Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

CMD 24-H5.18

File / dossier : 6.01.07
Date: 2024-04-23
e-Doc: 7237032

Written submission from the Canadian Association of Nuclear Host Communities

In the Matter of the

Ontario Power Generation Inc.

Application to extend the operation of Pickering Nuclear Generating Station Units 5 to 8 until December 31, 2026

Commission Public Hearing

June 2024

Mémoire de la Canadian Association of Nuclear Host Communities

À l'égard d'

Ontario Power Generation Inc.

Demande visant à prolonger l'exploitation des tranches 5 à 8 de la centrale nucléaire de Pickering jusqu'au 31 décembre 2026

Audience publique de la Commission

Juin 2024

Canada

CANADIAN ASSOCIATION OF
NUCLEAR HOST COMMUNITIES
www.canhc.ca

April 23, 2024

Participant Funding Program Administrator
Canadian Nuclear Safety Commission
280 Slater Street
Ottawa, ON K1P 5S9

To the Commission:

Please find attached the Canadian Association of Nuclear Host Communities' consultant's report by Dr. Kirk Atkinson, Ontario Tech University, regarding Ontario Power Generation's application for authorization to operate Pickering Nuclear Generating Station Units 5 to 8 until 2026.

CANHC fully supports the approval of OPG's application. We would like to thank the CNSC for the opportunity to comment on these matters.

Sincerely,

Adrian Foster
Chair, Canadian Association of Nuclear Host Communities

TECHNICAL CRITIQUE

Ontario Power Generation Pickering Nuclear Generating Station Power Reactor Operating Licence Amendment Application

Introduction

In September 2018, the Canadian Nuclear Safety Commission (CNSC) granted Ontario Power Generation (OPG) a ten-year Power Reactor Operating Licence (PROL 48.01 / 2028) for Pickering Nuclear Generating Station (NGS) that included power-generating operations until the end of 2024, followed by safe storage activities ending in 2028. As requested by the commission, a mid-term update was presented to them in December 2023. Due to electricity demands in the Province of Ontario, and the perceived continued viability of the station, OPG has requested a change in its licencing basis and submitted a Licence Amendment Application to the CNSC, requesting authorization to operate PNGS Units 5-8 until the end of 2026. This application included an amendment to the Pickering NGS Periodic Safety Review (PSR).

Scope of critique

It is important to recognise that the Licence Amendment Application does not replace the extant ten-year PROL for PNGS. It seeks permission solely to operate Units 5-8 for two additional years in a manner equivalent to how they have been operated to date. Other activities will continue, as licenced, irrespective of the outcome. It does not consider plans for refurbishment. The sole question that needs investigating is whether it appears OPG has adequately substantiated its request to continue operating the aforementioned units in such a way that continued their operation can be justified in terms of safety and need. This technical critique summaries any significant findings resulting from a review of OPG's Pickering NGS Power Reactor Operating Licence Amendment Application (and related documents), highlighting strengths, weaknesses, shortfalls, and potential impacts to the host community (City of Pickering), if apparent. Significant findings are those that describe a different activity or condition to that approved in the extant PROL. An explanation of technical details suitable for a layperson is provided where necessary. Unless stated otherwise, the base reference for this critique is the Licence Amendment Application itself.

Background

Pickering NGS currently operates six [6] Canada Deuterium Uranium (CANDU) reactors, a domestic pressurised heavy water reactor (PHWR) design. Each reactor is housed in its own reinforced concrete containment building. Containment buildings are connected to a shared vacuum building held at negative pressure. This is a safety feature. The reactor (core) itself is assembled within a calandria, a large steel tank filled with heavy water at low temperature and pressure. Heavy water acts as a moderator, a material that slows down fast-moving neutrons (uncharged subatomic particles) emitted during energy-releasing nuclear fission reactions so they can be more easily captured in the nuclei of uranium atoms in nuclear fuel, allowing further fissions to occur. It is this self-sustaining

chain reaction that is controlled within a nuclear reactor. The fuel itself comes in the form of a cylindrical bundle of uranium dioxide fuel pins. Bundles, roughly 50 cm long and 10 cm in diameter, are inserted into pressure tubes, which are themselves inserted into horizontal tubes within the calandria (calandria tubes). Part of the reactor's closed loop primary circuit, in each pressure tube flows pressurised heavy water that, as well as moderating neutrons, removes the heat energy from fission, cooling the fuel. This hotter water is pumped out of the core, through a steam generator (to produce steam to drive turbines that generate electricity), losing heat and re-entering the core cooler. As the pressure tubes are much hotter than the calandria tubes surrounding them, spacers are utilised to keep the two separated. Insulating carbon dioxide gas fills the intervening gap. A combined calandria tube-pressure tube assembly comprises a fuel channel (FC). There are 380 fuel channels in each reactor, each filled with twelve fuel bundles when operating.

Pickering Units 5 to 8 (Pickering B) were commissioned into service in sequence, one per year, from 1983 to 1986. On final shutdown, herein assumed to be December 2026 (per the Licence Amendment Application), the aforementioned units will have been in power operation for 40 years or longer. Whilst a two-year operating lifetime extension will not result in any materially different activities to those for which a licence has already been granted by the CNSC; the systems, structures, and components (SSCs) will have been in use beyond their expected design lifetimes.

OPG's approach to justifying a two-year extension to power operation of Units 5-8

Recognising Pickering Units 5-8 are beyond their intended design life, like other nuclear generating stations worldwide that have been granted plant life extensions, this does not mean they are no longer safe to operate. What it means is, to do so, it must be adequately proven that they will remain safe if power operation is to continue. This shifts the burden of proof onto the licensee (OPG) to undertake whatever work is necessary to demonstrate this to the satisfaction of the regulator. Like with most machines, it is typically the working parts that experience the greatest aging or wear. The same is true for CANDU reactors, the most significant aging concerns typically pertaining to fuel channels. The reason for concern is the fact they serve both as pressure boundaries and barriers to radiological release, and because they support fuel bundles. Over time, continual exposure to strong radiation fields, heat, and hydrogen chemistry may compromise the structural integrity of pressure tubes, whilst thermal expansion and gravity (due to their horizontal orientation) may cause sagging that leads to contact with the calandria tube, or even obstruction of the fuel channel itself.

Within the Licence Amendment Application, Ontario Power Generation has made a clear and compelling case around the **need** for continued power operation of Units 5-8 based on electricity demand within the province of Ontario; production of medical isotopes for domestic and global markets; and continued employment of up to 4,500 personnel, many of whom live in the Region of Durham. Associated economic activity in the surrounding community (City of Pickering) and any burdens (e.g., on highways) would continue as-is.

With the need established, and recalling that PNGS is licenced through 2028 regardless, OPG appears to adequately explain in the Licence Amendment Application how, via a range of actions and activities, it has assured Units 5-8 are **safe** for power operations to continue as requested. Determination of these actions and activities stemmed largely from re-assessment of the Periodic Safety Review, PSR2, submitted when the extant licence was applied for and was necessary in large part because the condition of plant SSCs, in some cases, has a time-dependence (SSCs would be in-service for beyond the lifetime assessed in PSR2). The reassessment, PSR2-B, appears to demonstrate the design, condition and planned operation of PNGS is, and will remain, safe to support two additional years of electricity generation. PSR2-B also provided an opportunity for the implementation of new or revised requirements, expectations and practices that have arisen since PSR2 was frozen. Given Pickering B has been in-service since the 1980's, and testament to OPG's commitment to continual improvement, unsurprisingly, PSR2-B did not identify any (new) previously unforeseen gaps.

As it was a revision of an extant document, itself a comparison of the plant against requirements in 15 Safety Factor areas and modern Laws, Regulations, Codes and Standards (along with the identification of practicable safety enhancements based on said comparison), OPG limited the scope of work on PSR2-B to the identification of Global Issues in PSR2 with potential significance to power operations past 2024; open regulatory commitments, action items, and obligations applicable to extending power operations; actual condition assessments (evaluations) of PNGS SSCs; and, for completeness and lessons learned, reviews or results from relevant recent PSR activities at Darlington NGS. PSR2-B gaps were grouped into existing PSR2 Global Issues or new ones, based on similarity. After prioritisation in terms of safety and significance, taking account of Defence-in-Depth and impact of Acceptable Deviations (which OPG concluded were either not time-sensitive, so the PSR2 assessment held, or had no impact), residual Global Issues were consolidated into an Integrated Implementation Plan (IIP) with their resolutions and required (planned) actions. The PSR2-B IIP resulted in 9 Global Issues (GIs), 13 Resolution Statements and 19 actions. This is shown in Table 1. Whilst some GIs pertain to Assessment (e.g., for Environmental Qualification and Safety Analysis) Governance and Enhancements (e.g., to procedures, or instrumentation), most of the resolutions (and the bulk of the effort) reflect the age of SSCs and the need for robust assurance of the Fitness-for-Service(FFS) and acceptable condition of Fuel Channels, Feeders (the small pipes that connect and supply primary coolant to the Pressure Tubes in Fuel Channels), Steam Generators, and Reactor Components and Structures.

OPG has updated its Environmental Risk Assessment and Predictive Effects Assessment Addendum Reports to reflect two additional years of power operations, submitting both to the CNSC in April 2023. In both cases, it was shown that PNGS will continue to operate in a manner protective of human health and the environment, with no potential adverse effects predicted. In essence, activities and conclusions that underpin the extant licence remain bounding.

Table 1: Integrated Implementation Plan [from Licence Amendment Application]

Globe Issue Title	Resolution Description
Fitness for Service for Fuel Channels	Update the Fuel Channels Pressure Tubes Periodic Inspection Plan (PIP) Plan for Pickering 5-8 to reflect an extended operating period up to the end of 2026.
	Establish the basis for continued demonstration of fitness for service of fuel channels for Pickering NGS Units 5 to 8 for the extended operating period up to the end of 2026. Fitness for service of fuel channels includes demonstration of sufficient margin on the FFS limits of the pressure tubes, calandria tubes and garter springs (annulus spacers) during the continued operational life of the plant.
	Demonstrate fitness for service for Zr-Nb-Cu and Inconel X-750 Pickering NGS Units 5 to 8 Spacers for the extended operation to the end of 2026.
	Develop and submit an implementation plan for developing inputs to satisfy the methodology in the Non-Mandatory Annex G of CSA N285.8-15, Update #1 to perform uncertainty analyses in probabilistic evaluations where the threshold requirement is met per CSA N285.8.
Fitness for Service for Feeders	Establish the basis for continued demonstration of fitness for service of feeders for Pickering NGS Units 5 to 8 for the extended operating period up to the end of 2026. Fitness for service of feeders includes demonstration that predicted feeder condition, with identified and planned mitigations, is acceptable for the intended operation.
Fitness for Service for Steam Generators	Establish the basis for continued demonstration of fitness for service of steam generators for Pickering NGS Units 5 to 8 for the extended operating period up to the end of 2026. Fitness for service of steam generators includes demonstration that predicted steam generator condition, with identified and planned mitigations, is acceptable for the intended operation.
Fitness for Service for Reactor Components and Structures	Establish the basis for continued demonstration of fitness for service of reactor components and structures for Pickering NGS Units 5 to 8 for the extended operating period up to the end of 2026. This includes demonstration that predicted reactor components and structures condition, with identified and planned mitigations, is acceptable for the intended operation. This also includes the required inspection activities to update the Calandria Tube – Liquid Injection Shutdown System (CT-LISS) nozzle gap assessments and identification of mitigation strategies if CT-LISS contact is predicted within the extended operating period.
Governance Implementation / Effectiveness Issues	Install an enhancement to the Emergency Water Supply Reactor Building Water Level Measurement to install 67138-LT566/LIA566 for Pickering NGS Units 5 to 8.
Safety Analysis to Support the Extended Operating Period	Update the Heat Transport System aging safety analysis models and perform the required safety analysis of events most impacted by aging (Small Break Loss of Coolant Accident, Loss of Flow and Neutron Overpower) to support continued operation for Pickering NGS Units 5 to 8 up to the end of 2026.
Safety-Related Structures (Non-Containment) for Nuclear Power Plants	Complete PSR2-B review of the aging management strategy for non-Containment safety-related structures. The purpose of the review is to confirm that the bases for the associated Aging Management Plan and PIP Program remain valid for the extended operation and to determine if any follow-up actions are necessary for extended operation of Pickering NGS Units 5 to 8 up to the end of 2026.
Fire Protection – National Building Code of Canada (NBCC) and National Fire Code of Canada (NFCC)	Apply NBCC 2015 Part 3 for future construction or modification related to fire protection, occupant safety and accessibility.
	Update current applicable governance documents to include, when appropriate, the new requirements, codes or standards identified in NFCC 2015 and develop strategy for appropriate and practicable operational and programmatic changes.
Safety-Related Structures (Non-Containment) for Nuclear Power Plants	Re-assess Pickering NGS EQAs to support extended operation of Pickering NGS Units 5 to 8 to the end of 2026.

Resolution of PSR2-B Global Issues by OPG

Resolution of the Assessment, Governance and Enhancement issues specified in the IIP was straightforward or procedural. They are well described in Table 1. On the other hand, demonstrating Fitness-for-Service of major components (Fuel Channels, Feeders, Steam Generators, and Reactor Components and Structures) was more involved. OPG's Major Components Program was identified as being responsible for providing the Fitness-for-Service (FFS) assessments necessary to support licence requirements. In all cases the design basis and safety margins required for continued operation required data-informed demonstration that their actual condition remains, and will remain, acceptable for a further two years of use. OPG has reported this was fulfilled through the synthesis of (principally) inspection and surveillance data confirming by direct or derivative measurement, imaging, or visualisation, that physical and/or chemical parameters are within their design basis at points in time; experimental data (where available) that provides insight into performance under controlled conditions; and various modelling or trend analysis activities that show how parameters and performance have changed over the operational lifetime to date, and how they are can be predicted to change in future. Whilst, at the point of Licence Amendment Application submission all conditions, with identified or planned mitigations, were shown to be acceptable by OPG through to the end of 2026; OPG's normal periodic inspection activities will allow ongoing monitoring of time sensitive conditions until End-of-Life. This feedback loop of operation, monitoring during operation, and maintenance or remedial actions perhaps based on said monitoring, appears to provide a check against the Life Cycle Management (LCM) Plan that informs ongoing safe operations.

In addition to the common approach to SSC justification, due to their safety significance, OPG identified specific confirmatory activities for the Fuel Channels in Units 5-8. FCs have complex aging mechanisms that fall into three categories: PT deformation, changes to PT material properties, and PT flaws. The design lifetime of a nuclear reactor is not based on chronological time, but rather on the number of hours operated at full power, a measure termed Effective Full Power Hours (EFPH). Supporting two additional years of power operation, OPG explained how they addressed and managed the aforementioned aging mechanisms and justified that the Fuel Channels in Units 5-8 are safe to operate to 297.5k, 305k, 298k, and 283k EFPH, respectively, the FC ages at End-of-Life. This assessment was based on a number of factors, including four decades of operational experience that has led to a mature LCM program with substantial measurement data to validate assessment methods or analysis, and provide prognostic information.

Like for all major SSCs, Fuel Channel FFS is founded on a suite of programmatic controls, Defence-in-Depth being provided from Level 1 (Standard Operating Procedures) through Level 5 (Emergency Response). The Level 1 controls include a continuing focus on Pressure Tube (PT) degradation supported by a comprehensive program of research and testing (i.e., burst testing) to understand the mechanistic basis. To assure design margins are not exceeded, OPG explained how various surveillance techniques are, and will continue to be, employed until End-of-Life. In the unlikely event that design margins are

exceeded, OPG has explained that they have a set of Emergency Operating Procedures (Level 2 and 3 controls) that can be followed to mitigate postulated degraded conditions. In tandem with these EOPs, OPG notes the presence of leak detection capabilities to facilitate safe shutdown and PT depressurization. Should FC integrity be compromised, guidelines for the use of Emergency Mitigating Equipment (EMEGs) and Severe Accident Management Measures (SAMGs) are in place. The described Level 4 controls include further barriers to radiological release along with alternative and diverse ways of cooling the fuel. The last line of defence to limit radiation release to the public and environment, a Level 5 control, is provided by the containment system (building).

To minimise the effects of component aging, thereby ensuring the station can operated to target End-of-Life (with mitigating actions, as required), OPG has an IAEA Safety Guide NS-G-2.12 and CNSC REGDOC 2.6.3 compliant Aging Management Program in place. It was explained how Periodic inspections, including sampling, are, and will continue to be, conducted in accordance with the CSA N285.4 standard. OPG, in collaboration with industry partners, has developed advanced inspection equipment to facilitate this activity. If meeting the acceptance criteria, FCs remain within their design basis unconditionally. If an inspection does not satisfy the acceptance criteria, OPG has to comply with the technical requirements of the CSA N285.8 standard to demonstrate continued FFS. This would require assessment of known and projected conditions, evaluation of material properties, and risk assessment of the uninspected population of PTs in the reactor core. This evaluation process requires a disposition that must be submitted to the CNSC for acceptance. The Record of Decision for the extant licence permits FCs in Units 5-8 to be operated to 295k EFPH, around 3% less than in the Licence Amendment Application described herein. Together, the various aging management strategies and mitigation options, appear to provide an adequate safety margin for FCs through to their projected EFPH. OPG has a process in place to accommodate emergent issues.

With respect to Fuel Channels, it should be noted that as a result of their extensive and ongoing monitoring activities, OPG confirmed that for Units 5-8, wall thinning, diametral expansion, PT sag, and other flaws, do not exceed specified limits or thresholds, and in the case of axial elongation (where longways expansion of PTs could affect their bearing) are mitigated via maintenance. Assessment of deuterium ingress and increased hydrogen equivalent concentration in PTs, a potential crack initiator that is worse at certain points (e.g., like rolled joint regions, where additional ultrasonic inspections are targeted), has been a focus of work since Fall 2021 due to findings by Bruce Power. Material scrapes and subsequent chemical analysis are employed by OPG in this effort. To date of Licence Amendment Application submission, it is stated that such scrapes have met acceptance criteria or been dispositioned by CNSC. Additionally, OPG appears to have an adequate plan in place to manage FC fracture toughness.

Two PSR2-B gaps were identified relating to spacer integrity, and uncertainty analysis for core assessments. Spacers are responsible for maintaining the distance, and preventing contact, between PT and Calandria Tube. In most FCs, spacers are made from an Zr-Nb-

Cu alloy and sit loosely in place (their proclivity for minor shifting over time due to vibration is well known and regularly monitored). Whilst there are no obvious degradation issues from carrying filled PT loads, they were apparently only qualified to an EFPH of 300k, not the 305k required for lifetime extension of Unit 6. As such, to confirm continued integrity, some were removed in an outage in 2022. At time of Licence Amendment Application submission, it appears the results the 2022 Unit 5 outage spacers had not been returned (it is stated they were in Q4 2023) so their assumed integrity remains uncertain. Thirty-seven FCs employ tighter-fitting spacers made from Inconel X-750, a nickel-based alloy. Whilst the Inconel spacers are less subject to movement, they do experience degradation over time (e.g., due to nuclear transmutation), and have only been quantified to an EFPH of 264k (that it is not clear whether this age pertains to reactor age, or component age, so the significance of it may be overstated). OPG mention that integrity assessments of the equivalent spacers from Darlington NGS were expected in late 2023, after submission of the Licence Amendment Application. It is not known whether OPG's expectation that of no degradation of concern was upheld. With respect to uncertainty analysis, to comply with the CSA N285.8 standard, in its probabilistic reactor core assessments of various failure scenarios (or the avoidance thereof) it is assumed OPG has, or will, make more quantifiable efforts. However, in the Amendment Application itself, there seems to be a scarcity of information on how this gap has, or is being, addressed.

Elsewhere within their Application, OPG has clearly stated where they have updated their regulatory compliance since 2018; how they endeavour to innovate where possible and appropriate; and they describe how they continue to improve their public communication and engagement efforts in both scale and inclusivity. None of these either changes the need or reduces the safety of the public or environment over that accepted today in PROL 48.01 / 2028. With respect to End of Commercial Operations (ECO) and safe storage, the sustainable operations plan required modification to reflect the new timeline, now tapering after shutdown of Units 1 and 4 in 2024, to include only Units 5-8 in 2025 and 2026. With respect to all Safety and Control Areas, there is nothing of surprise in terms of planned actions and activities given two additional years of power operations and reflect the strong safety culture and commitment to continuous improvement at PNGS.

Observations and conclusions

Noting that SMR Insights is only offering opinions or advice and has not undertaken any independent safety analysis (or seen of been involved in any of the assessment activities described herein), after reviewing the Licence Amendment Application and the PSR2-B, it appears that OPG has adequately demonstrated that PNGS can be safely operated, at power, for two additional years beyond that for which it is currently licenced. Whilst this is unlikely to be a satisfactory conclusion for persons holding unfavourable opinions about nuclear energy, reality hangs on establishing what differences there really are between operating Units 5-8 in late 2024 and in late 2026. In terms of what happens during power operations, there is no difference. Similarly, there are no significant differences in terms of the consequences from either normal operations or hypothesised accident conditions.

What is different, however, is the age (in terms of Effectve Full Power Hours) reached by the various SSCs, and the implications thereof. Assuring this will not pose a greater hazard than is currently licenced for (and that this remains compliant with applicable Laws, Regulations, Codes, and Standards) was the dominant theme within the Licence Amendment Application. In this regard, the Fuel Channels are the principal concern given their function as both a pressure boundary and a barrier to radiological release. OPG has methodically assessed each SSC of concern (and any aggregated effects) and shown that Units 5-8 can be operated safely until end of 2026. The approach to assessment meets or exceeds international best practice and necessary standards for the post-Fukushima era. Given the modest lifetime extension and the safeguards in place vis-à-vis condition monitoring, it is not obvious that OPG could do anything differently to make their case beyond refurbishment itself.

In conclusion, from a safe use of nuclear energy perspective, SMR Insights would advise CANHC and the City of Pickering that they can comfortably support, or at a minimum be neutral towards, the Licence Amendment Application, depending on local factors. There is no obvious reasoned case to oppose it, especially since such opposition will not impact the fact that PNGS has an extant Class 1A licence from the CNSC valid through 2028. In the spirit of due diligence, CANHC and the City of Pickering could consider requesting further clarification around:

- Outstanding condition assessments (e.g., those pertaining to spacers that had not been returned before the point the Application was submitted – it appears from OPG's Supplemental Written Submission that this is now rectified but is unclear, especially since a justification of 285k EFPH for tight-fitting spacers is <305k).
- The implications (e.g., in terms of on-site activity and staffing) of shutting down Pickering A in full whilst continuing to operate Pickering B.

There may also be positive or negative local implications, e.g., from workforce dynamics, as a result of the operational lifetime extension, but these are out of scope of this critique.

References

Pickering Nuclear Generating Station Power Reactor Operating Licence Amendment Application, https://www.opg.com/documents/letter-to-cnsc-re-pickering-licence-amendment-application-pdf, June 2023.

Pickering NGS Periodic Safety Review 2-B (PSR2-B): Global Assessment Report, https://www.opg.com/documents/pickering-ngs-periodic-safety-review-2-b-pdf, April 28, 2023.

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