NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Used Nuclear Fuel Reprocessing

Canadians have expressed interest in knowing more about the possibility of recycling or reusing used nuclear fuel. Reprocessing involves the separation of potentially fissile materials, such as plutonium, from used nuclear fuel through the application of chemical and physical processes for recycling in a reactor. Over the past half century, the principal reason to reprocess used nuclear fuel is to gain more energy from the original uranium and contribute to a country's nuclear energy security.

Today, several countries, including France, Japan, the United Kingdom and Russia, reprocess used nuclear fuel. Other countries such as Germany, Switzerland, Sweden and Belgium that had previously reprocessed used nuclear fuel are no longer doing so. Some have issued a ban or moratorium on reprocessing for reasons that include economic viability and environmental or nuclear proliferation concerns. In the United States, no civil reprocessing plants are currently operating largely due to concerns about proliferation potential of the technology. However, with the recent cancellation of the Yucca Mountain Project, there has been renewed interest in examining the reprocessing question in that country, together with consideration of advanced nuclear fuel cycles.

In Canada, independent studies commissioned by the Nuclear Waste Management Organization (NWMO) have concluded that reprocessing CANDU used nuclear fuel produces residual radioactive wastes that could be more difficult to manage than used nuclear fuel in its un-reprocessed form, potentially separates out material that could be used in the production of nuclear weapons, and is prohibitively expensive and far from being economically viable at this time. However, the NWMO is committed to continue to keep abreast of international developments in reprocessing and alternative waste management technologies.

Regardless of whether or not a country chooses to reprocess used nuclear fuel, a long-term management approach such as a deep geological repository would still be required for the used nuclear fuel or the residual high-level radioactive waste and other by-products from reprocessing. The NWMO's current reference plan is the containment and isolation of used nuclear fuel in a deep geological repository with the possibility to retrieve the used fuel if needed. This is consistent with the practice followed in Sweden, Finland and almost all other countries with a large nuclear energy program. As well, a deep geological repository is the preferred approach for the long-term management of high-level wastes from the reprocessing cycle (e.g. in France, Japan and the United Kingdom).

Reprocessing in Canada would be a joint decision by the nuclear energy producers, the associated provincial governments and the federal government. Should such a decision be made to reprocess some of or all Canada's used nuclear fuel, the NWMO would review its plans in consultation with interested parties with regard to the management of high-level waste arising from reprocessing. Canada's plan for the long-term management of used nuclear fuel, called Adaptive Phased Management, has sufficient flexibility to manage used nuclear fuel directly or the high-level waste products resulting from reprocessing.

What is used nuclear fuel reprocessing?

When used (or sometimes called "spent") nuclear fuel is removed from a commercial nuclear power reactor, it contains a small amount of plutonium 239 that can be physically and chemically separated from the bulk uranium (mostly uranium 238). The used nuclear fuel also contains other materials such as the highly radioactive fission products and minor actinides. The recovered plutonium 239 can, in principle, be recycled into fresh unirradiated nuclear fuel to form mixed-oxide (MOX) fuel to use in existing or future nuclear power plants. Among the by-products of reprocessing are highly radioactive substances that require careful long-term management.

The most commonly used reprocessing method is to dissolve used fuel in a nitric acid bath and use chemical methods to separate the constituents. This takes place after the used fuel is removed from the reactor and is allowed to cool for a number of years. Commercial reprocessing plants are large, complex facilities requiring significant capital investments.

Can used nuclear fuel from CANDU reactors in Canada be reprocessed?

Most of the existing used nuclear fuel in the world is produced by light water reactors (LWRs) that use enriched uranium. Used fuel from LWRs contains a larger amount of fissile material that may potentially be recovered from reprocessing – about five times as much as used CANDU fuel, which is based on natural uranium.

The specific composition of used CANDU fuel offers very little incentive to reprocess used fuel in Canada if the sole purpose is to recover fissile material. In fact, the concentration of fissile plutonium 239 (and uranium 235) in used CANDU fuel is substantially smaller than the concentration of these isotopes in enriched pressurized water reactor (PWR) fuel. As well, the concentration of uranium 235 in used CANDU fuel is similar to the concentration of uranium 235 in depleted uranium from the light water fuel enrichment process. Used CANDU fuel contains very little fissile material, much less than natural uranium, and the only incentive for recycling would be to recover the small amounts of plutonium 239 it contains. Small-scale reprocessing experiments were conducted at Atomic Energy of Canada Limited's (AECL) Chalk River Laboratories many years ago.

Did the NWMO consider reprocessing as a waste management option?

Yes. The *Nuclear Fuel Waste Act (NFWA)* required the NWMO to study approaches based on three methods for the long-term management of used nuclear fuel: deep geological disposal in the Canadian Shield; storage at nuclear reactor sites; and centralized storage, either above or below ground. The *NFWA* also allowed the NWMO to consider other management approaches in the course of its study.

The first NWMO discussion document, *Asking the Right Questions?*, identified other methods that have been advanced in the past by governments, industry and researchers. These methods included reprocessing, partitioning and transmutation of used nuclear fuel. The NWMO noted the high level of interest by Canadians in knowing more about the possibility of "recycling" or "reusing" used nuclear fuel, practices that society has come to expect in many other areas of our lives. Following its study, the NWMO did not identify reprocessing as a practical or desirable management approach for Canada's used nuclear fuel under current circumstances. The NWMO keeps a watching brief on the development of these and other alternative used nuclear fuel management technologies as part of its ongoing effort to incorporate new learning and knowledge, and it reviews and adjusts Canada's management plans for used nuclear fuel as needed over time.

Why is reprocessing not considered a viable waste management option in Canada at the present time?

For a number of reasons, reprocessing is considered highly unlikely to be a viable nuclear waste management method for Canada at this time.

First, nuclear reactors in Canada use the CANDU reactor system. At present, these reactors use natural uranium fuel in a once-through fuel cycle, meaning the nuclear fuel is placed in the reactor one time and then discharged for interim storage and future long-term management. CANDU fuel contains fissile uranium 235 at a natural concentration of about 0.7%. Most (400+) other nuclear reactors in the world are light water reactors, such as pressurized water reactors (PWR), that use fuel enriched in uranium 235 at a concentration of about 3.5% to 4.5% and have proportionally higher concentrations of plutonium 239, uranium 235 and other fission products in the used fuel. The relatively low concentration of these potentially recoverable materials in used CANDU fuel has been an economic disincentive to proceed with reprocessing in Canada using technologies available today.

Second, while there is no purely technical obstacle to reprocessing, the abundant reserves of natural uranium in Canada suggest that it is unlikely that Canada would need to implement reprocessing in the near future for energy security reasons. Canada is a leader in uranium mining, and Canadian uranium reserves are far from being depleted. The cost of reprocessing used nuclear fuel is very high, and it is not expected to be exceeded in the near future by the cost of mined natural uranium.

Third, reprocessing facilities are expensive and produce residual high-level radioactive wastes that could be more difficult to manage than used nuclear fuel in its un-reprocessed form. Recent estimates on reprocessing using existing technology have indicated a cost of $250 billion to $320 billion to reprocess an inventory of about 4 million used CANDU fuel bundles. Reprocessing also requires a commitment to a continuing nuclear fuel cycle, and it can potentially separate out material that could be used in the production of nuclear weapons in the course of the process. Research studies are examining methods to reprocess light water reactor fuel in a form that would be more proliferation resistant and less expensive.

Is the NWMO currently undertaking any studies to determine whether used nuclear fuel should be reprocessed in the future?

No. Used nuclear fuel in Canada is owned by the nuclear energy producers, Ontario Power Generation, Hydro-Québec, New Brunswick Power and Atomic Energy of Canada Limited. Any consideration or decision on reprocessing would be made by these owners of used nuclear fuel, in conjunction with regulators, provincial governments and the Government of Canada.

If at some point Canada were to take a decision to reprocess used nuclear fuel, the NWMO would be responsible for the long-term management of any high-level radioactive wastes resulting from that process.

Why proceed towards a deep geological repository if reprocessing is possible in the future?

Canadians have told the NWMO that this generation of citizens that has enjoyed the benefits of nuclear energy has an obligation to begin provision for managing the waste over the long term. A cornerstone of Canada's plan for the long-term management of used nuclear fuel is the containment and isolation of the used nuclear fuel in a deep repository constructed in a suitable geological formation. This multiple-barrier

system is consistent with programs that have been developed in many other countries with nuclear power programs such as Sweden, Finland, France and the United Kingdom.

Regardless of any future decision on reprocessing, Canada will still require a deep geological repository.

Reprocessing leaves residual high-level radioactive wastes that must be safely managed over the long term. For example, France, which is the country leading research on reprocessing in the world today, has also identified the need for the construction of a deep geological repository as part of its long-term management plan and is in the process of selecting a site for the repository.

Canadians have told the NWMO that safety and security are the top priority now and in the future, that this generation must take action now, and that Canada's plan must be consistent with international best practices and be flexible to accommodate changes in technology and social priorities. Proceeding with a deep geological repository is consistent with meeting these needs, including leaving open the option of reprocessing and isolating residual high-level wastes in a deep geological repository.

Are the NWMO's current used nuclear fuel management plans sufficiently adaptable to respond to potential future scenarios that may involve reprocessing?

Yes. By design, Canada's Adaptive Phased Management approach for used nuclear fuel provides the flexibility to adapt management plans as may be required to changes in policy decisions, technological developments and societal priorities.

We do not know what nuclear technologies or waste management methods may be available to future generations, or what they may choose to do with the nuclear wastes that have been generated. We also do not know what the capacity of future generations will be to take an active role in managing this waste. In light of these uncertainties, our obligation is to give them a real choice and the opportunity to shape their own decisions while at the same time not imposing a burden that they may not be able to manage.

Adaptive Phased Management provides for monitoring and retrievability of the used fuel in the repository for an extended period of time. This ensures accessibility to the used fuel for future generations, providing future societies with the flexibility to retrieve the fuel for reprocessing, if required.

Adaptive Phased Management is flexible, and it is capable of addressing waste management issues such as reprocessing in both a social and technical manner. Should Canada reprocess used nuclear fuel in the future, the safe and secure management of the residual wastes from that process would need to be the subject of extensive engagement with Canadians.

Continuous learning through research and development and monitoring of emerging knowledge is paramount to informed decision-making in implementing Canada's plan for the long-term management approach for used nuclear fuel. The NWMO is committed to keeping abreast of international developments in reprocessing and alternative waste management technologies.

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