High-Level Radioactive Waste in Canada: The Eleventh Hour

Report of the Standing Committee on Environment and Forestry on the Storage and Disposal of High-Level Radioactive Waste

Compliments Of:
Michael Wilson, P.C., M.P.
Etobicoke Centre

HOUSE OF COMMONS

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Chairman: Bob Brisco

Minutes of Proceedings and Evidence of the Standing Committee on

Environment and Forestry

RESPECTING:

In accordance with its mandate under Standing Order 96(2), an examination of the storage and disposal of high-level radioactive waste

INCLUDING:

The First Report to the House

Second Session of the
Thirty-Third Parliament, 1986-87

CHAMBRE DES COMMUNES

Fascicule nº 21

Le mardi 1er décembre 1987
Le jeudi 3 décembre 1987

Président: Bob Brisco

Procès-verbaux et témoignages du Comité permanent de

L'environnement et des forêts

CONCERNANT:

En vertu de l'article 96(2) du Règlement, un examen de l'entreposage et de l'évacuation des déchets hautement radioactifs

Y COMPRIS:

Le Premier rapport à la Chambre

Deuxième session de la
trente-troisième législature, 1986-1987

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(Second Session, Thirty-Third Parliament)

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The Standing Committee on Environment and Forestry has the honour to present its

FIRST REPORT

In accordance with its mandate under Standing Order 96(2), your Committee agreed to study the storage and disposal of high-level radioactive waste in Canada.

Pursuant to Standing Order 99(2), your Committee requests that the Government table a comprehensive response to the Report.

ACKNOWLEDGEMENTS

The Chairman and Members of the Committee acknowledge, with gratitude, the cooperation and support of all those who contributed to their study of the storage and disposal of high-level radioactive waste in Canada. The Members extend their thanks to all of the witnesses who appeared and shared with them their knowledge and insight on this complex subject.

The Chairman and Members express their appreciation of the assistance of Jean-Pierre Amyot, Research Officer from the Research Branch of the Library of Parliament, and Janice Hilchie, Clerk of the Committee.

The Committee wishes also to acknowledge the valuable cooperation of the staff of the Committees and Private Legislation Directorate, the Translation Bureau of the Secretary of State, and the support services of the House of Commons and the Research Branch of the Library of Parliament.

Finally, the Chairman wishes to thank the Members of the Committee for their dedication and perseverance in bringing this report to its conclusion.

Bob Brisco, M.P., Chairman

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High-Level Radioactive Waste in Canada: The Eleventh Hour

Introduction

Nuclear generation of electricity has been hailed by some as a source of hope, condemned and attacked by others as a threat. It is being debated, as the end of the twentieth century approaches, with great intensity. Born of scientific discoveries in the earlier years of our century, atomic power exploded into history with the terrifying events at Hiroshima and Nagasaki, and its "domestication" has been a controversial issue ever since: how should nuclear energy be used, and is it safe as a source of energy?

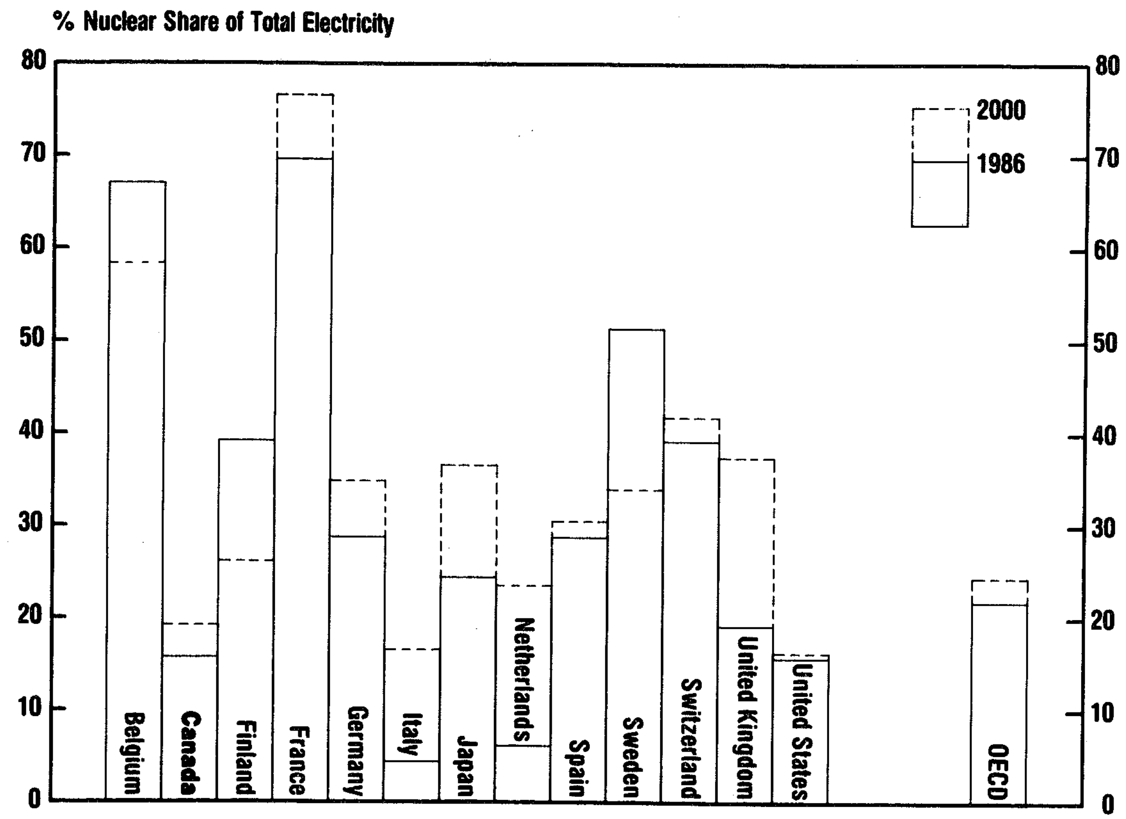
Nuclear-generated electricity was first produced in 1951 by an American reactor. By 1955, the first nuclear generating stations were in operation: Obninsk in the Soviet Union, Shippingport in the United States, Calder Hall in Great Britain, and Marcoule in France. Thirty years later, 13% of the world's electricity was being produced with the help of 370 nuclear power plants, in 26 countries.[1]

Hence, nuclear power is certainly one of the energy-source options in today's world. So far, France has the highest proportion of nuclear-generated electricity, with 70%; Belgium's proportion is 67%, Sweden's 50%, the Federal Republic of Germany 30%, Japan's 25%, the United States' 17%, and Canada's 15% (see Figure 1).

While some humanists, scientists and moralists point to Chernobyl as proof that the nuclear venture is too risky, other thinkers go so far as to claim that nuclear energy is the only way to meet our enormous energy demands. But the debate is not the exclusive preserve of specialists: it arouses so much interest generally that the political will of governments is now an important factor in deciding whether this technology will be shelved or developed. Some countries, like France, the United States, the United Kingdom, the USSR and Japan have opted firmly for nuclear energy, because they are convinced that the risks can be reduced and the problems can be dealt with, to the point that an acceptable level of safety can be assured. At the other end of the spectrum are countries like Australia, Austria, Denmark and Norway, which refuse to use nuclear energy. And finally, there is also the option of a reduced nuclear program, which Sweden has adopted:[2] while waiting for alternative solutions to be developed, Sweden will decommission its twelve nuclear power plants one by one from the present until the year 2010.[3]

(1) Jacques Leclercq, *The Nuclear Age*, Paris, Hachette, 1986, p. 13.
(2) After a national referendum in 1980, the Swedish Parliament decided that its nuclear power programs would be limited to the 12 power reactors then in operation or under construction.
(3) World Commission on Environment and Development, *Our Common Future*, Oxford University Press, Oxford, April 1987, p. 187.

Figure 1
Nuclear Energy's Share of Electricity Generation in OECD Countries



Source: OECD Nuclear Energy Agency, *Electricity, Nuclear Power and Fuel Cycle in OECD Countries: Main Data*, Paris, 1987, p. 26.

Although the Standing Committee on Environment and Forestry recognizes the overriding importance of the issue "to use or not to use" the nuclear option, it does not intend to pronounce itself in favour of one or the other of the alternatives described above. Like the World Commission on Environment and Development, the Committee supports the thesis that nuclear production of electrical power is only justified under circumstances where certain problems, still unanswered, can be solved in a way that is satisfactory from the social, economic, environmental and ethical standpoints. These problems include the decommissioning of nuclear power stations and the disposal of high-level radioactive waste.[4]

Few scientific discoveries have excited public opinion as nuclear energy has, and it is generally conceded that popular perceptions of it are strongly influenced by the difficulties connected with management of spent fuel and other radioactive products.[5] The thorny problem of storage of high-level radioactive waste is without a doubt one of those that give rise to the most questions. By the end of 1987, 25 years after Canada's first nuclear power plant went into operation, some 12,400 metric tonnes of spent fuel will be stored in our various nuclear power plants. By the year 2000, that amount will have grown to 42,000 tonnes; and to 100,000 tonnes in 2024 (see Figures 2 and 3).[6] This takes on very great importance indeed in light of the fact that there is still no proven method for disposing of this highly radioactive material.

If one thing is certain about nuclear energy, it is that — whatever its future — the waste which it produces must be disposed of. Governments and the nuclear industry must do everything possible to understand and tackle openly the public's real concerns about disposal. Having heard from nine groups of witnesses, and visited the Whiteshell Nuclear Research Establishment in Manitoba, the Committee wishes to reflect on what it has heard and seen by presenting the following report and recommendations.

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(4) The expression "high-level radioactive waste" refers essentially to spent (or used) nuclear fuel, whether it has been reprocessed or not.

(5) International Atomic Energy Agency/OECD Nuclear Energy Agency, *Nuclear Energy: Prospects to 2000*, Paris, 1982, p. 112.

(6) OECD Nuclear Energy Agency, *Nuclear Spent Fuel Management: Experience and Options*, Paris, 1986, p. 61.

Figure 2
Canada's Projected Nuclear Power Capacity

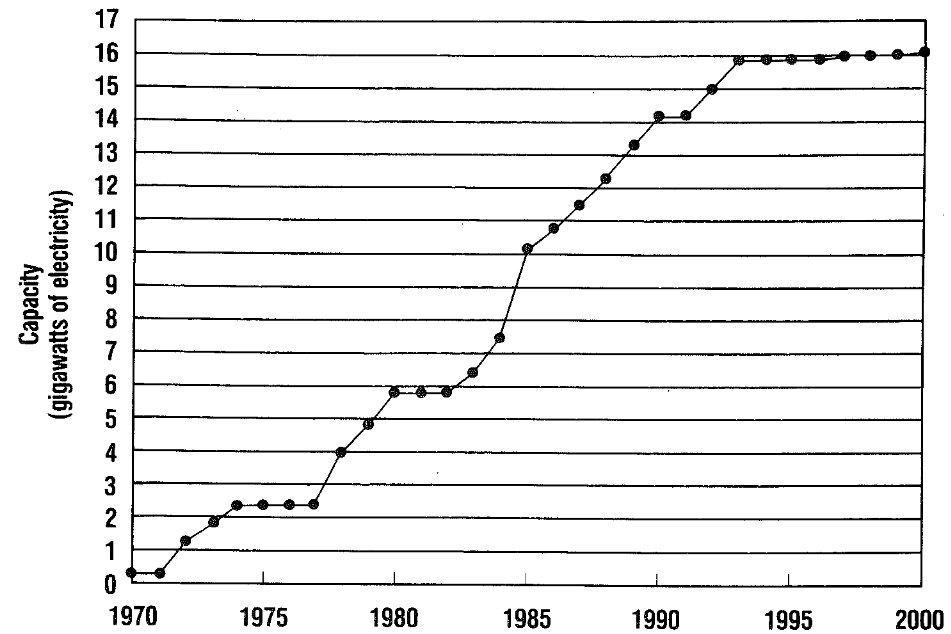
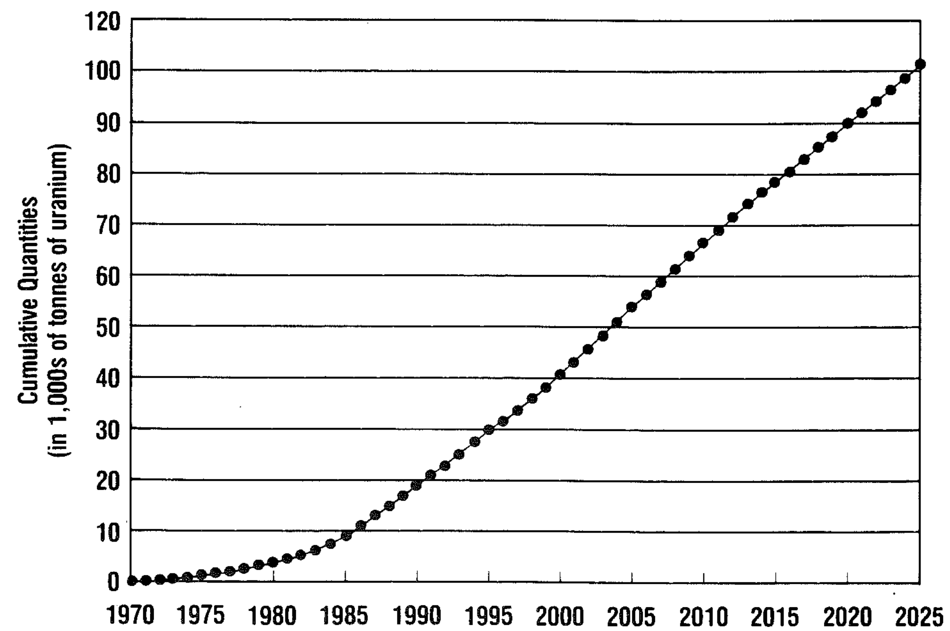


Figure 3
Projected Spent Fuel Accumulations in Canada



N.B.: These graphs assume that Canada's nuclear power capacity will reach a plateau in 1993.

Source: OECD Nuclear Energy Agency, *Nuclear Spent Fuel Management: Experience and Options*, Paris, 1986, p. 61.

Chapter 1

Background Information

Mr. Chairman, our research program is clearly recognized by international scientists as being world class. I believe our approach could well serve as a model for society in dealing with other kinds of toxic waste, and that many aspects of our technology can be applied to these other wastes.

Stanley R. Hatcher, President,
Atomic Energy of Canada Ltd.
Research Company

A Profile of the Nuclear Power Industry in Canada

Acknowledged to be one of the best reactors in the world, the CANDU (an acronym for *CANada Deuterium Uranium*) passed the test beginning in 1962 with the commissioning of a small 25-megawatt (MW) test generating station (Nuclear Power Demonstration, or NPD) in Rolphton, Ontario. Following this successful experiment, Canada developed a first generation of 200 MW generators with the commissioning of the Douglas Point Nuclear Generating Station on Lake Huron in 1966 (closed down in 1984): reactors of this generation were sold to India and Pakistan. The power of commercial reactors increased subsequently, and Ontario Hydro, *Hydro-Québec* and the New Brunswick Electric Power Commission in turn acquired CANDUs,[7] so that by March 1987 Canada had 18 operating nuclear power plants, of which 16 were in Ontario (see Table 1). It should be noted, that once Ontario's Darlington plant becomes operational, the nuclear industry will be providing 62% of that province's electricity.[8]

Although the CANDU is being used in five other countries (Argentina, South Korea, India, Rumania and Pakistan), its commercial success outside of Canada is not necessarily assured. Currently, a large part of the foreign market lies with developing countries, which have difficulty financing the capital cost of a nuclear installation. Given this economic reality, Atomic Energy of Canada Ltd. has had to adjust its sights, and it has developed a new, smaller reactor, the CANDU 300, with a capacity of from 380 to 400 MW depending on water cooling temperatures. Its short construction schedule, low operating cost and flexibility should prove attractive to utilities with limited financial resources.[9]

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(7) Atomic Energy of Canada Ltd. "CANDU leads the world in performance", *Aspects*, Vol. 5, No. 4, 1985, p. 14.
(8) House of Commons, Standing Committee on Environment and Forestry, *Minutes of Proceedings and Evidence*; the Hon. Marcel Masse, Minister of Energy, Mines and Resources, Issue No. 14, April 1, 1987, p. 7. (Henceforth references to evidence heard before the Committee will comprise only the witness's name and the information that follows it).
(9) Mac Keillor, "Satisfying Market Demand: CANDU 300, A New Reactor from Canada", *Aspects*, Vol. 6, No. 4, 1987, p. 11-14.

Table 1

Nuclear Electricity Generation in Canada (March 1987)

		Gross Generation MWe	Gross Generation MWh	Capacity Factor	Lifetime Generation MWh
1	NPD	25	6,461	34.7	3,680,201
2	Pickering-1	542	0	0	47,911,946
2	Pickering-2	542	0	0	46,803,376
	Pickering-3	542	383,620	95.1	54,968,460
	Pickering-4	542	397,460	98.6	54,090,313
	Pickering-5	540	406,600	100.0	16,313,766
	Pickering-6	540	412,300	100.0	12,543,024
	Pickering-7	540	403,600	100.0	9,461,097
3	Pickering-8	540	62,440	15.5	4,846,670
4,5	Bruce-1	826	78,204	12.7	58,149,847
5	Bruce-2	904	531,879	79.1	56,354,101
5	Bruce-3	904	658,560	97.9	58,189,544
5	Bruce-4	904	644,926	95.9	52,176,765
	Bruce-5	885	661,600	100.0	15,581,000
	Bruce-6	890	622,100	93.9	17,574,499
	Bruce-7	890	552,300	83.4	7,339,400
	Pointe Lepreau	680	507,036	100.0	23,660,190
	Gentilly-2	685	477,900	93.8	13,670,600

1 — Power cut back for repairs.
2 — Continued outage for large-scale fuel channel replacement.
3 — Scheduled outage.
4 — Western shift outage.
5 — Production and capacity figures include electricity and steam.

Source: Canadian Nuclear Association, *Nuclear Canada*, Vol. 26, No. 5, June 1987, p. 8.

Radioactivity and Radiological Protection

As anxiety increases over long-term safety and environmental protection, solving the problems of the management of radioactive waste is a crucial factor in making the atom a fully acceptable energy source. Despite the many clashes over this question, all parties agree that protection of human health remains the decisive factor in the choice of a radioactive waste management policy.[10] The result of all safety measures must be to ensure, that in any reasonably likely circumstances, these dangerous products will not emit radiation at a level capable of damaging human health. According to the OECD Nuclear Energy Agency, the environmental goals of nuclear waste management may be summarized as follows:

i) to comply with general radiological protection principles;

ii) to preserve the quality of the natural environment;

[10] S. Fareeduddin and J. Hirling, "The Radioactive Waste Management Conference", *International Atomic Energy Agency Bulletin*, Vol. 25, No. 4, December 1983, p. 4.

iii) to avoid interfering with present or future exploitation of natural resources; and

iv) to minimize, as far as possible, any impact on future generations.[11]

The fundamental principles of radiological protection on which nuclear waste management practices are based, are derived from the system of dose limitation recommended by the International Commission on Radiological Protection (ICRP). The goal of this system is to ensure that human exposure to radiation is maintained at acceptable levels. Certain standards, called "derived emission limits",[12] are applied which in Canada are set by the Atomic Energy Control Board, with the cooperation of Health and Welfare Canada and the provincial departments of health. Derived emission limits are established, not through direct measurements of radiation levels in environmental media (air, water, soil), but rather by making assumptions and modelling predictions about the movement of radionuclides through various environmental media and the food chain. These assumptions are used to relate the global distribution of radioactivity to the dose received by humans.[13]

Radioactivity is not a simple phenomenon. It is the property inherent in certain atoms by which the nucleus spontaneously disintegrate into a new structure. Radiation, in the form of alpha (helium nuclei), beta (electrons) and neutron particles; and gamma or X electromagnetic rays, is emitted during this transformation. Radiation that is emitted is ionizing radiation, that is, it causes the molecules of any substance which it touches to become electrically charged (ionized). It can thus change the chemical structure of cells, including those of living tissue; and if enough radioactivity is absorbed, cells may be damaged or killed.[14]

Radioactivity acts on human beings by irradiation or by contamination. Irradiation occurs when someone is exposed to radiation emitted by a radioactive source. Contamination results from contact with radioactive material, either externally (on the skin) or internally (in the digestive system, lungs, etc.), and obviously it leads to localized irradiation.

Innumerable studies have been done on the effects of ionizing radiation since the ICRP was founded in 1928. The frequent changes in the standards set by that organization testify to the difficulties in determining the critical dose at which radionuclides become dangerous to human beings. For example, between 1979 and 1981, less stringent standards were announced for the "maximum allowable dose" of radium 226 (a radionuclide naturally present in uranium mine and mill tailings), while new standards for neptunium 237, in soluble form, were *3,600* times more severe than previously.[15]

The biological effects of radiation may become apparent in the individual who has suffered an exposure ("somatic effects"), or in his or her offspring ("genetic effects"). Some somatic effects appear in all subjects exposed to a sufficiently high dose ("obligatory effects") and other effects appear in only a few ("random effects").[16] There is a whole range of units of measurement for quantifying radiation and the dose received by the subject, some of which are defined in Table 2. We must bear in mind, however, that in addition to radiation's dangers to health, there are certain artificial sources of radiation that can be used to maintain human health. For example, we need look no further than the treatment of cancer by cobalt. Equally, we all receive several millirems (1000ths of a rem) of radiation every year from cosmic rays, water (which dissolves radon and radium salts), and various industrial products and medical instruments. In the United States, for example, every person

[11] OECD Nuclear Energy Agency, *Long-Term Management of Radioactive Waste: Legal, Administrative and Financial Aspects*, Paris, 1984, p. 17.
[12] This expression has now replaced "maximum permissible concentration" or MPC.
[13] Environmental Assessment Panel, *Second Nuclear Reactor, Point Lepreau, New Brunswick*, 1985, p. 9.
[14] Atomic Energy Control Board, "Radiation: A Modern Tool", *Control*, Ottawa, 1986, p. 4-5.
[15] Louis Puiseaux, *Crépuscule des atomes*, Paris, Hachette, 1986, p. 129-130.
[16] Leclercq (1986), p. 158.

Table 2

Definitions of radiation units and ionizing radiation doses

The *curie*:	measure of activity, i.e. of the rate at which radioactive material disintegrates. 1 curie = 37 billion disintegrations per second, approximately the radioactivity of one gram of radium 226.
The *becquerel*:	means 1 disintegration per second. 1 curie = 3.7×10^{10} becquerels, and 1 becquerel = 27 picocuries (10^{-12} curies).
The *gray*:	measures the "absorbed dose", i.e. the amount of energy divided by the mass of the material in which it is absorbed. 1 gray (Gy) means that 1 joule of energy is being absorbed by 1 kilogram of mass. The milligray (mGy) is more commonly used.
The *rad*:	formerly used to express absorbed dose; now replaced by the gray (1 rad = 0.01 Gy).
The *sievert*:	equal absorbed doses of different types of radiation have different likelihoods of producing biological injury. To account for this, the absorbed dose is multiplied by a quality factor for the particular type of radiation, resulting in a "dose equivalent" measured in sieverts (Sv). For beta or gamma radiation, or X-rays, which have a weaker ionization density than does alpha radiation, the quality factor is 1 (1 Sv = 1 Gy); for neutrons, it varies between 1 and 10; and for alpha radiation it is equal to 10 (1 Sv = 10 Gy). It should be noted that the average Canadian receives between 1 and 2 millisieverts (mSv) per year from natural radiation sources in the environment. Three chest X-rays result in a dose of about 1 mSv.
The *rem*:	formerly used to express dose equivalent; now replaced by the sievert (1 rem = 0.01 Sv). The rem (*r*öntgen *e*quivalent *m*an) will continue to be used from time to time until conversion to the new unit (Sv) is complete.

Sources: Jean-Michel Bader *et al.*, "Tchernobyl: les réponses aux 11 questions que tout le monde se pose", *Science et Vie*, No. 825, June 1986, p. 26.
Atomic Energy Control Board, "Definitions", *Control*, Ottawa, 1986, p. 6.

receives an average annual dose of 160 millirems of radiation, two-thirds of which comes from natural background sources. To put this amount in perspective, it should be borne in mind that an acute radiation dose of 50 rems or more, over a 24-hour period, results in radiation sickness within one hour to several weeks. The chance of surviving a dose above 1,000 rems is virtually nil; 0 to 10% for a dose of from 600 to 1,000 rems, and 50% for a dose of 400 rems. With a dose of 200 rems or less, survival is almost certain. However, other consequences can occur, ranging from gastrointestinal and circulatory disorders to long-term effects like cancer, birth abnormalities, genetic defects and poor general health. Long-term effects can also result from chronic exposure to low-level radiation, and it is this type of exposure, rather than acute doses, that is the concern with radioactive waste disposal.[17]

In formulating the concept of deep geological disposal of nuclear fuel wastes (discussed starting on page 16 and in Chapter 3) certain minimum requirements must be incorporated relating to radiological health and safety, conventional health and safety, environmental protection, usage safeguards, and transportation. Work is in fact underway on formulating specific criteria for each of these areas.

(17) United States Congress, Office of Technology Assessment, *Managing the Nation's Commercial High-Level Radioactive Water*, Washington, 1985, p. 23.

In the opinion of the Atomic Energy Control Board (AECB), the performance of a waste repository must be such that there will be only the slightest probability of radiation doses to individuals from the stored waste exceeding a small fraction of the doses that can be received from natural background radiation.[18] To assess the acceptability of any disposal facility for which projected doses are being established, we must abide by criteria expressed in terms of the risk involved. "Risk" is defined as the probability that a fatal cancer or a serious genetic effect will occur in an individual or in his or her descendants. With respect to ongoing, lifelong exposure to radiation, the ICRP's current opinion is that the principal limit on effective dose equivalent to members of the public ought to be 100 millirems (1 millisievert) per year, taking into account exposure from all sources other than medical irradiation and natural background radiation. It should be noted that the probability of a fatal cancer or serious genetic effects associated with a dose of 1 mSv is two cases per 100,000.

The AECB regards one case per million people per year as an acceptable level of risk in meeting the objective of minimizing repercussions on future generations. This risk corresponds to an individual dose level of 0.05 mSv per year, or 2.5 per cent of the dose received annually from natural background radiation by the Canadian population generally (see Appendix B).[19]

The Characteristics and Dangers of Nuclear Fuel Waste

The production of radioactive waste is part of the fuel cycle, which goes from extraction to (potentially) reprocessing. Although there is no universally applicable classification of wastes, the nuclear industry does recognize different categories of waste: low level (for example, certain medical or industrial material), intermediate or medium level (certain solid wastes from nuclear reactors) and high level (products of fission and actinides).[20] Actinides (plutonium, americium and curium) are heavier elements than uranium, created when a uranium atom[21] absorbs a neutron without the occurence of fission. The most common actinide is plutonium 239, a fissionable element that can produce energy in a reactor and which consequently has great potential as fuel (hence the attraction of recycling spent fuel). The products of fission (iodine, xenon, krypton, etc.) slow down the chain reaction produced in the heart of the reactor, by absorbing neutrons and preventing them from causing the fission of other uranium atoms (see Tables 3 and 4). When too many products of fission accumulate in a fuel bundle, it ceases to function and must be removed from the reactor. It also becomes highly radioactive and gives off a great deal of heat. It should be noted that a fuel bundle stays in the reactor for about a year and a half, until approximately 70% of its uranium 235 has been consumed.[22]

The term "waste" refers to any material for which no further commercial use is envisaged, and which must therefore be disposed of. As a general rule, the phases of the management of radioactive waste include collection, assessment, processing, treatment, transportation, storage and disposal. High-level radioactive wastes are stored in facilities

(18) Atomic Energy Control Board, *Deep Geological Disposal of Nuclear Fuel Waste: Background Information and Regulatory Requirements Regarding the Concept Assessment Phase*, regulatory document R-71, Ottawa, January 29, 1985, p. 9.
(19) Atomic Energy Control Board, *Regulatory Objectives, Requirements and Guidelines for the Disposal of Radioactive Wastes — Long-Term Aspects*, regulatory document R-104, Ottawa, June 5, 1987, p. 5-6.
(20) OECD Nuclear Energy Agency (1984), p. 17.
(21) The only chemical element capable of fission under the action of slow neutrons is uranium 235.
(22) Robert Lyon and Marvis Tutiah, *Nuclear Waste Management: Protecting the Future*, Pinawa, Atomic Energy of Canada Ltd., January 1984, p. 18-20.

Table 3

Actinide Components and Fission Products in One Kilogram of CANDU Spent Fuel

	Radioactive half-life[1] (years)	Type of radiation	Specific Activity (curies/gram)	Mass (grams)
Actinides				
Plutonium 239[2]	24,390	alpha	6.1×10^{-2}	2.7
Plutonium 241[2]	14	beta	112	
Plutonium 238	87	alpha	17	
Plutonium 240	6,660	alpha	2.3×10^{-1}	1.1
Plutonium 242	387,000	alpha	4.0×10^{-3}	
Americium 241	458	alpha, gamma	3.2	
Americium 242	0,0018	beta, gamma	8.2×10^{5}	
Americium 243	8,000	alpha	1.9×10^{1}	1.2
Curium 242	0.51	alpha, neutrons	3,320	
Curium 243	32	alpha	47	
Curium 244	17.6	alpha, neutrons	83	
Fission Products	Radioactive half-life (days)			
Iodine 131	8.1	beta, gamma	1.2×10^{5}	
Xenon 133	5.3	beta, gamma	1.9×10^{5}	
Krypton 85	3,944.0	beta, gamma	391	9
Ruthenium 106	368.0	beta	3.35×10^{3}	
Tellurium 127	109.0	beta, gamma	9.43×10^{3}	
Cesium 137	10,957.0	beta, gamma	87	

(1) The time required for half the atoms of a radioactive substance to disintegrate.
(2) Fissionable actinide.

Source: Ontario, Royal Commission on Electric Power Planning (Arthur Porter, President), *A Race Against Time: Interim Report on Nuclear Power in Ontario*, 1978, p. 74-75.

equipped with appropriate cooling systems, using either water or air. In Canada, fuel bundles are stored in water-filled bays for about five years, after which they can be stored in dry concrete containers. Although this storage is temporary, it can be maintained for several decades, until a disposal or a more long-term storage method can be determined.

After considering disposal of high-level radioactive wastes by such methods as burial in the polar ice caps or in ocean trenches, shooting them into space, or transforming radioactive elements somehow into non-radioactive elements, most scientists have decided to focus their research on burial of the waste deep in geological formations judged to be stable. A number of very expensive pilot underground installations have been built, in, among other countries, Belgium, Canada, the United States, the Federal Republic of Germany, Sweden and Switzerland.[23] For its part, Canada is participating actively in international projects and the exchange of information on radioactive waste management. Atomic Energy of Canada Ltd.

(23) Fareeduddin and Hirling (1983), p. 4.

Table 4

Proportion of Constituent Elements in one Kilogram of CANDU Spent Fuel

Constituent Elements	Fresh Fuel (grams)	Fresh Fuel (%)	Spent Fuel (grams)	Spent Fuel (%)
Uranium 238	993	99.3	984	98.4
Uranium 235	7	0.7	2	0.2
Actinides	—	—	5	0.5
Fission Products	—	—	9	0.9
TOTAL	1,000	100	1,000	100

Source: Ontario, Royal Commission on Electric Power Planning (Arthur Porter, President), *A Race Against Time: Interim Report on Nuclear Power in Ontario*, 1978, p. 88.

(AECL) has been put in charge of research and development in the area of safe immobilization and disposal of fuel wastes, while regulation of all aspects of nuclear energy in Canada, including waste management, is the responsibility of the Atomic Energy Control Board. The AECB recently published a policy statement outlining its long-term regulatory objectives, requirements and guidelines for disposal of radioactive wastes (see Appendix B). That statement explains that the objectives of radioactive waste disposal are to:

i) minimize any burden on future generations;

ii) protect the environment; and

iii) protect human health,

while taking social and economic factors into account.[24]

The Committee is concerned by the interpretation that might be given to the somewhat timid notions of "minimizing" and "protecting," in the context of social and economic factors whose nature and relative importance are not yet very well defined. The Committee is especially troubled by the uncertainty that still exists over the biological effects of low-level doses of radiation. In the view of certain members of the scientific community, doubts must be cast on "acceptable" radiation thresholds, because the toxicity of radiation may hitherto have been consistently underestimated.[25] Obviously, a position such as this could have considerable influence on the perception of the risk involved in the use of nuclear fuel.

The perception of a risk is based not only on emotion and feelings but also on cognition. The reliability a person attributes to available information is an important element in his or her thought process on the matter. Thus the question of the motivation, credibility and competence of the research and regulatory bodies involved in radiological production

(24) Atomic Energy Control Board (1987), p. 2.
(25) Pierre Baron, "Les normes actuelles sont fausses," *Science et Avenir*, No. 487, September 1987, p. 79-84.

constitutes a major factor in risk assessment.[26] Consequently, and considering the importance of establishing criteria on health and environmental protection, the Committee hopes that bodies whose expertise and independence cannot be doubted will play an active part in the debate on assessing the radiological risks associated with any potential waste fuel disposal facility.

The Energy Challenge

In its report entitled *Our Common Future*, the World Commission on Environment and Development argues that the human race has the capacity to ensure sustained development and to meet present energy needs without mortgaging the prospects of future generations. As far as energy is concerned, the Commission argues that the principle of sustainability has certain key elements that must be reconciled, two of these being recognition of the safety risks inherent in energy sources, and protection of the biosphere.[27,28]

Although it is not part of the Committee's mandate to launch a debate on the advantages and disadvantages of the various energy options, the Committee was pleased when, in the spring of 1987, the Department of Energy, Mines and Resources created a national advisory committee to preside over a public review of Canada's energy options into the twenty-first century. As we head into an era of "energy plurality," the "energy options" approach is one that will enable us to investigate the principles that should shape the formulation of an energy policy for Canada.[29] The Committee is also pleased to note that the House of Commons Standing Committee on Energy, Mines and Resources is conducting a study of the economics of nuclear power in Canada.

Following the lead of the World Commission on Environment and Development, the Committee believes that an intensive effort must be made to promote the development and use of renewable energies (solar, wind, tidal, etc.). Of these, hydrogen constitutes one of the most promising avenues to explore. In addition to having the highest energy density per unit weight, hydrogen burns, leaving water as its only by-product. Moreover, unlike other fuels, hydrogen can be easily produced by electrolysis.[30] Hydrogen has been the subject of many major studies,[31] and its potential use in Canada remains very attractive from the environmental standpoint. The recent report of the Advisory Group on Hydrogen Opportunities maintains that the introduction of hydrogen use would be beneficial on four environmental levels: "site-critical environments", which include confined spaces such as mines and warehouses; urban environments; continental environments (reduction in acid rain); and the world environment (slowing of the greenhouse effect).[32]

In the same vein, the Committee is interested in the current state of knowledge about nuclear fusion and its applicability. It is generally conceded that "perhaps the greatest scientific and technical challenge the human race has so far undertaken is the attempt to

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[26] Advisory Committee on Nuclear Safety, Atomic Energy Control Board, *A Report on the Public Perception of Risk*, Ottawa, July 1986, 46 p.

[27] World Commission on Environment and Development (1987), p. 169.

[28] A National Task Force on Environment and Economy, established by the Canadian Council of Resource and Environment Ministers (CCREM) in October 1986, recently tabled a report recommending that Canada increase its role in the international movement to integrate environmental protection and economic development.

[29] Energy Options Advisory Committee, *The Energy Question*, Ottawa, 1987, 28 p.

[30] House of Commons, Special Committee on Alternative Energy and Oil Substitution (Thomas H. Lefebvre, Chairman), *Energy Alternatives*, Ottawa, 1981, p. 183-184.

[31] National Research Council of Canada, Energy Division, *Program Overview: Hydrogen and Energy Storage, 1979 to 1985*, Ottawa, October 1985, 106 p.

[32] Advisory Group on Hydrogen Opportunities, *National Mission for Canada*, June 1987, p. 35-38.

harness and control the power of nuclear fusion, the process that enables the stars, including our sun, to produce light and heat."[33] "Measured by weight of fuel, the fusion process would produce about one million times the energy of fossil fuels."[34] Nuclear fusion offers the possibility of a virtually unlimited energy source, based on a fuel available everywhere [${}^2_1H$ (deuterium) + ${}^3_1H$ (tritium) $\rightarrow$ ${}^4_2He$ (helium) + ${}^1_0n$ (neutron) + energy]. It also represents some important advantages, including a number of benefits for the environment:

- It is one of the very few energy sources with the potential to handle [virtually all of] the energy requirements of humankind in its long-term occupation of the planet.
- Proper design of fusion reactors should reduce the generation of radioactive by-products to levels far below those of fission reactors. The fusion by-products would also have shorter half-lives than fission by-products.
- Fusion activation products are nonvolatile, whereas a substantial fraction of fission activation products are volatile. Controlling radioactivity in the event of an accident should therefore be easier in a fusion reactor.
- The fusion reaction does not generate chemical combustion products and in that sense represents a benign energy technology.
- Materials used and by-products generated in a commercial fusion reactor would not lend themselves to the production of nuclear weapons.
- The development of fusion power systems, by virtue of their complexity and highly demanding engineering design, will promote technological advances with applications in other industrial sectors.[35]

The commercial exploitation of fusion energy may indeed have attractive potential, but the fact remains that immense technical and economic problems will have to be resolved before it becomes a feasible alternative.

Hydrogen and nuclear fusion are only two of the options to which Canada will have to devote a great deal more attention over the coming years. Accordingly, in a perspective of environmental protection and reduction of the health risks inherent in energy production, and recognizing the existence of an Interdepartmental Committee on Energy and Environment, the Committee recommends that:

Recommendation 1

The federal government should step up its efforts to determine the extent to which the various renewable energy vectors or sources can meet Canadians' demand for energy. In addition, the Departments of the Environment and of Energy, Mines and Resources should establish the best possible terms on which:

(*a*) energy can be economized and energy consumption reduced;

(*b*) the use of energy resources can be optimized, given the available resources and their impact on health and the environment; and

(*c*) wastes resulting from energy-production techniques can be properly managed.

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[33] National Research Council of Canada, Energy Division, *Alternative Energy Technology in Canada*, Ottawa, September 1986, p. 121.

[34] *Ibid.*

[35] House of Commons, Special Committee on Alternative Energy and Oil Substitution (1981), p. 166.

Chapter 2

The Canadian Nuclear Fuel Waste Management Program: The Agencies Involved

The federal government is not only not against the creation of nuclear waste, the federal government is not even neutral on the subject. The federal government is subsidizing the waste-makers; the federal government has from the start taken ownership of the nuclear industry, which has brought us this problem.

Norman Rubin, Director of
Nuclear Research for Energy
Probe

The Regulatory Framework

In 1946, the Canadian Parliament passed the *Atomic Energy Control Act* (RSC 1970, c.A-19), and in so doing declared nuclear energy to be a matter of national interest and thus under federal jurisdiction. The Atomic Energy Control Board (AECB) was created by that Act to control and supervise the development, application and use of nuclear energy.

The current bases for Canada's nuclear regulation are contained in that Act and more especially in the *Atomic Energy Control Regulations* (CRC 1978, c. 365), which define the authorization and supervisory structure for nuclear activities as a whole. Because the legislation did not cover certain matters, Parliament passed the *Nuclear Liability Act* (RSC 1970, sup. I, c. 29), which defined a limited civil liability in cases of nuclear damage. It came into force on October 11, 1976. Radioactive waste management facilities are subject to the general requirements of the *Atomic Energy Control Regulations*, and operators must obtain a licence from the AECB. To obtain a licence for any other category of activity (extraction of minerals, possession and marketing of nuclear materials, equipment or technology), applicants must prove that they have made adequate provision for storage or disposal of wastes, to ensure that appropriate conditions are spelled out in every permit.[36]

The Institutional Framework

Many government departments and agencies play a role in the regulation of nuclear activities and waste management in Canada. The federal and provincial departments of the environment assess the environmental repercussions of proposed nuclear installations and related projects (for example, waste burial sites). Environment Canada also participates in

[36] OECD Nuclear Energy Agency, *Nuclear Legislation: Analytical Study*, Paris, Vol. 1, 1983, p. 66-70.

nuclear regulation by setting Canadian standards for all toxic substances, including radioactive substances, in the environment. Transport Canada shares responsibility with the AECB for transportation of radioactive substances, and sets standards for carriers in accordance with the *Transportation of Dangerous Goods Act*. Finally, Health and Welfare Canada is the AECB's principal adviser on the health aspects of radiological exposure and radiation safety.[37]

The following pages provide additional information on the organizations that play important roles in the management of high-level radioactive wastes in Canada, along with comments from the witnesses on their performance.

A. Atomic Energy of Canada Ltd.

In Canada, the leading role in the development of peaceful uses for nuclear energy is played by Atomic Energy of Canada Ltd. (AECL). It has vast responsibilities, which translate into activities ranging from fundamental research to commercial operations and national and international transfers of nuclear technology. To carry out all of these aspects of its mandate successfully, AECL has set up a number of administrative entities. There is, for example, the AECL Research Company, which is responsible among other things for conducting research into management of nuclear fuel wastes.

Under an agreement signed by the governments of Canada and Ontario in 1978, Ontario Hydro is responsible for developing technologies for temporary storage and transportation of spent fuel. AECL is in charge of coordinating and administering the research and development program for seeking safe immobilization and disposal of fuel wastes.[38]

Under the generic disposal method that AECL is currently investigating, waste would be deposited in vaults some 500 to 1,000 metres deep in, what is considered to be stable, crystalline rock formations within the Canadian Shield. A disposal site will not be chosen unless and until this method has been assessed and approved by the governments.

The Canadian Nuclear Fuel Waste Management Program (CNFWMP) is administered by the Whiteshell Nuclear Research Establishment in Pinawa, Manitoba. Its research focuses mainly on immobilization of fuel wastes (i.e. techniques for making them insoluble and sealing them in durable containers), container technology (100,000 containers will be needed by the year 2000 to immobilize spent fuel), buffer and backfill materials, geological barriers and assessment of the behaviour of waste during burial lasting thousands of years.[39] With the concept of burying waste in hermetically-sealed vaults goes that of a "multiple barrier system", designed to create a series of barriers between the waste and the surface of the earth.

Pointing out that Canada's research program is considered by international researchers to be one of the best in the world, the President of AECL's Research Company, S.R.

(37) Atomic Energy Control Board (1986), p. 9-10.

(38) T.E. Rummery and F.L.J. Rosinger, *Nuclear Fuel Waste Management: The Canadian Approach*, Whiteshell, September 1981, p. 2-3.

(39) According to AECB, taking into account the characteristics of radioactive wastes, the options for their disposal, and the uncertainties in long-term predictions, it is considered that 10,000 years, after the time of waste emplacement, is a reasonable maximum period for assessments of individual risk.

Hatcher, reminded Members of the Committee that, given the current price of uranium, Canada has not yet looked into reprocessing[40] its spent fuel.[41]

However, in a brief submitted to the Committee, the Canadian Coalition for Nuclear Responsibility argued that the ultimate goal of AECL was to promote the reprocessing of nuclear waste.[42] Their brief alleged, among other things, that "much of the federal money allotted for research into nuclear waste disposal has actually been used by AECL to further research in plutonium reprocessing".[43]

The interest in reprocessing expressed by much of the international community is summed up well in the following paragraph:

> Sweden and Canada have expressed little interest in reprocessing and are therefore inclined towards eventual direct disposal of spent fuel. Neither one, however, expects to be operating a commercial repository until one or two decades after the end of the century. The United States, the Federal Republic of Germany and Switzerland are also actively engaged in development work on the direct disposal technique, although they have each had varying proportions of their spent fuel reprocessed in the past and may continue to do so in the future. Finland is also investigating direct disposal for some of its fuel capacity. It ships some spent fuel to the USSR. Spain and the Netherlands have only limited nuclear capacity and have so far pursued a policy of securing reprocessing contracts abroad; this situation could change at any time, particularly in the former country, which has announced its intention to limit its long-term nuclear capacity to ten reactors. The remaining OECD countries either operate domestic reprocessing plants or have announced plans to do so.[44]

There is no consensus among specialists in the nuclear industry on this question. At the present time, most of the countries using nuclear power to produce electricity take the "wait and see" position. However, some are convinced of the value of reprocessing. This support was indicated during the second international conference on the reprocessing of nuclear fuel, held in Paris in August 1987, when the president of the *Commissariat à l'énergie atomique de France*, Jean-Pierre Capron, stated that reprocessing is a uniquely responsible approach in consideration of future generations. His claim is that it allows a safe long-term approach to waste management.[45]

Spent fuel is the main waste produced by a nuclear power plant. The initial concept of the CANDU reactor is based on the use of natural uranium (containing only 0.7 per cent fissile material, uranium 235) which goes through the heart of the reactor only once. When this fuel cycle (known as a "once through" or "throw-away" cycle) was first designed, no

(40) By reprocessing is meant the separation of actinides (such as plutonium, uranium and thorium) from fission products by chemical and physicochemical techniques. The fission products are left behind in the form of high-level radioactive waste, which must be disposed of.

(41) S.R. Hatcher, Atomic Energy of Canada Ltd. Research Company, Issue No. 6, February 2, 1987, p. 5-7.

(42) In spite of the fact that Canada ratified the *Treaty on the Non-Proliferation of Nuclear Weapons*, in 1969, and that the exports of nuclear technologies, equipment and materials are now limited to those countries which have signed the Treaty or agree to submit to equivalent international control, there is always a certain concern among the public about the potential diversion of by-products of fission reactors, such as plutonium, to the production of nuclear weapons.

(43) Gordon Edwards, "Nuclear Waste — What, Me Worry?", Montreal, Canadian Coalition for Nuclear Responsibility, June 1986, p. 5.

(44) OECD Nuclear Energy Agency (1986), p. 28.

(45) Elisabeth Gordon, "La prolifération des déchets nucléaires," *Le Monde*, Paris, August 28, 1987, p. 21.

economic value was assigned to the spent fuel.[46] However, it must be kept in mind that only 70 per cent of the fissile material is used during this fuel cycle, and that the spent fuel contains products such as plutonium 239 and 241. Recovery of plutonium (an artificial fissionable element) through reprocessing of the spent fuel is carried out because other fuel cycles based on plutonium are possible.

The development and use of plutonium cycles are increasing the amount of energy that can be extracted from natural uranium. The use of plutonium recovered from spent fuel makes it possible to produce twice as much electricity while cutting the demand for uranium in half. Thorium cycles (thorium 232 + neutrons = uranium 233) or thorium-plutonium cycles are also possible. To this may be added the fast neutron, or breeder reactor, which makes it possible to use almost all of the uranium by transforming non-fissionable uranium 238 into plutonium.[47]

It is not up to this Committee to determine definitively whether waste should be reprocessed or not. However, we note that there are techniques likely to reduce the volume of spent fuel, that countries such as France, England, Japan, Belgium, West Germany and Italy either use or are very interested in; but the Canadian concept of spent fuel waste disposal does not include the possibility of reprocessing waste. Considering the risks associated with the handling and the future transportation of high-level radioactive waste, the lifetime and the specific activity of the fissionable plutonium (see Table 3), the Committee recommends that:

Recommendation 2

> **The Department of Energy, Mines and Resources, in collaboration with the National Research Council, should produce a detailed study on the short and long-term advantages of using various fuel cycles that could reduce the volume and diminish the risks of the waste produced by CANDU reactors. In addition, Energy, Mines and Resources should work to develop techniques that reduce the volume of waste produced by existing reactors.**

During the Committee's hearings, arguments have been invoked against AECL's current participation in research into disposal of high-level radioactive waste including conflicts of interest, a past record sullied by fanciful predictions, and foreign involvement in its research projects. According to Norman Rubin, Director of Nuclear Research for Energy Probe, the nuclear industry, which has always insisted that it could dispose of its waste in an acceptable and economical manner, will find a solution that strikes it as economical and will then do its best to make the rest of us accept it. Energy Probe claims that AECL cannot run a viable and credible research project because its own spokesmen are on record as saying that nuclear waste is a public relations problem rather than a technical one.[48] Energy Probe therefore recommends that:

> This Committee should formally recognize the inappropriateness of giving prime responsibility for, and control over, the waste program to AECL, and should strongly recommend a restructuring of the program. It may be possible for many of the staff and facilities of the Whiteshell Nuclear Research Establishment to continue in this program, but it is vital that they no longer report to AECL management, and that they

(46) A.M. Aikin, J.M. Harrison and F.K. Hare, *The Management of Canada's Nuclear Waste*, Energy, Mines and Resources Canada, Ottawa, 1977, p. 13.

(47) OECD Nuclear Energy Agency, International Atomic Energy Agency, *Nuclear Energy and Its Fuel Cycle: Prospects to 2025*, Paris, 1987, p. 72-76.

(48) Norman Rubin, "The Mismanagement of Canada's Nuclear Waste Management Program", brief presented to the Standing Committee on Environment and Forestry, Ottawa, February 3, 1987, p. 5.

> conduct their work in an environment that is conducive to the scientific method, i.e. one in which they can expect the greatest reward for showing the problems and weaknesses in any proposed disposal concept or plan.[49]

The Committee considers there is something to be said for this suggestion. However, as L.W. Shemilt, Chairman of the Technical Advisory Committee (TAC) on the Canadian Nuclear Fuel Waste Management Program (CNFWMP) stated clearly, AECL may be the leading force in the Program, but outside participation is very important. The Geological Survey of Canada, the Canadian Centre for Mineral and Energy Technology (CANMET), Environment Canada, Ontario Hydro, *Hydro-Québec*, the private industrial sector and more than a dozen universities are also carrying out independent research connected with the research program.[50] Like TAC, the Committee does not question the good faith of the people in charge of the CNFWMP. Furthermore, since the Program will very shortly be the subject of an evaluation by an environmental assessment panel and by the AECB, the Committee considers that it would be more appropriate to concentrate on ensuring that the membership and functioning of those two bodies are well-suited to making informed decisions on the management of high-level radioactive waste.

B. The Technical Advisory Committee on the Canadian Nuclear Fuel Waste Management Program

The Technical Advisory Committee on the CNFWMP, which is responsible for advising AECL, was set up in 1979 following recommendations of government reports and suggestions from certain sectors of the scientific community. Its members are chosen from a list of candidates submitted by the main scientific and technical societies and associations in Canada. Currently it has 13 members representing a range of disciplines.

TAC's purpose is to serve as an independent review committee advising AECL on the scope and quality of the CNFWMP. Its responsibility, therefore, is to review the content of the proposed research projects and their scientific methodology, ensure that the best available technology is being applied to the program, review program results and ensure that the conclusions drawn are valid within the limits claimed, and make recommendations on any specific areas of work for which research should be undertaken, either by existing staff or through research contracts. TAC's annual reports, and its work generally, are oriented along four major research axes:

- engineering of the multiple barriers;
- geoscience research;
- environmental research; and
- environmental and safety assessment.

In its annual report of 1986, TAC presents an assessment of the work currently underway at the Underground Research Laboratory. In summary, it concludes that the experimental construction phase was well designed and flawlessly carried out. On the other hand, it recognizes that the choice of a means of estimating the possible effects of a leak of radionuclides, the establishment of an acceptable criterion for judging those effects, and the whole question of risk, pose problems that will be particularly difficult to solve. It recommends that the general public be helped and encouraged to participate in the concept

(49) *Ibid.*, p. 8.

(50) L.W. Shemilt, Technical Advisory Committee on the Canadian Nuclear Fuel Waste Management Program, Issue No. 6, February 2, 1987, p. 34.

assessment process.[51] Moreover, the TAC's 1987 annual report mentions that "the time may be opportune for a more direct participation by learned societies, scientific and professional associations, general interest groups and various elements from the university and college communities in independent evaluation of program [CNFWMP] progress and issues involved."[52]

During his testimony before the Committee, TAC Chairman L.W. Shemilt stressed his group's independence from AECL. He added that one measure of TAC's worth is that the Government of Sweden has twice asked it to judge Sweden's own research program on deep geological disposal of high-level radioactive nuclear waste.[53]

C. The Atomic Energy Control Board

The Atomic Energy Control Board (AECB) was set up in 1946 under the *Atomic Energy Control Act*. It reports to the Minister of Energy, Mines and Resources. Four of its five members are appointed by Order in Council; the fifth is the President of the National Research Council, himself appointed by Order in Council, and a member of the AECB *ex officio*. The Board members are backed by 250 scientific, technical and administrative staff.

The role of the AECB as a federal body is "to make provision for the control and supervision of the development, application and use of atomic energy, and to enable Canada to participate effectively in measures of international control of atomic energy". Originally responsible for all nuclear activity, from research and development to regulation, it now deals solely with the control of prescribed substances and nuclear facilities from the standpoint of health and safety, by means of a licensing system.[54]

There are many people involved in the licence-granting process including: most of the Board's own specialists, advisory committees of technical experts, and experts from provincial and federal institutions, including the universities. According to the *Atomic Energy Control Regulations*, any person or body wishing to extract, refine, process, export or use prescribed substances (uranium, thorium, plutonium, etc.) or to operate a heavy-water (deuterium oxide) production plant or a nuclear facility, must obtain a licence. The Board's final role is to make sure that operators live up to their responsibilities.

With respect to waste management, the Board makes a distinction between storage, which is the confining of material with the intention of recovering it, and disposal, which is a form of management without any intention of recovery, and which must be able to last indefinitely without human involvement. Currently the AECB is assessing the concept of disposing high-level radioactive wastes deep within geological formations. The concept assessment process, which includes public hearings, is expected to be complete by the early 1990s. Not until then will the search for a site begin, and the Board will have to approve a licence for any chosen site.

Although none of its members appeared before the Committee, special attention was nonetheless paid to the Board, with many witnesses offering comments and recommendations on it. In the opinion of David Poch, legal counsel representing some fifteen churches,

(51) Technical Advisory Committee on the Canadian Nuclear Fuel Waste Management Program, *Seventh Annual Report*, July, 1986, 111 p.
(52) Technical Advisory Committee on the Canadian Nuclear Fuel Waste Management Program, *Eighth Annual Report*, July, 1987, p. 70.
(53) Shemilt (1987), p. 37.
(54) Atomic Energy Control Board, "Walking the Extra Mile: the Role of the AECB", *Control*, Ottawa, 1986, p. 11.

environmental and citizens' groups, the AECB is going outside its role as a regulatory agency and trespassing on the domain of the legislator, by setting criteria for AECL for a matter that is not purely technical in nature.[55] In a letter addressed to the Honourable Pat Carney when she was Minister of Energy, Mines and Resources, Mr. Poch pointed out that:

> In its licensing hearing guidelines, the AECB have themselves excluded consideration of economics, employment, alternative energy options, tourism, choice of lifestyle, and the number of persons supporting or opposing an application. [...] The willingness of the AECB to evaluate the proposed concept without simultaneously thoroughly reviewing alternative approaches to the problem brings the Board's competence to evaluate even narrow technical matters into doubt.[56]

For his part, Norman Rubin of Energy Probe argues that the CNFWMP will provoke a confrontation between the government and the public at large. Problems with the existing procedure arise from the fact that it was, from the very beginning designed, set up and regulated by people with a personal or collective commitment to the nuclear industry. According to Mr. Rubin, the AECB is in no position to arbitrate a conflict between the Canadian public and nuclear interests, because it has already come out clearly in favour of the industry. Consequently, to ensure the validity of decisions relating to nuclear fuel waste and other nuclear energy regulatory issues, and to enable Canadians to have confidence in the decisions reached by their governments on nuclear energy, the AECB should undergo certain reforms. This Committee agrees that the public must have confidence in the impartiality and competence of the agency that holds the regulatory power. The Committee has therefore taken Energy Probe's suggestions under consideration and recommends that:

Recommendation 3

The Government should introduce the following reforms at the Atomic Energy Control Board:

(*a*) a consultation mechanism should be set up to require public participation in making decisions on moral or ethical questions;

(*b*) the membership of the Board should be modified to reflect more fully the reservations expressed by the public about nuclear energy; and

(*c*) the Board should be responsible to Environment Canada rather than to the Department of Energy, Mines and Resources.

(55) David Poch, Energy Probe *et al.*, Issue No. 7, February 3, 1987, p. 49.
(56) David Poch, letter addressed to the Honourable Pat Carney, Minister of Energy, Mines and Resources, Ottawa, April 10, 1986, p. 2-3.

and immobilization of spent fuel wastes, the definitive disposal of immobilized material remains the most challenging and disturbing aspect of the nuclear waste management program. Most of the testimony heard by the Committee concentrated on this aspect.

The Technical Aspect

During the testimony of representatives of Atomic Energy of Canada Ltd., W.T. Hancox, Vice-President in charge of Waste Management Research and Development, listed some of the characteristics of nuclear fuel wastes:

- Ten years after being discharged from the reactor, a used CANDU fuel bundle generates about the same amount of heat as a standard household lightbulb.
- Most of the highly radioactive constituents of spent nuclear fuel decay relatively rapidly, so that the hazard from penetrating radiation is negligible after 500 years.
- Some of the long-lived radioactive materials, such as iodine, cesium, technetium and plutonium, remain toxic for hundreds of thousands of years. Their potential hazard is similar to that of many non-radioactive toxic wastes.
- The long-lived radioactive materials can do harm only if they are ingested or inhaled. The purpose of the disposal system is to isolate them from the environment.
- One hundred years after a vault has been closed, the overall toxicity of its contents would be comparable to that of high-grade uranium ore deposits found in nature.[58]

The performance of the disposal system is currently being assessed by AECL, on the basis of safety criteria, within the framework of the Concept Assessment Program. This is an integrated program of laboratory and field analysis, engineering design and mathematical modelling. AECL is thus involved in perfecting and validating the technology for selecting a site and constructing a disposal system.[59] Considering the importance given to the use of computerized mathematical models in verifying the safety of the concept, the Committee would like to review some of the elements in the testimony of Al Rycroft and Alayne McGregor of the organization called Initiative for the Peaceful Use of Technology (INPUT).

According to the INPUT spokespersons, a computer model is a logical representation, within a computer, of real events and processes. Such a representation can only be a simplified version of reality. It follows that the first difficulty that arises from the use of computer models for nuclear waste disposal is the impossibility of modelling programs that correspond to factual realities, because they typically deal in tens or hundreds of thousands of years. For Al Rycroft, "To accept their conclusions wholeheartedly is an act of faith". In addition to making predictions that are not necessarily accurate, computer models may contain a variety of serious errors. In a nuclear waste disposal model, for example, a typing mistake, a false assumption, a logical error or a conceptual inadequacy could falsify the scenario produced.[60]

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(58) W.T. Hancox, Atomic Energy of Canada Ltd., Issue No. 6, February 2, 1987, p. 6-9.
(59) W.T. Hancox, "Progress Toward a Canadian Concept for Disposal of Nuclear Fuel Waste", document produced for the Standing Committee on Environment and Forestry, Ottawa, February 2, 1987, p. 4.
(60) Al Rycroft and Alayne McGregor, Initiative for the Peaceful Use of Technology, Issue No. 10, March 17, 1987, p. 7-15.

Recognizing the value and relevance of the comments by the INPUT spokespersons, the Committee recommends that:

Recommendation 4

The Atomic Energy Control Board should fund an independent scientific assessment of the computer models used to verify the Canadian high-level radioactive waste disposal concept.

It is now recognized that spent fuel can be disposed of without any additional processing. In addition, the development of containers with metal (titanium or copper) exteriors ensures against leaks for at least 500 years. Field research in this area is being carried out in the Atikokan and East Bull Lake regions of Northern Ontario, and in the Whiteshell region of southern Manitoba.

Excavations at the Whiteshell Underground Research Laboratory include vertical access and ventilation shafts 255 metres deep, and a laboratory room 240 metres below the earth's surface. Preparations are currently underway to extend the access shafts to 455 metres, under an agreement signed with the U.S. Department of Energy.

The concept assessment phase, which includes generic research on geological disposal, is critical to the waste management program. The key to assessing the effectiveness and safety of any high-level radioactive waste disposal facility lies in the capability to predict with certainty the nature and effect of geological processes and events. According to Gordon Edwards, of the Canadian Coalition for Nuclear Responsibility, mathematical models simulating the movement of buried waste are based on knowledge of geology, which is a descriptive and not a predictive science. Moreover, Dr. Edwards argues that we in fact do not know how to "dispose" of anything: all we know how to do is store it. He concludes that the Achilles heel of the entire idea of deep geological disposal lies in the impossibility of refilling the shaft that has been drilled in such a way that the drilled rock regains the integrity which it had as solid rock.[61]

Echoing Dr. Edwards' concerns, Carole Duyf of the Concerned Citizens of Manitoba Inc., attacked the scope and focus of AECL's Underground Research Laboratory at Pinawa, and argued that "The presence of the Lac du Bonnet hole proves only one thing: that AECL is capable of creating a hole in the rock".[62] Speaking for the same organization, Donovan Timmers argued that it is utterly immoral to place the risk of a repository failure on the shoulders of future generations.[63] Norman Rubin of Energy Probe considers that since we can neither determine nor predict what nuclear wastes will do underground, it would be a serious mistake to bury them deep in a geological formation. Furthermore, since the scientific community cannot guarantee the future integrity of a waste burial site, it is up to the population as a whole to make a decision, based on scientific models and opinions. Mr. Rubin believes that once the Canadian people have been informed about the latest predictions and unknowns, they will opt for storing existing wastes on the surface for another generation or two.[64] This view is shared by Gordon Edwards, who

> If we keep [the waste] safely on the surface and carefully monitored, there is no reason to think that in coming decades, perhaps in 30 or 40 years, scientists will [not] develop

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(61) Gordon Edwards, Canadian Coalition for Nuclear Responsibility, Issue No. 7, February 3, 1987, p. 7 and 13.
(62) Carole Duyf, Concerned Citizens of Manitoba Inc., Issue No. 7, February 3, 1987, p. 29.
(63) Donovan Timmers, *ibid.*, p. 28.
(64) Rubin (1987), p. 5.

new techniques which may lead to a process of neutralizing these wastes and making them harmless. This would be the ideal solution. It is one of the reasons I believe we should not be too hasty in rushing ahead to put it underground and making it irretrievable.[65]

In refusing even to consider the solution under review, Mr. Rubin and Dr. Edwards take a still more extreme position than the Royal Commission on Electric Power Planning, which in 1980 recommended that a moratorium be declared on additional nuclear generating stations if progress in high-level nuclear waste research and development was not sufficiently advanced by 1990.[66]

So far, two preliminary concept assessments have been carried out by representatives of government and private organizations and citizens' groups, in 1981 and 1985. The definitive assessment will be performed after the Technical Advisory Committee (TAC) submits its final assessment. For its part, TAC believes that the deep geological disposal concept is promising and worthy of in-depth research, and that the results of on-going work will continue to diminish the uncertainties related to various aspects of the overall concept. TAC maintains that it is vital that funding be kept at a level that will ensure the project's viability.[67] The Committee agrees, and therefore recommends that:

Recommendation 5

Given that the goal of a nuclear waste management program must be to protect Canadians' health and safety, short-term considerations of economy must not be invoked as an obstacle to achieving that goal. Consequently, the resources necessary for verification of the Canadian disposal concept must remain adequate until the concept has received its final assessment by the scientific community, and the public at large has either accepted or rejected the proposal.

The Assessment Process

The 1981 Canada-Ontario joint statement defined the assessment process for the Canadian high-level radioactive waste management concept, and designated the Atomic Energy Control Board as the body in charge of the regulatory and ecological review of the disposal concept. The review will be carried out by an Interagency Review Committee (IRC), set up by the AECB, Ontario's Ministry of the Environment, and the federal Department of the Environment. The IRC will issue a public report on the official concept assessment document produced by AECL. Both these documents will be the subject of public debate, under the auspices of the federal government, probably via an environmental assessment panel. The recommendations that come out of that debate will be submitted to the AECB, which will publish a statement as to the acceptability, conditional acceptability or non-acceptability of the concept.[68]

Like some of the witnesses who appeared before it, the Committee has questions about the role of the agencies involved in the process, and about the resources that will be made available to the general public during the final assessment of the concept. The Committee

[65] Gordon Edwards, Canadian Coalition for Nuclear Responsibility, Issue No. 7, February 3, 1987, p. 15.
[66] Royal Commission on Electric Power Planning (Arthur Porter, Chairman), *Report: Concepts, Conclusions and Recommendations*, Vol. 1, 1980, p. XIX.
[67] Technical Advisory Committee, "Nuclear Fuel Waste Management Program", brief presented to the Standing Committee on Environment and Forestry, Hamilton, January 1987, p. 12.
[68] Technical Advisory Committee on the Nuclear Fuel Waste Management Program, *Sixth Annual Report*, July 1985, p. 25.

shares the view of Gordon Edwards, who thinks that governments should provide funding to independent groups for critical studies of the Canadian Nuclear Fuel Waste Management Program. Dr. Edwards pointed out that:

> [...] With a budget of about $3 million, one could do a year-long study, possibly under the auspices of the Science Council of Canada, drawing upon independent scientists across Canada to do a real critique of what Atomic Energy of Canada is putting forward as their eventual solution to the waste disposal problem.[69]

The Committee is aware of the excellent reputation that TAC and AECL have earned for themselves, and of the quality of the work they do. However, in light of the arguments put forward during the current discussions, it might be timely to obtain the advice of a group of informed experts whose independence cannot be doubted and whose mandate would include a review of alternative solutions as well as an analysis of the social and moral aspects of the proposed solution. Consequently the Committee recommends that:

Recommendation 6

The Canadian nuclear fuel waste management concept should be the subject of an independent comprehensive study, which would examine the social, moral, economic and environmental consequences of the Program. The Committee considers it desirable that this study be completed by no later than 1989. The resulting report would be submitted to the environmental assessment panel set up to facilitate a public debate on AECL's proposal.

In addition, the Committee is somewhat concerned about Environment Canada's role and relative clout within the concept assessment process. The Minister of the Environment himself says that his Department acts essentially as an adviser, with the main responsibility for elimination of radioactive waste falling on the Department of Energy, Mines and Resources.[70] Even though these two Departments have set up an interdepartmental committee on energy and environment, the Committee believes there are grounds for expanding Environment Canada's responsibilities ties and giving it a greater role. And lastly, given that Environment Canada is currently reviewing a number of ways to fund participation by representatives of public interest groups, the Committee recommends that:

Recommendation 7

Environment Canada should rapidly assemble resources with a view to defending the environmental standpoint during the upcoming debate on the Canadian Nuclear Fuel Waste Management Program (CNFWMP). Environment Canada should also take all necessary steps to encourage participation by the general public in the hearings held by any future environmental assessment panel.

Currently, Environment Canada monitors nuclear issues through its scientific and technical services and the Federal Environmental Assessment Review Office (FEARO). The AECB will be taking primary responsibility for assessing the spent nuclear fuel disposal concept, while Ontario's Ministry of the Environment and Environment Canada will also be contributing, as members of the IRC.[71] Plainly, the other provinces — those that operate nuclear generating stations, like Quebec and New Brunswick; or produce uranium, like

[69] Gordon Edwards, Canadian Coalition for Nuclear Responsibility, Issue No. 7, February 3, 1987, p. 8.
[70] The Hon. Thomas M. McMillan, Minister of the Environment, Issue No. 15, April 7, 1987, p. 5.
[71] *Ibid.*

Saskatchewan; or have nuclear waste disposal research sites on their territory, like Manitoba — have an interest in participating actively in the concept assessment process. The Committee therefore recommends that:

Recommendation 8

The environment department of every province involved in or affected by nuclear production of electrical power should be a member of the Interagency Review Committee (IRC) which will be studying the spent nuclear fuel disposal concept.

Following the example of many of its witnesses, the Committee wishes to stress that it wants to see established, once and for all, the consultation and decision-making processes that will decide on the value of the disposal concept. Of relevance here is another extract from Davod Poch's letter to the Honourable Pat Carney on April 10, 1986:

> The [decision-making] process is characterized by uncertainty. We do not know who will make up the "Environmental Assessment Panel", how they will operate, how social and ethical assessment guidelines will be developed, or the extent to which the report of the Interagency Working Group (which the AECB has convened and is a member of) will determine matters before the Panel hears the case.
>
> [...] The recommendations arising from the Public Hearing Process will be submitted to the AECB, who will then issue a statement on the acceptability of the proposed concept and the matter will then fall into the hands of the two governments. The Environmental Assessment Panel appears to have only an advisory role. Thus the AECB could approve a concept about which the Panel has some reservations.[72]

To eliminate these uncertainties and to provide a clearer understanding of the various phases of the decision-making process connected with the concept assessment, the Committee recommends that:

Recommendation 9

Environment Canada should take over the implementation of the fuel waste disposal concept assessment process. In addition, in collaboration with the Department of Energy, Mines and Resources, Environment Canada should within the next six months produce and publish a detailed plan on the mandate, the resources, the timetable and the powers of the environmental assessment panel that will be responsible for reviewing the results obtained by the concept's promoters.

The Concept's Applicability

According to AECL, the results of the second preliminary assessment of the concept, published in September 1985, showed that no radioactive material at all would reach the surface for tens of thousands of years following the sealing of the vault. In the last analysis, AECL concludes that waste disposal can be carried out both economically and safely. With respect to the financial aspects of the concept, the Committee hopes that everything possible will be done to publish immediately rigorous data on the costs associated with disposal deep in crystalline rock formations. Consequently the Committee recommends that:

(72) David Poch (1986), p. 1-2.

Recommendation 10

Atomic Energy of Canada Ltd. should be able to provide the public with detailed and accurate data on the costs that would result from the short and long-term use of nuclear waste repositories. This cost-study analysis should also enable its readers to determine the present and future competitiveness of nuclear-generated electricity.

The burial of waste in one particular spot also raises the question of the risks involved in its handling and transportation. At the present time, spent fuel wastes are stored on reactor sites. It must therefore be asked, what are the relative advantages and disadvantages of one centralized disposal site as compared to several regional disposal sites? Consequently the Committee recommends that:

Recommendation 11

Environment Canada, in collaboration with the Department of Energy, Mines and Resources, should produce a cost-benefit analysis comparing the establishment of one centralized storage or disposal site for spent fuel wastes with the establishment of several regional sites performing similar functions. This study should identify the risks, especially in the area of transportation, and associated protective measures resulting from each of these options.

In 1981, AECL signed a 20-year lease with the Manitoba government for one and a half sections of Crown land about 15 miles northeast of Pinawa, for the purpose of constructing an underground research laboratory. The lease forbids the use of free nuclear materials in the laboratory, as well as the use of the land for storage of nuclear waste, and it provides for restoration of the land to its original state when the lease expires. A second land lease was arranged in early 1986, to permit a groundwater study of the region around the laboratory.

Manitoba thus seems to have decided to support AECL's research work, in exchange for a guarantee from AECL and the federal government that the province will not be considered for a nuclear waste disposal site. As the Honourable Gérard Lécuyer, Manitoba's Minister of Environment and Workplace Safety and Health, neatly put it:

> We gather that the provinces that produce electricity from nuclear power, namely Ontario, Quebec and New Brunswick, are not particularly keen on having this research done at home. If the research is done in [a] province, there is a greater likelihood that a disposal centre will be located [on its] territory.[73]
>
> In the case of Canadian nuclear waste, the province of Ontario overwhelmingly benefits from its generation and therefore should accept whatever risks will be associated with its disposal. On the other hand, Manitoba will accept the risk associated with the non-nuclear hazardous wastes it does generate.[74]

Although Manitoba has apparently obtained the best guarantees possible, and continues to take measures to ensure that no disposal facility will ever be constructed within its borders, many Manitobans simply do not trust AECL.

Another important point in Mr. Lécuyer's brief involved the repercussions of the installation of nuclear waste disposal facilities in the United States, near the Manitoba

(73) The Hon. Gérard Lécuyer, Minister, Department of Environment and Workplace Safety and Health of Manitoba, Issue No. 9, February 5, 1987, p. 21.
(74) *Ibid.*, p. 7.

border. On January 16, 1986, the American Department of Energy published a draft report naming 20 regions being considered as locations for nuclear waste disposal sites: five of these are situated in the drainage basin of the Red River, which flows into Manitoba. In the fall of 1986, American Congress suspended the search for a site, though without abandoning the idea permanently. Here is an extract from Manitoba's presentation to the American Department of Energy's public hearings in April 1986:

> Because Manitoba is so vitally dependent on the Red River and its watershed, because there will be an ultimately undefinable risk to the valley from a nuclear waste disposal system in the drainage basin, and because Manitoba is a non-nuclear province which does not generate high-level nuclear waste, we feel that Manitobans should not be asked to bear any risk associated with nuclear waste disposal. We have previously taken this position with respect to nuclear waste disposal within our own boundaries, and have been assured by our federal government that there will not be a disposal site in Manitoba.(75)

Manitoba's Deputy Minister of the Environment, Thomas H. Owen, added that the American government had placed itself in a difficult position, because it had made a commitment to locate one disposal site in the southwest of the United States and one in the northeast; but almost all of the northeastern United States is on watersheds that drain into Canada.(76)

Although AECL insists that no research has yet been undertaken to determine potential disposal sites, the Committee, following the lead of the Concerned Citizens of Manitoba Inc., maintains that in light of the upcoming debate, it is imperative to obtain a list of the criteria that will be used in selecting the ideal site. The Committee therefore recommends that:

Recommendation 12

In the event that a Canadian nuclear fuel waste disposal concept should prove safe and scientifically and economically acceptable, Environment Canada, in collaboration with the Atomic Energy Control Board and the other federal and provincial departments and ministries concerned, should immediately formulate and make public the selection criteria for potential disposal sites for high-level radioactive waste. Furthermore, the provinces that produce nuclear-generated electricity, where it has been proven that safe disposal is possible, should be considered for disposal sites. The provinces, and especially the municipalities under consideration as a repository, must be guaranteed full public hearings.

Even if the Canadian government's current policy is not to accept waste from other countries,(77) organizations like the Concerned Citizens of Manitoba Inc. are worried that Canada may at some point decide to take in foreign nuclear waste.(78) In order to inform the public at large adequately, and to allow Canadians to make a free choice, the Committee recommends:

Recommendation 13

A public review process should be launched if the Department of Energy, Mines and Resources should envisage the possibility of accepting nuclear waste from other countries.

(75) *Ibid.*, p. 18.
(76) Thomas H. Owen, Deputy Minister, Department of Environment and Workplace Safety and Health of Manitoba, *ibid.*, p. 18-19.
(77) The Hon. Marcel Masse, Minister of Energy, Mines and Resources, Issue No. 14, April 1, 1987, p. 19-20.
(78) Carol Duyf, Concerned Citizens of Manitoba Inc., Issue No. 7, February 3, 1987, p. 30.

The Committee also notes that some witnesses were concerned about what would happen to nuclear power plants that had been shut down. Gordon Edwards considers that the federal government ought to ask AECL to dismantle a nuclear reactor, like the Gentilly-1, so that some data could be gathered as to the safety risks and the cost of such a procedure. The expertise thus acquired could be marketed throughout the world.(79) Operators in the nuclear energy field today foresee an average operating lifespan of 40 years for a nuclear power plant.(80) When that lifespan ends, the plant presents a permanent risk to the environment, because it contains radioactive materials. Given that most of Canada's nuclear installations will have to be dismantled or renovated in the next few decades, the Committee considers it vitally important that an in-depth study be done on the problems posed by decommissioning of nuclear installations. Progress demands that an immense amount of information emanate from those who have the knowledge. The Committee therefore recommends:

Recommendation 14

To diminish the uncertainties associated with the decommissioning of nuclear generating stations, Atomic Energy of Canada Ltd. must produce and publish a study setting out its policy, its resources and its orientation in this area.

In the final analysis, the Committee recognizes that it is precisely because there are uncertainties and value differences, and because fairness is one of the principal qualities of a valid regulatory decision, that the role of the expert has its limitations. The problem arises when one tries to define criteria for risk and safety:

> A useful way of defining "safe", one presently gaining currency, is as "that level of *risk* judged *acceptable*". In this context, *risk* is defined as "the probability that harm will occur at all, multiplied by the severity of the consequences if it does occur". Thus *risk* objectively measures the potential hazard, while *safety* reflects a subjective judgement of the acceptability of that hazard. *Risk* is legitimately the subject of scientific investigation. [...] Scientists, however, cannot determine when something is *safe* or *safe enough*, because that is a matter of preference or judgement. Does the group want to live with the risks described by the scientist as accompanying the product; pay for reducing the risks; or forego the product?(81)

This then is the challenge that the supporters of nuclear energy must meet: convincing the population that the risks inherent in the atom are worth the associated problems. If a problem is especially difficult to solve, we cannot claim to have solved it merely by pointing out how hard we have tried to do so. Therefore, considering that it is estimated that the environmental assessment panel will require three years to reach a decision on the storage and disposal of spent fuel wastes, the Committee recommends that:

Recommendation 15

A moratorium on the construction of nuclear power plants in Canada should be imposed until the people of Canada have agreed on an acceptable solution for the disposal of high-level radioactive waste. Furthermore, the Canadian energy strategy should formulate alternatives that would encourage a reduction in energy consumption and a decrease in stress on the environment from waste created by the various energy-producing techniques.

(79) Gordon Edwards, Canadian Coalition for Nuclear Responsibility, Issue No. 7, February 3, 1987, p. 16.
(80) Pierre Tanguy, "Le déclassement des installations nucléaires", *La Recherche*, Vol. 18, No. 187, April 1987, p. 546-555.
(81) Elizabeth S. Rolph, *Nuclear Power and the Public Safety*, Lexington (Mass.), Lexington Books, 1979, p. xiii; cited in Wolfgang Koerner, *Civilian Nuclear Power: Problems and Prospects*, Backgrounder BP-124E, Ottawa, Library of Parliament, Research Branch, May 1985, p. 7-8.

APPENDICES

Appendix A

The Recommendations

Recommendation 1

The federal government should step up its efforts to determine the extent to which the various renewable energy vectors or sources can meet Canadians' demand for energy. In addition, the Departments of the Environment and of Energy, Mines and Resources should establish the best possible terms on which:

(*a*) energy can be economized and energy consumption reduced;

(*b*) the use of energy resources can be optimized, given the available resources and their impact on health and the environment; and

(*c*) wastes resulting from energy-production techniques can be properly managed.

Recommendation 2

The Department of Energy, Mines and Resources, in collaboration with the National Research Council, should produce a detailed study on the short and long-term advantages of using various fuel cycles that could reduce the volume and diminish the risks of the waste produced by CANDU reactors. In addition, Energy, Mines and Resources should work to develop techniques that reduce the volume of waste produced by existing reactors.

Recommendation 3

The Government should introduce the following reforms at the Atomic Energy Control Board:

(*a*) a consultation mechanism should be set up to require public participation in making decisions on moral or ethical questions;

(*b*) the membership of the Board should be modified to reflect more fully the reservations expressed by the public about nuclear energy; and

(*c*) the Board should be responsible to Environment Canada rather than to the Department of Energy, Mines and Resources.

Recommendation 4

The Atomic Energy Control Board should fund an independent scientific assessment of the computer models used to verify the Canadian high-level radioactive waste disposal concept.

Recommendation 5

Given that the goal of a nuclear waste management program must be to protect Canadians' health and safety, short-term considerations of economy must not be invoked as an obstacle to achieving that goal. Consequently, the resources necessary for verification of the Canadian disposal concept must remain adequate until the concept has received its final assessment by the scientific community, and the public at large has either accepted or rejected the proposal.

Recommendation 6

The Canadian nuclear fuel waste management concept should be the subject of an independent comprehensive study, which would examine the social, moral, economic and environmental consequences of the Program. The Committee considers it desirable that this study be completed by no later than 1989. The resulting report would be submitted to the environmental assessment panel set up to facilitate a public debate on AECL's proposal.

Recommendation 7

Environment Canada should rapidly assemble resources with a view to defending the environmental standpoint during the upcoming debate on the Canadian Nuclear Fuel Waste Management Program (CNFWMP). Environment Canada should also take all necessary steps to encourage participation by the general public in the hearings held by any future environmental assessment panel.

Recommendation 8

The environment department of every province involved in or affected by nuclear production of electrical power should be a member of the Interagency Review Committee (IRC) which will be studying the spent nuclear fuel disposal concept.

Recommendation 9

Environment Canada should take over the implementation of the fuel waste disposal concept assessment process. In addition, in collaboration with the Department of Energy, Mines and Resources, Environment Canada should within the next six months produce and publish a detailed plan on the mandate, the resources, the timetable and the powers of the environmental assessment panel that will be responsible for reviewing the results obtained by the concept's promoters.

Recommendation 10

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Recommendation 11

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regional sites performing similar functions. This study should identify the risks, especially in the area of transportation, and associated protective measures resulting from each of these options.

Recommendation 12

In the event that a Canadian nuclear fuel waste disposal concept should prove safe and scientifically and economically acceptable, Environment Canada, in collaboration with the Atomic Energy Control Board and the other federal and provincial departments and ministries concerned, should immediately formulate and make public the selection criteria for potential disposal sites for high-level radioactive waste. Furthermore, the provinces that produce nuclear-generated electricity, where it has been proven that safe disposal is possible, should be considered for disposal sites. The provinces, and especially the municipalities under consideration as a repository, must be guaranteed full public hearings.

Recommendation 13

A public review process should be launched if the Department of Energy, Mines and Resources should envisage the possibility of accepting nuclear waste from other countries.

Recommendation 14

To diminish the uncertainties associated with the decommissioning of nuclear generating stations, Atomic Energy of Canada Ltd. must produce and publish a study setting out its policy, its resources and its orientation in this area.

Recommendation 15

A moratorium on the construction of nuclear power plants in Canada should be imposed until the people of Canada have agreed on an acceptable solution for the disposal of high-level radioactive waste. Furthermore, the Canadian energy strategy should formulate alternatives that would encourage a reduction in energy consumption and a decrease in stress on the environment from waste created by the various energy-producing techniques.

Appendix B

Regulatory Objectives, Requirements and Guidelines for the Disposal of Radioactive Wastes — Long-term Aspects

(excerpt from Atomic Energy Control Board's Regulatory Document R-104)

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1. Objectives of Radioactive Waste Disposal

The objectives of radioactive waste disposal are to:

—minimize any burden placed on future generations,

—protect the environment, and

—protect human health,

taking into account social and economic factors.

2. Basic Regulatory Requirements

2.1 *Burden on future generations*

The burden on future generations shall be minimized by:

(*a*) selection of disposal options for radioactive wastes which, to the extent reasonably achievable, do not rely on long-term institutional controls as a necessary safety feature;

(*b*) implementing these disposal options at an appropriate time, technical, social and economic factors being taken into account; and

(*c*) ensuring that there are no predicted future risks to human health and the environment that would not be currently accepted.

2.2 *Protection of the environment*

Radioactive waste disposal options shall be implemented in a manner such that there are no predicted future impacts on the environment that would not be currently accepted and such that the future use of natural resources is not prevented by either radioactive or non-radioactive contaminants.

2.3.1 *Protection of human health: General requirement*

The predicted radiological risk to individuals from a waste disposal facility shall not exceed 10^{-6} fatal cancers and serious genetic effects in a year, calculated without taking advantage of long-term institutional controls as a safety feature.

2.3.2 *Variance from the general requirement*

If there is no practicable method of fully meeting the requirements of Section 2.3.1, an optimization study shall be performed in order to determine the preferred option. A disposal facility, under these circumstances, shall be:

(*a*) compatible with the results of such a study, and

(*b*) such that the predicted risk to individuals does not exceed that which is presently accepted from current operations involving the same wastes.

3. Guidelines for Application of the Basic Radiological Requirements

3.1 *Identifying the individuals concerned*

The individual risk requirements in the long term should be applied to a group of people that is assumed to be located at a time and place where the risks are likely to be the greatest, irrespective of national boundaries.

3.2 *Probabilities-of-exposure scenarios*

The probabilities-of-exposure scenarios should be assigned numerical values either on the basis of relative frequency of occurrence or through best estimates and engineering judgements.

3.3 *Timescale of concern*

The period for demonstrating compliance with the individual risk requirements using predictive mathematical models need not exceed 10,000 years. Where predicted risks do not peak before 10,000 years, there must be reasoned arguments that beyond 10,000 years the rate of radionuclide release to the environment will not suddenly and dramatically increase and acute radiological risks will not be encountered by individuals.

3.4 *Output from predictive modelling*

Calculations of individual risks should be made by using the risk conversion factor of 2×10^{-2} per sievert and the probability-of-exposure scenario with either:

(*a*) the annual individual dose* calculated as the output from deterministic pathways analysis, or

(*b*) the arithmetic mean value of annual individual doses from the distribution of individual doses in a year calculated as the output from probabilistic analysis.

3.5 *Optimization*

When an optimization study is required in accordance with Section 2.3.2, it should take into account of all relevant radiological and non-radiological factors.

* "Dose" refers to the effective dose equivalent committed per year of exposure.

Appendix C

List of Witnesses

	Issue	Date
1. Atomic Energy of Canada Ltd. Stanley R. Hatcher, President, Research Company; William T. Hancox, Vice-President, Waste Management; Kenneth Dormuth, Director Geological and Environmental Science.	6	February 2, 1987
2. Technical Consultative Committee on the Canadian Nuclear Fuel Waste Management Program L.W. Shemilt, Chairman; George Skippen, member; Branko Ladanji, member.	6	February 2, 1987
3. Canadian Coalition for Nuclear Responsibility Gordon Edwards.	7	February 3, 1987
4. Concerned Citizens of Manitoba, Inc. Donovan Timmers; Carol Duyf; Walter Robbins.	7	February 3, 1987
5. Energy Probe *et al.* Norman Rubin, Director of Nuclear Research; David Poch, Counsel for Energy Probe and other groups.	7	February 3, 1987
6. Department of Environment and Workplace Safety and Health, Province of Manitoba.	9	February 5, 1987

	Issue	Date
The Hon. Gérard Lécuyer, Minister; Thomas Owen, Deputy Minister.		
7. Initiative for the Peaceful Use of Technology (INPUT)	10	March 17, 1987
Al Rycroft; Alayne McGregor.		
8. Department of Energy, Mines and Resources	14	April 1, 1987
The Hon. Marcel Masse, Minister; Eva L.J. Rosinger, Executive Assistant to the President, AECL; Bob Morrison, Director General, Uranium and Nuclear Energy Board; André Scott, Executive Assistant to Mr. Masse; Joe Howieson, Advisor.		
9. Department of the Environment	15	April 7, 1987
The Hon. Tom McMillan, Minister; Claude Barraud, Nuclear Coordinator.		

A copy of the relevant Minutes of Proceedings and Evidence of the Standing Committee on Environment and Forestry (*Issues Nos. 6, 7, 9, 10, 14, 15, 19, 20 and 21, which includes this Report*) is tabled.

Respectfully submitted,

BOB BRISCO,
Chairman.

MINUTES OF PROCEEDINGS

TUESDAY, DECEMBER 1, 1987
(35)

[*Text*]

The Standing Committee on Environment and Forestry met *in camera* at 9:12 o'clock a.m. this day, in Room 307 W.B., the Chairman, Bob Brisco, presiding.

Members of the Committee present: Bob Brisco, Charles Caccia, Elliott Hardey and Ted Schellenberg.

Alternate Member present: Bill Blaikie.

In attendance: *From the Library of Parliament*: Jean-Pierre Amyot, Research Officer.

In accordance with its mandate under Standing Order 96(2), the Committee resumed its examination of the storage and disposal of high-level radioactive waste.

The Committee resumed consideration of a draft report.

At 10:53 o'clock a.m., the Committee adjourned to the call of the Chair.

THURSDAY, DECEMBER 3, 1987
(36)

The Standing Committee on Environment and Forestry met *in camera* at 9:20 o'clock a.m. this day, in Room 307 W.B., the Chairman, Bob Brisco, presiding.

Members of the Committee present: Bob Brisco, Charles Caccia, Elliott Hardey, Lynn McDonald and Barry Moore.

In attendance: *From the Library of Parliament*: Jean-Pierre Amyot, Research Officer.

In accordance with its mandate under Standing Order 96(2), the Committee resumed its examination of the storage and disposal of high-level radioactive waste.

The Committee resumed examination of its draft report.

It was agreed,— That the draft report, as amended, be adopted as the First Report of the Committee.

It was agreed,— That 3,000 copies of the report be printed.

It was agreed,— That the Chairman be authorized to table the report in the House.

It was agreed,— That the report be printed with a special cover.

Janice Hilchie,
Clerk of the Committee.