Comments on the Initial Project Description for the Peace River Nuclear Power Project

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The Canadian Coalition for Nuclear Responsibility (CCNR) was created in 1974 by a group of 30 professionals in Montreal. The Coalition is a pan-Canadian organization dedicated to education and research on all issues related to nuclear energy, whether civilian or military – including non-nuclear alternatives – especially those pertaining to Canada. It was federally incorporated as a not-for-profit organization in 1978. CCNR has participated in licencing hearings, intervened in Environmental Assessment hearings, made submissions to provincial and federal legislatures, and testified in court on many issues related to uranium mining, uranium processing, nuclear reactor safety, radioactive waste, biomedical effects of radiation exposure, nuclear economics, medical isotopes and nuclear weapons – including the proliferation of nuclear weapons capabilities. CCNR played a role in 2008 when Bruce Power was proposing building a single large CANDU reactor in the Peace River region of Northern Alberta. CCNR participated in many public meetings, including a public debate, and met with officials in Calgary and Edmonton as well as Peace River and environs.

The following comments are made on the Initial Project Description (henceforth called the Description) for the proposed Peace River Nuclear Project by Energy Alberta.

This is, to date, the largest four-unit nuclear generating station ever proposed in Canada. It would consist of four Monark reactors, each with a nominal capacity of 1000 megawatts electrical (MWe), but with a total electrical output from the four reactors of 4800 MWe (according to the Description). The proposed Peace Rive Nuclear Power station would have a substantially greater capacity than the entire eight-reactor generating station at Pickering in its heyday, when all eight reactors were operating at full capacity, producing 4144 MWe. The difference between the four-unit Peace River Project and the eight-unit Pickering station is 656 megawatts of electricity, which is approximately equal to the capacity of the

Point Lepreau reactor in New Brunswick, located beside the Bay of Fundy. Thus the 4-unit Peace River Project has a capacity equivalent to nine other power reactors, as described.

In any nuclear reactor, the production of high-level radioactive waste in the form of fission products is, to a good approximation, directly proportional to the thermal energy released by the fissioning of the nuclear fuel. Thus the annual production of high-level nuclear waste at the proposed Peace River facility will be equivalent to the annual production of such waste at the nine nuclear power reactors mentioned above, when they were operating at full capacity. It is important that detailed plans are in place regarding the production, on-site storage, repackaging, transportation, and long-term storage of this very large quantity of high-level radioactive waste. They should be clearly laid out and accounted for before the Peace River Project is approved. The environmental impacts of the project should include the environmental impacts of the transportation of high-level nuclear waste, including the options of highway transport and rail transport. If, as the proponent has suggested, transport of all that high-level waste to Ontario would be prohibitively expensive, then where will the waste go? Will Alberta be required to construct a Deep Geological Repository at an estimated cost of about $26 billion (in 2020 dollars) similar to the one planned by the Nuclear Waste Management Organization (NWMO)?

In reactors fuelled with natural uranium and moderated by heavy water, the production of plutonium and other transuranic actinides (e.g. neptunium, americium, curium…) is considerably greater (per unit of energy produced) than is the case for nuclear reactors fuelled with low-enriched uranium (LEU) and cooled with light water. Per unit mass, the concentration of plutonium itself in spent fuel from a Monark reactor will be between 0.4% and 0.5%. The total amount of plutonium and other transuranic actinides produced annually by the four reactors of the Peace River Project will be equivalent to the annual production of those same materials in the nine previously mentioned CANDU reactors.

Reactors that are moderated by deuterium oxide, commonly known as heavy water, are prodigious producers of radioactive hydrogen, commonly known as tritium, as well as radioactive carbon-14. These radionuclides are produced in the moderator when stray neutrons are absorbed by deuterium atoms (transforming them into tritium atoms) or by atoms of oxygen-17 (transforming them into carbon-14 atoms). Deuterium atoms are non-radioactive hydrogen atoms (atomic number 1) that are twice as heavy as usual. Similarly, non-radioactive oxygen-17 atoms are just a tad heavier than normal oxygen-16 atoms. But when these heavier-than-usual hydrogen and oxygen atoms are bombarded with stray neutrons from the fissioning of the nuclear fuel, they become unstable atoms of tritium and carbon-14. We call these unstable atoms radioactive. Such atoms will eventually disintegrate, giving off damaging subatomic shrapnel called atomic radiation. Both tritium and carbon-14 are "beta emitters" – when the atoms disintegrate, fast-moving electrically charged beta particles are given off.

Chemically speaking, all water molecules behave pretty much the same way. They all have one oxygen atom combined with two hydrogen atoms – H_2O. Whether the hydrogen atom is non-radioactive deuterium or radioactive tritium makes very little difference to the chemistry. But water molecules containing tritium are radioactive and, when ingested or inhaled or absorbed through the skin, they become "internal emitters" of beta particles. Beta radiation is an ionizing agent, meaning that it breaks molecular bonds randomly, and in living cells this can lead to macroscopic biomedical effects such as cancers. Or, damaged DNA molecules in reproductive cells can later be passed on to offspring. It is true that the beta radiation from tritium is very low energy, but it is an ionizing form of energy, and all types of ionizing radiation are Class 1 carcinogens according to the International Agency for Research on Cancer (IARC). The same is true of radioactive carbon-14. Chemically it behaves the same way as non-radioactive carbon, but it is also a weak beta-emitter, meaning that once inside the body it is a Class 1 carcinogen.

Because it is difficult to separate radioactive varieties of an element from non-radioactive varieties of the same element, all heavy-water moderated nuclear reactors (such as the Monark reactors proposed for the Peace River Project) release large quantities of tritium and carbon-14 into the environment, some of it in the form of atmospheric releases of radioactive steam or water vapour or radioactive carbon dioxide, and the rest is released in routine liquid effluents. Due to the vastly greater number of fissions occurring annually in the proposed Peace River reactors than in the Pickering or Point Lepreau reactors, there will be a correspondingly larger routine annual production of both tritium and carbon-14 in the Peace River Monark reactors.

Already, the annual environmental releases of tritium and carbon-14 from Pickering, Lepreau, Bruce and Darlington are measured in the trillions of becquerels. One becquerel is one atomic disintegration per second. In the case of tritium, each large heavy-water-moderated reactor releases hundreds of trillions of becquerels annually. As the Select Committee on Ontario Hydro Affairs pointed out many years ago,

"Carbon-14 and tritium are of comparable and special concern for similar reasons.

- ***First, they each have long half-lives: 5 730 years for carbon-14 and 12.3 years for tritium. Long half-lives allow them to accumulate in the environment around a reactor and in the global biosphere.***
- ***Second, they are easily incorporated into human tissue. Carbon-14 is incorporated into the carbon that comprises about 18 percent of total body weight, including the fatty tissue, proteins and DNA [molecules]. Tritium is incorporated into all parts of the body that contain water.***

"Thus the radiological significance of both elements is not related to their inherent toxicity, as each is a very low energy form of radiation, but to their easy incorporation in the body."

From The Safety of Ontario's Nuclear Reactors (Ontario Legislature, 1980)

How and to what extent will these accumulating tritium and carbon-14 emissions affect the local environment? We are told in the Project Description that the sites selected are agricultural in nature. How and to what extent will these radioactive materials be incorporated into agricultural produce? As water is fundamental to life, radioactive tritium-contaminated water molecules readily enter into all living things. Since carbon and hydrogen are the basic building blocks of all organic molecules, tritium and carbon-14 can be, and are, readily incorporated into the organic molecules of the body, including DNA molecules. There is no readily available water treatment system that can remove tritium from drinking water or from irrigation systems. The fraction of tritium and carbon-14 that ends up being incorporated into the body's organic molecules is said to be the "organically bound" portion; the rest is excreted much more quickly.

Routine radioactive emissions are one thing, but catastrophic radioactive releases caused by a serious nuclear accident involving severe core damage is quite another. Fission products and actinides will then escape from the damaged fuel in a cloud of radioactive gases, vapours and aerosols, potentially contaminating large land areas, making them unfit for habitation or cultivation, and also contaminating enormous volumes of water, that would be carried down the Peace River to the Mackenzie River and eventually to the Beaufort Sea. Every nuclear reactor contains in its core an astonishingly large inventory of radioactive wastes. That can be released if the fuel is badly damaged. For example, if for whatever reason that core of the reactor cannot be cooled for a period of time, even after the complete shutdown of the fission reaction, the radioactivity of the nuclear fuel is so great that the heat produced by the unstoppable radioactive disintegrations will drive the temperature up to the melting point of 2800 degrees C, at which point fuel melting and massive releases of radioactive poisons are unavoidable. Of course all nuclear reactors have multiply redundant safety systems designed to prevent this from happening, but there is no such thing as a foolproof system, because "the fool is always greater than the proof". Those famous nuclear meltdowns that have already occurred at Chalk River, Detroit, Harrisburg, Windscale, Lucens, Chernobyl and Fukushima attest to that fact.

In the context of water contamination following a severe nuclear accident with major fuel damage, it is worth bearing in mind that over one million tonnes of radioactively contaminated water stored in over a thousand large steel tanks at Fukushima Daiichi (the site of the triple meltdown that occurred in 2011) are being gradually dumped into the Pacific Ocean. This water was originally contaminated with dozens of varieties of radionuclides from the molten cores of the crippled reactors, but the majority of these radioactive poisons were removed from the water by a sophisticated filtration system. The main contaminant that could not be filtered out was tritium. Japan has proceeded to begin dumping this large volume of contaminated water into the Ocean despite the vehement protests of Japanese fishermen and strict boycotts on the purchase of Japanese seafood by the governments of both South Korea and China. Imagine how the Peace River would fare under such circumstances.

Although such catastrophic accidents are considered highly unlikely, they are not impossible. Insurance companies are well aware of this, as they make sure that every property-owner's insurance policy in the western world has a "nuclear exclusion clause" which states that the insurance is automatically voided if there is radioactive contamination of that property caused by a nuclear accident.

Major accidents may or may not occur, but routine radioactive emissions are virtually guaranteed unless the Peace River Project proponents has some new tricks up their sleeves. Whatever containment strategies and technologies are advanced by the proponent, they must be subjected to the most uncompromising scrutiny, for the consequences of failure of containment can be utterly devastating. In the meantime, the Dene populations that live downstream from the proposed plant as well as the Inuit populations that receive the long-lived radionuclides released into the Peace River deserve to be fully advised and consulted on the proposed project.

In any water-cooled nuclear power plant , approximately 2/3 of the thermal energy released by the fissioning of fuel is released to the environment. At the Peace River Project, only one-third of that heat will be converted into 4800 megawatts of electricity. That means that twice that amount – close to 10,000 megawatts of heat – will escape as waste heat, either into the local environment surrounding the proposed plant or into the Peace River. The cooling needs of the reactor will require an enormous throughput of water that must be carefully calculated. Inevitably, tonnes of larval fish and other biota will be killed on the intake screens. The effects of all this on the river ecosystem must be treated as a matter of great concern in the subsequent assessment of the project. Consideration of the effects of global warming must also come into play. In France, excessive warming of certain rivers has necessitated the shutdown or power reduction of selected nuclear power plants, as the necessary efficiency of cooling could no longer be assured.

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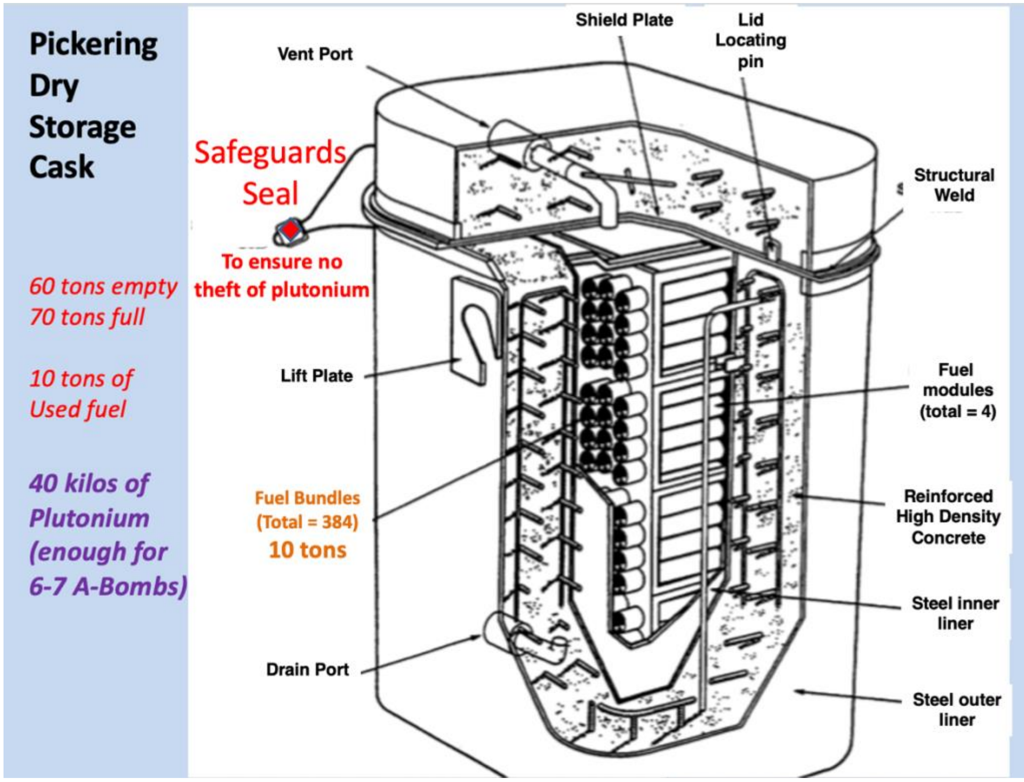
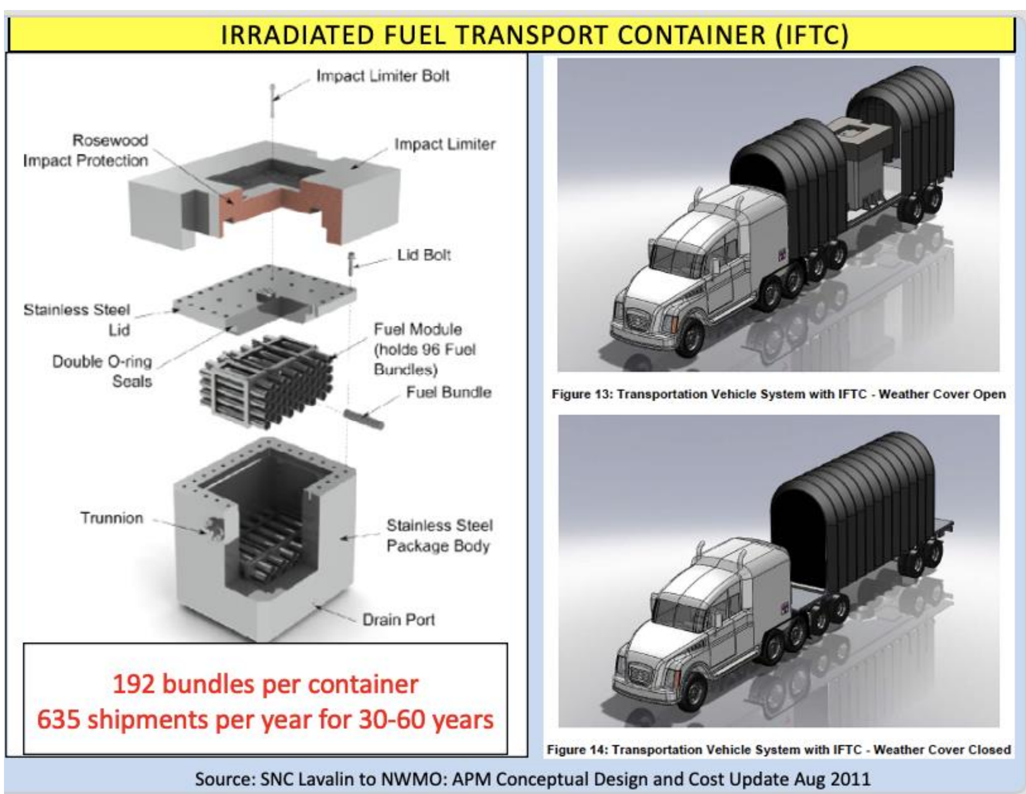
Technical epilogue.

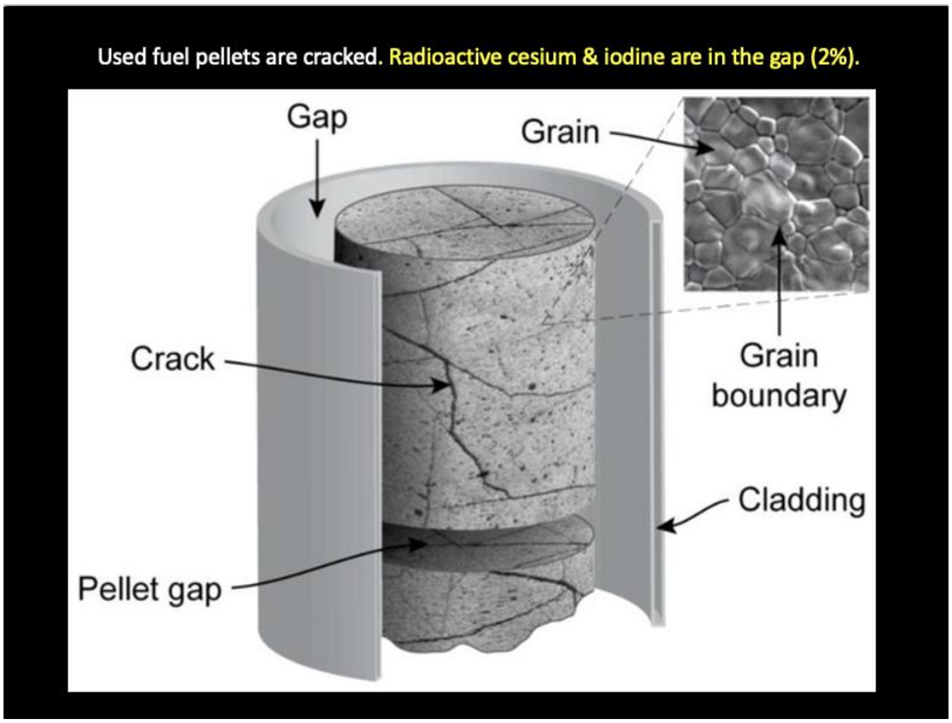
Heavy water is naturally occurring, but the fraction of heavy water molecules in ordinary water is extremely small. Similarly, oxygen-17 is naturally occurring and is found in some water molecules, but again it is a small percentage. To prepare heavy water for use in a nuclear reactor, the heavier water molecules must be separated and harvested from the lighter molecules. This ensures not only that you end up with much more "heavy hydrogen" (called deuterium) but you also end up with much more "heavy oxygen" (that is, oxygen-17). So "heavy water" is highly enriched in deuterium, and somewhat enriched in oxygen-17. When an oxygen-17 atom absorbs a stray neutron from the reactor core, it becomes very destabilized and spontaneously ejects an alpha particle (two protons and two neutrons, bound very tightly together) thereby turning itself into an atom of carbon-14.



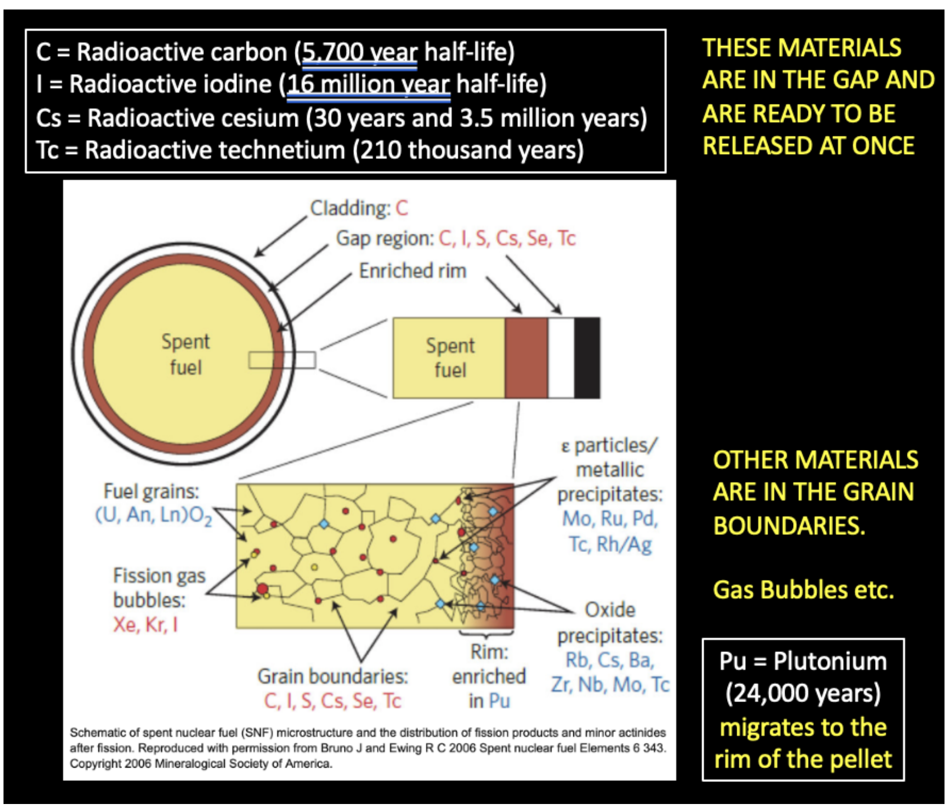
A Pickering dry storage cask is 6 times more massive than the used fuel inside



Repackaging the used fuel for transport (robotically) is no easy task



A uranium fuel pellet after being irradiated in a nuclear reactor/



Many radionuclides are released when the cladding is damaged

Verbatim excerpt from
"A Race Against Time ~
An Interim Report on Nuclear Power"
by the Royal Commission on Electric Power Planning
published in September 1978

with editorial remarks in square brackets

"Assuming absolute independence of the process and safety systems, the probability of a core meltdown per reactor at Pickering is said to be in the order of 1 in 1,000,000 years [once in a million years] . At Bruce, because there are two independent shutdown systems (i.e. shutdown rods and "poison" injection), the theoretical probability per reactor might be considerably lower, perhaps in the order of 1 in 1,000,000,000 years [once in a billion years] .

"However, two well-informed nuclear critics who participated in the hearings, Dr. Gordon Edwards and Ralph Torrie, have argued that the probability of a dual failure could be about 100 times higher than the theoretical levels. This estimate is based on failure rates in the high pressure piping of the primary heat transport system being 10 times higher than has been assumed, and also on the fact that the availability of the Pickering ECCS [EMERGENCY CORE COOLING SYSTEM] has been demonstrated to be 10 times lower than postulated by the designers.

"We believe that the Edwards/Torrie estimate [of 1 in 10,000] is more realistic than the theoretical probability*, not least because the Rasmussen Report has concluded that the probability of an uncontained meltdown in a light water (U.S.) reactor is 1 in 20,000 per reactor per year (it has been suggested, moreover, that this figure could be out by a factor of "5 either way").*

"Assuming, for the sake of argument, that within the next forty years Canada will have 100 operating reactors, the probability of a core meltdown might be in the order of 1 in 40 years, if the most pessimistic estimate of probability is assumed."

from pp. 78-79, A Race Against Time