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Exposé oral

Mémoire de Northwatch

In the Matter of the

À l'égard de

Ontario Power Generation Inc. - Darlington Waste Management Facility

Ontario Power Generation Inc. - Installation de gestion des déchets de Darlington

Application to Renew the Class IB Waste Facility Operating Licence for Ontario Power Generation in Darlington, Ontario

Demande de renouvellement du permis d'installation de déchets de catégorie IB pour Ontario Power Generation à Darlington (Ontario)

Commission Public Hearing

Audience publique de la Commission

January 26, 2023

26 janvier 2023

Canada

Northwatch Comment on the Application by Ontario Power Generation's to Renew its Darlington Waste Management Facility operating licence

Ref. 2023-H-09

NORTHWATCH

Submitted to the Canadian Nuclear Safety Commission by

Northwatch

December 5, 2022

Image on cover page: Figure 1, page 5, Attachment 5 CD# 00044-CORR-00531-01153 , Nuclear Sustainability Services – Darlington License Renewal Application

1. Context

In July 2022 the Canadian Nuclear Safety Commission (CNSC) issued a notice that it would conduct a public hearing on Ontario Power Generation's application to renew its Darlington Waste Management Facility operating licence for a period of 10 years.

The Darlington Waste Management Facility (DWMF) is located on the site of the Darlington Nuclear Generating Station (DNGS) in the Municipality of Clarington, Ontario, on the traditional territory of the Wendat, Anishinabek Nation, and the territory covered by the Williams Treaties with the Michi Saagiig and Chippewa Nations.

The current licence, which expires on April 30, 2023, authorizes OPG to operate the DWMF to process and store dry storage containers holding used nuclear fuel from the DNGS.

A revised notice was issued on November 14th to announce a change to the location of the public hearing and that the hearing would now be held virtually only. The hearing dates of January 25 or 26, 2023 remained unchanged.

The immediately previous license hearing was held in December 2012 under Ref. 2012-H-09 and considered not just Ontario Power Generation's application to renew the operating license for the Darlington Waste Management Facility, but three matters related to OPG's Darlington nuclear site:

- The Environmental Assessment of OPG's proposed Refurbishment and Continued Operation of the Darlington Nuclear Generating Station (DNGS);
- An application by OPG to renew the Darlington Waste Management Facility (DWMF) licence; and,
- An Application by OPG to renew the Nuclear Power Reactor Operating Licence for the DNGS until December 31, 2014.

That public hearing took place on December 3 to 6, 2012[1] and the Record of Proceedings, Including Reasons for Decision was released the following year, dated March 13, 2013[2] renewing the license until April 30, 2013 and including in the licence the conditions as recommended by CNSC staff and set out in the draft licence attached to CMD 12-H-14.

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[1] Hearing notice issued October 25, 2012 Ref. 2012-H-09 Revision 1 by the Canadian Nuclear Safety Commission
[2]Record of Decision dated March 13, 1959, as found at https://nuclearsafety.gc.ca/eng/the-commission/pdf/2012-12-03-DecisionDarlingtonWMF-e-Edocs4105484-final.pdf

2. 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 support and promotion of public participation in environment-related decision-making.

Northwatch is interested in OPG'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 OPG's operations. The wastes of concern include those wastes which will result from continued and future reactor operation, including continued operation at CANDU reactors already constructed at the DNGS and the novel wastes the from BWRX-300 reactor that OPG has announced it intends to construct at the DNGS.

Given Ontario Power Generation's interest as expressed through the OPG controlled Nuclear Waste Management Organization's current investigation of the Revell Lake area in northern Ontario as a potential burial location for high level nuclear (irradiated) fuel waste and potentially other radioactive wastes - including wastes that will be generated by OPG's proposed additional reactor – Northwatch has a particular interest in the management nuclear fuel waste in the short, medium and long term.

Northwatch was an intervenor in the review process for the 2012 licence renewal for the Darlington Waste Management Facility and more recently in the 2021 review of OPG's application to extend their site preparation license for the Darlington site. Northwatch also intervened in an in-writing-only hearing in 2017 with respect to Ontario Power Generation's proposal to revise the financial guarantee for its nuclear facilities[3]

[3] Ref. 2017-H-05

In 2016, the Canadian Nuclear Safety Commission held a hearing to consider an application from Ontario Power Generation Inc. (OPG) to amend its licence for the Darlington Waste Management Facility, including removing a condition, modifying the operational performance reporting transmittal period, and "updating" the licence format. The public was not permitted to comment.[4]

[4] Ref.2016-H-102

3. OPG's Application to Renew the Darlington Waste Management License

3.1 Requested Changes to the DWMF Operating License

As outlined in Ontario Power Generation's main submission and referenced in OPG's license renewal application and CNSC staff Commission Member Document (CMD), OPG is requesting the following changes to the WFOL-W4- 355.01/2023 operating licence:

1) A ten-year licence term to April 30, 2033 for the Darlington Waste Management Facility waste facility operating licence
2) A change in the name of the facility from the Darlington Waste Management Facility (DWMF) into Nuclear Sustainability Services – Darlington (NSS-D).
3) The inclusion of the construction and operation of additional Used Fuel Dry Storage Buildings (UFDSBs) #3 and #4 and a name change from UFDSBs to Used Fuel Dry Storage Structures (UFDSSs).
4) A change in the total capacity of UFDSSs #3 and #4 from 1,000 DSCs to 1,200 DSCs.[5]

CNSC staff are recommending that the Commission approve these requests, and amend the WFOL-W4- 355.01/2023 operating licence accordingly. Northwatch disagrees with this staff recommendation, for reasons set out in the following sections.

REQUEST: Northwatch requests that the CNSC limit the license term to not greater than five years, that OPG's request for a name change be denied, that the carry-over of the construction and operation of additional Used Dry Storage Buildings / Structures be deferred to the next license term or – at minimum – be subject to license hold-points with public involvement in the decision process to remove the hold-point, and that the increase in capacity of the Used Dry Storage Buildings / Structures be contingent on OPG provided additional information and a substantive rationale for the increased capacity.

[5] CMD 23-H9.1, Page 1

3.1.1 *A ten-year licence term to April 30,2033 for the DWMF*

The top-listed of OPG's several requests for changes to the WFOL-W4- 355.01/2023 operating licence is that the ten-year license term for the Darlington Waste Management Facility waste facility operating licence be changed to end on April 30, 2033.

As CNSC staff set out in the CMD, the Commission issued an operating licence to OPG in 2013 for 10 years which will expire on April 30, 2023. This is not a matter of dispute.[6]

What is a matter of dispute is that when OPG submitted their application to renew the operating licence it was for another 10-year period, and CNSC staff recommended this request be granted.

Northwatch is not arguing against the license being extended, but strongly disagrees with the term length. As set out below neither OPG or CNSC staff presented a rationale for a ten year term versus a five year term, and given the large number of uncertainties and impending or potential changed conditions with both OPG's fuel waste management program and the Darlington nuclear site, and given the information gaps in the application, a five year term would be more prudent.

While the outline of requested changes at the opening of the OPG CMD differ somewhat in presentation and perhaps emphasis that the "highlights" of the OPG application as presented in the CNSC staff CMD,[7] the two documents are consistent in the presentation of one of the proposed changes being the license term period, and the two documents are similar in that they both fail to provide a rationale having selected (in the case of OPG) and /or supported (in the case of CNSC) ten years as the term length.

OPG's best effort in this department – such as it is – is found in the following:

> *The current operating licence for the DWMF expires on April 30, 2023. OPG is requesting a renewal of the operating licence for another ten (10) years from May 1, 2023 to April 30, 2033. The renewal would allow OPG to continue with the safe interim processing and storage of used fuel from the Darlington Nuclear Generating Station (DNGS) and the safe storage of intermediate Level Waste (ILW) from DNGS's refurbishment activities.*[8]

We agreed that renewing the operating license for another ten years would allow OPG to continue these activities, but so would an operating licence of five years or even two years. A statement such as this shares an observation, but it does not provide a rationale for the selection – or approval – of a particular term length, in this case one of ten years.

[6] CNSC Staff CMD Page 1
[7] CNSC Staff CMD pages 5-6
[8] OPG CMD 23-H-9.1 page 2

Northwatch acknowledges that the current license term is also for ten years. We have also observed that the Commission has been setting license terms of ten years more frequently in the last decade that was the case previously. However, we do not consider either of these factors to be normative or to be the factors that determine the term length for any particular license, licences or licensed facility. We expect that the term length is set based on the Commission considering factors specific to the facility, facility conditions, and relevant circumstance. In this particular case, we believe those factors favour a five-year term, rather than a ten-year term.

Conditions and factor which support a shorter license term, such as a five-year term, include but are not limited to the following:

- During the current license term, there're were several license amendments made; of those, the license amendment in 2017 limited public comment to in-writing-only, the license amendment in 2016 excluded all public comment or input, and a license amendment in 2015 appears to have been made by the Commission without public knowledge, with Northwatch's first notice of it being a reference in CMD 23-H-9[9]; given the number of changes made in the middle years of the license term, a shorter license term would have resulted in a more orderly process with greater transparency, and if not a greater degree of public trust as a result at least the inverse effect of reduced public trust in response to opaque decision-making might have been avoided
- Further to the point made immediately above, a shorter license period allows changes to be anticipated and dealt with in the normal course of business rather than as exceptions; exceptions in licensing process reduce rigor, scrutiny, transparency and public participation
- There are a number of significant changes anticipated over the next ten years in the Darlington Waste Management Facility, including potential construction of two additional dry storage container buildings / structures of different design and capacity than the current structures; this information should be available during the license review period, and given its absence the reasonable remedy is to reduce the license term and have these additional modified structures considered during the next license review
- There are a number of significant changes anticipated over the next ten years at the Darlington Nuclear Site, including potential construction of one or more additional reactors; Ontario Power Generation announced after the review of the License to Prepare the Site but in advance of the Darlington Waste Management Facility license review that it intends to construct and then operate one or more additional reactors, and have selected GE-Hitachi's BWRX-300 design; this reactor uses fuel which is significantly different than the CANDU

[9] In Section 5.9.1 the CMD states that "In February 2015, the Commission amended the DWMF operating license …" but we were unable to identify any corresponding public notice or hearing. CMD H-23-H-9, page 79

reactors already operating on the Darlington site and the irradiated fuel waste will be significantly different in dimensions, characteristics and management requirements, but OPG has provided no information about waste management plans or structures for the BWRX-300 irradiated fuel waste

- There are a number of significant developments anticipated over the next few years in Nuclear Waste Management Organization's "Adaptive Phased Management Plan", upon which OPG is relying to provide an off-site end point for the long term disposition of the irradiated fuel waste currently under management at the Darlington Waste Management Facility; the NWMO is anticipating selection of a preferred site in 2024 (as of writing) and the commencement of the regulatory approvals process for their plan components, including a deep geological repository, a used fuel transfer and encapsulation facility, and a system of waste transfers and transportation (it must be noted that these are the components of the NWMO's Adaptive Phased Management Plan but it is not yet clear whether the NWMO's plan to begin seeking regulatory approvals will be for the three major project components or for select items – it may emerge that the NWMO intends to engage in project-splitting for the purpose of the Impact Assessment); should the NWMO's expectation of being able to demonstrate that a siting area is "informed and willing" to "host" the APM project not be realized, the NWMO and the NMWO member companies, including OPG, may be required by circumstance to consider alternative arrangements, including extending storage of the irradiated fuel waste at the reactor stations and this would be a licensing consideration
- Should the NWMO's expectation of being able to demonstrate that a siting area is "informed and willing" to "host" the APM project is realized, Ontario Power Generation will be responsible for the extraction of the aging irradiated fuel waste from the dry storage containers in the DWMF for emplacement in transportation containers; the NWMO is silent on this step in the process deeming it to be the sole responsibly of the waste owners (i.e. OPG) but OPG is equally silent; within a five year license period is reasonable to expect that if the NWMO's APM project is to proceed, OPG will be in the design stages of an extraction and transfer process, and this facility would be including in the licensing review, at least as a design concept (to date all components of the NWMO project are in the concept stage, with the exception of one transportation package which was certified by Ontario Hydro in the 1990s and which NWMO implies but has been subject to safety test but for which no evidence of safety testing has been presented).

Taken singly or in combination, the above factors support a shorter license term than that requested by OPG and recommended by the CNSC staff.

REQUEST: The Commission should grant a license extension of not longer than five years.

REQUEST: The Commission should direct that design details for future construction of Used Dry Storage Buildings / Structures be ready for full consideration in the next license review, and that construction and modification – including added capacity – not be undertaken during the 2023-2028 license term

3.1.2 Name Change from the Darlington Waste Management Facility to "Nuclear Sustainability Services – Darlington (NSS-D)"

Ontario Power Generation is requesting to change the name of the Darlington Waste Management Facility (DWMF) to "Nuclear Sustainability Services – Darlington (NSS-D)" in the operating license issued by the Canadian Nuclear Safety Commission.

The request is introduced in the opening pages of OPG's CMD as follows:

> *"Nuclear waste" is a phrase with negative associations in the public perception; and the term is inaccurate when describing all the nuclear materials OPG handles, including materials that are clean, recyclable, and valuable – from copper and steel to heavy water and to important medical isotopes. Nuclear Sustainability Services is a name that is both true and inspirational, aligned with OPG's Climate Change Plan. In both name and deed, NSS demonstrates that nuclear energy is clean energy and vital to net-zero climate action. With a focus on safety and protection of public and the environment, NSS demonstrates good stewardship of nuclear by-products, while developing lasting solutions for disposal, and ensuring public peace of mind. In this submission, Nuclear Waste Management (NWM) division will be replaced with Nuclear Sustainability Services (NSS) and the Darlington Waste Management Facility (DWMF) will be replaced with Nuclear Sustainability Services – Darlington (NSS-D).*[10]

Northwatch provides the following comments on the above paragraph:

- If nuclear waste has negative associations for the public it is because of the very real challenges in isolating wastes such as spent nuclear fuel from the environment into perpetuity; that challenge is a reality, not a "perception" and seeking to disguise or diminish the real challenges of nuclear waste management can be expected to further erode public confidence and deepen the negative associations the public may have with both nuclear waste and the industry which generates it
- Regulatory oversight and the licensing process is not a public relations exercise and a desire by the industry to manipulate public perception should not be a driver or determinant in licensing decisions
- The Darlington Waste Management Facility is a facility which manages high level and some intermediate level waste; it does not recycle copper and steel, it does not manage heavy waters, it does not produce medical isotopes; these activities are outside the function of the DWMF and reciting them in the discussion of the DWMF is an annoying distraction
- It may be OPGs perception that the name "Nuclear Sustainability Services" is "true and inspirational" but that perception is not the public reality; it is not "true" because nuclear

[10] CMD 23-H9.1, page 3

waste is not a "sustainable" product and it will, regrettably, be more likely to inspire ridicule than any other reaction

- There rest of the paragraph is simply jingoistic promotional piece, and in no way speaks to the function or purpose of the waste management facility

The Canadian Nuclear Safety Commission licenses facilities, including the Darlington Nuclear Waste Management Facility, under the General Nuclear Safety and Control Regulations (SOR/2000-202)[11], made pursuant to section 44 of the Nuclear Safety and Control Act, which is the act that also establishes the Commission.[12]

The General Nuclear Safety and Control Regulations (SOR/2000-202) uses the terminology of waste. The Regulation does not euphemize or attempt to popularize the challenge of waste management.

The Darlington Waste Management Facility is licenced under Section 19 of the General Nuclear Safety and Control Regulations:

> ***Prescribed Nuclear Facilities Installations***
>
> *19 The following facilities are prescribed as nuclear facilities for the purpose of paragraph (i) of the definition nuclear facility in section 2 of the Act:*
>
> *(a) a facility for the management, storage or disposal of waste containing radioactive nuclear substances at which the resident inventory of radioactive nuclear substances contained in the waste is 1015 Bq or more;*

Further, Canada is party to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management[13]. The following paragraphs describe the purpose and function of the Joint Convention:

> *The Joint Convention is the first legal instrument to address the issue of spent fuel and radioactive waste management safety on a global scale. It does so by establishing fundamental safety principles and creating a similar "peer review" process to the Convention on Nuclear Safety.*
>
> *The Convention applies to spent fuel resulting from the operation of civilian nuclear reactors and to radioactive waste resulting from civilian applications. It also applies to spent fuel and radioactive waste from military or defence programmes if such materials are transferred permanently to and managed within exclusively civilian programmes, or when declared as spent fuel or radioactive waste for the purpose of the Convention by the Contracting Party concerned. In addition, it covers planned and controlled releases*

[11] As found at https://laws-lois.justice.gc.ca/eng/regulations/sor-2000-202/index.html

[12] As found at https://laws-lois.justice.gc.ca/eng/acts/n-28.3/

[13] As found at https://www.iaea.org/topics/nuclear-safety-conventions/joint-convention-safety-spent-fuel-management-and-safety-radioactive-waste

into the environment of liquid or gaseous radioactive materials from regulated nuclear facilities.[14]

The terminology used by the Commission in instances such as the names of facilities it licenses should be consistent with its own regulations and regulatory documents and Canada's international commitments, rather than bending to a licensee's initiatives to manipulate public perception or avoid public scrutiny. These are serious matters, and the Commission should respond with seriousness.

OPG goes on in later sections of its CMD to inform the Commission that it has already changed the name of the Darlington Waste Management Facility to Nuclear Sustainability Services – Darlington, and after the fact is asking for a corresponding change to the name of the license.[15] While the CNSC may not be able to save OPG from its own follies, it does not have to follow suit.

Later sections describe OPGs larger name-changing initiative:

> *In 2021, the NWM division became NSS. Simultaneously, NSS changed the name of their three facilities: formerly Pickering Waste Management Facility, Darlington Waste Management Facility and Western Waste Management Facility, now Nuclear Sustainability Services – Pickering, Darlington and Western. NSS has developed a change management plan that includes all the changes to the Nuclear Management system required to rename the division and three facilities. Per OPG's Organizational Design Change procedure the change management plan will ensure the risks related to these changes are managed and the regulatory requirements met. The changes are being implemented and will be evaluated for effectiveness, in alignment with OPG's Standard on Managing Change. The change management plan is being tracked as an initiative within the NSS Strategic Plan Portfolio. NSS expects to satisfy the initiative's actions and meet the overall intent of the change management plan by Q4 2028.*[16]

This request follows changes already made by Ontario Power Generation to their corporate communications including their web site.

There is no longer a heading or section visible upon entry into the OPG web site for information related to nuclear waste and using the site's search function for the phrase "nuclear waste" does not yield a link to a page about nuclear waste, or even to the OPGs new handle "nuclear sustainability services".

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[14] As found at https://www.iaea.org/topics/nuclear-safety-conventions/joint-convention-safety-spent-fuel-management-and-safety-radioactive-waste

[15] CMD 23-H9.1, page 23

[16] CMD 23-H9.1, page 32

Visitors to the OPG site must channel OPG's public relations approach to find their way to any section that bears any connection to the topic of nuclear waste. The user must select "power Ontario", then "our generation" then "nuclear power" and then "nuclear sustainabililty services". Once there, the site users must recognize OPG's stand in term of "Types of nuclear by-products", to read that there are "byproducts" and "materials". But no nuclear waste.[17]

Over many years, Northwatch has been a regular users of both the CNSC and OPGs web site. We have visited the site multiple times in the last six month, and find it frustrating to use and in many or most cases find it difficult to locate information or are unable to locate information we expect to find there or have previously found on the site. The changes in name and terminology – all seemingly with the goal of avoiding having to use the term "nuclear waste" or radioactive waste – make the web site even more difficult to navigate. We also receive requests from members of the public who are looking for information related to OPG's operations, and in most cases the interest relates to radioactive / nuclear waste. We no longer direct information seekers to the OPG web site without giving them additional information about how to navigate through the site. We assume that we hear from only a very small fraction of Ontario residents who are seeking this information, particularly given that we are a northern Ontario based organization and the nuclear waste generators – and so the waste storage facilities – are all located in southern Ontario.

In their Commission Member Document CNSC staff relay that OPG has made the changes in nomenclature and is requesting a corresponding change to the license name.[18] CNSC staff state that they "*accept the licensee's chosen name for the facility and wish to stress that the name of a facility has no impact on regulatory activities. Regulatory effort is driven by the licensed activities carried out at the facility, and in this case, OPG does not propose to alter the licensed activities*."[19] CNSC staff further state that "this change is administrative and has no impact on the activities authorized in the licence or CNSC regulatory oversight of the waste management facility. In general, CNSC staff accepts the licensees' chosen name for a facility, location, or site." [20]

Northwatch disagrees with the staff assertion that this is "administrative" only. It may not alter the licensed activities, but it may well alter – and erode – public confidence in the Commission. We full accept that the Commission cannot govern Ontario Power Generation's messaging and

[17] As found on 4 December 2022 at https://www.opg.com/powering-ontario/our-generation/nuclear/nuclear-sustainability-services/types-of-nuclear-by-products/
[18] CMD 23-H9, page 1
[19] CMD 23-H9, page 7
[20] CMD 23-H9, page 77

promotional efforts, but the Commission can very well regulate that of the Commission and Commission staff. To adopt OPG's jingoistic name change would be demeaning to the Commission and would put them in league with a license who is prioritizing public perception over public information.

Ontario Power Generation states in their CMD that these changes will be "evaluated for effectiveness, in alignment with OPG's Standard on Managing Change" and indicates that his evaluation and the overall change management plan will be completed by Q4 2028.[21] The Commission would be well advised to resist adopting OPG's window dressing approach until after that time. We fully expect that if the evaluation is legitimate the findings will be that this particular promotional effort has not been successful, and terminology will be changed again.

REQUEST: The Commission should reject Ontario Power Generation's request to change the name of the Darlington Waste Management Facility to "Nuclear Sustainability Services – Darlington (NSS-D

[21] CMD 23-H9.1, page 32

3.1.3 Name Change, Construction and Operation of Additional Used Fuel Storage Buildings

As summarized by CNSC staff , in December 2021 OPG submitted an application to renew the operating licence for a 10-year period. In their application OPG requested to carry over into the new licence term the future construction of 2 additional storage structures for used fuel dry storage containers.[22] OPG is also requesting to change the name for the not-yet constructed used fuel storage buildings from used fuel storage buildings to used fuel storage structures, to increase the capacity of these two additional buildings / structures, and to modify the design for these structures.

We are puzzled by the statement by CNSC staff that "*Beside the name change no changes requested to licensed activities*"[23] when on the following page and in later sections of the document[24] CNSC staff identify additional significant changes to the licensed activities. i.e. changing capacity and design of the used fuel storage buildings/structures.

<u>Name Change from Used Fuel Storage Buildings to Used Fuel Storage Structures</u>

As outlined by CNSC staff in their CMD, Ontario Power Generation has requested a change of name for the used fuel storage buildings that have not yet been constructed:

> *Name Change of Used Fuel Dry Storage Buildings to Storage Structures*
>
> *In the licence application, OPG has requested that the name of the two future DSC storage buildings be changed from UFDSBs to UFDSSs. This change is reflected in section IV) LICENSED ACTIVITIES of the proposed licence (see attachment of this CMD).*
>
> *CNSC staff agree that the change to the name UFDSS for the two future storage structures is an acceptable term. Further details on CNSC staff's assessment are provided in section 5.8 of this CMD.*[25]

There was no reason for this name change request presented in the CNSC CMD. CNSC found that OPG's requested name change was consistent with regulatory terminology, and that the the change was administrative and would have no impact on the activities authorized in the licence or CNSC regulatory oversight of the waste management facility.[26]

Other than stating that they are requesting a name change from UFDSBs to Used Fuel Dry

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[22] CMD 23-H9 Page 1
[23] CMD 23-H9 Page 7
[24] CMD 23-H9 Page 8, 78-82
[25] CMD 23-H9, Page 7
[26] CMD 23-H9, Page 77

Storage Structures (UFDSSs) there was no discussion of this request or reason or rationale provided in the OPG's Commission Member Document.[27]

OPG uses more text to state the same in their application:

> *OPG is also changing the nomenclature of the structures for the storage of the DSCs. OPG requests a change to the description of the facilities listed in Part IV - (iv) of the WFOL to a used fuel dry storage structure (UFDSS).*
>
> *Therefore, the licenced activity would be re-worded to the following:*
>
> *(iv) carry out the site preparation, construction, or construction modifications at the facility associated with the authorized additional storage buildings, when on completion will result in a total of no more than 2 used fuel dry storage buildings and 2 used fuel dry storage structures, no more than 1 intermediate level radioactive waste storage building*[28]

We note with interest that neither OPG or CNSC staff provide a reason for this name change.

If we were optimistic about OPG's motivation we would hope that it signals design changes that are going to result in storage structures which are more robust than conventional warehouse buildings and may align with some of the criteria for hardened on-site-storage, which can include structures for fortification and increased security. If we were to be pessimistic, we would worry that the change in name will create a further complication for the public in understanding the various facilities and functions which comprise the Darlington Waste Management Facility. We are, however, neutral with respect to this requested name change.

We make no request of the Commission on this matter.

Storage of Irradiate Reactor Fuel in Wet versus Dry Systems

In general, both practically and on principle, Northwatch supports the construction of additional used fuel storage buildings at the Darlington nuclear site and the transfer of used fuel from wet to dry storage in a timely manner. Fuel waste is more secure in dry storage than in wet storage, and is less vulnerable to loss of cooling (due to loss of water cover, power supply and/or human error) and if the dry storage structures are robust, the waste will be less vulnerable to extreme weather events and to malevolent or terrorist actions.

[27] CMD 23-H9-1, Page 1

[28] OPG Application, Attachment 5 CD# 00044-CORR-00531-01153, page 21 of 103

As of June 30, 2021 there were 313,756 fuel bundles in wet storage in the irradiated fuel bays at the Darlington Nuclear Station, and 293,669 fuel bundles in dry storage at Darlington Waste Management Facility, for a total of 607,425 total at the Darlington nuclear site.[29]

Based on an annual processing rate of 22,000 bundles (assume four operating reactors), if Ontario Power Generation was actually processing used fuel from wet to dry storage after ten years out of the reactor (OPG and the industry more generally frequently describe the fuel waste as staying in wet storage for ten years and then being moved to dry storage) in June 2021 there would have been 220,000 fuel bundles in wet storage, and the remainder – 387,425 fuel bundles – would have been in dry storage, in contrast to the 293,669 fuel bundles that actually were in dry storage.

Ontario Power Generation has had an approval in place for the construction of two additional used fuel storage buildings since 2013. By June 2021 – eight years later - in practical terms they had 93,756 used fuel bundles in wet storage that were overdue for transfer to dry storage. This is very close to the equivalent of the 100,000 fuel bundle capacity of an already-approved dry storage container building.

REQUEST: The Commission should require OPG to engage in forward-looking planning and to provide the Commission with a timeline for the transfer of irradiated fuel waste from wet to dry storage.

Construction and Operation of Additional Used Fuel Storage Buildings

In their CMD, CNSC staff indicated that OPG has requested a change to the storage capacity and design for the future UFDSS#3 and #4[30]. Northwatch comments on the request for increased capacity for each storage building / structure in the following section. In this section, Northwatch's comments are with respect to the request to modify the design of the two additional structures.

CNSC staff state in their CMD that OPG is currently authorized to construct two additional UFDSB with a storage capacity of 500 DSCs each, for a total increase of 1000 DSCs and that the construction of two additional UFDSS for a total increase of 1200 DSCs would enable adequate DSC storage capacity until 2043.[31] Please see the following section for Northwatch's comments

[29] Nuclear Fuel Waste Projections in Canada – 2021 Update, NWMO-TR-2021-17, September 2021. As found at https://www.nwmo.ca/~/media/Site/Reports/2021/10/05/21/19/NWMOTR202117.ashx?la=en
[30] CMD 23-H9 Page 7
[31] CMD 23-H9 Page 7

with respect to the selection of the year 2043 as a planning milestone by both OPG and CNSC staff.

Very little information is provided about the changes to the design of the storage structures which OPG is intending. The information provided is limited to the following points:

- the revised design may be a non-shielded structure on a concrete slab capable of supporting the distributed weight of the DSCs.[32]
- CNSC intends to modify licence condition 15.1 to include the submission of a preliminary safety analysis report and require formal acceptance from the Commission or a person authorized by the Commission.[33]
- The design will be modified
- total storage capacity will be increased from from 1000 DSCs over two buildings to 1200 DSCs over two buildings;[34] it is not clear if this means an increase from 500 to 600 per building or if it is a total increase of 200 between the two buildings, or if the design modifications will be the same for each building

Several licence conditions included in the 2013 licence WFOL-W4-355.00/2023 were specific to the design and construction of these additional UFDSBs, and included requirements that OPG submit an environmental management plan and a construction verification plan, the project design requirements prior to the commencement of construction, and that OPG would not carry out certain activities that relate to completed construction activities until the submission of a commissioning report that is acceptable to the Commission, or a person authorized by the Commission or until the submission of the proposed security arrangements and measures for the new building, or any potential modifications to the protected area that may be associated with this new building, that is acceptable to the Commission or a person authorized by the Commission.[35]

The CNSC staff CMD also reports that in February 2015 – through a proceeding for which Northwatch can find no record[36] - the Commission amended the DWMF operating licence which included the modification of the licence conditions for new storage buildings to align with the standardized licence format. The resulting licence conditions for the additional USFDBs are as follows:

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[32] CMD 23-H9 Page 7
[33] CMD 23-H9 Page 8
[34] CMD 23-H9 Page 78
[35] CMD 23-H9 Page 78-79
[36] Records searched at https://nuclearsafety.gc.ca/eng/the-commission/hearings/documents_browse/index.cfm?yr=2015

- *12.2 Construction - The licensee shall not carry out the activities referred to in paragraph (ii) of Part IV of this licence that relates to completed construction activities in paragraph (iv) of Part IV of this licence until the submission of the proposed security arrangements and measures for the new structure, or any potential modifications to the protected area that may be associated with this new structure, that is acceptable to the Commission or a person authorized by the Commission.*
- *15.1 Construction Plans - The licensee shall submit an environmental management plan, a construction verification plan, and the project design requirements prior to the commencement of construction activities described in paragraph (iv) of Par IV of this licence.*
- *15.2 Commissioning Report - The licensee shall not carry out the activities referred to in paragraph (ii) of Part IV of this licence that relate to completed construction activities in paragraph (iv) of Part IV of this licence until the submission of a commissioning report that is acceptable to the Commission, or a person authorized by the Commission.*

At the time of CNSC staff's assessment of the current application for license renewal, the designs for UFDSS#3 and #4 were not completed. However, as communicated through the CNSC staff CMD, OPG has stated to the CNSC that the new storage structures will meet regulatory requirements, that OPG will submit to the CNSC, a preliminary safety analysis report, demonstrating compliance with these targets for UFDSS#3 and UFDSS#4 at least 270 days (9 months) prior to the submission of the commissioning reports for the storage structures, that design and design characteristics of the used fuel storage structure will be submitted to the CSNC within 30 days prior to the start of construction, that the preliminary safety analysis report, which will include the dose to public for the storage structures, will be provided to the CNSC at least 270 days (9 months) prior to the submission of the commissioning reports.[37]

We found no information in the OPG CMD or application that was additional to that included in the CNSC staff CMD.

Northwatch disagrees with the authorization to construct two additional used fuel storage buildings / structures being carried for in the license conditions in the absence of detailed information about the designed modifications that will be applied. We also disagree with the some aspects of the time frame OPG has set out for their provision of documents to the CNSC in advance of certain project milestones. For example, submitting the design and design characteristics of the used fuel storage structure to the CSNC only 30 days prior to the start of construction is unacceptable. OPG has had the initial approval in place for a decade and the modified approval in place for several years. That the design and design characteristics are not available for review and consideration as part of this review process is unacceptable; that the

[37] CMD 23-H9 Page 80-81

regulator would complete the review of this important information in private and in only thirty days is unthinkable.

REQUEST: The timing requirements for the approval of the two additional used fuel storage buildings / structures should be adjusted to allow adequate review by the public and the regulator

REQUEST: The timeline for the review of the design and design characteristics should be a minimum of six months, with the public review period being no shorter than 90 days, commencing no less than thirty days after notice of the review process and the making available of the review documents.

REQUEST: The review of design and design characteristics of the additional used fuel storage buildings/structures, the preliminary safety analysis report, the environmental management plan and the construction plan should all be subject to public review, either as part of the next license review process or by inserting these milestone reviews as license hold-points and holding stand-alone public hearings before the Commission.

<u>Location of Additional Used Fuel Storage Structures</u>

Ontario Power Generation provides no information to support their selection of a location immediately adjacent to Lake Ontario for the construction of two additional used fuel storage structures, with the exception of two images showing their proposed location relative to the Darlington Nuclear Generating Station and the Darlington Waste Management Facility (and, de facto, relative to Lake Ontario).

Source: Attachment 5 to OPG letter, J. Van Wart to M. Leblanc, "Licence Application for the Renewal of the Darlington Waste Management Facility Operating Licence WFOL-W4-355.01/2023" CD# 00044-CORR-00531-01153

Three issues / concerns arise:

- The absence of any supporting information with respect to the location of these additional structures immediately adjacent to Lake Ontario is further evidence of a weak planning process and lack of environmental, technical or social rigour
- The location of the facilities immediately adjacent to Lake Ontario makes them in the most vulnerable position possible with respect to extreme weather events on Lake Ontario; it is well known that one of the effects of climate change is an increase in extreme weather events, and Lake Ontario will be – and is - no exception; for example, in 2022 the Lake Ontario coastal area was the subject of high water levels, flooding, high waves, and storm surges;[38] as was discussed during the Joint Review Panel public hearing on the proposal to construct up to four new nuclear reactors at the Darlington site, Lake Ontario is subject to frequent tornadoes with an upward trend identified as early as 2011[39]
- The location of the facilities immediately adjacent to Lake Ontario with clear site lines to Lake Onario makes them very vulnerable to terrorist action and / or malevolent acts; Ontario Power Generation's security strategies are land based, and their response units are mobilized in land vehicles, limiting their ability to detect or respond to threats from the water and water craft, which can come in close proximity to the shoreline and to the proposed location of the additional used fuel storage structures

REQUEST: That the Commission require OPG to do a risk assessment of the additional used fuel storage structures focused on increased threat levels due to the close proximity of the selected site to Lake Ontario; this assessment should include identification and assessment of alternative sites within the Darlington property and an explicit examination of those alternatives compared to the selected site relative to security of the facility

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[38] See, for example, the report at https://www.theweathernetwork.com/ca/news/article/lake-ontario-water-levels-still-hazardous-great-lakes-toronto-island-erosion-storm-surge

[39] Cai, Huaqing, Detection of Tornado Frequency Trend Over Ontario, Canada, March 2011, Environment and Climate Change Canada

3.1.4 A change in the total capacity for Used Fuel Dry Storage Structures

As outlined in Ontario Power Generation's main submission and referenced in OPG's license renewal application and CNSC staff Commission Member Document (CMD), OPG is requesting a change in the total capacity of UFDSSs #3 and #4 from 1,000 DSCs to 1,200 DSCs.[40]

In the overview section of their CMD, CNSC staff set out their view that the waste facility operating licence currently authorizes OPG to construct two additional UFDSBs, which would allow for an additional storage capacity of 1,000 DSCs[41], and in a later section describe the current storge buildings with a nominal capacity of 1000 DSCs as being sufficient to store DSCs until approximately 2026.[42] CNSC staff then recommend that OPG be allowed to construct different used fuel storage buildings or structures (modified design) with different capacity (increased capacity from 1,000 DSCs to 1,200 DSCs) under the same authorization.[43] CNSC staff further restates without question the statement from the OPG application that based on the annual processing rates and with consideration of the Darlington Refurbishment Project, the construction of UFDSS #3 and #4 with a capacity to store 1,200 DSCs, will enable adequate DSC storage capacity until 2043.[44] These statements are repeated in later sections of the staff CMD:

> *In its licence application, OPG stated its plan to increase the nominal storage capacity and to change the design of the future UFDSS #3 and #4.*[45]
>
> *OPG plan to increase the total storage capacity for UFDSS #3 and #4 from 1000 DSCs to 1200. OPG stated the following justification for the increase in storage capacity:*
>
> ▪ *based on the annual processing rates of approximately 60 DSCs per year and with consideration of the Darlington Refurbishment Project, there is a need for an additional storage capacity of approximately 1,200 DSCs.*
>
> ▪ *the construction of UFDSS #3 and #4 that has the capacity to store 1,200 DSCs, will be adequate DSC storage capacity until 2043.*[46]

While CNSC provides no explicit rationale for the increase of capacity from 1,000 to 1200 (other than the unsupported assumption that 2043 will mark a change of some sort in storage requirements at the Darlington nuclear site) OPG does, albeit in a very limited way:

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[40] CMD 23-H9.1, Page 1
[41] CMD 23-H9.1, Page 4
[42] CMD 23-H9.1, Page 6
[43] CMD 23-H9.1, Page 7
[44] CMD 23-H9.1, Page 7
[45] CMD 23-H9.1, Page 79
[46] CMD 23-H9.1, Page 80

> *OPG is optimizing the DSC storage capacity of USDSSs#3 and #4 from 1,000 to 1,200 to avoid the need for a fifth storage building.*
>
> *Current plans include the construction of Structure #3 with an anticipated in service date of 2025/2026; and Structure #4 with an anticipated in-service date of 2031 or later, to support continued operations at the DNGS.*
>
> *With the construction of UFDSS #3 and #4 at NSS-D, there will be adequate DSC storage capacity until 2043, when a Deep Geologic Repository is expected to be constructed and operational.*

As set out in the previous section, Northwatch does not disagree with the addition of used fuel storage and has been and remains critical of the slow pace with which Ontario Power Generation processes used fuel from wet storage to dry storage. In Nortwatch's view, OPG has been irresponsible in maintain a very slow pace of transfer from wet to dry storage at the Darlingont nuclear site. However, Northwatch's support for the transfer of used fuel from wet storage to more secure conditions in dry storage does not necessarily translate into support for any and each proposal OPG might produce to accommodate additional storage needs.

Northwatch strongly disagrees with the assumptions CNSC staff and OPG seemingly rely on as rationale for the expanding storage capacity of USDSSs#3 and #4 from 1,000 to 1,200 to avoide the need for a fifth storage building. OPG states the construction of UFDSS #3 and #4 at NSS-D, will provide adequate DSC storage capacity until 2043 "when a Deep Geologic Repository is expected to be constructed and operational" and that expanding capacity from 1,000 to 1,200 will avoid the need for a fifth storage building. CNSC similarly references storage capacity being needed <u>until</u> 2043.

Northwatch's reasons for disagreement include but are not limited to the following:

- Other than a very generalized figures, neither OPG or CNSC support their estimate that these additions will enable adequate capacity until 2043
- Both OPG and CNSC appears to be relying on the availability of a deep geological repository for nuclear fuel waste having been constructed and brought into operation by the NWMO by 2043; this is highly speculative at best; at the time of writing, the NWMO has only concepts of some components of each of the three major elements of their Adaptive Phased Management Project (*a deep geological repository, a used fuel transfer and encapsulation facility, and a system of waste transfers and transportation)* and has not yet determined whether a community will actually declare itself through a "compelling demonstration of willingness" to be accepting of the NWMO project
- The reliance on the NWMO's still conceptual 'Adaptive Phased Management Project" to be receiving wastes by 2043 is particularly misplaced given that the NMMO has repeatedly adjusted their timelines, and there is no certainty that the regulatory process will proceed with the speed which the NWMO is projecting; there is no other operating

deep geological repository for nuclear fuel waste approved and / or operating anywhere in the world, but the SKB project in Sweden was for some period of time pointed to be the NWMO and others as a frontrunner; however SKB's application entered the regulatory process in 2012, has been returned to the proponent for technical deficiencies several times, and has still not received an approval; the Commission must be careful to not confuse political approvals with regulatory approvals, such as with the Swedish example

- The expectation that the NWMO would be receiving nuclear fuel waste by 2043 from the Darlington Nuclear Generating station is wholly unfounded; while for the reasons set out above it should not be assumed that there will be an operating DGR for nuclear waste in Canada by 2043, the Nuclear Waste Management Organization's own projections are that waste transfers would not begin from the Darlington Nuclear Generating Station prior to 2050, which NWMO identifies as the 'assumed date', so even 2050 should not be relied upon at this point as a planning date[47];
- The references to 2043 suggest that storage requirements will end at that time; documenting the basis for statements around capacity needs may have avoided the asking of obvious questions, including how that expectation of an end of storage capacity in 2043 aligns – or does not – with OPG statements and activities related to the refurbishment of the four CANDU reactors at Darlington, and OPGs stated expectations for operation until 2055[48]; if operations continue until 2055, expectations would be that the used fuel would remain in wet storage for 10 years following removal and then 30 years in dry storage before transfer would be possible to the (still conceptual) deep geological repository, meaning storage requirements would continue until at least 2095; note that this does not align with the NWMO's estimate of 2088 as the "finish year" in their "Summary of Conceptual Annual Shipping Assumptions".[49]
- The documents from CNSC and OPG omit any information - they fail to even mention – OPG's announced plans to construct a new reactor at the Darlington Nuclear Site;[50] OPG states elsewhere that it intends to construct a BWRX-300 reactor, and has filed a license application and claimed that they expect to have the reactor in operation by 2028; there is

[47] Deep Geological Repository Transportation System Conceptual Design Report Crystalline / Sedimentary Rock, APM-REP-00440-0209 R001, September 2021, Page 16. As found at https://www.nwmo.ca/~/media/Site/Reports/2021/09/21/19/56/APMREP004400209.ashx?la=en

[48] See various OPG statements including those at https://www.opg.com/strengthening-the-economy/our-projects/darlington-refurbishment/

[49] Deep Geological Repository Transportation System Conceptual Design Report Crystalline / Sedimentary Rock, APM-REP-00440-0209 R001, September 2021, Page 16. As found at https://www.nwmo.ca/~/media/Site/Reports/2021/09/21/19/56/APMREP004400209.ashx?la=en

[50] See https://www.opg.com/powering-ontario/our-generation/nuclear/darlington-nuclear/darlington-new-nuclear/

no information readily available on the OPG web site with respect to the operating life or the wastes the BWRX-300 will generate, but it is known from others sources that the fuel waste will be of very different dimensions and characterization than CANDU fuel waste[51]

The exclusion of any information or consideration of the BWRX-300 from documents supporting this license application exemplifies Ontario Power Generation's failure to demonstrate good planning and being forward thinking. The current application creates a picture of OPG careening up to a license application deadline, having failed to implement the current licence approval (such as constructing an additional and already approved dry storage container building), rushing a request for a repeated but modified approval (see comments in the previous section about timeline for approval of modified designs), and completely omitting or neglecting a significant planning need which they themselves suggest is on the near horizon (OPG has initiated the licensing process for the BWRX-300 but omits any information about waste management from the review and renewal process for the Darlington Waste Management Facility).

Finally, the change total capacity of UFDSSs #3 and #4 from 1,000 DSCs to 1,200 DSCs cannot be separated from their anticipated request for design modifications for these two additional storage building / structures.

REQUEST: That as per Northwatch's comments on the proposed design modifications for the additional used fuel storage buildings / structures, the proposed design modifications must be the subject of a pubic review process, preferably as part of the DWMF license review process.

[51] See, for example, the report "Advances in Small Modular Reactor Technology Developments", International Atomic Energy Agency, September 2020, as found at https://aris.iaea.org/Publications/SMR_Book_2020.pdf

4.0 Safety Issues

Northwatch engaged Dr. Sunil Nijhawan, PhD, P.Eng. with the nuclear consulting firm Prolet Inc. to undertake a review of OPG's Safety Assessment Report and design and safety considerations with respect to OPG's dry storage containers employed at the Darlington nuclear site. The full report is appended to this submission, and is summarized with key points presented in the following two sections.

The review undertaken by Prolet Inc. had a number of findings that do not fit neatly under either topic of safety assessment report review of the storage container design. These findings – some of which were broader or more over-arching – include the following:

- The OPG application for license renewal of the Darlington waste management facility (and implicitly to their 30 year old cask design and operational and safety assessment procedures) s failed to demonstrate that it meets a number of common safety targets, operational capabilities and due diligence.
- OPG failed to present evidence that there has been adequate qualification of the state of each fuel bundle before storage; that the storage allowed containment of any escaping gaseous fission products in each of the dry storage casks (DSC) that they store now; that there has been good radiation shielding or monitoring and that the long stored spent fuel has been kept below allowable maximum temperatures; in a favorable storage environment; is still intact and is going to be easily retrievable today or at the yet undefined end state and ever shifting end date of dry storage.
- The application did not demonstrate with hard data that the *structures, systems, and components important to safety will continue to perform their intended function for the requested period of extended operation*[1].
- The defective fuel detection system at Darlington is limited to the on-reactor system and the the on-line Gaseous Fission Product Detection System was largely operationally ineffective (due to legacy design error issues with the electronics and detector assembly system) for a very long time, potentially for as long as a twenty year period, meaning that defective fuel may not have been identified, and it is now in general storage in the dry storage containers
- The dry storage containers are not individually unmonitored, e.g. for heat or radioactive releases
- The Dry Storage Casks defy almost all design norms and provide storage geometries that are unsuitable for effective heat removal
- The dry storage containers allow retention of larger than anticipated quantities of water after vacuum drying which can cause undue oxidation and hydrogen intake over the years and can cause potential fuel sheath failures and sport seals that are inadequate for Helium retention.

Prolet concluded that OPG needs to improve examinations of defected and deteriorated fuel bundles prior to their transfer into DSCs with better storage geometries and concrete additives that reduce radiation fields and that OPG has not remained apace with advances in the design of dry spent fuel storage options and designs. In response to these findings, Prolet is recommending a redesign of OPG's used fuel waste management system, which would include revised storage system designs and monitoring each of the dry storage casks with newly developed instrumentation and analytical techniques for any changes in thermal and gamma/neutron profiles.

The complete report is appended to this submission.

4.1 Safety Assessment Report

Prolet Inc. reviewed the safety assessment report and identified numerous shortcomings, including the following:

- The summaries of safety assessments for off-site dose estimates and worker exposures following accidents involving fuel module transfer activities for placement of fuel modules in the DSC (cask drop) made assumptions that are unrealistic and arbitrary and deviate signicantly from the established norms for safety analyses.
- A technically proper evaluation of doses to workers within the three building through which a typical cask transits, and likely to the general public, upon a bounding cask accident or fuel module accident has not been made by OPG.
- Methods used for dose calculations from a reactor accident seem to have been applied to report the strangely miniscule dose to public from an accident involving about 8% of the reactor core inventory of long lived species.
- There are a number of unsubstantiated statements in the Summary Safety Assessment report. The actual detailed Safety Assessment Report was not made available but the summary itself was instructive of the freedom taken with due diligence
- Examples of the assumptions included, those in Section 3.2.1.2 where anumber of statements were made with respect to dose and dose rates for which no supporting details were provided, including no radiation field measurements or computed doses to workers
- There was no assessment of effect of ageing on long stored DSCs included, including no discussion of changes in concrete properties with time and radiation, fuel failure propagation, the effects of radiolysis, the effect of Helium escaped from the cask and replaced by studio air or of potential deterioration of the steel liner
- The safety assessment excluded credible accident initiators which are routinely analyzed for reactor safety assessments, including external events such tornadoes, earthquakes, floods, rail line blasts, aircraft impact, fires, etc.
- The SAR does not specify radiation level limits and the estimates presented in it are just estimates. The SAR does not specify the design targets for OPG DSCs and compare them to actual data.
- The Safety Assessment Report does not reflect advanced international experience

The complete report is appended to this submission.

4.2 Issues with the Dry Storage Container Design

The Prolet review identified a number of safety concerns linked directly to container design, including the following:

- The Darlington OPG Dry Storage Cask is an unventilated closed container with practically no means of convective heat removal from the spent fuel bundles encased in storage tubes. There also are plenty of horizontal surfaces for excess water to pool and be absorbed into, and present challenges to evacuation of water by vacuum drying. Research and development work at institutions that partake in DSC storage designs has demonstrated that orders of magnitude higher quantities of water is still retained after vacuum drying. This water is instrumental in long term sheath decay and fuel failures.
- A spent fuel dry storage system is required to dissipate fuel decay and chemical heat by convection of the enveloping gas moving around the fuel elements within the bundles. However, this OPG DSC design does everything to inhibit convective currents around fuel elements by first encasing two bundles in a tube, figuratively suffocating them, and then stacking the tubes in a horizontal geometry very close each other and close as well too to the walls of the thick steel lined concrete filled container. The used fuel in such a storage system does not have the benefit of a circulating current of natural convection gas flows to remove heat from the fuel elements and thus remain at elevated temperature throughout its journey; certainly much higher compared to a design in which it was put in a cask that permitted a substantive convective currents along the fuel surfaces; one that that was deigned against some commonly used criteria like the CANDU MACSTOR.
- There are no mechanisms or processes in place to identify defected bundles in the DSC either in the process of loading the DSC, or during its vacuum drying, or long term storage. The defected fuel bundle identification systems in place are only at channel refueling stage and even they were faulty for years and only much later corrected. As a result there is no data on actual fuel failures during that period, although this was not discussed in the submissions.
- In the OPG design and spent fuel handling processes outlined in their documentation, no degree of fuel sheath degradations, short of a strong leak of fission gases can be detected prior to transfer into dry storage unless the modules are emptied, bundles examined individually and repackaged. That means the status of fuel bundles OPG sends into dry storage is largely unknown.

- A tightly packed horizontal placement of 384 uncatalogued spent fuel bundles inside a closely spaced pile of tubes within the enveloping concrete container that is totally not conducive to convective heat removal is a serious DSC design weakness. This is contrary to the most fundamental of design requirements of adequate and demonstrable nuclear decay and chemical heat removal and maintenance of conditions that inhibit fuel sheath degradation.

5.0 Additional Issues

5.1 Consideration of Future Fuel Waste Generation

A set out in a preceding section of this report[52], there are a number of significant changes anticipated over the next ten years at the Darlington Nuclear Site, including potential construction of one or more additional reactors.

Ontario Power Generation announced after the review of the License to Prepare the Site but in advance of the Darlington Waste Management Facility license review that it intends to construct and then operate one or more additional reactors, and have selected GE-Hitachi's BWRX-300 design.

The BWRX-300 is a "tenth generation" boiling water reactor. The BWRX-300 will use fuel which is significantly different than the CANDU reactors already operating on the Darlington site and the irradiated fuel waste will be significantly different in dimensions, characteristics and management requirements.

OPG has provided no information about the characteristics of the fuel waste that will be generated by the BWRX-300 or about their waste management plans, including proposed waste storage systems. In fact, there is not a single reference to the BWRX-300 in the OPG application, or in the OPG CMD.

REQUEST: That the Commission provide OPG with explicit direction that their application to construct the BWRX-300, for which the regulatory process has already commenced, must be accompanied by a detailed characterization of the irradiated fuel waste that will be generated by the project and a proposal to amend the Darlington Waste Management Facility license as necessary to house the BWRX-300 spent fuel.

REQUEST: That the Commission include in their decision on the subject Darlington Waste Management Facility license a license condition that includes a hold-point with a mini-hearing (a public hearing, with participant funding and oral interventions) should the license to construct hearing proceed in advance of the next license review for the DWMF.

[52] See Section 3.1.1's discussion of OPG's request for a ten-year licence term to April 30,2033 for the DWMF

5.2 Long Term Management of Nuclear Fuel Waste

Ontario Power Generation states explicitly in their Commission Member Document their expectation that waste transfers will commence from the Darlington station when operations commence:

> *Under the Nuclear Waste Management Organization's Adaptive Phased Management program, established by the federal government, the long-term facility for used fuel is expected to be in service no earlier than 2043, at which time used fuel will start to be transferred from the interim storage location at NSS-D to the Adaptive Phased Management facility.*[53]

The expectation that the NWMO would be receiving nuclear fuel waste by 2043 from the Darlington Nuclear Generating station is wholly unfounded; while for the reasons set out above it should not be assumed that there will be an operating DGR for nuclear waste in Canada by 2043, the Nuclear Waste Management Organization's own projections are that waste transfers would not begin from the Darlington Nuclear Generating Station prior to 2050, which NWMO identifies as the 'assumed date', so even 2050 should not be relied upon at this point as a planning date[54];

In addition to the above noted misunderstanding or misrepresentation, as set out in a preceding section of this report[55] there are a number of significant developments anticipated over the next few years in the Nuclear Waste Management Organization's "Adaptive Phased Management Plan", and these developments could prove to be different than what is expected by either the NWMO or OPG.

The NWMO is anticipating selection of a preferred site in 2024 (as of writing) and the commencement of the regulatory approvals process for their plan components, including a deep geological repository, a used fuel transfer and encapsulation facility, and a system of waste transfers and transportation the same year (it must be noted that these are the components of the NWMO's Adaptive Phased Management Plan but it is not yet clear whether the NWMO's plan to begin seeking regulatory approvals will be for the three major project components or for select items – it may emerge that the NWMO intends to engage in project-splitting for the purpose of the Impact Assessment).

Should the NWMO's expectation of being able to demonstrate that a siting area is "informed and willing" to "host" the APM project not be realized, the NWMO and the NMWO member companies, including OPG, may be required by circumstance to consider alternative

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[53] CMD 23-H9.1, page 86

[54] Deep Geological Repository Transportation System Conceptual Design Report Crystalline / Sedimentary Rock, APM-REP-00440-0209 R001, September 2021, Page 16. As found at https://www.nwmo.ca/~/media/Site/Reports/2021/09/21/19/56/APMREP004400209.ashx?la=en

[55] See Section 3.1.1's discussion of OPG's request for a ten-year licence term to April 30,2033 for the DWMF

arrangements, including extending storage of the irradiated fuel waste at the reactor stations and this would be a licensing consideration.

If NWMO's expectation of being able to demonstrate that a siting area is "informed and willing" to "host" the APM project is realized and the NWMO project proceeds beyond the site selection stage – something which Northwatch and others in the siting regions and along transportation routes do not expect will be the case - Ontario Power Generation will be responsible for the extraction of the aging irradiated fuel waste from the dry storage containers in the DWMF for emplacement in transportation containers. The NWMO is silent on this step in the process deeming it to be the sole responsibility of the waste owners (i.e. OPG) to undertake this transfer. However, OPG is equally silent.

Within a five year license period it is reasonable to expect that if the NWMO's APM project is to proceed, OPG will be in the design stages of an extraction and transfer process, and this facility would be including in the licensing review, at least as a design concept (to date all components of the NWMO project are in the concept stage, with the exception of one transportation package which was certified by Ontario Hydro in the 1990s and which NWMO implies but has been subject to safety test but for which no evidence of safety testing has been presented).

Ontario Power Generation appears to be unprepared and not yet giving adequate consideration to either possible outcome: there is no indication that they have begun to prepare to meet the challenge of designing and implementing a system and methodology for extracting aging fuel waste from a tightly packed dry storage container which has been effectively unmonitored and is potentially laden with defective fuel bundles. Nor do they appear to have been developing contingency plans to transition to long term management of the fuel waste on-site.

Recognizing that a contingency plan was in order, the Joint Panel Review for the environmental assessment of the Darlington New Nuclear Project (DNNP) included a number of radioactive waste-related recommendations, including the following:[56]

> *Recommendation 52.*
> *The Panel recommends that prior to construction, the CNSC require OPG to make provisions for on-site storage of all used fuel for the duration of the Project, in the event that a suitable off-site solution for the long-term management for used fuel waste is not found.*

REQUEST: That the Commission adopt Recommendation #52 of the DNNP Joint Review Panel and require Ontario Power Generation to develop a contingency plan for the long term on-site storage of nuclear fuel waste.

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[56] CMD: 21-H4, Appendix E, E.2 Status of JRP Recommendations, beginning at page 72

5.3 Extended On-Site Storage

In the late 1950s, the U.S. was one of the first jurisdictions to declare its intention to "solve" the problem of nuclear waste by what was referred to at the time as "land disposal", with the preferred option being to place it in salt mines. The "runner up" options were solidifying the wastes and placing it in "sheds" on arid land, or injecting liquid radioactive wastes 5,000 feet below the surface. Canada followed two decades later, with a three month study resulting in the identification of "geological disposal" as the preferred option, either in the Canadian Shield or salt formations.

Almost another three decades have passed, and numerous countries have spent considerable time and research effort in the development of a program to investigate or support deep geological repositories for the "disposal" of highly radioactive reactor fuel waste, but to date no country has actually implemented a nuclear waste burial program.

Increasingly, discussion both in North America and internationally is shifting to an examination of options related to extending on-site storage of nuclear fuel waste into the long or very long term, for periods ranging from 100 to 300 years.

There are three primary motivations for this shift:

- After several decades and a number of failed attempts, there is no geological repository on the near horizon
- Post 9/11 there are increased security concerns and – correspondingly – increased security benefits to moving the fuel wastes into more robust conditions
- Following the Fukushima crisis commencing in March 2011, there is growing awareness of the vulnerability of the spent fuel while being maintained in the Irradiated Fuel Bays

> "*Disposal in cavities mined in salt beds and salt domes is suggested as the possibility promising the most practical immediate solution of the problem. Disposal could be greatly simplified if the waste could be gotten into solid form of relatively insoluble character. In the future the injection of large volumes of dilute liquid waste into porous rock strata at depths in excess of 5,000 feet may become feasible.*"
> National Academy of Sciences - National Research Council Division of Earth Sciences Committee On Waste Disposal, Report on Disposal of Radioactive Waste on Land, U.S.A., 1977

In addition, in some situations, particularly in the U.S., pools are reaching capacity, and action must be taken in the short term to keep the waste secure over the short, medium and long term.

In the U.S., reactors are generally single units, whereas in Canada – and particularly Ontario – the practice of having multi-unit reactor stations has *de facto* created centralized storage, with up to eight reactors operating on a single property. That said, the precise location of the waste management facility within the nuclear generating station boundaries may not be the most appropriate for extended storage that may reasonably be expected to be in place for 100 to 300 years. This will be particularly evident in light of the features of robust storage as described below.

Moving to a program of long term at-reactor-site storage will present both opportunities and challenges. Challenges include shifting program momentum after several decades of focus on illusory repository programs, and responding to reactor communities expectations that the waste will be moved off-site, after decades of having been told that this would be the case. Technical challenges include having to potentially manage newer fuels with higher burn-ups, and maintaining technical capacity over the longer term in order to adequately maintain and where necessary upgrade or replace system components. Noteably, these technical challenges will be part of any management scenario. For Canada, an additional challenge is that there appears to have been very little attention given to CANDU spent-fuel management in the international programs. With 10% of reactors world-wide using the CANDU design, this is a gap that should be of concern to more than just Canada.

The opportunities include increased security benefits, avoiding the risk of off-site transfer and transportation, and receiving better returns on investment to make storage systems more robust. A necessary first step in the evaluation of the extended on-site storage is the evaluation of how mature current technologies are in their ability to meet storage needs over a 200-300 year period, and of the regulatory regime to determine the degree to which it can accommodate an extended on-site storage program or the degree to which it would need to be supplemented in order to provide regulatory oversight.

In Canada, very little work has been done in this area. A generalized report was prepared for Ontario Power Generation on behalf of Canadian nuclear fuel owners in 2003, discussing conceptual designs for reactor-site extended storage facility alternatives for used nuclear fuel. In comparison, there are numerous reports by U.S. agencies and organizations, some of which include very detailed technical discussions of aging of both fuel and storage system components, and others which provide detailed discussions of options to increase the robustness of a storage site or system. Unfortunately, we do not have the corollary work done for the Canadian / CANDU context.

Five features make spent fuel storage more secure, in terms of potential security threats:

- Wastes are placed in a condition where it is passively safe, i.e. it does not rely on electrical power, cooling water or active ongoing maintenance
- The facility is "hardened", through layers of concrete, steel, gravel or other materials being placed – in various combinations – above and around the irradiated fuel waste
- Siting with the waste storage facility in such as was to remove line-of-sight access to the dry casks from outside the property
- Containers are located within the property to reduce exposure to extreme weather events to the greatest degree possible
- The fuel wastes are dispersed, with the fuel spread more uniformly across the site rather than concentrated in a single area

The feature of passive safety is key in making the waste more secure from human or operational error of natural events. In some situations and designs, dispersal can also be advantageous in keeping the waste secure from human or operational error of natural events.

Inarguably, there are benefits to taking a planned approach to extending on site storage, rather than simply have "short term" or "interim" storage extend over the long term simply due to program failure.

REQUEST: That the Commission adopt Recommendation #52 of the DNNP Joint Review Panel and require Ontario Power Generation to adopt the features of storages systems which are more secure and robust, including in current on-site storage practices in in developing a contingency plan for the long term on-site storage of nuclear fuel waste.

5.0 Conclusions

In conclusion, Northwatch draws three main findings from our review:

1. Ontario Power Generation's application to renew the operating license for the Darlington Waste Management Facility was incomplete and lacked necessary information.
2. The Safety Assessment was inadequate and should be redone and the full report should be made available to the public.
3. Ontario Power Generation demonstrates poor planning practices and is failing to plan on appropriate timelines and to prepare to meet foreseeable waste management and safety requirements.

Further to those findings, we make the following requests of the Commission:

REQUESTS:

1. **REQUEST:** Northwatch requests that the CNSC limit the license term to not greater than five years, that OPG's request for a name change be denied, that the carry-over of the construction and operation of additional Used Dry Storage Buildings / Structures be deferred to the next license term or – at minimum – be subject to license hold-points with public involvement in the decision process to remove the hold-point, and that the increase in capacity of the Used Dry Storage Buildings / Structures be contingent on OPG provided additional information and a substantive rationale for the increased capacity.
2. **REQUEST**: The Commission should grant a license extension of not longer than five years.
3. **REQUEST:** The Commission should direct that design details for future construction of Used Dry Storage Buildings / Structures be ready for full consideration in the next license review, and that construction and modification – including added capacity – not be undertaken during the 2023-2028 license term
4. **REQUEST:** The Commission should reject Ontario Power Generation's request to change the name of the Darlington Waste Management Facility to "Nuclear Sustainability Services – Darlington (NSS-D)
5. **REQUEST:** The Commission should require OPG to engage in forward-looking planning and to provide the Commission with a timeline for the transfer of irradiated fuel waste from wet to dry storage.

6. **REQUEST:** That the timing requirements for the approval of the two additional used fuel storage buildings / structures should be adjusted to allow adequate review by the public and the regulator
7. **REQUEST:** That the timeline for the review of the design and design characteristics should be a minimum of six months, with the public review period being no shorter than 90 days, commencing no less than thirty days after notice of the review process and the making available of the review documents.
8. **REQUEST:** That the review of design and design characteristics of the additional used fuel storage buildings/structures, the preliminary safety analysis report, the environmental management plan and the construction plan should all be subject to public review, either as part of the next license review process or by inserting these milestone reviews as license hold-points and holding stand-alone public hearings before the Commission.
9. **REQUEST:** That the Commission require OPG to do a risk assessment of the additional used fuel storage structures focused on increased threat levels due to the close proximity of the selected site to Lake Ontario; this assessment should include identification and assessment of alternative sites within the Darlington property and an explicit examination of those alternatives compared to the selected site relative to security of the facility
10. **REQUEST:** That as per Northwatch's comments on the proposed design modifications for the additional used fuel storage buildings / structures, the proposed design modifications must be the subject of a pubic review process, preferably as part of the DWMF license review process.
11. **REQUEST:** That the Commission provide OPG with explicit direction that their application to construct the BWRX-300, for which the regulatory process has already commenced, must be accompanied by a detailed characterization of the irradiated fuel waste that will be generated by the project and a proposal to amend the Darlington Waste Management Facility license as necessary to house the BWRX-300 spent fuel.
12. **REQUEST:** That the Commission include in their decision on the subject Darlington Waste Management Facility license a license condition that includes a hold-point with a mini-hearing (a public hearing, with participant funding and oral interventions) should the license to construct hearing proceed in advance of the next license review for the DWMF.
13. **REQUEST:** That the Commission adopt Recommendation #52 of the DNNP Joint Review Panel and require Ontario Power Generation to develop a contingency plan for the long term on-site storage of nuclear fuel waste.

14. **REQUEST:** That the Commission adopt Recommendation #52 of the DNNP Joint Review Panel and require Ontario Power Generation to adopt the features of storages systems which are more secure and robust, including in current on-site storage practices in in developing a contingency plan for the long-term on-site storage of nuclear fuel waste.

As was the case in the relicensing of the Pickering Waste Management Facility, the Canadian Nuclear Safety Commission has the opportunity to do something exemplary: to require Ontario Power Generation to re-examine their proposed locations for new waste storage and processing buildings on the Darlington nuclear site. The opportunity was not seized with Pickering, but with the advantages of a larger property that the Darlington site affords, the Commission is urged to take this action.

Given that OPG's proposed waste storage buildings #3 and #4 will be directly adjacent to the north shore of Lake Ontario and with an unfettered sight line from the lake and given the potential that the waste storage buildings will be in operation for many decades, it is incumbent on the CNSC to give the highest regard to measures that could increase the safety and security of these fuel wastes.

All of which is respectfully submitted on behalf of Northwatch on December 5, 2022.

[1] Storage of Spent Nuclear Fuel, Safety Standards Series No. SSG–15, IAEA, Vienna (2012).

REVIEW OF OPG APPLICATION TO RENEW OPERATING LICENCE FOR ITS NUCLEAR WASTE MANAGEMENT FACILITY AT DARLINGTON SITE

PREPARED FOR NORTHWATCH

5 December 2022

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1. REVIEW SCOPE & SUMMARY RECOMMENDATIONS

We have reviewed the documents made available to us relating to OPG submission for 10 year license renewal for their Darlington Nuclear Waste Management Facility. We compared the available information on facility design, operating procedures and safety assessment and evaluated them against established norms in reports/submissions on the topic of CANDU spent fuel storage by various Canadian and overseas utilities and support organizations for CANDUs as well as other reactor types (PWR, BWR, VVER, RBMK, MAGNOX, HTGR, research reactors). We examined in considerable detail the features and safety assessments of dry storage solutions developed for LWR designs and how they evolved, were modified over time, regulated, approved and relicensed after each modification (List of approved spent fuel storage Casks are listed in the US federal register in 10 CFR 172.214). Examination of a large number of IAEA documents, including the IAEA Safety Standard in the Safety Guide SSG-15(Rev.1) that '*reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from harmful effects of ionizing radiation'* and '*present international good practices, and increasingly they reflect best practices, to help users striving to achieve high levels of safety'* also helped us arrive at some of the conclusions we present. We have included some information created by IAEA of what is expected to be included in a safety assessment of a waste management facility and examined the OPG submission in comparison to that list. We have included our comments on what was made available, was likely undertaken and likely not undertaken in support of the summary of OPG Safety Assessment Report, giving us additional evidence on whether the OPG safety assessment was adequate. We investigated the defected fuel detection system designs at Darlington and their effectiveness. We generated recommendations on use by reviewers of material in a number of IAEA documents we cite and some helpful reference material (i.e., Reference 1,2,3) on the topic of the necessary scope of a proper assessment for license renewal of such facilities.

The gist of our findings is as follows: The OPG application for license renewal of their Nuclear Waste Management Facility and implicitly to their 30 year old cask design and operational and safety assessment procedures has failed to demonstrate meeting a number of common safety targets, operational capabilities and due diligence. They have presented no evidence that there has been adequate qualification of state of each fuel bundle before storage; that the storage allowed containment of any escaping gaseous fission products in each of the dry storage casks (DSC) that they store now; that there has been good radiation shielding or monitoring and that the long stored spent fuel has been kept below allowable maximum temperatures; in a favorable storage environment; is still intact and is going to be easily retrievable today or at the yet undefined end state and ever shifting end date of dry storage. There also is nothing in the application that would demonstrate with hard data that the *structures, systems, and components important to safety will continue to perform their intended function for the requested period of extended operation*[4]. We note that defected fuel detection system at Darlington is limited to the on-reactor system and that the on-line Gaseous Fission Product Detection System was largely operationally ineffective due to legacy design error issues with the electronics and detector assembly system for a very long time (a project was initiated 20 years later to address the design deficiency). So, some defected fuel may be amply stored, unidentified in dry storage casks which remain individually unmonitored. We believe that a complete redesign of spent fuel handling at Darlington Nuclear Waste Facility is required. The Dry Storage Casks defy almost all design norms; provide storage geometries that are unsuitable for effective heat removal; will allow retention of larger than anticipated quantities of water after vacuum drying; cause undue oxidation and hydrogen intake over the years; cause potential fuel sheath failures and sport seals that are inadequate for Helium retention. OPG needs to improve examinations of defected and deteriorated fuel bundles prior to their transfer into DSCs with better storage geometries and concrete additives that reduce radiation fields. The OPG design is in complete unawareness of the advances in design of dry spent fuel storage solutions and poses potentially extreme economic burden in the future. What we propose is an achievable task and so necessary in the interest of public safety. Remediation and redesign must go hand in hand. The first step is in monitoring each of the dry storage casks with newly developed instrumentation and analytical techniques for any changes in thermal and gamma/neutron profiles. There are substantive reasons to believe that the present inventory of DSCs is hiding fuel failures, and either is already releasing unmonitored quantities of certain radioactivity though the ventilation or will when casks are opened for repackaging. Monitoring each cask is not a new idea. The Korea institute for nuclear safety (KINS), for example, recommends the enforcement of continuous monitoring and integrity assessments of the spent fuel bundles in Casks. CNSC must insure that as well.

2. REVIEW OF OPG APPLICATION, SAFETY ASSESSMENT AND DRY STORAGE CASK DESIGN

We have known of the OPG's DSC design for decades and have agonized over the apparent lack of sound technical basis in its design given that it deviated so much from what the rest of the world was doing in positioning spent fuel assemblies/bundles in water pools for wet storage or in elaborate multi layered containers for dry storage (a good overview is in reference 5).

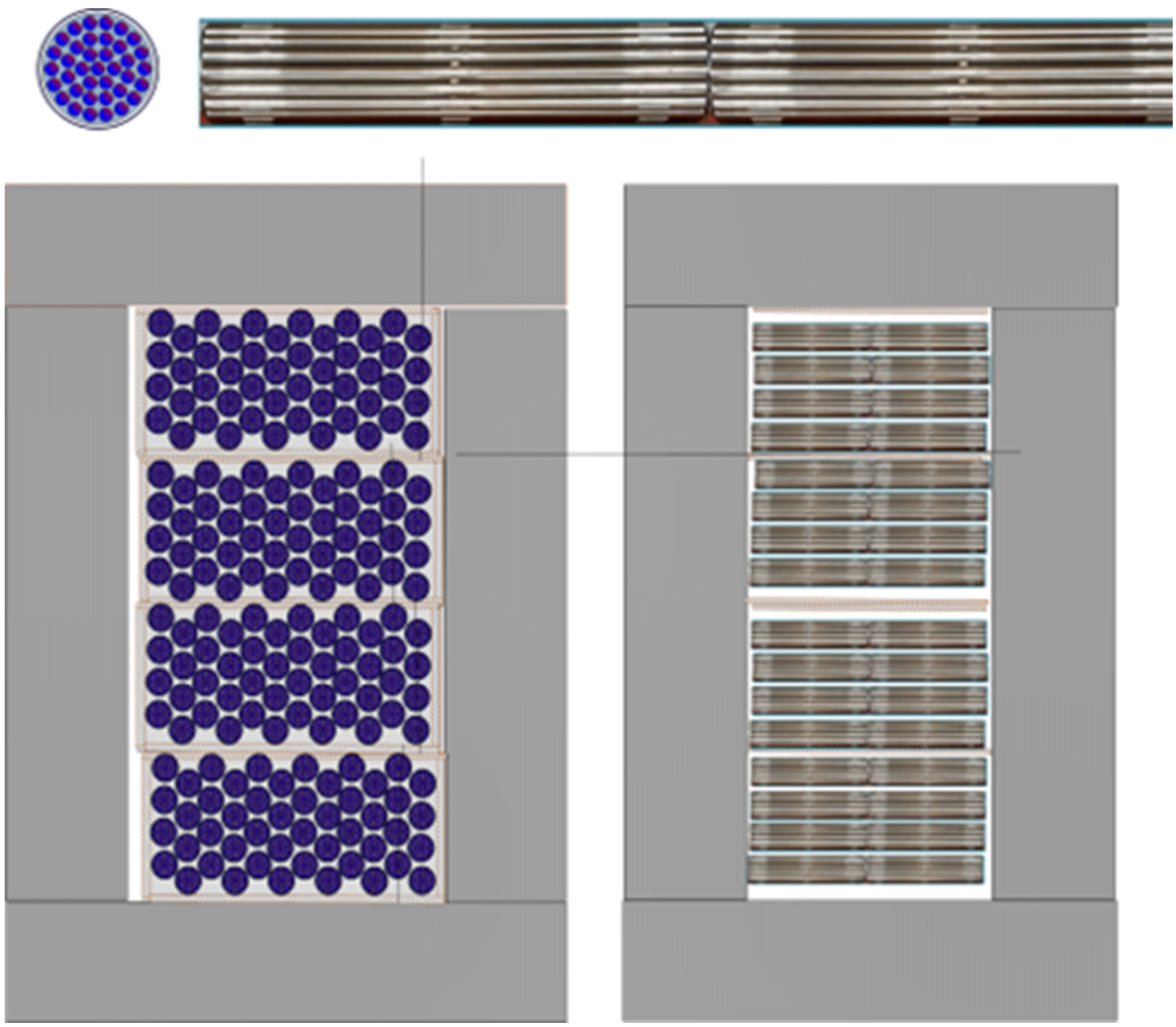

Figure 1 : A to-scale schematic of 4 'modules' of 48 tubes each with a pair of bundles showing minimal clearances in all dimensions

The DSC cavity is 1.06m wide; 1.22m long and 6.5m high and is packed with 4 spent fuel modules, each housing 48 storage tubes with a pair of spent fuel bundles each stored there since their removal from the reactor. Darlington safety report states that the fuel modules contain 96 fuel bundles in 4 rows of 12 storage tubes. This is not quite incorrect. Such a straight layout will not fit in the DSC (12 *0.12 =1.44m which is > available width of 1.22 m). The fuel storage tubes are in 8 staggered rows of 6 tubes each, with alternate rows pretty much sitting on each other and shifted vertically.

An image of an ordered, well spaced separated from each other 48 storage tubes as illustrated in Figure 2 is in conflict with the actual photograph of a fuel module in Figure 3where it is implied that a pair of vertical plates with holes separate various fuel tubes. The actual picture in Figure 3 suggests fuel tubes are practically piled on each other; sitting very close to on top of each other, as illustrated in Figure 4. Once loaded with 45 kg of fuel in each tube, the module of 48 tubes is a formidable handling challenge and a steel mesh is installed on the tube ends to stop any spillage.

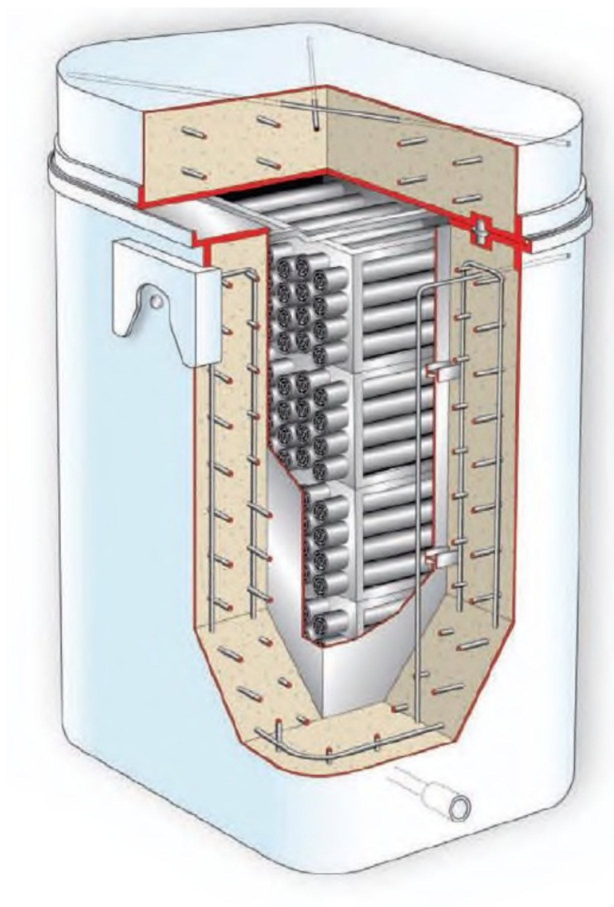

Figure 2: **Idealized** OPG **sketch of 48 storage tubes in each of four fuel modules in DSC**

Once you examine the spent fuel placement in dry and wet storage in these three figures, it becomes apparent that the Darlington OPG Dry Storage Cask is an unventilated closed container with practically no means of convective heat removal from the spent fuel bundles encased in storage tubes. There also are plenty of horizontal surfaces for excess water to pool and be absorbed into, and present challenges to evacuation of water by vacuum drying. R&D work at institutions that partake in DSC storage designs has demonstrated that orders of magnitude higher quantities of water is still retained after vacuum drying. Experience in Pharmaceutical industry confirms that deviation from the simplistic modelling typically made of a thermodynamically predictable small quantity. This water is instrumental in long term sheath decay and fuel failures.

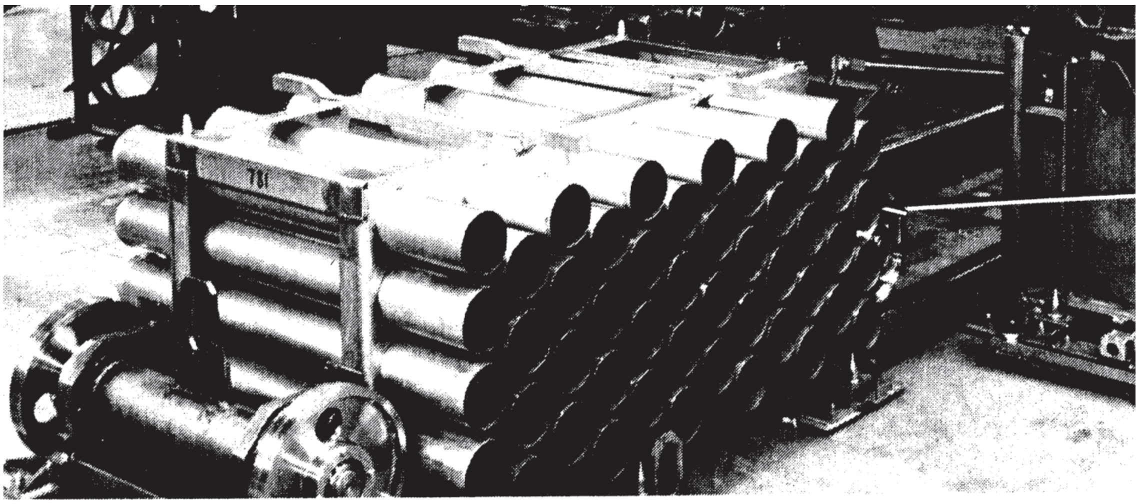

Figure 3: A photograph of fuel module showing stacked fuel storage tubes each of which will hold 2 bundles (Reference 6)

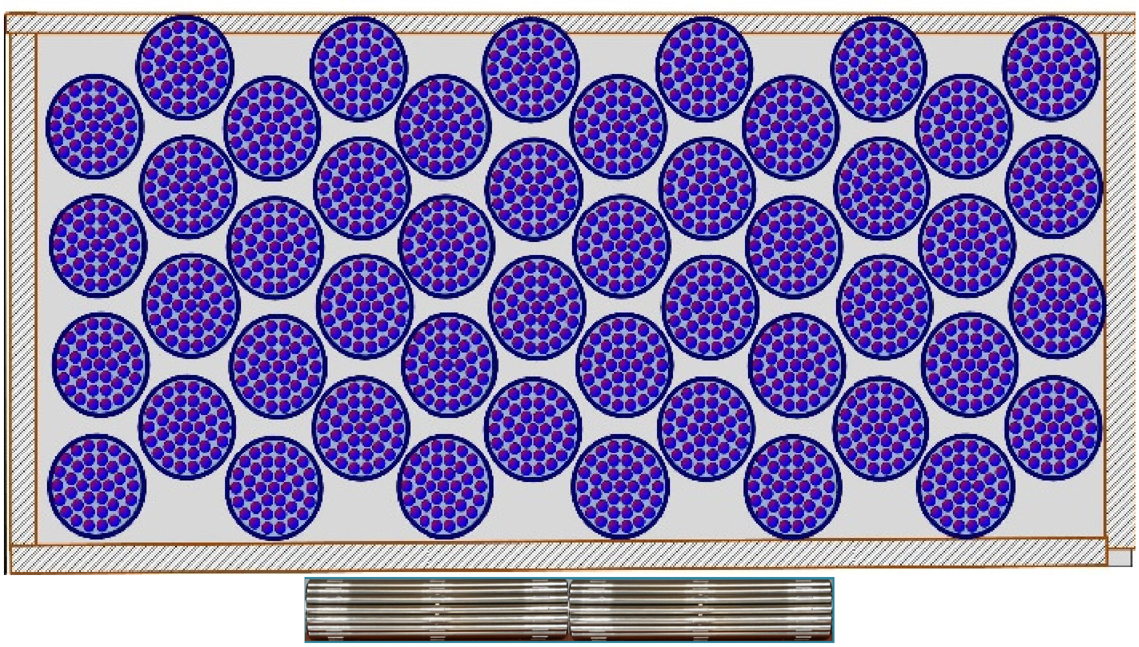

Figure 4 : Darlington spent fuel bundles encased in 48 storage tubes tightly spaced in the same 'module' used both in dry and wet storage and never removed for examination

A spent fuel dry storage system is required to dissipate fuel decay and chemical heat by convection of the enveloping gas moving around the fuel elements within the bundles. However, this OPG DSC design does everything to inhibit convective currents around fuel elements by first encasing two bundles in a tube, figuratively suffocating them, and then stacking the tubes in a horizontal geometry very close each other and close as well too to the walls of the thick steel lined concrete filled container. Figure 1, drawn largely to scale, shows the absence of any clear paths for heat removal and potentially practically zero convective heat transfer from the 3^+ rings of fuel elements within the fuel bundles firmly encaged within the respective storage tubes. The wet stored 48 tube module is carried over to the dry storage cask and snuggled into its deep cavity underwater. A total of four storage modules populate a DSC.

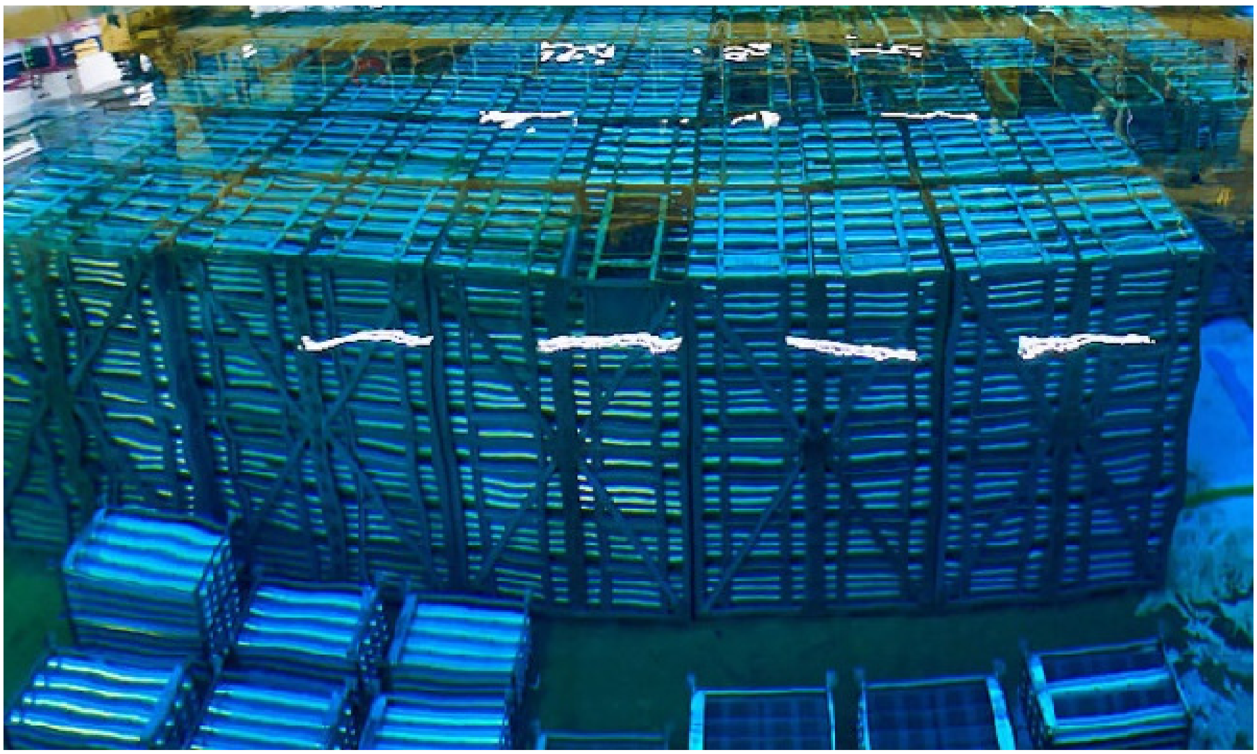

Figure 5 : Spent Fuel Storage Modules under water, ready for a direct transfer into long term storage in DSCs without much scrutiny

The following subsections summarize our reservations and misgivings about the OPG treatment of its obligations to safe storage of spent fuel bundles from removal. We also suggest a path forward as eventually the job has to be done. With professionalism, integrity and the engineering acumen that my old employer Ontario Hydro always demonstrated plenty of.

2.1 The spent fuel bundle storage module concept is an unresolved safety issue even for wet storage safety

Enclosing a pair of CANDU fuel bundles in a horizontal tube, stacking 48 tubes in a closely packed space as a 'module' would work in low temperature liquid water pool. But imagine a sustained loss of pool water inventory accident with these rows of encased bundles in stacks of modules (Figure 5) getting slowly uncovered. The module design would certainly annul any chances of convective cooling of the tube wrapped bundle internal surfaces by air. Remember these bundles may be fresh off the reactor, not 10 years old. Depending upon the accident that caused a loss of water, the fuel heatup to depletion and fuel heatup may take anywhere from 1 to 10 days. The freshest of all first uncovered fuel bundles within the storage tubes will heat up, start exothermic oxidation with air it will draw in, deform and melt the steel storage tubes early and soon start Zircaloy fires. An open fuel bundle – not enclosed in a tube, on the other hand, will benefit from cooling by water boiling in an underneath tray and air cooling (Figure 6). The OPG module will not have that benefit and a number of other advantages offered by open bundle storage. So, the design is really not well thought out for wet storage either. As far as we know, OPG has never modelled this accident to the detail required. Everybody does after Fukushima. We did, and in great detail using our new computer code FUELPOOL for CANDU 6 PHWR fuel bundles stored open 24 abreast in trays and demonstrated the positive contribution of air convection on accident transient consequences. Also, the overall outcome is predicted to be a lot different and in some respects, a pleasant surprise. Typical analyses for fuel pool accidents are content demonstrating and celebrating the long time available for operator action and do not model the fuel heatup, stack disassembly transients and Zircaloy fires. We did and therefore recognize now the issues with OPG module storage concept. There are a number of scenarios in which operator action to refill the pool cannot be credited and the worldwide practice of leaving the fuel bundles bare for efficient heat removal during normal operation by freely flowing water currents, keeping them crud free and available for inspection makes so much more sense. The OPG DSC design does not.

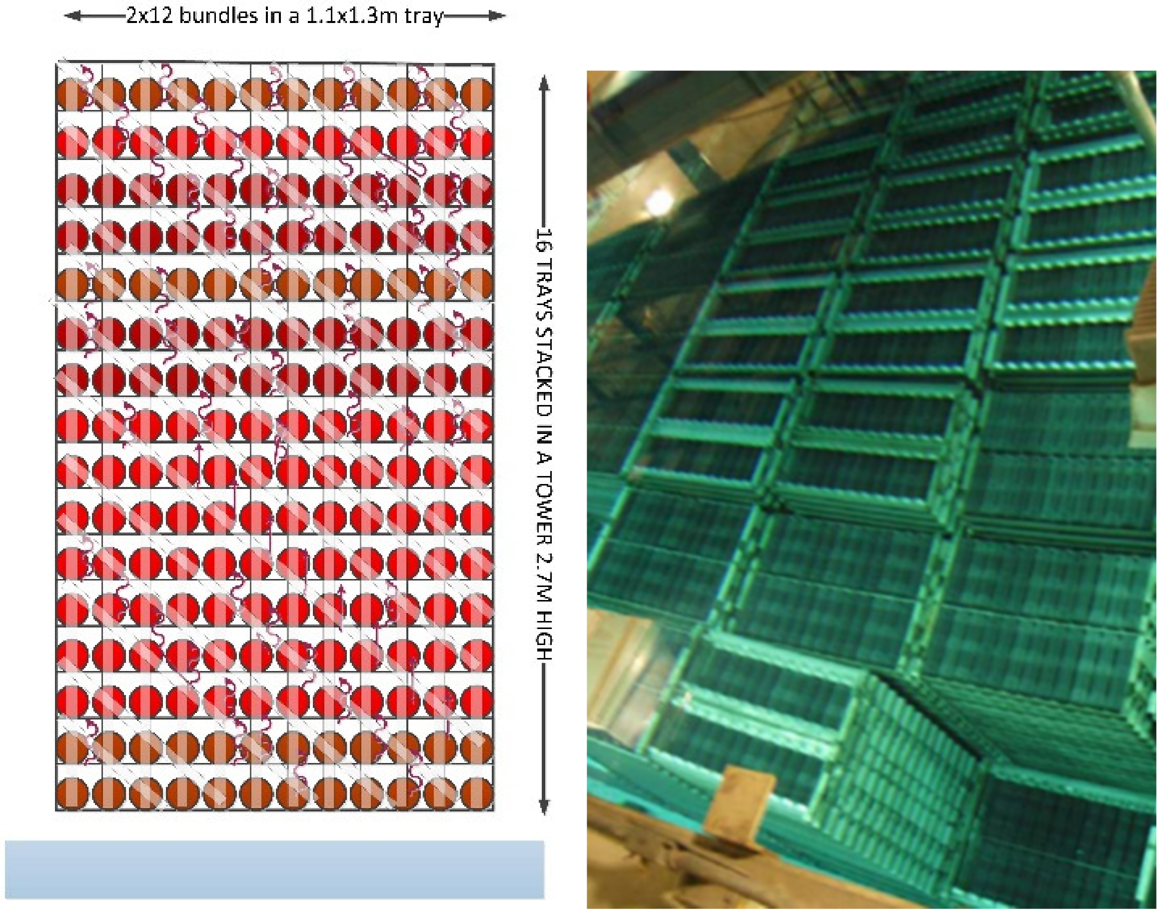

Figure 6: CANDU-6 fuel bundles in open storage baskets

2.2 The spent fuel storage module design is a safety issue for dry storage

It would also be a greater challenge to ensure adequate heat removal when that module is tightly enclosed in a concrete cask upon dry storage (Figure 1 through Figure 4). There is just very little clearance between the 32 rows of 192 storage tubes, between 4 modules or between cask steel walls and ends of 384 bundles packed inside the cask (Figure 1). In this case, fuel will not have the benefit of a circulating current of natural convection gas flows to remove heat from the fuel elements and thus remain at elevated temperature throughout its journey; certainly much higher compared to a design in which it was put in a cask that permitted a substantive convective currents along the fuel surfaces; one that that was deigned against some commonly used criteria like the CANDU MACSTOR, 10 odd LWR dry storage cask designs like CANSTORE and others that we examined and evaluated their thermal modelling / analysis of. What the OPG DSC essentially is a space to dump the fuel modules in and hope for the best. OPG has failed to provide any information on the design requirements, safety targets for these DSCs and how they are met with this design.

There are no mechanisms or processes in place to identify defected bundles in the DSC either in the process of loading the DSC, or during its vacuum drying, or long term storage. The defected fuel bundle identification systems in place are only at channel refueling stage and even they were faulty for years and only much later corrected. As a result there is no data on actual fuel failures during that period, although this was not discussed in the submissions.

One would imagine that emptying the wet storage modules to even visually examine the fuel bundles between storage locations would be a challenging task that would introduce additional failures and worker doses. OPG has not indicated that the fuel bundles are ever removed from their storage tubes in wet storage and visually or otherwise examined for damage or crud or any other deterioration over the 10 years of storage in relatively quiescent water pool. They are expected to remain in those tubes for decades now with health status unknown.

Enclosing fuel bundles or fuel assemblies in horizontal multi tube/enclosure configuration for dry storage of LWR fuel assemblies has been successfully engineered in a small number of cases, but never without making provisions for adequate removal of heat from tube/enclosure outer surfaces by adequate volume of air made available for convective cooling. Vertical placement of fuel bundles is the norm, the most logical way of ensuring that most favorable conditions for heat removal and hence margin to failure are provided. There will be other reasons for a loss of fuel sheath integrity, but it will not be high temperature and the thermos-mechanical and thermos-chemical consequences thereof.

Figure 7 : Storage Plan of OPG NWMF building # 1 (left); Store casks (right) - see how an efficient use of space to store also means you cannot remove a specific cask easily

In the OPG design and spent fuel handling processes outlined in their documentation, no degree of fuel sheath degradations, short of a strong leak of fission gases can be detected prior to transfer into dry storage unless the modules are emptied, bundles examined individually and repackaged. That means the status of fuel bundles OPG sends into dry storage is largely unknown. The longevity of this design also raises a number of troubling questions about regulatory oversight as well. To a lay outsider – a CNSC Commissioner for example - one good briefing on the DSC used by OPG and a review of DSCs used by some other CANDU utilities and other reactor systems combined with public safety expectations as outlined in IAEA SSG-15, will likely also raise similarly disturbing questions (see reference 5 for a recent overview of dry storage designs; also IAEA references 18 thru 24).

Our hope is that Commissioners will see the design errors, functional inadequacy and potential danger of this OPG dry cask design and the large gaps in the accompanying safety analysis submissions. Even the earlier Safety Assessment for Pickering Nuclear Waste Management Facility (reference 7) follows a normal safety assessment reporting pattern and the Commissioners may want to look at both to see the stark difference in quality of analytics. In order to assist them in making an educated ruling, we have included in section 3 – page 27 - the safety assessment topics that IAEA compiled and that should have been included in a systematic review of the safety of the present arrangement that OPG should have prepared.

We conclude that the safety assessment provided by OPG is incomplete and largely inconsistent. We recommend that the Commissioners may also want to look at Reference 1 that details a detailed method of reviewing submissions in support of renewing dry spent fuel storage license renewal. That will help you understand why this application is so wanting both in inherent design, procedures, safety engineering including monitoring and engineering support.

A tightly packed horizontal placement of 384 uncatalogued spent fuel bundles inside a closely spaced pile of tubes within the enveloping concrete container that is totally not conducive to convective heat removal is a serious DSC design weakness. This is contrary to the most fundamental of design requirements of adequate and demonstrable nuclear decay and chemical heat removal and maintenance of conditions that inhibit fuel sheath degradation. We understand from **Error! Reference source not found.** that the two vertical plates across the module and about a quarter of the way from ends allow a minimal separation of storage tubes from each other. Of course, these plates will also create another barrier to heat removal by natural circulation, if any tries to develop. One should understand that the heat will eventually be removed but not without elevating the fuel temperatures to unnecessarily higher levels at which fuel sheath deterioration is accelerated by a variety of mechanisms.

A proper thermal evaluation of the temperature fields in 37 elements of each of the 384 fuel bundles by finite element modelling is required with consideration of nuances like the bundle end peaking and missing in the OPG submission. What we know to be the temperature limit for PHWR fuel rod cladding in dry storage at 200ºC (one analyst suggests 160º C) is significantly lower than the temperature limits accepted for LWR fuel assemblies at 340º -350ºC under normal dry storage operating conditions

2.3 With long duration past failure of Fission Gas Monitoring System, no reliable information on defected fuel presence in current inventory of dry storage casks

Defected fuel bundles in Darlington fuel channels were likely not detected for decades by the designated in-line fission gas detection system that was never properly calibrated as evidence by the Engineering Change design notices that was raised during routine replacement of the electronics associated with the system. This importance of discovery of this ‘legacy’ mis-operating, defective Fission Gas Monitoring System over 10 years ago has implications on future operation of the OPG facility. The information of the failure of the detection system is from the 2012 Darlington Safety report.

Once removed from the reactor, there is no other routine method of detecting defective or deteriorated fuel bundles. Once the bundles are placed in storage tunes, they are never removed for inspection again. Small incipient defects or defects that have ceased to release because of oxidation of UO_2 (as claimed in the safety report chapters reporting on mandated safety assessments for an on-power end fitting failure and ejection of all fuel bundles) are no longer detectable by any routine radiation monitoring systems at the discharge ports, reception bays or in wet fuel transfer locations.

Therefore, it is alarming that no such information on the implication of failure of the only credible defected fuel detection system for many years was put forward in the OPG application or the accompanying safety assessment report.

With practically no apparent systems in place that would travel through the field of DSCs (see Figure 7), focus on each DSC and take thermal and radiation field measurements, etc., one wonders if the Darlington Nuclear Waste Facility mandate now is merely to dump the fuel in the DSCs in a big hall and forget about any further obligation in this lifetime.

2.4 No reports of regular Monitoring / Measurement of radiation fields around Casks

There are no reported measurements of radiation fields around Casks. All information in SAR is from modelling with convenient, simple, mostly unsubstantiated assumptions.

The following five principal radiation sources associated with dry casks are of concern regarding radiation shielding:

1. Fuel gamma rays emitted from fission products and actinides.
2. Structure gamma rays emitted from the decay of Co-60 from the fuel assembly structure material.
3. Secondary gamma rays generated from the radiative capture of neutrons by cask shielding materials, which is known as the (n, gamma) reaction.
4. Neutrons generated from spontaneous and subcritical fission.
5. Neutrons emitted from the {alpha, n} reaction of fissile material.

OPG should consider employing instrumentation to map the above continuously so that any changes provide information on the status of the encased fuel and initiate an investigation into potential remedial measures if defects are developing.

2.5 No consideration of additional residual water in the cask after vacuum drying

A dozen research papers, a text book and a US DOE-Nuclear Energy projects on Spent Fuel and Waste Disposition campaign (Reference 8), show that contrary to previous assumptions of a low quantity of water remaining in a spent fuel cannister after a prototypical vacuum drying, actual amounts available for future reactions may be upto 25 times higher.
Horizontally placed CANDU fuel bundle surfaces in relatively stagnant water within the fuel tubes will entrap crud and the iron (from feeder thinning) and oxide deposits on fuel bundles will absorb water. The drying process can also cause supercooling and the horizontal surfaces are shown to end up with entrapped water.

There is no recognition in any of the OPG submissions of widespread findings by external researchers of higher than anticipated residual water inventory in the casks after the previously considered perfect steps of draining and then of vacuum drying after underwater cask loading. Additional water that will cause more radiolysis (production of O2 and H2), corrosion and oxidation, is likely sourced from de-absorption from large wall surfaces in bundles, storage tube and steel plates and appendages. Also involved in that additional absorption/de-absorption will be the CANDU specific iron deposits on fuel surfaces. Water retention is also likely in the nooks and crannies from the unfortunate placement in horizontal storage tubes stacked tightly together and almost abutting the cask walls with a steel mesh. Resulting fuel sheath failures from increased hydriding and elevated temperatures following oxidation of Zircaloy and UO2 may make fuel bundle retrieval for transfer to transportation casks or final repository casks extremely challenging technically and economically.

Therefore, periodic examination of fuel state is important. It is noted that iron oxide deposits on CANDU fuel bundles may play an appreciable role in water absorption and later de absorption leading to increased and continued radiolysis.

Recent findings of a US DOE project, show that residual free water can be well above (upto 2 orders of magnitude more) the amount of approximately 0.4 gm-moles that had been assumed for a 3 torr rebound pressure and may remain within an SNF canister following prototypic drying to cause:

1. Water radiolysis creating H_2 and O_2
2. Cladding oxidation – additional oxidation (post-discharge) using freed O_2
3. Fuel pellet oxidation – additional oxidation (post-discharge) from UO2 to U4O9 to U3O8
4. Cladding rupture due to fuel oxidation using freed O_2
5. Flawed cladding crack extension under fracture condition

It is expected that water retention within horizontal fuel tubes can be significantly higher. Experiments conducted at a university (reference 9) show that "High surface areas are present in the canister, representing both the fuel and assembly hardware ($Zr0_2$) and the surface area of the CRUD. It is likely that some fraction of the observed water, perhaps most of it, entered the gas phase by desorption from metal oxide surface within the cask."

The OPG DSC presents a very favourable possible arrangements for residual water retention for CANDU spent fuel. That brings up the natural question – why not engineer a fuel transfer system that never includes flooding the DSC cask and have a relatively dry bundle enter the Cask.

2.6 The spent fuel bundle storage geometry is wrong and storage environment not optimal

As a result of this unconventional spent fuel bundle arrangement that contravenes all norms, conditions are created for an undesirable storage environment and un-necessarily elevated fuel temperatures and material degradation during projected years of storage. The danger is also from enhanced radiolysis from unanticipated and larger amounts of actual water retention (references 10) in this storage geometry leading to potential accelerated fuel sheath degradation from oxidation and hydrogen intake, bundle deformations and therefore more likely also an inability, when needed, to safely retrieve fuel bundles for eternal storage and the individual bundle hot cell preprocessing that will go with it. Delayed hydrogen cracking is considered to be a limiting degradation mechanism for CANDU bundles. When properly stored in dry storage as in MACSTORE, the lower temperatures due to lower fission product inventory of the lower burnup CANDU spent fuel bundles help achieve slower cladding degradation in most known degradation processes. However, hydride precipitation and thermal cycling effects are enhanced at much lower temperatures causing early ductile–brittle transition with excess hydrogen made available by radiolysis.

Since low fuel storage temperatures cannot be facilitated in the DSCs as likely can be in MACSTORE or the dozens of designs adaptable from LWR applications, creep rupture, once not considered a limiting mechanism, may need to be investigated as part of extensive R&D the Commission may require OPG to undertake. Failures due to delayed hydride cracking (DHC) of the endcap/endplate welds is still the most critical mechanism challenging bundle integrity during long years of dry storage. Therefore, examination of existing DSCs, especially those with over 25 years of storage, using remote instrumentation may be in order. There have been extensive compilations of international experience in spent fuel degradation in dry storage. (See references 18 through 24, for example)

It is reported in Reference 23 that CANDU bindles stored in moist air at 150°C for 2 years were observed to have endcap fractures in dry storage conditions in a lab setting. Therefore, control of presence of moisture next to fuel bundles is critical even for long term storage where moisture levels may be lower, but the storage periods are longer.

2.7 Cask design does not show favourable assurances of spent fuel retrieval for further transport / terminal storage and may force abandonment

There is no data on safe retrieval of spent fuel bundles from an OPG DSC after decades of storage. Safe retrieval implicitly implies no appreciable fission product releases from the DSC so that the DSC can be opened and transfer of modules to their next destination and then of the undamaged bundles made without additional radiation exposures. That is something that this DSC design would be hard pressed to demonstrate.

There also is little evidence of the transportability of the OPG DSC casks to terminal storage sites.

Also, there is no less of a possibility of an abandonment of the DSC storage buildings within station boundaries following prolonged (>50 year) storage in by then likely severely deteriorated concrete casks because the irradiated fuel retrieval process was difficult.

2.8 Fuel heatup doing vacuum drying not monitored or considered

We note that fuel heatup during the prolonged vacuum drying was never monitored. Likely it was not even quantified / measured. This is an unfortunate oversight / omission.

Safety assessments should have included details, including timing for all processes involved with fuel module handling after removal from wet storage.

2.9 Incomplete Safety Assessment Report and unsubstantiated claims therein

In addition to ignoring the design weaknesses, the submitted summaries of safety assessments for off-site dose estimates and worker exposures following accidents involving fuel module transfer activities for placement of fuel modules in the DSC (cask drop) make assumptions that are unrealistic & arbitrary and in complete neglect of the established norms for safety analyses.

Limiting Values of Radionuclide Intake and Air Concentration in worker submersion are not considered and no recommendations developed on how fast the workers must evacuate the wet storage transfer room or the reception bay.

A technically proper evaluation of doses to workers within the three building through which a typical cask transits, and likely to the general public, upon a bounding cask accident or fuel module accident has not been made by OPG. Methods used for dose calculations from a reactor accident seem to have been applied to report the strangely miniscule dose to public from an accident involving about 8% of the reactor core inventory of long lived species.

A cloud shine dose to public from all 1000 odd casks in the facility was also not reported. Also, a set of comprehensive recommendations for emergency measures and facility evacuation have not been discussed.

There are a number of unsubstantiated statements in the Summary Safety Assessment report. The actual detailed Safety Assessment Report was not made available but the summary itself was instructive of the freedom taken with due diligence. Here are a few examples of the assumptions that are easy to present:

1. Section 3.2.1.2

    - Analysis has already predicted dose rate reductions up to a factor of three for a 10 percent increase in concrete density.
    - Actual concrete densities are higher than 3.57 Mg/m^3
    - The measured dose rates from the DSCs during actual operations are lower than those predicted.

No supporting detailed information that supports the above statements available. No radiation field measurements and computed doses to workers provided.

We suggest a more scientific approach to engineered reduction in radiation fields, such as inclusion of specific additives to the concrete as, for example reported in references 11, 12 , as opposed to just increasing concrete density by addition of any aggregate.

- Analysis has shown that as expected, due to the heavy concrete used as shielding in the DSC, the dose rates produced by neutrons are negligible compared to those generated by gamma radiation.

Given that radiation fields were not reported, this is not consistent with other information in the literature. Dose and actual measurements from neutrons are reported to be 5 times higher than from Gammas in reference 13, albeit for a LWR fuel assembly.

OPG should have followed at least the content of Pickering SAR on the subject of dry fuel storage and the assumptions made by Bruce SAR on what constitutes a Bounding Accident for a dry cask accident, such as the **the failure of 100% of the elements in all of the 384 bundles, for a total of 14,208 failed fuel elements** and release into DSC cavity of the free inventory of tritium and krypton-85 in all used fuel elements; with all barriers to release ignored and all 100% the radionuclides in the DSC assumed to be released into the environment.

One cannot make any other assumptions and then call them 'conservative' in this case.

Other egregious 'assumptions' are discussed elsewhere.

2.10 No assessment of effect of ageing on long stored DSCS and facility health reported

An application to extend the storage life of 30-year-old casks that did not have a longer stated design life should include a whole treatise on evaluation of ageing effects and data on long stored DSCs in addition to pictures of fresh paint. No effect of changes in concrete properties with time and radiation? No fuel failure propagation? No effects of radiolysis? No effect of Helium escaped from the cask and replaced by studio air? No deterioration of steel liner?

There is much talk on on-site storage for 50 or more years, so an ageing effect report was due.

2.11 Safety Assessment Incomplete

To top it all the more serious externally induced accidents are arbitrarily assessed as INCREDIBLE (!):

- Rail line Blast
- Tornadoes
- Floods
- Toxic Corrosive rail line accident
- Aircraft crash

Also missing is treatment of DSC behavior in case of a fire.

These Credible Accident initiators are routinely analyzed for reactor safety assessments. It should be understood that the dry storage site contains many times more of long term, high risk, high dose fission products than the station.

Safety assessments for potential challenges from external events like tornadoes, earthquakes, floods, rail line blasts, aircraft impact, fires, etc. commonly undertaken for such facilities and even for operating OPG reactors are inexplicably brushed aside in the OPG safety assessment as being 'incredible', only to be replaced by unsubstantiated 'assumptions' in the few accident scenarios analyses the applicant did look at.

Internal accidents also need reconsideration. For example, consistency with similar analyses undertaken for Pickering and Bruce are desirable.

2.11.1 No defined Radiation level limits close to Casks

The SAR does not specify radiation level limits and the estimates presented in it are just estimates. The SAR does not specify the design targets for OPG DSCs and compare them to actual data.

For information, 10CFR 71.47 states radiation limits as:

> *(1) 2 mSv/h (200 mrem/h) on the external surface of the package, unless the following conditions are met, in which case the limit is 10 mSv/h (1000 mrem/h):*
>
> *(i) The shipment is made in a closed transport vehicle;*
>
> *(ii) The package is secured within the vehicle so that its position remains fixed during transportation; and*
>
> *(iii) There are no loading or unloading operations between the beginning and end of the transportation;*
>
> *(2) 2 mSv/h (200 mrem/h) at any point on the outer surface of the vehicle, including the top and underside of the vehicle; or in the case of a flat-bed style vehicle, at any point on the vertical planes projected from the outer edges of the vehicle, on the upper surface of the load or enclosure, if used, and on the lower external surface of the vehicle; and*
>
> *(3) 0.1 mSv/h (10 mrem/h) at any point 2 meters (80 in) from the outer lateral surfaces of the vehicle (excluding the top and underside of the vehicle); or in the case of a flat-bed style vehicle, at any point 2 meters (6.6 feet) from the vertical planes projected by the outer edges of the vehicle (excluding the top and underside of the vehicle); and*

(4) 0.02 mSv/h (2 mrem/h) in any normally occupied space, except that this provision does not apply to private carriers, if exposed personnel under their control wear radiation dosimetry devices in conformance with 10 CFR 20.1502.

2.12 Radiation dose to workers following a limiting cask drop accident are unacceptable

Estimates of radiological consequences of an accidental release from nuclear fuel are made by estimating the fission product inventory in the subject fuel, estimating release transients and fractions and knowing dose conversion factors (references 14). The multitude of fission products are grouped according to their chemical and physical forms, half-life, inventory and release mechanisms of release from the fuel grain, boundaries of grain and free spaces between grains. Typically releases of certain representative species are calculated with the common mistake made of forgetting to consider the effect of all isotopes that the 'representative' isotope stands for.

2.12.1 Fission Product inventory in spent fuel in DSC

The 480 fuel channels in the Darlington CANDU PHWR sport a wide range of nominal powers and the 13 fuel bundles within each of these channels have a unique burnup, power history and hence a unique decay heat. It is not clear that OPG had the foresight to monitor the location and power history of each fuel bundle as it made its way to a storage cask. So, safety analysis are typically done for a DSC populated with 384 'reference' fuel bundles. Such a bundle has a core average bundle power during operation of 467 kW with a residence time of 441 Full Power Days and a burnup of 250 MWh/kgU. The other option is to assume that the cask contains bundles from the highest power and highest burnup. In either case there is significant discrepancies between the fission product inventories considered in accident consequence assessments for the 3 Ontario reactors and the one created by NWMO (reference 15).

There are significant uncertainties in prediction of bundle decay heat after it leaves wet storage as the computational algorithms have not been validated to those long conditions. Even uncertainties in prediction of bundle fission product inventories for the reference bundle by using codes like ORIGEN 2 are not insignificant. In addition, estimates of distribution of the fission products between grain, grain boundary and in free space between grains must be related to actual burnup and thermal history of the specific fuel element.

The safety assessment summary we were given did not provide any of the information. We have estimated doses to a worker inside one of the three buildings from just gaseous release of the heavy gas Krypton-85 and found it to be totally at odds with the estimates provided in the summary SAR.

2.13 Fission product releases and doses from 'Bounding Accident' not conservative

A reading of the summary safety assessment report quickly raises questions. The RWC/DSO drop 'bounding accident' consequences are brazenly called 'conservative' with the following baseless assumptions:

- The release will be 0.1% of the particulate of the radioactive material that could become airborne within the container as a result of the accident.
- C-14 is assumed to be only released in particulate form.
- Worker uptake of any release is assumed to be 0.1% of the total release in one half-hour.

Compare that to the treatment or PWR spent fuel of 100% releases from a dropped cask. For example, Bruce Safety report in its section 1.6.3 on DSC DROP DURING ON-SITE TRANSFER (BOUNDING SCENARIO) states:" *To provide an upper bound estimate of a release resulting from an accident related to handling used fuel in station, during transfer or at WWMF, public doses were estimated assuming 100% failure of used fuel contents (14,208 elements) in a DSC and the immediate release to the atmosphere of its available radionuclide inventory."*

It was postulated that the free inventory of tritium and krypton-85 in all used fuel elements assumed to be damaged, is released into the DSC cavity. The barriers provided by the transfer clamp with elastomeric seal and the slightly sub-atmospheric pressure inside the DSC cavity are ignored in the consideration and the radionuclides in the DSC are assumed to be completely released into the environment.

Similarly, there is no technical basis of the assumption that only 1 fuel element in 1% of fuel bundles can fail over their manufacture, transport, installation, irradiation, removal, transport, positioning into fuel tubes, storage in pool, removal from water, transport to DSC, positioning in stack of tubes with the bottom tubes bearing the weight of 6 layers above, vacuum drying, etc.

Therefore, the dose calculation in section 3.2.1.1 of the Safety Assessment summary report is not valid.

2.13.1 Simple to understand dose prediction for workers show that storage cask accidents are unacceptable

Using information from Bruce SAR and postulating that 100% of the tritium and krypton-85 present in the gap will be released, along with 100% of the Tritium and krypton-85 present in the uranium dioxide grain boundary and using the inventory of the fission products per an average ‘reference’ bundle from its Table 1-29, we also used from ICRP-11, the Exposure to dose conversion factor for Helium as 1.19E-15 ((Sv/hr per Bq/m3) and 4.7E-13 ((Sv/hr per Bq/m^3) for Krypton-85. Sor a dissolution of the heavy gas into lower 1000 m^3 of workspace, the dose rate is about 0.46 mSv per minute. And it is too high even without consideration of a number of other fission product species.

An example of radiation fields around spent fuel casks are in Table form in Reference 16.

2.14 No known Measurement of thermal fields around Casks

Recorded variations in thermal fields on casks can augment changes in radiation field data to indicate movement of spent fuel inside the casks.

2.15 No knowledge of Fuel Failures Under operation

Incipient fuel failures under normal operation are not evaluated from any data but ASSUMED as stated in the following extract from OPG submission:

> Since each DSC has the capacity to hold 384 fuel bundles and assuming the facility processes about 70 containers per year, it is postulated that a total of 280 fuel elements (four elements per DSC, i.e., one fuel element in 1 percent of the fuel bundles is assumed to be damaged) fail during 1 year under normal operating conditions (a very conservative scenario).

2.16 Cask Storage Building Ventilation Unmonitored Discharge to Atmosphere

We also note that the atmosphere in the storage buildings is ventilated to the atmosphere indiscriminately and continuously. Given that there is no monitoring of the casks, nobody will know how much of the release of long lived volatile and gaseous fission products like ^{3}He, ^{85}Kr and ^{129}I has occurred and released along with non-radioactive Helium that the Cask free space is populated with. See Reference 17 for a case for installing systems to capture these elements and why these elements should be captured in interest of the environment.

Figure 8: Top of OPG western waste management facility in Tiverton, ON – installation of storage building ventilation louvers that discharge unfiltered air from DSC storage building (Source NAENG.COM)

2.17 Health Status data on previously populated casks missing

There is no summary report of continuous and scheduled periodic monitoring within cask processing buildings & cask storage buildings of each individual cask for status of fuel within casks or of any seal failures.

There is no mention of any evaluation by examination of fuel bundle status in the more than 25-year-old casks and any concrete data on why a continued storage and status of existing casks is satisfactory. An IAEA summary document from 2014 (reference 23) that summarizes worldwide experience in dry cask storage, reports no examination of dry stored CANDU fuel from OPG DSCs. There also is no mention of dry storage of fuel characterized as damaged upon retrieval from reactor or wet storage casks populated by stacked storage tubes.

There is a rather dense layout of storage casks (

Figure **7).** Continuous monitoring of changes in live radiation fields around casks, detection of miniscule gaseous emissions and monitoring of thermal fields around each cask is a fundamental requirement in operation of such a facility as, for example required by US NRC regulations in 10 CFR 72.

There are extensive R&D programs all over the world on developing and installing monitoring equipment. For example, Solid State Track Recorder (SSTR) neutron dosimetry that has been successfully applied for non-destructive spent fuel actinide assay and for characterization of the radiation environment associated with spent reactor fuel assemblies.

Since radiation fields are not continuously and visibly monitored / measured / in proximity of each DSC, how is worker safety assured?

Why would these employees be used for photo op? There is really nothing to read on casks. And

WHY ARE THERE NO INTERNATIONAL RADIATION SIGNS ON THE CASKS?

With no more than a serial number on the cask, wonder upon a sudden abandonment of the site, how would the contents be identified by later generations confused with the moniker of Sustainability on the front gates?

2.18 Safety Assessment Report does not reflect advanced international experience

It is apparent from OPG submission that its Nuclear Waste Management Facility has seemingly not kept up with advances in spent fuel facility management research. Besides ignoring the practices, expectations and regulatory requirements of other, more advanced and cognizant of public safety, jurisdictions, it has also not even adapted some of the advantages in other utility solutions to CANDU spent fuel storage solutions like MACSTOR or its more recent upgrades in Korea. There is no recognition in the OPG application of other utility experience or even the most elementary evaluation of the international body recommendations over the last decade (like dual use casks) that has seen a flurry of activity at IAEA (see references 18, 19, 20, 21, 22, 23, 24) or even other design requirements and in practices from other jurisdictions that may be useful to Canada.

2.19 Much information missing in the OPG Application

We have included check lists in section 3 and have covered scores of items in other sections but here are 2 more:

- What is the design basis for the buildings? (Against wind, fire, earthquakes, aircraft impact, external weather-initiated missile impact, snow, lake ice dams etc.).
- What is the end game for these DSCs. How will the fuel in Fuel Modules be extracted from the DSCs for storage into transport containers?

2.20 Correlation with accident at Darlington Station not established / ignored

There also is no mention of how an accident including a severe core damage at the adjoining reactors will affect the Nuclear Waste Management Facility operations and how will an extreme case of an abandonment of the whole facility due to other accidents or reasons, affect health of the casks and public safety. It is not clear if there are any plans to put in systems in place for remote access to built-in radiation and thermal instrumentation, if there is any. If there is no such instrumentation, then there are strong reasons to ask OPG to consider their installation.

2.21 Safety Assessment does not compare well to previous safety assessments from OPG

The used nuclear fuel in question gets low only in its decay heat with time; the radiation source term within is potent and dangerous to humans for much longer than seems to be understood by this organization. Claims of sub micro Sievert doses to public are likely based on erroneous assumptions, misuse of established methods by untrained analysts and of creative writing.

2.22 Worker Occupational doses not provided and reasons for reported doses not acceptable

The SAR summary states, 'Operators receive most of their dose performing DSC weld repair work." This is alarming. How many welds have to be repaired and when.

Why can not these repairs, just like original welds be automated and performed remotely so that worker doses are minimized?

2.23 Contents of each cask not traceable

There is no evidence that OPG tracks the history of each fuel bundle in each fuel module (origin, ID, irradiation history, channel location, batch defect population data in the specific batch of bundles). There are a number of findings that may require specific actions based on contents of a cask. The casks cannot all be treated as if identical.

The Korea institute for nuclear safety (KINS) recommended the enforcement of continuous integrity assessments of the spent fuel bundles in Casks. It is reported in a number of research studies that fuel rods with defects not originally detected might lead to cladding failure due to UO_2 oxidation related swelling. This happens if an oxidizing atmosphere as following vacuum drying comes in contact with the pellets.

There is no evidence that OPG has considered any Dry Storage Casks Monitoring, for example by means of Ultrasonic Tomography.

2.24 Commission can ask for a review of the whole system of storage of nuclear spent fuel at Darlington

And some food for thought for the Commissioners. Can this industry not be asked to design a single spent fuel bundle storage container for use from receipt from the reactor to final resting[1] at the bottom of whatever the NWMO comes up with so that there is no repackaging of what are expected to be millions of ultimately fragile brittle spent fuel bundles, ever? And should that not be a condition for renewal of license for the plant and explicably tied to it the spent fuel wet and dry storage, transport and disposal outcomes? Imagine going manually through several million spent fuel bundles in 'hot cells' as envisioned by the NWMO plans in a Used Fuel Packaging Plant (UFPP) at final repository site and then imagine the resistance from any community to such an operation within their boundaries once they realize the associated hazards in manual fuel processing at ground level in buildings that themselves become contaminated.

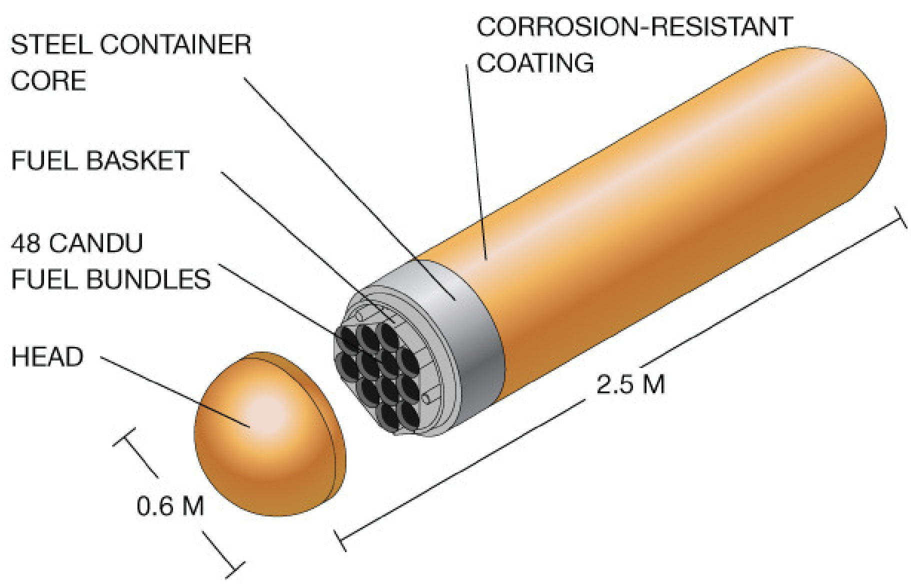

Figure 9: NWMO planned configuration for ultimate storage of CANDU Darlington fuel bundles (Source : NWMO)

We need to put our best minds together at this instead of continuing to repeat the spent fuel storage Cask design errors in the nuclear waste management and its present seemingly weak supervision The Commissioners should take a hard look at this application and at their own mandate to act in public interest and common good and ask OPG to do some real R&D to come up with a new design prior to extending their license. And please ask them to put some internationally recognized radiation warning label on those now shiny, freshly painted DSCs.

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[1] *the folks who came up with 'Sustainability Services' to replace 'Nuclear Waste Management" may likely call that final repository 'Temple of Eternal Peace' or similar.*

Even researchers in countries just contemplating nuclear power (e.g.. Egypt) are giving more thought to the potential barriers to a prolonged dry storage of spent power reactor fuel. Just packing pairs of bundles within isolating steel tubes and stacking the tubes closely together in, largely unmarked on the outside surface of the radiation danger within, concrete silos is not a responsible treatment of a very grave responsibility.

2.25 Our recommendations for denial of license extension are based on science and established norms

Once our findings are properly understood and concerns accepted as legitimate and solely in public interest, our regulatory body should not extend the license for this facility without enforcing basic, common sense requirements for decay heat removal without elevating spent fuel temperatures unnecessarily, radiation and cask leakage monitoring, assured containment of fission product releases, monitoring of casks and their leakage, fuel retrievability and cask transportability – all also described in detail in a number of IAEA documents and adopted by almost all nuclear utilities around the world grappling with the issue of now longer than expected storage of spent fuel in site. The OPG organization with no significant change in Cask design for 30 years, will benefit from CNSC requirement to also partake in greater research and development, lack of which is evident in the paucity of any peer reviewed publications on the OPG casks and related sciences and technologies by their staff or others under their sponsorship or tutelage.

We are happy to help in their endeavors.

3. Summary Observations on Relevant Requirements for Safety Assessment from IAEA Safety Guide SG-15

We list in this section recommendations on site conditions, processes and accidents, events for consideration in a safety assessment as recommended by the IAEA Safety Guide on Dry Fuel storage. Also instructive, and very useful are the elements of a Standard Review Plan for Dry Storage Casks from NRC. The safety assessments prepared by OPG fail on many fronts to present a comprehensive evaluation of hazards associated with operation of such a facility and together we can do better.

Reviews are undertaken fuel storage designs for protection against internal and external instigators, just like for a reactor starting with a PSA and then systematically performing deterministic analyses using state of the art codes and qualified personnel for:

- natural phenomena, such as seismic events, tornados, and flooding
- system failures – internal events
- dynamic effects, such as flying debris or drops from fuel handling equipment and drops of fuel storage and handling equipment
- hazards to the storage site from nearby activities, such a railway lines, reactors, shipping

The following sections present a convenient checklist taken from IAEA SDG 15(Ver 1).

3.1 Consideration of safety in processes in handling fuel

	REVIEW NOTES
(a) Descriptive title, with revision number, date and approval status;	
(b) Purpose of the procedure;	
(c) Initial conditions required before the procedure can be used;	
(d) Precautions and limitations that must be observed;	
(e) Limitations and action levels on parameters being controlled (e.g., pool water composition) and corrective measures to return parameters to within a normal range;	
(f) Procedures providing detailed, step by step operating instructions;	
(g) Acceptance criteria, where applicable, for judging the success or failure of activities;	None discussed
(h) Checklists for complex procedures (either included or referenced);	
(i) References used in developing the procedure;	
(j) Testing to verify radiation dose levels and heat removal performance after spent fuel loading;	None discussed
(k) Monitoring of bore wells around the facility;	
(l) Monitoring of stack discharge.	None discussed

3.2 Consideration in Safety Assessments of 'EXTERNAL NATURAL PHENOMENA'

ANNEX III of IAEA Safety design Guide SDG 15

In making use of this list, it is to be recognized that the initiating events included would not necessarily be applicable to all facilities and to all sites:

(1)		**The meteorology and climatology of the site and region:**	
	(i)	Precipitation (averages and extremes, including frequency, duration and intensity):	Not discussed
		— Rain, hail, snow and ice;	Not discussed
		— Snow cover and ice cover (including the potential for blocking inlets or outlets);	Not discussed
		— Drought.	
	(ii)	Wind (averages and extremes, including frequency, duration and intensity):	Not discussed
		— Tornadoes, hurricanes and cyclones.	Not discussed
	(iii)	Rate and duration of the input of direct solar radiation (insolation, averages and extremes).	
	(iv)	Temperature (averages and extremes, including frequency and duration):	Not discussed
		— Permafrost and the cyclic freezing and thawing of soil.	Not discussed
	(v)	Barometric pressure (averages and extremes, including frequency and duration).	
	(vi)	Humidity (averages and extremes, including frequency and duration):	
		— Fog and frost.	
	(vii)	Lightning (frequency and intensity).	Not discussed
(2)		**The hydrology and hydrogeology of the site and region:**	
	(i)	Surface runoff (averages and extremes, including frequency, duration and intensity):	Not discussed
		— Flooding (frequency, duration and intensity);	Not discussed
		— Erosion (rate).	
	(ii)	Groundwater conditions (averages and extremes, including frequency and duration).	Not discussed

	(iii)	Wave action (averages and extremes, including frequency, duration and intensity):	Not discussed
		— High tides, storm surges and tsunami;	Not discussed
		— Flooding (frequency, duration and intensity);	Not discussed
		— Shore erosion (rate).	
(3)		**The geology of the site and region:**	
	(i)	Lithology and stratigraphy:	
		— The geotechnical characteristics of site materials.	Not discussed
	(ii)	Seismicity:	
		— Faults and zones of weakness;	Not discussed
		— Earthquakes (frequency and intensity).	Not discussed
	(iii)	Vulcanology:	
		— Volcanic debris and ash.	Not discussed
	(iv)	Historical mining and quarrying:	
		— Ground subsidence.	Not discussed
(4)		**The geomorphology and topography of the site:**	
	(i)	Stability of natural material:	
		— Slope failures, landslides and subsidence;	Not discussed
		— Avalanches.	Not discussed
	(ii)	Surface erosion.	
	(iii)	The effects of the terrain (topography) on weather conditions or on the consequences of extreme weather.	
(5)		**The terrestrial and aquatic flora and fauna of the site (in terms of their effects on the facility):**	
	(i)	Vegetation (terrestrial and aquatic):	
		— The blocking of inlets and outlets;	Not discussed
		— Damage to structures.	Not discussed
	(ii)	Rodents, birds and other wildlife:	
		— Direct damage due to burrowing or chewing;	Not discussed
		— Accumulation of nesting debris or guano.	Not discussed
(6)		**The potential for:**	
	(i)	Naturally occurring fires and explosions at the site;	Not discussed
	(ii)	Methane gas or natural toxic gas (from marshland or landfill sites);	Not discussed
	(iii)	Dust storms or sandstorms (including the possible blocking of inlets and outlets).	Not discussed

3.3 Consideration in Safety Assessments of 'EXTERNAL HUMAN INDUCED PHENOMENA'

ANNEX V

In making use of this list, it is to be recognized that the initiating events included would not necessarily be applicable to all facilities and all sites:

(1)		**Explosion:**	
	(i)	Solid substance;	Not discussed
	(ii)	Gas, dust or aerosol cloud.	Not discussed
(2)		**Fire:**	
	(i)	Solid substance;	Not discussed
	(ii)	Liquid substance;	Not discussed
	(iii)	Gas, dust or aerosol cloud.	Not discussed
(3)		**Aircraft crash.**	Not discussed
(4)		**Missiles generated as a result of structural or mechanical failure in nearby installations.**	Not discussed
(5)		**Flooding:**	
	(i)	The structural failure of a dam;	Not discussed
	(il)	The blockage of a river.	Not discussed
(6)		**Ground subsidence or collapse due to tunnelling or mining.**	Not discussed
(7)		**Ground vibration.**	Not discussed
(8)		**The release of any corrosive, toxic or radioactive substance:**	Not discussed
	(i)	Liquid;	Not discussed
	(ii)	Gas, dust or aerosol cloud.	Not discussed
(9)		**Geographic and demographic data:**	
	(i)	Population density and expected changes over the lifetime of the facility;	Not discussed
	(ii)	Industrial and military installations and related activities and the effects on the facility of accidents at such installations;	Not discussed
	(iii)	Traffic;	Not discussed
	(iv)	Transport infrastructure (highways, airports and flight paths, railway lines, rivers and canals, pipelines and the potential for impacts or accidents involving hazardous material).	Not discussed
(10)		**Power supply and the potential loss of power.**	Not discussed
(11)		**Civil strife:**	Not discussed
	(i)	Terrorism, sabotage and perimeter incursions;	Not discussed
	(ii)	The failure of infrastructure;	Not discussed
	(iii)	Civil disorder;	Not discussed
	(iv)	Strikes and blockades;	Not discussed

	(v)	Health issues (e.g., endemic diseases or epidemics).	Not discussed

3.4 Consideration in Safety Assessments of 'INTERNAL PHENOMENA'

ANNEX VI

In making use of this list, it is to be recognized that the initiating events included would not necessarily be applicable to all facilities and all sites:

	Recommendation	Notes
(1)	**The acceptance (inadvertent or otherwise) of incoming spent fuel, spent fuel containers, process chemicals and conditioning agents that do not meet the specifications (acceptance criteria) included in the design basis.**	Not discussed
(2)	**The processing of spent fuel that meets acceptance criteria, but which is subsequently processed in an inappropriate way for the particular type of spent fuel (either inadvertently or otherwise).**	Not discussed
(3)	**A criticality accident due to the inappropriate accumulation of fissile material, change of geometrical configuration, introduction of moderating material, removal of neutron absorbing material or various combinations of these.**	Not discussed
(4)	**Explosion due to the evolution of explosive gas mixtures as a result of:**	
(i)	Radiolysis.	Not discussed
(ii)	Off-gassing or volatilization.	Not discussed
(iii)	Chemical reactions from inappropriate mixing or contact with:	Not discussed
	— Different spent fuel streams;	Not discussed
	— Spent fuel and conditioning agents;	Not discussed
	— Spent fuel cask material and conditioning agents;	Not discussed
	— Process chemicals;	Not discussed
	— Spent fuel, spent fuel casks, conditioning agents, process chemicals and the prevailing conditions of the working environment or storage environment.	Not discussed
(iv)	The inclusion of items such as bottles of compressed gas in the input to incinerators or compactors.	Not discussed

	Recommendation	Notes
(5)	**Fire due to:**	
(i)	Spontaneous combustion;	Not discussed
(ii)	Local hot spots generated by malfunctions of structures, systems or components.	Not discussed
(iii)	Sparks from machinery, equipment or electrical circuits.	Not discussed
(iv)	Sparks from human activities, such as welding or smoking.	Not discussed
(v)	Explosions.	Not discussed
(6)	**Gross incompatibilities between the components of a process system and the materials introduced into the system.**	Not discussed
(7)	**The degradation of process materials (chemicals, additives or binders) due to improper handling or storage.**	Not discussed
(8)	**The failure to take account of the non-radiological hazards presented by the spent fuel (physical, chemical or pathogenic).**	Not discussed
(9)	**The generation of a toxic atmosphere by chemical reactions due to inappropriate mixing or contact of various reagents and materials.**	Not discussed
(10)	**Dropping of spent fuel elements or other loads due to mishandling or equipment failure, with consequences for the dropped spent fuel elements and possibly for other spent fuel elements or to the structures, systems and components of the facility.**	Not discussed
(11)	**Collisions of vehicles or suspended loads with structures, systems and components of the facility or with spent fuel elements, spent fuel casks and pipes.**	Not discussed
(12)	**Failures of structures, systems and components due to:**	Not discussed
(i)	A loss of structural integrity or mechanical integrity;	
(ii)	Vibrations originating within the facility;	
(iii)	Pressure imbalances (pressure surges or pressure collapses);	
(iv)	Internal corrosion or erosion or the chemical effects of the working environment or storage environment.	
(13)	**The generation of missiles and flying debris due to explosion of pressurized components or gross failure of rotating equipment.**	Not discussed

	Recommendation	Notes
(14)	The malfunctioning of heating or cooling equipment, leading to unintended temperature excursions in process systems or storage systems.	Not discussed
(15)	The malfunctioning of process control equipment.	Not discussed
(16)	The malfunctioning of equipment that maintains the ambient conditions in the facility, such as the ventilation system or the dewatering system.	Not discussed
(17)	The malfunctioning of monitoring or alarm systems so that an adverse condition goes unnoticed.	Not discussed
(18)	Incorrect settings (errors or unauthorized changes) on monitors, alarms or control equipment.	Not discussed
(19)	The failure of emergency equipment, such as the fire suppression system, pressure relief valves and ducts, to function when called upon.	Not discussed
(20)	The failure of the power supply, either the main system or a subsystem.	Not discussed
(21)	The malfunctioning of key equipment for handling spent fuel, such as transfer cranes or conveyors.	Not discussed
(22)	The malfunctioning of structures, systems and components that control releases to the environment, such as filters or valves.	Not discussed
(23)	The failure properly to inspect, test and maintain structures, systems and components.	Not discussed
(24)	Incorrect operator action due to inaccurate or incomplete information.	Not discussed
(25)	Incorrect operator action in spite of having accurate and complete information.	Not discussed
(26)	Sabotage by employees.	Not discussed

4. FURTHER DISCUSSION

The safety of a spent fuel storage facility, and the spent fuel stored within it, is ensured by appropriate containment of the radionuclides involved, criticality safety, heat removal, radiation shielding and retrievability" during all normal, off-normal and design basis accident conditions, as well as addressing beyond design basis accident conditions.

A dry storage cask for spent power reactor fuel typically receives spent fuel after it has been stored in water pools for a number of years. While the decay heat has significantly reduced by this time, the radioactive fission product inventory is still significantly potent. A typical CANDU bundle after 10 years of wet and dry storage is still left with over 70 TBq decay of long lived species of which the noble gases and actinides still carry significant exposure risk. The radiation fields from gammas and neutrons are also still significant, although seldom mapped out by OPG with any sensitive instrumentation.

With the inevitable fuel degradation due to radioactive transformations, creep, ageing, mechanical loads of storage and handling, corrosion, hydriding, fuel oxidation and other chemical interactions over the decades of anticipated long term storage, the dry storage solutions must last be thoughtful and anticipatory, so that the next 'downstream' stages in the life of the spent power reactor fuel, namely the removal from dry storage, inspection, repackaging into the transport containers, removal for preparation for ultimate burial and its hot cell handling minimize risk and surprises.

The fuel bundle sheath integrity can only be assured by limiting the hoop stress and hoop strain as well as the maximum temperature to certain values. For CANDU reactor fuel with thin sheaths that temperature is about 200^{o}C for an average 'representative' bundle. Other cladding degradation instigators such as irradiation damages in cladding material crystal structure, doble sided oxide layer formation, hydrogen pick up, helium generation from alpha decay, and long-term fission gas release are the degradation mechanisms that need to be considered. None of these seems to be of discussed adequately in OPG submission.

What is really interesting that of the large variety of dry storage solutions available and drawing from the experience of the utilities employing them, with most seem to be designed without consideration of the possibility that these may turn out to be the only known resting places, the one employed by OPG shows up after serious reconsiderations to be wanting in technical basis. An examination of the OPG application for a license renewal quickly shows that the applicant will benefit from putting additional and significant efforts into cask monitoring (see references) and into doing safety assessment consistent with norms. Dose estimates to workers need to be better calculated and actual doses from repeat welding repairs need to be eliminated.

CANDU PHWR spent fuel is stored in both ventilated (CANDU 6 MACSTOR) and un-ventilated, closed casks (OPG DSC casks). The same is true for LWR spent fuel casks. In almost all cases with positive outcomes, the design is typically such that the fuel decay heat is transferred by thermosyphon of enveloping inert gas over free standing, unloaded, vertical fuel bundles within a sealed metal casing in turn transferring heat out on its external surface by recirculating or once through convection to or through a surrounding concrete cask.

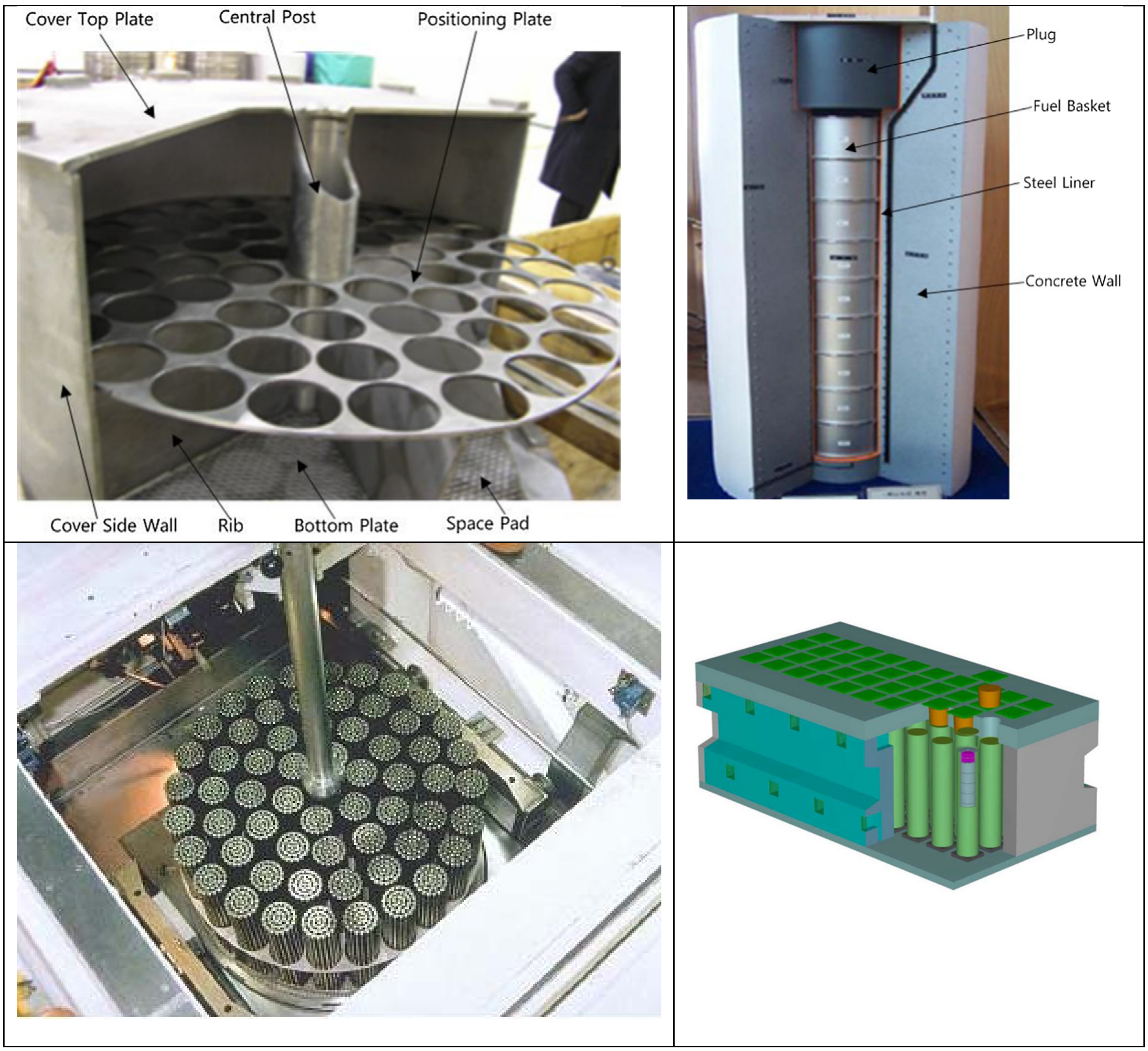

Figure 10: MACSTOR the other CANDU PHWR dry storage solution

The fuel cavity inside the metal casing is earlier emptied of water by vacuum drying and refilling with an inert gas like Helium. Those who monitor the state of fuel inside by sophisticated means since developed or by physically examining the fuel after years of storage, report that significant and unanticipated amounts of water likely still remained within the casing no matter how well they thought the vacuum drying process was carried out. (reference 25)

Thus, spent fuel degradation and sheath failures in dry stored fuels are endemic and unavoidable as is the failures in steel containers and degradation of concrete under thermal and radiation loads as well as ageing. That lead to the IAEA and other organizations requiring consideration of dual purpose casks – single storage and transport casks that can also likely be the ultimate entombment solutions. There are then special, more stringent design requirements for these casks. For example, according to the current U.S. Nuclear Regulatory Commission regulations, transportation containers for hazardous waste must be assessed for a fire with an average fire temperature of at least 800◦C for at least 30 min. The current OPG DSC cask may well be the very wrong design if used to store spent fuel bundles for 100 years as is being surreptitiously discussed now.

As summarized in this submission, the OPG application to continue using the current dry storage solutions for another 10 years is contrary to public interests. There is so much benefit to draw from participating more actively in research and development carried out all over the world, something that we will summarize in our oral presentation with a pointed lack of any R&D work reported by OPG, an organization responsible for most of the spent fuel in Canada.

The OPG submission is incomplete and foggy in places. The storage casks do not meet any serious design or QA expectations and there is no mention of any serious monitoring or radioactive characterization of contents of each cask (besides a shiny paint job and an identification number in big letters); the safety report summary is inconsistent with any international Standard Review Plans for DSCs. The cask storage of reactor 384 fuel bundles in 4 vertically stacked modules of 48 storage tubes, closely spaced on top of each other like horizontal firewood logs, defies all logic and good engineering sense. The current plan to maintain the spent fuel in that geometry and oversight will undoubtedly open up huge risk in future handling of the fuel.

OPG needs to incorporate more the advances made in storage configurations, monitoring of changes in radiation fields, consideration of ageing effects on cask materials, monitoring of state of spent fuel bundles.

We were able to amass a hundred-odd, good peer reviewed research papers on the issue of dry storage of spent nuclear fuel. There was none from OPG or for that matter from Canada. This really is a direct result of there being no express compulsion to the utility to do any research.

With a recognition of need following an independent review of the existing practice of fuel storage in 48 tube modules right after removal from the reactor and its storage in the same modules into dry storage casks where heat removal is a challenge, it will be prudent to design an upgraded wet and dry storage solution that meets all the design requirements and minimizes worker doses.

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