Dear Dr. Gierszewski,

Thank you for your e-mail dated February 20th, 2014. I am pleased to see that you mostly agree with my comments with regard to errors and omissions in OPG's "*Reference Low and Intermediate Level Waste Inventory for the Deep Geological Repository*" OPG Report 00216-REP-03902-00003, issued in December 2010.

I certainly appreciate the opportunity to contribute to the discussion of issues surrounding OPG's intention to bury radioactive waste in the Municipality of Kincardine, Ontario. Radioactive reactor core materials generated by CANDU refurbishments are one of the most intensely radioactive wastes slated for disposal in the proposed DGR, and pressure tubes are undoubtedly the most significant of these components. Fortunately, pressure tubes are closely monitored for a number of critical parameters relating to their in-reactor performance throughout their operational life. Indeed, a measure of the level of effort expended in this regard is the fact that more than $8 million *per year* has been spent by the CANDU Owners Group (COG) over the past 30 years on pressure tube research and development. Furthermore, a number of COG Working Parties, such as WP 34 and 35, have projects specifically dedicated to pressure tube characterization including:

● Pellet Sampling and Metallography of Surveillance Pressure Tubes
● Hot Vacuum Extraction Mass Spectrometry of Zirconium Alloys
● Inert Gas Fusion of Zirconium Alloys
● Standards and Quality Assurance for Zirconium Alloy Analysis
● Depth Profiling of Irradiated Pressure Tube Samples by SIMS
● Nuclear Reaction Analysis
● Chlorine in Zirconium by Neutron Activation Analysis

Given the level of effort expended on CANDU pressure tube characterization over the past 30 years, a very extensive collection of data on the chemical and radiochemical characteristics of irradiated pressure tubes has been accumulated by organizations such as AECL, OPG and Kinectrics. Thus one would expect that the compilation of radioactive inventories for pressure tube waste would be largely a matter of transposition and transcription of data on previously measured radionuclide activities.

I therefore have to ask once again why OPG chose to ***calculate*** pressure tube radionuclide inventories and ignore the large body of radiochemical data on removed pressure tubes collected over the past 30 years. That this was *no*t a wise choice on the part of OPG is demonstrated by the large number of errors and omissions made in the reported calculations. It is certainly a step forward for OPG to acknowledge these errors, but such "mistakes" clearly require an "extent of condition" assessment, an issue I have already addressed in letters to CEAA and the CNSC – see attachment.

Nevertheless, I also wish to draw your attention to the fact that you did not respond to many of the specific comments or requests for information I sent to you in letters or e-mails in January of this year. To clarify what these comments and/or requests were, I am providing them again as listed below:

1. The NWMO Website includes a section entitled: "Transparency Policy", where we read the following:

> *"The NWMO is committed to making accessible to the public the information we create, receive and analyze in support of our work. We will also describe how we used this information when we document our decision-making*".

In light of this policy, and the fact that the use of scaling factors is so controversial, I wish to request a copy of the Kinectrics Report K-015417-001-RA-0001-R01: "*Reference Scaling Factors for Ontario Power Generation's Low and Intermediate Level Waste: 2011 Update*".

2. Please provide data, and the associated rationale, used by OPG or NWMO with regard to (i) Scaling factors, (ii) Used fuel ratios and (iii) Neutron activation calculations, *including numerical values of all input parameters and references to the source of each of these values*.

3. In Section 2.5 of your letter you state that the use of scaling factors must be tested with data. Could you please provide examples of such tests of data.

4. How are inventory calculations validated and verified by OPG or the NWMO?

5. Please explain how the uncertainties in radionuclide inventory data are determined?

6. Can you categorically assert that the radionuclide waste inventories for calandria tubes, end fittings and steam generators are accurately known to within a factor of three? (This question pertains to the "extent of condition" issue discussed below).

7. Please explain how OPG and/or NWMO could underestimate the inventories of tritium in pressure tube waste by factors up to 600.

8. Please explain why garter springs were *not* included in OPG's 2010 inventory report.

9. Please provide information/data on the following:

(i) Measurements of the radionuclide content of garter springs removed from CANDU reactors.
(ii) Dose rate measurements on contact and 1 meter from an irradiated garter spring.

10. Please provide data on the radioactivity of removed flux detectors.

11. In "*Reference Low and Intermediate Level Waste Inventory for the Deep Geological Repository*" OPG Report 00216-REP-03902-00003, issued in December 2010, we find the following statement:

    "*ORIGEN calculates radionuclides to within a factor of 3 in general (some exceptions), and Zr and Nb within 30% for a specific irradiation history. There is also some indication that the ORIGEN results are generally higher than actual inventories by a factor of 1 to 3*"

Please provide evidence for the claim that neutron activation calculations using the ORIGEN-2 code tend to give high numbers.

12. Is OPG aware that ORIGEN-2 code calculations are calibrated for radionuclide production *in fuel* and are largely untested for highly non-homogeneous or distorted neutron spectra in other regions? (Swiss, German, Korean and Russian researchers have all shown that ORIGEN-2 generally *underestimates* radionuclide inventories in non-fuel components). Please explain what steps were taken in the neutron activation calculations to adjust neutron spectra and cross-section libraries for non-fuel components.

13. Please justify the following with regard to OPG's methodology for estimating uncertainties in radionuclide waste inventories:

● Data for Zircaloy-2, (used in pressure tubes for Pickering Units 1 & 2) are mixed with data for Zr-2.5%Nb. These alloys have quite different levels of trace elements such as Ni, Cr, Sn and Ta

● Data for PWR/BWR fuel, (which is enriched in U-235), are used instead of data for non-enriched CANDU fuel

14. Please explain how OPG deals with the following issue:

● Uncertainties in the appropriate application of decay corrections to measured and calculated data. (Measured data are only available for pressure tubes with irradiations up to about 15 years but calculations were generally for 30 years)

15. OPG claims to address the issue of surface contamination of pressure tubes - See for example page 29 of their report: "*Reference Low and Intermediate Level Waste Inventory for the Deep Geological Repository*" OPG Report 00216-REP-03902-00003, where we read:

    > "*The contribution from surface contamination is included for pressure tubes based on data from outlet feeder pipes*"

Please justify the use of outlet feeder data to determine the activities or concentrations of species on pressure tube surfaces when direct measurement data of surface species for removed pressure tubes are available.

Additional Comments:

Section 2.3 of your letter addresses the issue of Uranium and Transuranic (TRU) inventories in pressure tubes. In this Section you acknowledge the errors in OPG's calculations of transuranic isotopes, especially Cm-244, where you state:

> *Cm-244 was not identified in PT in the 2010 Reference Inventory [3]. As you note, and consistent with samples we have also since tested, Cm-244 is the dominant PT transuranic radionuclide in terms of activity at reactor shutdown. Hence, we agree that the 2010 reference radionuclide inventories in PTs are low for radionuclides expected to be present primarily in surface layers. The 2010 estimate was based on feeder pipe data, and actual PT data indicates the values should be higher. PT data also indicates that Cm-244 is present at high activity on the surface at shutdown.*

However, in Section 3 of your letter you comment on the implications of this under-estimation to the DGR safety case, and note that, because Cm-244 has a half-life of 18 years, "*within about 180 years it will have largely decayed to Pu-240, and this does not significantly increase the projected total Pu-240 within the DGR*".

These comments, downplaying the significance of Cm-244 in refurbishment waste, are surely inappropriate given the serious consequences of ignoring alpha contamination of retube waste; a situation that occurred during the refurbishments of Units 1 & 2 at Bruce. See: *Independent Review of the Exposure of Workers to Alpha Radiation at Bruce A Restart, Reactor Unit 1 Bruce Power,* Ontario. FINAL REPORT by the Radiation Safety Institute of Canada Toronto, Ontario, Canada July 14, 2011.

Most unfortunately this is not the only time CANDU "industry experts" have demonstrated an inability to assess radionuclide inventories and the potential radiation hazards associated with refurbishment waste. Consider, for example, the 2010 Kinectrics study of the potential release of C-14 from pressure tube waste as described below.

In 2009 Kinectrics was contracted by Bruce Power to determine the Maximum Probable Emission Rate (MPER) of C-14 from its retube operations to decide if C-14 emission monitoring should be implemented at the CRB stack. The results of this study were issued in the 2010 MPER Report B-REP-03480-00005 which recommended that C-14 emissions via the CRB stack should indeed be monitored. The basis for this recommendation was the perceived consequence of a breach of a pressure tube radioactive waste container or RWC-PT in the CRB with the postulated release of a significant fraction of the C-14 in the container. The 2010 MPER Report prepared by Kinectrics quantifies this C-14 release by first assuming the total β/γ activity in a pressure tube waste container is 71400 Ci and then arguing as follows:

> "*A smear of an end-fitting from Bruce Unit 2 detected carbon-14 as 0.3% of the total activity on the smear. Assuming 0.3% of the activity in a RWC-PT is carbon-14, the total carbon-14 activity in an RWC-PT is 210 Ci.*"

The 2010 MPER Report further assumed that the fraction of material in a pressure tube waste container that would be impacted by a drop accident is 0.1; hence the C-14 escaping from a breached RWC-PT, and potentially passing through the CRB stack, was calculated to be (0.1 × 210 Ci) or 21 Ci. The technical basis for the use of a 10% damage ratio is described in the OPG *Deep Geologic Repository Preclosure Safety Assessment (VI) Report*, NWMO Report No. DGR-TR-2009-09 issued in August 2009. However, the scenario described in this 2009 OPG Report actually pertains to a low energy impact of a 3 m^3 moderator IX resin container which has little relevance to a RWC-PT container.

The release of C-14 from a refurbishment waste container drop was actually first considered in the 2005 environmental assessment of the Bruce A refurbishment project - See Bruce Power Report: "*Bruce A Refurbishment for Life Extension and Continued Operations Project Environmental Assessment: Environmental Assessment Study Report Volume 2: Appendices*", issued in December 2005. This type of C-14 release was also discussed as part of the environmental assessment for the proposed refurbishment of Pickering B – See OPG Report: "*Credible Malfunction and Accident Scenarios Technical Support Document: Refurbishment and Continued Operation of Pickering B Nuclear Generating Station Environmental Assessment*". OPG Report No. NK30-REP-07701-00014, December 2007. Therefore I ask if OPG stands by this estimate of C-14 releases in the event that a RWC-PT is breached.

PUBLIC INTEREST IN DISCLOSURE:

In a July 2000 ruling it was noted by the Ontario Privacy Commissioner that there is a compelling public interest in disclosure of nuclear safety-related information:

In my view, there is a need for all members of the public to know that any safety issues related to the use of nuclear energy which may exist are being properly addressed by [OPG] and others involved in the nuclear industry. This is in no way to suggest that the institution is not properly carrying out its mandate in this area. In this appeal disclosure of the information could have the effect of providing assurances to the public that the institution and others are aware of safety related issues and that action is being taken. In the case of nuclear energy, perhaps unlike any other area, the potential consequences of inaction are enormous. I believe that [OPG], with the assistance and participation of others, has been entrusted with the task of protecting the safety of all members of the public. Accordingly, certain information, almost by its very nature, should generally be publicly available. In view of the above, it is my opinion that there is a compelling public interest in the disclosure of nuclear safety related information.

As a final question, I ask if OPG and NWMO agree with this view of the need for full public disclosure of nuclear safety related information, especially as it applies to the proposed DGR.

I look forward to hearing your answers to these questions, and seeing OPG's plan for an "extent of condition" assessment of its EIS non-conformance with regard to pressure tube inventories.

Sincerely, Frank Greening