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Oral presentation

Written submission from Simon J Daigle

Exposé oral

Mémoire de Simon J Daigle

In the Matter of the

À l'égard d'

Ontario Power Generation Inc.

Ontario Power Generation Inc.

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

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

Commission Public Hearing

Audience publique de la Commission

January 2024

Janvier 2024

Canada

Dear CNSC,

Please accept my response to the proposed development of OPGs BWRX-300 reactors at the Darlington CANDU reactors site and the items below are all real public concerns and must all be addressed independently and individually, as per the following categories:

CNSC licensing of the BWRX-300 reactors & Multiple Reactors nearby a NPP is inadequate [References: 1, 2, 4, 5]

- BWRX-300 stands for Boiling Water Reactor eXperimental 300 and developed by GE Hitachi Nuclear Energy (GEH) and will not aim to address any key challenges faced by traditional nuclear power plants. In fact, they will be costly, and generate extremely toxic nuclear wastes more than what would be expected by traditional NPP plants. **[Ref. 4].**
- This experimental compact design will not reduce construction costs, will not simplify operation nearby one NPP, or will ever enhanced safety measures. In fact, it will do the exact opposite as per IAEA **[Ref. 1 and 5].**
- It is questionable to say the least that by utilizing natural circulation and passive safety systems you will eliminate the need for external pumps and active cooling mechanisms because during a meltdown, fire or catastrophic event (lightening, flooding, extreme air temperatures over decades because of climate change), who will shut it off? A worker? I'm more reassured when a Pilot on commercial flight is present when he or she is using the auto-pilot function **[Ref. 1].**
- CNSC license to built an experimental reactor based on the CNSC's decision that OPG has met the recommendations of the 2011 Environmental Assessment Report by the JRP is not objectively verifiable or can be validated based on the 2023 Update report **[Ref. 2].**
- No objective evidence is available to validate what specific recommendations of the JRP have been adopted, analysed and/or implemented by OPG or CNSC. **[Ref. 2].**
- No BWRX-300 reactors are operating anywhere in the world and is a real public concern for the citizens living nearby as well as the potential impacts of a catastrophic environmental event that could be transboundary across many municipalities.

Engineering Design Risks: Experimental, Natural water cooling & neutron leakage [4,5].

- Water cannot be used to cool a reactor as it is experimental design reactor that will use use low pressure water to remove heat from the core. A distinct feature of this reactor design is that water is circulated within the core by natural circulation and yet no data is measured or validated by any laboratory confirmed analysis or modelling study.
- Neutron leakage will be problematic for any SMR design as well as for the BRMX-300 reactor as no proof of any safe SMR reactor system can be validated or compared too to this very day.
- This is no experimental data to elude or conclude that this experimental reactor will work in terms of an internal cooling system of the core.
- BWRX-300 is by all means not small as it covers a full football field.
- No BWRX-300 reactors are operating anywhere in the world.

- The proposed design and operation of a BWRX-300 is entirely different from the CANDU design and involves a structure and a method of operating which is, in large part, below ground level.
- No data on any potential meltdown of the core of any modular nuclear including BWRX-300 including catastrophic events cascading located nearby a Nuclear Power Plant.
- Neutron leakage is a huge problem with SMRs and will be as well with the BWRX-300.
- **SMR Neutronics and Design: [Ref. 4].**
    - "A nuclear reactor is designed to sustain criticality, a chain reaction of fission events that generates energy (~200 MeV per fission event) and extra neutrons that can cause fission in nearby fissile nuclides.
    - The neutron "economy" of a reactor depends on the efficiency of the chain reaction process; the fate of neutrons absorbed by abundant nuclides, such as 238U or 232Th; the fission of newly generated fissile nuclides, such as 239Pu and 233U; and the loss of neutrons across the fuel boundary.
    - These "lost" neutrons can activate structural materials that surround the fuel assemblies. Each of these physical processes generates radioactive waste.
    - Thus, the final composition of the SNF and associated wastes depend on the initial composition of the fuel, the physical design of the fuel, burnup, and the types of structural materials of the reactor.
    - The probability of neutron leakage is a function of the reactor dimensions and the neutron diffusion length, the latter of which is determined by the neutron scattering properties of the fuel, coolant, moderator, and structural materials in the reactor core.
    - The neutron diffusion length will be the same in reactors that use similar fuel cycles and fuel–coolant–moderator combinations**; thus, the neutron leakage probability will be larger for an SMR than for a larger reactor of a similar type."**

Public Consultation, indigenous peoples and social acceptability: [Ref. 2].

- No objective evidence has been elucidated or clearly documented with transparency.

EIA Impact statement: page 84 of [Ref. 2].

- EIA impact statement, nor final PPE parameters, did not follow IAEA Multi-Unit Probabilistic Safety Assessment required for 1 or 4 experimental reactors nearby a Nuclear Power Plant despite the fact that EIA significance analysis had assessed all the residual adverse effects **[Ref. 1, 5].** Please refer to the list of EIA and PPE selected quotes below as the reference to compare with the IAEA Multi-Unit Probabilistic Safety Assessment that is lacking **[Ref. 1, 5].**

- **EIA and PPE selected quotes:**
  "EIS significance analysis had assessed all the residual adverse effects to be "Not Significant". Of the likely residual adverse effects that were forwarded for assessment of significance in the EIS:
  • Seven (7) were also determined to result in minor residual adverse effects from the BWRX-300 but less than that described in the EIS,

• Four (4) were not applicable to the BWRX-300 reactor,
• Five (5) were determined to have residual adverse effects not significant after completion of additional studies to assess the likely effects to retained terrestrial features not considered in the EIS.

- **The PPE Of the 198 PPE parameters, 60 PPE parameters were not applicable to the BWRX-300**. Of the 138 applicable PPE parameters evaluated, eight (8) BWRX-300 parameters are currently not within their respective PPE parameters. These are largely due to characteristics inherent to the design of the GEH reactor technology. These eight parameters are related to the following topics:
    - The rate of fire protection water withdrawal and the quantity of water in storage,
    - Deeper foundations (38 m below grade) than the reactors previously assessed in the EIS (13.5 m),
    - Airborne releases of radioactive contaminants and normal operation minimum release height above finished grade,
    - The different proportions of radionuclides in solid wastes generated by the operation of the BWRX-300,
    - The weight of the cask used to transport the BWRX-300 spent fuel on site, and
    - The multiplication factors applied to basic wind speed to develop the plant design.

- A full environmental impact assessment is required to fulfill provincial and federal jurisdiction best practices for air, water and soil & biosphere impacts during a catastrophic event or meltdown of this experimental reactor as well as maritime and lake biosphere impacts.

Nuclear accidents, incidents, multiple explosion risks or 1 or 4 BMRX-300 reactors nearby a NPP, Soil Stability, hydrogeology, lithospheric & seismic Risks: [Ref. 1,2, 5].

- No objective risk assessment has been completed by OPG or CNSC as per the required IAEA Multi-Unit Probabilistic Safety Assessment required for 1 or 4 experimental reactors nearby a Nuclear Power Plant. **[Ref. 1,5].**
- The appropriateness of building 1 or 4 untested reactors next to the 4 existing CANDUs at Darlington as well as the current and potential stored nuclear waste is questionable given the fact that the probabilistic safety assessment was not completed according to the IAEA methodology **[Ref. 1].**
- JRP recommendations concerning the physical conditions of the Darlington site need to be applied with transparency by OPG and the CNSC. **[Ref. 2].**

Other public and safety concerns: these issues need to be addressed

- Climate change impacts have not been included in the EIS report.
- Unknown: reliability data to reduce the risk of potential accidents.
- Unknown: demonstrating that the BMRX-300 is a clean and reliable source of electricity, capable of generating vast amounts of energy without producing greenhouse gas emissions as it is only an experimental design.

- Concerns surrounding safety, waste disposal, and cost have hindered its widespread adoption globally. A handful of countries have adopted this design but no data on the true financial costs to governments or to that taxpayer. **[Ref. 4].**
- Unknown: BWRX-300 did not address safety concerns, efficiency, efficacy as a cost-effective alternative compared to renewables such as hydro, solar or wind energy generation.
- Unknown: sustainability and reliability compared to wind and solar energies to meet the growing demand for electricity.
- BWRX-300 represents a significant step backwards in power technology. It is not compact, it does not meet nuclear wastes (as per the IAEA ALARA principle) that will last for thousands of years, and most certainly, it is not cost effective over time to store and monitor SMR or BWRX-300 nuclear wastes based on the probability of any heat instability of the nuclear core over time and the generation of highly toxic nuclear waste. **You cannot turn off radioactivity like an electrical light bulb as there are no fuse switch off for ionizing radiation.**

Cordially,

Simon J Daigle, B.Sc., M.Sc., M.Sc(A)
Concerned Canadian Citizen,
Industrial / Occupational Hygienist
Air quality expert (Tropospheric O3 (Ozone) / Stratospheric Heavy Ozone (O18/O17/O16))
Climatologist (Micrometeorology, Snow impaction, O18/O16 isotopes)
Epidemiologist (Communicable and non-communicable diseases, Social epidemiology)
Earth Scientist (Geophysics, Isotope geochemistry, Paleoclimatology, Geothermal energy).
PhD interests: UFP Ultrafine particles < 0.1 microns (stratospheric long range transport).

References:

[1] Safety Reports Series 110. Multi-Unit Probabilistic Safety Assessment.
IAEA, Austria. September 2023. STI/PUB/1974
Link: https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1974_web.pdf

Selected quotes:
VI–1.4.MU risk consideration for non-LWRs or advanced reactors with more than one module
More recently, the NRC issued Revision 3 to Chapter 19 of NUREG-0800 [VI–19] to include considerations for multimodule risk.

This update states: **"For small, modular integral pressurized water reactor designs, the staff reviews the results and description of the applicant's risk assessment for a single reactor module; and, if the applicant is seeking approval of an application for a plant containing multiple modules, the staff reviews the applicant's assessment of risk from accidents that could affect multiple modules to ensure appropriate treatment of important insights related to multi-module design and operation.** The staff will verify that the applicant has: i. Used a systematic process to identify accident sequences, including significant human errors, that could lead to multiple module core damages or large releases and described them in the application ii Selected alternative features, operational strategies, and design options to prevent these sequences from occurring and demonstrated that these accident sequences are not significant contributors to risk. Operational strategies should also provide reasonable assurance that there is sufficient ability to mitigate multiple core damages accidents."

This guidance states: **"If applicable, the PRA should include event sequences involving two or more reactor modules as well as two or more sources of radioactive material. This enables the identification and evaluation of risk management strategies for reactor modules and sources within the scope of a single application to ensure that sequences involving multiple reactor modules and sources are not risk significant."**

[2] EIS Review - June 2023 OPG. DARLINGTON NEW NUCLEAR PROJECT ENVIRONMENTAL IMPACT STATEMENT REVIEW REPORT FOR SMALL MODULAR REACTOR BWRX-300 NK054-REP-07730-00055-R001 June 28, 2023 OPG Proprietary.
Link: https://www.opg.com/documents/dnnp-environmental-impact-statement-review-report-for-small-modular-reactor-bwrx-300-pdf/

[3] World Nuclear News. BWRX-300 completes Phases 1 & 2 of Canadian pre-licensing review. 15 March 2023.
The Canadian Nuclear Safety Commission (CNSC) has completed a combined Phases 1 and 2 vendor design review (VDR) of GE Hitachi Nuclear Energy's BWRX-300 small modular reactor. The regulator said that no fundamental barriers to licensing were identified during the review.
Link: https://world-nuclear-news.org/Articles/BWRX-300-completes-Phases-1-2-of-Canadian-pre-lice

[4] SMR Nuclear Waste. Nuclear waste from small modular reactors (2022).
Lindsay M. Krall ,Allison M. Macfarlane, and Rodney C. Ewing
Edited by Eric J. Schelter, University of Pennsylvania, Philadelphia, PA; received June 26, 2021; accepted March 17, 2022 by Editorial Board Member Peter J. Rossky

Selected quotes:

"Results reveal that water-, molten salt–, and sodium-cooled SMR designs will increase the volume of nuclear waste in need of management and disposal by factors of 2 to 30."
"The excess waste volume is attributed to the use of neutron reflectors and/or of chemically reactive fuels and coolants in SMR designs."
"That said, volume is not the most important evaluation metric; rather, geologic repository performance is driven by the decay heat power and the (radio-)chemistry of spent nuclear fuel, for which SMRs provide no benefit."
"SMRs will not reduce the generation of geochemically mobile 129I, 99Tc, and 79Se fission products, which are important dose contributors for most repository designs."
"In addition, SMR spent fuel will contain relatively high concentrations of fissile nuclides, which will demand novel approaches to evaluating criticality during storage and disposal."
"Since waste stream properties are influenced by neutron leakage, a basic physical process that is enhanced in small reactor cores, SMRs will exacerbate the challenges of nuclear waste management and disposal."
Link: https://www.pnas.org/doi/10.1073/pnas.2111833119

[5] Multi-unit nuclear power plant probabilistic risk assessment: A comprehensive survey. Reliability Engineering & System Safety. Volume 213, September 2021, 107782

Abstract

A growing concern regarding probabilistic risk assessments (PRA) is the impact of dependencies among reactor units co-located at a nuclear power site, especially after the March 2011 Fukushima Daiichi accident. To address these dependencies and identify the critical contributors to the entire site risk, multi-unit probabilistic risk assessment (MUPRA) has been actively developed by various research and regulatory agencies. However, possible inter-unit dependencies in MUPRA have led to some technical issues and challenges associated with the development and modeling of initiating events, accident sequences, end states, and risk metrics relevant to multi-unit sites. This paper provides a comprehensive survey and assessment of the state of current knowledge in MUPRA. The critical recent literature is synthesized and discussed, focusing on three facets: multi-unit event characterization, MUPRA methodological development, and site-based risk metrics and risk aggregation. This survey aims to identify the key issues addressed and challenges faced by the research and development activities of MUPRA, and identifies gaps and opportunities for future research and developments.

Introduction

Probabilistic risk assessment (PRA), also referred to as probabilistic safety assessment (PSA), is a systematic methodology used by the nuclear power industry to evaluate risks and offer insights into the safety of the design and operation of a nuclear power plant (NPP) [1]. PRAs help to estimate plant risk and identify contributors to the risk by addressing three questions: what can go wrong, how likely it is, and what are its consequences [2]. The risk is numerically expressed by the sum of the products of the accident scenario consequences and their frequencies [3]. Three levels of PRAs, namely, Level-1 PRA, Level-2 PRA, and Level-3 PRA, have been established to determine the risks regarding the damages to the nuclear reactor core, the released radioactivity of the nuclear power plant, and the resulting human health and environmental damages, respectively [4].

Conventional PRA studies have traditionally been restricted to single reactor units and are referred to as single-unit PRAs (SUPRAs) [5]. The SUPRAs include accident scenarios exclusive to one reactor unit, assuming the effects of other units are not critical. Hence, SUPRAs only consider the dependencies between the structures, systems, and components (SSCs) within a single reactor unit [6]. These dependencies, referred to as intra-unit dependencies, are likely to induce multiple failure events that may overcome redundancies or diversities and ultimately lead to a class of SSC failures called dependent failures. Although these dependent events are usually much less frequent than the independent events, they have proven to be the most critical contributors to the likelihood of reactor core damage, environmental radioactive exposure, and overall plant risk. Typically, the influence of these dependencies is explicitly modeled in the PRA event tree and fault tree logics or implicitly treated as the type of dependencies commonly referred to as common cause failure (CCF) events [7].

Since the Fukushima Daiichi accident in March 2011, the dependencies across reactor units in a plant site, referred to as inter-unit dependencies, have attracted growing attention in the nuclear industry, academia and regulatory agencies. These inter-unit dependencies can play critical roles in nuclear accident risks with the possibility of multiple core damages, including damages to the spent fuel pool and other radioactive waste storage facilities. Proper characterization of these site-level dependencies is thus critical to obtain an accurate risk profile of a nuclear power plant site. Examples of these inter-unit dependencies include certain initiating events simultaneously occurring in multiple units, a transient event in one unit affecting some or all of the other units, the proximity of the units to each other, shared structures, components (e.g., shared batteries and diesel generators), common operation practices, and substantial procedural and other organizational similarities.

According to the Power Reactor Information System of the International Atomic Energy Agency (IAEA), as of April 2020 [8], there are 183 nuclear power plant sites worldwide with 442 nuclear reactors under operation. As shown in Fig. 1, 73.2% of these nuclear power plant sites house two or more nuclear reactor units. Accordingly, 88.9% of the operating reactors are located on multi-unit sites. The two-unit sites account for 43.7%, and 23.0% of sites are constructed with three or four reactor units. Table 1 lists the sites with more than four reactor units, accounting for 6.6% of the total operating sites. Note that some NPP sites are located within a few kilometers of each other. Therefore, more than one NPP site could be co-located in the same regional, in which site-to-site dependencies could also exist. For instance, the Fangjiashan NPP site (i.e., two-unit) is a neighbor and essentially an extension of the Qinshan NPP site (a seven-unit site), which results in nine units in the region of Jiaxing, China. Ling Ao NPP site (a four-unit site) is adjacent to the Daya Bay NPP site (a two-unit site), which results in six units in Shenzhen, China. Moreover, the proportion of multi-unit sites is expected to increase, since additional reactor units are under construction, and construction of new reactor units on the existing site is preferred by stakeholders due to economic considerations [9]. **Several countries, especially China, Canada, South Korea and Japan, may face significant multi-unit risks.**

The significance of the inter-unit dependencies demonstrated by the Fukushima Daiichi accident [10], has prompted the PRA community to re-examine the current safety regulations, which were designed in the context of a single reactor unit [11]. The findings recognize the urgent need for a methodology that integrates multiple radiological sources to assess the risk profile of multi-unit sites and identify the critical contributors to the entire site risk. This methodology is referred to as multi-unit PRA (MUPRA) in this paper. Therefore, the main differentiating factor between MUPRA and SUPRA is the consideration of critical inter-unit dependencies, including all radiological sources on a plant site. Indeed, the authors recognize the name of this methodology varies depending on the scope of analysis, as summarized below:

- Multi-unit PRA, which considers the dependencies across reactor units co-located at the same site.
- Site-level PRA, which considers the dependencies across all radiological sources (i.e., reactor unit, spent fuel pool, and other radioactive waste storage facilities) co-located at the same site.
- Regional-level PRA, which considers the dependencies across all radiological sources (i.e., reactor unit, spent fuel pool, and other radioactive waste storage facilities) at all the plant sites in the same region.

The potential inter-unit dependencies in MUPRA have led to some technical issues and challenges associated with the development and modeling of initiating events, accident sequences, end states, and risk metrics relevant to multi-unit sites. Recently, possible solutions have been developed by international organizations, experts and research groups, particularly from the U.S., South Korea, Canada, Japan, France, India, and China. These include different facets relevant to multi-unit sites, i.e., hazards, methodological challenges, site risk metrics, safety goals, and associated quantitative health objectives. To help identify the key issues facing research and development in MUPRA, there is a need for a systematic and comprehensive survey to collect and examine the state of current knowledge in the field of MUPRA. While there have been some review articles about MUPRA [[12], [13], [14], [15]], the relevant literature has not been comprehensive, and the most recent research has not been synthesized effectively.

Link: https://www.sciencedirect.com/science/article/abs/pii/S0951832021003070