

# **Proposed Guiding Principles for Recycling/Reprocessing Used Fuel in Canada**

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**P.D. Thompson**  
NB Power  
[pthompson@nbpower.com](mailto:pthompson@nbpower.com)

## **Abstract**

The commercial nuclear power industry in Canada currently utilizes a once through fuel cycle strategy of the natural uranium dioxide fuel in CANDU reactors. This fuel cycle is well known, safe, cost effective, and the end of cycle disposal pathway is by the waste owners funded and managed through the Nuclear Waste Management Organization's establishment of a Deep Geological Repository. Reprocessing of used nuclear fuel to extract the fission products and reuse the fissile and fissionable transuranic isotopes to produce energy in a commercial power reactor, is not currently performed in Canada. This paper outlines the potential benefits to recycling/reprocessing of used nuclear fuel in Canada and proposes guiding principles that would need to be followed. The paper also discusses how the existing regulatory framework in Canada would ensure these guiding principles would be adhered to.

## **1. Background**

Reprocessing of used nuclear fuel to extract the fission products and reuse the fissile and fissionable transuranic isotopes to produce energy in a commercial power reactor, is not currently performed in Canada, although chemical extraction of fuel targets at Canadian National Laboratories (CNL) to extract medical isotopes has been routinely performed. A number of other countries however either have, or continue to, reprocess used fuel. Most but not all of these countries happen to be nuclear weapons states.

The reprocessing and recycling of used nuclear fuel has some important advantages which, depending on the design and fuel conversion ratio of the reactor, can include:

- Improved efficiency of the fuel cycle by extracting more energy from what would otherwise be treated as waste,

- Significantly reduced amount/volume of long-lived isotopes, thereby improving the public acceptability of nuclear power and the disposal of radioactive waste,
- The establishment of a sustainable fuel cycle and significantly extending the availability of uranium supply, and
- Reduced demand for fuel enrichment, including that for the production of high assay low enriched uranium.

While reprocessing of used CANDU fuel for re-use in CANDU reactors has not been economically attractive to pursue, the above benefits could potentially be realized in a cost-effective manner for advanced Gen IV fast fission reactors, two of which are specifically being developed currently in New Brunswick, Canada.

## **2. Need for a Policy Statement**

Review of the various policies, regulations, international agreements, etc. reveal there appears to be no policy inhibitors to prevent the reprocessing of used nuclear fuel for peaceful purposes in Canada. However, this topic is expected to be of sufficient interest to the Canadian public, Indigenous population, and the international community. In addition, given the sensitivity resulting from the atomic weapons test performed by India in 1974 using reprocessed used fuel from a research reactor supplied by Canada in 1954, it is felt it is essential for Canada to be open, transparent, and beyond reproach with its plans and guiding policy related to the reprocessing of used nuclear fuel.

## **3. Development of Guiding Principles**

The nuclear industry established an SMR recycling/reprocessing task team under the CANDU Owners Group. Following several discussions with senior representatives in NRCAN, Global Affairs Canada, and the CNSC departments of security, safeguards, import and export control, high level principles were developed that the task team believes provides the necessary guidance on the key areas of interest. These principles could form the basis of a national policy.

## **4. Proposed High Level Guiding Principles**

- I. Recycling/reprocessing in Canada would only be done for peaceful uses***
- II. Adequate provisions must be in place to respect Canada's international obligations related to nuclear non-proliferation of controlled nuclear substances, equipment, and information***
- III. Adequate provisions need to be in place to limit risks to the health and safety of persons and the environment***

- IV. Waste owners shall arrange for long-term management of radioactive wastes generated by recycling/reprocessing activities***
- V. Adequate provisions need to be in place to limit risks to the health and safety of persons and the environment related to the secure transportation of reprocessed fuel***
- VI. Import/export of controlled nuclear substances, equipment and information, would be governed through Nuclear Co-operation Agreements with supporting Administrative Arrangements, as well as the Additional Protocol to Canada's comprehensive safeguards agreement with the IAEA.***

Canada already has the necessary legislative and regulatory framework in place that would ensure that these principles would be adhered to, thereby ensuring reprocessing would be done safely with regards to impact on workers, the public and environment, and that Canada's international obligations (*to non-proliferation*) would be met.

## **5. Legislative and Regulatory Framework that already exists in Canada**

Canada has an extensive legislative and regulatory framework that appears to address all of these principles. The key elements of the framework involve:

- Canada being a signatory to the Treaty on Non-Proliferation of Nuclear Weapons (NPT) and a Canadian comprehensive safeguard agreement with the IAEA
- Canada being a signatory to an additional Protocol to Canada's comprehensive safeguards agreement with the IAEA
- Nuclear Cooperation Agreements that Canada has with other countries
- Administrative Arrangements with CNSC
- The Canadian Nuclear Regulatory Framework starting with the Nuclear Safety and Control Act, the associated regulations and CNSC regulatory documents
- The Transport of Dangerous Good Regulations
- The Government of Canada's Policy Framework for Radioactive Waste (currently under review)
- The Nuclear Fuel Waste Act
- Impact Assessment Act

Appendix I provides a mapping of the principles to the elements of the framework along with providing additional commentary that serves to the extensive rigour that will be undertaken to ensure reprocessing would be done safely with regards to impact on workers, the public and environment, and that Canada's international obligations (*to non-proliferation*) would be met.

## **6. Communication will be a key ingredient in implementing a Policy**

A good communication and engagement plan that is well executed is a key ingredient of rolling out a policy such as this. It is important to convey to the general public, Indigenous groups and the international community that these principles address all the key areas and that they are supported by Canada's rigorous and extensive existing legislative and regulatory framework.

## **7. Summary and Conclusion**

Reprocessing and recycling of used nuclear fuel has a number of important advantages that will become important in the future, especially when Generation IV fast reactors are introduced to Canada. While there are no policy inhibitors to prevent the reprocessing of used nuclear fuel for peaceful purposes in Canada, this topic is expected to be of sufficient interest to the Canadian public, Indigenous population, and the international community that a policy would be warranted.

The paper presents high level guiding principles that could form the basis for a policy to ensure that if reprocessing were to take place in Canada, that it would be done safely with regards to impact on workers, the public and environment, and that Canada's international obligations (*to non-proliferation*) would be met.

Canada already has an extensive and rigorous legislative and regulatory framework to ensure that these principles would be adhered to.

A well executed communication and engagement plan is viewed as a key ingredient of success in introducing the policy.

With such a policy in place, a proponent would be in a position to decide, based on their assessment of the technological and economic feasibility of a given reprocessing process, if and when, they were going to proceed with a specific reprocessing project. Control to ensure the guidelines/policy is met would be through the regulatory process to licence such a facility and its associated required impact/environmental assessment.

## **8. Acknowledgements**

The author acknowledges the contributions of the COG SMR Recycling/Reprocessing Task Team and the excellent discussions with senior level representatives of NRCan, Global Affairs Canada, and the CNSC departments of security, safeguards, import and export control.

## APPENDIX I

### Canada's Framework to ensure that the Guiding Principles are met

The existing framework already exists in Canada to ensure the guiding principles are met. This is discussed below.

#### Non-proliferation and Security

Principles 1,2 and 6.

- *Recycling/reprocessing in Canada would only be done for peaceful uses,*
- *Adequate provisions must be in place to respect Canada's international obligations related to nuclear non-proliferation of controlled nuclear substances, equipment and information,*
- *Import/export of technology, material and equipment would be governed through Nuclear Co-operation agreements with supporting Administrative Arrangements*

Existing framework and discussion:

Canada was the first country with substantial nuclear capability to reject nuclear weapons. Canada continues to be actively involved in the international promotion of the peaceful use of nuclear energy.

The Canadian Nuclear Safety Commission (CNSC) is responsible for implementing Canada's nuclear non-proliferation policy.

In addition, the CNSC participates in several international nuclear organizations in order to strengthen nuclear safety and non-proliferation at home and abroad.

- [IAEA Emergency Preparedness Review \(EPREV\) mission to Canada](#)
- [IAEA Integrated Regulatory Review Service mission to Canada](#)
- [International agreements](#)
- [Nuclear non-proliferation](#)
- [Nuclear materials verification \(IAEA safeguards\)](#)

The CNSC is responsible for implementing Canada's nuclear non-proliferation policy, which contains two broad, long-standing objectives:

1. to assure Canadians and the international community that Canada's nuclear exports do not contribute to the development of nuclear weapons or other nuclear explosive devices
2. to promote a more effective and comprehensive international nuclear non-proliferation regime

The cornerstone of the international nuclear non-proliferation regime is the [Treaty on the Non-Proliferation of Nuclear Weapons](#) (NPT).

The NPT establishes commitments to prevent the spread of nuclear weapons, promote cooperation on the peaceful uses of nuclear energy and achieve nuclear disarmament.

Canada is an original signatory to the NPT and has centered on the treaty's provisions.

The CNSC, through the [\*Nuclear Safety and Control Act\*](#) (NSCA) and corresponding regulations, implements Canada's NPT commitments:

- not to receive, manufacture or acquire nuclear weapons or other nuclear explosive devices
- to accept International Atomic Energy Agency (IAEA) safeguards on all nuclear material in peaceful uses in Canada
- to ensure that Canada's nuclear exports to non-nuclear-weapon states are subject to IAEA safeguards

Under the NSCA and its regulations, Canadian importers and exporters are required to obtain and comply with CNSC licences controlling the international transfer of nuclear and nuclear-related items. Licensees must respect Canada's nuclear non-proliferation commitments.

Through the licensing process, the CNSC takes steps to ensure that nuclear imports and exports are consistent with Canada's nuclear non-proliferation policy.

The policy requires major nuclear exports to be subject to a nuclear cooperation agreement between Canada and the importing country.

These agreements establish reciprocal obligations that are designed to minimize the risk of proliferation associated with the international transfer of major nuclear items.

The CNSC participates with Foreign Affairs, Trade and Development Canada (DFATD) in the negotiation of bilateral nuclear cooperation agreements and implements administrative arrangements with its foreign counterparts to effectively fulfill the terms and conditions of these agreements.

The approaches and measures utilized by the IAEA to verify that nuclear material is not diverted from peaceful uses to nuclear weapons or other nuclear explosive devices in accordance with NPT commitments are commonly referred to as "safeguards".

In 1972, Canada was the first country to bring into force a [\*comprehensive safeguards agreement\*](#) with the IAEA pursuant to the NPT. The safeguards agreement gives the IAEA the right and obligation to monitor Canada's nuclear-related activities and verify nuclear material inventories and flows in Canada.

In 2000, as part of worldwide efforts to strengthen IAEA safeguards, Canada brought into force the Additional Protocol to its comprehensive safeguards agreement with the IAEA.

The Additional Protocol gives the IAEA enhanced rights of access to nuclear sites and other locations and provides it with access to information about nuclear-related activities in Canada above and beyond its rights under the original safeguards agreement.

The CNSC is responsible for implementing the Canada/IAEA safeguards agreement and the Additional Protocol. Through the [NSCA](#), regulations and licences, the CNSC implements regulatory controls for the production, use, storage and movement of nuclear material in Canada.

Conditions for the application of IAEA safeguards are contained in nuclear facility operating licences.

Through its regulatory process, the CNSC ensures that all relevant licensees have in place safeguards policies and procedures that include:

- the reporting and monitoring of nuclear material and activities
- the provision of IAEA safeguards inspector access to nuclear facilities

The CNSC performs compliance and auditing activities to ensure licensees' safeguards policies and procedures remain sufficient to meet the safeguards requirements of the agreement and Additional Protocol.

The CNSC maintains a national system that accounts for and controls nuclear materials in Canada, and supplies reports to the IAEA that serve as a basis for IAEA inspection and monitoring activities.

The CNSC also cooperates with the IAEA in developing new safeguards approaches for Canadian facilities and contributes to efforts to strengthen safeguards internationally.

As part of this effort, the CNSC, through its Safeguards Support Program, assists the IAEA in developing advanced safeguards equipment or techniques aimed at strengthening the effectiveness and efficiency of safeguards implementation.

The program also supports domestic needs in resolving specific safeguards issues related to Canadian nuclear facilities and the use of nuclear material.

The CNSC participates in a number of international committees and groups as well as international meetings and research projects committed to ensuring the safe, secure and peaceful use of nuclear materials and technology.

Membership and participation in these international activities ensure that the CNSC's regulatory activities are consistent, as appropriate, with internationally agreed upon best practices and principles.

Membership and participation also ensure that CNSC guidance, policies and technical standards are current. Through the CNSC's participation in various international nuclear fora, Canada's position on nuclear regulatory matters is heard.

In particular, the CNSC participates in various committees and activities of the [IAEA](#) and [Nuclear Energy Agency](#). As part of its work with these organizations, the CNSC represents Canada, or participates in broader Canadian delegations in a wide variety of relevant multilateral discussions, symposia and conferences that address such issues as:

- the physical protection of nuclear materials and facilities
- international transport of nuclear and other radioactive material
- nuclear safety
- radiation protection
- radioactive waste management
- nuclear safeguards
- nuclear regulation

In 2015, the CNSC gained observer status in the [Western European Nuclear Regulators Association](#) (WENRA). The CNSC made the request to become an observer, to promote the exchange of experiences with fellow regulators and learn from international best practices. As an observer, the CNSC will have the opportunity to participate in WENRA's working groups on reactor harmonization and on waste and decommissioning.

The CNSC also participates with Global Affairs Canada in two multilateral nuclear export control mechanisms: the Nuclear Suppliers Group and the Zangger Committee. Canada was a founding member of both these bodies.

The CNSC contributes technical and policy expertise in meetings and working groups of these committees to:

- ensure that the guidelines established by these bodies relating to conditions of nuclear supply effectively address proliferation threats
- ensure that the lists of controlled items take into account advances in nuclear and nuclear-related technology

The implementation of the CNSC's statutory responsibilities for the regulation of Canadian nuclear exports is consistent with the guidelines of these bodies.

The IAEA implements State-level safeguards in Canada, whereby the frequency and intensity of verification activities, facilitated by the CNSC, are dependent, *inter alia*, upon the IAEA's independent assessment of the technical pathways available to Canada for the acquisition of weapons-usable material. The potential impact on these activities of a new domestic reprocessing capability within the Canadian nuclear industry will be assessed by CNSC in discussion with the IAEA, through a best-practice process known as Safeguards by Design.

## **Security**



Nuclear security is a major consideration for all CNSC activities. The CNSC is responsible for enforcing Canada's Nuclear Security Regulations, as enabled by the Nuclear Safety and Control Act. Nuclear security in Canada is aided by federal regulations, which set out detailed security requirements for licensed nuclear facilities. The CNSC's approach follows international physical protection best practices and standards recommended by the International Atomic Energy Agency.

CNSC staff assess if licensees meet the requirements of the Nuclear Security Regulations and the conditions of their licences through ongoing compliance verification activities. The specific areas of security include: facilities and equipment, security practices, response arrangements, and drills and exercises. The CNSC has worked closely with nuclear facility operators, law enforcement and intelligence agencies, international organizations and other governmental departments to ensure that nuclear materials and facilities are adequately protected.

## **Safety**

### **Principle 3**

***Adequate provisions need to be in place to limit risks to the health and safety of persons and the environment.***

The Canadian Nuclear Safety Commission regulates the full life cycle of a facility. The mandate of the CNSC as defined in the Nuclear Safety and Control act is to:

- (a)** to regulate the development, production and use of nuclear energy and the production, possession and use of nuclear substances, prescribed equipment and prescribed information in order to
  - (i)** prevent unreasonable risk, to the environment and to the health and safety of persons, associated with that development, production, possession or use,
  - (ii)** prevent unreasonable risk to national security associated with that development, production, possession or use, and
  - (iii)** achieve conformity with measures of control and international obligations to which Canada has agreed; and
- (b)** to disseminate objective scientific, technical and regulatory information to the public concerning the activities of the Commission and the effects, on the environment and on the health and safety of persons, of the development, production, possession and use referred to in paragraph (a).

The CNSC carries out this mandate through a comprehensive framework of regulations supported by regulatory documents, and Licences covering the entire life cycle of a facility. Facility licences are required for; the Licence to prepare site, Licence to

construct, Licence to operate, and Licence to decommission. The CNSC conducts the licensing process in an open and transparent manner, holding public hearings that allow for public and indigenous interventions.

The licence application process ensures the following safety and control areas are addressed in a systematic and comprehensive manner.

- management system
- human performance management
- operating performance
- safety analysis
- physical design
- fitness for service
- radiation protection
- conventional health and safety
- environmental protection
- emergency management and fire protection
- waste management
- security
- safeguards and non-proliferation
- packaging and transport

## **Waste**

### Principle 4

***Waste owners shall arrange for long-term management of radioactive wastes generated by recycling/reprocessing activities***

The Regulatory framework including any Environmental Assessment or Impact Assessment under the Impact Assessment Act, ensures the full life cycle of a facility, including waste management is considered upfront in the licensing of a facility. Thus, an EA or IA can not be granted, or a licence to prepare a site issued, unless there is a credible pathway for the management and disposal of radioactive wastes. The licensing process also ensures there are adequate plans and financial guarantees for the decommissioning of the facility and long term disposal of used nuclear fuel.

The Nuclear Waste Management Organization (NWMO) was established as an outcome of the Nuclear Fuel Waste Act. The NWMO is responsible to take used nuclear fuel from waste owners, or in the case of reprocessing, high level radioactive waste. NWMO follows and adaptive phase management approach that utilizes the concept of a Deep Geological Repository (DGR).

## **Transportation**

### Principle 5

***Adequate provisions need to be in place to limit risks to the health and safety of persons and the environment related to the secure transportation of reprocessed fuel***

In Canada such shipments fall under Class 7 of Transport Canada's Transportation of Dangerous Goods Regulations. They also fall under CNSC's Nuclear Safety and Control Act and are regulated under the Packaging and Transport of Nuclear Substances Regulations, which in turn is in alignment with IAEA Safety Standards Series No. SSR-6, Regulations for the Safe Transport of Radioactive Material. Transport Canada and the CNSC cooperate in regulating the transport of nuclear substances through a Memorandum of Understanding (MOU)

### Packaging and transport of nuclear substances

All nuclear substances are transported in packages that are selected based on the nature, form, and quantity or activity of the substance. There are general design requirements that apply to all package types to ensure that they can be handled safely and easily, secured properly, and are able to withstand routine transport conditions.

The CNSC issues licences and certificates in certain cases for the packaging and transport of nuclear substances as stipulated in the [\*Packaging and Transport of Nuclear Substances Regulations, 2015\*](#) (PTNSR 2015). These regulations are based on the International Atomic Energy Agency's (IAEA's) SSR-6, [\*Regulations for the Safe Transport of Radioactive Material, 2018 Edition\*](#).

The PTNSR 2015 introduced an ambulatory reference to the IAEA Regulations and no longer explicitly identify and list relevant paragraphs from them. This change ensures that Canadian regulations will continue to align with international regulations if international regulations are modified.

The CNSC published [\*REGDOC-2.14.1, Volume I: Information Incorporated by Reference in Canada's Packaging and Transport of Nuclear Substances Regulations, 2015\*](#), to help the regulated community comply with the PTNSR 2015. REGDOC-2.14.1 links provisions in the regulations to relevant content in the IAEA Regulations, the *Nuclear Safety and Control Act*, other CNSC regulations, and other related information.

### Certification of transport packages and special form radioactive material

The CNSC regulates all aspects of the packaging and transport of nuclear substances, including the design, production, use, inspection, maintenance and repair of packages. In addition, the PTNSR 2015 require that certain types of package design be certified by the CNSC prior to being used in Canada. They also include provisions for the certification of special form radioactive material, which specify that the sealed source containing the radioactive material must be designed to be strong enough to maintain leak tightness under the conditions of use and wear for which it was designed.

Learn more about the [certification process for transport packages](#).

See the list of [CNSC certified transport packages and special form radioactive material](#).

## Transport licences

The transport of nuclear substances is a regulated activity in Canada, with CNSC licensees involved in the majority of shipments. In general, the transport of nuclear substances does not require a CNSC transport-specific licence. The PTNSR 2015 require that specific transport licences be issued only in the following circumstances:

- transport of Category I, II or III nuclear material
- transport of nuclear substances while in transit
- transport of nuclear substances contained in large objects
- transport of nuclear substances when the transport cannot meet all of the regulatory requirements
- transport of nuclear substances that require a multilateral approval of shipments
- transport of nuclear substances that require a special use vessel

The majority of these licences are issued for the transport of in-transit shipments (i.e., nuclear substances transiting Canada while being transported from one country to another) and for the transport of Category I, II and III nuclear material.

Details on the specific information requirements for each type of transport licence application can be found in section 6 and section 7 of the [PTNSR 2015](#).

### Category I, II and III nuclear material

A CNSC licence to transport Category I, II or III nuclear material is required to transport material that is defined in section 1 of the [Nuclear Security Regulations](#), such as plutonium, various grades of unirradiated uranium-235, and irradiated fuels consisting of depleted or natural uranium, thorium or low-enriched fuel.

[REGDOC-2.12.3, Security of Nuclear Substances: Sealed Sources and Category I, II and III Nuclear Material](#), offers assistance in preparing a written transportation security plan as required under section 5 of the *Nuclear Security Regulations* when applying for these licences.