nwmo
NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

October 2003

NWMO BACKGROUND PAPERS
5. ECONOMIC FACTORS

5-2 STATUS OF FINANCING SYSTEMS FOR HIGH-LEVEL RADIOACTIVE WASTE MANAGEMENT (HLRWM)

GF Energy, LLC

NWMO Background Papers

NWMO has commissioned a series of background papers which present concepts and contextual information about the state of our knowledge on important topics related to the management of radioactive waste. The intent of these background papers is to provide input to defining possible approaches for the long-term management of used nuclear fuel and to contribute to an informed dialogue with the public and other stakeholders. The papers currently available are posted on NWMO's web site. Additional papers may be commissioned.

The topics of the background papers can be classified under the following broad headings:

1. **Guiding Concepts** – describe key concepts which can help guide an informed dialogue with the public and other stakeholders on the topic of radioactive waste management. They include perspectives on risk, security, the precautionary approach, adaptive management, traditional knowledge and sustainable development.
2. **Social and Ethical Dimensions** - provide perspectives on the social and ethical dimensions of radioactive waste management. They include background papers prepared for roundtable discussions.
3. **Health and Safety** – provide information on the status of relevant research, technologies, standards and procedures to reduce radiation and security risk associated with radioactive waste management.
4. **Science and Environment** – provide information on the current status of relevant research on ecosystem processes and environmental management issues. They include descriptions of the current efforts, as well as the status of research into our understanding of the biosphere and geosphere.
5. **Economic Factors** - provide insight into the economic factors and financial requirements for the long-term management of used nuclear fuel.
6. **Technical Methods** - provide general descriptions of the three methods for the long-term management of used nuclear fuel as defined in the NFWA, as well as other possible methods and related system requirements.
7. **Institutions and Governance** - outline the current relevant legal, administrative and institutional requirements that may be applicable to the long-term management of spent nuclear fuel in Canada, including legislation, regulations, guidelines, protocols, directives, policies and procedures of various jurisdictions.

Table of Contents

Executive Summary

This report examines financial systems related to the management of high-level radioactive waste.

GF Energy approached the report by studying and profiling a selection of key countries – the United States, France, Germany, Sweden, United Kingdom, Japan and South Korea – which it believes provide the most relevant information to the NWMO to move forward with its own mandate to provide recommendations to the Government of Canada on how to manage Canada's high-level waste (spent fuel).

General Findings are laid out in the Introduction, in addition to individual Country Profiles organized by geographic location, which provide detailed information to support the following observations:

- Progress on decision-making related to a country's final policy on a waste management solution is closely linked to the progress that country has made with respect to setting in place its related financial systems (including establishment of funding mechanisms, delegation of authorities, management and investment strategies)

- Adoption of open[1] versus closed fuel cycle[2] policies require different funding approaches

- Changes in political climate can easily affect not only a country's policy on waste management, but also its financial system (*i.e.*, the United States has completed R&D, selected a site, won political endorsement and is underway with licensing, but the country's annual Congressional process for allocating federal funds is a significant political hurdle)

- Countries such as Canada and Sweden that use the open fuel cycle and are accumulating volumes of waste (spent fuel) on site tend to be under

[1] See Glossary.

[2] See Glossary.

more pressure to make a final policy decision to deal with long-term management of waste.

- Countries such as France and the United Kingdom that reprocess spent fuel and are able to store waste off-site tend to be under less pressure to make a final policy decision on waste management.

- Regardless of whether or not a policy decision has been made on waste management solutions, all countries covered in this report have implemented financial systems that attempt to address the projected costs for long-term waste management.

Introduction

Assignment

Canada's Nuclear Waste Management Organization (NWMO) asked GF Energy, LLC, to provide a plain-language report on the status of financing systems for high-level waste management.

Interpretation and meaning of the phrase 'high-level waste management' varies widely and may include handling, storage and/or disposal, decommissioning, R&D and many other related expenses. The term is also used to describe not only waste from defense-related activities and concentrated waste that comes from reprocessing, but also spent fuel. For the purposes of this paper, GF Energy has employed the term 'spent fuel waste' when describing waste that comes directly from a commercial nuclear reactor and is not subject to reprocessing. Similarly, the term 'high-level waste' or 'HLW' has been used to describe waste that comes from reprocessing of spent fuel, legacy waste or defense-related waste.

The term 'management' has also been used in this paper to describe the many stages involved in dealing with the long-term nature of spent fuel and HLW. Although some countries such as the US, Germany, Sweden and Japan (which also has a policy to reprocess all of spent fuel) have elected to pursue disposal as a means of managing their spent fuel and waste, other countries have opted for various types of storage.

Whatever the country's management path, financial systems are an integral part of each country's overall strategy in determining responsibilities, accountability and timing. Financial systems entail the financial considerations, cost estimates, arrangements for funds and revenues to cover costs, delegation of authority over funds, in addition to many other factors which are covered throughout this report.

This report covers the variety of approaches currently employed by a selection of different countries, with the aim of providing the NWMO with salient

information to move forward with its own mandate to provide recommendations to the Government of Canada on how to manage spent fuel from Canada's CANDU fleet.

Approach

For the purposes of this report, GF Energy has studied and profiled a selection of key countries – the United States, France, Germany, Sweden, United Kingdom, Japan and South Korea – which it believes provide the most relevant information to the NWMO.

Information was gathered by consulting individuals, databases, publications and electronic media from the Nuclear Energy Agency (the nuclear wing of the Organization for Economic Cooperation and Development), the International Atomic Energy Agency, embassies of individual countries, government departments with responsibility in the area of nuclear energy, and nuclear waste producers and owners (utilities) themselves.

The countries profiled were chosen because they represent the broad spectrum of approaches to financing systems related to the management of high-level waste (including countries that have a once-through cycle[3] and those that are pursuing reprocessing[4]). Very few countries (all except the US, the UK, Sweden and Japan) have come to a final decision on how to manage waste in the long term, but all have endorsed the 'polluter pays principle'[5] either

---

[3] 'Once-through cycle,' also referred to as an 'open fuel cycle' refers to a fuel cycle that does not reprocess spent fuel into new fuel elements. Spent fuel in an open fuel cycle is destined for final disposal or permanent storage, as is the case in Canada, the US and Sweden. See **Glossary** for further explanation.

[4] 'Closed fuel cycle' refers to a fuel cycle that takes spent fuel and after a cooling period reprocesses the material into new fuel elements, as is the case in the United Kingdom and France. See **Glossary** for further explanation.

[5] The 'polluter pays' principle means that all funds for future liabilities such as waste management and reactor decommissioning reactors should be in place in order to avoid the financial burden falling on future generations. The "polluter pays" principle puts the onus not only on the generation that produces the waste but also on the actual producer of the waste.

through legislation or through official government statements. Similarly, waste producers included in country profiles are both public and privately owned entities and have nuclear programs of significant size.

Despite difficulty in estimating costs when no final decision has been made on a waste management policy, each country profiled in this report has established or implemented some form of financial system to support the 'polluter pays principle.'

All countries studied in this report are also members of the Organization for Economic Cooperation and Development (OECD) and are judged by GF Energy to be as economically and politically capable as Canada to manage their waste programs.

Organization

The General Findings section of this report provides observations about common elements and themes emerging across different countries' financial systems.

Country profiles follow the General Findings, providing more detailed information, and are grouped according to geographic location. Each profile includes a brief Background on the status of the country's waste management program, and a detailed explanation of Responsible Authorities for the financing system, Financial Mechanism employed to either collect or secure funds, Management of Funds and, lastly, information on Liability and Title of waste.

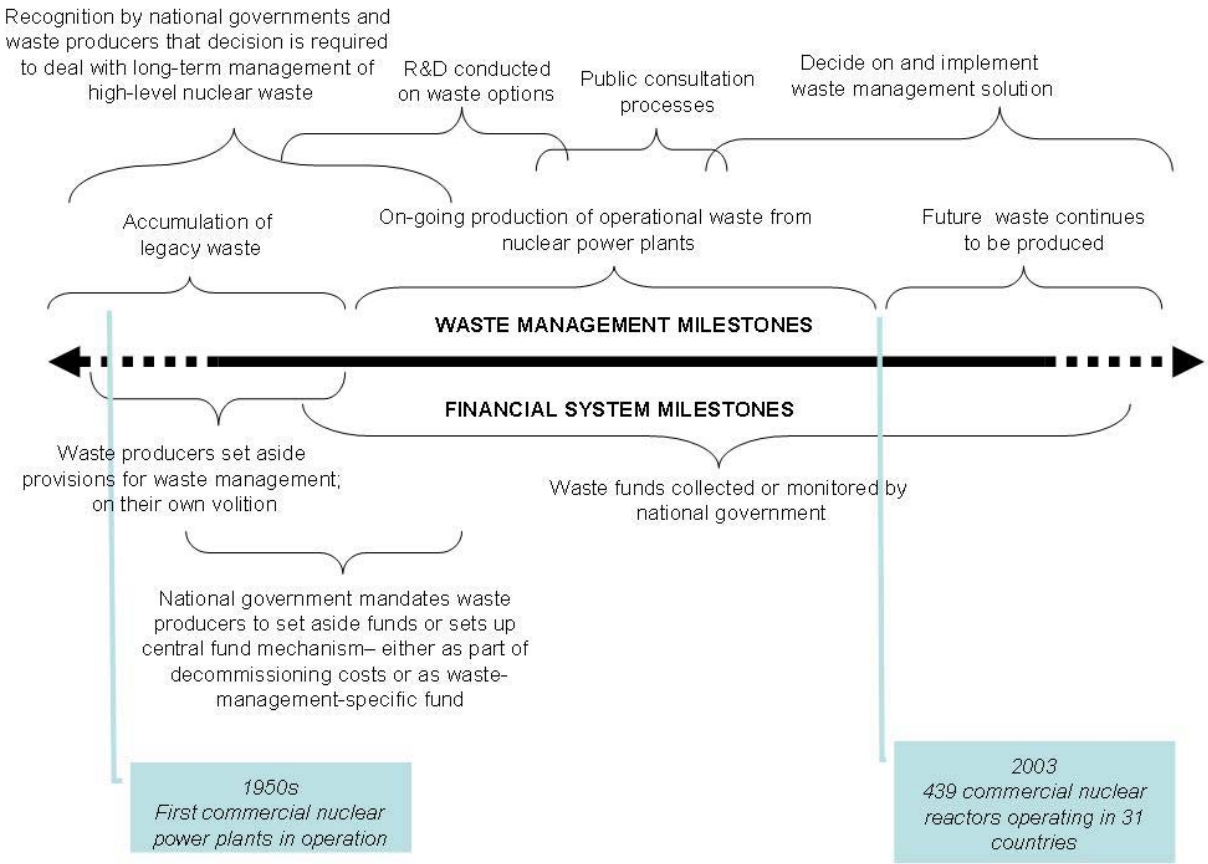
General Findings

Financial considerations are, as always, key to moving any program forward. In the case of spent fuel/high-level waste management, many factors contribute to the design and implementation of related financial systems such as the expected life cycle of nuclear reactors, the long-lived, multi-generational radioactivity of waste and political uncertainty about nuclear policy. What becomes increasingly clear from each country profile is the fact that although

all countries herein are tackling the same general issue – how best to manage their HLW and spent fuel in the long term – each approaches it differently, which in turn impacts the approach and timing of each country's financial system.

The following 'milestones' diagram attempts to illustrate how all countries deal with the same general issues but along their own respective timelines and with an open or closed approach to the fuel cycle.

Figure 1: Milestones in High-level Waste Management and Related Financial Systems



Source: GF Energy, LLC, 2003.

Other key observations are:

- All countries are following the same general 'polluter pays principle' under which commercial nuclear waste producers are financially responsible for long-term management. As much as possible, it also applies to state-owned companies like Canada's nuclear utilities.

- Countries such as France and the UK that reprocess spent fuel before disposing of it do not feel the same pressure to make waste disposal decisions as do countries such as Canada and the US that have a national policy of direct disposal of spent fuel and, hence, do not have a de facto intermediate storage facility. Also, Sweden does have an intermediate storage facility, as described in the Country Profile.

- Unless a country has made a specific decision on its official approach to waste disposal and specific budget projections have been adopted, it is difficult for these countries to begin assessing and collecting fees. Most countries, such as Canada, France and the UK are still in this stage of development of a long-term management solution. Sweden and the US are the furthest along in final policy decision-making, designing facilities and identifying actual projected costs and committing spending to actual facilities.

- One of the major financial uncertainties for all countries is the lack of finite data on the cost of long-term interim storage prior to a disposal process being in place. Another source of financial uncertainty is the lack of consensus on how long the producer of the waste should maintain primary financial responsibility. Sweden and the US have the most specific financial formulae for determining this liability.

- For countries that have smaller commercial nuclear programs, such as Belgium and Switzerland, the financial impact of dealing with their own waste is less favorable than combining efforts with other countries.

- Sweden is furthest ahead in terms of progress on its financial system, largely as a result of the maturity of its repository program.

- The United States has one of the simplest and most successful fund collection mechanisms, but the waste management program is now many years behind. As a result, the Nuclear Waste Fund is very well endowed with a current balance of about US$14 billion.

- There is an assumption on the part of all countries (including the US and Sweden, that have chosen the disposal option and are moving toward that goal) that current storage facilities will need to be upgraded to some degree to prepare for the possibility that a management solution is not implemented on schedule. Extended storage is looking like a de facto interim solution in many countries.

Financial Mechanisms

- Methods of ensuring that adequate funding is available for waste management vary widely, but all work with the same goal in mind – to ensure that funding is sufficient, readily available, that it covers best estimates for each country's needs and that funds are protected against financial impairment should companies be in financial jeopardy.

- Countries including the United States, Spain and Sweden explicitly collect funds that are based largely on a fee per kilowatt hour and are passed on through electricity fees charged to customers.

- In countries such as the United Kingdom the national government may contribute to reserve funds in addition to fees charged to commercial waste producers due to legacy performance issues.

Management of Funds

- Funds are generally managed by the following entities:

- Waste producers or third parties[6] such as in Canada
- An agency of the national government such as the Nuclear Waste Management Organization (NUMO) in Japan or the Office of Civilian Radioactive Management in the United States.

- Funds in all countries are held in combinations of cash, cash equivalents and low-risk, short-term and easily accessible investment options such as bonds.

Liability / Title

- Financial and legal liability for spent fuel and HLW generally remains in the hands of the waste producer until it is accepted for long-term management.
- Under programs in countries that have chosen to pursue deep geologic disposal, such as the United States and Japan, title and liability of spent fuel and HLW would change to the entity responsible for the repository once that entity has taken physical possession of the material.
- All countries are dealing with liability issues that have major financial implications, including:
  - In the United States, the 1998 deadline for the US Department of Energy accepting waste has passed, meaning that the financial responsibility for continued on-site storage is now being questioned in litigation.
  - Financial non performance.

[6] For example, an independent third party financial management company.

- Changing political approval or disapproval of management solutions and site selection.

Country Profiles: NORTH AMERICA

Canada

Background

Following almost 25 years of study, public consultation and consideration, Canada passed the Nuclear Fuel Waste Act (NFWA) in June 2002. The Act came into force in November 2002, mandating the creation by the waste producers of the Nuclear Waste Management Organization (NWMO) which has a mandate to investigate approaches for managing spent fuel waste and to provide recommendations to the Government of Canada within three years.

Canada employs the 'open fuel cycle' concept, whereby spent fuel is not reprocessed, rather it is considered to be a waste product of nuclear power generation. Spent fuel waste from Canadian nuclear reactors is currently stored on site at nuclear facilities – initially in large water-filled pools, and then later it is transferred to dry storage in steel and concrete canisters.

The options being pursued by the NWMO for management of spent fuel waste include deep geological disposal in the Canadian Shield,[7] storage at nuclear reactor sites and centralized storage, either above or below ground. The organization also has the option to propose a new approach if any arises from the work it has undertaken throughout its initial three-year mandate.

---

[7] The concept of disposing of spent fuel in a geologic disposal facility in the Canadian Shield is based on the concept described by Atomic Energy of Canada Limited in the Environmental Impact Statement on the Concept for Disposal of Canada's Nuclear Fuel Waste and also takes into account the views of the environmental assessment panel set out in the Report of the Nuclear Fuel Waste Management and Disposal Concept Environmental Assessment Panel, as published by the Canadian Environmental Protection Agency in February 1998.

Responsible Authorities

Spent fuel waste in Canada is owned by the entities that produce it, which translates to three Canadian utilities – Ontario Power Generation (OPG), Hydro-Québec, New Brunswick Power (NB Power) – and Atomic Energy of Canada Limited (AECL).

All nuclear power plants in Canada are both owned and operated by provincial government utilities, with only one exception. OPG (which is owned 100 percent by the Province of Ontario) owns nuclear power and waste storage facilities at the Bruce site in Tiverton, Ontario, but leases the nuclear power facilities to Bruce Power Inc. (Bruce Power), a private company who is responsible for their operation. Ownership of the spent fuel waste, however, remains with the facility owner, OPG. AECL also owns three prototype or demonstration nuclear power plants that have ceased operation but that have generated significant amounts of spent fuel: Gentilly –1, Nuclear Power Demonstration (NPD) and Douglas Point.

As laid out in 1996 by Natural Resources Canada in its *Radioactive Waste Policy Framework*[8] all four spent fuel waste producers (who are also owners) are responsible for paying for its management in Canada and setting up their respective trust funds, which are managed and audited by third parties.

The Natural Resources Canada, a department of the Government of Canada, sets nuclear policy in Canada. Regulation of nuclear power and substances is executed by the Canadian Nuclear Safety Commission, an arm's-length regulatory agency that also reports to the Government of Canada through the Minister of Natural Resources.

The NWMO, established in November 2002 by the Nuclear Fuel Waste Act, is responsible for managing the process for selecting a long-term solution for managing spent fuel and making a recommendation to the Government of

---

[8] "Radioactive Waste Policy Framework" and "McLellan Announces Policy Framework for Radioactive Waste," Natural Resources Canada, July 10, 1996.

Canada, which will make the final decision on the preferred approach. The NWMO is an independent organization that functions at arm's length from the government and waste producers. It also submits regular reports to the Government of Canada through the Minister of Natural Resources, but it does not report to the government in terms of day-to-day operational responsibilities. The NWMO's involvement in the financial aspects of waste management was to oversee the establishment of the waste producers' trust funds and to disclose annually the balance of each fund. The NWMO is also involved financially as the only entity that has the authority to spend the contents of the trust funds.

Financial Mechanism

In accordance with the 'polluter pays' principle, Canada uses a combination of two mechanisms to ensure that financial considerations are covered and secured for managing spent fuel waste.

Although the Nuclear Safety and Control Act (1997) (NSCA) does not technically require financial guarantees for spent fuel waste management (considered in the NSCA as part of decommissioning costs), it provides the CNSC with the power to decide on a case-by-case basis whether to impose guarantees upon its licensees.[9] As part of the terms and conditions for operating licenses for nuclear facilities, the CNSC now requires all spent fuel waste producers to put in place financial guarantees for waste and decommissioning.[10] Financial guarantees are based upon cost estimates submitted by the licensee to the CNSC in their preliminary decommissioning plans (which include management of both operational and decommissioning

---

[9] See Nuclear Safety and Control Act, Section 24(5):"A license may contain any term or condition that the Commission considers necessary for the purposes of this Act, including a condition that the applicant provide a financial guarantee in a form that is acceptable to the Commission."

[10] Interview with Richard Ferch, Director, Wastes and Geosciences Division, Canadian Nuclear Safety Commission, July 17, 2003.

waste).[11] Importantly, the CNSC requires licensees to assess costs of all three waste management options[12] that are currently under consideration in Canada and to base figures for guarantees upon the most expensive.[13]

Working in tandem with the CNSC's license terms and conditions are the new requirements set out in the Nuclear Fuel Waste Act (2002) (NFWA). The NFWA requires producers of spent fuel to establish trust funds to finance its long-term management. These trust funds are taken into account by the CNSC as a portion of the financial guarantees required as part of terms and conditions for operating licenses.

Management of Funds

One key difference between the two mechanisms – the decommissioning financial guarantees and the waste management trust funds – is that the larger financial guarantees required by the CNSC for overall decommissioning costs may be presented in the form of guarantees from provincial or federal governments (i.e., not necessarily accessible as cash), whereas the trust funds required under the NFWA are required to be held in low-risk, easily accessible forms such as cash or bonds.[14,15]

---

[11] For further detail, please refer to CNSC Regulatory Guides *G-206 Financial Guarantees for the Decommissioning of Licensed Activities* and *G-219 Decommissioning Planning for Licensed Activities*.

[12] Canada is currently exploring deep geological disposal in the Canadian Shield, storage at nuclear reactor sites and centralized storage, either above or below ground.

[13] For example of this concept in practice, please refer to CNSC Record of Proceedings, Including Reasons for Decision In the Matter of OPG and Bruce Power, p. 5, May 14, 2003.

[14] Interview with Richard Ferch, Director, Wastes and Geosciences Division, Canadian Nuclear Safety Commission, July 17, 2003.

[15] Audited financial statements from the November-December 2002 period indicate that trust funds for OPG, Hydro-Québec, NB Power and AECL are all held in similar portfolios of cash, cash equivalents, short term investments and bonds.

The CNSC is currently in the process of securing guarantees from all four of Canada's spent fuel producers.[16]

- OPG and the Government of Ontario have and recently signed an agreement with the CNSC to secure the full financial requirement of $6.2 billion for waste and decommissioning costs. The agreement between the three parties comes into force on August 1, 2003.

- OPG's Ontario Nuclear Funds Agreement (ONFA, a segregated fund set up in 1999 to cover financing of future decommissioning of OPG's nuclear facilities) currently contains approximately $4.7 billion. The outstanding amount is covered partly by a Provincial Guarantee Agreement (PGA) with the Government of Ontario ($1,710 million) and partly by the current balance of OPG's Nuclear Fuel Waste Act trust fund ($503 million). OPG expects its ONFA to grow sufficiently in seven years to cover the full $6.2 billion (depending on its yearly contributions and growth rate of its investments), at which time the PGA will expire.[17]

- An agreement with NB Power, the Government of New Brunswick and the CSNC is near completion and expected to be in place by August 1, 2003. As NB Power is currently being restructured, the agreement will likely be similar to that of OPG and the Government of Ontario, whereby the Government of New Brunswick provides a guarantee for a portion of the funds. Fund amounts are not currently available.

---

[16] Information on the status of financial guarantees between waste producers and the CNSC is based on latest CNSC license hearing documents and telephone interviews with Richard Ferch, Director, Wastes and Geosciences Division, Canadian Nuclear Safety Commission, July 17, 2003.

[17] CNSC Record of Proceedings, Including Reasons for Decision In the Matter of OPG and Bruce Power, p. 7-8, May 14, 2003.

- As Hydro-Québec is owned by the Government of Québec its agreement with the CNSC, which is expected to be in effect by September 31, 2003, will see the provincial government provide the bulk of the guarantee. Fund amounts are not currently available.

- Atomic Energy of Canada Limited, as a Crown Corporation (a company fully owned by the Government of Canada) is already effectively guaranteed by the federal government. An official agreement laying out specifics is expected to be signed with the CNSC by December 31, 2003.[18]

With respect to trust funds required under the NWFA, waste owners are required to use a third party to manage their respective funds.[19] The NWMO is not involved in their management except to make financial statements public each year as part of the organization's annual report.

Only the NWMO may make withdrawals from trust funds and only for the purpose of implementing the management approach selected by the Government of Canada and only once a construction and operating license for the waste facility has been issued by the CNSC.

Initial trust fund deposits were made in November 2002. The NFWA requires the utilities and AECL to continue making annual deposits on the anniversary of the NWFA coming into force (November 15, 2002) and until the federal government makes a decision on the long-term management of spent fuel. At that time, the formula to determine annual trust fund deposits will be based on the cost method of the chosen management option.[20] Annual deposits are currently set at 20 percent of the original deposit for each entity. The NFWA allows for the annual contributions to be recalculated should conditions change and also requires the NWMO to make specific recommendations for

---

[18] Interview with Richard Ferch, Director, Wastes and Geosciences Division, Canadian Nuclear Safety Commission, July 17, 2003.

[19] Nuclear Fuel Waste Act, Financing, Section 10(1).

formulas consistent with each approach the organization studies. Interest accumulates on any portion of a deposit not paid by the anniversary date at the prime rate plus 2 percent, calculated daily.

Table 1: Nuclear Waste Trust Funds

	Initial deposit (Nov 2002)	Annual contributions
Ontario Power Generation	$ 500,000,000	$100,000,000
Hydro-Québec	$ 20,000,000	$4,000,000
NBPower	$ 20,000,000	$4,000,000
Atomic Energy of Canada Ltd.	$ 10,000,000	$2,000,000

Source: Nuclear Fuel Waste Act, 2002.

Liability / Title

Spent fuel waste in Canada remains the liability of the waste producers which are also the waste owners.[21,22]

As described above, owners of nuclear power plants are also the licensed operators, except in the case of Bruce Power. Bruce Power is the licensed operator of the reactors situated at the Bruce site in Tiverton, Ontario, which are owned by OPG. In this special case, spent fuel becomes the property of the plant owner, OPG, once it is removed from the reactor and is transported to OPG's Western Waste Management Facility.[23]

---

[20] "Institutional Framework for the Long-Term Management of High-Level Waste and Spent Nuclear Fuel (TECDOC 1323)," International Atomic Energy Agency, 2002.

[21] Interview with Peter Brown, Director, Uranium and Radioactive Waste Division, Natural Resource Canada, June 2003.

[22] "Radioactive Waste Policy Framework" and "McLellan Announces Policy Framework for Radioactive Waste," Natural Resources Canada, July 10, 1996.

[23] Interview with Richard Ferch, Director, Wastes and Geosciences Division, Canadian Nuclear Safety Commission, June 2003.

United States

Background

The United States adopted geologic disposal as its long-term strategy for management of radioactive wastes in 1982 with the enactment of the Nuclear Waste Policy Act (NWPA).

Like Canada, the US employs the 'open fuel cycle' concept with respect to commercial nuclear power generation, meaning that spent nuclear fuel is not reprocessed. Although the US has reprocessed high-level waste from other sources (*i.e.*, Department of Defense programs, Megatonnes to Megawatts program) and at one time considered doing so with spent fuel, the nation decided to forego this approach in 1975 under the presidency of Gerald Ford.[24] Spent fuel from commercial power generation in the US is considered to be waste.

The majority of spent fuel waste in the US is currently stored on site in 33 different states at 72 commercial nuclear power plant sites in wet and dry storage.[25] A small portion is stored at an off-site wet storage facility owned by General Electric. On-site storage of spent fuel waste is a temporary arrangement, in anticipation of eventual disposal in a geologic repository to be constructed by the DOE.

The Yucca Mountain site in Nevada was signed into law in 2002 as the future site for the US' central geologic disposal repository for high-level waste, including spent nuclear fuel from commercial operations and high-level waste from Defense programs. For the DOE, this milestone means the department

[24] "Appendix B: History of the Civilian Radioactive Waste Management Program, Revision 3," Office of Civilian Radioactive Waste Management, p. 66.

[25] "Civilian Radioactive Waste Management Program Plan, Revision 3," Office of Civilian Radioactive Waste Management, p. 1.

must now change its focus from research on site selection to preparations for the rigorous licensing process for construction and operation of the facility.

The NWPA set a capacity limit of 70,000 metric tons of heavy metal (MTHM) for the repository at the Yucca Mountain site and requires the DOE to report to Congress between 2007 and 2010 on the need for a second national repository. The DOE's Environmental Impact Statement on the Yucca Mountain site indicates that the site could take up to 120,000 MTHM.

As of 2002, approximately 44,000 MTHM of commercial spent fuel waste and about 12,000 MTHM of defense-related HLW was awaiting disposal. An additional 2,000 metric tons is generated each year. Given that DOE expects to begin receiving up to 3,000 metric tons a year of used fuel beginning in 2010, the 70,000 MTHM limit will not be reached until at least 2036.[26]

Responsible Authorities

Spent fuel is produced and owned by utilities operating over 100 licensed nuclear power plants across the United States.

The Federal Treasury holds the Nuclear Waste Fund, but does not have discretion to authorize use of the monies held within the fund. Funds are subject to the appropriations[27] process by Congress providing an annual opportunity for reopening program priorities and spending. DOE makes investment decisions regarding managing of the fund's investments.

As confirmed by the enactment of the NWPA in 1982, the US federal government, by way of the DOE, is responsible for the management and disposal of spent fuel waste. These activities are carried out on a day-to-day basis by the Office of Civilian Radioactive Waste Management, which resides within the DOE.

---

[26] "Frequently Asked Questions on Yucca Mountain," Nuclear Energy Institute, 2002.

[27] 'Appropriations' refers to the legislative process used in the US to authorize expenditures of public funds, i.e, requiring approval from Congress.

Financial Mechanism

The Nuclear Waste Fund was established in the United States in 1982 under the Nuclear Waste Policy Act, which went into effect in 1984. Its purpose is to cover all costs ranging from construction of a central geologic repository to its operation and eventual closure. Today, the fund contains about US$14 billion. Program costs estimates for a central repository take into consideration a number of issues, which include:

- Acceptance and disposal of approximately 83,000 MTHM of spent nuclear fuel waste from commercial nuclear power generation
- Planned years of operation for existing nuclear power reactors based on current US Nuclear Regulatory Commission licenses; re-licensing and subsequent life-extension of reactors is also taken into account
- Acceptance and disposal of approximately 2,500 MTHM and 22,000 canisters of government-managed waste derived from DOE spent fuel waste, which includes naval spent fuel and HLW generated by weapons production activities and immobilized plutonium waste and also solidified HLW from spent fuel generated prior to enactment of the NWPA[28]
- Very little future generation of HLW from DOE sites is anticipated, but quantities of HLW may vary according to future decisions on how the waste may be processed[29]

Seventy percent of the Nuclear Waste Fund is financed by spent fuel waste producers. The remainder is paid for by the US Department of Energy's Defense Nuclear Waste Disposal account. The division of fund sources reflects the dual purpose of the repository the US intends to build and the two main sources of spent fuel waste and HLW.

---

[28] "Nuclear Waste Fund Fee Adequacy: An Assessment," US Department of Energy, Office of Civilian Radioactive Waste Management, May 2001, p. 2.

[29] "Analysis of the Total Life Cycle Cost of the Civilian Radioactive Waste Management Program," US Department of Energy, Office of Civilian Radioactive Waste Management, May 2001, p. 1-4 to 1-5.

Latest cost estimates were published in May 2001 by the OCRWM in its "Analysis of the Total System Life Cycle Cost of the Civilian Radioactive Waste Management Program." Although the NWPA specifies the need to assess in 2007-2010 the potential for a second potential repository, current estimates are calculated assuming a single repository at Yucca Mountain capable of handling all projected waste streams. The cost estimate is comprised of integrated costs from six time phases as outlined in the table below.[30]

Table 2: Monitored Geologic Repository Costs by Phase (in millions of 2000$US)

Phase	Historical[31] (1983-2000)	Future Costs (2001-2119)
Development and Evaluation (1983-2003)	5,780	800
Licensing (2003-2006)	0	1,290
Pre-Emplacement Construction (2006-2010)	0	4,450
Emplacement Operations (2010-2041)	0	19,710
Monitoring (2041-2110)	0	6,000
Closure and Decommissioning (2110-2119)	0	4,040
Total	**5,780**	**36,290**

Source: Office of Civilian Radioactive Waste Management, May 2001.

All producers of spent fuel in the United States are required to pay two fees into the Nuclear Waste Fund. Nuclear power plant operators are required by law to enter into contracts with the DOE to pay such fees. The terms of payment are set out in the contract as follows:

1. One-time fee: This covers spent nuclear fuel that was generated or in core prior to April 7, 1983. The contract between utilities and the DOE allow for three payment options:

[30] Ibid, p. 3-8.

[31] Historical costs total $4.8 billion in year-of-expenditure dollars.

   a. *Pro-rated evenly over forty (40) quarters, whereby the total amount owed consists of the fee plus interest on the outstanding fee balance*
   b. *Single payment prior to first delivery of spent fuel waste to the repository*
   c. *Early payment, made prior to June 30, 1985, or two years after contract execution*

2. On-going fee payment: The fee charged is 1 mill per kilowatt hour (1M/kWh) of electricity generated and sold on or after April 7, 1983, paid to the Nuclear Waste Fund on a quarterly basis.[32]

The adequacy of the on-going fee 1 mil/kWh fee is assessed regularly by the OCRWM, based on the need for full cost-recovery. The last assessment published in May 2001 in its report, "Nuclear Waste Fund Fee Adequacy: An Assessment." The report considers estimated program costs as presented in the TSLCC report (May 2001), the current balance of the Nuclear Waste Fund, projected fee revenues and economic projections and makes recommendations for any adjustments to the fee. Although significant changes have occurred in the program since the last Fee Adequacy Assessment was published in 1998 (*i.e.*, approval of the Yucca Mountain site) and the estimate of program costs have increased, the bulk of the cost increase occurs late in the program life cycle, resulting in the need for a larger Nuclear Waste Fund balance at the end of the operational phase of the repository to fund post-operational costs. To date, the 1 mill/kWh fee remains unchanged.[33]

A target date of 1998 for opening the waste repository was used when these fees were originally set in 1982. Since the target date has passed (estimates now focus on very optimistically on 2010 as the earliest date that used fuel will arrive at a repository at the Yucca Mountain site), program costs continue to increase and the timetable for the repository opening continues to slip, the relationship between fees and program costs is now under scrutiny. A number

[32] Text excerpted directly from the standard contract 10 CR 961.

[33] "Nuclear Waste Fund Fee Adequacy: An Assessment," US Department of Energy, Office of Civilian Radioactive Waste Management, May 2001, p. 2-5.

of waste producers are currently pursuing legal action against the DOE for breach of contract to begin accepting used fuel. This situation has created what some estimate to be a potential taxpayer liability of approximately $56 billion due to the requirement for waste producers to invest in additional on-site storage for used fuel.

Management of Funds

To date, more than US$22 billion in fees have been paid into the Nuclear Waste Fund. The balance of the fund as of September 2002 was approximately US$13.1 billion. It is expected to grow to US$14.6 billion by the end of the 2003 fiscal year on September 30, 2003.

The balance of the Nuclear Waste Fund is currently growing at a rate of nearly US$1 billion per year. Interest on the fund is accruing at approximately US$400 million annually.

When it was originally established, the Nuclear Waste Fund was a separate account in the Federal Treasury that was appropriated on annually and subject to overall federal budget ceilings and caps. The status of the account changed in the 1990s. Appropriations from the fund are now under a discretionary spending cap, which means they are subject to appropriations caps and budget rules but are not affected by overall deficit cutting and other congressional caps and ceilings. Although this arrangement is set to expire in September 2004, it is expected to be renewed.

Table 3: Nuclear Waste Fund Fee Income and Appropriations (US $million)

	1998	1999	2000	2001	2002
Fee Income	$600	$662	$702	$689	$707
Appropriations	$156	$162	$241	$191	$95

Source: US Department of Energy, 2003.

There is also a move afoot to increase the discretionary spending cap. Fees would still be kept in the central Nuclear Waste Fund and would be subject to the annual appropriations process by Congress, but an increased discretionary spending cap would mean greater funding certainty for the development of the repository.

Liability / Title

The utilities responsible for producing the spent nuclear fuel retain title for the fuel while it is located on the grounds of their facilities. According to the NWPA, title transfer to the DOE will occur when the spent nuclear fuel leaves the gate of the facility, 'freight-on-board (FOB)', during the DOE's waste acceptance process.[34]

Since the 1998 deadline passed for DOE to begin collecting waste from nuclear reactor sites the issue of title and liability has become a significant concern for nuclear utilities in terms of both financial liability and also available space for on-site storage.

[34] Interview with Richard Minning, Office of Civilian Radioactive Waste Management, June 23, 2003.

Country Profiles: EUROPE

France

Background

France employs the 'closed fuel cycle' concept and, as such, considers spent fuel to be an asset, not a waste product. Rather than directly disposing of it or putting it into long-term storage, France reprocesses spent fuel to retrieve unused uranium and plutonium that can be re-used as mixed oxide fuel (MOX) at its nuclear plants. The remaining HLW material from the reprocessing process is solidified via vitrification.[35] France has been reprocessing at its La Hague UP2 facility since 1976 and UP3 since 1990. Because of its closed fuel cycle policy and the fact that nuclear waste is stored at La Hague, France is under less pressure than countries that use the 'open fuel cycle' to find a long-term off-site disposal option.

In 1991, the French government, including the Atomic Energy Commission (CEA) undertook to spend 15 years studying three options for long term waste management. Research is currently underway on geological storage, reprocessing and transmutation and long term intermediate storage. Results are due to be presented to Parliament in 2006, at which time a decision is expected to be made on a permanent disposal option.[36]

---

[35] 'Vitrification' refers to the process by which HLW material is mixed with borosilicate glass (similar to Pyrex) and when cooled becomes a solid.

[36] Interview with Regis Babinet, Nuclear Energy Counsellor, Embassy of France (Washington, DC), May 14, 2003.

The French Parliament has imposed a legal deadline of January 1, 2007, for a policy decision on how to deal with French radioactive waste. Current projections estimate that France will have about 5000 m^3 of HLW in 2020.[37]

Responsible Authorities

ANDRA, the National Radioactive Waste Management Agency, was established by the French Atomic Energy Commission (CEA) in 1979. ANDRA was transformed in 1991 into a state-owned organization which reports to three ministers – Industry, Research and Environment – but operates independently of both regulatory authorities and waste producers.

Électricité de France (EdF) owns and operates all nuclear power plants in France and is the sole producer of commercial spent fuel.

CEA, the French Atomic Energy Commission, and universities, also produce nuclear waste but from non-commercial activities.

COGEMA reprocesses the spent fuel produced by EdF's nuclear power plants; EdF remains the owner of the products of reprocessing, including vitrified HLW that is kept in storage by COGEMA.[38] COGEMA is under contract to EdF to reprocess only enough spent fuel to produce the quantity of MOX fuel that will be used in authorized pressurized water reactors. Today that means all EdF spent fuel is reprocessed; at some point in the future, some spent fuel will not be reprocessed and EdF is currently negotiating with COGEMA to further reduce the amount to be reprocessed. The remaining spent fuel is to be placed in storage by EdF and moved into permanent disposal at some future time.

---

[37] CEA, *Informations Utiles*, Édition 2002.

[38] Interview with Jacques Tamborini, Head, International Department, ANDRA, June 30, 2003.

Financial Mechanism

France follows the philosophy familiar to most countries addressing this issue – the 'polluter pays principle.'

No central fund exists in France for waste disposal. With the decision still pending as to which option France will pursue for long-term management of its waste, no cost analysis for any of these options has yet been completed.

EdF is, however, required by law to provision the necessary funding for the implementation of the French waste management policy; it currently pays Cogema to reprocess and store spent fuel and waste. As there is not yet a long-term HLW policy, the budget for ANDRA's R&D for HLW management is funded by the waste generators through pre-payments based on EdF's long-term forecasts of waste production and is formalized in contracts with ANDRA.

Management of funds

EdF keeps the provisions in its own account; no French law requires a separate fund or directs investment of the provisions. European Union directives project that this situation could be modified.[39]

Liability / Title

Operators are responsible for future liabilities. They must set up balance sheet provisions to cover future costs and must justify such estimates to supervisory bodies or independent auditors. Future liabilities are calculated using a present value method, adjusted annually for inflation and periodically revised to account for technological or regulatory changes affecting costs. EdF secures provisions for future liabilities from income from its nuclear power plants.

---

[39] Interview with Jacques Tamborini, Head, International Department, ANDRA, June 30, 2003.

Germany

Background

Spent fuel originating from German nuclear power plants used to be reprocessed in France and in the United Kingdom (these contracts have not been renewed) with HLW being returned to Germany for storage. Today, Germany has an 'open fuel cycle' policy and is accumulating spent fuel as waste. In the absence of a permanent repository, spent fuel is stored inside reactor pools and in interim dry storage facilities on site at nuclear power plants. In exceptional cases where on-site storage is not possible (*i.e.*, if on-site storage has reached capacity), Ahaus and Gorleben are available as central storage. HLW returning from reprocessing in France and the UK is also stored at the Gorleben central storage facility.

The Federal Government in Germany is currently aiming to establish a deep geologic repository by 2030 which will be suitable for all types of radioactive wastes. The nuclear energy phase-out agreement of June 14, 2000 defines a new waste disposal policy aimed at providing final storage exclusively for nuclear waste created in Germany. In the meantime, spent fuel waste is to be placed in temporary storage at the respective nuclear power plant locations before being placed in the final repository final storage as of 2030.

Responsible Authorities

The Federal Government is responsible for establishing waste disposal facilities in Germany. These activities are carried out by the Federal Ministry of Environment and Nature Conservation and Reactor Safety, which is represented by BfS (Federal Office of Radiation Protection).

DBE (German Company for the Construction and Operation of Repositories for Waste) is authorized by BfS to design, plan, construct and operate a repository facility.

Electric utilities, RWE and E.ON are Germany's producers of spent fuel waste and are responsible for financing waste management. The two utilities must construct and operate interim treatment and storage facilities on nuclear power plant sites at their expense.

Financial Mechanism

The German Atomic Energy Act requires nuclear waste producers to bear the cost of safe waste management and disposal. Percentage splits between the various waste producers are 93 percent nuclear power plant operators, 4 percent Karlsruhe pilot reprocessing plant and 3 percent small producers. These shares are intended to reflect the effort needed to dispose of the volume of waste expected to be produced.[40]

A mechanism for financing the operational costs of repository facilities has not yet been determined.[41] Once the facilities are operational, advance payments will be offset with real costs. In the meantime, operators of nuclear power plants are required by the German Government to build up reserves, which are exempt from corporate taxes, to pay for future waste disposal and decommissioning of facilities. Privately owned nuclear power plants (19 in operation, 5 decommissioned) are required to set aside reserves during the operational phase of the power plant's life. These reserves are also exempt from corporate taxes.

Management of funds

The Federal Government oversees the allocation of the necessary expenses associated with the planning and construction of waste disposal facilities. The Government recovers costs by contributions or advanced payments from the

---

[40] "Schemes for financing radioactive waste storage and disposal," European Commission, 1999, p. 33.

[41] Ibid, p. 33.

waste producers. The use of storage and disposal facilities is financed by fees levied from the waste producers.

Reserves accrued from privately-owned power plants by March 2003 totaled approximately €35 billion (CDN$55.8 billion[42]), of which 55 percent is designated for management and disposal of spent fuel. The remaining 45 percent is slated for decommissioning.

Liability / Title

In 1990, Germany inherited six Soviet-design nuclear power plants from the former GDR (1 WWER-70 in Rheinsberg and 5 WWER-440 in Greifswald), which were subsequently shut down due to safety reasons. The Government took over financial liability for the decommissioning activities, which are due to be completed in 2012. Total costs for dismantling the plants and storing waste are estimated to be €3.1 billion.

[42] Bank of Canada conversion rate, March 2003 average.

Sweden

Background

Similar to Canada and the US, Sweden employs the 'open fuel cycle,' where by spent fuel from reactors is not reprocessed into new fuel, rather it is considered waste.

Sweden is pursuing a final disposal program for spent fuel waste from commercial nuclear power (in addition to a small quantity of MOX fuel and waste from earlier reprocessing contracts). Research and development on spent fuel disposal, including financial considerations, started as far back as 1976 in Sweden with the release of a report by the AKA Commission. It outlined a full system for the management of spent fuel and associated waste, including costs.

Components of the system as laid out in the 1976 report have been developed since, including sea transportation (MS Sigyn) and a central spent fuel storage facility called CLAB, the Central Interim Storage Facility for Spent Nuclear Fuel, situated near the Oskarshamn Nuclear Power Plant.[43] Planning and research for additional facilities required in order to complete the waste management system are at an advanced stage.

Although no official time schedule has been adopted yet by the Swedish Government or the country's nuclear regulatory authorities, the Swedish Nuclear Fuel and Waste Management Co. (SKB) is working towards 2009 as its goal to start construction of a final repository for spent fuel waste. SKB is currently investigating two prospective sites (in Simpervarp and Forsmark) and expects to apply for construction permits for one of these sites by 2006.

---

[43] Sweden also already operates SFR (Repository for Radioactive Operational Waste located at the Forsmark Nuclear Power Plant), which receives short-lived low and intermediate-level waste from nuclear power plants, hospitals, industry and research facilities in Sweden.

The licensing phase is expected to take up to two years and SKB anticipates commencing construction of the facility by 2009 and operation by 2015. According to SKB's plans, disposal of spent fuel waste and decommissioning of Swedish nuclear facilities is expected to be completed by approximately 2050.[44]

At present, following a short period of on-site storage at reactor sites, all spent fuel waste in Sweden is shipped by sea to the CLAB interim storage facility.

Responsible Authorities

SKB (Swedish Nuclear Fuel Waste Management Co.), established jointly by Sweden's nuclear power utilities as a not-for-profit company in 1972, is responsible for decommissioning and waste management for Sweden's four nuclear utilities.

Vattenfall AB (Ringhals), Barsebäck Kraft AB (Barsebäck), Forsmarks Kraftgrupp AB (Forsemark) and OKG Aktiebolag (Oskarshamn) are Sweden's four nuclear utilities, owners and operators of nuclear power plants and producers and owners of their spent fuel waste.

Regulation of waste management is performed by two governmental authorities. SSI (Swedish Radiation Protection Institute) verifies SKB's technical activities and oversees safety of nuclear power plant operation and radioactive waste management.

SKI (Swedish Nuclear Power Inspectorate) works in a regulatory role with respect to verifying SKB's annual plans and ensuring that it has available adequate funding for present and future operations. SKI also reviews SKB's plans and recommends financial mechanisms (*i.e.* fees to generate revenue) to the Swedish Government, which then decides on the size of the fee that is used to satisfy the needs of the Nuclear Waste Fund.

---

[44] "Annual Report," Kärnavfallsfonens Styrelse, The Board of the Swedish Nuclear Waste Fund, 2002, p. 3.

KAFF (the Board of the Swedish Nuclear Waste Fund), established in 1996, is the government authority that administers the Nuclear Waste Fund and the underlying securities which must be provided by the reactor owners (*i.e.*, waste owners). KAFF reports annually to the Swedish Government on the status of the funds.[45]

Financial Mechanism

Since 1981, Swedish nuclear power utilities have been required to accumulate funds for waste management by way of paying set fees into interest-bearing accounts at the Riksbank.[46] The administration of the fund was taken over in 1996 by KAFF, the Board of the Swedish Nuclear Waste Fund.

The Act on the Financing of Future Expenses for Spent Fuel, as amended in 1992, specifies the way in which expenses are to be calculated and how they are to be paid. Estimated costs for management of spent fuel waste and decommissioning waste are based on the assumption that reactors will be operated for at least 25 years and not longer than 40 years. Expenses also cover a full range of responsibilities including safe handling of spent fuel waste, research and development, construction and operation of the disposal facilities and any other related expenses. [47]

SKB makes annual estimates for all nuclear power plants and SKI follows up by reviewing the nuclear power utilities' cost estimates. Upon completion of its review process, SKI submits a proposal to the Swedish Government specifying the fees and guarantees required for that year. KAFF is then responsible for administering the funds.

Methods for collecting revenue for the Nuclear Waste Fund include advance contributions, a flat annual fee to SKI and SSI and fees applied to electricity

---

[45] "Annual Report," Kärnavfallsfonens Styrelse, The Board of the Swedish Nuclear Waste Fund, 2002, p. 2.

[46] "Financing: Covering the expenses for nuclear waste," SKI (Swedish Nuclear Power Inspectorate), November 1998, p. 2.

[47] Ibid, p. 6.

generated by nuclear power. Such fees are worked into electricity rates paid by the consumer. Exact fees vary from year to year. The size of the fee also varies in relation to the energy delivered by the individual reactor, which is translated to an overall 'factor' applied to the reactor owner.

Table 4: 2001 and 2002 Fees (öre/kWh, 1 öre = SEK 0.01)

	2001		2002	
	öre	**CDN¢[48]**	**öre**	**CDN¢[49]**
Forsmarks Kraftgrupp AB	1.2	**0.18**	1.2	**0.19**
OKG AB (Oskarshamn)	0.6	**0.09**	0.5	**0.08**
Ringhals AB	1.0	**0.15**	0.8	**0.13**
Barsebäck Kraft AB	0.0	**0.0**	0.0	**0.0**

Source: KAFF, 2002.

Annual fees paid to SKI cover a range of activities – not all fees apply to spent fuel management. To date, the Nuclear Waste Fund has covered the expenses for:

- the CLAB interim storage facility;
- the transport system (the Sigyn ship, transport containers, special trucks);
- the Canister Laboratory and the Äspö Hard Rock Laboratory; and
- SKB's research and development costs, including siting activities.

The Nuclear Waste Fund (fees plus interest on monies already in the Fund) will eventually cover expenses for:

- the encapsulation of spent nuclear fuel;
- the repositories for spent nuclear fuel and long-lived low and intermediate level waste;

[48] Bank of Canada average exchange rate for 2001.

[49] Bank of Canada average exchange rate for 2002.

- the dismantling of nuclear power plants and the disposal of decommissioning waste;
- continuing research and development work;
- regulatory control and supervision after closure of the reactors.

The Swedish Nuclear Waste Fund currently totals SEK 28.9 billion (approx. CDN$5 billion[50]). Nuclear power plants pay approximately SEK 350 million (approx. CDN$61 million[51]) per year to the fund.

Table 5: Fund balance and reimbursement

Date	Total fund	
	SEK (million)	CDN$ (millon)[52]
1982	7,000	**1,381**
1985	5,000	**986**
1990	10,000	**1,972**
1995	18,000	**3,466**
1997	23,000	**4,171**
1999	24,000	**4,316**
2002	29,000	**4,695**

Source: SKI

As of 1989, a special fee was levied on the nuclear power utilities according to a special law, the Studsvik Act. The fee, which is added to the Nuclear Waste Fund, is intended to cover expenses for managing nuclear waste from old experimental facilities, in particular the facilities at Studsvik, the Agesta reactor and the uranium mine in Ranstad. It must also cover future expenses for dismantling these facilities. According to estimates, SEK 1.4 billion will be

[50] Bank of Canada average exchange rate for 2003.

[51] Bank of Canada average exchange rate for 2003.

[52] All figures are calculated using Bank of Canada average exchange rates for corresponding years, with exception of 1982 and 1985 which are estimates based on 1990 exchange rates.

needed up to 2030 to meet these expenses. This special fee is also reassessed each year based on a proposal by SKI.

Sweden has not yet concluded its long-time national debate mandating the early closure of all of the country's nuclear power plants. The resolution of this issue will, of course, affect the disposal budgets significantly.

Management of funds

SKI recently (2002) released a report on their research strategy. One of the key points made is that the change in economic conditions of the power utilities combined with the high cost of decommissioning have meant that utilities are often trying to reduce fees paid to the Nuclear Waste Fund. SKI believes that its goals going forward should be increased supervision of plants to make sure that they are being operated in a safe manner, even if they are threatened with closure or the closure date has already been set, that the licensees are planning far enough in advance to be able to decommission and dismantle the plants in a safe manner, and that sufficient funds are being set aside to carry out decommissioning.

Management of the Nuclear Waste Fund has changed over the past decade, most significantly with KAFF becoming responsible for administration of the fund. Changes to the fund have allowed for better management in terms of investing in higher interest bearing instruments. Most recently, in 2002, investment rules were changed for the fund through an amendment to the Act on Financing Future Expenses for Spent Nuclear Fuel which allows the assets of the Nuclear Waste Fund to be invested in interest-bearing accounts at the National Debt Office or in promissory notes issued by the Swedish state. KAFF's investment strategy for the Fund is focused on an average annual real return – for the period of 1996 to 2020 – of a minimum of 4 percent on the fund capital.[53]

---

[53] "Annual Report," Kärnavfallsfonens Styrelse, The Board of the Swedish Nuclear Waste Fund, 2002, p. 4.

Liability / Title

Responsibility and nuclear liability for radioactive waste and spent fuel is transferred from the waste owner to SKB when it departs from the nuclear power plant. Ownership of the waste is transferred to SKB, while ownership of the spent fuel remains with the utilities. What does ownership mean, without responsibility or liability?

United Kingdom

Background

Like France, the United Kingdom employs the 'closed fuel cycle,' and regards spent fuel as an asset. It reprocesses spent fuel, producing MOX fuel (which uses uranium and plutonium from the spent fuel). The UK's current policy requires vitrified HLW from reprocessing to be stored above ground for at least 50 years. A policy for HLW disposal has not yet been adopted, although a 1998 enquiry on the management of nuclear waste, held by the House of Lords Select Committee on Science and Technology, recommended that the UK would pursue the geologic disposal approach.

Uncertainty about the UK's nuclear future has further decreased the pressure to make a decision on long-term waste management. In 2002, British Energy (BE), the privatized commercial nuclear generator, went into virtual receivership. In late 2002, the UK government released a white paper announcing that it was not the intent of the government to replace the UK's aging nuclear stations with new nuclear plants, as it is a private sector decision to be made in a competitive electricity market by interested players.

As a result of these events and others related to defense-related HLW waste, the UK government has decided to drastically change its arrangements for government-owned (as opposed to commercially-owned) nuclear waste through the establishment of a new organization, the Nuclear Decommissioning Authority (NDA), to ensure that the UK's nuclear legacy is cleaned up safely, securely, cost effectively and in ways which protect the environment.[54] Draft legislation was recently published to set up and fund the NDA, which in April 2005 is slated to take over all designated liabilities and assets from British Nuclear Fuels (BNFL) and the UK Atomic Energy Authority (UKAEA).[55] The assets include many facilities from the early years

[54] The plan was laid out in a UK Government White Paper, *Managing the Nuclear Legacy – A Strategy for Actions*, published 4 July 2002.

[55] "Nuclear Sites & Radioactive Substances Bill," British Government, June 24, 2003.

of nuclear power in the UK including the former Magnox plants and BNFL's decommissioning funds.

BE, the owner and operator of the UK's eight commercial nuclear power plants, was privatized in 1996 and its restructuring announced in November 2002. The restructuring is intended to achieve the long-term financial viability of the British Energy Group, and to reduce its exposure to the uncertainty and long term risks inherent in the group's decommissioning liabilities and historic liabilities to BNFL.[56]

However, the UK government has not embarked on an equally drastic policy of any kind regarding commercial nuclear waste. Most, if not all, of British Energy's spent fuel is under contract to BNFL for reprocessing. Even before its collapse, BE was trying to renegotiate its contracts with BNFL. BE's November 2002 restructuring proposal includes negotiation of new contracts with BNFL, which is likely to cover most if not all of BE's spent fuel.

No separate fund for commercial waste disposal exists in the UK at this time, aside from provisions historically made in the accounts of waste producers themselves. There is not any active movement of any kind toward the creation of such a fund.

Responsible Authorities

British Energy (formerly Nuclear Electric and Scottish Electric) is currently the sole producer of commercial spent fuel in the United Kingdom. HLW in the UK is owned by the former UKAEA, BNFL and BE.

The Secretary of State for the Environment, Transport and Regions is responsible for radioactive waste management. The Nuclear Installations Inspectorate is responsible for licensing all nuclear facilities, including a repository.

---

[56] "Announcement of restructuring proposals and extension of HMG loan facility," British Energy, November 28, 2002.

Nirex is responsible for providing disposal solutions and developing the packaging and transport system for commercial waste. The company was formed in 1982 by the nuclear industry with agreement from the government (the company shares were held by British Energy, BNFL, the UK Atomic Energy Authority and the British government) to examine safe, environmental and economic aspects of deep geological disposal of radioactive waste, dealing primarily with intermediate-level waste. As part of reforms within the British nuclear industry, the government will assume control of Nirex to give the company independence from the industry and to achieve greater transparency for its endeavors.[57]

The Department of Trade and Industry has established a special team, known as the Liabilities Management Unit (LMU), which includes staff from both private and public sectors and is supported by a partner contractor (Bechtel). LMU is responsible for preparatory work enabling the NDA to function as planned. Its primary tasks, regarding legacy waste which includes historic commercial waste, are:

- Acquiring a detailed knowledge of BNFL and UKAEA liabilities
- Establishing common methodologies
- Developing the contracting strategy
- Establishing close working arrangements with the nuclear regulators

The Liabilities Management Authority (LMA), predecessor to the Nuclear Decommissioning Authority (NDA), was established in order to provide strategic management and direction in developing a coherent strategy for dealing with the UK's non-commercial waste, also referred to as nuclear legacy. The LMA is legally and financially responsible for legacy sites.

The NDA will take responsibility for civil nuclear liabilities and in doing so will deal not only with legacy waste, but also waste from commercial

[57] News Briefing 03.29, World Nuclear Association, July 23, 2003.

operations that is destined either for disposal at the Drigg facility or reprocessing at the Sellefield facility.[58]

Financial Mechanism

The UK government statement on radioactive waste management policy is consistent with other countries, endorsing the 'polluter pays' principle.[59]

An assessment of the cost of managing liabilities related to nuclear waste is not well developed and is usually presented as a lump sum including both decommissioning and management of spent fuel and nuclear waste. Costs to deal with The UK's nuclear legacy are estimated at anywhere from around £48 billion (CDN$ 112.4 billion[60]) to more than £85 billion (CDN$ 199 billion[61]). The Nuclear Decommissioning Authority is forecast to expend over £1 billion annually for the first 10-15 years of its existence.

Because all of the nuclear waste has been generated by government-owned or previously-government-owned bodies, much of the existing waste cost is to be paid for by the government. BE's predecessor company, Central Electricity Generating Board, was at one time responsible for producing nuclear weapon material at commercial nuclear stations, complicating the legacy allocation of costs and financial responsibility.

BE's restructuring plan is not expected to be completed until mid 2004 because the plan must be approved by significant creditors, the British government, existing shareholders, the Inland Revenue and the European Commission. BE announced in February 2003 that it had reached agreement in principle with significant creditors, and on May 16, 2003, announced that the contracts had been exchanged with BNFL to give effect to the non-binding heads of terms

---

[58] Interview with Johnathan Temple, Senior Energy Policy Analyst, British Embassy (Washington, DC), June 2003.

[59] UK Government *White Paper*, CM 2426 and 2919, 1995.

[60] Bank of Canada conversion, January to July 2003 average.

[61] Bank of Canada conversion, January to July 2003 average.

entered into with BNFL on November 28, 2002. These principles for restructuring include:[62]

- BNFL will provide two new contracts to replace the agreements under which BNFL currently provides front and back-end fuel related services to BE.
- All un-contracted nuclear liabilities and decommissioning liabilities of the nuclear power stations owned by BE and historic liabilities relating to spent fuel will be met through a Nuclear Liability Fund (NLF). BE will make ongoing contributions to this fund and the British Government has agreed to assume financial responsibility for such liabilities to the extent that they exceed the assets in the NLF.
- BE will issue new bonds (not more than £550 million) to significant creditors, together with new ordinary shares, in exchange for the extinguishment of existing obligations. BE will also issue new bonds to the NLF (£275 million).
- The NLF will also receive a contractual entitlement to receive 65 percent of the net cash flow of the British Energy Group (after tax, financing costs, and transfer to cash reserves).

There are also on-going discussions between the Department of Trade and Industry and BE about future financial arrangements for decommissioning, but this does not involve passing the NLF to the NDA.[63]

Liability / Title

BE has liability for management of its spent fuel. Some of BE's spent fuel liabilities are covered by long term contracts with BNFL for reprocessing, but

---

[62] "Announcement of restructuring proposals and extension of HMG loan facility," British Energy, November 28, 2002.

[63] Interview with Jonathan Temple, Senior Energy Policy Analyst, British Embassy (Washington, DC), June 2003.

the remainder is not under contract. BE's November 28, 2002, restructuring proposal stipulates that, with respect to the back-end fuel services, "BNFL will assume title to new spent fuel on delivery to BNFL from British Energy."[64]

BE also has an obligation, under its nuclear licenses, to decommission its nuclear plants at the end of their useful life. Certain of the decommissioning liabilities are covered by the Nuclear Decommissioning Fund (NDF) to which BE contributes; however, there is no certainty that this fund will be sufficient to cover all of the liabilities to which it relates.

A payment of 65 percent of future net cash is to go into the Nuclear Liabilities Fund and the UK Government has agreed to fund any difference between the un-contracted nuclear and decommissioning liabilities covered by the NLF and the assets in the NLF contributed by BE.[65] As a result of the restructured BNFL contracts, cash operating costs in the nuclear operations, on an assumption of 67 TWh output and at electricity prices of £16 per MWh (in 2002-3 prices), are expected to be approximately £14.50/MWh[66].

[64] BE press release, *British Energy Exchanges Fuel Contracts with BNFL*, May 16, 2003.

[65] *Company Strategy*, www.british-energy.co.uk, July 2003.

[66] Bank of Canada average exchange rate for 2002-2003 period is £1.00 = CDN$2.35

Country Profiles: ASIA

Japan

Background

Like France and the UK, Japan uses the 'closed fuel cycle.' Spent fuel from Japanese nuclear reactors is sent to the UK and France for reprocessing and the resultant MOX fuel and HLW is returned to Japan. Japan is also completing construction of its second reprocessing plant.

The Japanese parliament (the Diet) passed the Law on Final Disposal of Specified Radioactive Waste in May 2000, mandating the deep geological disposal of high-level wastes. In October of the same year, the Nuclear Waste Management Organization (NUMO) was set up by the private sector to move forward with plans for disposal, including site selection, demonstration of technology there, licensing, construction, operation and closure of the repository. Estimates indicate that approximately 40,000 canisters of vitrified HLW will require storage by 2020. Repository operation is expected to be available towards 2030.

In 1995, Japan's first high-level waste (HLW) interim storage facility opened in Rokkasho-mura. The first shipment of vitrified HLW from Europe (from the reprocessing of Japanese fuel) also arrived in the same year.

Responsible Authorities

The Radioactive Waste Management Centre was established by the Japanese government in 1976 as a specialized research organization focusing on treatment and disposal of radioactive waste. The organization was reorganized in 2000 and with a widened focus it was renamed the Radioactive Waste Management Funding and Research Centre (RWMFRC). It is now

responsible not only for research, but also for managing the common fund reserved for disposal of HLW to which all Japanese nuclear utilities contribute.

Japan Nuclear Fuels Ltd. (JNFL) is responsible for reprocessing and temporary storage of HLW for a period of 20 to 30 years (*i.e.*, until a final disposal repository is available).

Financial Mechanism

All utilities using nuclear power in Japan are required by law to make annual contributions into the common fund dedicated to HLW disposal. The fund was started in 2000 and under present regulations, contributions will continue for fifteen years.

Estimates for disposal of HLW in Japan are approximately US$30 billion.[67] Contributions from waste producers (utilities) are calculated based on the total quantity of nuclear power produced by each utility on an annual basis.[68]

Table 6: Fund Contributions for 2000

Electric Utility	Contribution (billion Yen)	Converted to CDN$[69] (million)
Hokkaido	2.3	31.7
Tohoku	2.6	35.8
Tokyo	38.0	523.6
Chubu	8.3	114.4
Hokuriku	0.9	12.4
Kansai	23.7	326.6
Chugoku	3.3	45.5

[67] Interview with Mamoru Nishiyama, Japan Electric Power Information Centre, June 29, 2003.

[68] Interview with Mamoru Nishiyama, Japan Electric Power Information Centre, June 29, 2003.

[69] Bank of Canada, average 2000 conversion rate: Japanese Yen to Canadian Dollar.

Shikoku	4.7	64.8
Kyushu	11.4	157.1
Genden	7.2	99.2
Total	***102.4***	***1,411.1***

Management of funds

NUMO is responsible for managing the reserve fund for nuclear waste management in Japan. The fund is managed by investing in stable bonds such as government guaranteed bonds, local government bonds and corporate bonds. Approximately 50 percent of the fund is currently held in national bonds.

Liability / Title

NUMO implements Japans waste management and disposal policy and has liability for spent fuel and HLW.

South Korea

Background

South Korea follows an open cycle approach. The Ministry of Commerce Industry and Energy (MOCIE) announced in July 2003 that Wido Island, Puan County will be the site of the country's centralized interim storage facility for all radioactive wastes.[70] In anticipation of construction and operation of this facility by 2016, spent fuel is currently stored on site at reactor facilities. By the end of 2000, about 6000 tonnes of spent fuel was stored on site. The centralized interim storage facility is expected to have a capacity of 20,000 tonnes.

Long term, Korea plans to construct a deep geological disposal repository.[71] Following numerous failed attempts to select a site for the repository facility, the Ministry of Commerce, Industry & Energy (MOCIE) selected four sites in 2003 for detailed consideration and preliminary environmental review, with the intention to negotiate acceptance with local governments starting in 2004.

Responsible Authorities

Korea Hydro & Nuclear Power Co., Ltd (KHNP) is a subsidiary of Korea Electric Power Company (KEPCO) and is the sole producer and owner of commercial spent fuel in South Korea.

Ultimate responsibility for management of spent nuclear fuel rests with the Korean government. The Ministry of Science and Technology (MOST) is responsible for overseeing the management of KHNP's Nuclear Waste

---

[70] Weekly Digest, Uranium Information Center, July 25, 2003.

[71] "Information Brief: Nuclear Power in South Korea," World Nuclear Association, June 2003.

Management Fund. MOST and the Ministry of Commerce, Industry and Energy (MOCIE) are responsible for interim storage of spent fuel.

The Korea Atomic Energy Research Institute (KAERI), responsible for R&D on wastes, functions as part of MOST.

Financial Mechanism

The 'polluter pays' principle was adopted by South Korea on 1988 with the passing of the Atomic Energy Act. Under the Act, KNHP is required to levy a fee of 1.2 WON/kWh (1 CDN$ = approx 885 WON) on power generated.[72]

The Act also set in place a fee levied on Korea Nuclear Fuel Company (KNFC), which supplies PWR and CANDU fuel to KNHP.

Management of funds

At present there is no independent organization to manage South Korea's Nuclear Waste Fund. Fees are currently paid by KHNP into the Fund, which is managed by KHNP, with some supervision from MOST.

The arrangement is said to be somewhat controversial at the moment and there have been calls to move the fund to an external third party.

Liability / Title

Korea Hydro & Nuclear Co., Ltd owns the spent nuclear fuel that it produces. MOCIE is responsible for interim storage and MOST and MOCIE are jointly responsible for final management of spent fuel.

[72] Interview with Dr. Jungmin Kang, The Nautilis Institute, June 19, 2003.

Glossary

Terminology

Appropriations – The legislative process used in the United States to authorize expenditures of public funds, i.e., requiring approval by Congress.

Closed fuel cycle – When removed from reactor, spent fuel is stored under water to remove remaining heat and to provide shielding from radiation. In a closed fuel cycle, the spent fuel is reprocessed to produce a product that can be fabricated into mixed oxide (MOX) fuel, HLW and other waste products.

Dry storage – A method of storing spent fuel whereby the fuel is placed inside containers made of metal or concrete. See also 'wet storage.'

HLW or high-level waste – The term is used to describe materials that maintain a high level of long-lived radioactivity. Such materials can contain fission products and transuranic elements generated in the reactor core which are highly radioactive and hot. In the case of reprocessing spent fuel, the 3 percent of it which emerges as HLW is largely liquid, containing the "ash" from burning uranium. This material is vitrified into borosilicate glass (similar to Pyrex) for encapsulation, interim storage, and eventual disposal deep underground.[73] HLW is sufficiently radioactive to require both shielding and cooling, generates >2 kW/m^3 of heat and has a high level of long-lived alpha-emitting isotopes.[74]

Legacy waste – Refers to waste that has accumulated from historic nuclear operations, either commercial nuclear power generation or more often defense-related operations.

Liability – Legal obligation or responsibility.

---

[73] "Nuclear Electricity (Seventh edition)," World Nuclear Association, 2003.
[74] "Information Brief: Radioactive Wastes," World Nuclear Association, March 2001.

Open or 'once-through' fuel cycle – When removed from reactor, spent fuel is stored under water to remove remaining heat and to provide shielding from radiation. In an open or 'once-through' fuel cycle, the spent fuel would then be destined for final disposal or permanent storage, such as in the US and Sweden. Spent fuel is stored initially at the reactor site and then it may be moved to a disposal or storage facility. See also fuel cycle and closed fuel cycle.

Ownership – Legal obligation of possession.

'Polluter pays principle' – The principle by which all funds for future liabilities such as waste management and reactor decommissioning reactors should be in place, ideally funded by the waste producers with the costs passed on to their customers, in order to avoid the financial burden falling on future generations.

Provisions – Used to define funds formally recognized and set aside by a waste producer to cover future financial liabilities for waste management.

Reprocessing – The process of separating spent fuel to retrieve unused uranium and plutonium that can be re-used as mixed oxide fuel (MOX). This process also produces quantities of HLW which are then solidified by the process of vitrification in anticipation of storage or disposal.

Acronyms

AECL – Atomic Energy of Canada Limited

CEA – Atomic Energy Commission (France)

MTHM – Metric tons of heavy metal

NEA – Nuclear Energy Agency

NFWA – Nuclear Fuel Waste Act of 2002 (Canada)

NWMO – Nuclear Waste Management Organization (Canada)

NWPA – Nuclear Waste Policy Act (United States)

NSCA – Nuclear Safety and Control Act of 1997 (Canada)

NUMO – Nuclear Waste Management Organization (Japan)

OCRWM – Office of Civilian Radioactive Waste Management, US Department of Energy

OECD – Organization for Economic Cooperation and Development

Sources

Interviews

- Regis Babinet, Nuclear Energy Counsellor, Embassy of France (Washington, DC), May 15, 2003.
- Peter Brown, Director, Uranium and Radioactive Waste Division, Natural Resources Canada, June 2003.
- Peter Elder, Head, Regulatory Management and Government Relations Division, Canadian Nuclear Safety Commission, June 2003.
- Richard Ferch, Director, Wastes and Geosciences Division, Canadian Nuclear Safety Commission, June 2003.
- Dr. Jungmin Kang, The Nautilis Institute, June 19, 2003.
- Richard Minning, Office of Civilian Radioactive Waste Management, US Department of Energy, May and June 2003.
- Mamoru Nishiyama, Japan Electric Power Information Centre, June 29, 2003.
- Dr. Claudio Pescatore, Radioactive Waste Management, Nuclear Energy Agency, May and June 2003.
- Jacques Tamborini, Head, International Department, ANDRA, June 30, 2003.
- Jonathan Temple, Senior Energy Policy Analyst, British Embassy (Washington, DC), June 2003.
- Karl Wollen, Energy Counsellor, Germany Embassy (Washington, DC) June 2003.

Publications

- "Informations Utiles," Atomic Energy Commission (CEA, France), Édition 2002.
- "Annual Report," Kärnavfallfones Styrelse, The Board of the Swedish Nuclear Waste Fund, 2002.
- "Announcement of Restructuring Proposals and Extension of HMG Loan Facility," British Energy, November 28, 2002.
- "British Energy Exchanges Fuel Contracts with BNFL," British Energy press release, May 16, 2003.
- British Energy Company Strategy, www.british-energy.co.uk, British Energy, July 2003.
- "Managing the Nuclear Legacy – A Strategy for Actions," British Government, July 4, 2002.
- "Nuclear Sites & Radioactive Substances Bill," British Government, June 24, 2003.
- "White Paper: Managing the Nuclear Legacy – A Strategy for Actions," British Government, July 4, 2002.
- "Regulatory Guide G-206: Financial Guarantees for the Decommissioning of Licensed Activities," Canadian Nuclear Safety Commission, June 2000.
- "Regulatory Guide G-219: Decommissioning Plans for Licensed Activities," Canadian Nuclear Safety Commission, June 2000.
- "Record of Proceedings, Including Reasons for Decision In the Matter of OPG and Bruce Power," Canadian Nuclear Safety Commission, May 15, 2003.
- "Schemes for financing radioactive waste storage and disposal," European Commission, 1999, p. 33.

- Nuclear Safety and Control Act, Government of Canada, 2000.
- Nuclear Fuel Waste Act, Government of Canada, 2002.
- "Institutional Framework for the Long-Term Management of High-Level Waste and Spent Nuclear Fuel (TECDOC 1323)," International Atomic Energy Agency, 2002.
- "Radioactive Waste Policy Framework," Natural Resources Canada, July 10, 1996.
- "McLellan Announces Policy Framework for Radioactive Waste," Natural Resources Canada, July 10, 1996.
- "Future financial liabilities arising from nuclear activities," *NEA Newsletter*, Nuclear Energy Agency, Spring 1996, p. 16-20.
- "Future Financial Liabilities of Nuclear Activities," Nuclear Energy Agency / Organization for Economic Co-operation and Development, 1996.
- "Nuclear Waste Bulletin: Update on Waste Management Policies and Programmes," Nuclear Energy Agency, No. 14, 2000.
- Radioactive Waste Management Committee (RWMC)-36 conference proceedings (Country updates on financial schemes), Nuclear Energy Agency, March 2003.
- "Frequently Asked Questions," Nuclear Energy Institute, 2002.
- "Total System Life Cycle Cost," Office of Civilian Radioactive Waste Management (US Department of Energy), May 2001.
- "Nuclear Waste Fund Fee Adequacy: An Assessment," Office of Civilian Radioactive Waste Management (US Department of Energy), May 2001.
- "Civilian Radioactive Waste Management Program Plan, Revision 3," Office of Civilian Radioactive Waste Management, no date.

- "Financing: Covering the expenses for nuclear waste," SKI (Swedish Nuclear Power Inspectorate), November 1998.
- Weekly Digest, Uranium Information Center, July 25, 2003.
- "Information Brief: Radioactive Waste," World Nuclear Association, March 2001.
- "Information Brief: Nuclear Power in South Korea," World Nuclear Association, June 2003.
- News Briefing 03.29, World Nuclear Association, July 23, 2003.