which Ontario Power Generation has selected for construction, operation and decommissioning at the Darlington Nuclear Generating Station.

Given Ontario Power Generation's established practice of transferring radioactive wastes from the Darlington NGS to the Western Waste Management Facility on the eastern shore of Lake Huron, and given the OPG-controlled Nuclear Waste Management Organization's current investigation of the Revell Lake area between Ignace and Dryden in Kenora District in northern Ontario as a potential burial location for high level nuclear (irradiated) fuel waste and potentially other radioactive wastes - including wastes generated through the construction, operation and decommissioning of so-called "small modular reactors" – all licensing stages related to the development of new reactors at the DNN are of direct interest to Northwatch.

Project Licensing History for the Darlington New Nuclear Project

In 2007 Ontario Power Generation (OPG) considered nine reactor designs under offer or development by six different vendors: the EC6 and ACR-1000 from AECL, the EPR from Areva, the ABWR and ESBWR from GE Hitachi, the OPR1000 and APR1400 from KHNP, the US-APWR from Mitsubishi, and the AP-1000 from Westinghouse.

In March 2008, Infrastructure Ontario (IO) issued a competitive Request for Proposal (RFP) for a new nuclear power station in Ontario and four vendors were invited to participate in the RFP process: AECL (the ACR-1000), Areva (the EPR), GE-Hitachi (the ESBWR) and Westinghouse (the AP1000). GE-Hitachi chose not to participate in the process.

In September 2009 Ontario Power Generation submitted an Application for a Licence to Prepare a Site (LTPS) and an Environmental Impact Statement (EIS) for the Darlington New Nuclear Project (DNNP). In response to an August 2010 information request from the Joint Review Panel reviewing OPG's EIS, OPG provided information to the JRP about the Enhanced CANDU 6 (EC6) heavy water reactor, in consultation with the EC6 vendor, AECL.

The Joint Review Panel carried out an environmental assessment review and hearing in the absence of a selected reactor design or the detailed information that would - presumably – have been under consideration in an actual environmental assessment of an identified reactor design. Northwatch was an intervenor in the public hearing, providing expert and general submissions in writing and participating throughout the hearing.

The JRP released its report on August 25, 2011 and presented 67 recommendations in its report, including recommendation #1: "*The Panel understands that prior to construction, the Canadian Nuclear Safety Commission will determine whether this environmental assessment is applicable to the reactor technology selected by the Government of Ontario for the Project. Nevertheless, if the selected reactor technology is fundamentally different from the specific reactor technologies bounded by the plant parameter envelope, the Panel recommends that a new environmental assessment be conducted*."

The Government of Canada supported this recommendation, stipulating as follows:

> *"Any RA (Regulatory Authority) under the CEAA will need to determine whether the future proposal by the proponent is fundamentally different from the specific reactor technologies assessed by the JRP and if a new EA is required under the CEAA."*

In 2013 the Government of Ontario deferred the procurement of large new nuclear reactors at the Darlington site.

Between 2019 and 2021 OPG reviewed several different concepts or conceptual designs for various "small modular reactor technologies", and in December 2021 announced that it had selected the BWRX-300 as the technology to be deployed at the DNNP site.

Prior to their December 2021 announcement of their selected reactor design, OPG had sought and received a renewal of their site preparation license for the Darlington New Nuclear Project.

Northwatch intervened in that license review process and objected to the license being renewed at that time for a number of reasons, including the absence of a selected reactor design, despite the imminence of OPG's selection decision and announcement.

In their *Application to Renew the DNN Site Preparation License*, Ontario Power Generation OPG acknowledged that the basis for their existing licence included the safety analysis that was performed during the last application period, and that detailed assessment reports in support of the original application were submitted to the CNSC[12]; Northwatch had noted that these assessments were done when Ontario Power Generation was considering a completely different set of potential designs. At no point did the 2020 / 2021 documentation indicate that assessments have been undertaken with consideration of the three new under-development reactor designs that were under review by OPG at that time, including the now-selected BWRX-300.

Northwatch argued during the site licence review that the information necessary for the Commission to make its decision for a licence to prepare a site for nuclear reactor operations included descriptions of those reactors and their spatial requirements and factors which would affect the site configuration. Key site configuration factors include the spatial requirements of not only the reactors, but also of their associated infrastructure including heat transport systems, fuel handling and storage, and waste handling and storage. Neither OPG's license application or the Commission Member Documents for the site preparation licence review included that information

While it was – and remains – Northwatch's assessment that it was erroneous for the 2009 environmental assessment to be carried out without a reactor design having been selected and a detailed description made available (this absence in effect made the EA a project review without a project), that was equally or even more the case in the application for site preparation license renewal.

During the review of OPG's licence to prepare the Darlington expanded site Northwatch proposed that a complete project description was required, and that OPG should provide such a description. Such a project description would provide the CNSC and those interested and

[12] Application to Renew the DNN Site Preparation License. Ref. 2021-H-04, Pg 90

engaged in this review process the basis for determining if a new environmental assessment should be conducted. OPG has not done that.

There is not a full project description included in either of the two documents to which CNSC is proposing that this consultation be scoped, i.e. the Darlington New Nuclear Project Environmental Impact Statement Review Report for Small Modular Reactor BWRX-300 report and the Use of Plant Parameters Envelope to Encompass the Reactor Designs being considered for the Darlington Site report. There is also not a complete project description included in the Application to Construct which OPG filed in October 2022.

During the site preparation licence renewal review, it was CNSC's position that "when OPG submits documentation regarding technology selection CNSC staff will review and confirm whether OPG has clearly demonstrated that reactor technology selected remains within the bounds of the JRP EA report and complies with CNSC regulatory requirements outlined in REGDOC 1.1.1"[13] while it was Northwatch's position that that this assessment should have been done prior to the review of OPG's application to renew the license to prepare the site. The CNSC staff CMD expressed their position as follows:

> *If OPG submits an application for a licence to construct that includes any changes to the predicted environmental effects from any revised design and/or baseline information, CNSC staff will conduct an environmental review determination to assess whether the proposed project is outside the bounds of the scope, predictions and conclusions of the previous EA. If CNSC staff determine that, the proposed project is outside the bounds of the previous EA scope, predictions and conclusions a further review will be required. CNSC staff would then determine what type of environmental review would be required.*

Northwatch contended at the time that (in the context of CNSC decision-making) such a decision should rest with the Commission. We continue to hold that view in the context of CNSC decision-making, but with the knowledge of OPG's selected reactor design and having reviewed the EIS Review Report, we have concluded that while the CNSC or OPG could voluntarily initiate an environmental assessment process, the decision on the applicability of the previous EA to the current project could also be moved to the federal Minister of the Environment, and that it is within the Minister's purview to delegate the BWRX-300 reactor project for a federal assessment, should CNSC fail to require one.

That stated, the Commission hearing in January 2024 presents the clear opportunity for the Commission to act as the decision-maker and make a determination that the reasoned decision that the BWRX-300 is a fundamentally different technology than those assessed in the 2009 EA and 2011 EA hearing, and that a new environmental assessment is required.

[13] CNSC Staff CMD: 21-H4, 8 March 2021, Pg 43

Scope and Approach of Current CNSC Staff-Led Consultation

CNSC staff devised what Northwatch believes to be a unique (to date) approach to the review of the licence to construct a nuclear power reactor in the case of OPG's project to construct up to four BWRX-300 reactors at the Darlington site with a staff-led/staff-only set of consultations prior to a repeat round of the same-subject consultations involving the Commission.

As announced by CNSC staff, the scope of the first round of consultations (2022-2023) was limited to "*solely on the 2 OPG documents that address JRP recommendation 1: "The Panel understands that prior to construction, the Canadian Nuclear Safety Commission will determine whether this environmental assessment is applicable to the reactor technology selected by the Government of Ontario for the Project. Nevertheless, if the selected reactor technology is fundamentally different from the specific reactor technologies bounded by the plant parameter envelope, the Panel recommends that a new environmental assessment be conducted*."

The CNSC web page further stated that "*feedback that is out of scope, such as comments related to energy mix, financing of small modular reactors, and construction of the proposed facility, will not be considered during this consultation period. Out-of-scope comments will however not be deleted*."[14]

During the review of OPG's application to renew their license to prepare the site Northwatch made the following request:

> **21-H4 REQUEST:** The Commission require OPG to provide a complete project description following selection of their preferred reactor design prior to re-filing their application to renew the site preparation licence, to provide the Commission with an information base to consider whether the previous EA was for the same project as which OPG is not proposing to undertake.

After reviewing the *Darlington New Nuclear Project Environmental Impact Statement Review Report for Small Modular Reactor BWRX-300* report and the *Use of Plant Parameters Envelope to Encompass the Reactor Designs being considered for the Darlington Site* report and having considered the comments we received from our expert advisers who had also reviewed these reports, we maintained that assessment: As a next step in this review, Ontario Power Generation should be required prepare and make public a completed project description.

As set out in our submissions to CNSC staff in March 2023, the fundamental question posted by the JRP Recommendation 1 is whether or not a new environmental assessment must be undertaken. In order to make that determination, the CNSC must have an adequate description

[14] As found at https://www.letstalknuclearsafety.ca/dnnp-pre-licensing-consultation

of the project, including reactor construction, operation and decommissioning and ancillary structures and activities, including waste and waste management over various time scales. That project description is not available. If the decision at this point is a “yes / no” decision on whether a new environmental assessment is required, the default position is most definitely a “yes”, given there is not sufficient information available about the project to determine that the previous environmental assessment is applicable.

Review of DNNP EIS Review Report & Plant Parameters Envelope Report

Fundamental Differences

As outlined elsewhere in this submission, Ontario Power Generation has not provided a sufficiently detailed project description to allow full evaluation of the differences between the BWRX-300 reactor design and that of the four reactors included in the 2009 EIS. Therefore, this identification of differences between the BWRX-300 and the four reactors included in the 2009 EIS is limited and almost certainly incomplete.

Based on the incomplete information set provided by Ontario Power Generation and a limited amount of information available through other sources, the means and manner in which the BWRX-300 is fundamentally different from the four reactors included in the 2009 EIS includes but is not limited to the following:

- The BWRX-300 is a boiling water reactor; no designs assessed in 2009 were BWRs and there is no history of operating BWR reactors in Canada
- The four reactors assessed in 2009 would have produced 4,800 mW with four units operating; the BWRX-300 will produce only 1,200 mW, or one quarter of the energy output; this is a fundamentally different scale of operation and output, albeit with a seemingly equivalent level of risk
- Fuel waste dimensions are significantly different, necessitating fundamentally different approaches and designs for interim and long term dry storage of used fuel
- The BWRX-300 is of a fundamentally different design as a deeply embedded reactor with a depth of 38 metres below surface and the reactor building constructed in the subsurface within the excavation
- The 2009 EIS estimated a collective dose of 2.68 person-SV for four units producing 4,800 mw of energy versus an estimate of a collective dose of 1.96 person-Sv for four BWRX reactors producing 1,200; this is half the collective for ¼ of the energy production, representing a fundamentally different cost-benefit scenario
- The BWRX-300 will require a significantly reduced workforce size from that predicted in the 2009 EIS; estimates are approximately half for both construction and operation phases; as a result, the Darlington New Nuclear Project will play a fundamentally different role in economic activity and employment opportunities in the area

In addition, the BWRX-300 design is significantly different in several respects, including:

- For the BWRX-300 public dose rates are significantly higher – an estimated 10 x higher – for one accident scenario (pool fire) and 54% higher doses were estimated for the public in a dry storage container accident
- The BWRX-300 used fuel pool is smaller; the smaller used fuel pool will necessitate earlier transfer of the used fuel from wet to dry storage; this could have significant consequences for worker and off-site exposures
- emissions of iodine are higher for the BWRX-300 than the values assumed in the EIS
- BWRX-300 radiological waste contains different proportions of radionuclides than the waste that was assessed in 2009 EIS
- the mass of fuel placed in the spent fuel transfer cask is different than what had been assessed in the EIS
- Airborne radioactive emissions from the BWRX-300 are in different proportions
- Radioiodines and carbon-14 emissions from the BWRX-300 are higher for the BWRX-300
- Radioactive waste volumes are different and in different proportions for the BWRX-300
- Alpha and beta-gamma activity per cubic metre of waste is higher for the BWRX-300
- The BWRX-300 will result in increases in tritium concentrations in on-site ground water and in nearby off-site wells
- The BWRX-300 will generate higher activity spent fuel
- The BWRX-300 spent fuel will require heavier spent fuel casks
- The BWRX-300 will require higher rates of water withdrawal from Lake Ontario
- The BWRX-300 will require larger quantity of water stored in water supply system
- The BWRX-300 will produce considerably higher water temperature at discharge into Lake Ontario

With the exception of the last three items, these significant changes all increase dose, exposure and/or radioactive risk for workers and the public, on-site and /or off-site of the operation. While each of these are significant differences from the 2009 EIS estimates, in combination they create a fundamentally different risk profile for the Darlington New Nuclear Project operating and post-closure conditions.

Fatal Flaws

Northwatch characterizes the issues identified in this section as “fatal flaws” because they are fatal to the supposition that the 2009 EIS is sufficient and that the 2022 EIS Review Report and the PPE (both flawed in themselves) are sufficient substitutions for a full environmental assessment.

Northwatch has identified four fatal flaws, set out below, but we do not assert that this is a comprehensive list and fully anticipate that other commenters may add to this list.

CNSC Staff Did Not Evaluate Whether the Selected Technology is Fundamentally Different

As has been previously outlined, the Government of Canada accepted JRP Recommendation #1 and directed that the regulatory authority (in this case, the CNSC) would need to determine whether the future selected technology (in this case, the BWRX-300) is fundamentally different from the specific reactor technologies assessed by the JRP, as outlined in the 2009 EIS and during the 2011 hearing and related exchange of information. If the technology is found to be fundamentally different a new EA is required under the CEAA.

This is not the comparison that was undertaken by CNSC staff. Rather than compare the technologies, CNSC staff chose to compare the outcomes of two very generalized reviews and as summarized in relatively brief reports with regulatory requirements.

CNSC staff documents this chosen approach as follows:

> "CNSC staff's assessment focused on determining whether the predictions and conclusions of the EA remain valid, taking into consideration the BWRX-300 technology selected by OPG, currently under review for a licence to construct".[15]

At best, CNSC staff chose to substitute a comparison of estimated environment effects for a comparison of specific reactor technologies. In effect, this approach had the effect of masking the very definite and fundamental difference in technology by relying on very generalized estimates and speculated outcomes rather than relying on detailed and factual descriptions of the different technologies and comparing those different technologies in real terms.

Further, CNSAC relied on OPG's analysis of the BWRX-300 against the PPE and OPG's very generalized determination of whether parameters fall within or outside the PPE.[16] We found no documentation of CNSC actually carrying out the evaluation or analysis to independently determine whether the BWRX-300 (the "future proposal") is fundamentally different from the specific reactor technologies assessed by the JRP, despite the GOC conclusion specifically, directly and definitely stating that this is the responsibility of the regulatory authority, not of the proponent.

[15] CMD 24-H1, page 7
[16] CMD 24-H1, page 7

Even when CNSC staff acknowledged that BWRX-300 was outside the bounding of the PPE and that the different technology would have adverse affects that were not assigned to the reactors included in the 2009 EIS, CNSC staff avoided the comparison of the technologies by arguing that the estimated doses are lower than the regulatory dose limits from the *Radiation Protection Regulations*, and that OPG will be expected to put compensatory measures in place to maintain doses to workers ALARA throughout the lifecycle of the facility.[17]

The CNSC staff concluded that "these dose estimates remain consistent with the evaluation criteria from the EA for both workers and members of the public, and the conclusions of the EA remain valid".[18]

Consistent with not having carried out a comparison of the technologies to assess whether the BWRX-300 is fundamentally different from the specific reactor technologies assessed by the JRP, CNSC staff did not include a conclusion as to whether or not the BWRX-300 is fundamentally different from the specific reactor technologies assessed by the JRP.

In the absence of staff having provided an evaluation or a conclusion, we request that the Commission accept the findings of the public intervenors, including Northwatch, and find that the BWRX-300 is fundamentally different from the specific reactor technologies assessed by the JRP and that an environmental assessment is therefore required.

OPG's Review Documents Do Not Address Radioactive Waste

The generation of radioactive wastes by the proposed construction and operation of four boiling water reactors is a significant issue, as is the long-term challenge of the care and containment of these wastes, including irradiated fuel wastes, which must be isolated from the environment into perpetuity. Beyond very brief mentions, the EIS Review Report and the PPE report did not address radioactive waste concerns.

For example:

- in outlining the "review" approach it is stated that "the EIS review examined fundamental elements of the EIS" and lists seven areas, but radioactive waste and its generation and management is not included.
- Figure 5 in Section 3.2 on Conceptual Plant Layout does not identify the location of the various radioactive waste storage facilities; these are listed on page 17 but their locations are not identified and there are no or inadequate descriptions provided

[17] CMD 24-H1, page 62
[18] CMD 24-H1, page 63

- the EIS Review Report blithely references the Nuclear Waste Management Organization (NWMO) created under the auspices of the federal Nuclear Fuel Waste Act (NFWA) as being charged with development of a long-term management approach for used fuel, but overlooks that the NWMO has been in a siting process for 13 years in which it describes to potential "host" communities a transportation, packaging and repository system which is completely designed for CANDU fuel; in a 2022 technical report the NWMO acknowledged the potential construction of a non-CANDU fueled reactor in Ontario, but to date has excluded the potential shift to include a fuel waste which higher levels of activity and very different characteristics and dimensions from its interface with potentially impacted communities

The Project Lacks Consistent Definition

Across the documents considered in this review, the most fundamental question about the project is not answered consistently, that question being about how many reactors will be constructed as part of this "project" and the application for a license to construct.

The Canadian Nuclear Safety Commission contends that Ontario Power Generation (OPG) is proposing to construct a small modular reactor (as in one reactor)[19] or that OPG's DNNP is a project for the construction and operation of up to four new nuclear reactors, or that OPG has submitted an application to the CNSC for a licence to construct.[20]

Ontario Power Generation Inc. is similarly inconsistent, in the Licence to Construct application stating that they are applying for a Canadian Nuclear Safety Commission (CNSC) Licence to Construct (LTC) the first of up to four nuclear power reactors on the Darlington New Nuclear site, and in the EIS review report stating that the activities in the licence application includes the construction and the fuel-out commissioning of a single BWRX-300 reactor on the DNNP site in one section, and stating that the completion of construction of the fourth reactors is scheduled for 2035.[21]

The documents do not provide sufficient information

While CNSC staff have scoped this comment period to exclude Ontario Power Generation's application to construct additional reactors at the Darlington site, Northwatch has completed a preliminary review and can firmly include the LTC application on the list of documents which

[19] https://www.nuclearsafety.gc.ca/eng/stay-connected/get-involved/meet-the-nuclear-regulator/darlington-webinar.cfm
[20] https://www.letstalknuclearsafety.ca/dnnp-pre-licensing-consultation
[21] Darlington New Nuclear Project Environmental Impact Statement Review Report for Small Modular Reactor BWRX-300, NK054-REP-07730-00055 R000, October 5, 2022

do not provide a satisfactory description of the project, including with respect to radioactive wastes and their generation and management. As is noted elsewhere in this submission, OPG has simply not provided the documentation and supporting references necessary to this review.

Northwatch Findings in Review of the EIS Review Report and the PPE Report

Northwatch undertook a review of OPG's documents with respect to the Use of Plant Parameters Envelope to Encompass the Reactor Designs being Considered for the Darlington Site, and the Darlington New Nuclear Project Environmental Impact Statement Review Report for Small Modular Reactor BWRX-300, and several related documents, including the updated EIS review report and PPE report both made available after the March 2023 comment deadline for the CNSC-staff-led consultation.

Northwatch's review focused on those aspects of the PPE and the EA Review Report related to the fuel and the fuel waste.

In the first phase of the review (prior to the March 2023 deadline) Northwatch was assisted by two technical experts, namely Arnie Gunderson (Fairewinds Energy Education) who supported our review of the plant parameters envelope as revised by Ontario Power Generation, and Professor Rodney C. Ewing (Stanford University[22]) who supported our review of the address of radioactive waste in the review documents. In the second phase of this review (between April 2023 and November 2023) Northwatch was assisted by Jungmin Kang[23] who supported our review comparing spent fuel from the BWRX-300 with spent fuels from reactor types the CANDU6 and the AP100 reactors.

The conclusions of the three expert reviews and of Northwatch's own review were consistent: there was not information included in the documents to carry out a sufficient review, and the BWRX-300 reactor design is fundamentally different from the reactor designs considered in the 2009 environmental impact statement.

What follows are Northwatch's specific comments on each of the two reports; these comments are a blend of those provided by our expert reviewers and those generated through Northwatch's own review. There were no conflicts between the observations and comments of the various reviewers; had there been, those conflicts or variations would have been noted, with comment sources identified. That stated, this submission has not been reviewed by those who provided

[22] https://cisac.fsi.stanford.edu/people/rodney_c_ewing
[23] https://thebulletin.org/biography/jungmin-kang/

technical assistance (due to time constraints) and any errors in technical details or technical interpretation can be assigned to Northwatch, rather than to our technical experts.

Darlington New Nuclear Project Environmental Impact Statement Review Report for Small Modular Reactor BWRX-300[24]

In October 2022 Ontario Power Generation released an Environmental Impact Statement Review Report for the deployment of up to four BWRX-300 small modular reactors (SMR) for the Darlington New Nuclear Project (DNNP), formerly referred to as the New Nuclear Darlington (NND) Project, produced by their consultants Calian Nuclear. Two OPG reviewers were identified, but the personnel involved in producing the report or their areas or expertise were not.

As stated in the report, the focus of the EIS Review was "to ensure that the conclusion of the EIS remains valid for the deployment of the BWRX-300 at the DNNP site".

The EIS Review covered the two components: the Plant Parameter Envelope (PPE), and the Environmental Impact Statement (EIS). And, as noted in the report "positive environmental effects are also identified and explained."

The report self-describes as having "examined the fundamental elements of the EIS and compared to those resulting from the deployment of four BWRX-300 reactors at the DNNP site to confirm the EIS conclusion remains valid." It states that "in comparison to the environmental conditions described in the EIS, prevailing conditions are largely similar, but have not been static over the years. For example, since 2009, several bat species now inhabit areas of the DNNP site. Durham Region and its area municipalities have also continued to change due to population growth, urbanization, and economic development" and that "the BWRX-300 deployment is expected to involve works and activities that are essentially the same as those evaluated in the EIS. Compared to the reactors considered in the EIS, the BWRX- 300 reactors are smaller in physical size and electrical power. As a result, the effects of the BWRX-300 deployment on the environment are generally less than those examined in the EIS. In addition, there are opportunities with the BWRX-300 deployment to retain some terrestrial habitats on the DNNP site."

In general, and persistently, the OPG authors of the EIS Review report promote the idea that the comparatively smaller size of the BWRX-300 reactors can be extrapolated to mean that the impacts, outcomes, outputs and effect of this project will also be "smaller".

[24] Darlington New Nuclear Project Environmental Impact Statement Review Report for Small Modular Reactor BWRX-300, NK054-REP-07730-00055 R000, October 5, 2022

This is a nonsensical thesis, similar to a thesis that a three-inch ball will hurt less when it is hurled at a person than would a twelve-inch ball. It is not the size that matters as much as the composition and "operation" (throwing) of that ball. Similarly, a smaller reactor is not necessarily a safer reactor, and the radioactive wastes generated by a smaller reactor cannot be expected to be less radioactive or less requiring of long-term management and containment. It may be the case, but it unlikely to be the case, and the review would be better served by actual information in the form of a detailed project description than this type of unsupported conjecture.

Our review of the EIS Review Report generated numerous questions and comments, including the following which are listed and identified by the section they occurred, or where the issue or question first arose:

- While section 3.1 provided a reasonable summary of the of the general characteristics of the reactor, this section of the report – or other sections – did not provide an indication of burn-up; it is important to know the expected burn-up in order to anticipate composition and properties of the spent fuel and this information is not provided
- Table 1 identifies a very significant difference between the BWRX-300 and any other reactor designs considered in the 2009 EIS, that being that the reactor structure will penetrate 38 metres below ground level; this very important difference is given minimal treatment, and there is not enough information provided to fully evaluate, or to have confidence that OPG or their consultants have adequately evaluated the potential environmental consequences, including but not limited to migration of radio-contaminants from the sub-surface structure to surrounding groundwater and potentially reporting to surface water; for example, there is no description of how monitoring will be undertaken or what mitigation measures might be employed; noted that there is a very brief (but inadequate) description in Section 4.1.2 and again in 5.2.2 where the potential for an effect on groundwater flow was identified as not having been considered in the 2009 EIS but this statement is not followed by any substantive discussion
- Figure 5 in Section 3.2 on Conceptual Plant Layout does not identify the location of the various radioactive waste storage facilities; these are listed on page 17 but their locations are not identified and there are no or inadequate descriptions provided
- Section 3.4 indicates that irradiated fuel and low and intermediate level waste will be stored on the site, but the report does not include a detailed description of liquid, radioactive waste management systems, although a generic description is found in later sections of the report.
- Section 3.6 states that "There is no change to the description of waste management practices in Ontario. The process in this section applies to the BWRX-300 deployment; L&ILW will also be produced, and will be processed on-site, and shipped to an off- site OPG licensed

facility"; while that may very well be the case, the very general statements offer little basis for review and are not a substitute for a detailed discussion of radioactive wastes

- The statement in Table 3 in Section 3.6 that "There is no change in the description of waste management practices" is misleading at best; while little information is provided in these documents about the fuel or the waste or their characteristics it is known that the wastes will have different characteristics (for example, a different burnup rate) and different dimensions than CANDU waste, which is the subject of all waste management practices at Ontario Power Generation reactor stations at present; so the document may parse the situation to say there is "no change to the description" of waste management practices, but that could only be the case if the 'description' was of management practices other than for the current and past wastes generated by OPG reactors; this parsing characterizes the problem with the approach CNSC as adopted, wherein the comparison is being made to an inadequate report about theoretical reactors from over a decade ago, rather than describing the currently proposed reactor in sufficient detail, including the associated and ancillary activities, such as and particularly waste generation and management
- Table 4 similarly makes the assertion that "the description of the on-site dry storage facility in the EIS is applicable to the BWRX0-300 deployment; this statement is unsupported by an actual detailed description of the on-site dry storage facility, and would require comparison to a detailed description of dry storage facilities for the 2009 fleet of conceptual reactors; at minimum, a comparison of the BWRX-300 "Radioactive Waste Management Plan"(scheduled for release in Q1 2023) to the 2009 Nuclear Waste TSD would be required, although at this point we cannot be confident that the BWRX-300 "Radioactive Waste Management Plan"(scheduled for release in Q1 2023) will contain sufficient detail and information about dry storage facilities
- The report states in Section 3.7 that "*The volume of L&ILW and used fuel generated from the BWRX-300 deployment over the 60 years of operation is estimated to be less than for the larger reactors assessed in the EIS";* this statement is not consistent with the findings set out in the expert paper *Nuclear waste from small modular reactors*[25] (Krall et al.,2022); this is a key point – do the report authors have actual information to support this questionable statement?
- The BWRX-300 deployment will transport the L&ILW off-site to an OPG licensed facility. The description of the on-site dry storage facility in the EIS is applicable to the BWRX-300

[25] Nuclear waste from small modular reactors, Lindsay M. Krall, Allison M. Macfarlane and Rodney C. Ewing, Edited by Eric J. Schelter, University of Pennsylvania, Philadelphia, PA; received June 26, 2021; accepted March 17, 2022 by Editorial Board Member Peter J. Rossky May 31, 2022, as posted at https://www.pnas.org/doi/10.1073/pnas.2111833119

deployment. Again, not much can be said about such statements without more documentation.

- Section 3.7 states that "Management of spent fuel for BWRX-300 will also use an on-site dry storage facility", but no additional information is provided, such as: how long will the dry cask storage be in operation? What will be the state of the fuel after this period? Are there provisions for repackaging defective fuel assemblies?
- *Section* 4.13 discussed three parameters associated with airborne and waterborne releases of radioactive contaminants that result in doses to the public outside of the parameters assessed in the EIS, and notes that "The three parameters associated with airborne and waterborne radioactive releases required a separate study to assess their effect and compare it with what was assessed in the EIS…."; Northwatch requested the Reference [14] A. "Amendola and R. Parker, "DN Dose Calculations for Gap Analysis," on February 23 and received it on March 10th, but this arrival date – regrettably - left insufficient time for our experts' review; the referenced documents are not available online and there can be a significant time lag between making the request and receiving the document, in those instances where the document is provided and this is problematic in all reviews, including in this instance
- Section 4.1.4 "Solid Waste and Spent Fuel" states that a) solid waste volumetric activity (Bq/m3) generated by the operation of the BWRX-300 is higher than what was assessed in the EIS but that there will be equipment changes in response and b) the weight of the cask used to transport the BWRX-300 spent fuel on site (113 tonnes) is heavier than the cask assessed in the EIS, but the roads will be upgraded in response , and then indicates that "there is no impact on the EIS conclusions as a result of these mitigation measures"; insufficient details is included about the waste and the waste containers, but this is far too simplistic a response to be credible; this is another example of why a full examination of the project through a full environmental assessment is required
- Table 5 includes a note that "the radionuclides in gaseous effluents, liquid effluents, and solid waste are the same as in the EIS, but their proportions have changed" but there is no reference for a supporting document; it would be useful to have the data on how their proportions have changed.
- Section 5.2.8 makes assertions with respect to the volumes of L&ILW and used fuel to be generated from the BWRX-300 being lower and the land area required for used fuel dry storage being smaller than what was assessed in the 2009 EIS but provides no actual information about the fuel, the various wastes, or the dry storage systems; the document should include supporting data, or at least live links to documents which include the supporting data

- Section 5.2.13 “Operation and Maintenance Phase” includes statements that the BWRX-300 used fuel pool is smaller than what was assessed in the EIS but that the change in capacity is accounted for through the availability to move used fuel earlier and that it is planned that used fuel storage facilities will be available once the BWRX-300 starts operation and that dose consequence due to higher activity will be managed through appropriate cask and shielding design; these statements are not referenced, and no supporting information is provided; several questions arise, including: why, how and to where will used fuel be moved earlier? Which casks are being referred to in the statement that the higher activity will be managed through cask and shielding design? i.e. interim dry storage, transportation, etc.
- Section 5.3.6 “Radiation and Radioactivity Environment” makes an important statement about Radiation and Radioactivity Environment being considered a pathway to effects in other environmental components, but provides no supporting documentation
- Section 5.3.6 “Radiation and Radioactivity Environment” also states that “A comparison of emissions from the BWRX-300 reactor and the reactors assessed in the EIS, found that tritium, carbon-14, particulates, and noble gases emissions from the BWRX-300 are less than these emissions for the reactors assessed in the EIS. In contrast, the emissions of iodine are higher for the BWRX-300 than the values assumed in the EIS”; again, no supporting information is provided, and equally troubling is the absence of any discussion of the consequences of higher levels of iodine emissions
- Section 5.7.2 “Radiological and Transportation Malfunctions and Accidents” describes the BWRX-300 radiological waste as containing different proportions of radionuclides than the waste that was assessed in 2009 EIS, and notes that the mass of fuel placed in the spent fuel transfer cask is different than what had been assessed in the EIS; this section states that the assessment of radiological malfunctions and accidents involving radioactive waste and used nuclear fuel was reanalyzed for the BWRX-300 “using the same scenario as was examined in the EIS” and then goes on to say that the reassessment lead to the same conclusion, but it does not provide any of the supporting data, discussion of documentation; for this and for the other re-evaluations of accidents (e.g. transportation accidents, damage to spent fuel) further information is required; also, in evaluating the probability and consequences of accidents all four of the proposed BWRX-300 reactors should be considered as a system, and this cannot be determined based on the very limited information provided; one of the lessons at Fukushima was that there can be disadvantages to having reactors connected by the same supporting systems and it is not clear from these documents if the systems for each reactor unit are independent or combined; more detail is required in order to assess or review critical assertions on exposure to the public.

Northwatch reviewed the updated EIS review report. Our observations remain unchanged.

Use of Plant Parameters Envelope to Encompass the Reactor Designs Being Considered for the Darlington Site[26]

As stated in the 2009 EIS, "A PPE is a set of design parameters that delimit the bounding framework for key features of the Project. A fully developed PPE represents the limiting values for the common elements of the different design options being considered and serves as a conservative surrogate for actual reactor design information that varies among the options."[27]

In Section 1.0 of the 2022 PPE report[28] OPG introduces the concept of the PPE as an approach to resolve issues before a reactor design had been chosen. Later in the same paragraph OPG states that "high level design information is required for the environmental assessment that precedes the licensing decision for a License to Prepare the site".

In summary, OPG explains that the purpose of the PPE is to act as a surrogate in the absence of a selected reactor design, for the purpose of supporting an application for a license to prepare a site.

As of last year, a reactor design been selected, the GE-Hitachi BWRX-300. Also as of last year, the licence to prepare the site has been renewed. Therefore, there is no longer a need for a surrogate for a reactor design during a site preparation licence review. Nor is there a need for a substitute for a reactor design, when a reactor has been selected and presumably the reactor design is already well-know to OPG (otherwise, on what basis did they make their reactor design selection?)

A PPE review and the EIS Review report may have served some purpose during the review process for the license to prepare a site, which was carried out in 2021 and 2022. However, that work was not undertaken by OPG during that license review process and was not required by CNSC. Northwatch sees little point in the exercise at this juncture.

That being the case, Northwatch did – despite the lack of utility for this exercise – carry out a review of the PPE.

In general, Northwatch and our technical advisors found that the PPE update was poorly done and lacked sufficient content to support a meaningful review.

[26] Use of Plant Parameters Envelope to Encompass the Reactor Designs being considered for the Darlington Site, N-REP-01200-10000 R005, October 4, 2022

[27] Darlington New Nuclear Project Environmental Impact Statement Review Report for Small Modular Reactor BWRX-300, NK054-REP-07730-00055 R000, October 5, 2022, page 6

[28] Use of Plant Parameters Envelope to Encompass the Reactor Designs being considered for the Darlington Site, N-REP-01200-10000 R005, October 4, 2022

What seems to be the key message in the PPE report is as stated in Section 6.2 in the EIS Review Report:

> *"Overall, given that the BWRX-300 is smaller in size and requires less footprint, it is expected that effects on the environment within the EA Study Areas would be less than those assessed in the EIS. Therefore, the determinations regarding the significance of residual adverse effects made in the EIS remain valid. The DNNP, considering the mitigation measures identified, will not result in significant adverse environmental effects, including effects from accidents, malfunctions and malevolent acts, effects of the environment on the Project, and cumulative effects.*

This suggestion that size and footprint are the determinants of risk and / potential consequences or adverse impacts of an operation or activity is unsupported, as has been noted elsewhere in this submission.

While the PPE process may be an accepted regulatory process from the regulators or licensees' perspective, it has the effect of obscuring the actual basis for the determination of safety for an actual reactor system.

However, from a waste management perspective the use of bounding values for different classes of reactor could potentially provide a means by which actual waste generation (L- , IL- and HL-waste) values could be calculated, although that certainly does not appear to have been done in the case of this PPE, or is not documented as having been done. Northwatch would be interested in seeing OPG compare waste generation parameters to the BWRX-300 to a) BWRs in the GWe range, and b) conventional CANDU reactors following procedures similar to those used by Krall et al (2022).

In summary, even if a PPE approach were appropriate, the selected reactor is fundamentally different from those considered in the 2009 EIS. In that case, the PPE considered three water-cooled designs, two pressurized water reactor designs, and one pressurized heavy water design. No boiling water reactor design was considered. We note again that GE-Hitachi had been invited to submit design details but had opted out.

Finally, and perhaps most importantly, GE-Hitachi and OPG have not made public the design details for the BWRX-300, and CNSC has not disclosed the information considered in their Vendor Design Review exercise. Relying on an "updated" PPE is not a valid substitution for making this information available and the basis for the review process.

Northwatch reviewed the updated PPE report. Our observations remain unchanged.

Conclusions

As outlined earlier in this submission, having reviewed the *Darlington New Nuclear Project Environmental Impact Statement Review Report for Small Modular Reactor BWRX-300* report and the *Use of Plant Parameters Envelope to Encompass the Reactor Designs being considered for the Darlington Site* report and having considered the comments we received from our expert advisers who had also reviewed these reports, Northwatch's conclusion is that Ontario Power Generation must be required prepare and make public a completed project description as the first step in an environmental assessment.

The fundamental question posed by the JRP Recommendation #1 and the Government of Canada response was whether or not a new environmental assessment must be undertaken. Having fully engaged in this phase of the CNSC review, Northwatch is amending our previous recommendation that Ontario Power Generation must be required to prepare a detailed project description. All factors taken into consideration, including the submissions of other commenters in the previous phase and the submissions of CNSC staff and OPG as set out in CMD 24-H2 and CMD 24-H2.1 respectively, Northwatch is firmly of the view that a new environmental assessment must be undertaken; accordingly, a detailed project description must be prepared as an early step in that environmental assessment.

We request that the Commission include direction to CNSC staff and OPG to operate with greater openness and transparency in any future steps related to the assessment and / or licensing of OPG's Darlington New Nuclear Project in its decision, including but not limited to:

- Posting of all public comments submitted to the CNSC; submissions for the March 20th 2023 comment deadline are not available online
- Posting of all reference and supporting documents associated with OPG's application on the OPG web site with links from the CNSC web site to the specific urls for each document
- Dispositioning of comments submitted to the CNSC staff or Commission with respect to this review and licensing process
- Announcement of any future participant funding opportunities as part of a hearing notice or alternate notice that includes the review timeline, dates of document availability, comment deadlines and hearing time frames, as per the usual practice (which was not followed in the most recent instance)

All of which is respectfully submitted by Northwatch on November 20th, 2023.

For return correspondence contact Northwatch at northwatch@nortwatch.org.

Appendix 1

Technical analyses of spent fuel from BWRX-300: Comparison with spent fuels from CANDU6 reactor and AP1000 reactor

Jungmin Kang

November 2023

Technical analyses of spent fuel from BWRX-300: Comparison with spent fuels from CANDU6 reactor and AP1000 reactor

Jungmin Kang

November 2023

Core and fuel descriptions

Design parameters of interest for cores and fuels of BWRX-300, CANDU6[1] and AP1000[2] reactors are given in Table 1.

The BWRX-300 core design includes a 240-bundle configuration. A BWR fuel assembly consists of a fuel bundle and a coolant channel. The fuel bundle contains the fuel rods and the hardware necessary to support and maintain spacing between fuel rods. The channel is a Zircaloy box surrounding the fuel bundle and directing core coolant flow through the bundle; it also serves to guide the movable control rods. The BWRX-300 GNF2 design is a 10x10 array of 78 full-length fuel rods, 14 part-length rods and two large central water rods. Figure 1 shows the GNF2 fuel bundle design with major components identified. This figure shows the bundle in a horizonal orientation but during storage and operation the bundles are in a vertical position.

Table 1. Design parameters of interest for cores and fuels of BWRX-300, CANDU and AP1000 reactors

Item	BWRX-300[3]	CANDU6[4]	AP1000[5]
Reactor Type	BWR	HWR	PWR
Reactor thermal power (MWt)	870	2060	3415
Electrical power (MWe)	300	626	1110
Capacity factor (%)	95	80[6]	93

[1] Point Lepreau (CANDU6) has been selected as the reference plant because it is typical of CANDU reactors worldwide. Robin Chaplin, "Chapter 2 – Genealogy of CANDU Reactors," The Essential CANDU, https://unene.ca/education/candu-textbook/.

[2] The AP100 was selected as the reference case for this study because itis one of the PWR designs considered in the initial environmental assessment for the Darlington New Nuclear Project.

[3] "BWRX-300 General Description," GE Hitachi Nuclear Energy, August 2023, https://nuclear.gepower.com/content/dam/gepower-nuclear/global/en_US/documents/BWRX-300%20General%20Description%20Revision%20E.pdf.

[4] K. Heckman, J. Edward, "Radionuclide Inventory for Reference CANDU Fuel Bundles," NWMO-TR-2020-05, July 2020; Robin Chaplin, "Chapter 2 – Genealogy of CANDU Reactors," The Essential CANDU, https://unene.ca/education/candu-textbook/.

[5] "AP1000® Plant Design," https://www.westinghousenuclear.com/energy-systems/ap1000-pwr/overview; "Improved Nuclear Power Plant Operations," https://www.westinghousenuclear.com/energy-systems/ap1000-pwr/operations-and-maintenance; Westinghouse AP1000 Design Control Document Rev. 16 - Tier 2 CHAPTER 4, REACTOR, 4.1 Summary Description, https://www.nrc.gov/docs/ML0715/ML071580895.pdf; Westinghouse AP1000 Design Control Document Rev. 16 - Tier 2 Chapter 4 – Reactor – Section 4.3 Nuclear Design, https://www.nrc.gov/docs/ML0715/ML071580897.pdf; David E. Ames II et al., "High Fidelity Nuclear Energy System Optimization Towards an Environmentally Benign, Sustainable, and Secure Energy Source," SAND2010-6684, October 2010.

[6] "World Nuclear Performance Report 2023," World Nuclear Association, July 2023, https://www.world-

Fuel material	UO_2	UO_2	UO_2
Average fuel enrichment (w/o)	3.8	0.7[7]	4.8
Average discharge burnup (GWd/MTU)	50	7	60
Mass of one Fuel Unit (kg)	324	24	796
Mass of one fuel unit (kgU)	186.5	19.2	539.4
Number of fuel units in the core	240	380x12[8]	157
Mass of the core loading (kgU)	44,760	84,000	84,687
Design life time (years)	60	30	60

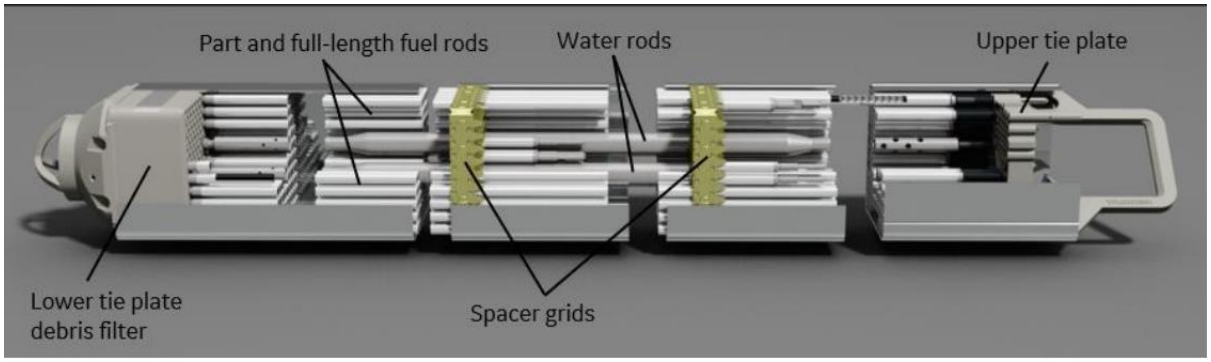

Figure 1. GNF2 fuel bundle of BWRX-300

The CANDU6 core design includes a 380-bundle configuration. All CANDU fuel bundles are fabricated from natural UO2 pellets that are contained in a Zirconium-alloy (Zircaloy-4) tube (cladding). The diagram of the standard Bruce/Darlington 37-element bundle with nominal dimensional information is given at Figure 2. Regular and modified 37-element fuel bundles are used in the Bruce and Darlington reactors. Both Bruce and Darlington use standard and long bundles. Regular 37-element bundles are also used in the CANDU 6 utilities (NB Power and Hydro Quebec).

nuclear.org/getmedia/0156a8d7-01c6-42d9-97be-3f04f34cb8fa/performance-report-2023-final.pdf.aspx.

[7] Natural uranium contains 0.7 percent uranium-235.

[8] Number of fuel channels in core: 380; Number of fuel bundles per channel: 12

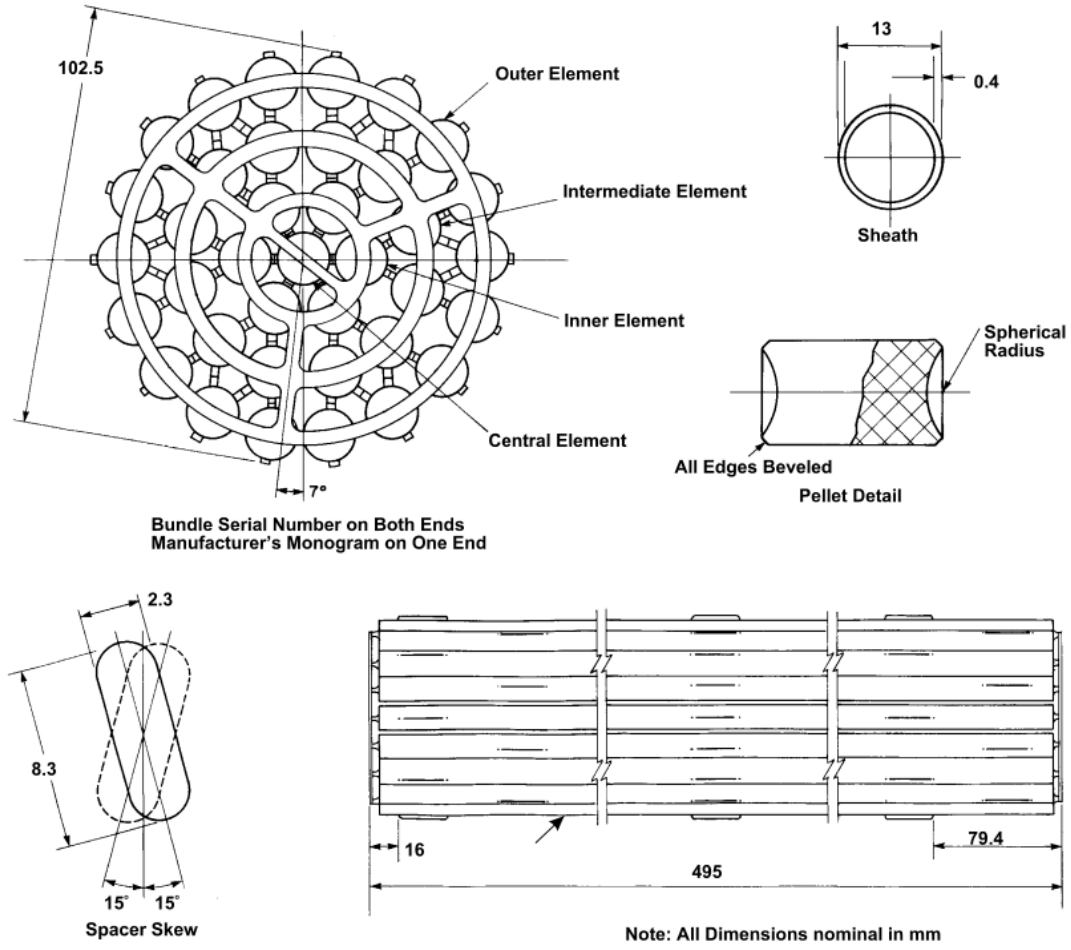

Figure 2. A standard 37-element fuel bundle design

With a gross power rating of 3,415 megawatt thermal (MWt) and a nominal net electrical output of 1,110 megawatt electric (MWe), the AP1000 reactor is composed of a 157-fuel-assembly core. An AP1000 fuel assembly consists of 264 fuel rods in a 17x17 square array. The center position in the fuel assembly has a guide thimble that is reserved for in-core instrumentation. The remaining 24 positions in the fuel assembly have guide thimbles. The guide thimbles are joined to the top and bottom nozzles of the fuel assembly and provide the supporting structure for the fuel grids. The fuel assembly's overall transverse dimensions and active fuel length are 21.40 cm and 4.3 m, respectively. Figure 3 shows a cross-sectional view of the fuel assembly and related fuel rod and guide tube placements.

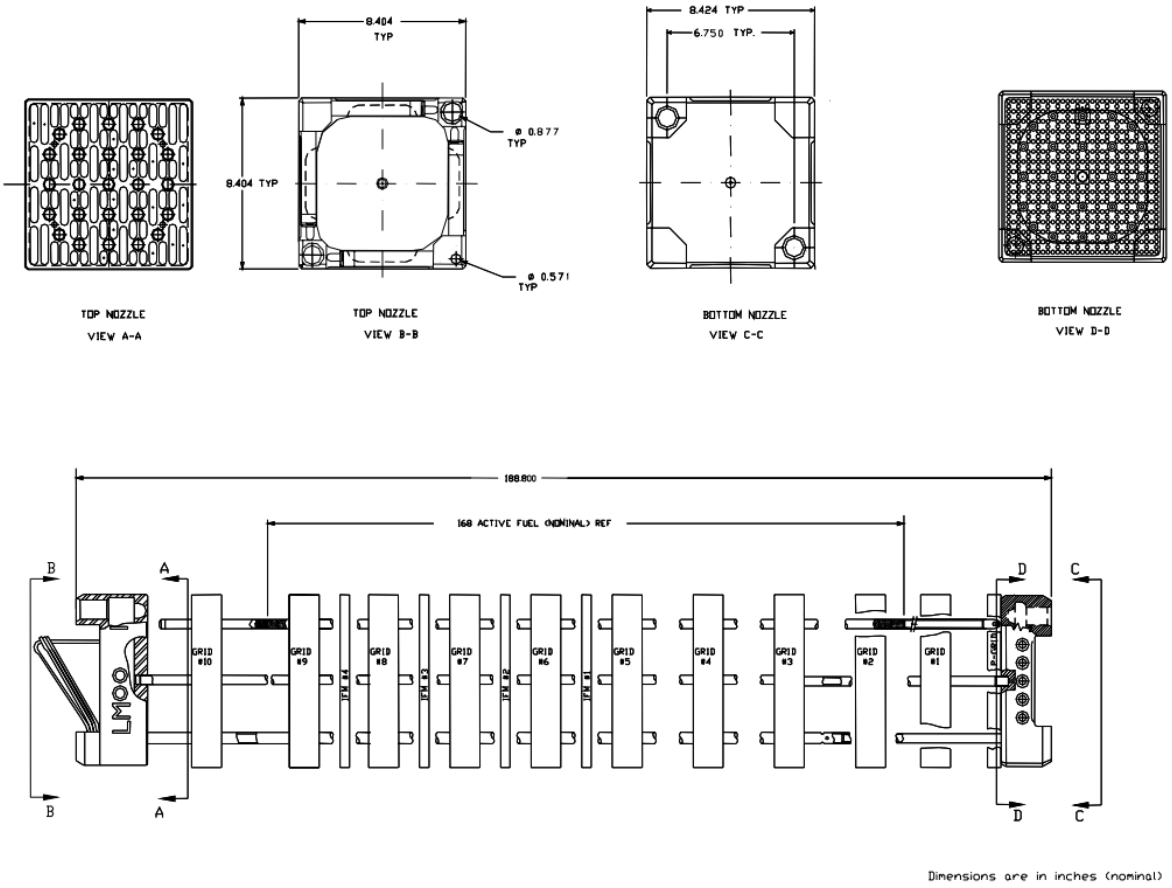

Figure 3. AP1000 fuel assembly outline[9]

Arisings and characteristics of spent fuels

The amount of spent fuel discharged from a nuclear power plant depends upon the fuel "burn-up," i.e., the thermal energy (heat) generated per unit mass of fuel. Table 2 shows the approximate amount of spent fuel that would be discharged per year and accumulated for the life time of BWRX-300, CANDU6 and AP1000 reactors.

Table 2. Arisings of spent fuels from BWRX-300, CANDU and AP1000 reactors

Item	BWRX-300	CANDU6	AP1000
Reactor thermal power (MWt)	870	2060	3415
Capacity factor (%)	95	80	93

[9] Westinghouse AP1000 Design Control Document Rev. 16 - Tier 2 Chapter 4 – Reactor – Section 4.2 Fuel System Design, https://www.nrc.gov/docs/ML0715/ML071580896.pdf.

Average discharge burnup (GWd/MTU)[10]	50	7	60
Annual discharge of spent fuel (MTU)	*6.0*	*85.9*	*19.3*
Mass of the core loading (MTU)	44.8	84.0	84.7
Design life time (years)	60	30	60
Accumulated for the life time (MTU)	*401*	*2576*	*1225*

The composition, heat output and radioactivity per ton of heavy metal of the spent fuel depend upon the initial compositions of fresh fuel and the burn-up of the spent fuel. Irradiation calculations of fresh fuels of BWRX-300, CANDU6 and AP1000 are performed by the ORIGEN2 code.[11] Table 3 shows the compositions of spent fuels of average discharge burnups of BWRX-300, CANDU6 and AP1000.

Table 3. Compositions of spent fuels of average discharge burnups of BWRX-300, CANDU and AP1000 reactors

Item	BWRX-300	CANDU6	AP1000
Average discharge burnup (GWd/MTU)	50	7	60
Uranium (%)	93.5	98.9	92.5
U-235 (%)	0.6	0.2	0.6
Plutonium (%)	1.3	0.4	1.2
Minor transuranic elements (neptunium, americium, and curium) (%)	0.2	0.01	0.2
Fission products (%)	5.1	0.7	6.2

As the radioactive elements in the spent fuel decay, they produce heat. As the abundance of these elements decreases with time, so does the heat production. Table 4 shows the reduction in decay heat for the time after the spent fuel has been discharged from the reactor. Table 5 shows the reduction in radioactivity of spent fuels as a function of time after discharged from the reactor.

Table 4. Decay heat of spent fuels as a function of time since discharged

[10] Giga watt day/metric ton uranium. Burnup is a way to measure how much uranium is burned in the reactor. It is the amount of energy produced by the uranium. Burnup is expressed in gigawatt-days per metric ton of uranium (GWd/MTU). Projections of spent fuel generation depend on assumptions concerning capacity factors and thermal efficiencies of the reactors and the burnups of the spent fuel. For natural-uranium-fueled heavy water reactors, the rate of spent-fuel discharge is several times higher because the burnup is lower.

[11] A. G. Croff, ORIGEN2 - A Revised and Updated Version of the Oak Ridge Isotope and Depletion Code, ORNL-5621, Oak Ridge National Laboratory, 1980, https://technicalreports.ornl.gov/1980/3445603828473.pdf.

Decay time (years)	BWRX-300 (Watts/MTHM)	CANDU6 (Watts/MTHM)	AP1000 (Watts/MTHM)
0	1.570E+06	1.470E+06	2.269E+06
5	3.095E+03	3.628E+02	3.561E+03
10	2.057E+03	2.091E+02	2.288E+03
15	1.754E+03	1.819E+02	1.940E+03
20	1.568E+03	1.643E+02	1.728E+03
30	1.294E+03	1.370E+02	1.419E+03
40	1.087E+03	1.155E+02	1.185E+03
50	9.261E+02	9.841E+01	1.003E+03
70	6.984E+02	7.372E+01	7.454E+02
100	4.982E+02	5.212E+01	5.197E+02
200	2.677E+02	3.041E+01	2.684E+02
300	1.994E+02	2.596E+01	1.999E+02
500	9.606E+01	1.761E+01	9.616E+01
1,000	6.121E+01	1.380E+01	5.996E+01
10,000	1.843E+01	6.230E+00	1.708E+01
100,000	1.515E+00	3.431E-01	1.440E+00
1,000,000	5.785E-01	1.266E-01	5.912E-01
10,000,000	1.257E-01	1.003E-01	1.269E-01

Table 5. Radioactivity of spent fuels as a function of time since discharged

Decay time (years)	BWRX-300 (Ci/MTHM)	CANDU6 (Ci/MTHM)	AP1000 (Ci/MTHM)
0	1.65E+08	1.56E+08	2.35E+08
5	7.98E+05	1.28E+05	9.58E+05
10	5.69E+05	7.96E+04	6.74E+05
15	4.76E+05	6.58E+04	5.65E+05
20	4.09E+05	5.66E+04	4.87E+05
30	3.11E+05	4.33E+04	3.70E+05
40	2.40E+05	3.36E+04	2.86E+05
50	1.87E+05	2.63E+04	2.23E+05
70	1.16E+05	1.64E+04	1.39E+05
100	6.09E+04	8.42E+03	7.18E+04
200	1.26E+04	1.60E+03	1.36E+04
300	6.65E+03	8.78E+02	6.74E+03
500	3.05E+03	5.60E+02	3.05E+03
1,000	1.99E+03	4.45E+02	1.95E+03
10,000	6.44E+02	2.06E+02	6.05E+02
100,000	7.76E+01	1.52E+01	7.82E+01
1,000,000	2.94E+01	6.60E+00	3.07E+01
10,000,000	6.06E+00	4.92E+00	6.12E+00

As Table 4 shows, decay heat releases of spent fuels from BWRX-300 are roughly ten times greater than those of spent fuels from CANDU6 and is about 10% less of those of spent fuels

from AP1000 for a century. It means that the size of the geologic disposal site of the spent fuel discharged per electricity generated from BWRX-300 would be several times greater than that for the disposal site of spent fuels from CANDU6, although the amount of spent fuel discharged per electricity generated from BWRX-300 is about seven times less than that from CANDU6.

The radioactivity of spent fuels from BWRX-300 are roughly seven times greater than those of spent fuels from CANDU6 and is about 15% less of those of spent fuels from AP1000 for a century, as shown in Table 5.

Summary

Decay heat releases of spent fuels from BWRX-300 are roughly ten times greater than those of spent fuels from CANDU6 and is about 10% less of those of spent fuels from AP1000 for a century.

The radioactivity of spent fuels from BWRX-300 are roughly seven times greater than those of spent fuels from CANDU6 and is about 15% less of those of spent fuels from AP1000 for a century.