“Tritium Removal”

A Report on the Proposed MCECE Facility at Chalk River

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for the Keboawek First Nation

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Executive Summary

In a letter to Keboawek First Nation dated February 2, 2024 (reference # 2), we read that "CNL is restoring and protecting Canada's environment by reducing and effectively managing nuclear liabilities. Among these liabilities is Atomic Energy of Canada's (AECL) large inventory of tritium-contaminated heavy water." In an accompanying Fact Sheet (reference # 3) CNL states that "tritiated heavy water cannot be used, re-used or disposed of in its current form."

The fact that tritium-contaminated heavy water cannot be used, re-used, or even disposed of in its present form is a testament to the considerable hazards posed by radioactive tritium. Nevertheless, tritiated heavy water can be safely stored, and kept out of the environment, as is being done at present. There is no reason given by CNL as to why such storage cannot be continued indefinitely, until the radioactive tritium has disintegrated to innocuous levels.

Instead, Canadian Nuclear Laboratories (CNL) plans to build a tritium removal facility called the Modernized Combined Electrolysis and Catalytic Exchange facility (MCECE) to extract radioactive tritium in a gaseous form from the non-radioactive heavy water. In the above-mentioned letter from CNL, we learn that CNL expects tritium emissions into the environment from this facility. Some simple arithmetic reveals that up to 10.7 trillion becquerels of tritium will be dispersed into the environment per year from this facility. (In the letter, up to 2 curies per week of tritium gas (T_2) and up to 5 curies per week of deuterium tritium (DT) will be released into the atmosphere, for a total of 259 billion becquerels of tritium per week. Assuming an 80 percent capacity factor, that's 10.7 trillion becquerels of tritium released per year.)

It is concluded that there is no justification for the proposed facility in terms of "protecting the environment by reducing and effectively managing nuclear liabilities". The proposed facility does nothing to reduce the amount of radioactive tritium, but it does provide a mechanism for dispersing trillions of becquerels of tritium into the environment every year. Much larger amounts are packaged and sold to clients, often with environmentally harmful effects. Tritium is not effectively managed to protect the environment. Clearly, indefinite safe storage of tritiiated heavy water is the preferred option if protecting the environment is the goal.

About the Author

Gordon Edwards graduated from the University of Toronto in 1961 with a gold medal in Mathematics and Physics. He obtained two Master's degrees from the University of Chicago under a Woodrow Wilson Fellowship, and earned a doctorate in mathematics from Queen's University. He directed a nation-wide study of the Mathematical Sciences in Canada for the Science Council of Canada and co-founded the Canadian Coalition for Nuclear Responsibility (CCNR), a not-for-profit corporation that he currently heads. Dr. Edwards has served as a consultant on nuclear issues for governmental and nongovernmetal entities for over 40 years, and has been qualified as an expert witness in courts of law. His Curriculum Vitae can be found on-line at www.ccnr.org/GE_CV.pdf .

Hydrogen – Normal, Heavy, and Radioactive

Hydrogen (H) is the lightest and most abundant element in the universe.
Deuterium (D) is a rare form of hydrogen whose atoms are twice as heavy as ordinary H atoms.
Tritium (T) is the only radioactive form of hydrogen; it is 3 times heavier than H.

Every tritium atom will disintegrate, or explode, unlike other hydrogen atoms that are eternal.
When a tritium atom disintegrates it gives off a damaging projectile called a "beta particle".
Living cells exposed to beta particles are damaged and can sometimes reproduce abnormally,

Tritium exposures can result, years later, in increased incidence of cancer in the exposed populations. It is known that, per unit of energy, tritium exposure is significantly more damaging than gamma rays. (See Table 5.1.2 in reference # 4.)

Animal studies have shown conclusively that if their reproductive cells are exposed to tritium, genetic damage can be done in the form of damaged chromosomes or genes. In many cases such genetic damage can be passed on to offspring and to subsequent generations.

Animal studies have also shown that if a developing conceptus, fetus or embryo is exposed to tritium, malformations or other developmental irregularities may occur. Tritium administered to a pregnant mother has ready and rapid access to the unborn conceptus, embryo or fetus.

The unit of radioactivity is the becquerel. One becquerel indicates one disintegration per second.
The half-life of a radioactive element is the time it takes for half of the atoms to disintegrate.
The half-life of tritium is 12.3 years, so after 24.6 years (two half-lives) only one quarter of the original tritium atoms will remain, assuming no new tritium atoms are introduced.

Stated Purpose of MCECE

Canadian Nuclear Laboratories (CNL) is planning a Modernized Combined Electrolysis and Catalytic Exchange Facility, or MCECE. It is intended to replace an earlier Chalk River facility, a

Combined Electrolysis and Catalytic Exchange Upgrading & Detritiation Test Facility (CECEUP) that operated for about four years, from 1998 until 2001. Both are Tritium Removal Facilities.

For technical reasons, Canadian reactors use heavy water (D_2O) instead of ordinary water (H_2O) as both a moderator (to slow neutrons) and as a coolant (to remove the heat of fission reactions). Heavy water is an expensive non-radioactive liquid, costing several hundred dollars per kilogram in 2022 and 2023, depending on the degree of purity. Heavy water is normally obtained for industrial use by extracting it from natural water sources. Non-nuclear demand for D_2O is a growing market.

Inside a reactor, heavy water becomes very radioactive because of the creation of tritium. When a deuterium atom absorbs a neutron, that atom is transformed into a tritium atom. That happens a lot because trillions of neutrons are flying around inside every nuclear reactor, given off by fissioning uranium atoms and by some of the resulting fission products. Heavy water used as either a neutron moderator or as a coolant in a nuclear reactor becomes "tritiated" – D_2O becomes DTO, tritiated water. In general, the tritium concentration in the heavy water used as moderator is about an order of magnitude greater than that of the heavy water used as coolant.

The "activity" of heavy water after use in a nuclear reactor ranges from several hundred to several thousand gigabecquerels of tritium per kilogram. A gigabecquerel is a billion becquerels. After 123 years (ten half-lives) the amount of undisintegrated tritium atoms is reduced by a factor of 1000. After 123 years, a gigabecquerel of tritium becomes a megabecquerel, and after another 123 years it becomes a kilobecquerel. (A megabecquerel is a million becquerels, a kilobecquerel is a thousand.)

The sole purpose of MCECE is the extraction of tritium from contaminated heavy water in the form of tritiated hydrogen gas, whose molecules are either DT (one atom of deuterium bonded to one atom of tritium, called "deuterium tritium") or T_2 (two tritium atoms bonded together).

CNL says it wants to reduce AECL's "radioactive liability" associated with its used heavy water. That goal is what justifies the federal government funding of the MCECE facility, through AECL.

AECL's contaminated heavy water comes primarily from closed federally-owned nuclear reactors.

These are Douglas Point (Kincardine), Gentilly-1 (Bécancour), NPD (Rolphton), WR-1 (Pinawa Manitoba), and CRL's ZEEP, NRX, and NRU reactors (Chalk River). Evidentily, most of the contaminated heavy water is not produced at Chalk River, it is transported to Chalk River.

In a fact sheet, CNL says that the tritium-contaminated heavy water "cannot be used, re-used or disposed of in its current form". This testifies to the radioactive dangers of the tritium contained in the heavy water. It is only due to health and safety hazards to workers and to living things in the environment, posed by radioactive tritium, that the heavy water cannot be re-used or re-sold.

The dangers of tritium are sufficiently great that tritiated heavy water cannot even be disposed of in its present form, according to CNL. It can, however, be safely stored – a less expensive option.

Tritium Contamination from Tritium Removal Facilities

Ontario Power Generation (OPG) has operated a tritium removal facility (TRF) on the Darlington site since 1990 for its fleet of CANDU reactors. CANDUs all use heavy water. Tritium removal is justified by OPG to reduce tritium exposures to workers and the environment. The "detritiated" heavy water is subsequently made available for re-use in OPG reactors.

OPG says that tritium gas, once extracted, is safely stored in a solid form embedded in titanium metal as a hydride compound. The tritium can be recovered from the metal later by reheating and evacuation. OPG also sells tritium to manufacturers of self-illuminating lights, such as exit signs, that are filled with tritium gas. These factories have led to local tritium contamination.

TRF does not reduce the overall amount of tritium (T). It changes the tritium from a heavy liquid into a light gas. That gas (which CNL calls "elemental tritium") is harder to contain than the liquid. Airborne emissions of tritiated hydrogen gas are vented from TRF into the atmosphere. The facility also discharges tritiated water as both a radioactive vapour and as a liquid effluent.

According to OPG, "Annual production of tritium in a CANDU reactor is typically 52-74 TBq/MWe [that's terabecquerels (TBq) of tritium per megawatt (MWe) of electricity]. Some CANDU reactor operators have implemented detritiation technology to reduce both tritium emissions and dose to workers and the public from reactor operations. However, tritium removal facilities also have the potential to emit both elemental tritium and tritiated water vapor during operation. "

Tritium Emissions from a Detritiation Facility (2017)

Once airborne, tritiated hydrogen gas released from TRF will combine with oxygen to produce tritiated water vapour (HTO). Tritiated water vapour, when inhaled, is 15 to 20 thousand times more biologically damaging than inhaled tritium gas. Tritiated water vapour in air can later return to earth as radioactive rain, radioactive snow, or radioactive condensation (dew).

In 2020, the annual release of gaseous tritium from the Darlington tritium removal facility (TRF) amounted to 15 terabecquerels. A terabecquerel is a trillion becquerels, that is, a million million, or a thousand billion, becquerels. The Darlington Tritium Removal Facility is larger than MCECE but the same problem will exist at MCECE on a smaller scale.

CNL calls tritium gas (T_2 or DT) "elemental tritium" ; CNL calls tritiated water (HTO) "tritium oxide".

Q: What is the total amount of AECL's tritiated heavy ?

According to the letter from CNL to KFN dated February 2, 2024, reference # 1, there will be 935 cubic metres of used heavy water to be processed by the MCECE facility. That's about a thousand tonnes.

Q: How much of the tritium will be extracted in the form of tritiated hydrogen gas and how much will escape into the atmosphere*? [Note: One Curie = 37 billion becquerels.]*

The above-mentioned letter from Canadian Nuclear Laboratories states that CNL expects "Tritium Oxide Emissions < 2 Ci/week and Deuterium Tritium < 5 Ci/week". [Ci = Curie] So every week, up to 74 billion becquerels of tritiated water vapour and up to 185 billion becquerels of tritiated hydrogen gas will be released. That's a total of up to 259 billion becquerels per week of tritium released, or (assuming an 80 percent capacity factor for the MCECE) up to 10.7 trillion becquerels (terabecquerels) of tritium per year. (If the plant operates well, releases may be less).

Because of the relatively long half-life of tritium, this radioactive form of hydrogen will accumulate in the environment, week after week and year after year. Such an environmental buildup of tritium can be prevented if the contaminated heavy water is stored rather than processed.

Q: How much tritiated heavy water HTO will escape in the form of (a) vapour? (b) liquid effluent?

This question is so far unanswered. But it must be borne in mind that virtually all of the tritiated gas will become tritiated water vapour as the hydrogen atoms combine with the oxygen in air.

Health and Environmental Hazards of Tritium

The International Agency for Research on Cancer (IARC) has categorized all radioactive materials as Class 1 carcinogens. This includes tritium.

The beta particle emitted by the disintegration of a tritium atom cannot penetrate the dead layer of skin on the outside of the body, hence tritium is not an external hazard. However, tritium, being a form of hydrogen, has ready access to all body parts and all living things – especially in the form of tritiated water – and so it is an internal hazard when inhaled, ingested, or absorbed through the skin.

Two independent expert bodies were asked by the Ontario government to advise it on an acceptable standard for tritium contamination in drinking water. Both of them – the Advisory Committee on Environmental Standards (ACES) and the Ontario Drinking Water Advisory Council (ODWAC) – recommended a maximum permissible level of 20 becquerels per litre. That level is 350 times more stringent than the current Canadian regulatory limit of 7,000 becquerels per litre.

Those expert recommended limits were based mainly on a comparison between tritium (in the form of tritiated water) and other known carcinogens. The recommendations assumed that the damaging energy deposited in tissue from the beta particle emitted by a tritium atom is comparable (in carcinogenic terms) with the same energy deposited by a gamma ray. (Called “ionizing energy”.)

However it has been well-documented for many decades that tritium exposures are more effective than gamma rays in cancer induction, and according to a background paper from the UK’s Committee Examining the Radiation Risks of Internal Emitters (CERRIE) tritium exposures could be as much as fifteen times more effective than comparable gamma exposures. In technical terms, this is expressed by saying that the Relative Biological Effectiveness (RBE) factor for could be as high as 15. That would lower the 20 becquerel per litre recommendation down to 1 or 2 becquerels per litre.

The Canadian nuclear regulator does not accept these findings, but its own documentation shows a range of RBE factors from tritium ranging from RBE=1 to RBE=4. (See Table 5.1.2, pages 99 ff)

Moreover, it appears that cancer may not be the most significant detrimental effect from tritium exposure, especially in the case of pregnant women and their babies. Sound scientific research with animals has demonstrated that tritium is not only a carcinogen, but also a mutagen and a teratogen. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) warns that, unlike most radionuclides, tritium entering the body of the mother is readily transferred into the developing baby, giving a larger radiation exposure to the latter than to the former.

In 2023, Dr. Arjun Makhijani published an important book entitled Exploring Tritium Dangers, Health and Ecosystem Risks of Internally Incorporated Radionuclides. In it, he summarizes important scientific evidence related to the extraordinarily high sensitivity to pregnant women and their unborn children to tritium-induced damage. He points out that, whereas regulatory agencies have assigned an RBE factor of 20 to alpha particles emitted by radioactive materials such as plutonium, those same agencies – having focussed their standards on adult males, using a model called "Reference Man" – have neglected to assign a similarly protective RBE factor to tritium.

In both cases, plutonium and tritium, each radioactive disintegration produces a damaging projectile, an alpha particle from plutonium and a beta particle from tritium, that expends its entire energy in a very small number of cells, and accordingly does more damage to those cells than more penetrating forms of radiation can do. This is referred to "low linear energy transfer" or "low-LET" radiation as opposed to "high linear energy transfer" or "high-LET" radiation. It has long been recognized that low-LET radiation is significantly more harmful that high-LET radiation, per unit of ionizing energy deposited in tissue.

And, as noted earlier, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) has devoted extensive appendices in the past to provide evidence on detrimental genetic effects as well as developmental effects during embryogenesis in mammals.

Dr. Makhijani's book also calls attention to a recent study that may have important implications for ecosystem contamination by tritium: "a Chernobyl study compared laboratory experiments on a single species with the impact of radiation on wildlife seen in the field over a wide range of dose rates. It concluded that wildlife is eight times more sensitive to radiation than indicated by laboratory experiments." This is specifically related to low-LET radiation. (p. 68, reference # 5)

Significant Environmental Impacts

In order to determine whether the MCECE facility is likely to have a significant environmental impact it is necessary to have an up-to-date assessment of the entire spectrum of biological hazards associated with chronic tritium exposures. Such assessments must not be limited to adult males but must consider girls and women as well as embryos and foetuses. Such assessments must not be limited to cancer as the sole endpoint of importance and must include mutagenic and teratogenic effects. Such assessments must also not be limited to humans but should take in other species – birds, animals, fish, vegetation – that will act as receptors and transmitters of the radioactive material.

To be credible, such an assessment should be independent of the nuclear industry and the nuclear regulator, both of whom are on record as trivializing the health risks of tritium as an environmental carcinogen, mutagen and teratogen. The Ontario government found that independent toxicological study of the maximum acceptable level for tritium contamination in drinking water is far more concerning than the assessments conducted by agencies that routinely work closely with nuclear proponents and government agencies that foster nuclear expansion. In a similar way, an environmental study of the potential kinds of impacts from chronic tritium contamination of the environment should be entrusted to a body that is devoid of conflict of interest,

Organically Bound Tritium

In this context it must be borne in mind that all organic molecules (including DNA) contain many hydrogen atoms, and radioactive tritium atoms freely exchange with the non-radioactive H atoms. Not only do water molecules become radioactive, but organic molecules of all kinds – even DNA – become radioactive too. This is called Organically Bound Tritium (OBT) and there is a great deal that is still unknown about the ultimate biological damage that may be done as a result of OBT.

There is evidence that OBT can accumulate in certain tissues (e.g. foods) to levels of radioactivity much higher than ambient levels. It is unknown as to whether biological magnification of OBT occurs in the food chain, or to what extent this occurs.

The fact that tritium can be incorporated directly into DNA molecules, unlike most other radionuclides, suggests that the effects of tritium on reproduction and embryogenesis can be disproportionately more significant than is the case with other radioactive pollutants.

Cost and Effectiveness of Tritium Removal

Japan is dumping 1.2 million tonnes of tritium contaminated water (not heavy water) into the Pacific. This tritium-contaminated water has been collected on a daily basis ever since the triple meltdown at Fukushima Daiichi in 2011. The contaminated water has been stored on-site in large steel tanks. The dumping of the contaminated water into the Pacific is opposed by Japanese fishermen, and by the governments of China & Korea, both of whom have banned imports of seafood from Japan as a result of the dumping. The Tokyo Electric Power Company (TEPCO) and the International Atomic Energy Agency (IAEA) say that there is no "practical" way to remove the tritium.

For 12 years, from 2011 to 2023, Japan stored the water in large steel tanks. With over 1000 such tanks built, and more being built each week, the only reason given for dumping the tritium-contaminated water was that TEPCO was "running out of room" for building more tanks. If they had more room, they said, they could have kept on storing the water in steel tanks indefinitely.

Which raises a question – why not store AECL's contaminated heavy water in tanks until the tritium disintegrates to harmless levels? A couple of centuries should do the trick, as 246 years waiting time will reduce the tritium by a factor of a million.

Alternatively, who not use OPG's TRF at Darlington to detritiate AECL's heavy water? Wouldn't this be less expensive than building a new facility at Chalk River? And wouldn't it be less impactful on the Ottawa River and the CRL site?

CNL says that an earlier version of the MCECE, called CECEUD, ran at CRL for 4 years (1998-2001). This older test facility could not have been very affordable and/or very successful, or Japan would have used that technology to “clean” their own large volume of tritiated water.

So the question is, what justifies the high cost of the proposed new MCECE facility?
Answer: Selling the products. But this requires a cost-benefit analysis, an analysis of alternatives such as storage, and a fact-based business plan.

Commercial Motives

The three multinational companies that co-own CNL are profit-making corporations. They are AtkinsRéalis (formerly SNC-Lavalin) and two Texas companies, Fluor and Jacobs.

Outside of the stated goals of “reducing AECL’s liability” and protecting the health and safety of people and the environment, CNL has clearly indicated a desire to sell the byproducts of the MCECE facility: detritiated heavy water and tritium.

Indeed CNL states very clearly that the “detritiated” heavy water can be re-sold or re-used. On its fact sheet, CNL also indicates that the tritium (once separated) can also be sold. Are the revenues from such sales expected to exceed the cost of building and operating the MCECE facility? There is no information on this score.

Marketing Used Heavy Water

Who are the customers for used, detritiated, heavy water? All AECL’s reactors are shut down. All so-called “small nodular reactors” currently considered in Canada have no need of heavy water. All of the Ontario reactors are serviced by OPG’s TRF at Darlington.

The two Quebec CANDU reactors, Gentilly-1 and Gentilly-2, are also shut down.
That leaves Point Lepreau as the solitary Canadian customer. Perhaps. But maybe not.
Will MCECE be competing with OPG’s TRF for customers?

It appears that the main market for the heavy water from MCECE will be foreign. Foreign sales of heavy water have been carefully controlled in the past for national security reasons as D_2O can be used to produce plutonium in a pool-type nuclear reactor without the need for enriched uranium, allowing for the proliferation of a nuclear weapons capability to non-nuclear weapons states. That's why heavy water was one item on the nuclear"trigger list".

There is always a possibility that heavy water sold for non-nuclear purposes (a growing market) can be diverted and end up in plutonium production.

Marketing Tritium

The main markets for tritium are (a) self-illuminating lights, as previously mentioned;
(b) scientific research, especially in relation to fusion reactors; (c) nuclear weapons programs.

(a) Self-illuminating Lights

In order to prevent discarded tritium lights ending up in landfills, resulting in uncontrolled radioactive off-site leakage for decades to come, Canadian manufacturers have arranged to take back the disused radioactive waste from its clients. Those tritium-contaminated wastes have been transported to Chalk River for storage and/or disposal.

If one disregards the cobalt-60 contribution to the initial radioactive inventory of the Chalk River Near Surface Disposal Facility (NSDF), which many critics believe should be disallowed on the grounds that cobalt-60 sources are not low-level waste, we find that 98% of the remaining initial inventory of radioactivity is due to tritium.

How much of that tritium waste is due to discarded self-illuminating lights, filled with tritium extracted from contaminated heavy water, has not been revealed. Nevertheless, it is likely that tritium removed from AECL's contaminated heavy water and then sold for such self-illuminating lights will return to the Chalk River site. Tritium has not been eliminated but just reshuffled.

What used to be a financial liability for AECL will have ultimately become an environmental liability for the Indigenous and non-Indigenous inhabitants of the Ottawa River valley.

Reducing liability associated with nuclear waste does not mean eliminating radioactive materials, which are not eliminated by any human technology but only by the inexorable and unalterable rate of atomic disintegration, which humans can neither shut off nor speed up.

Tritium is a very expensive commodity, currently selling at about $30,000 (US) per gram. The price is expected to rise sharply to well over $100,000 per gram in the foreseeable future.

(b) Fusion Research

Research into nuclear fusion requires a great deal of tritium. That is a very significant market. Both nuclear fission and nuclear fusion are capable of unleashing the enormous energy that is locked up in the atomic nucleus. Indeed, that is why it is called "nuclear" energy.

Instead of breaking very heavy atoms apart, as happens in a nuclear fission reactor, nuclear fusion does the opposite – it "fuses" very light atoms together to make heavier atoms. Since the lightest atoms are atoms of hydrogen – including deuterium and tritium – these hydrogen atoms serve as the fuel for a nuclear fusion reactor.

Atoms are very resistant to being fused together because the positively charged nucleus of one atom repels the positively charged nucleus of the other. If the atoms can be forced together by overcoming that powerful electrical repulsion, then the nuclear force takes over and "glues" the two atoms together making a single atom with a much heavier nucleus. One way of doing it is to heat the hydrogen up to a temperature of 100 million degrees to "smash" the atoms together.

Tritium turns out to be the best, or at least the easiest hydrogen atom to fuse with another hydrogen atom, because the electrical repulsion is just the same for all hydrogen atoms, but the more massive tritium nucleus exerts a much more irresistible nuclear force.

The stars are powered by nuclear fusion. Thermonuclear weapons (which were once called “H-bombs”) are based on nuclear fusion. However, scientists have never succeeded in achieving a self-sustaining “peaceful” nuclear fusion reaction.

When and if they do, the reaction will generate its own tritium and there will be no need for an external supply. Until then, however, fusion researchers need to acquire large amounts of tritium in order to continue their efforts to get a self-sustaining nuclear fusion reaction started.

Despite optimistic predictions, it seems that “peaceful nuclear fusion” has been “just around the corner, within five years of implementation”, for the last 60 years or more.

(c) Nuclear Weapons

There is also a very significant and growing military demand for tritium to be used as a booster in atomic bombs. As little as 2 grams of tritium in an implosion-type bomb can multiply the explosive power of the bomb by a factor of ten. The “boost” is achieved by the fusion of tritium atoms, triggered by the enormous blast of heat from the atomic bomb itself. Since tritium has a relatively short half-life of 12.3 years, modernized nuclear arsenals must regularly replenish their supply of tritium for “boosters” which will otherwise dwindle and decline in effectiveness.

By boosting the explosive power, the use of tritium reduces the need for fissile material. Bombs can be made that are equally powerful but reduced in size. Tritium is an important factor in “miniaturizing” a modern nuclear arsenal, making it easier to deliver each bomb to its target.

An “unofficial” nuclear weapons state such as India or Pakistan could profit militarily by having ready access to tritium to modernize its nuclear weapons. Canada provided India with the CIRUS reactor that was used to produce the plutonium in that country’s first atomic bomb test in 1974. Will Canada now supply India with tritium, or with our best available technology to extract tritium from used heavy water, to help make the Indian nuclear arsenal all the more deadly?

Such questions must be asked of all tritium sales to foreign customers. Do Canadian agencies have the ability to provide effective and reliable oversight to meet these challenges?

Conclusion

In a letter to Keboawek First Nation dated February 2, 2024 (reference # 2), we read that "CNL is restoring and protecting Canada's environment by reducing and effectively managing nuclear liabilities. Among these liabilities is Atomic Energy of Canada's (AECL) large inventory of tritium-contaminated heavy water." In an accompanying Fact Sheet (reference # 3) CNL states that "tritiated heavy water cannot be used, re-used or disposed of in its current form."

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Instead, CNL plans to build a tritium removal facility called the Modernized Combined Electrolysis and Catalytic Exchange facility (MCECE) to extract the radioactive tritium in a gaseous form from the non-radioactive heavy water. In the above-mentioned letter from CNL, we learn that CNL expects tritium emissions into the environment from this facility, and some simple arithmetic reveals that up to 10.7 trillion becquerels of tritium will be dispersed into the environment per year from this facility. (In the letter, up to 2 curies per week of tritium gas and up to 5 curies per week of deuterium tritium can be released into the atmosphere, for a total of 259 billion becquerels per week. Assuming an 80 percent capacity factor, that's 10.7 trillion becquerels per year.)

The conclusion is that there is no justification for the proposed facility in terms of "protecting the environment by reducing and effectively managing nuclear liabilities". The proposed facility does nothing to reduce the amount of radioactive tritium, but it does provide a mechanism for a yearly release of trillions of becquerels of tritium into the environment. Evidently, indefinite safe storage of contaminated heavy water is the preferred option if protecting the environment is the goal.

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