INTERNATIONAL INSTITUTE OF CONCERN FOR PUBLIC HEALTH (IICPH)

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Panel Secretariat
Darlington New Nuclear Power Plant Project Joint Review Panel
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Re: Final Comments to the Joint Review Panel (JRP) on the proposed Darlington New Nuclear Power Plant Project by Ontario Power Generation (OPG)

Dear Mr. Graham;

The International Institute of Concern for Public Health (IICPH) intervened in the recently held JRP Hearing under the Canadian Environmental Assessment Act (CEAA) in regard to the Darlington New Nuclear Power Plant Project (NNPP). This submission addresses a number of issues raised at the Hearing and provides a summary of the position of IICPH on these issues, the rationale for IICPH's position, and recommendations for consideration.

Part 1 – Introductory Remarks

This submission will present the case that the proposal by Ontario Power Generation (OPG) is seriously flawed in many respects and riddled with uncertainties and insufficient information. It has not given due consideration to the precautionary principle or sustainable development, as required under CEAA. It has not addressed the full range of cumulative environmental impacts or detrimental effects on human health and the environment. It does not adequately address the need for additional nuclear power stations, nor does it consider alternatives to new nuclear facilities, such as sustainable clean energy options and conservation. It has not assessed the full cost of the project (from cradle to grave).

It is our view that this project, if allowed to be carried out, will do great and totally unnecessary harm to the environment, health, and economic well-being of millions of people, now and in the future. On the basis of the record before the JRP, IICPH's position is that the JRP recommend that the Darlington NNPP Project be rejected.

The Hearing for this Project came on the heels of the earthquake and tsunami in Japan that have resulted in a nuclear disaster at the Fukushima Daiichi Nuclear Power Station that is now considered to be of the same scale as Chernobyl.

It is not yet known what the extent or severity of the ultimate effects of radiation exposure will be on the population near the Fukushima Daiichi nuclear power station, on people outside of Japan, or on future generations. We do know that many essential food items (milk and produce), including seafood, are contaminated with radioactive substances, that the radioactive plume has been detected well beyond Japan, extending to areas in North America, and that a pool of molten fuel has been discovered at the bottom of the containment vessel of one of the reactors.

Within 25 years, there have now been 2 major accidents from nuclear power plants involving breach of containment. The tragedy at Chernobyl, and now at Fukushima, must never be repeated. The risks from nuclear power are simply not acceptable. Even one nuclear accident is one too many.

Over the course of the hearings, OPG has stated that reactors (including CANDUs) are "even safer" than previous designs. The "earthquake" factor has been brought into the Hearing, to try to reassure people that what happened in Japan could not happen here in Ontario.

But nuclear reactors are not infallible, there is no way to predict what may trigger a major nuclear accident, and there is no guarantee of absolute safety. Any technology with such precise and complicated requirements as a nuclear reactor is most likely to run into serious problems that could not be foreseen.

After the nuclear disaster in Japan, a number of countries are re-thinking nuclear energy. Yet the province of Ontario, through OPG, insists on pursuing this most dangerous means of producing steam to generate electricity that will burden future generations with lethal radioactive waste that lasts essentially forever.

Part 2 – Sustainable Development and the Precautionary Principle

According to the Guiding Principles of the Environmental Impact Statement (EIS) Section 2**,**

> *"Environmental assessment is a planning tool used to ensure that projects are considered in a careful and precautionary manner in order to avoid or mitigate the possible adverse effects of development on the environment and to encourage decision-makers to take actions that promote sustainable development and thereby achieve or maintain a healthy environment and a healthy economy."*

With respect to promoting sustainable development, under CEAA, sustainable development is defined as follows: [EIS Guidelines (Section 2.4)]

"Sustainable development seeks to meet the needs of present generations without compromising the ability of future generations to meet their own needs."

OPG claims that it "considered issues of sustainable development". Little or no evidence has been presented by OPG to substantiate this claim.

No consideration is given to the effect on future human generations and the ecosystem, and the enormous burden that would be placed on them by this project. No economic costs for the Project over its entire life cycle have been provided, most of which will be passed on to the next generation. No evidence is provided to indicate that the nuclear option is the best or only option to meet the energy demands or needs of Ontarians at present or in the future. In fact, it locks Ontario into nuclear reliance, without proper informed consent.

In its EIS, OPG concludes that the project "*will not result in any significant environmental effects. Most importantly, no significant adverse effects on the health and safety of workers, members of the public or non-human biota are anticipated.*" [EIS p.6]

It is inconceivable that such a conclusion could be drawn. Given the magnitude of this Project, and long-term issues such as nuclear waste, decommissioning and abandonment, adverse environmental effects and harm to human life and health are inevitable.

Regarding the application of the precautionary principle, under the EIS (Section 2.5),

> *"The proponent must demonstrate that all aspects of the project have been examined and planned in a careful and precautionary manner in order to ensure that they do not cause serious or irreversible damage to the environment and/or the health of current or future human generations; and*
>
> *provide that contingency plans explicitly address worst-case scenarios and include risk assessments and evaluations of the degree of uncertainty."*

IICPH contends that the proponent has not fulfilled any of these requirements.

Part 2 – Comments on Specific Issues

1. Proposed Reactor Designs

The proponent is considering a range of designs to deliver up to 4800 MW of power to the grid. As yet, no decision has been made on a specific reactor type. OPG anticipates that these reactors would have approximately a 60-year operating life, possibly including mid-life refurbishment. [1]

Three proposed Generation III+ reactors require enriched fuel. They are enhancements of existing reactors, and are not yet in operation. A fourth reactor, the EC-6, is an enhancement of the current CANDU-6 reactors, and does not use enriched fuel.

The failure to specify the specific reactor design and the number of reactors (two, three or four), leads to a high degree of uncertainty with respect to the preparation of the site, the type of fuel, and the ancillary costs of the project. In fact, at the Hearing, the JRP commented on the confusion between Ontario's Green Energy Plan (calling for two reactors) and the Darlington NNPP (calling for three or four reactors).

Without knowing the number of reactors and the reactor type, it is virtually impossible to assess this proposal properly or ensure that the project has been prepared in a precautionary manner.

Enriched uranium

Any operation that handles enriched uranium must ensure that the conditions for a sustained nuclear reaction (criticality) are not created. However, IICPH remarked that according to the EIS, **a Canadian set of criticality safety standards does not exist**. [EIS 7.3.3.2 p. 7-66]

[1] The "project for EA Purposes" is defined within a bounding framework, the Plant Parameter Envelope (PPE), which brackets the range of variables to be assessed for the different design options [ES-3].

The Canadian Nuclear Safety Commission (CNSC) pointed out that a criticality standard was established by CNSC in December 2010, after publication of the EIS. CNSC also stated that while no nuclear power plants use enriched fuel in Canada, there is experience regarding the handling of enriched fuel because the NRU reactor at the Chalk River site is fuelled with low enriched fuel. (Transcript, p. 207 March 31)

According to the regulatory requirements, the proponent must demonstrate that criticality cannot occur or "demonstrate that they can build a facility that should criticality occur, that it can withstand the event".

Clearly, the proponent has not demonstrated either of these things. A criticality accident would be very serious. The lack of such vital information shows the complete absence of precaution.

Furthermore, any information on criticality safety standards should have been brought to the attention of the Hearing. Without this information, it was not possible for us to comment on whether critically standards in Canada are appropriate or adequate for the reactor designs proposed.

Operational Lifespan

The average age at which existing reactors have shut down is about 25 years. The projected lifetime for the proposed reactors is estimated to be about 60 years, based on models.

For models to be valid as predictors of performance and safety, they must be complete, accurate, and tested against actual performance. As none of the proposed reactors is in service, models of them cannot be tested against their performance. Furthermore, no reactor to date has operated for the projected lifetime of 60 years. Based on past experience, it is doubtful whether this projection is realistic.

Refurbishment

There has been no discussion or information provided regarding refurbishment of the reactors to extend their lifespan. To date, refurbishment has been costly, and extended well beyond projected time periods. The experience at Point Lepreau, for example, demonstrates exorbitant cost overruns and lengthy delays in refurbishment.

2. Site Preparation and Construction Phase

With respect to OPG's application for a Licence to Prepare a Site under the Nuclear Safety Control Act (NSCA), IICPH's position is that the Licence should not be issued to the proponent for the following reasons;

Excessive Emissions – Health Effects

This phase is projected to extend for about fifteen years, from 2010 to 2025. Over this period, the work involved in clearing, excavation, crushing and removal of existing soil and rock, lake infilling and bottom dredging and construction would result in excessive emissions of pollutants, many of which are toxic under the *Canadian Environmental Protection Act* (CEPA 1999).

The health, both mental and physical, of workers and residents nearby may be seriously compromised during these operations and long after, because of excessive levels of air pollutants. The impact on vulnerable populations (children, pregnant women, the elderly) and people whose health is already compromised (e.g., asthmatics) has not been addressed.

Other activities – cumulative effects

Major structural projects and industrial operations occurring during the same period (St. Mary's cement, directly adjacent to the site, road and highway construction, the Durham incinerator, etc.), combined with the construction activities at the Darlington site, would have a cumulative impact that would harm air quality, groundwater, surface water, and terrestrial and aquatic habitats. Restoration and mitigation may never be able to repair the harm done by this massive disturbance to the site.

The stability of the four existing reactors and the ancillary facilities may be affected by all the excavation, infilling, and construction activities. There has been no discussion on the potential impacts to existing facilities of all this construction activity. A number of intervenors residing in the area have noted that operations at the St. Mary's Cement quarry alone, adjacent to the Darlington Nuclear Station, have made their houses vibrate.

The impact of the site preparation and construction phase, in combination with other major activities occurring at the same time, has not been properly investigated.

Suitability of the Site for the Expansion of Nuclear Facilities

The already existing sizeable population and the rapid growth in population forecasted over the next decades, that will result in close to 1,000,000 people living adjacent to and in close proximity to the Darlington location, make the site inherently unsuitable for the NNPP Project.

Granting a licence for a location at which there are already existing reactors, and used nuclear fuel storage in close proximity, is totally inappropriate and further compromises the health and environment of the affected communities. The catastrophe at Japan's Fukushima Daiichi plant has all too clearly demonstrated that the proximity of multiple reactors in one location leads to much higher potential for disaster in the event of unexpected calamity.

The various risks and unacceptable consequences of accidents and malfunctions over the entire lifecycle of the NNPP Project have not been considered.

- Inadequate consideration has been given to the impacts of routine or accidental emissions of radionuclides from the Darlington site into nearby and downstream sources of drinking water.
- The effectiveness of emergency planning and/or mass evacuation measures in the event of a catastrophic nuclear incident at the Darlington site has not been demonstrated.

  A review of evacuation planning was conducted for only a 10 km zone around the plant. Evacuation of even a 20 or 30 kilometre zone around the Darlington site would be extremely difficult if not impossible, with a very large population (about 1, 000,000 projected by 2030) potentially impacted. OPG has not demonstrated that emergency planning measures for very serious accidents that might require evacuation ranges of 20 to 80 km are in place, or could be carried out well enough to give adequate protection to the population.

3. Nuclear Waste

Spent fuel, (High Level Radioactive Waste) consists of over 200 deadly radioactive elements, such as plutonium, cesium, krypton, strontium, radon, and iodine, and many other highly toxic substances, including lead and arsenic. Many of these radioactive substances have extremely long half-lives, guaranteeing their presence and that of their dangerous progeny for millions of years. This waste must be kept completely isolated from the environment for very long periods of time, essentially forever.

The storage of spent fuel waste cannot be assumed to be reliable beyond a few hundred years. No material has yet been discovered that is impervious to all chemical and radiological assaults for a million years.

As of June 30, 2010, approximately 2.1 million bundles of spent fuel (containing 44,000 tonnes of heavy metal (t-HM)) from Canada's nuclear power reactors were in storage at the reactor sites. If no new reactors are built, depending on whether some reactors are to be refurbished, the total number of used fuel bundles produced to end of life is projected to range from 2.8 million bundles (no refurbishment) to around 5.1 million (56,000 t-HM to 102,000 t-HM), assuming refurbishment extends operating life for 30 years. [2]

The Nuclear Waste Management Organization (NWMO) is conducting a search for a host site for a deep geological repository (DGR) to store the spent fuel from existing reactors. This is an unresolved issue. Moreover, the additional spent fuel from new reactors has not been factored into the amounts that would need to be stored.

According to the proponent, the responsibility for used nuclear fuel is subject to a separate federal approvals process, and does not have to be addressed in the EIS.

We argue otherwise. It is irresponsible and inappropriate for the proponent not to address what is arguably the most contentious issue faced by the nuclear industry.

The JRP is mandated to carry out an environmental assessment of the complete life cycle of the project. Therefore, the Panel must require that the management of used nuclear fuel, for as long as it remains hazardous, be included in the assessment. Otherwise, the validity of the assessment process will be fatally flawed.

Activation Products

Apart from the radioactive fission products from the reactor fuel, radioactive activation of elements occurs wherever neutrons impact other nearby material. This contaminates the surrounding air, water, pipes and containment buildings. Over time, this makes a nuclear facility unstable, and all of it becomes radioactive waste.

[2] Nuclear Fuel Waste projections in Canada –2010 Update Nuclear Waste Management Organization NWMO TR-2010-17 December 2010 http://www.nwmo.ca/uploads_managed/MediaFiles/1678_nwmotr-2010-17_nuclearfuelwast.pdf

There has been no consideration of activation products that would be produced at the Darlington site, and the effect this would have on the surrounding community for many generations.

Low Level and Intermediate Level Radioactive Waste: (L& ILRW)

As of 2008, the total amount of L&ILRW produced by nuclear power plants is approximately 90,000 m^3. If no further plants are built, the projected total for 2050 would be about 175,000 m^3. [3] The proposed new reactors would add a significant portion of L&ILRW to this inventory.

Insufficient information has been provided as to the management of L&ILRW waste. The proponent must provide this information. It also pertains to other important matters, such as the construction of facilities to store the waste, and the transportation of nuclear waste.

4. Accident Scenarios

Unforeseen events and consequences from technical malfunctions and human error have been and continue to be part and parcel of nuclear power. To date, within twenty-five years, there have been at least two accidents in which containment has been breached, Chernobyl and Fukushima. So the probability of a serious accident is at least one per generation, or one in 10,000 reactor years (RY).

This is a hundred times greater than the estimate of 1 per million RY, the threshold specified by the CNSC for a nuclear accident scenario to be credible for consideration in an environmental assessment. [EIS 7.3.2.4] This threshold has no scientific basis, and is certainly not supported by experience to date.

Even if these accidents are considered unlikely, the consequences are extremely severe. To choose to ignore this possibility is a serious compromise that society cannot afford.

Predictions based on probability are only reliable when applied to a large number of cases. The safety of a single nuclear reactor over a limited timespan can never be guaranteed. But over a million years, it is certain that nuclear waste will escape containment, if there is even the tiniest chance that it can do so. Much nuclear waste already has.

Seismology: As a consequence of the events at Fukushima, presentations were given at the Hearing on seismic hazards that the site is located in an area of low seismic activity. However, accident scenarios may occur as a result of many other unpredictable, unforeseen events. Even though redundancies are part of the safety designs for nuclear reactors, there is no guarantee of ultimate safety. That is impossible.

According to Section 2.6 of the Guidelines,

> *"the proponent must document how it used scientific, engineering, traditional and other knowledge to reach its conclusions. Assumptions must be clearly identified and justified. All data, models and studies must be documented such that the analyses are transparent and reproducible. All data collection methods must be specified….*

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[3] Inventory of Radioactive Waste in Canada 2009 p.35
http://www.llrwmo.org/en/pdf/Inventory%20Reports/English%20Inventory%20Report%202009.pdf

The EIS must identify all significant gaps in knowledge and understanding where they are relevant to key conclusions presented in the EIS. The steps to be taken by the proponent to address these gaps must also be identified."

We argue that the proponent has not identified all significant gaps in knowledge and understanding where they are relevant to key conclusions presented in the EIS. In fact, the proponent has minimized and denied risks of very serious accidents or malfunctions, or consequences to operations of serious acts of malfeasance, based on its probabilistic analysis, which has no mathematical or scientific validity, for reasons explained in the following section.

For example, the proponent maintains that "an inadvertent out-of-core criticality event is considered not credible". This statement is itself not credible, since such events have already happened. Out-of-core criticality can occur anywhere that enriched uranium fuel is present, including fuel fabricating plants, transportation vehicles, and on-site storage facilities. Furthermore, the proponent's own assessment of the consequences of such a "hypothetical event" claims to show that public evacuation would not be triggered, even though this has already happened in Japan. [EIS p. 7-66] This assessment also acknowledges "that workers in the immediate vicinity of such an event would be subject to substantial risk". [ES 17]

At nuclear power plants using enriched uranium fuel, the pools used to store the spent fuel currently employ high density racks, to maximize the amount of spent fuel that can be stored in each pool. This practice has been adopted because it is the cheapest mode of storage for spent fuel. This could well lead to an out-of-core criticality accident.[4]

Section 2.5, Precautionary Approach, Guidelines of the EIS, requires that the proponent

"provide that contingency plans explicitly address worst-case scenarios and include risk assessments and evaluations of the degree of uncertainty."

Ignoring the potential risks of a major accident is contrary to the precautionary principle, which requires a project to err on the side of caution, especially where there is a large degree of uncertainty, or the risk of very great harm.

5. Probability

The probabilistic models used by CNSC to determine the probability of an accident at a nuclear power plant are not mathematically or scientifically valid for a great many reasons. First of all, a mathematical model is only valid, and can only give reliable results, if it is both complete and accurate. This means that it must take into account everything that might affect the number it is calculating, and must represent every last one of these essential factors accurately enough to give an accurate final result. It is a well-known principle of mathematics (and computer science) that the final result of a computation is only as accurate as the <u>least</u> accurate number that went into it.

[4] Ibid p.35

It is completely impossible to foresee everything that could cause a serious nuclear accident, let alone take it into account in a mathematical model. There's no telling what human errors might occur, such as the one that caused the accident at Chernobyl. And the reactors at Fukushima were designed to withstand a major earthquake, because this possibility was foreseen; but the enormous tsunami that caused the disaster there was not foreseen as a possibility, so adequate provision was not made for it. Just one oversight like this is enough to make any model that calculates the probability of a nuclear accident completely worthless, and it is impossible to avoid all oversights of this kind.

Furthermore, it is impossible to determine accurately the probabilities of all the accident scenarios that <u>are</u> foreseen. Just as logic and experience are the sole basis for all genuine science, so logic and experience are the only basis for determining probabilities. There is no logical basis for determining the probability of any particular kind of human error, or a tsunami such as the one at Fukushima, or many other chance occurrences that might cause a serious nuclear accident. And we can never have long enough experience with nuclear accidents (without being destroyed by them first) to determine such probabilities on the basis of experience. So there is simply no way to determine them accurately at all.

Finally, even if we could accurately determine the probability of a serious nuclear accident at one of the proposed nuclear power plants, it would provide no guarantee of safety, no matter how small it was. Probabilistic predictions are only reliable when they are applied to a large number of cases. In a single case anything can happen at any time, even when it's highly improbable. For example life insurance companies, our most conservative financial institutions, make profits reliably year after year because they have a large enough number of customers that they can predict very accurately how many of them of each particular age will die in a given year, based on the number that died the year before. But if an insurance company risks too much money on the outcomes of individual events, it goes bankrupt. This is what happened to Lloyd's of London.

Given that anything can happen in a single instance, it is only sensible never to risk more than you can afford to lose. This is precisely what the Precautionary Principle requires. Since every nuclear power plant carries the risk of a nuclear accident that would cost us more than we can afford to lose, the Precautionary Principle, which must be followed under the Guidelines for this Environmental Assessment, requires that it not be built. Above all, this is essential to ensure the safety of all the people who would suffer unacceptable harm from such an accident. There is no way to guarantee that it could never occur, certainly not with any probabilistic calculations. Obviously it could.

But probabilistic considerations guarantee very reliably that we will not be able to keep our nuclear waste contained for the millions of years that will be necessary to protect ourselves from it. It is impossible to make their containment so perfect that there will never be any risk of leaks. Even if that risk is very small, if we keep taking it over and over again over millions of years, we will lose our gamble again and again, until a fatal amount escapes. This kind of probabilistic prediction is extremely reliable, because it is based on a very large number of trials, i.e. different situations at different times and different places where leaks might occur. This is the basis for the common-sense principle that if you keep on taking chances you're bound to lose, and the longer you keep on taking chances the more often you're going to lose. And when you're risking more than you can afford to lose, as we are in this case, it's not a matter of risk any more. It's an absolute guarantee of disaster, just as much as playing Russian Roulette every day. It's something we just can't get away with.

6. Cumulative Effects Assessment

Under CEAA (16(1))

> *"The proponent must identify and assess the cumulative adverse and beneficial environmental effects of the project in combination with other past, present or reasonably foreseeable projects and/or activities within the study areas.*
>
> *Projects that are conceptual in nature or limited as to available information may be insufficiently developed to contribute to this assessment in a meaningful manner."* (Section 13, Guidelines p.52, 53)

A cumulative effects approach assesses the full range of human-generated aggregate stresses, (i.e., additive, interactive, synergistic, multiple sources, spatial and temporal) on the ecosystem over time, from cradle to grave, that is the complete life cycle. It must include accidents etc., and address all aspects of the nuclear chain associated with human health and environmental impacts.

The role of the Panel in the review is:[5]

> *to carry out an environmental assessment of the complete life cycle of the project in accordance with the Canadian Environmental Assessment Act and to review the application for a Licence to Prepare a Site under the Nuclear Safety and Control Act.*

For a project of this complexity and dimension, any and all effects on the ecosystem (human health and the environment) are cumulative and very long-term. It is critical that the approach to assess cumulative effects be broadened to the fullest extent, in accordance with the charge to the Panel.

However, the EIS has restricted its consideration of cumulative effects to activities within the study area. It fails to consider the full impact of the entire nuclear chain, from obtaining nuclear fuel through to operation, refurbishment, decommissioning and abandonment. Nor does it consider the ***final*** disposal of all radioactive waste (spent fuel **and** low level radioactive waste. It does not address the cumulative impact of the entire life cycle of the project on human health and the environment. It does not address the possible impact of malfunctions or accidents, not only proposed new reactors, but also for existing reactors.

The cumulative effects of malfunction or accident scenarios are excluded from consideration in the EIS

> *"because these scenarios have a very low probability of occurrence and Canadian EA guidance indicates that such events should be assessed as "unique scenarios", not together with the more likely effects of normal operational activities."[EIS 16-17]*

By excluding these topics, the EIS has completely ignored the most serious environmental impacts of its proposal.

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[5] Public Hearing Procedures http://www.ceaa-acee.gc.ca/050/documents/46908/46908E.pdf

IICPH's position is that the proponent has not carried out a cumulative assessment in accordance with CEAA, and does not consider *the complete life cycle of the project* Therefore the JRP has not received the information needed to fulfil its mandate.

7. Public Health and Safety

i) Overview

An assessment of the risks and costs to human health and the environment of this project must take into account, cumulatively, all stages of the nuclear chain, from cradle to grave.

This includes mining, milling, processing (refining), enrichment and transportation, in addition to construction, operation and maintenance, decommissioning, abandonment and waste. It is also necessary to consider the impact of malfunctions and accidents, including worst-case scenarios.

Uranium mining and milling result in vast amounts of radioactive and non-radioactive solid and liquid wastes (tailings), which contaminate air, waterways, local aquifers, and soil for eons. These mining sites remain radioactive for many thousands of years.

The crushing of ore produces fine radioactive dust particles containing uranium and its progeny, including radon, a potent lung carcinogen. This dust can easily travel 1,500 km in just a few days. The tailings also generate radon gas continuously.

Not only are workers exposed to cancer-causing radiation, they are also exposed to non-threshold carcinogens (hydrazine etc.) and other toxic substances. The interaction and potential synergy between different carcinogens is not well understood, so a precautionary approach is called for in assessing human health risks.

The long-term generational impacts of the proposed project on human health must be assessed, with special attention to workers and vulnerable populations (the foetus, children, women, especially pregnant women, the elderly, and the immune-compromised). It must consider all possible contaminants (radiological and non-radiological), not only in the local area, but over a far more extensive area than the regional study area indicated in the EIS [ES-7].

ii) Damage from Radiation

The most recent publication in the National Academy of Science series "Biological Effects of Ionizing Radiation", the BEIR VII Report, concludes that there is a no-threshold dose-response relationship between exposure to ionizing radiation and the development of cancer in humans. The report also found evidence of non-cancer health outcomes (such as cardiovascular disease and stroke). [6]

Therefore, from a health perspective, there is no safe level of exposure to ionizing radiation. The maximum safe dose of any ionizing radiation is zero. Any other value set for a safe dose is based on the degree of harm to human health and the environment tolerated by regulatory bodies.

[6] BEIR VII report: http://dels.nas.edu/resources/static-assets/materials-based-on-reports/reports-in-brief/beir_vii_final.pdf

Radiation damage can affect any part of a cell, and can interfere with many cellular processes. Most importantly, damage to the genetic material of the cell can lead to cancer, non-cancerous tumours, birth defects, hereditary illness, and immune system diseases. Any amount of exposure to ionizing radiation is harmful.

Ionizing radiation induces oxidative stress, something admitted by radiobiology but discussed only in terms of its thermal effects. This same oxidative stress induces measurable inflammation, including a massive cascade of fatty acids in various states of oxidation. The perturbation of cellular communication, regulation and homeostasis by low doses has major consequences for human health and development. It is irrational and unscientific to take the failure to observe high dose effects at low doses as "proof" that low doses are "safe". [7]

Studies done in Russia after the Chernobyl disaster indicate that at very low doses of radiation, cellular repair mechanisms are not stimulated, and the damage goes unrepaired.

iii) The Sievert

The Sievert is a risk-based unit developed by for radiation dose by the International Commission on Radiological Protection (ICRP). It estimates the probability that a given exposure to radiation will result in a fatal cancer or severe hereditary defect. [8]

The current recommended dose limits set by the ICRP, using the Sievert (Sv), are: [9]

> Members of the public (with the exception of occupational exposure) - 1 mSv/yr [millisievert per year] (In special (infrequent) circumstances, an effective dose of up to 5 mSv in a year may be permitted).
>
> Nuclear Energy Workers (NEWs) - 100 mSv over 5 years (i.e. an average of 20 mSv/yr) with a maximum of 50 mSv in a single year.

The level of exposure for nuclear workers is based on the expectation that 3.2 excess cases of fatal cancer per 100 workers would be generated over a 40-year career. For other non-radiological industrial toxicological situations, 1/10,000 to 1/million excess fatalities are considered acceptable.[10]

iv) Dose Limit Issues

There are several issues with respect to these permissible effective dose levels, which are referred to and used in Canada.

In order to calculate the effective dose, a mixture of radionuclides, having a variety of energies and types of emissions, multiple pathways to humans, and a variety of target

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[7] Dr. Rosalie Bertell "Limitations of the IRP Recommendations for Worker and Public Protection from Ionizing radiation" European Parliament, Brussels, February 1998

[8] Measuring radiation and Assessing its effects: http://www.sievert-system.org/WebMasters/en/frame.php?page=contenu_mesure.html%23tit2

[9] Ionizing Radiation-Safety Standards, Health Physics Society, rev. 2003 http://www.hps.org/documents/publicdose03.pdf

[10] International Commission on Radiation Protection: ICRP Document 60: 1990 Recommendations of the ICRP. Oxford, UK: Pergamon, Elsevier Science.

18) World Information Service on Energy-Uranium Project www.wise-uranium.com.

human organs with different sensitivities for developing cancer, are combined into one simple formula. Weighting factors are assigned to different forms of ionizing radiation and to the various organs and tissues.

The ICRP methodology and its underlying assumptions for calculating the effective dose and permissible limits are flawed for a number of reasons.[11]

- Several assumptions are built into the methodology for calculating the effective whole body dose, the Sievert, and the expected number of radiation-induced cancers. The determination of these weighting factors is not scientifically rigorous and relies on arbitrary judgement assessing the harm to a specific organ or caused by a specific ionizing particle.
- ICRP recognizes only severe genetic effects in live-born offspring, and does not take into account other radiation-related health effects, such as miscarriage and stillbirth, teratogenic effects (such as congenital malformations and diseases), childhood asthma, heart disease, and diabetes.
- Salient factors such as chronic exposure, and chronic illnesses due to non-functional enzymes, hormones and essential proteins are not considered, despite evidence that these effects occur.
- The radiation weighting factor for beta particles (e.g., emitted from tritium)) is 1, which is considered to severely underestimate the harm done by beta radiation. [12]
- The ICRP risk-based system of protection relates to "reference persons", and does not take account of age, size and sex differences in its risk factors.
- These limits do not make proper allowance for doses that occur over a number of years. They ignore the accumulation of radionuclides in the environment and in individuals, in particular the most vulnerable (children, the foetus).
- Radiation-induced bystander effect creates the possibility that extra-nuclear and extracellular effects may also contribute to the final biological consequences of exposure to low doses of radiation. [13] This issue is of particular concern among genetically susceptible populations. The bystander effect is an example of another factor that is not considered.
- Nuclear workers and their families are placed at an unacceptably high risk. In fact, the IARC (International Agency for Research on Cancer) study of nuclear workers found that radiation-related cancer rates of Canadian nuclear workers are higher

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[11] Dr. Rosalie Bertell: Health effects of tritium. (*Health Effects of Tritium*, Submitted to the CNSC, November 27, 2006)

[12] Straume T and Carsten AL (1993) Tritium radiobiology and relative biological effectiveness. Health Phys. 65:657-672.Teratogenic risks for tritium have been estimated to be six-fold higher than the risks of fatal cancers. The weighting factor for electron and photon radiation is 1, for neutron radiation (10), and for alpha radiation, 20.

[13] NIH Program Project on Radiation Bystander Effects: Mechanism; Columbia University Center for Radiological Research www.radiation-bystander.columbia.edu/

than those of other nuclear workers receiving the same radiation dose.[14] The limit for worker exposure is equivalent to 400 chest X-rays in one year.

Many administrative decisions are embedded into the methodology for calculating effective whole body dose and for calculating the expected number of radiation-induced fatal cancers. The ICRP approach rests primarily on its ability to quickly convert a multidimensional problem into a linear system amenable to management decisions.

However, in risk assessments, in cases of long term chronic exposure in the aftermath of a disaster, or in worker compensation hearings, this methodology clouds reality and works against justice for the victims.

The ICRP limits are used in the EIS to evaluate health risks resulting from the "bounding radiological malfunction or accident scenarios". The EIS states [EIS 7-36]:

> *"As accident scenarios are a one time occurrence, the 50 mSv maximum annual dose is used as the regulatory dose limit for comparison to the worker dose resulting from the accident".*

IICPH has seriously questioned the validity of using ICRP recommended exposure limits. These limits are not based on worker health and public health criteria. Rather, they contain value judgements with respect to what harm is "acceptable" to the individual and to society, in return for what it sees as the "benefits" of the activities. These limits are not precautionary.

In the current application of radiation protection standards at nuclear reactors, the focus must be changed from maximally exposed individuals to maximally susceptible individuals, in order to truly protect against the most severe detriments of radiation exposure.[15]

v) The Atomic Bomb Studies [16]

The atomic bomb studies are claimed to be the biological basis of the cancer death risk estimates used by ICRP. However, the atomic bomb studies came after the setting of the radiation protection guidelines recommended by ICRP and followed internationally until 1990. The main recommendations were made in 1952, and the first doses assigned to A-bomb survivors were not available until 1965.

Moreover, the research was designed to determine the effects of an atomic bomb, not the health effects of exposure to ionizing radiation. For example, the radiation dose received by the Hiroshima and Nagasaki survivors from fallout, and the contamination of food, water and air, has never even been calculated. Only the initial bomb blast, modified by personal shielding, is included in the US Oak Ridge National Laboratory assigned "dose".

The research was undertaken by military researchers from both the US and Japan familiar with, and primarily concerned with the military uses of atomic, chemical and biological warfare agents. The research has focused on cancer deaths, is uncorrected for healthy survivor effect, and does not include all of the radiation exposures of cases and controls

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[14] Dr. Rosalie Bertell: Health effects of tritium. (*Health Effects of Tritium*, Submitted to the CNSC, November 27, 2006)

[15] Dr. R. Bertell "Limitations of the ICRP Recommendations for Worker and Public Protection from Ionizing Radiation", European Parliament, Brussels. February 1998

[16] Ibid

(dose calculations omit fallout, residual ground radiation, contamination of food and water, and individual medical X-rays), and fails to include all relevant biological mechanisms and endpoints of concern.

Hiroshima and Nagasaki studies of non-cancer effects of exposure to ionizing radiation are either very poor or non-existent. Diabetes among Hiroshima males had shown a linear trend with dose for causing death. Since diabetes is not normally a first cause of death, one could well question the relationship of radiation with incidence rate of diabetes.

Diabetes rates are extremely high in the nuclear fallout areas of the Pacific, downwind of the Nevada Test Site, and in areas of heavy fallout in the Arctic. However, no research has been done into the possible causal links with nuclear fallout.

vi) Tritium

All nuclear reactors routinely release radioactive material into the air and into the water that is used to cool them. Because Canadian reactors depend on heavy water as a moderator, they release larger amounts of tritium to the environment than light water reactors.

Tritium is absorbed through inhalation, ingestion and dermal absorption. Inhalation is the most dangerous portal for tritium, because it is absorbed into the body more readily than by ingestion or skin absorption. [17]

Tritium is a carcinogen, mutagen, teratogen and developmental toxin. It becomes incorporated into DNA and disrupts the genetic code of men's and women's reproductive cells. It easily crosses the placenta, which raises concern for spontaneous abortions, stillbirths, and congenital malformations and diseases. The cells most at risk from tritium are those dividing at the time of exposure (precursor cells for the ovum), the embryo, and nerve cells.

Since tritium spontaneously disintegrates, the resulting recoil excitation can disrupt chemical bonds. These disruptions, when repeated, cause chronic diseases such as allergies or hormonal dysfunction.

In addition to the studies on the effects of radiation on nuclear workers, a number of studies in Canada have demonstrated the health detriments of tritium, including an increase in the number of fatal birth defects and neonatal deaths in the area of the Pickering nuclear facility, an increase in Down's syndrome and central nervous system anomalies in births in the Pickering area, and an increase in child leukemia deaths near the Bruce plant. [18]

The current Canada Guideline and Ontario Drinking Water Quality Standard for tritium is 7,000 Bq/L, which is based on the permissible ICRP dose limit of 1 mSv/year (lowered to

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[17] Reference: CNSC 2009: CNSC Tritium Releases and Dose Consequences in Canada in 2006, p. 17, 18 http://nuclearsafety.gc.ca/pubs_catalogue/uploads/CNSC_Release_and_Dose_eng_rev2.pdf

[18] Dr. Rosalie Bertell: Health effects of tritium. (*Health Effects of Tritium*, Submitted to the CNSC, November 27, 2006)

0.1 mSv in water). [19] This "standard" corresponds to a risk of 350 excess fatal cancers per million people from just *one year's* consumption of drinking water, not a lifetime (70 years).

It has been recommended that the Ontario Drinking Water Guideline for Tritium be revised to 20 Bq/L. [20] This level relates to heath effects from long-term, chronic exposure over a lifetime of 70 years, and limits the lifetime risk to about one excess fatal cancer per million people. This matches the current Canadian Federal (and Provincial) limits for other chemicals, which are set at levels that provide a lifetime risk of 1-10 excess fatal cancers per million people.

vii) Other Radionuclides

In addition to tritium, all functioning reactors routinely release many other radioactive substances to the air and into the cooling water. The noble gases xenon 137 and krypton 90 decay relatively quickly into the deadly cesium 137 and strontium 90 radionuclides. Cesium 137 accumulates in muscle, including the muscle of animals such as cattle, pigs and sheep; strontium 90 accumulates in bone. Other radioactive isotopes of xenon, krypton and argon are also released. Iodine 131 is mostly trapped by filters, but can escape in accidental releases. It is highly toxic to the thyroid, particularly in children.[21]

Summary Comments

A single radionuclide can cause a lethal cancer, and damage to DNA that may be carried to future generations. This is why there is no safe dose of any radionuclide. This is confirmed by the fact that human exposure, measured in Sieverts, estimates the probability that a given exposure will result in a fatal cancer. This acknowledges that human casualties are an inevitable result of releasing radionuclides into the environment, and merely strives to keep these casualties at an "acceptable" or "reasonable" level.

But no level of casualties is "acceptable" or "reasonable" to a population that has not chosen to accept them by giving the informed consent that scientific ethics require, nor is even a single casualty "acceptable" to the unfortunate individual and family that suffer it.

In conclusion, it is IICPH's position that the current ICRP permissible limits are unacceptable as a guarantee of safety, especially as there is more than sufficient evidence that there is no safe level of exposure to ionizing radiation.

8. Costs/Liability

In the EIS, OPG indicated that it did not have a cost estimate for the project since no decision has been made with regard to technology or vendor, which makes the costs for the project "unclear". [EIS p.10.81-2]

With respect to ensuring effective cost management, OPG indicated that

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[19] CNSC Standards and Guidelines for Tritium in Drinking Water (January 2008) http://nuclearsafety.gc.ca/pubs_catalogue/uploads/info_0766_e.pdf

[20] http://www.odwac.gov.on.ca/reports/052109_ODWAC_Tritium_Report.pdf

[21] Human Health Implications of Uranium Mining and Nuclear Power Generation Dr. Cathy Vakil M.D., C.C.F.P., F.C.F.P. Dr. Linda Harvey B.Sc., M.Sc., M.D. http://pgs.ca/wp-content/uploads/2008/03/human-health-im ation2009-21.pdf

"if it is directed to proceed with new nuclear, schedule and cost performance commitments would be built into the contract and the builder would be required to provide things such as performance guarantees and a turnkey agreement to limit the risk of cost overruns."

Any new nuclear reactor is a very expensive proposition, requiring government subsidies and insurance guarantees, and a skilled workforce. Cost overruns and long lead times, coupled with uncertainties as to completion dates, are inherent in the nuclear industry. Many billions are needed for decommissioning and legacy wastes. As no major power plant has been decommissioned, the true costs are not known.

The true financial cost has been hidden by extensive government subsidies, by unrealistically low limits on the facility's liability for accidents, and by leaving the costs of waste storage for an indefinite future, and the costs for decommissioning, out of pricing structures. [22]

The escalating costs that have already plagued the industry should absolutely prevent the construction of any new reactors.

The initial estimate for Darlington Station in Ontario, Canada's last-built nuclear reactors was $ 5 billion. That cost has nearly tripled to $14 billion or more. This additional cost has been passed on to Ontario's taxpayers, and they are still paying it (the stranded debt).

Without an estimate of costs for this Project, the JRP should recommend that it be rejected. Otherwise, an unfair burden is being placed on future generations who inherit the debt.

9. Demonstration of Need

The Terms of Reference of the JRP specifically state that the scope of the Review will include "need", "purpose", "alternatives to", and "alternative means."

However, OPG did not present evidence within the EIS to firmly justify the "need" for the NNPP Project. Instead, the EIS cites the Energy Minister's 2006 directive, with the implication that it does not call for OPG to address "need" and "purpose" under CEAA. OPG continued to use the directive in its presentations as its justification for not addressing "need" or "purpose".

Thus, IICPH argues that OPG did not provide, as required, evidence of "need" within the meaning of CEAA, and thus, there is no proof provided that the Project is, in fact, needed.

10. Alternatives

CEAA, the EIS Guidelines and the JRP Terms of Reference clearly indicate that this EA process requires "an analysis of alternatives to the project".

Under Section 7.2, Alternatives to the Project, CEAA requires an examination of alternatives, but the Guidelines limit the analysis of alternatives to ones that

"*meet the project's need and achieve the project's purpose from the perspective of the proponent."*

The EIS guidelines further state that

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[22] Schneider M., Thomas S. et al: The World Nuclear Industry Status Report 2009

> *"Alternatives to the project need not include alternatives that are contrary to Ontario's formal plans or directives. However, the EIS must explain where this rationale has been applied to exclude consideration of possible alternatives to the project."*

At present, Ontario has no approved plan, only a draft directive. Therefore, this restriction with respect to the scope of alternatives does not apply.

Furthermore, under Section 14 of the EIS Guidelines;

> *"The EIS must describe the effects of the project on the capacity of renewable resources to meet the needs of the present and those of the future. The EIS must identify those resources likely to be impacted by the project, and describe how the project could affect their sustainable use. The EIS must also identify and describe any criteria used in considering sustainable use. Sustainable use may be based on ecological considerations such as integrity, productivity, and carrying capacity."*

Clearly, the proposed project *does* have an impact on the capacity of renewable resources to meet the needs of the present and those of the future. This matter was raised by several intervenors at the hearing.

The range of "alternatives to" which should have been evaluated within this EA process include all forms of non-nuclear electricity generation, demand management, smart grid development, electricity imports from other jurisdictions, and energy conservation/efficiency options. The construction of new nuclear power plants without consideration of alternatives is an impediment to the development of renewable sources and sustainable energy for present and future needs.

As we raised in our intervention, under Ontario's "Long Term Energy Plan" (LTEP), the supply mix over the next twenty years includes approximately 50% electricity generated from nuclear power plants.

Over the next ten years, 10 nuclear power plants are scheduled to be shut down for refurbishment. As each plant is shut down, rather than refurbishing it, this would be the opportunity to replace the electricity generated by each of these plants with electricity from alternative clean renewable resources, and conservation measures.

Conclusion

The radionuclides that the nuclear industry brings into the world are the most deadly, intractable toxins that have ever existed. They barely exist at all in the natural world, or the human race could never have evolved. A single radionuclide can kill a human being, and the longest-lived ones remain deadly for millions of years. The nuclear industry has created far more of these long-lived radionuclides than all the grains of wheat the human race has ever grown. If they were dispersed across the Earth, they would destroy the human race. There is no way to get rid of them, and it is inconceivable that we will be able to keep them all contained. Over a period of millions of years it is inevitable that human errors, the imperfections of human technology, and unforeseeable random occurrences, such as natural disasters, will release these radionuclides into our natural environment. This will be the greatest human and environmental disaster of all time.

Nuclear waste has already caused enormous environmental damage. Large numbers of deadly radionuclides have been released by nuclear weapons testing, by nuclear reactors, by leaks from nuclear waste dumps, and most of all by nuclear accidents, especially those at Chernobyl and Fukushima. They have cost thousands of people their lives, and millions of people their health. They will cost millions and probably billions of people their health and their lives for millions of years to come, if the human race is able to survive nuclear waste for that long.

Given all this, how could anyone possibly claim that building new nuclear reactors, and creating even more nuclear waste, will do no significant harm to any human beings or to the natural environment? Genuine science is based entirely on rejecting all claims that are contrary to either logic or experience. This claim is contrary to both. There is no logical reason why these most deadly of all toxins cannot do any significant harm to human beings or the natural environment. On the contrary, the logical expectation is that it will be impossible to keep these toxins artificially contained down to the level of atoms for millions of years, which is the only way to prevent them from doing enormous human and environmental harm. This has been amply confirmed by our experience over the last fifty years, let alone for millions of years to come.

Even the nuclear industry itself is so afraid of the massive human and environmental harm that a nuclear power plant could cause that it refuses to build one if it has to accept full liability for any accident that might occur. And obviously they are right, because no-one could ever afford to pay the full human and environmental costs for either Chernobyl or Fukushima. Those costs have had to be borne by innocent people who will never receive proper compensation for the harm they have suffered. It would be unconscionable to expose even more innocent people to such risks. No-one should ever have to risk more than they can afford to lose. As the people of Chernobyl and Fukushima know all too well, lightning can strike at any time, for all kinds of unforeseeable reasons.

So far, we've actually been lucky. It could have been very much worse. As the former Soviet leader Mikhail Gorbachev has testified, it took heroic human sacrifice at Chernobyl to prevent a second explosion that could have wiped out half of Europe. If that had happened, no-one would be contemplating the construction of any new nuclear power plants, and everyone would be rushing to shut down the ones that are already in operation. Do we really have to wait for a disaster of this magnitude before we finally abandon the suicidal folly of nuclear power?

In view of all this, why is the construction of new nuclear power plants at Darlington even being considered? Years ago one of us (Dr. Albright) attended a public session of the Porter Commission on the Future of Electrical Power Generation in Ontario, which was held at York University to present interim conclusions for public discussion. One of these conclusions was that while nuclear fission was a very dangerous way to generate electricity, it could be safely used for another twenty-five years. Dr. Albright asked how they had determined that twenty-five years was the period for which nuclear fission could be safely used. The first response was that this was a very embarrassing question. Then a member of the Commission admitted that twenty-five years was the time they estimated it would take for electrical power from nuclear fusion to become commercially available. Until that happened, they didn't see how Ontario's demand for electricity could be met without using nuclear fission.

More than twenty-five years have passed since then, and commercial electrical power from nuclear fusion is still nowhere in sight. But because of its reliance on nuclear fission power as a stopgap measure, Ontario is now one of the few backwards jurisdictions in the world that remains heavily dependent on power from nuclear fission. It is now proposing to become even more heavily dependent on it, when other jurisdictions are moving away from it after Fukushima. The great historian Arnold Toynbee has concluded that civilizations decline and fall when they start meeting their challenges with temporary expedients of this kind. This only fends off challenges for a short while, and then they come back worse than ever. Toynbee eloquently describes this vicious downward spiral that a civilization falls into when it resorts to more and more desperate temporary expedients to meet an immediate challenge:

> "...after each successive failure to respond to it, the old unanswered challenge presents itself ever more insistently and in an ever more formidable shape, until at last it quite dominates and obsesses and overwhelms the unhappy souls that are being progressively defeated by it."
>
> A Study of History

This aptly describes the situation we have fallen into in trying to meet the challenge of satisfying our ever-growing demand for electrical power.

Toynbee says that civilizations rise and grow only when they permanently overcome their challenges with lasting solutions. Nuclear fission is clearly a very desperate temporary expedient to meet our demand for electricity, that has already caused far worse problems than it has ever solved. To continue to rely on it can only bring us down. It is essential to pursue alternatives that will permanently overcome the challenge we face, without creating even greater challenges in the near future.

Many such alternatives to nuclear fission have been presented to this Environmental Assessment Review Panel, and part of its mandate is to consider them. But the most important part of its mandate is to carry out an objective, scientific assessment of the environmental impact of the proposed nuclear fission power plants, whether there are good alternatives or not. The deadly, intractable toxins produced by nuclear fission power plants have already had a devastating human and environmental impact, which will continue to grow for millions of years. Their large-scale release in another nuclear accident would have catastrophic immediate consequences. Simply bringing these terrible toxins into the world is an act of appalling environmental irresponsibility. Future generations will have to protect themselves against this toxic legacy as best they can for millions of years to come, if they can even survive it. At the very least, it will cause millions and probably billions of human casualties over that time. And all to supply a limited number of people a portion of their electrical power consumption for half a century! In the face of all this we don’t see how, in all fairness, reasonableness, scientific integrity and conscience, the Panel can find that the proposed project will not cause completely unacceptable danger and harm to human lives, human health, and the natural environment.