Radioactive Waste Policy: Long Term Management of Irradiated Fuel

Northwatch Submission to Natural Resources Canada - 31 May 2021

In November 2020 Natural Resources Canada announced a review of Canada's radioactive waste policy framework and launched a virtual hub with four discussions papers and a forum for posting comments online. A series of online sessions were held through direct arrangement – there were no engagement sessions announced on the radwastereview.ca web site and Northwatch is not aware of any opportunities for unaffiliated Canadians to be part of such sessions – and comments were invited by email.

The four discussion papers addressed waste minimization, waste storage, waste disposal, and decommissioning. Northwatch has posted summary comments identifying what was missing from each of these papers and responded to the questions posed in each paper through the online forum.

There are several subject areas which are central to the review and improvement of Canada's radioactive waste policy which were either not addressed in any of the four discussion papers or were addressed only indirectly or in insufficient detail. This submission is one of a series prepared by Northwatch to provide input into the review and to propose additions to Canada's radioactive waste policy.

This submission is made by Northwatch in support of the following radioactive waste policy recommendations related to the long term isolation and containment of nuclear fuel waste.

<u>Summary of NRCan's Waste Disposal Discussion Paper</u>
The paper begins with a number of general statements about radioactive waste "disposal", including describing disposal as being "the final step in the management of radioactive waste" and defining it as "the placement of radioactive waste without intention of retrieval".

The paper describes the Policy Framework for Radioactive Waste and lists "a number of approaches to the disposal of radioactive waste" including near-surface disposal, below ground caverns, borehole disposal, geological disposal and "in-situ" disposal, many of which have not been done in Canada and some of which have not been done anywhere in the world.

It goes on to list phases for a disposal facility (site selection, site preparation, construction, operation, closure and decommissioning of ancillary facilities, and post-closure) as if these stages have actually been applied in Canada (application has been inconsistent or absent).

The paper makes claims that all of Canada's radioactive wastes are currently being safely managed and refers to the Nuclear Waste Management Organization's "Adaptive Phased Management" plan to bury all of Canada's high-level waste in one location (not yet determined or accepted) and the Port Hope Area Initiative as if they are examples of successful "disposal" projects. It ends with a very generalized paraphrasing of select IAEA principles and policies.

Noticeable absent from the paper, related to the long term management of irradiated fuel / nuclear fuel waste are the following:

- Discussion or acknowledgement of the conceptual nature and the large number of technical and scientific uncertainties associated with some of the options the paper lists, such as borehole disposal or geological disposal
- Discussion of the role of retrievability in a “disposal” option
- Analysis or links to analysis of current programs cited by the paper, such as the NWMO’s siting program for a deep geological repository for nuclear fuel waste or the Port Hope Area Initiative projects, both of which are problematic and are either still in the design / development stage or are in flux during implementation
- Examples of relevant policies from other countries, such as Scotland’s Proximity Principle which directs that radioactive waste is managed as close to the point of generation as possible, or France’s policy on retrievability which requires all “disposal” plans to include means of retrieving the wastes after placement

POLICY RECOMMENDATIONS

Northwatch’s primary policy recommendation is that **radioactive waste should NOT be abandoned**; Canada’s radioactive waste policy should direct perpetual care and monitoring of all wastes, including and particularly nuclear fuel waste.

The notion presented of “disposal” should be replaced by an approach of long-term management. All management options – whether short, medium or long term – should be designed to accommodate detailed monitoring, measures of how the containment system is performing, and means to replace or remediate system failures (such as failed containers or barriers, or failures in monitoring systems). Transportation should be avoided or minimized, security of the wastes should be maximized, and the absolute containment of the wastes realized.

Independence and transparency are the central principles in determining and defining roles and responsibilities. To meet these principles:

- An independent agency that is arms-length from government and industry should be established for the management of radioactive wastes
- Independent scientific, technical and social advisory groups should be established to support the independent agency
- A regulatory body which licenses nuclear facilities should report to Parliament through Environment Canada
- Waste management should be funded by the waste owners and generators, but how the funds are used should be directed by the independent agency
- Indigenous peoples and the public should be engaged in policy and project development and review, with funded access to legal and technical advisors and all relevant documentation

To modernize Canada’s radioactive waste policies, the Government of Canada needs to move on from the 1970s thinking of deep geological repositories as a “final solution” and move forward with a policy and related strategies of extended on-site storage with secure and hardened storage facilities, extensive monitoring, and options for repair, replacement and remediation. The attached paper outlines Northwatch’s evolving proposal for extended on-site storage.

Securing the Future

A Risk-Reduced Approach to Nuclear Fuel Waste Management

For more than four decades Canada and several other countries have invested considerable time and research effort into programs to investigate or support deep geological repositories[1] for the "disposal" of highly radioactive reactor fuel waste. To date, no country has actually licensed or implemented a nuclear fuel waste burial program and Canada has not yet secured a location or completed design of a repository.

Increasingly, discussion both in North America and internationally is shifting to an examination of options related to extending on-site storage[2] of nuclear fuel waste into the medium or long term, for periods ranging from 100 to 300 years or longer. There are three primary motivations for this shift:

- After several decades and a number of failed attempts, there is no geological repository on the near horizon
- Following the 9/11 terrorist attacks there are increased security concerns and – correspondingly – increased security benefits to moving the fuel wastes into more robust storage
- Following the Fukushima crisis commencing in March 2011, there is growing awareness of the vulnerability of the spent fuel while being maintained in the Irradiated Fuel Bays

The international failure of the geological repository programs, the continued scientific and technical uncertainties[3] surrounding the deep repository concept, the lack of social acceptance of nuclear waste burial, and the pressing need to improve the current on-site storage of high level nuclear fuel waste motivate this brief outline of a Canadian approach to securing high level nuclear waste into at least the medium term (100 to 300 years). The approach neither relies on nor rules out an eventual resolution of the technical and social obstacles to a deep geological repository or some other technical method not yet determined.

Placing Parameters

The containment and isolation of high-level radioactive waste is an intractable problem as long as wastes continue to be generated. The nuclear industry's go-to argument in defence of deep geological repositories as an end point for the long-term management of radioactive wastes is that society cannot be expected to continue uninterrupted on surface, referencing the risks of war, climate catastrophe and social collapse. However, as long as wastes continue to be generated, the most dangerous wastes must remain on surface, and at the reactor site. Irradiated fuel (nuclear fuel waste) must be water cooled in for the first 6-10 years in the irradiated fuel bay[4], and for at least thirty years above surface due to the heat generated by the irradiated fuel.[5]

Who makes the calculation as to when social collapse is going to occur? And who can accurately foresee that "moment" of collapse forty years into the future?

In practical terms, no sites can be closed, no nuclear generation stations decommissioned, and no relief found from the most radioactive and most vulnerable wastes being at greatest risk as long as wastes continue to be generated through the operation of nuclear generating stations.

Ending production is the essential first step in establishing a foundation for a successful long-term waste management plan. The following elements comprise a risk-reduced approach for the long term management of nuclear fuel waste. A similar or only slightly modified approach could be applied to the long-term management of so-called intermediate level wastes, all of which are highly radioactive and some with levels of radioactivity and hazard similar to irradiated fuel. However, the focus of this brief paper is irradiated fuel, also known as nuclear fuel waste or spent fuel, and categorized in Canada as "high level" radioactive waste.

Pre-Conditions

In addition to the above noted necessity of ceasing production, the following are necessary components to any effective radioactive or hazardous waste management system, including the one under discussion:

- Wastes must be appropriately categorized, commensurate with their hazards and management requirements
- Wastes must be fully characterized, including a radiological and chemical characterization
- Wastes must be inventoried, and these inventories must be peer reviewed by a multi-disciplinary team, and readily available to decision-makers, the public, and Indigenous peoples
- Wastes must be labeled and tracked, in a system which links the inventory with the location, characterization and containment method for each waste package
- Waste storage must be monitored, and performance of the storage systems measured for any releases
- Waste storage monitoring results must be recorded and must be readily available to decision-makers, the public, and Indigenous peoples

Prepared for the Future

In Canada, very little work has been done in the field of extending and making on-site storage of radioactive wastes more secure. A generalized report was prepared for Ontario Power Generation on behalf of Canadian nuclear fuel owners in 2003 which described conceptual designs for reactor-site extended storage facilities for used nuclear fuel[6]. In comparison, there are numerous reports by U.S. agencies and organizations, some of which include very detailed technical discussions of aging of both fuel and storage system components[7], and others which provide detailed discussions of options to increase the robustness of a storage site or system.[8] Unfortunately, the corollary work has not yet been done for the Canadian / CANDU context.

In other jurisdictions, three features have been identified for a storage / management system which would make spent fuel storage more secure, particularly in terms of potential security threats, extreme weather events, or human error:

- Wastes are placed in a condition where the waste is passively safe, i.e. the system does not rely on electrical power, cooling water or active ongoing maintenance
- The facility is "hardened", by placing layers of concrete, steel, gravel or other materials – in various combinations – above and / or around the irradiated fuel waste storage structure
- The fuel waste storage facilities are dispersed, with the fuel storage structures distributed across the site, subject to site conditions, rather than being concentrated in a single area

The feature of passive safety is key in making the waste more secure from human or operational error or natural events. In some situations and designs, dispersal can also be advantageous in keeping the waste secure from human or operational error, extreme weather events, or terrorist attacks.

There are certain fundamental requirements of any reliable management system for radioactive wastes, regardless of the time frame. Whether the storage is intended for fifty years or for fifty thousand years, the following elements must be in place:

- The system must be developed with **monitoring** as a design fundamental; monitoring is required of the containment systems in order to detect any releases of radionuclides, including via the movement of water or gasses
- The system – including monitoring methods – must provide means to **measure** the performance of each of the barriers which form the containment system, and to be able to not only identify failures, but also anticipate failure by detecting material changes to any of the barriers or barrier materials (e.g. corrosion, embrittlement)
- The ability to access and **retrieve** waste packages or containers is key to being able to respond to any failures detected through the monitoring program and the measured performance of the system elements
- Waste packages and containers and the overall containment system – including layout, location and design – must support the **replacement, repair and/or re-encapsulation** of failed containers; an expectation that this will be required must be built into the system, rather than simply assigning this management step the status of a "contingency" which will be developed should the need arise. The system must assume that the need will arise, and have built into the system the ability to meet that need

In addition to meeting the very necessary and fundamental requirements outlined above, the system must align with sound principles of radioactive waste management, such as the "proximity principle" which directs that the waste is dealt with as close to its point of generation as is reasonably possible, plus key principles embedded in Canadian environmental decision-making, including risk and harm reduction, precautionary principle, and polluter play.

Perpetual Care

Radioactive wastes will require perpetual care. With the potential to cause harm to humans and the environment humans rely upon for hundreds of thousands of years, there is no easy solution and no quick way out. A sound approach to radioactive waste management – essentially, the containment of radioactive wastes such that they are kept separate and isolated from the environment – must be one of perpetual care.

Two mutually compatible approaches have been developed by civil society organizations which adopt the principles and responsibility for perpetual care. The first is described as Nuclear Guardianship,[9] and was developed in the U.S. in the 1990s and has evolved since its first release. The second is "Rolling Stewardship"[10], a concept also developed in the 1990s and more recently applied to radioactive waste management by the Canadian Coalition for Nuclear Responsibility.

Nuclear Guardianship is a citizen commitment to present and future generations to keep radioactive materials out of the biosphere.

Nuclear Guardianship requires:

- interim containment of radioactive materials in accessible, monitored storage, so that leaks can be repaired, and future technologies for reducing and containing their radioactivity can be applied;
- stringent limits on transport of radioactive materials, to avoid contaminating new sites, and to minimize spills and accidents;
- cessation of the production of nuclear weapons and nuclear energy;
- transmission to future generations of the knowledge necessary for their self-protection and ongoing guardianship through time.

The Concept of Rolling Stewardship

1. Humans can contain waste securely for decades at a time.
2. Recognizes a solution to the problem does not yet exist
3. Continual monitoring of waste is essential.
4. Retrieval is anticipated and actively planned for.
5. Periodic repackaging is an integral part of the process.
6. If leakage occurs timely corrective action will be taken.
7. Rolling Stewardship is based on persistence of memory.
8. Information is readily transmitted to the next generation .
9. Ongoing reminder that the problem remains to be solved.

Next Steps

This brief paper does not aspire to set out technical options or design details for extended on-site storage systems for CANDU fuel waste. Its purpose it to establish a framework for moving forward on improving the short and mid-term (100 to 300 years) security of nuclear fuel waste in Canada, including the parameters and pre-conditions set out above, and the principles of perpetual care. The next step is a peer review of this paper, followed by a technical review of early conceptual work done by Canadian utilities on options for extended on-site storage, with improving robustness and security as the primary objective

ENDNOTES

---

[1] Deep geological repository: The definition by the Canadian Nuclear Safety Commission is "A facility where radioactive waste is placed in a deep, stable geological formation (usually several hundred metres or more below the surface). The facility is engineered to isolate and contain radioactive waste to provide the long-term isolation of nuclear substances from the biosphere. Also called deep geologic repository."

[2] See for example, these two papers on extended on-site storage: 1) IAEA, "International Atomic Energy Agency (IAEA) Technical Meeting on Extending Spent Fuel Storage Beyond The Long Term", 22–24 October 2012, and 2)Nuclear Regulatory Commission, "Project Plan for the Regulatory Program Review to Support Extended Storage and Transportation of Spent Nuclear Fuel", June 2010

[3] Technical and design concerns with the deep geological repository concept include increased risk of releases and failures associated with damaged fuel, container failure including due to corrosion, risks associated with repackaging, transportation risk, opportunity for human error over the life expectancy of the repository, issues related to failures in the various engineered and geological barriers upon which the concept relies, including but not limited to those of gas generation, heat, microbial activity and synergistic effects. Related reports include "Rock Solid? A scientific review of geological disposal of high-level radioactive waste", Wallace, Helen, 2010

[4] See, for example, the description at http://nuclearsafety.gc.ca/eng/waste/high-level-waste/index.cfm

[5] See, for example, "Postclosure Safety Assessment of a Used Fuel Repository in Sedimentary Rock, Document Number: NWMO TR-2013-07", as posted at https://ceaa-acee.gc.ca/050/documents/p17520/117099E.pdf

[6] CANTech, "Conceptual Designs for Reactor-site Extended Storage Facility Alternatives for Used Nuclear Fuel Alternatives for the Pickering, Bruce and Darlington Reactor Sites Report of a Study carried out for Ontario Power Generation, New Brunswick Power, Hydro- Québec and Atomic Energy of Canada Limited, April 2003

[7] See, for example, 1) Mcconnell1, Paul*, Brady Hanson2, Moo Lee3, And Ken Sorenson1 1Transportation Manager, "Extended Dry Storage Of Used Nuclear Fuel, Technical Issues: A USA Perspective", US Department of Energy Fuel Cycle Technologies Program Received September 28, 2011, or 2) Rigby, Dr. Douglas B, "United States Nuclear Waste Technical Review Board Evaluation of the Technical Basis for Extended Dry Storage and Transportation of Used Nuclear Fuel"
December 2010

[8] See, for example, 1) Alvarez, Robert, et al "Reducing the Hazards from Stored Spent Power-Reactor Fuel in the United States", *Science and Global Security, 11:1–51, 2003, 2)* Alvarez, Robert "Improving Spent-Fuel Storage at Nuclear Reactors", Winter 2012, 3) Thompson, Gordon, "ROBUST STORAGE OF SPENT NUCLEAR FUEL: A Neglected Issue of Homeland Security" Institute for Resource and Security Studies, January 2003 or 4) "Storage of Spent Nuclear Fuel at the Pickering Site: Risks and Risk-Reducing Options", Institute for Resource and Security Studies for the Ontario Clean Air Alliance, 2018.

[9] Based on the pioneering work of eco-philosopher Joanna Macy, Nuclear Guardianship combines art, science, and remembrance to address the seemingly intractable human-caused problem of nuclear contamination with wisdom and creativity. Read more HERE

[10] Rolling Stewardship is an intergenerational waste management concept whereby each successive generation passes on the knowledge and provides the necessary resources to the next generation, so that nuclear wastes are never placed beyond human control and are never left unattended. Read more HERE and HERE