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Nuclear Waste Disposal: An International Legal Perspective

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As the world contends with an energy shortage, the development of alternative sources of energy has become a critical problem. Nuclear power is both an obvious and controversial alternative to traditional fossil fuels.¹ As-

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The views of the authors are their own and should not be attributed to any institution, publication or other individual.

¹ For an overview of the technical and institutional challenges to safe nuclear waste disposal, see generally D. DEESE, *NUCLEAR POWER AND RADIOACTIVE WASTE* (1978); K. HARMON, *INTERNATIONAL SOURCE BOOK: A COMPENDIUM OF WORLDWIDE PROGRAMS IN NUCLEAR ENERGY SUPPLY AND RADIOACTIVE WASTE MANAGEMENT RESEARCH AND DEVELOPMENT* (1978); INTER-AGENCY REVIEW GROUP ON NUCLEAR WASTE MANAGEMENT, *REPORT TO THE PRESIDENT* (TID-29442) (1979) [hereinafter cited as IRG REPORT]; S. KEENEY, *NUCLEAR POWER ISSUES AND CHOICES: REPORT OF THE NUCLEAR SUBGROUP* (1977) (sponsored by the Ford Foundation and administered by the Mitre Corporation) [hereinafter cited as FORD-MITRE STUDY]; ROYAL COMMISSION ON ENVIRONMENTAL POLLUTION, *NUCLEAR POWER AND THE ENVIRONMENT, SIXTH REPORT* (London: HMSO, 1976) [hereinafter cited as ROYAL COMMISSION REPORT]; 1 & 2 U.S. DEP'T OF ENERGY, *ENVIRONMENTAL IMPACT STATEMENT, MANAGEMENT OF COMMERCIALLY GENERATED RADIOACTIVE WASTE* (DOE/EIS-0046-D) (April 1979) [hereinafter cited as DOE COMMERCIAL WASTE MANAGEMENT DRAFT EIS]; U.S. DEP'T OF ENERGY, *ENVIRONMENTAL IMPACT STATEMENT, STORAGE OF FOREIGN SPENT POWER REACTOR FUEL* (DOE/EIS-0040-D) (Dec. 1978); M. WILLRICH & R. LESTER, *RADIOACTIVE WASTE MANAGEMENT AND REGULATION* (1977) (good glossary of terms and selected bibliography); Dreschhoff, Saunders & Zeller, *International High Level Nuclear Waste Management*, 30 BULL. ATOM. SCIENTISTS 28 (Jan. 1974);

sociated with the use of nuclear power is the important question of nuclear waste disposal. In this article, Messrs. Shields and Spector discuss the nuclear fuel cycle, bring together a survey of how countries around the world are dealing with the question of nuclear waste disposal both domestically and on an international level, and make suggestions for a more aggressive international regulation of nuclear waste disposal.

The common threat posed to the economies of the United States, Western Europe, and Japan by the monopoly power of the oil exporting nations is one of the most deeply etched realities of the Seventies. During 1978, imported oil accounted for 50.1% of energy consumption in Western Europe, 72.0% in Japan, and 20.5% in the United States.² The bulk of this oil comes from the Middle East where the OPEC oil embargo of 1973 and the Iranian revolution of 1979 clearly demonstrated the instability of oil supplies. Added to the political turmoil of the Middle East is the vulnerability of its oil to interception on the sea lanes along which oil tankers travel to the West. The strategic folly of dependence on Middle East oil is accompanied by the detrimental impact of such dependence on our economy and those of our chief trading partners. Indeed, rapidly escalating oil prices, which between January 1970 and July 1979 jumped over tenfold from \$1.80 to \$20.00 per barrel,³ are credited as being largely responsible for the long term decline in the rate of growth of most of the world's economies.⁴

Nuclear energy can substitute for foreign oil in the production of electricity; and, in nations lacking untapped coal or hydroelectric resources such as Japan and those in Western Europe, it is often the only attractive alternative to oil. At the current price of oil, it is less expensive to produce electricity by nuclear means than by oil fueled power plants; and in some settings nuclear generating costs are less than the costs of coal plants.⁵ The Department of Energy projects that this disparity will continue to grow.⁶

For these reasons, the industrialized countries of the West have turned their hopes increasingly to the use of nuclear energy for electric

Faltmeyer, *Burying Nuclear Trash Where It Will Stay Put*, FORTUNE, March 26, 1979, at 98; Feates, *Nuclear Power and Radioactive Waste Management*, 19 CONTEMP. PHYS. 531-542 (1978, No. 6.); Nathanson, *International Management of Radioactive Wastes*, 5 ENV'T'L AFF. 363-80 (Spring 1976). For an excellent discussion of transnational pollution, see Handl, *Territorial Sovereignty and the Problem of Transnat'l Pollution*, 69 AM. J. INT'L L. 50 (Jan. 1975).

² BRITISH PETROLEUM, LTD., BP STATISTICAL REVIEW OF THE WORLD OIL INDUSTRY 10, 16 (1978).

³ See *The Next Blow from OPEC*, NEWSWEEK, June 25, 1979, at 33-34.

⁴ *Id.*

⁵ See Halloran, *Nuclear Energy Confusion*, N.Y. Times, Jan. 28, 1979, § 3 (Finance), at 17, col. 1 (city ed.).

⁶ *Id.*

power generation.⁷ Until the recent slowdown in nuclear power development, it had been widely estimated that by the mid-eighties nuclear power would provide 20% of all electricity in the United States, Great Britain, and Japan; 30% of the electricity in Sweden and Switzerland; and 50% of the electricity in France and West Germany⁸ with additional major growth in nuclear power use projected through the end of the century. Finland, Spain, Belgium, Italy, Brazil, India and Canada are also launched on major nuclear power programs.⁹

The increasing use of nuclear power has given rise to many difficult health, safety and strategic problems.¹⁰ This article deals with one of those problems—the disposal of radioactive wastes generated during nuclear power production.

In their efforts to obtain a measure of energy independence, the advanced industrialized countries have failed in several important ways to deal effectively with the long-term hazard posed by these materials. Indeed, no country has yet developed a proven and widely-accepted solution to the disposal of these wastes, a failure which, along with other factors, has caused several important set-backs of government programs to develop nuclear power.¹¹

Austria's first nuclear power plant at Zwetendorf, for example, has never operated.¹² It stands idle as a result of a referendum in November 1978 in which voters acted to prevent the plant's operation because no clear method for the disposal of its waste was in hand.¹³ In Sweden, a 1977 law prohibiting construction or operation of any new reactors unless plans are provided for the absolutely safe disposal of their wastes has prevented operation of two fully-constructed facilities for

⁷ See text accompanying notes 74-192 *infra*.

⁸ Conversation between Leonard S. Spector and Atomic Industrial Forum Staff (Aug. 1979). See text at notes 74-192 *infra* and related footnotes for discussion of projected development of nuclear generating capacity. But see *Britain Plans Nuclear Energy Increase*, Washington Post, Oct. 17, 1979 at A9, col. 1. For information on the recent slowdown, see NUCLEONICS WK., July 12, 1979, at 3-4 (NEA predicts that expected nuclear growth for remainder of century has dropped by 38% for OECD countries); *Euratom Study Notes EEC Nuclear Slowdown*, NUCLEAR FUEL, June 25, 1979 (EEC forecast of nuclear growth down 60% since 1974 estimate); *Gorleben Hearings Start With Germany's Nuclear Future Riding On Them*, NUCLEONICS WK., Mar. 29, 1979, at 11-12; *Japan Intends to Slow Its Plans to Increase Nuclear Power Output*, Wall St. J., Aug. 2, 1979, at 20, col. 3.

⁹ *Id.*

¹⁰ See generally FORD-MITRE STUDY, note 1 *supra*.

¹¹ See, e.g., *Enthusiasm about Nuclear Power Turns to Anxiety in West Germany*, N.Y. Times, Feb. 7, 1977, at A8, col. 2 (city ed.); *Opposition to Nuclear Power*, 4 ENERGY POL'Y 286-307 (Dec. 1976).

¹² See NUCLEONICS WK., Nov. 9, 1978, at 4.

¹³ *Id.*

nearly a year and delayed construction plans for a number of other plants.¹⁴

West Germany has also suffered a reactor construction moratorium because of the lack of an acceptable nuclear waste disposal program.¹⁵ Today, its proposed solution to the waste management problem, the construction of a major waste repository and processing facility at Gorleben, is threatened because of local opposition.¹⁶

In Japan, the shutdown of several operating nuclear power plants was threatened when difficulties arose in obtaining U.S. approval for the shipment of spent nuclear fuel from those facilities to processing plants in England and France.¹⁷ Here in the United States, at least four states, California, Iowa, Maine, and Wisconsin, have prohibited further construction of nuclear power plants within their respective borders until an acceptable nuclear waste management program has been developed by the federal government.¹⁸ The legislatures in several other states are scheduled to consider similar action.¹⁹

Although no ban on the development of additional power reactors has yet occurred in England or Canada, blue ribbon commissions in both nations have decried the lack of permanent waste disposal programs and demanded prompt remedial actions.²⁰ Switzerland narrowly averted a *de facto* prohibition on further reactor construction in February 1979 when a referendum in which nuclear waste issues figured prominently was defeated by a slim 51% margin.²¹

The disposal of nuclear wastes has thus become an important domestic political issue in the great majority of advanced nations using

¹⁴ 21 NUCLEAR L. BULL. 24 (summary of Act No. 140, § 2, Apr. 21, 1977); *The Swedish Coalition Government Has Agreed to Allow Two Reactors to Be Started*, NUCLEONICS WK., Oct. 5, 1978, at 7.

¹⁵ *Gorleben Hearings Start with Germany's Nuclear Future Riding on Them*, NUCLEONICS WK., March 29, 1979, at 11-12.

¹⁶ See *Germany's Nuclear Project on the Skids*, Energy Daily, May 17, 1979, at 1.

¹⁷ See MacLachlan, *Once Again Japan Asks U.S. Consent for Spent Fuel Reprocessing*, Energy Daily, Dec. 15, 1979, at 30; *Hearings on Nuclear Transfer for Reprocessing: Pending Cases, Before the Subcomm. on Int'l Policy and Trade of the House Comm. on Int'l Relations*, 95th Cong., 2d Sess. (1978) [hereinafter cited as *Nuclear Fuel Transfer Hearings*].

¹⁸ U.S. GENERAL ACCOUNTING OFFICE, *THE NATION'S NUCLEAR WASTE—PROPOSALS FOR ORGANIZATION AND SITING* 3-6 (EMD-79-77) (June 21, 1979).

¹⁹ *Id.*

²⁰ See ROYAL COMMISSION REPORT, note 1 *supra*; Mayman, *The Canadian Program for Storage and Disposal of Spent Fuel and High-Level Wastes*, in PROCEEDINGS OF IAEA AND NEA SYMPOSIUM ON MANAGEMENT OF RADIOACTIVE WASTES FROM THE NUCLEAR FUEL CYCLE 49 (IAEA-SM-207/91) (Mar. 1976).

²¹ See *Swiss Referendum Narrowly Approves Nuclear Program*, Wall Street J., Feb. 20, 1979, at 10, col. 4; *Swiss Reject Curb on Nuclear Power*, Wash. Post, Feb. 19, 1979, at A35, col. 1.

nuclear power.²² This universality, seen against the background of common concerns over energy supply, provides the most compelling reason for considering the nuclear waste issue from an international perspective.

It does something of an injustice to public concerns for the safe disposal of nuclear waste to view the issue simply in terms of its political manifestations. The extreme toxicity and long life of nuclear wastes pose potentially grave health hazards unless these materials are cared for properly. While the health- and environment-related dangers from nuclear wastes would, in the first instance, affect the populations of the countries in which the wastes are generated, they also have an international component because of the risks of transnational pollution and of the adverse environmental impacts upon global common areas, such as the high seas and Antarctica. One of the key technical problems in permanently disposing of nuclear wastes within geologic formations, for example, is the risk of ground water contamination, which could affect drinking water supplies many miles from the repository site. If repositories are located close to national borders (the proposed West German Gorleben facility is about three miles from East Germany) the possibility of transnational pollution is manifest.²³ Pollution of the high seas is threatened both by transportation accidents, which are increasingly likely as more and more nations begin shipping used reactor fuel to other countries for processing or storage, and by deliberate dumping as a method of waste disposal. Although the 1972 London Convention on Ocean Dumping²⁴ bans such disposal of the most toxic nuclear wastes, it expressly permits dumping of lower level nuclear waste.²⁵ The possibility of waste disposal within the sediments of the ocean floor is still receiving consideration in a number of countries, including the United

²² See generally Donnelly & Kramer, *Evidence of Opposition to Nuclear Power in Europe*, reprinted in CONG. RESEARCH SERV., LIB. CONGRESS, REPORT NO. 78-210 ENR (Oct. 16, 1978). This study reviews major events concerning opposition to nuclear power plant development as reported in *Nucleonics Wk.*, *Energy Daily*, and *Nuclear Eng'r Int'l*. The study concludes that concern about the risks of long-term nuclear waste disposal and the absence of a demonstrated long-term disposal methodology have been major concerns of those parties in Europe and Japan opposed to development of nuclear power. See also P. Lewis, *All Over Europe, the Atoms are Restless*, N.Y. Times, Dec. 3, 1978, at E3, col. 1 (city ed.).

²³ Rippon, *Prospects Look Good for Gorleben Center*, 21 NUCLEAR NEWS 48, 49 (Feb. 1978). See also Teclaff & Teclaff, *Transboundary Ground Water Pollution: Survey and Trends in Treaty Law*, NAT. RESOURCES J. 629, 635 (1979).

²⁴ INTERGOVERNMENTAL CONFERENCE ON THE CONVENTION ON THE DUMPING OF WASTES AT SEA, FINAL DOCUMENTS, adopted Nov. 13, 1972 [hereinafter cited as London Convention]. For further discussion of the London Convention, see text accompanying notes 349-56 *infra*.

²⁵ *Id.*

States and Britain.²⁶ In sum, along with the political impact of the nuclear waste issue on the expanded use of nuclear power, the international aspects of these health and safety risks must also be considered.

There is a third international dimension to nuclear wastes: the programs of certain advanced nations to export nuclear power plants to less developed countries. West Germany, France, Canada, and the United States have active export programs with such nations as India, Pakistan, Brazil, Argentina, the Philippines, Korea, Taiwan, and, until recently, Iran.²⁷ In addition to nuclear fuels and facilities, however, the supplier countries are also exporting the problems of coping with nuclear wastes to nations which may well lack the technical expertise and financial resources to develop sound indigenous nuclear waste disposal programs. Some less developed countries (LDC's) importing nuclear technology, moreover, appear to be exercising lower safety standards than the supplier countries in the building and operation of nuclear power plants and in the intermediate storage of nuclear wastes.²⁸ These problems suggest that LDC's may be more likely than developed countries to have safety problems in their permanent disposal of nuclear wastes.

None of the supplier countries, including the United States, address the subject of nuclear wastes in their export agreements with recipient countries, either to urge that these materials be disposed of safely or to offer specific technical assistance in achieving this result.²⁹ Wastes generated in recipient countries can affect not only the particular recipient involved, but also neighboring nations and global common areas, compounding the potential problems nuclear export programs may engender in this regard.

Finally, the unique chemical and physical conditions which give rise to nuclear reactor wastes mean that the issue of disposing of these wastes is intimately bound up with the question of nuclear weapons

²⁶ See D. DEESE, NUCLEAR POWER AND RADIOACTIVE WASTE 123-41 (1978).

²⁷ For discussion of nuclear export programs and supplier nations' practices with respect to the radioactive wastes produced therefrom, see text accompanying notes 259-345 *infra*. Iran's nuclear power program has been abandoned. See note 179 *infra*.

²⁸ For discussion suggesting that less rigorous safety standards have been implemented among less developed countries using nuclear energy, see Benjamin, *Atomic Power, The Spread of Nuclear Technology Holds Promise and Peril for Developing World*, Wash. Post, Dec. 3, 1978, at A1, col. 2; Benjamin, *Building Atom Plants: 'It's a Bit Scary,'* Wash. Post, Dec. 4, 1978, at A1, col. 1; Benjamin, *It's Hard to Keep Atom Plants Running Without Parts*, Wash. Post, Dec. 4, 1978, at A16, col. 1-3; Benjamin, *The Only Reactor Protected by God*, Wash. Post, Dec. 5, 1978, at A16, col. 1. See also note 181 *supra*.

²⁹ See text accompanying notes 259-345 *infra*.

proliferation.³⁰ In the course of reactor operation, plutonium is created in the irradiated nuclear fuel.³¹ Plutonium can serve as an important indigenously-produced reactor fuel, but, unlike the uranium fuels now used in power reactors, it is also a crucial component in the manufacture of nuclear weapons.³² At present, those nations eager to utilize plutonium's energy potential and those nations which fear that widescale use of plutonium will lead to nuclear weapons proliferation are engaged in a major international debate over whether plutonium should be extracted from used nuclear fuel.³³ The outcome of this debate in particular nations will have a major impact on their nuclear waste disposal programs, determining such basic questions as what materials will be considered to be waste and whether construction of major facilities for separating plutonium will be needed.³⁴

Making this matter still more complicated is that for the many nations which have imported nuclear fuels from the U.S.—including Japan, Sweden, Switzerland, Spain, and several developing countries—the decision on whether to extract plutonium from the used fuel is subject to prior U.S. approval.³⁵ Since the U.S. is trying to discourage plutonium separation in order to curb the spread of nuclear weapons, while most of the nations subject to the U.S. veto have long planned to recover and use this material as a reactor fuel, the waste management plans of these nations are presently subject to major uncertainties. Non-proliferation concerns are thus a central issue to be considered along with worldwide reliance on nuclear power, global pollution, and nuclear supplier/recipient relations in assessing the international dimensions of the nuclear waste problem.

This article presents a summary of the domestic waste disposal programs of nuclear power producing countries. It suggests that no country in the world has perfected the technology of waste disposal nor built even a demonstration facility for the permanent disposal of the most toxic of these radioactive materials. It then discusses the efforts of the multilateral institutions, demonstrating that they have been ade-

³⁰ For a discussion of the interrelationship between the nuclear weapons proliferation question and the waste disposal question, see text accompanying notes 91-97, 191, 276-89, 293-305 *infra*.

³¹ See notes 43-47 and 58 and accompanying text *infra*.

³² FORD-MITRE STUDY, *supra* note 1, at ch. 9.

³³ See text accompanying notes 91-97 and 115-92 *infra*.

³⁴ Benjamin, *Carter's Nuclear Policy Wins Few Converts Abroad*, Wash. Post, Dec. 6, 1978, at A10, col. 1; Benjamin, *Plutonium Reprocessing: The Step the U.S. is Most Eager to Block*, Wash. Post, Dec. 5, 1978, at A16, col. 1; Benjamin, *Taiwan's Nuclear Plans Concern U.S. Officials*, Wash. Post, Dec. 20, 1978, at A21, col. 2.

³⁵ See text accompanying notes 191, 276-89, and 293-305 *infra*.

quate for the exchange of information on waste disposal, but have been unable to regulate disposal of the most hazardous radioactive wastes or even to propound minimum disposal standards. Next, the practices of those free world countries which supply nuclear fuel and equipment are analyzed with respect to the nuclear wastes generated from their exports in recipient countries. In that section the authors indicate that exporters have largely failed to address the matter, although a number of avenues for exporter initiatives appear to be available. Fourth, international treaties which deal with radioactive wastes or related nuclear energy or environmental issues will be reviewed. In this section the authors note that although there has been no accord which deals with the overall nuclear waste disposal problem, existing treaties afford some useful safeguards as well as suggest that a multilateral accord on nuclear waste disposal might be widely adopted. Finally, the authors conclude by suggesting a number of ways in which an international consensus on safe and effective means of nuclear waste disposal can be encouraged.

THE PRODUCTION AND CHARACTERISTICS OF NUCLEAR WASTES

Although a variety of radioactive waste materials are produced at various stages of the fuel cycle associated with nuclear electric power production, this article is concerned specifically with the radiotoxic by-products produced in the nuclear fuel itself during the operation of nuclear power reactors. These wastes, because of their intense radioactivity and exceptionally long life, have become the principal focus of public concerns and political debate regarding nuclear wastes around the globe.³⁶

³⁶ These wastes will hereinafter be referred to as "post-fission wastes."

As explained more fully below at the text accompanying notes 43-65 *infra*, irradiated nuclear fuel contains a variety of unwanted constituents which, because of their long lifespan and high radioactivity, require long-term isolation from the environment. If it were decided not to separate these constituents from irradiated reactor fuel, such fuel, itself, would be treated as waste material and would require long-term sequestration. "Post-fission waste" is used in this article as a convenient short-hand phrase to include the material which would need permanent disposal under both alternatives: the unwanted constituents of irradiated fuel, if separated (together with equipment contaminated by such constituents in the course of separating them), and such fuel itself where it is considered to be a waste product. Unifying these apparently diverse wastes under a single rubric also serves to highlight their essential similarity. The wastes in either case pose roughly comparable public health hazards and would require comparable long-term disposal measures. Thus, the nuclear fission process confronts the nuclear power user with what is basically the same irreducible problem.

Numerous other radioactive wastes are generated in the course of the nuclear fuel cycle in addition to those indicated in the preceeding paragraph. These include the residues from the processing of uranium ore, known as uranium mill tailings, which are hazardous because of their

Nuclear power reactors produce energy through the controlled splitting, or fission, of atoms of uranium.³⁷ In simplified terms, fission occurs when these atoms, some of which are inherently unstable, are struck by neutrons, spontaneously emitted by certain nuclear fuel isotopes.³⁸ Upon splitting apart, the fissioned atoms give off energy in the form of heat and emit additional neutrons, which strike other unstable fuel atoms in a continuing, heat generating chain reaction whose rate can be controlled by various devices in the reactor. The heat produced is used to turn water into steam which drives a turbine producing electricity.³⁹

The most widely built reactor type is the "light water" reactor (LWR), the type which strongly predominates in the United States, Western Europe, Japan, and in a significant number of developing countries.⁴⁰ LWR's are fueled with enriched uranium; i.e., uranium in

radium and radon content; the liquid and gaseous effluents of normal nuclear power plant operation which occur as radioactive substances migrate through small fuel rod defects into reactor cooling water; "low level" wastes, which are clothing and equipment contaminated in the course of reactor operation and other nuclear fuel cycle activities with modest amounts of radioactive material; and disused nuclear facilities, themselves, which require decontamination and decommissioning. See generally FORD-MITRE STUDY, *supra* note 1, at ch. 8; M. WILLRICH & R. LESTER, note 1 *supra*; IRG REPORT, note 1 *supra*.

³⁷ Virtually all nuclear power reactors in operation today use uranium fuel. As discussed in the text at note 58 *infra*, plutonium may serve as a substitute for fissionable uranium in some applications; mixed uranium-plutonium fuels would be used in breeder reactors which are now under development.

³⁸ An isotope is one of several different species of a chemical element, which is distinguished from other isotopes of the same element by variations in the number of neutrons in the atomic nucleus, but indistinguishable by chemical means. FORD-MITRE STUDY, *supra* note 1, at 409. Uranium-235 is the fissionable isotope of uranium of importance to nuclear power production. Uranium-233, another fissionable isotope of uranium, may play an important role in the nuclear fuel cycles associated with certain experimental reactors.

³⁹ For a brief introduction to nuclear power reactor operation and technology, see FORD-MITRE STUDY, *supra* note 1, at appendix.

⁴⁰ The following table indicates the number of operating LWR's in each of the nations listed and their total generating capacity in megawatts (one megawatt equals 1,000,000 watts):

	<u>LWR's</u>	
	Operating	Under Construction
Austria	1	0
Belgium	3	4
Fed. Rep. of Germany	5	5
Finland	3	1
France	3	26
Italy	3	2
Japan	17	7
Netherlands	2	0
Spain	2	7
Sweden	6	2
Switzerland	3	2

which the readily fissionable isotope, uranium-235, has been artificially concentrated from its naturally occurring rate of .7% to a concentration of between 2 and 4 percent.⁴¹ The increased uranium-235 permits the chain reaction to be initiated and sustained when the enriched uranium fuel is submerged in normal, or "light," water. LWR fuel consists of pellets of enriched uranium encased in closed, stainless steel or zirconium alloy tubes about one centimeter in diameter and between 380 and 410 centimeters long, which are assembled into bundles (fuel assemblies) in a square array, with the rods spaced apart and supported

World List of Nuclear Power Plants, 22 NUCLEAR NEWS 59-64 (Feb. 1979) (figures as of Dec. 31, 1978). For LWR's in use in less developed countries, see note 179 *infra*. The United Kingdom has 32 power reactors in operation with a total capacity of 7706 megawatts and 6 more under construction (3700 megawatts). All are gas-cooled reactors of British design as opposed to LWR's. *Id.*

The second principal type of nuclear power reactor in use today is the "heavy water reactor" (HWR). Because HWR's immerse their nuclear fuel in deuterium-oxide—"heavy water"—which permits more efficient use of the neutrons emitted by the uranium fuel than does normal "light" water, HWR's do not require fuel in which the fissionable isotope of uranium has been concentrated, or enriched; instead these reactors operate on natural uranium fuel. Canada manufactures the HWR which is available commercially today, known as the "CANDU" reactor for "Canadian-deuterium-uranium." FORD-MITRE STUDY, *supra* note 36, at appendix. The following table shows the deployment of CANDU and other HWR's currently:

	HWR's	
	Operating	Under Construction
Argentina	1	1
Canada	8	9
India	1	5
Korea	0	1
Pakistan	1	0

World List of Nuclear Power Plants, supra.

Unless otherwise indicated, the figures used in the text to describe waste production in nuclear fuel refer to light water reactors. Figures on accumulations of used nuclear fuel include fuel from all types of reactors. Although the characteristics of irradiated HWR fuel differ in certain respects from those of irradiated LWR fuel, these differences do not alter the general considerations presented in this paper. See INTERAGENCY REVIEW GROUP ON NUCLEAR WASTE MANAGEMENT, DRAFT SUBGROUP REPORT ON ALTERNATIVE TECHNOLOGY STRATEGIES FOR THE ISOLATION OF NUCLEAR WASTE 3 (TID-28818) (Oct. 1978) [hereinafter cited as IRG SUBGROUP REPORT].

⁴¹ U.S. DEP'T OF ENERGY, DRAFT ENVIRONMENTAL IMPACT STATEMENT ON THE STORAGE OF U.S. SPENT POWER REACTOR FUEL II-2 (DOE/EIS-0015-D) (Aug. 1978) (Supp. DOE/EIS-0015-D) (Dec. 1978) [hereinafter cited as DOE DOMESTIC SPENT FUEL STORAGE DRAFT EIS].

by grid structures and end pieces.⁴²

In the course of the nuclear chain reaction, uranium atoms which are fissioned break apart into smaller, lighter, and usually highly radioactive⁴³ isotopes, such as strontium-90, cesium-137, and iodine-131; these are known as "fission products."⁴⁴ Some neutrons in the reactor, however, rather than splitting nuclear fuel atoms, are absorbed by them, producing heavier isotopes than those found in the fuel initially. These new isotopes either decay or absorb another neutron and, in turn, fission or transmute so that through these complex processes, a spectrum of heavy isotopes⁴⁵ is eventually created in the nuclear fuel. Virtually all of these heavy atoms are also radioactive and, in addition, have extremely long half-lives. Their radioactive nature endures for many thousands of years, with some, such as neptunium-237, enduring for millions of years.⁴⁶ In contrast, the vast majority of fission products have shorter half-lives, losing their radiotoxicity in 500 to 1000 years.⁴⁷

When nuclear fuel can no longer sustain a nuclear chain reaction at economic power levels, it is considered to be spent and is removed

⁴² 1 U.S. NUCLEAR REGULATORY COMMISSION, FINAL GENERIC ENVIRONMENTAL IMPACT STATEMENT ON HANDLING AND STORAGE OF SPENT LIGHT WATER POWER REACTOR FUEL 2-1 (NUREG-0575) (August 1979).

⁴³ Radioactivity is the emission of energy in the form of electromagnetic radiation, such as gamma rays, or in the form of high speed subatomic particles, including alpha particles (the nuclei of helium), beta particles (electrons) and neutrons. Nuclei in radioactive materials are unstable and emit this energy spontaneously; in so doing, the nuclei are transmuted, or "decay", into other nuclei which, themselves, may or may not be radioactive. Every radioactive nucleus eventually decays into a stable nucleus through a chain of such transmutations, with the length of the chain and the duration of each transmutation in the chain varying according to the particular radioactive nucleus involved. The period needed for a given type of radioactive nucleus (or radioisotope) to decay into its next form is measured in terms of the half-life of that radioisotope, that is, the time necessary for half of a sample of that radioisotope to decay into its next phase on the chain. M. WILLRICH & R. LESTER, *supra* note 1, at 1-4.

⁴⁴ FORD-MITRE STUDY, *supra* note 1, at 246.

⁴⁵ Heavy isotopes are generally considered to be those with atomic weights (the total of protons and neutrons in the atomic nucleus) greater than that of lead. Those heavy elements with atomic weights which are also greater than uranium's are known as the "transuranic" elements, including neptunium, plutonium, americium, and curium, all of which are found in spent fuel. IRG SUBGROUP REPORT, *supra* note 40, at app. A, 2.

⁴⁶ For a listing of the half-lives of the isotopes referred to in the preceding note, including neptunium-237, see M. WILLRICH & R. LESTER, *supra* note 1, at 3.

⁴⁷ DOE COMMERCIAL WASTE MANAGEMENT DRAFT EIS, *supra* note 1, at 1.9 (500 years); FORD-MITRE STUDY, *supra* note 1, at 257 (700 years); IRG SUBGROUP REPORT, *supra* note 40, at 16 (1000 years); *Hearings on Nuclear Waste Management Before the Senate Subcomm. on Energy, Nuclear Proliferation, and Federal Services of the Governmental Affairs Comm.*, 95th Cong., 2d Sess. 80 (1978) (statement of Dr. Charles L. Hebel) (600 years) [complete hearings hereinafter cited as *Glenn 1978 Hearings*]; Bredehoeft, *Geological Disposal of High-Level Radioactive Wastes: Earth-Science Perspective*, U.S. GEOLOGICAL SURVEY CIRCULAR No. 779 (1978) (several hundred years) [hereinafter cited as U.S.G.S. STUDY]; *Hearings on Nuclear Waste Management Before the House Subcomm. on Fossil and Nuclear Energy Research, Development, and Demonstration of the*

from the reactor. Typically, one quarter to one third of the fuel in a LWR is replaced during an annual reload, resulting in the discharge of about 30 tons of spent fuel, which is initially stored in water-filled pools adjacent to the reactor.⁴⁸ At this point, the highly radioactive spent fuel contains virtually all of the fission products produced during reactor operation, all the heavy isotopes built up by neutron absorption that have not, themselves, fissioned, and a significant percentage of the uranium originally charged into the reactor. By weight, the respective proportions of these three components in spent fuel are approximately 3%, 1%, and 96%.⁴⁹

If radiation from spent fuel or any other source reaches the tissues of the human body, the result, depending on the intensity of the dose of radiation received, is cell damage or destruction.⁵⁰ This in turn can lead to the growth of cancerous cells, damage to chromosomes causing genetic defects in future generations, or, if the radiation is sufficient,

Comm. on Science and Technology, 95th Cong., 2d Sess. 40 (1978) (statement of Milton Levenson) (1000 years) [complete hearings hereinafter cited as *McCormack 1978 Hearings*].

It may be noted that two fission product isotopes, iodine-129 and technetium-99, are exceptions to the rule, remaining radioactive for many thousands of years. *FORD-MITRE STUDY*, *supra* note 1, at 243.

⁴⁸ The following table shows current estimates of existing quantities of spent fuel in the United States and abroad, with projections of future amounts through the year 2000.

The volume of spent nuclear fuel is projected to increase very rapidly in the U.S. and abroad through the end of the century. It seems likely that a rapid expansion will continue beyond the year 2000 as well.

TABLE

Projected Spent Fuel Generation
(Cumulative)

<u>Year</u>	<u>United States^a</u>		<u>Foreign^b</u>	
	<u>MTHM^c</u>	<u>TCF^d</u>	<u>MTHM</u>	<u>TCF</u>
1977	3300	43.2	9000	117.9
1980	7000	91.7	18000	235.8
1985	16800	220.1	40000	524.0
1990	34800	455.9	78000	1021.8
2000	97800	1281.2	217000	2842.7

^a Based on a nuclear growth consistent with National Energy Plan.

^b Free-world only.

^c Metric tons of heavy metal.

^d Thousands of cubic feet.

IRG REPORT, *supra* note 1, at D-28.

⁴⁹ See IRG SUBGROUP REPORT, *supra* note 40, at app. A, 3-4.

⁵⁰ See *FORD-MITRE STUDY*, *supra* note 1, at ch. 5. This chapter provides a detailed but readily comprehended explanation of the various types of radiation hazard posed by spent fuel.

acute illness and death.⁵¹ Depending on the type of radioactive isotope involved, the dangers posed to man will vary. Generally speaking, the radioactive fission products found in spent fuel emit what is known as beta or gamma radiation. Such radiation is highly penetrating, requiring several millimeters of lead or other heavy shielding to reduce its intensity appreciably.⁵² In contrast, the heavy transuranic elements in spent fuel, formed from neutron absorption, emit alpha radiation. Alpha radiation has very little penetrating force and can be stopped by an inch of air or by the outside layer of human skin.⁵³ If, however, alpha emitting radioisotopes lodge in sensitive parts of the body, such as the lungs, through inhalation or through ingestion, they can cause considerable damage.⁵⁴ In spent fuel, the presence of high amounts of penetrating gamma and beta radiation from the fission products make direct exposure to the fuel extremely dangerous, requiring that it be heavily shielded.⁵⁵ At reactor sites, it is kept deeply submerged in water-filled pools, with the water providing such shielding. When it is transported off-site, it must be placed in massive metal canisters weighing some 70 to 100 tons. Even as the beta radioactivity in spent fuel diminishes—it approaches background levels in 500 to 1000 years—the fuel remains extremely hazardous because of the risk that the longer-lived alpha-emitting heavy elements might enter the biosphere and be inhaled or ingested by man.⁵⁶ Alpha-emitting radioactivity will continue at high levels in spent fuel for over 100,000 years.⁵⁷

Because spent fuel contains potentially valuable quantities of both unused uranium and plutonium, a readily fissionable material which can serve as a substitute fuel in LWR's or as the fuel for future breeder reactors, it has long been assumed that spent fuel would undergo chemical "reprocessing" to recover these fuel resources.⁵⁸ In reprocessing,

⁵¹ *Id.*

⁵² *Id.*

⁵³ *Id.*

⁵⁴ *Id.*

⁵⁵ *Id.*

⁵⁶ *Id.*

⁵⁷ *Id.*

⁵⁸ See generally FORD-MITRE STUDY, *supra* note 1, at 247; M. WILLRICH & R. LESTER, *supra* note 1, at 10-11; U.S. NUCLEAR REGULATORY COMM'N, FINAL GENERIC ENVIRONMENTAL IMPACT STATEMENT ON THE USE OF RECYCLED PLUTONIUM IN MIXED OXIDE FUEL IN LIGHT WATER COOLED REACTORS (GESMO) (NUREG-002) (Aug. 1976). See also FUNDAMENTAL REALIZABILITY OF THE WASTE TREATMENT AND STORAGE CENTRE FROM THE SAFETY ENGINEERING ASPECTS, ASSESSMENT AND RECOMMENDATIONS OF THE [WEST GERMAN] REACTOR SAFETY COMMISSION (RSK) AND THE RADIOLOGICAL PROTECTION COMMISSION (SSK) 2-3 (Oct. 1977); NUCLEAR POWER AND THE ENVIRONMENT, THE GOVERNMENT'S RESPONSE TO THE SIXTH ROYAL COMMISSION ON ENVIRONMENTAL POLLUTION 8 (London 1977) (citing ROYAL COMMIS-

spent fuel rods are chopped into small pieces and then dissolved in nitric acid. The plutonium and uranium are chemically separated from this solution, leaving behind the unwanted fission products, and all of the heavy elements (including about 0.5% of the originally present plutonium). Following the reprocessing stage, this residue, termed "liquid high-level waste," must be stored and, ultimately, disposed of in a manner that will not endanger the public. Typically, reprocessing programs have contemplated an initial period of storage of these liquid wastes in steel tanks at the reprocessing plant site, followed by solidification of this material in glass or another enduring substance, and, finally, emplacement of the solidified high-level waste in cavities mined in stable geologic formations.⁵⁹ Here the waste would remain until it had decayed to innocuous levels, a period usually measured in millenia because of the long-term hazard posed by the heavy alpha-emitting elements.⁶⁰ Although the separated plutonium would not require disposal since it would be reused as a reactor fuel and, in effect, be "burned up," the reprocessing itself and the subsequent fabrication of plutonium bearing fuels results in the production of waste materials heavily contaminated with plutonium. These "transuranic wastes," as they are known, because of their long-lived alpha radioactivity, require isolation from the environment for periods similar to those necessary

SION REPORT, *supra* note 1, at 80-81); NUCLEAR ENERGY AGENCY GROUP OF EXPERTS, OBJECTIVES, CONCEPTS AND STRATEGIES FOR THE MANAGEMENT OF RADIOACTIVE WASTE ARISING FROM NUCLEAR POWER PROGRAMMES 66, 69 (Sept. 1977) [hereinafter cited as NEA GROUP REPORT].

⁵⁹ Glassification, or vitrification, as a means of solidifying high-level waste is being pursued by Germany, France, India, the U.S.S.R., the U.K., and the United States.

Some notion of the overall toxicity of post-reprocessing high-level waste can be obtained from the estimate that by the year 2000, dilution of accumulated U.S. high-level wastes (about 60 percent or more would be from civilian power applications) to safe levels would require almost twice the volume of fresh water in the world's lakes, rivers, ground water, and glaciers. U.S.G.S. STUDY, *supra* note 47, at 2. Another commentator has noted that the wastes produced from just one year of U.S. nuclear power production contain the potential, if ingested, for producing millions to billions of cancers; the possibility of such wholesale ingestion is, however, exceedingly remote. *Id.* (citing COHEN, *The Disposal of Radioactive Wastes from Fission Reactors*, 236 SCIENTIFIC AM. 28 (1977)).

⁶⁰ See, e.g., DOE COMMERCIAL WASTE DRAFT EIS, note 1 *supra*; FORD-MITRE STUDY, *supra* note 1, at 243, 254; U.S. ENVIRONMENTAL PROTECTION AGENCY, STATE OF GEOLOGICAL KNOWLEDGE REGARDING POTENTIAL TRANSPORT OF HIGH LEVEL RADIOACTIVE WASTE FROM DEEP CONTINENTAL REPOSITORIES (EPA/520/4-78-004) (1978) [hereinafter cited as EPA STUDY]; U.S.G.S. STUDY, note 47 *supra*; Glenn 1978 Hearings, note 47 *supra*.

Current U.S. conceptualizations of a geologic repository envision that such facilities would be 2000 acres in size and located approximately 1500 feet below the surface. By the year 2000, accumulated wastes would require constructions of 2 to 5 such facilities. For a detailed discussion of repository design, see DOE COMMERCIAL WASTE MANAGEMENT DRAFT EIS, *supra* note 1, at 3.1.104. See also IRG REPORT, *supra* note 1, at 12.

for high-level wastes.⁶¹

In the last several years, U.S. concerns over the possible misuse of separated plutonium, which is one of the two fissionable materials from which atomic weapons can be made, have led the United States to promote the concept of direct permanent disposal of spent fuel itself, without the intermediate step of reprocessing.⁶² Under this alternative, after a period of interim storage at the reactor site or at an "away-from-reactor" surface storage facility, the spent fuel would be specially packaged in metal cannisters to protect against future radiation leakage and would then be emplaced in a permanent repository similar to that envisioned for the disposal of post-reprocessing, high-level waste.⁶³

As may readily be seen, unlike the permanent disposal of this latter material, direct disposal of spent fuel entails the permanent emplacement of all plutonium originally discharged from the reactor. This means that once the fission products in the spent fuel have decayed to safe levels in 500 to 1000 years, considerably greater quantities of long-lived alpha-emitting materials would remain in the repository than in the case of post-reprocessing high-level wastes, necessitating special care in repository design.⁶⁴ Overall, however, the challenge of disposing of spent fuel directly is considered to be roughly comparable to that of disposing of post-reprocessing high-level waste and the attendant transuranic contaminated waste from reprocessing and plutonium fuel fabrication.⁶⁵ The term "post-fission" is being used in this

⁶¹ See, e.g., IRG REPORT, *supra* note 1, at 38.

⁶² See text accompanying notes 91-99 *infra*.

⁶³ For a general analysis of this alternative, see DOE COMMERCIAL WASTE MANAGEMENT DRAFT EIS, note 1 *supra*.

⁶⁴ McCormack 1978 Hearings, *supra* note 47, at 5, 11 (testimony of J. Edward Howard).

⁶⁵ See FORD-MITRE STUDY, *supra* note 1, at 254; IRG REPORT, *supra* note 1, at 73; Glenn 1978 Hearings, *supra* note 47, at 80; McCormack 1978 Hearings, *supra* note 47, at 5, 11. But see NEA GROUP REPORT, *supra* note 58, at 66-67. It may be noted, for example, that when spent reactor fuel containing recycled plutonium from a previous round of reprocessing is, itself, reprocessed, the resulting high-level waste contains higher concentrations of long-lived alpha-emitting isotopes than did the first "generation" of high-level waste. This means that over repeated cycles of reprocessing the difference in the long-term hazard posed by high-level waste and spent fuel is diminished, notwithstanding the fact that most of the plutonium originally present in each generation of spent fuel has been removed. See FORD-MITRE STUDY, *supra* note 1, at 248.

It is often argued that because the overall volume of solidified post-reprocessing high-level waste is considerably smaller than the volume of the spent fuel from which it is extracted, the reprocessing of spent fuel greatly reduces the scale of permanent disposal repository requirements in comparison to the alternative of direct disposal of spent fuel. The higher heat per unit volume emitted by the radioactivity in solidified high-level waste (which is highly concentrated), however, necessitates that containers of this material be more widely spaced in a permanent repository than containers holding spent fuel. In addition, the production of high-level waste by definition requires reprocessing which inevitably entails the generation of significant volumes of transuranic contaminated wastes, wastes which themselves need permanent disposal comparable to that re-

article to refer collectively to all of these wastes requiring long-term isolation from man.

The high inherent toxicity of post-fission wastes and their extraordinary longevity mean that programs for protecting the public from the long-term hazard they pose demand high levels of scientific understanding and technological competence.⁶⁶ It is widely accepted, for example, that because the hazard of post-fission wastes will endure over time periods which will beggar the life span of human institutions, disposal programs must be devised which will provide a high degree of protection for future generations without requiring active managing or monitoring of waste repositories.⁶⁷ This means that the siting, designing, and construction of waste repositories and the development of waste solidification and packaging technologies require great care so as to take into account a wide range of eventualities which might result in loss of isolation, including floods, vulcanism, glaciation, changes in sea and water table levels, and inadvertent intrusion by man as a result of mining or resource exploration.⁶⁸

quired for high-level waste. As a result of these and other factors, total repository acreage requirements for a nuclear fuel cycle based on reprocessing are of the same general magnitude as for a nuclear fuel cycle based on direct disposal of spent fuel. See DOE COMMERCIAL WASTE MANAGEMENT DRAFT EIS, *supra* note 1, at 1.10.

⁶⁶ See generally IRG SUBGROUP REPORT, *supra* note 40, at app. A; EPA STUDY, note 60 *supra*.

⁶⁷ See, e.g., DOE COMMERCIAL WASTE MANAGEMENT DRAFT EIS, *supra* note 1, at 3.1.64.

⁶⁸ *Id.* at 3.1.69. The following possible actions were listed as being one which might disrupt a repository.

Potential Disruptive Phenomena
for Waste Isolation Repositories

Natural Processes	Natural Events	Man-Caused Events	Repository-Caused Processes
Climatic Fluctuations	Flood Erosion	Improper Design/	Thermal, Chemical
Sea Level Fluctuations	Seismically Induced Shaft Seal Failure	Operation: Shaft Seal Failure	Potential, Radiation, and Mechanical
Glaciation	Seal Failure	Improper Waste Emplacement	Force Gradients:
River Erosion	Meteorite		Induced Local Fracturing
Sedimentation		Undetected Past Intrusion:	Chemical or Physical Changes in Local Geology
Tectonic Forces		Undiscovered Boreholes or Mine Shafts	Induced Ground Water Movement
Volcanic Extrusion			Waste Container Movement
Igneous Intrusion		Inadvertent Future Intrusion:	Increase in Internal Pressure
Diapirism		Archeological Exhumation	Shaft Seal Failure
Diagenesis		Weapons Testing	
New or Undetected Fault Rupture		Nonnuclear Waste Disposal	
Hydraulic Fracturing		Resource Mining (Mineral, Hydrocarbon, Geothermal, Salt)	
Dissolution			
Aquifer Flux Variations			

Of perhaps greatest concern, however, is that underground water might enter the repository, leach radioactive substances from emplaced post-fission wastes, and transport these substances to the human environment.⁶⁹ Although in the case of an actual repository many factors, such as slow leaching and underground water flow rates, could be expected to reduce the overall danger to the public from such a breach of repository integrity, one "worst case" analysis of such an event indicates the possibility (albeit remote) of up to 60,000 deaths or serious genetic defects occurring over a 50-year period following such a breach and suggests that persons living up to two hundred miles from the repository could be affected.⁷⁰

Notwithstanding these challenges, it is widely believed that permanent isolation of post-fission wastes in mined repositories is scientifically and technologically feasible and that a properly designed waste disposal program will expose the public to insignificant residual risks.⁷¹ Recent studies of the problem, however, have stressed that a number of

Man-Caused
Events (cont.)

Storage of Hydro-
carbon or Com-
pressed Air

Intentional Intrusion:

War
Sabotage
Waste Recovery

Perturbation of Ground
Water System:

Irrigation
Reservoirs
Intentional Artificial
Recharge
Establishment of
Population Center

Id.

⁶⁹ EPA STUDY, note 60 *supra*; FORD-MITRE STUDY, *supra* note 1, at 256-58; IRG SUBGROUP REPORT, *supra* note 39, at app. A, 37; *Glenn 1978 Hearings*, *supra* note 47, at 76 (statement of Charles Hebel).

⁷⁰ DOE COMMERCIAL WASTE MANAGEMENT DRAFT EIS, *supra* note 1, at 3.1.160, 3.1.163.

⁷¹ See, e.g., DOE COMMERCIAL WASTE MANAGEMENT DRAFT EIS, *supra* note 1, at 3.1.73; FORD-MITRE STUDY, *supra* note 1, at 262; NEA GROUP REPORT, *supra* note 58, at 66; ROYAL COMMISSION REPORT, *supra* note 1, at 81; *Glenn 1978 Hearings*, *supra* note 47, at 77, 104 (testimony of Charles Hebel and Dr. Philip M. Smith).

The costs of permanent disposal of nuclear wastes are thought to be relatively modest, amounting to approximately .5 mills per kilowatt hour by one estimate, in comparison to nuclear power generation costs of between 25 and 35 mills per kilowatt hour (of which approximately 6 mills per kilowatt hour are attributable to all nuclear fuel cycle costs). DOE COMMERCIAL WASTE MANAGEMENT DRAFT EIS, *supra* note 1, at 1.22. See also FORD-MITRE STUDY, *supra* note 1, at 122 (direct spent fuel disposal would cost .4 mills per kilowatt hour).

major gaps still remain in the current knowledge of repository behavior and have called for expansion of waste management research and development programs.⁷² Many of these studies have also emphasized the failure of governmental efforts to address the problem of post-fission waste disposal in a comprehensive and timely fashion.⁷³ In sum, a consensus appears to have emerged that post-fission wastes pose a potentially grave public health hazard for this and many future generations, but that the hazard can probably be managed if scientifically rigorous programs are diligently and carefully pursued. This consensus, however, appears to assume implicitly that adequate technical and financial resources will be made available by government or industry to tackle the job. This assumption may not always be warranted, especially in developing nations where such resources are often in short supply.

CURRENT PROGRAMS FOR THE DISPOSAL OF POST-FISSION NUCLEAR WASTES

This section surveys national and multilateral efforts to address the challenge of safely and permanently disposing of post-fission wastes. Although the problem of nuclear waste management confronts every country which has a nuclear generating capacity, approaches vary widely. Several of the developed nations are actively exploring waste management alternatives through private efforts or through direct government action.⁷⁴ Multilateral efforts are being made as well, through the Organization for Economic Cooperation and Development, the International Atomic Energy Agency, and other multilateral institutions.⁷⁵ The programs which have reached some degree of sophistication are described briefly below.

National Programs

Post-Fission Waste Disposal Activities in the United States. Spent fuel from power reactors in the United States is currently stored in water-cooled basins at reactor sites around the country.⁷⁶ At the pres-

⁷² EPA STUDY, note 60 *supra*; IRG SUBGROUP REPORT, *supra* note 40, at app. A; Glenn 1978 Hearings, *supra* note 47, at 102 (statement of Philip Smith).

⁷³ FORD-MITRE STUDY, *supra* note 1, at 263-64; IRG REPORT, *supra* note 1, at introduction; M. WILLRICH & R. LESTER, note 1 *supra*.

⁷⁴ See generally K. HARMON, SUMMARY OF NATIONAL AND INTERNATIONAL RADIOACTIVE WASTE MANAGEMENT PROGRAMS (EXCLUDING UNITED STATES) (1978); IRG REPORT, *supra* note 1, at app. G [hereinafter cited as Appendix G].

⁷⁵ Appendix G, *supra* note 74, at 1.

⁷⁶ See, e.g., DOE DOMESTIC SPENT FUEL STORAGE DRAFT EIS, *supra* note 41, at II-2; IRG

ent time, however, the United States government has not adopted definitive plans for the subsequent disposition of this material.⁷⁷ Although there appears to be a growing consensus that the ultimate goal of the U.S. post-fission waste disposal program for the next several decades should be the development of mined geologic repositories for the permanent sequestration of these substances,⁷⁸ crucial questions concerning the intermediate steps in the program remain unresolved, including whether and when spent fuel should be reprocessed,⁷⁹ whether centralized, government-owned facilities for interim spent fuel storage are needed,⁸⁰ and how repository site selection should proceed.⁸¹

Historically, from the start of the U.S. civilian nuclear program in the mid-1950's through 1974, responsibility for the U.S. post-fission waste disposal program lay with the Atomic Energy Commission.⁸² The AEC program was based on the assumption that the electrical utility companies operating nuclear power stations would have their spent nuclear fuel reprocessed by other private, commercial entities, with the

REPORT, *supra* note 1, at D-25. As of mid-1979, 70 nuclear power reactors were licensed to operate in the United States (two of these, the Indian Point I facility and the Three Mile Island Unit 2 facility, will not operate for an indefinite period of time, however). The 70 units had a total capacity of 51,000 megawatts (electric). Additional reactors with a combined capacity of 100,000 megawatts had received construction permits. Telephone communication with the Nuclear Regulatory Commission Office of Congressional Affairs (Sept. 14, 1979). Spent fuel accumulations at the end of 1979 were estimated to be approximately 5700 metric tons. (A metric ton is approximately 2200 pounds.) DOE DOMESTIC SPENT FUEL STORAGE DRAFT EIS, *supra* note 41, at II-7; IRG REPORT, *supra* note 1, at D-28. With the exception of approximately 300-350 metric tons of spent fuel stored at a never-opened reprocessing facility at Morris, Ill., and another 165 metric tons stored at a second, no longer operating, reprocessing plant at West Valley, N.Y., all spent fuel from U.S. nuclear power reactors is stored in water-filled pools at reactor sites. DOE DOMESTIC SPENT FUEL STORAGE DRAFT EIS, *supra* note 41, at II-12; U.S. GENERAL ACCOUNTING OFFICE, FEDERAL FACILITIES FOR STORING SPENT NUCLEAR FUEL—ARE THEY NEEDED? i, 13-15 (EMD-79-82) (June 27, 1979). No facilities for the reprocessing of commercial nuclear power reactor fuel are now operating in the United States.

⁷⁷ See, e.g., DOE COMMERCIAL WASTE MANAGEMENT DRAFT EIS, note 1 *supra*.

⁷⁸ See, e.g., *id*.

⁷⁹ See text accompanying notes 62-63 *supra* and 95-97 *infra*.

⁸⁰ See text accompanying notes 98-103 *infra*.

⁸¹ See text accompanying notes 106-08 *infra*.

⁸² For a brief review of the Atomic Energy Commission's programs for radioactive waste management, see IRG REPORT, *supra* note 1, at 2-5; U.S. DEP'T OF ENERGY, DRAFT ENVIRONMENTAL IMPACT STATEMENT ON WASTE ISOLATION PILOT PLANT 2-1 to 2-12, (DOE/EIS-0026-D Apr. 1979) [hereinafter cited as DOE WIPP DRAFT EIS]; U.S. DEP'T OF ENERGY, REPORT OF TASK FORCE FOR REVIEW OF NUCLEAR WASTE MANAGEMENT 47 (DOE-ER-0004/D) (Feb. 1978 draft) (no final version of this document was prepared as the responsibilities of the DOE task force were assigned to the Interagency Review Group on Nuclear Waste Management); U.S. GENERAL ACCOUNTING OFFICE, THE NATION'S NUCLEAR WASTE—PROPOSALS FOR ORGANIZATION AND SITING 3-5 (EMD-79-77) (June 21, 1979); M. WILLRICH & R. LESTER, *supra* note 1, at 13-18; Glenn 1978 Hearings, *supra* note 47, at 332-35.

U.S. government taking responsibility for the disposal of the resulting solidified high-level waste in caverns to be mined in deep geologic salt formations.⁸³

For a variety of reasons, however, including the slow evolution of commercial reprocessing and the public's apparent willingness to permit nuclear power development in the absence of a clear solution to post-fission waste disposal, the AEC's program remained poorly funded and narrowly focused on the deep salt option.⁸⁴ In addition, the program suffered a key setback in the early 1970's, when the AEC was forced to abandon, for technical and political reasons, a proposed waste repository near Lyons, Kansas.⁸⁵ As a result of these factors, when the Atomic Energy Commission was disbanded in 1975 and its waste disposal responsibilities transferred to the Energy Research and Development Administration (ERDA),⁸⁶ a definitive program for long-term management of post-fission wastes remained far from fruition.

Under ERDA, research and development activities were considerably broadened under greatly expanded budgets,⁸⁷ trends which have continued after ERDA was incorporated into the Department of Energy (DOE) in November 1977.⁸⁸ DOE's overall goal is to develop a

⁸³ FORD-MITRE STUDY, *supra* note 1, at 247; *Hearings on Nuclear Waste Disposal Before the Subcomm. on Science, Technology, and Space of the Senate Comm. on Commerce, Science, and Transportation*, 95th Cong., 2d Sess. 233 (1978) (statement of Sol Burstein) [hereinafter cited as *Schmitt 1978 Hearings*]; *McCormack 1978 Hearings*, *supra* note 47, at 7 (statement of J. Edward Howard).

⁸⁴ FORD-MITRE STUDY, *supra* note 1, at 257; IRG REPORT, *supra* note 1, at 3; M. WILLRICH & R. LESTER, *supra* note 1, at 52. For a brief history of unsuccessful attempts to develop commercial reprocessing in the United States, see FORD-MITRE STUDY, *supra* note 1, at 321-22.

⁸⁵ DOE WIPP DRAFT EIS, *supra* note 82, at 2-2; FORD-MITRE STUDY, *supra* note 1, at 257; IRG REPORT, *supra* note 1, at 3; U.S. GENERAL ACCOUNTING OFFICE, *supra* note 82, at 4; *Glenn 1978 Hearings*, *supra* note 47, at 334.

⁸⁶ Energy Reorganization Act of 1974, 42 U.S.C. §§ 5801, 5814 (1976).

⁸⁷ With the advent of the Energy Research and Development Administration in 1975, the budget for nuclear waste management activities was increased by over 50% from the AEC's \$61 million in 1974 to \$94 million in 1975. (These figures are for activities for the management of wastes from both the U.S. military program and for civilian nuclear wastes). In 1976, the budget was increased to \$158 million and in 1977, to \$230 million. IRG REPORT, *supra* note 1, at 4. ERDA's program of expanded study of underground formations as potential repository sites contemplated scrutiny of formations in 36 states. U.S. Energy Research and Development Administration, *ERDA Studies Geologic Formations Throughout Nation for Data on Potential Sites for Commercial Nuclear Waste Disposal*, Press Release No. 76-355 (Dec. 2, 1976). The objective of this ERDA program was the construction of six repositories, two each in salt, granite, and shale, before the year 2000—with the first pair to be in operation in 1985. *Id.*

⁸⁸ Department of Energy Organization Act of 1977, 42 U.S.C.A. §§ 7101, 7151 (Supp. I 1978). DOE's 1979 budget for waste management activities (civilian and military) was \$459 million. DOE's current program includes accelerated study of non-salt geologies leading to an operating, full-scale repository sometime after 1988. U.S. DEP'T OF ENERGY, DOE'S COMMERCIAL WASTE MANAGEMENT PROGRAM (DOE/ET-0042, March 1978); *Hearings on Dep't of Energy FY 1980*

permanent waste repository by 1988, or shortly thereafter.⁸⁹ Its present program also calls for the operation, sometime after 1986, of the Waste Isolation Pilot Plant (WIPP), a pilot scale repository to be built near Carlsbad, New Mexico, which would hold transuranic wastes from the U.S. military nuclear program and, possibly, experimental quantities of high-level waste (also from the military program) and of commercial spent fuel.⁹⁰

Notwithstanding the increased attention given nuclear waste disposal by the DOE, a number of controversial shifts in U.S. nuclear waste disposal policy under the Ford and Carter administrations have introduced considerable uncertainties as to the future course of the U.S. program. The first of these was articulated in President Ford's October 27, 1976, statement on nuclear policy in which he declared that the United States would defer commercial reprocessing of spent power reactor fuel and that U.S. efforts to develop a permanent waste disposal repository would be expanded to provide that any such repository be able to accept spent fuel itself as a waste form for permanent disposi-

Authorization, Before the Subcomm. on Energy and Environment of the House Comm. of Interior and Insular Affairs, 95th Cong., 2d Sess. 1, 3 (1979) (statement of Worth Bateman) [complete hearings hereinafter cited as 1979 Energy Hearings].

⁸⁹ See note 87 *supra*.

⁹⁰ DOE WIPP DRAFT EIS, note 82 *supra*. The WIPP proposal has proven controversial. First, DOE has—at least until quite recently—proposed that the facility be licensed by the Nuclear Regulatory Commission, in part because the facility would hold at least a modest quantity of commercial spent fuel. This has triggered strong opposition on the part of some in Congress who believe such licensing might improperly impinge on the U.S. nuclear weapons program. To address such objections, which threaten continued funding of the project, DOE has apparently agreed to limit the use of the facility to military wastes and to build it without its being licensed by the NRC. See *DOE Gives Up Attempt to License WIPP, Store Spent Fuel*, *Energy Daily*, July 24, 1979; *Hearings on Nuclear Waste Management Before the Subcomm. on Nuclear Regulation of the Senate Comm. on Environment and Public Works, 96th Cong., 1st Sess. (1979) (statement of Worth Bateman) [complete hearings hereinafter cited as Hart 1979 Hearings]; WIPP Changes Delay Carter Decision on Nuclear Waste Policy*, *NUCLEONICS WK.*, Aug. 23, 1979, at 1. But see *New Mexico Rejects DOE Funds for State WIPP Evaluation, Wants Licensing*, *INSIDE DOE*, Sept. 7, 1979, at 5. Last minute legislation embodying a compromise on some of these issues will provide funding during FY 1980 for the project as an unlicensed facility. See *Dep't of Energy National Security and Military Application of Nuclear Energy Authorization Act of 1980*, Pub. L. No. 96-164, § 213, 93 Stat. 1259 (1979). President Carter in signing this measure into law, however, stated that he did not endorse its approach to the project and that he would address WIPP's future in a forthcoming comprehensive statement on U.S. nuclear waste management. *A-Waste Measure Signed But Assailed*, *Wash. Post*, Jan. 1, 1980, at A18, col. 1.

In addition, the adequacy of the site chosen for WIPP has been challenged by some federal agencies. See *IRG REPORT*, *supra* note 1, at 57 (some IRG member agencies believe a broad range of sites should be considered before a first "intermediate scale facility" location is selected); *Carter to Consider Delaying Early Demo of Commercial Nuclear Waste*, *INSIDE DOE*, Mar. 12, 1979, at 1.

tion.⁹¹ This initiative was reaffirmed and extended by President Carter in an April 7, 1977, policy statement on nuclear weapons proliferation in which he announced that the U.S. deferral of spent power reactor fuel reprocessing would continue "indefinitely".⁹² Carter also reiterated Ford's decision that the U.S. would develop mechanisms for the permanent geologic disposal of spent fuel.⁹³ Like the Ford statement, the overall objective of the Carter policy was to discourage, by the example of U.S. conduct, reprocessing activities in other nations and the concomitant accumulation of separated plutonium, usable for nuclear weapons, under national control.⁹⁴

Although shortly after the Carter statement generic regulatory proceedings on commercial reprocessing and the recycling of plutonium in LWR fuel were terminated,⁹⁵ effectively precluding these activities in the United States for the present, the Carter policy has been strongly opposed by proponents of reprocessing in the Congress and the nuclear industry.⁹⁶ Others, while going along with the Carter policy for the time being, believe that the option to reprocess spent fuel at some later time must be retained and, accordingly, that premature irretrievable disposal of spent fuel should be avoided.⁹⁷ Even if it is assumed that the Carter policy will remain in force for some years to come, these political pressures cast doubt on whether current proposals

⁹¹ 12 WEEKLY COMP. OF PRES. DOC. 1624 (Oct. 27, 1976).

⁹² 1 PUB. PAPERS 587 (Apr. 7, 1977).

⁹³ *Id.*

⁹⁴ *Id.*

⁹⁵ Generic Environmental Statement on Mixed Oxide Fuel [1975-1978 Transfer Binder] NUC. REG. REP. (CCH) ¶ 30,296. This decision was promptly challenged by Westinghouse Electric, among others, as an abuse of agency discretion, but was sustained by the Third Circuit Court of Appeals in *Westinghouse Elec. Corp. v. United States Nuclear Regulatory Comm'n*, 598 F.2d 559 (3d Cir. 1979).

⁹⁶ See, e.g., *McCormack 1978 Hearings*, *supra* note 47, at 1 (opening statement of Mike McCormack), 45 (colloquy between Cong. McCormack and J. Edward Howard); *Schmitt 1978 Hearings*, *supra* note 83, at 111, 114 (letter from Carl Walske to Adlai E. Stevenson and Harrison Schmitt). For a general discussion of the potential energy contribution of plutonium in conventional or breeder reactors and countervailing non-proliferation concerns, see FORD-MITRE STUDY, *supra* note 1, at chapters 11, 12, and 14; SCHURR, *ENERGY IN AMERICA'S FUTURE: THE CHOICES BEFORE US* 31-32, 389-94, 492-512 (1979).

More broadly, the annual battle between the Congress and President Carter over the funding of the Clinch River Breeder Reactor has come to symbolize the sharp difference in views which exists over future U.S. reliance on plutonium as an energy source. See Corrigan, *Let's Make a Deal*, [1978] NAT'L J. 1402; Corrigan, *Stuck in the Middle of Clinch River*, [1978] NAT'L J. 1024; Pelham, *Annual Breeder Reactor Battle Set to Begin*, 37 CONG. Q. 752 (1979); *Clinch River Vote*, 37 CONG. Q. 939 (1979) (Senate Energy Committee votes in favor of Carter proposal to halt breeder construction); *Committee Refuses to Halt Clinch River Project*, 37 CONG. Q. 771 (1979).

⁹⁷ See *Glenn 1978 Hearings*, *supra* note 47 at 3, 53 (statements of John Glenn); *Schmitt 1978 Hearings*, *supra* note 83, at 82 (statement of Harrison Schmitt).

for the direct permanent disposal of U.S. spent fuel will ultimately be implemented or whether solidified, post-reprocessing high-level waste will turn out to be the material requiring disposal.

The deferral of commercial reprocessing and the lack of a full-scale geologic spent fuel repository for many years to come has meant that utilities operating nuclear power plants have had to retain the spent fuel discharged from these plants in storage pools at reactor sites.⁹⁸ Despite significant efforts to increase the storage capacity of existing spent fuel pools, some estimate that a widespread shortage of spent fuel storage capacity could arise as early as 1983, potentially requiring the shut-down of a number of operating power plants.⁹⁹

To alleviate this possible near-term shortage of spent fuel storage space at reactor sites, President Carter announced on October 18, 1977, a program for the U.S. government (through DOE) to accept spent fuel from domestic utilities (and in some limited cases from foreign nations) in return for the payment of a one-time charge which would cover the costs of continued interim storage at government owned "away-from-reactor" spent fuel storage facilities, as well as permanent disposal of this material once a geologic repository entered into operation.¹⁰⁰ Since the time of the President's announcement, DOE has published several major documents outlining the main elements of this program, including estimates of the fees to be charged and the methodology for fixing them,¹⁰¹ and has submitted enabling legislation to the Congress.¹⁰² Again, however, the Carter proposal has been controversial, and passage of such legislation at an early date appears unlikely.¹⁰³ To date, no spent fuel has actually been accepted by the federal govern-

⁹⁸ See IRG REPORT, *supra* note 1, at D-25.

⁹⁹ See, e.g., DOE DOMESTIC SPENT FUEL STORAGE DRAFT EIS, *supra* note 41, at I-3; *McCormack 1978 Hearings*, *supra* note 47, at 8 (statement of J. Edward Howard); *Schmitt 1978 Hearings*, *supra* note 83, at 233 (statement of Sol Burstein).

¹⁰⁰ U.S. Dep't of Energy, *DOE Announces New Spent Fuel Policy*, Press Release R-77-017 (Oct. 18, 1977).

¹⁰¹ See, e.g., DOE DOMESTIC SPENT FUEL STORAGE DRAFT EIS, note 41 *supra*; U.S. DEP'T OF ENERGY, DRAFT ENVIRONMENTAL IMPACT STATEMENT ON CHARGE FOR SPENT FUEL STORAGE, (DOE/EIS 0141-D, Dec. 1978); U.S. DEP'T OF ENERGY, DRAFT ENVIRONMENTAL IMPACT STATEMENT ON THE STORAGE OF FOREIGN SPENT POWER REACTOR FUEL, (DOE/EIS 0040-D, Dec. 1978).

¹⁰² *DOE Submits Legislation to Authorize Facilities for Storage of Spent Fuel*, DOE-News R-79-076 (Feb. 26, 1979). See Spent Nuclear Fuel Act of 1979, H.R. 2586, S. 797, 96th Cong., 1st Sess. (1979).

¹⁰³ See, e.g., U.S. GENERAL ACCOUNTING OFFICE, FEDERAL FACILITIES FOR STORING SPENT NUCLEAR FUEL—ARE THEY NEEDED? (EMD-79-82, June 27, 1979); *Committee Tells DOE to Avoid Building AFR* ["away-from-reactor" spent fuel storage facility] *But to Prepare to React to India's Threats*, NUCLEAR FUEL 11 (July 9, 1979).

ment, nor have specific plans for the acquisition or construction of storage capacity been announced by the Administration.

In parallel with the two foregoing policy initiatives, President Carter, on March 15, 1978, launched a major reassessment of the entire U.S. nuclear waste management program under the guidance of an Interagency Review Group (IRG) chaired by DOE.¹⁰⁴ The IRG's final report was published in March of 1979.¹⁰⁵ The most far-reaching of the Report's conclusions was its finding that major gaps exist in scientific and technological knowledge concerning geologic waste repositories and that, accordingly, U.S. efforts to develop such facilities must proceed with considerable caution and follow a scientifically conservative, step-by-step approach.¹⁰⁶ IRG member agencies disagreed, however, on how this joint recommendation should be implemented in the key area of selecting a site for the first U.S. repository.¹⁰⁷ The crux of the controversy was whether adequate information is currently available on the use of salt as a host rock for a repository to permit selection of a site in this medium, or whether a comparable understanding of alternative rock types should be developed first and a site then selected from this broader range of options.¹⁰⁸ The second alternative could delay the earliest date for operation of the first U.S. repository from 1988 to

¹⁰⁴ Memorandum from President Jimmy Carter to the Sec'y of State, *et al.*, on Interagency Nuclear Waste Management Task Force, March 13, 1978, *reprinted in* IRG REPORT, *supra* note 1, at app. A.

¹⁰⁵ IRG REPORT, note 1 *supra*.

¹⁰⁶ IRG REPORT, *supra* note 1, at 37, 48. Other major findings of the Report with respect to post-fission waste disposal were: (1) Near-term program activities should be based on the assumption that the first disposal facilities will be mined repositories. The longer-term alternative approaches of disposal in deep ocean sediments or very deep holes should be funded to allow their adequate evaluation as competitors. *Id.* at 58; (2) Near-term R&D and site characterization programs should be designed so that at the earliest date feasible, sites selected for location of a repository can be chosen from among a set with a variety of potential host rock and geohydrological characteristics. To accomplish this, R&D on several potential emplacement media and site characterization work on a variety of geologic environments should be increased promptly. *Id.* at 59; (3) A number of potential sites in a variety of geologic environments should be identified and early action should be taken to reserve the option to use them if needed at an appropriate time. Near-term options should include having at least two (and possibly three) repositories operational within this century, ideally and insofar as technical and other considerations permit, in different regions of the country. *Id.*; (4) Construction and operation of a repository should proceed on a step-wise basis and initial emplacement of waste in at least the first repository should be planned to proceed on a technically conservative basis and permit retrievability of the waste for some initial period of time. *Id.* at 62.

One of the IRG technical findings concerning the geologic repository program was that a systems approach should be used to select the geologic environment, repository site, and waste form. *Id.* at 37.

¹⁰⁷ IRG REPORT, *supra* note 1, at 52-53.

¹⁰⁸ *Id.* at 63; *Hart 1979 Hearings*, *supra* note 90, at 4 (statement of Worth Bateman).

1992, or longer.¹⁰⁹ As of this writing, this difference of view was awaiting resolution by the President. Also bound up in this controversy is whether the WIPP facility, which would be built in bedded salt, should proceed or whether an expanded site selection process should be employed for siting this pilot facility, as well.¹¹⁰

The IRG Report also stressed the need to remedy another uncertainty plaguing the U.S. nuclear waste management program, the continuing failure of the Nuclear Regulatory Commission and the Environmental Protection Agency, respectively, to issue their safety and environmental standards governing commercial post-fission waste repository construction and operation.¹¹¹ These standards will have a direct impact on the direction of DOE's research, development, and site selection activities. The IRG proposed they be issued before the end of 1980.¹¹²

An additional recommendation of the IRG, triggered by the strong concerns expressed by state governments during the past several years over the possible disposal of post-fission wastes within their jurisdictions, was that state governments be given the right as a matter of federal policy to concur in all phases of the DOE repository siting and development process.¹¹³ Irrespective of whether this policy is fully implemented, however, strong state opposition to nuclear waste facilities is likely to have a continuing and potentially profound impact on the timing and ultimate shape of the U.S. post-fission waste repository program.¹¹⁴

¹⁰⁹ IRG REPORT, *supra* note 1, at 143.

¹¹⁰ *Id.* at 72. WIPP has also been the subject of controversy within the Congress. See note 90 *supra*.

¹¹¹ *Id.* at 23-28.

¹¹² *Id.* at 140-41.

¹¹³ *Id.* at 93-95.

¹¹⁴ See, e.g., U.S. GENERAL ACCOUNTING OFFICE, *supra* note 82, at 3-6. This report notes the history of opposition at the state and local level to the siting of nuclear waste repositories. The report also states that "as of February 1979 nine states—Colorado, Louisiana, Michigan, Maryland, Minnesota, Montana, Oregon, South Dakota, and Vermont—had enacted legislation that might prohibit waste repository siting" and that nineteen other states had enacted or were considering legislation "asserting lesser degrees of State control." *Id.* at 5. See also *Hearings before the Subcomm. on Energy Regulation of the Senate Comm. on Energy and Natural Resources*, 96th Cong., 2d Sess. (1979) (statement of Steven V. Sklar) (notes the National Conference of State Legislatures' position that "State legislatures should exercise final approval power over the placement of nuclear waste disposal sites within the borders of their respective states.").

State and local opposition to the siting of post-fission waste repositories, it may be noted, is not confined to the United States, but has also been manifest in a number of foreign nations, as well. See *A Tougher Nuclear Opposition in Britain Grows at the Grass Roots Level*, NUCLEONICS WK., Aug. 23, 1979, at 6 (U.K. Atomic Energy Authority prevented from testing rock in Cheviot Hills area for potential waste disposal sites because of local opposition); *Canada is Beginning to*

While it is clear both from current funding levels and from the attention the subject is receiving at the highest levels of government that the United States is strongly committed to a vigorous, technically sound post-fission waste disposal program, crucial elements of that program thus remain unresolved at this time. Even if such uncertainties were promptly eliminated, however, it would still be 1988 at the earliest before a full-scale waste repository for these materials could be opened.

. *Japan.* Japan has fifteen commercial nuclear power plants in operation and another fifteen under construction, or under letter of intent.¹¹⁵ It is anticipated that the amount of nuclear generating capacity will increase six-fold between now and 1990.¹¹⁶

Currently, Japan's spent power reactor fuel is in water-cooled spent fuel pools at the reactor sites.¹¹⁷ A small amount has been reprocessed in a domestic pilot plant, and a modest quantity of spent fuel has been shipped to Great Britain and France for reprocessing.¹¹⁸ The Japanese waste management program is coordinated by the Japan Atomic Energy Commission (JAEC).¹¹⁹ The high-level liquid waste from the pilot reprocessing plant which began operation in the fall of 1977 is being stored as acid liquids in stainless steel tanks pending a decision on solidification or more sophisticated processing treatment.¹²⁰ Japanese plans at the present time contemplate major exports of spent fuel for reprocessing in England and France, and a number of spent fuel shipments to these nations have already been made.¹²¹ Japan also plans to develop a commercial scale domestic reprocessing capability to commence operation in the late 1980's.¹²² Japan's early reprocessing agreements with England apparently provide for retention of all resulting nuclear wastes in that country,¹²³ surely a masterstroke in this field. However, the bulk of the agreements, signed more recently, call for the return of the waste produced to Japan, assuming the material is

Experience the Same Problems as the US in Nuclear Waste, NUCLEONICS WK., Jan. 26, 1978, at 20 (Ontario provincial government resists national exploratory drilling program for repository); *German Officials Hedge on Waste Storage*, NUCLEAR FUEL, July 23, 1979, at 12 (Chancellor Schmidt's meeting with officials of 11 West German states failed to produce solution to country's waste management plight which stems from Lower Saxony's refusal to accept Gorleben facility).

¹¹⁵ Adopted and updated from *World List of Nuclear Power Plants*, note 40 *supra*.

¹¹⁶ K. HARMON, *supra* note 74, at 29. But see *Japan Intends to Slow Its Plans to Increase Nuclear Power Output*, Wall St. J., Aug. 2, 1979, at 20, col. 3.

¹¹⁷ Appendix G, *supra* note 74, at G-5.

¹¹⁸ K. HARMON, *supra* note 74, at 29. See text accompanying notes 290-98 *infra*.

¹¹⁹ Appendix G, *supra* note 74, at G-5.

¹²⁰ *Id.*

¹²¹ K. HARMON, *supra* note 74, at 29.

¹²² *Id.*

¹²³ See *Nuclear Fuel Transfer Hearings*, *supra* note 17, at 87 (testimony of Joseph Nye).

processed into a material suitable for transport.¹²⁴ A major problem confronting Japan is that the country's high degree of seismic activity puts serious technical constraints on the feasibility of burying nuclear wastes permanently in mined repositories, as other nations are planning. For this reason, deep seabed disposal would appear to be especially attractive to Japan.

Japan's spent fuel shipments to France and England have been controversial because they involve the retransfer for reprocessing of nuclear fuel material originally exported from the United States. As discussed below,¹²⁵ the U.S. retains the right to veto the shipment of U.S.-origin spent nuclear fuel for reprocessing in third countries. Since the U.S. is now trying to discourage reprocessing, conflicts have arisen as to whether the plans of Japan and these other nations to have their spent fuel reprocessed in France and in Great Britain will be permitted to go forward. To date, the U.S. position has been to permit reprocessing under contracts entered into before the 1977 shift in U.S. policy and to examine other retransfers of U.S.-origin spent fuel for reprocessing on a case-by-case basis, with the U.S. likely to take a fairly restrictive stand on approving them.¹²⁶ Japan's domestic reprocessing efforts are also subject to a U.S. veto and are controversial for the reasons noted below.¹²⁷

Because Japan is densely populated and earthquake prone, the Japanese have tentatively concluded that Japan may have difficulty identifying a geologically suitable formation for below ground long-term post-fission waste disposal.¹²⁸ Therefore, Japan is interested in seabed disposal or disposal on or within a deserted island.¹²⁹ However, consideration of possible geologic burial sites within Japan is continuing, with limestone, diamante, and shale formations under consideration.¹³⁰

United Kingdom. The United Kingdom has thirty-two commercial nuclear power plants in operation (many of them relatively small units) and six units under construction, on order, or under letter of intent.¹³¹

¹²⁴ *Cumbria County Council, Copeland Borough Council Inquiry into Application of British Nuclear Fuels, Ltd.*, Transcript of Day Eight, at 17 (June 1977)(testimony of Lord Silsoe, Counsel for British Nuclear Fuels, Ltd.) [hereinafter cited as *Windscale Inquiry*].

¹²⁵ See text accompanying notes 264 and 290-98 *infra*.

¹²⁶ MacLachlan, *Once Again, Japan Asks U.S. Consent For Spent Fuel Reprocessing*, *Energy Daily*, Dec. 15, 1978, at 3. See also text accompanying notes 290-98 *infra*.

¹²⁷ See text accompanying note 289 *infra*.

¹²⁸ Appendix G, *supra* note 74, at G-5.

¹²⁹ *Id.* at 6.

¹³⁰ K. HARMON, *supra* note 74, at 30.

¹³¹ Adopted and updated from *World List of Nuclear Power Plants*, note 40 *supra*.

The U.K. projections call for a ten-fold increase in generating capacity by 2000 to 100 GWE, although this may be slowed significantly if current opposition to nuclear power increases. The U.K. has been reprocessing its own fuel and, in addition, has entered into contracts to reprocess light water reactor fuel from other countries.¹³² It currently has an over 1,000 metric ton per year commercial reprocessing plant in operation, the "Windscale Works," and is hurrying with plans for a second.¹³³

The high-level wastes from the reprocessing are presently being stored in liquid form in double-walled steel tanks.¹³⁴ There has been extensive work in the U.K. on the waste processing technology for high-level waste and transuranic waste. The U.K. plans to store high-level liquid waste in double-walled steel tanks for an interim period and then to convert it to borosilicate glass.¹³⁵ In the meantime, the U.K. is engaged in a program to evaluate the permanent storage of radioactive waste in geological formations. The most probable options are clay formations and crystalline rock.¹³⁶

France. France currently has twelve commercial nuclear power plants in operation and thirty-seven units under construction, on order, or under letter of intent.¹³⁷ It has one facility for commercial-scale reprocessing of reactor fuel from its graphite-moderated, gas-cooled reactors at Marcoule and a second for reprocessing LWR fuel at La Hague.¹³⁸ An additional facility for commercial LWR fuel reprocessing, also at La Hague, is planned for the mid-1980's. France, like Britain, is offering to reprocess fuel from other countries and to store the residue for an interim period under contract with eventual shipment of cooled wastes to the country of origin.¹³⁹ To date, most of the reprocessing wastes have been stored in liquid form in holding tanks.¹⁴⁰ However, the French have recently started operation of a plant at Marcoule for the continuous vitrification of high-level wastes.¹⁴¹ Another vitrification plant to "glassify" liquid high-level waste into a solid form is

¹³² Appendix G, *supra* note 74, at G-4.

¹³³ *Id.*

¹³⁴ *Id.*

¹³⁵ *Id.*

¹³⁶ *Id.* See also K. HARMON, *supra* note 74, at 32; ROYAL COMMISSION REPORT, note 1 *supra*; *Nuclear Power and the Environment: The Government's Response to the Sixth Report of the Royal Commission on Environmental Pollution* (Cmd. 6618), Cmd. 6820 (May, 1977).

¹³⁷ Adopted and updated from *World List of Nuclear Power Plants*, note 40 *supra*.

¹³⁸ Appendix G, *supra* note 74, at G-4.

¹³⁹ *Id.* at G-5.

¹⁴⁰ *Id.*

¹⁴¹ *Id.*

scheduled for completion in the early 1980's.¹⁴²

With the start-up of the Marcoule solidification facility, the French are, perhaps, at a more advanced stage of development in the technology for converting high-level liquid waste to a borosilicate glass than any other nation discussed in this section.¹⁴³ As recent French reprocessing contracts permit the return of resulting high-level wastes to the foreign contracting party only in solidified form, France is seeking to gain international acceptance of its solidification process.¹⁴⁴ At home, France presently intends to dispose of high-level waste in a glassious form in below-ground geological formations, probably salt, and is studying salt domes in Southern France.¹⁴⁵ The French do not anticipate any large-scale permanent disposal for thirty years or so while a final solution to disposal is developed.¹⁴⁶

Belgium. Belgium has three operating power reactors and four more planned for operation by 1982.¹⁴⁷ At present, none of the fuel from the Belgian plants is being reprocessed. However, the Belgian government is considering refurbishing and reopening the reprocessing plant at Mol, Belgium.¹⁴⁸ It is also working on plans for disposal of wastes in clay beds below the Mol site, perhaps as early as 1981.

The Belgian government's proposed waste management research and development five-year plan for 1978-1982 includes work to be done under the framework of the Commission of European Communities in the following areas: (1) radioactive waste burial in geological formations; (2) studies of compaction and encapsulation of reactor fuel cladding waste; and (3) investigation of high temperature incineration of plutonium containing waste.¹⁴⁹

Belgium has also entered into a technical exchange agreement with the United States to cooperate in the following areas: technology of retrievable storage, terminal storage in geological formations, high-level waste solidification and environmental effects of radioactive waste disposal.¹⁵⁰

Sweden. Sweden has six LWR power plants in operation and will,

¹⁴² *Id.*

¹⁴³ See text accompanying notes 116-92 *supra*. United States efforts to develop waste solidification technology have focused most heavily on high-level military waste.

¹⁴⁴ K. HARMON, *supra* note 74, at 20. See also note 316 *infra*.

¹⁴⁵ K. HARMON, *supra* note 74, at 20.

¹⁴⁶ See K. HARMON, *supra* note 74, at 7; Appendix G, *supra* note 74, at G-4, G-5.

¹⁴⁷ Appendix G, *supra* note 74, at G-9.

¹⁴⁸ *Id.*

¹⁴⁹ *Id.*

¹⁵⁰ *Id.* See also K. HARMON, *supra* note 74, at 16.

under present plans, have six more in operation by 1983, though building of these plants is uncertain because of the anti-nuclear political climate in Sweden.¹⁵¹

The Swedish Government Committee on Radioactive Waste recommended in 1976 that Sweden develop a reprocessing and waste management capability.¹⁵² Soon after this, the Socialist Party in Sweden changed from a pro- to an anti-nuclear power development policy.¹⁵³ Subsequently, the Swedish Parliament enacted a law requiring that safe disposal of nuclear wastes be assured before any new reactors be loaded with fuel and commence operation.¹⁵⁴ In response, the Swedish utilities have sponsored a crash effort to develop a plan for geological disposal of either spent fuel elements or solidified high-level waste, and have contracted with France for reprocessing of Swedish spent fuel at La Hague.¹⁵⁵

Prior to reprocessing, Sweden stores its spent fuel above ground in water-filled pools at reactor sites. Sweden's announced policy is to have its fuel reprocessed by France and to store solidified waste and unprocessed spent fuel in near-surface bedrock (probably granite) for 30 years, followed by disposal in granite formations 500 meters underground. Swedish waste management research and development is directed toward this end. The present program includes: (1) preparation for commissioning a pilot plant for disposal of spent fuel or solidified high-level wastes; (2) design of underground storage areas; and (3) powder-pressing and sintering techniques for making waste glass forms and for making ceramic containers for spent fuels.¹⁵⁶

Although two detailed studies of waste disposal methodologies—one for disposal of post-reprocessing waste and one for direct disposal of spent fuel—completed under the auspices of the specially convened utility panel noted above, have generally been accepted in Sweden as describing technologies for the safe disposal of wastes, the actual implementation of these technologies remains something for the future. Recent Swedish government statements, moreover, have emphasized that the proposals in these reports may prove too expensive to be imple-

¹⁵¹ Adopted and updated from *World List of Nuclear Power Plants*, note 40 *supra*.

¹⁵² K. HARMON, *supra* note 74, at 31; Appendix G, *supra* note 74, at G-5. See also Donnelly & Kramer, *supra* note 22, at 15-18.

¹⁵³ Donnelly & Kramer, *supra* note 22, at 17.

¹⁵⁴ K. HARMON, *supra* note 74, at 31.

¹⁵⁵ *Id.*

¹⁵⁶ *Id.* at 31-32; Appendix G, *supra* note 74, at G-9, G-10. See also SWEDISH GOVERNMENT COMM. ON RADIOACTIVE WASTE SPENT NUCLEAR FUEL AND RADIOACTIVE WASTE, A SUMMARY OF A REPORT GIVEN BY THE SWEDISH GOVERNMENT COMMITTEE ON RADIOACTIVE WASTE (*Statens offer lliga atredning in 197632 Industri-departmentet-Stockholm*) (1976).

mented in practice;¹⁵⁷ thus the reports demonstrate on paper how the job can be done so as to meet public concerns but do not necessarily embody a blueprint for how the Swedes will, in fact, proceed.

West Germany. West Germany has ten commercial nuclear power plants in operation and nineteen units under construction, on order, or under letter of intent.¹⁵⁸

Except for the fuel reprocessed at a small experimental reprocessing facility, the Federal Republic of Germany (FRG) has contracted with a subsidiary of the French Atomic Energy Commission for the reprocessing of spent fuel in France.¹⁵⁹ The FRG position has been that reprocessing is an essential precondition to effective disposal of radioactive wastes.¹⁶⁰ The FRG does not expect to have its first commercial reprocessing plant in operation until the late 1980's. It proposes to concentrate reprocessing, recycling and waste treatment, storage, and permanent disposal at Gorleben.¹⁶¹ Its plan is to solidify high-level waste and to permit it to cool for an interim period of several decades prior to permanent disposal in geologic formations. Local opposition at Gorleben has put these programs somewhat in doubt. As a result, the bulk of West German spent fuel is currently stored at reactor sites, with relatively modest quantities undergoing reprocessing in West Germany's pilot-scale facility or in France.

Waste processing technology in the FRG is being developed for treating high-level and alpha-contaminated, intermediate-level waste.¹⁶² The plan for high-level, liquid waste disposal involves spray calcination and vitrification.¹⁶³ It is interesting to note that the FRG already uses a salt mine located at Asse for the storage of low-level waste.¹⁶⁴ Disposal of high-level waste in salt beds and in an abandoned iron mine are under study.¹⁶⁵

Canada. Canada has eight commercial nuclear power plants in operation and twelve units under construction, on order, or under letter of intent.¹⁶⁶ Though Canada does not now recycle its spent fuel, but stores it in pools at reactor sites, its long-range plan is to convert to a

¹⁵⁷ See note 156 *supra*.

¹⁵⁸ Adopted and updated from *World List of Nuclear Power Plants*, note 40 *supra*.

¹⁵⁹ Appendix G, *supra* note 74, at G-7.

¹⁶⁰ *Id.*

¹⁶¹ *Id.*

¹⁶² *Id.* at G-8.

¹⁶³ *Id.*

¹⁶⁴ *Id.*

¹⁶⁵ K. HARMON, *supra* note 74, at 22.

¹⁶⁶ Adopted and updated from *WORLD LIST OF NUCLEAR POWER PLANTS*, note 40 *supra*.

plutonium recycling process.¹⁶⁷ In August of 1977, Canada's Department of Energy, Mines and Resources published a report by a group of outside experts, entitled "Management of Canada's Nuclear Wastes."¹⁶⁸ The report concluded that the prospects were good for the safe, permanent disposal of post-reprocessing wastes and irradiated fuel and that, once stored in carefully selected subterranean repositories, these wastes should present no danger.¹⁶⁹

The report further concluded that underground disposal in igneous rock would be safest, and that a centralized location should be available for all Canadian utilities to use.¹⁷⁰ The schedule for providing a licensed repository calls for site selection by 1981, construction of the demonstration facility by 1986, and commissioning of the repository by 2000.¹⁷¹ The report also found that spent fuel reprocessing is not necessary for safe disposal and that both spent fuel and reprocessing waste can be disposed of in the same repository.¹⁷²

U.S.S.R. The Soviet Union has twenty-nine nuclear power plants in operation with several more under construction.¹⁷³ It is reportedly building a commercial scale spent fuel reprocessing plant and a large-scale vitrification plant to be located near that facility.¹⁷⁴ The Soviets also have been experimenting with a two-stage fluidized bed calcination process for solidifying high-level waste.¹⁷⁵

Although the U.S.S.R. has conducted studies of underground disposal, its program apparently has focused on long-term *above-ground* storage of solidified high-level waste, an unusual approach when compared to those of other advanced nations.¹⁷⁶ Guiding principles for its underground disposal studies apparently are that the disposal site should adjoin the vitrification building, be above the water table, and be converted section by section to a "tomb" as the waste ages and heat generation decreases.¹⁷⁷

Developing Countries. However unfinished may be the nuclear waste management efforts of the United States, Western Europe, and

¹⁶⁷ K. HARMON, *supra* note 74, at 17.

¹⁶⁸ *Id.* at 4. See also Appendix G, *supra* note 74, at G-6.

¹⁶⁹ Appendix G, *supra* note 74, at G-6.

¹⁷⁰ *Id.*

¹⁷¹ K. HARMON, *supra* note 74, at 18.

¹⁷² *Id.* See also Appendix G, *supra* note 74, at G-5.

¹⁷³ Adopted and updated from *World List of Nuclear Power Plants*, note 40 *supra*.

¹⁷⁴ Appendix G, *supra* note 74, at G-10.

¹⁷⁵ *Id.*

¹⁷⁶ K. HARMON, *supra* note 74, at 35.

¹⁷⁷ *Id.* at 35-36.

Japan,¹⁷⁸ they far surpass those under way in the less developed nations with budding nuclear power programs where, it appears, this subject has received only the most limited consideration.¹⁷⁹ Two recent

¹⁷⁸ See text accompanying notes 74-177 *supra*.

¹⁷⁹ The following table indicates the status of nuclear power programs in less developed countries:

	<u>Megawatts^a</u>	<u>Status</u>
Argentina	319	operating
	<u>600</u>	7% constructed
Total	919	
Brazil	626*	80% constructed
	1245*	5% constructed
	<u>1245*</u>	ordered
Total	3116	
Egypt ^b	622*	ordered
India	200*	operating
	200*	operating
	202	operating
	202	99% constructed
	220	84% constructed
	220	62% constructed
	220	27% constructed
	<u>220</u>	17% constructed
Total	1684	
Iran ^c	1200*	10% constructed
	1200*	5 % constructed
	900*	0
	<u>900*</u>	0
Total	4200	
Korea	564*	operating
	605*	20% constructed
	900*	5% constructed
	900*	5% constructed
	<u>629</u>	43% constructed
Total	3598	
Mexico	654*	18.5% constructed
	<u>654*</u>	8.6% constructed
Total	1308	
Pakistan	125	operating
Philippines	620*	11% constructed
	<u>620*</u>	ordered
Total	1240	
Taiwan	604*	operating
	604*	98% constructed
	951*	61% constructed
	951*	38% constructed
	907*	6% constructed
	<u>907*</u>	6% constructed
Total	4924	

* Reactors marked with an asterisk are light water reactors (LWR's).

^a Each number in this column indicates the capacity of a separate nuclear power reactor unless denoted "Total."

surveys of waste disposal programs world-wide,¹⁸⁰ for example, contain no mention of activities to provide for the permanent disposal of high-level waste or spent fuel in Argentina, Brazil, Iran, Korea, Mexico, Pakistan, the Philippines, or Taiwan.¹⁸¹ India, which now has two reprocessing plants in operation, appears to be the only exception; that nation is now building a high-level waste solidification plant and has conducted a geologic survey for potential repository sites.¹⁸² Solidified high-level waste will be stored in air-cooled vaults in the interim.¹⁸³

One likely explanation as to why, apart from India, these developing nations have not turned their attention to nuclear waste disposal is that they have not perceived the problem as an immediate one. Most of these nations appear to have contemplated that their spent fuel would be reprocessed, either in domestic facilities (in some cases to be

^b Egypt's power plant, to have been purchased from the United States, is contingent upon the future negotiation of an agreement for cooperation between the parties.

^c Iran's ambitious nuclear power program initiated under the Shah, has been terminated by the new government of that nation. *See Iran Cancels Reactors Raising Doubt on Link to Enrichment Plant*, Wall St. J., Apr. 10, 1979, at 4, col. 3. Discussion of the Iranian nuclear program hereinafter refers to the period prior to this change of policy.

Source: *World List of Nuclear Power Plants*, note 40 *supra*.

¹⁸⁰ *See generally* K. HARMON note 74 *supra*; INTERNATIONAL ATOMIC ENERGY AGENCY, THE MANAGEMENT OF RADIOACTIVE WASTE (Mar. 1977) (Supp. Aug., 1978).

¹⁸¹ *See also The Brazilian Nuclear Program*, BRAZILIAN BULL., Jul., 1977, at 3; Concise Environmental Review, Philippines Nuclear Power Plant Unit 1, Memorandum for James R. Shea, Nuclear Regulatory Comm'n, from Louis V. Nosenzo, Deputy Ass't Sec'y of State, Bureau of Oceans and International Environmental and Scientific Affairs 3 (Sept. 28, 1979) ("Common to many countries, especially those at the early stages of nuclear power development, the Philippines has not yet developed any plans for the longer term handling of spent fuel beyond ten to thirteen year's storage capacity in the reactor spent fuel storage pool.").

With respect to the difficulties encountered by developing countries in ensuring the safety of nuclear power related activities, see Fitz, *Regulatory Problems in Developing Countries*, in INTERNATIONAL SYMPOSIUM OF PROBLEMS ASSOCIATED WITH THE EXPORT OF NUCLEAR POWER PLANTS (IAEA-SM-223/22) (Mar. 1978) [hereinafter cited as SYMPOSIUM]; Jacobs & Chung, *Regulatory Difficulties in a Developing Country*, in SYMPOSIUM (IAEA-SM-223/25); Rosen, *Critical Issues of Nuclear Power Plant Safety In Developing Countries*, 19 INT'L ATOM. ENERGY AGENCY BULL. 12 (1979); Rosen, *Upgrading the Safety Assessment of Exported Nuclear Power Plants*, in SYMPOSIUM (IAEA-SM-223/22); Sanchez-Gutierrez & Vallalva, *The Laguna Verde Nuclear Power Project: Problems Confronted by a Small Regulatory Body*, in SYMPOSIUM (IAEA-SM-223/14); *Problems of Exporting to Developing Countries*, NUCLEAR ENGINEERING INT'L 13 (May 1978). In general, these articles cite small regulatory staffs, restricted budgets, limited availability of technically trained personnel and organizational deficiencies as constraining the effectiveness of LDC nuclear power safety efforts. Such difficulties would presumably extend into the area of post-fission waste disposal. *See also* note 28 *supra*.

¹⁸² K. HARMON, *supra* note 74, at 26-27.

¹⁸³ INTERNATIONAL ATOMIC ENERGY AGENCY, note 180 *supra*.

constructed with the assistance of an industrialized nuclear supplier nation)¹⁸⁴ or, possibly in foreign countries such as the U.K. or France. In either case, the resulting high-level waste (which would most likely be returned to the country of origin by foreign reprocessors)¹⁸⁵ would not be available for final disposal for many years, perhaps not for a decade or more,¹⁸⁶ leaving considerable leeway to address the disposal problem at a future date.

A number of recent developments, however, suggest that the role of reprocessing in developing nations' nuclear fuel cycles is likely to be substantially reduced in comparison to earlier expectations. First, in part as a result of U.S. non-proliferation efforts aimed at discouraging the separation of weapons-usable plutonium from spent fuel through reprocessing, nuclear supplier nations have drastically curtailed their export of the technology necessary for many developing nations to construct domestic commercial-scale reprocessing plants. France has abandoned its sales of such technology to Korea and Pakistan, for example, apparently because of non-proliferation concerns.¹⁸⁷ West Germany's agreement to provide this technology to Brazil may never reach fruition because of major delays and possible cutbacks in Brazil's nuclear energy program.¹⁸⁸ France and West Germany have, moreover, specifically indicated that they do not intend to engage in further trans-

¹⁸⁴ Argentina, for example, announced in 1978 plans to construct an "experimental" reprocessing plant near Buenos Aires. K. HARMON, *supra* note 74, at 14. A laboratory scale facility for reprocessing research fuel has also operated there in the past. ENVIRONMENT AND NATURAL RESOURCES POLICY DIVISION, CONGRESSIONAL RESEARCH SERVICE, LIBRARY OF CONGRESS, 95TH CONG., 2D SESS., NUCLEAR PROLIFERATION FACTBOOK 202 (Comm. Print 1977) [hereinafter cited as NUCLEAR PROLIFERATION FACTBOOK]. Brazil has a pilot scale reprocessing plant under construction, with design and technical assistance provided by West Germany. K. HARMON, *supra* note 74, at 17. In the case of Iran, reprocessing of U.S.-exported fuel was, reportedly, a major issue in the negotiations between these countries on an agreement for cooperation. Korea and Pakistan had hoped to purchase reprocessing equipment from France, although these deals have fallen through. *French Withdrawal of Nuclear Gear Sale to Pakistan Spurs Promise of U.S. Aid*, Wall St. J., Aug. 25, 1978, at 15, col. 1; *South Korea Drops Plan to Buy Nuclear Power Plant From France*, N.Y. Times, Jan. 30, 1976, at 1, col. 2. As of 1976, Taiwan, had also begun construction of a laboratory scale reprocessing plant. NUCLEAR PROLIFERATION FACTBOOK, *supra* at 198 (Taiwan's reprocessing activities are now said to have ceased).

¹⁸⁵ See notes 313 and 316 *infra*.

¹⁸⁶ Japanese fuel shipped to the U.K. Windscale facility, for example will not be reprocessed for at least 10 years. *Nuclear Fuel Transfer Hearings*, *supra* note 17, at 122 (letter from Nelson Sievering to Congressman Clement Zablocki).

¹⁸⁷ Burnham, *South Korea Drops Plan to Buy a Nuclear Plant from France*, N.Y. Times, Jan. 30, 1976, at 1, col. 2; *French Withdrawal of Nuclear Gear Sale to Pakistan Spurs Promise of U.S. Aid*, note 184 *supra*.

¹⁸⁸ *Nuclebras Will Run Brazilian Program After Angra-2*, NUCLEONICS WK., May 31, 1979, at 5.

fers of this technology;¹⁸⁹ and more broadly, a number of suppliers, meeting as the London Suppliers Group, have subscribed to guidelines under which suppliers agree to "exercise restraint" in the sale of reprocessing technology.¹⁹⁰

Secondly, the United States has begun to exercise its controls over reprocessing of U.S.-exported nuclear fuel (contained in its agreements for nuclear cooperation) far more restrictively than in the past, again for the purpose of limiting the availability of plutonium to decrease proliferation risks.¹⁹¹ Although, these restrictions have principally affected those nations with relatively well-developed nuclear programs, i.e., those with significant accumulations of U.S.-origin spent fuel and

¹⁸⁹ France announced its decision in December, 1976, Germany in June, 1977. Nye, *Non-Proliferation: A Long-Term Strategy*, 56 FOREIGN AFF. 602, 613 (1978).

¹⁹⁰ In January 1978, following discussions among a small group of major nuclear supplier states which began in 1974, each of the governments of Belgium, Canada, Czechoslovakia, France, the Federal Republic of Germany, the German Democratic Republic, Italy, Japan, the Netherlands, Poland, Switzerland, the Soviet Union, the United Kingdom, and the United States informed the Director General of the IAEA, by individual letters, that when considering the export of nuclear material, equipment or technology, it will act in accordance with the principles contained in documents attached to its letter. The identical documents were attached in each case and consisted of "Guidelines for Nuclear Transfer" and its annexes. The letters from each government and the Guidelines, including annexes, were published in February 1978 in IAEA document INFCIRC/254.

The Guidelines of the Nuclear Suppliers Group provide that items on the trigger list developed by the suppliers should be transferred to a non-nuclear weapon state only when covered by IAEA safeguards (i.e., inspections and accounting reviews to verify that nuclear material has not been diverted to non-peaceful uses), and specify additional requirements, including: formal governmental assurances from recipients, explicitly excluding uses which would result in any nuclear explosive device; agreement by recipients to provide physical protection of specified levels to supplied items; specified provisions for relevant safeguards agreements; safeguards requirements applicable to facilities utilizing certain categories of technology which is transferred; controls on retransfer of supplied items; and restraint in the transfer of sensitive facilities, technology and materials. In addition, the Guidelines outline a number of supporting activities in which supplier governments should engage, including the promotion of international cooperation on physical protection, support of effective implementation of IAEA safeguards, and consultations with other suppliers generally and specifically, such as in the case of violation of understandings resulting from the Guidelines. REPORT OF THE PRESIDENT TO THE CONGRESS PURSUANT TO SECTION 601 OF THE NUCLEAR NON-PROLIFERATION ACT OF 1978 26-27 (Jan. 1979) (unpublished report on file with Senate Foreign Relations Comm.) [hereinafter cited as REPORT OF THE PRESIDENT].

¹⁹¹ See generally *Nuclear Fuel Transfer Hearings*, note 17 *supra*. The U.S. has exercised its prior approval controls over the reprocessing of U.S.-origin spent fuel to prevent Indian reprocessing of any spent fuel from the Tarapur reactors, which use only U.S.-supplied fuel. See Agreement for Cooperation in the Civil Uses of Atomic Energy, Aug. 8, 1963, United States-India, 14 U.S.T. 1484, T.I.A.S. No. 5446, art. II(E); Memorandum to Lee V. Gossick, Nuclear Regulatory Comm'n, from Peter Tarnoff, U.S. Dep't of State (March 6, 1978), reprinted in *Hearings on Nuclear Exports to India before the Subcomm. on Arms Control, Oceans and International Environment of the Senate Comm. on Foreign Relations*, 95th Cong., 2d Sess. 197, 200 (1978). The evolution of current U.S. reprocessing approval policy is discussed in the text accompanying notes 264-65 and 290-98 *infra*.

those with fully or partially constructed reprocessing plants, the U.S. policy would also extend to the developing nations noted above. Since the U.S. has been the chief supplier of nuclear fuels to many of these nations,¹⁹² U.S. controls in its agreements for cooperation barring reprocessing without U.S. permission will cover the bulk of spent fuel eventually produced in these countries as their nuclear programs progress. This suggests that the shift in U.S. policy away from reprocessing may well result in a redirection of plans these nations may have had for this activity.

Taken together, the curtailment of reprocessing technology trans-

¹⁹² As of 1977, the United States was the dominant supplier, in terms of outstanding contracts for the uranium enrichment services necessary to produce light water reactor fuels in the case of Brazil, Taiwan, Korea, the Philippines, Mexico, and Egypt (assuming Egypt and the U.S. enter into the necessary umbrella agreement on civil nuclear cooperation). The following table compares the quantity of U.S. and non-U.S. enrichment services contracted for by each of these nations in metric tons of separative work units (the measure of uranium enrichment output):

	<u>U.S.</u>	<u>non-U.S.</u>
Brazil	6,669	1,500 ^a
Egypt	532	0
Korea	3,800	0
Philippines	1,230	0
Mexico	1,994 ^b	0

^a Brazil also has an option to purchase 1,900 additional units.

^b U.S. sales of enriched uranium fuel are made pursuant to the U.S.-IAEA agreements, which do not contain provisions granting the U.S. prior approval rights over reprocessing of fuel provided thereunder. Agreement for the Cooperation in the Civil Uses of Atomic Energy, Aug. 7, 1959, 10 U.S.T. 1424, T.I.A.S. No. 4291, *amended*, 25 U.S.T. 1199, T.I.A.S. No. 7852 [hereinafter cited as U.S.-IAEA Agreement]. Pursuant to § 126.a(2) of the Atomic Energy Act, however, a renegotiation of the agreement between the U.S. and the IAEA to provide such control for the U.S. is now underway.

Source: NUCLEAR PROLIFERATION FACTBOOK, *supra* note 184, at 177-85.

Argentina's Canadian-style reactors are fueled with unenriched uranium not supplied by the U.S. and, accordingly U.S. reprocessing controls do not apply. Had Iran continued its nuclear program, the United States would have been a secondary nuclear fuel supplier (4,700 metric tons, separative work units *versus* 8,800 for non-U.S. suppliers according to 1977 contract data). Finally, although the U.S. has barred the reprocessing of spent fuel from the two Indian Tarapur reactors having a combined capacity of 400 megawatts, unenriched fuel discharged from India's remaining power reactors (either operating or under construction) which have a combined capacity of 1284 megawatts will not be subject to U.S. controls.

It may be noted that Canada possesses controls over the reprocessing of irradiated fuel produced by the use of its exports. *See, e.g.*, Agreement on the Peaceful Uses of Atomic Energy, Jan. 7, 1973, Canada-Iran, [1973] Can. T.S. No. 2, art. IV(2)(c). Canada has, in a note accompanying one of its agreements, indicated that it will not approve this activity if requested to do so by the other party. Agreement for Cooperation in the Development and Application of Atomic Energy for Peaceful Purposes, Jan. 26, 1976, Canada-Korea, [1976] Can. T.S. No. 11. France appears to have exercised similar controls in at least one instance. *See* Diplomatic Note accompanying draft Agreement for Cooperation on the Koeberg Nuclear Power Station, Stages I and II, Oct. 15, 1975, France-South Africa (reprocessing in South Africa of fuel irradiated in French-exported reactors prohibited). How, on a more general basis, these nations will exercise these controls and the impact on recipient reprocessing activities remains to be seen.

fers and restrictions over the reprocessing of U.S.-origin spent fuel suggest that spent fuel, itself, may ultimately come to be viewed in these developing countries as the material requiring final disposal. This, in turn, could necessitate the development of long-term disposal facilities on a more accelerated schedule than had been previously planned. Seen against this background, the current failure of these nations to initiate waste management research and development activities may have a greater short-term impact on their nuclear power programs than has been heretofore appreciated.

Multilateral Programs

The achievements of multilateral organizations in the field of nuclear waste disposal have been primarily in the areas of research and development and facilitation of disposal efforts for non-high-level wastes. Multilateral organizations have not, so far, set minimum standards or established deadlines for post-fission waste disposal. Some of the accomplishments of the multilateral organizations, both in the area of waste management and in other areas of nuclear activity, suggest that these organizations may be able to lead the world toward early demonstration of waste disposal technology and toward minimum standards for waste disposal accepted by all, or nearly all, the countries which use nuclear power.

International Atomic Energy Agency. The International Atomic Energy Agency (IAEA) is an autonomous international organization dedicated to the promotion of the use of atomic energy for peaceful purposes under a system of non-proliferation controls which it administers. Although loosely affiliated with the United Nations, the Agency, which now has one hundred and three member nations, operates pursuant to its own independent charter and is legally independent of the U.N.¹⁹³ The principal activities of the IAEA consist of providing technical assistance to member states, promoting the exchange of technical information pertaining to nuclear power, and implementing a program of inspections and related activities to verify that nuclear materials and facilities subject to these safeguards in member states are being used exclusively for peaceful purposes.¹⁹⁴

Over the years the Agency has conducted an active, though modestly funded, program concerning a broad range of nuclear waste treat-

¹⁹³ Established by the Statute of the International Atomic Energy Agency, *opened for signature* Oct. 26, 1956, 8 U.S.T. 1093, T.I.A.S. No. 3873.

¹⁹⁴ See, e.g., INTERNATIONAL ATOMIC ENERGY AGENCY, ANNUAL REPORT FOR 1977, GC (XXII)/597 (July 1978).

ment and disposal issues, including disposal of post-fission radioactive wastes.¹⁹⁵ The objective of the program has been, on the one hand, to evaluate, disseminate and promote the exchange of information on the technologies relating to this subject and, on the other, to develop specific codes and guides for application in member states on a voluntary basis.¹⁹⁶

In the areas of information exchange, the Agency over the past several years has sponsored a number of major symposia on the subject of waste management and has published numerous technical documents on such subjects as the safe handling, storage and movement of irradiated fuel, characteristics of solidified high-level waste and the safe handling of liquid high-level waste.¹⁹⁷

A major Agency activity at the present time is the formulation of guidelines, which will ultimately lead to the preparation of more specific Codes of Practice and Safety Guides¹⁹⁸ for the underground disposal of post-fission radioactive wastes, including the disposal of these materials in geologic formations.¹⁹⁹ The Agency also hopes to publish shortly guidelines on safety assessments for geologic disposal, licensing and approval procedures for geologic repositories, and guidelines regarding the investigation of repository sites for solidified high-level waste.²⁰⁰ The Agency will also be preparing guidelines and Codes of

¹⁹⁵ In fiscal year 1979, for example, the total budget for the sub-program "Treatment and Disposal of Radioactive Wastes" (including wastes in addition to post-fission wastes) was estimated to be about \$.7 million. *The Agency's Programme for 1979-84 and Budget for 1979*, INT'L ATOM. ENERGY AGENCY GC(XXII)/600 (Aug. 1978) [hereinafter cited as *Budget for 1979*]. The proposed budget for fiscal year 1980 includes \$1.4 million for this area. INTERNATIONAL ATOMIC ENERGY AGENCY, *THE AGENCY'S BUDGET FOR 1980*, GC(XXIII)/612, at 27. For a description of the activities of the Agency in the area of radioactive waste management from 1958 when these activities were initiated, see generally *Budget for 1979*, *supra* at 72-73. See also Nathanson, note 1 *supra*.

¹⁹⁶ *Budget for 1979*, *supra* note 195, at 72. In addition to its information exchange and standards development activities the IAEA has provided limited funds (generally \$150,000 to \$200,000 annually) for research and development in selected areas of radioactive waste management and environmental assessment, usually for coordinated research programs involving participation by member states. See K. HARMON, *supra* note 74, at 37.

¹⁹⁷ *Id.* at 73.

¹⁹⁸ IAEA Codes of Practice for nuclear power plants, for example, establish safety objectives and minimum requirements; Safety Guides recommend procedures for implementing the Codes of Practice. See Hendrie, *Securing Reactor Safety Objectives In the Nuclear Power Program Worldwide*, 17 ATOM. ENERGY L.J. 338, 355 (1975). Adoption of such documents by the Agency involves a complex series of steps to ensure that they reflect an international consensus on their respective subjects. *Id.* at 35-358. See also Ha Vinh, *IAEA Safety Standards, Their Legal Status and Implementation*, in EXPERIENCE AND TRENDS IN NUCLEAR LAW, IAEA LEGAL SERIES, No. 8, STI/PUB/333 (1972).

¹⁹⁹ *Budget for 1979*, *supra* note 195, at 73.

²⁰⁰ *Id.*

Practice regarding the storage of high-level liquid wastes produced from reprocessing and for the solidification of these materials.²⁰¹ The Agency currently has underway, as well, a review of the state of technology and the requirements for the preparation of spent fuel elements for direct long-term storage and/or disposal.²⁰²

As noted above,²⁰³ the Agency's Guides and Codes are promulgated for voluntary adherence by member states; the IAEA statute does not require adherence to these issuances as a condition of membership.²⁰⁴ The sole exception to this rule is in the case of projects sponsored by the Agency within member states for the construction of research or commercial-scale nuclear facilities.²⁰⁵ For these projects, the Agency's statute mandates that the Agency undertake a safety review encompassing, among other issues, the disposal of produced nuclear wastes, with the adequacy of safety measures to be judged against safety standards agreed to by the recipient state and the Agency.²⁰⁶ In practice, these have been the Agency's own safety standards.²⁰⁷

Nuclear Energy Agency (NEA). The NEA is a specialized agency

²⁰¹ *Id.*

²⁰² *Id.*

²⁰³ See text accompanying note 196 *supra*.

²⁰⁴ Notwithstanding their voluntary character, IAEA standards have been widely adopted among IAEA member states in many cases. The Agency's model Regulations for the Safe Transport of Radioactive Materials (Safety Series No. 6, 1973 revision), for example, have been adopted by regulators in some 70 nations. Telephone communication with Wendall Carriker, U.S. Dep't of Transportation. According to the Agency's Director General, Sigvard Eklund, "The international transport of nuclear fuel would be almost unthinkable without them." Eklund, *The International Atomic Energy Agency and Its Role in World-Wide Security of Nuclear Fuels and Facilities and Non-Proliferation*, 17 *ATOM. ENERGY L.J.* 322, 327 (1976). (The U.S. regulations codifying these standards are 10 C.F.R. §§ 71.1-71.64 (1979), 49 C.F.R. §§ 101.1-192.743 (1978)).

Similarly, guidelines published by the Agency for the protection of nuclear material against theft or sabotage, INFCIRC/225, *The Physical Protection of Nuclear Materials*, (1975, revised 1977), have been widely embraced. The major nuclear supplier nations, for example, have each agreed to require their export recipients to conform with the essential elements of INFCIRC/225 as a condition for receipt of exports. Communications Received From Certain Member States Regarding Guidelines for the Export of Nuclear Material, Facilities, or Technology, INFCIRC/254, Annex B (February 1978). See note 190 *supra*. Virtually all U.S. nuclear export recipient nations (including the EURATOM nations, Japan, Canada, South Korea, Spain, Sweden, Switzerland, the Philippines, Brazil, Argentina, Austria, Australia, Denmark, Norway, Turkey, Thailand, Yugoslavia, and Mexico) now apply these guidelines. Telephone communication with Robin Delabarre, U.S. Dep't of State. Pursuant to recommendations in these guidelines, an international convention on the physical protection of nuclear materials was concluded in Vienna on Oct. 6, 1979. It will be opened for signature on March 3, 1980. Letter from J. Bryan Atwood, Ass't Sec'y of State, to Senator Frank Church (Nov. 1, 1979).

²⁰⁵ See *id.*

²⁰⁶ See Ha Vinh, *supra* note 198, at 4. The Agency's role in performing safety reviews with respect to Agency projects is discussed below. See text accompanying notes 318-32 *infra*.

²⁰⁷ See Ha Vinh, *supra* note 198, at 5-6.

of the Organization for Economic Cooperation and Development (OECD) established to promote cooperation among the OECD countries for development and application of nuclear power for peaceful purposes through international research and development projects and exchange of scientific and technical experience and information.

In 1975, the NEA established a Radioactive Waste Management Committee (RWMC).²⁰⁸ Its purpose is to initiate, encourage and coordinate cooperative research and development activities in the field of radioactive waste management, particularly within NEA states.²⁰⁹ RWMC has held a series of meetings and established a number of permanent and ad hoc committees and study groups to deal with specific technical areas.²¹⁰ Current NEA waste management activities are focused on the definition of cooperative programs to develop geologic waste isolation technology.²¹¹ It assists in joint projects of waste disposal of its members. For example, it has coordinated a series of ocean dumps of low-level nuclear waste from certain European countries.²¹² First it coordinated the research by experts from the participating countries to assess the danger of the project. Then the NEA commissioned the ship to make the dumps and oversaw the picking up of the nuclear wastes at several European ports and the actual dumping.²¹³ The NEA has coordinated development of packaging and dumping standards as well.

Eurochemic. The Eurochemic Company is sponsored by a number of OECD/NEA countries.²¹⁴ From 1968 through 1974 it operated a reprocessing plant at Mol, Belgium, and is presently negotiating with Belgium for turnover of the plant to a Belgian company for modernization and future operation.²¹⁵ Eurochemic is obligated to convert the reprocessing waste from its current liquid form to solid form suitable for interim storage and has determined to use the French AVM

²⁰⁸ K. HARMON, *supra* note 74, at 39. OECD member states are Australia, Austria, Belgium, Canada, Denmark, Finland, France, the Federal Republic of Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand (special status), Norway, Portugal, Spain, Sweden, Switzerland, Turkey, and the United Kingdom.

²⁰⁹ *Id.*

²¹⁰ *Id.*

²¹¹ *Id.*

²¹² D. DEESE, *supra* note 1, at 51-52 (1978).

²¹³ *Id.*

²¹⁴ K. HARMON, *supra* note 74, at 39. Member states of Eurochemic are Austria, Belgium, Denmark, France, the Federal Republic of Germany, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and Turkey.

²¹⁵ *Id.*

(Marcoule)²¹⁶ vitrification process for solidification of the high-level liquid wastes. Apparently, Belgium will assume responsibility for disposal of the solidified waste.²¹⁷

Commission of European Communities (CEC). The European Coal and Steel Community (ECSC) was created in 1951 to pool the coal and steel production of the six member states.²¹⁸ In 1957, the European Economic Community (EEC) and the European Atomic Energy Community (Euratom) were formed by the same six members. In 1967, Euratom was merged into the EEC and its former activities are now under the CEC, which formulates and implements policy for the Community.²¹⁹

Included within CEC's mandate are formulation of nuclear safety standards and research and development of waste management technology. CEC's resources include a Joint Research Center with research facilities in Italy, Belgium, the Netherlands, and the FRG. A number of research and development programs are currently underway in disposal and storage of nuclear waste.²²⁰

A five year program of nuclear waste disposal research was begun by the CEC in June, 1975.²²¹ At present, the CEC has outstanding approximately fifty research contracts in the areas of processing, storage, and disposal of radioactive waste, and the separation and recycling of plutonium. The processing research includes projects on (1) coating medium-activity waste with plastic resin; (2) decontamination and conditioning of irradiated fuel element claddings; (3) incineration of plutonium-contaminated solid waste; and (4) comparative studies of the properties of various materials suitable for the immobilization of high-activity waste. The storage and disposal research has included projects on storage of solidified high-level waste in engineered structures and disposal of this material in geological formations.

In addition, the CEC program has awarded grants to study the legal, administrative, and financial problems of nuclear waste disposal. These include: (1) the review of problems posed by the management of radioactive waste which could not be solved under existing interna-

²¹⁶ AVM is the name of the waste vitrification process developed by France. See text accompanying notes 141-43 *supra*.

²¹⁷ K. HARMON, *supra* note 74, at 39.

²¹⁸ The original members of the ECSC were Belgium, France, Italy, Luxembourg, the Federal Republic of Germany, and the Netherlands.

²¹⁹ The current members of the CEC are Belgium, Denmark, France, the Federal Republic of Germany, Ireland, Italy, Luxembourg, the Netherlands, and the United Kingdom.

²²⁰ K. HARMON, *supra* note 74, at 38 (Table 7).

²²¹ *Id.* at 37.

tional, legal, administrative, and financial provisions; and (2) studies of the principles which should govern the management of radioactive waste.²²² The CEC has also been instrumental in fostering treaties on third-party liability and transborder pollution which are discussed below.²²³

Council for Mutual Economic Assistance (CMEA). The CMEA, which is the counterpart of the OECD for countries with centrally-controlled economies, has a standing commission concerned with the use of atomic energy for peaceful purposes.²²⁴ In 1971, the CMEA established a coordinating scientific and technical council (CSTC) which is mainly concerned with radioactive waste management and decontamination of equipment. It meets twice a year. The main task of CSTC is to promote multilateral cooperation, analyze the status and trends of development in radioactive waste management technology, recommend the main direction of research and development, examine the economic efficiency of putting technology into practice, and organize the exchange of experience and information.²²⁵ The CSTC has given a high priority to the development of safe disposal methods for radioactive wastes, especially into geologic formations.²²⁶ The environmental aspects of radioactive waste management are covered by a CSTC committee on radiation protection.²²⁷ Apparently, neither minimum disposal standards nor time tables for disposal have been established by CMEA. Compliance with its recommendations is voluntary.

*International Nuclear Fuel Cycle Evaluation.*²²⁸ In his April 7, 1977 speech articulating United States nuclear non-proliferation policy, President Carter announced a major U.S. initiative aimed at promoting international cooperation in the development of nuclear fuel cycle activities more "proliferation-resistant" than the traditional nuclear fuel cycle based on the reprocessing of reactor fuels and the separation of plutonium usable in weapons.²²⁹ Reduced to its essentials, the International Nuclear Fuel Cycle Evaluation (INFCE) is a two-year study undertaken jointly by a group of fifty-three nations and four international

²²² COMMISSION OF THE EUROPEAN COMMUNITIES, PROGRAMME OF RESEARCH AND DEVELOPMENT ON RADIOACTIVE WASTE MANAGEMENT AND STORAGE (Eur. 6128EN, 1978).

²²³ *Id.* See text accompanying notes 357-59 and 367 *infra*.

²²⁴ K. HARMON, *supra* note 74, at 41. Member states are Bulgaria, Cuba, Czechoslovakia, East Germany, Hungary, Mongolia, Poland, Rumania, the USSR, and Yugoslavia (special status).

²²⁵ *Id.*

²²⁶ *Id.*

²²⁷ *Id.*

²²⁸ The purpose and scope of the International Nuclear Fuel Cycle Evaluation (INFCE) are described in REPORT OF THE PRESIDENT, *supra* note 190, at 13-20.

²²⁹ *Id.* at 13.

organizations whose basic purpose is to evaluate current nuclear technologies and possible alternatives to them in an effort to assess their relative economies, practicability, state of development, and, most important, the relative ease with which they can be turned from their ostensible civilian purpose to the military objective of making nuclear weapons.²³⁰

The initiation of INFCE as an international endeavor took place in Washington in October 1977 at the INFCE Organization Conference. At that conference, participants agreed that the study would be divided into eight parts, each generally covering one aspect of the nuclear fuel cycle.²³¹ A working group, co-chaired by representatives of two or three governments and having membership from twenty or thirty countries, would be responsible for each area.²³² In addition, a technical coordinating committee composed of the representatives of the twenty-two co-chairman countries was established to integrate the overall effort.²³³ The coordinating committee was to report to the Plenary Conference of all INFCE participants at two different times, at roughly the mid-point in the evaluation and at the conclusion of the study.²³⁴

Two of the eight working groups are of particular relevance to the subject here at issue: Working Group 6, Spent Fuel Storage, and Working Group 7, Waste Management and Disposal. The Spent Fuel Storage Working Group is focusing on short and intermediate storage options for spent fuel from various types of reactors as an alternative to immediate reprocessing of these materials.²³⁵ The working group on Waste Management and Disposal is studying the disposal of separated wastes from spent fuel reprocessing and the disposal of unprocessed spent fuel as a waste form.²³⁶ Specific differences in proliferation risk and safeguards, as well as environmental, technical, economic, and safety aspects, are being analyzed. One topic identified for particular treatment by both working groups is the "special needs of the develop-

²³⁰ *Id.* at 13-20.

²³¹ *Id.* at 15.

²³² *Id.* The eight Working Groups are: (1) fuel and heavy water availability, (2) enrichment availability, (3) assurance of long-term supply of technology, fuel, and heavy water and services in the interest of national needs consistent with "non-proliferation goals," (4) reprocessing, plutonium handling, recycling, (5) fast breeders, (6) spent fuel storage, (7) waste management and disposal, and (8) advanced fuel cycle and reactor concepts. *Id.* at 15-18.

²³³ *Id.*

²³⁴ *Id.*

²³⁵ *Id.* at 17.

²³⁶ *Id.*

ing countries.”²³⁷

Although the INFCE working groups have met several times since the beginning of the evaluation, the papers exchanged at these meetings and the views of the various working group participants have been kept confidential, undoubtedly to permit the free exchange of ideas and the emergence of the fullest degree of consensus.²³⁸ Thus, it is not possible at this writing to state whether the working groups concerned with spent fuel management and disposal will be able to establish any agreement on these topics which might serve as the basis for international norms in the future. According to press reports, one likely result is that agreement on certain very basic principles will be reached, such as the notion that there are no scientific or technological reasons why spent fuel cannot be disposed of directly on a permanent basis, and that accordingly, reprocessing is not a mandatory requirement for a safe nuclear waste disposal program.²³⁹

Given the terms of reference of the evaluation, however, it is unlikely that the INFCE endeavor will go beyond this to consider international guidelines in the area of nuclear waste storage or disposal, even those to which adherence would be entirely voluntary. Such an outcome appears to have been ruled out by the terms of the Final Communique of the Organizing Conference of INFCE which stated:

The participants agreed that INFCE was to be a technical and analytical study and not a negotiation. The results will be transmitted to governments for their consideration in developing their nuclear energy policies and in international discussions concerning nuclear energy cooperation and related controls and safeguards. Participants would not be committed to INFCE's results.

The evaluation will be carried out in a spirit of objectivity, with mutual respect for each country's choices and decisions in this field, without jeopardizing their respective fuel cycle policies or international cooperation, agreements, and contracts for the peaceful use of nuclear energy, provided that agreed safeguards measures are applied.²⁴⁰

Similarly, it is not possible to predict how INFCE will address the nuclear waste management concerns of developing nations.

Multinational Facilities for Post-Fission Waste Management. In the course of the past two years, a number of preliminary proposals have emerged for establishing international facilities for the storage of spent

²³⁷ *Id.*, app. A, at 5-6.

²³⁸ Conversation with George Rathjens, U.S. Dep't of State (Oct. 9, 1979).

²³⁹ *Spent Fuel Is Last, Working Group Seven Says*, NUCLEAR FUEL, Sept. 3, 1979, at 10.

²⁴⁰ *Final Communique of the Organizing Conference of the International Nuclear Fuel Cycle Evaluation*, Oct. 21, 1977, reprinted in REPORT OF THE PRESIDENT, *supra* note 190, app. A, at 2.

nuclear fuel or separated plutonium.²⁴¹ Generally speaking, the underlying motive for the development of such proposals has been the desire to reduce the risk of nuclear weapons proliferation which could be posed by the widespread future availability of separated plutonium.²⁴²

International spent fuel storage would provide a means for nations to reduce accumulations of this material at reactor sites. Since, today, the principal alternative means for accomplishing this result is reprocessing the spent fuel, either domestically or in the U.K. or France, an international spent fuel storage regime could ease near-term pressures to expand reprocessing activities in additional nations and the concomitant accumulation of separated plutonium.²⁴³ If at a future date, following, for example, the development of new technologies for reducing plutonium's proliferation risk, reprocessing were to become more acceptable, spent fuel could be released for reprocessing; or it could be disposed of permanently pursuant to agreement of the parties involved.²⁴⁴

Under the international plutonium storage concept, reprocessing would not necessarily be restricted; but after plutonium was separated through this activity, it would be transferred to a facility operated under international auspices. Retention in an international, as compared to a national, facility would reduce the risk of the plutonium being misappropriated for military purposes.²⁴⁵ Plutonium would be released from the international storage facility for specified civilian

²⁴¹ See, e.g., INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL MANAGEMENT AND STORAGE OF PLUTONIUM AND SPENT FUEL (DRAFT) (1978) (draft not publicly released) (*reported in IAEA Will Tackle Plutonium Storage and Management at December Meeting*, Energy Daily, Nov. 7, 1978, at 3). Working Group 6 of INFCE has also focused on international mechanisms for spent fuel storage. See text accompanying notes 234-39 *supra*. Its report will apparently identify a number of requirements for successful implementation of any such arrangement. See *Working Group 6 Faults Limits on Choice*, NUCLEAR FUEL, September 3, 1979, at 9. A third proposal is the U.S. initiative to examine the use of isolated Pacific islands as international storage sites for spent fuel from Pacific Basin countries. *Hearings on S. 1119 before the Senate Comm. on Energy and Natural Resources*, 96th Cong., 1st Sess. (1979) (testimony of Thomas R. Pickering, Ass't Sec. for Oceans and Int'l Environment and Scientific Affairs, U.S. Dep't of State) [hereinafter cited as *Pickering Pacific Isle Storage Testimony*]. See also Nuclear Non-Proliferation Act of 1978, Pub. L. No. 95-242, 92 Stat. 120 (1978) (codified in scattered sections of 22, 42 U.S.C.); Doub & Weiss, *International Nuclear Development in the Age of Interdependence*, 32 VAND. L. REV. 843, 879-85 (1979).

²⁴² See, e.g., *Pickering Pacific Isle Storage Testimony*, note 241 *supra*.

²⁴³ *Id.*

²⁴⁴ *Id.* Establishing agreed upon guidelines for the subsequent disposition of spent fuel is likely to be one of the more controversial aspects of this proposal. See *IAEA Will Tackle Plutonium Storage and Management at December Meeting*, note 241 *supra*. See also *Working Group 6 Faults Limits on Choice*, note 241 *supra*.

²⁴⁵ See, e.g., Doub & Weiss, *supra* note 241, at 859.

uses under strict controls which would provide added assurance that the material was not being diverted to weapons uses.²⁴⁶

Article XII(A)(5) of the International Atomic Energy Agency Statute contemplates the development of a plutonium storage regime supervised by the IAEA,²⁴⁷ and, during 1978, the Agency developed a preliminary report on this and the international spent fuel storage concepts.²⁴⁸ Discussions on these proposals were held during December, 1978, involving twenty-one countries,²⁴⁹ with the international plutonium storage concept apparently gaining wider support than the comparable regime for spent fuel.²⁵⁰ The United States, which has tended to favor the latter alternative,²⁵¹ has since assisted the IAEA in organizing a second meeting of experts, in November 1979, to address this option.²⁵² Further discussions are anticipated. Both alternatives, it may be noted, have also received considerable attention in the course of the International Nuclear Fuel Cycle Evaluation.²⁵³ Because of their many institutional, financial, legal, and political complexities,

²⁴⁶ Nuclear Non-Proliferation Act, 42 U.S.C.A. § 2153 (1978). See also Doub & Weiss, *supra* note 241, at 858, 861 n.88.

²⁴⁷ Article XII(A) of the IAEA Statute provides that in conjunction with the Agency's application of safeguards it shall have the right:

To approve the means to be used for the chemical processing of irradiated materials solely to ensure that this chemical processing will not lend itself to diversion of materials for military purposes and will comply with applicable health and safety standards; to require that special fissionable materials [e.g., plutonium] recovered or produced as a by-product be used for peaceful purposes under continuing Agency safeguards for research or in reactors, existing or under construction, specified by the member or members concerned; and to require deposit with the Agency of any excess of any special fissionable materials recovered or produced as a by-product over what is needed for the above-stated uses in order to prevent stockpiling of these materials, provided that thereafter at the request of the member or members concerned special fissionable materials so deposited with the Agency shall be returned promptly to the member or members concerned for use under the same provisions as stated above.

Statute of the International Atomic Energy Agency, art. XII (A)(5), *opened for signature* Oct. 26, 1956, 8 U.S.T. 1093, T.I.A.S. No. 3873.

²⁴⁸ According to press reports, the IAEA document provides estimates of the amount of spent fuel and plutonium likely to be produced through the year 2000 (25 metric tons of plutonium already separated by IAEA members, excluding eastern bloc countries; 250 metric tons estimated to be separated by 1990; 850 tons, by 2000). It also estimates the cost of spent fuel and plutonium storage (\$140-\$280 million to store 5000 metric tons of spent fuel versus \$8 million to store the 30 metric tons of plutonium this amount of fuel would yield) and notes the major issues associated with establishing workable storage arrangements (for spent fuel, identifying a host country and avoiding the risk that interim storage might become indefinite storage; for plutonium, how to safeguard plutonium stores against forcible seizure and what rules should govern release of stored plutonium). *IAEA Will Tackle Plutonium Storage and Management at December Meeting*, *supra* note 241, at 3.

²⁴⁹ *International Plutonium Storage Gets Big Boost*, Energy Daily, Dec. 12, 1978, at 4.

²⁵⁰ *Id.*

²⁵¹ *Pickering Pacific Isle Storage Testimony*, *supra* note 241, at 12.

²⁵² Conversation with Thomas Pickering, U.S. Dep't of State (Nov. 20, 1979).

²⁵³ See *Pickering Pacific Isle Storage Testimony*, *supra* note 241, at 11.

however, these international storage regime concepts will undoubtedly be many years in developing.

As generally conceived, it may be noted, neither international spent fuel nor plutonium storage options specifically address the ultimate disposal of post-fission wastes.²⁵⁴ Spent fuel storage regimes are usually described as interim measures whose purpose, in part, is to defer—rather than to resolve—decisions on reprocessing or other disposition of spent fuel.²⁵⁵ Indeed, one serious drawback to the international spent fuel storage concept is that any nation which accepted foreign spent fuel on an “interim” basis might find itself being used as a *de facto* nuclear waste dump indefinitely.²⁵⁶ Similarly, international plutonium storage by definition is concerned with only one of the end products of reprocessing, plutonium;²⁵⁷ presumably arrangements for dealing with the high-level liquid waste “product” from reprocessing would be unaffected, and the matter would be left to reprocessors and their customers, much as is the case today.

Even if these storage programs do not themselves address the problem of permanent post-fission waste disposal, international cooperation in developing such joint storage regimes may well “spill over” and foster cooperation in the latter area. This would seem especially likely in the case of international spent fuel storage, where the host nation would have a strong interest in developing mutually satisfactory arrangements with other participants on the later treatment of stored spent fuel. Indeed, according to press reports, INFCE Working Group 6 will recommend in its report on international spent fuel storage regimes that advance agreement on such subsequent disposal arrangements be a requirement for any international spent fuel storage program.²⁵⁸ This suggests that negotiations on such programs may ultimately play an important role in developing an international consensus on permanent post-fission waste disposal practices.

CONDITIONS IMPOSED BY EXPORTERS

Nations exporting nuclear fuel and power plant equipment have expanded the international dimension of the post-fission waste hazard. While seemingly in a strong position to influence the disposal practices

²⁵⁴ Cf. text accompanying notes 59-60 *supra* (discussing solidification and permanent burial of nuclear waste).

²⁵⁵ See, e.g., *Pickering Pacific Isle Storage Testimony*, *supra* note 241, at 21.

²⁵⁶ This drawback is apparently noted in the IAEA report on international spent fuel storage. *IAEA Will Tackle Plutonium Storage and Management at December Meeting*, note 241 *supra*.

²⁵⁷ See text accompanying notes 59-61 *supra*.

²⁵⁸ *Working Group 6 Faults Limits on Choice*, note 241 *supra*.

of their export recipients, these nuclear supplier nations have, in practice, declined to involve themselves actively in this facet of their customers' nuclear programs.

United States Practices

Until the relatively recent non-proliferation initiatives of the Carter Administration²⁵⁹ and the Nuclear Non-Proliferation Act of 1978²⁶⁰ aimed at discouraging the availability of separated plutonium under national control, the U.S. largely viewed disposal of post-fission wastes produced from its exports as a domestic health and safety concern of its export recipients, to be addressed by these sovereign governments as they saw fit, without interference or active guidance from the United States.²⁶¹ Controlling U.S. law, policy, and international agree-

²⁵⁹ See text accompanying notes 280-305 *infra*.

²⁶⁰ Nuclear Non-Proliferation Act of 1978, Pub. L. No. 95-242, 92 Stat. 120 (1978) (codified in scattered sections of 22, 42 U.S.C.).

²⁶¹ This policy with respect to post-fission wastes does not appear to have been formally announced, but to have evolved from the overall U.S. policy of non-interference in export recipients' management of the health, safety and environmental aspects of nuclear reactors and fuel imported from the United States. The basis for this broader policy was set forth in two opinions of the Nuclear Regulatory Commission. *Edlow Int'l Co.*, 3 Dec. Nuc. Reg. Comm'n 563, [1975-1978 Transfer Binder] NUC. REG. REP. (CCH) ¶ 30,069 (May 7, 1976), *aff'd on other grounds sub nom. Natural Resources Defense Council v. NRC*, 580 F.2d 698 (D.C. Cir. 1978) (per curiam), and *Babcock & Wilcox*, 5 Dec. Nuc. Reg. Comm'n 1332, [1975-1978 Transfer Binder] NUC. REG. REP. (CCH) ¶ 30,205 (June 27, 1977). In the former case, concerning a nuclear fuel export license for the U.S.-supplied reactors at Tarapur, India, the Commission ruled that the provisions of the Atomic Energy Act requiring the Commission to consider the "public health and safety" in granting certain licenses did not require that the Commission, in the context of reviewing nuclear export licenses, consider any foreign health and safety impacts which might result from such exports. *Edlow Int'l Co.*, 3 Dec. Nuc. Reg. Comm'n at 574, 582-83; [1975-1978 Transfer Binder] NUC. REG. REP. (CCH) ¶¶ 30,069.06, 30,069.10, at 27,394-95. Among other factors weighed by the Commission in interpreting its mandate in this area, the Commission noted that with respect to the health effects experienced in the vicinity of Tarapur "it would be extraordinary, as a matter of international law, to conclude that we had authority to address ourselves to, or to attempt to regulate, matters so clearly domestic to the Indian nation and within the purview of its own regulatory responsibilities." *Id.* at 582, [1975-1978 Transfer Binder] NUC. REG. REP. (CCH) at ¶ 30,069.10. The Commission also stressed that exclusion of such foreign health and safety impacts from nuclear export licensing decisions had long been the publicly declared practice of the NRC and its predecessor, the Atomic Energy Commission (whose export licensing functions had been transferred to the NRC on January 19, 1975, under the Energy Reorganization Act, 42 U.S.C. §§ 5801, 5841(f) (1976)), a practice at least tacitly approved by the Congress. *Id.*

In the *Babcock & Wilcox* case, which concerned the export of a nuclear reactor to West Germany, the Commission determined that the provisions of the National Environmental Policy Act, 42 U.S.C. § 4321 (1976), did not require the Commission to prepare an environmental impact statement on the proposed export examining its site-specific environmental impacts within West Germany. Again, the Commission gave considerable weight in interpreting the statute to the inappropriateness, under general principles of international law, of the United States' interfering in exclusively domestic matters confined to West Germany and subject to that nation's health,

ments²⁶² were essentially silent on the matter, leaving U.S. export re-

safety and environmental regulation. Babcock & Wilcox, 5 Dec. Nuc. Reg. Comm'n at 1343-46, [1975-1978 Transfer Binder] NUC. REG. REP. (CCH) at ¶ 30,205.08.

²⁶² Prior to the passage of the Non-Proliferation Act, U.S. nuclear exports were governed by the Atomic Energy Act of 1954, 42 U.S.C. § 2011 (1976), and additionally, after January 19, 1975, by the Energy Reorganization Act of 1974, 42 U.S.C. § 5801 (1976). The latter act abolished the Atomic Energy Commission and, *inter alia*, created the Nuclear Regulatory Commission, to which it transferred the AEC's export licensing functions; however, the substantive provisions of the Atomic Energy Act continued in force, governing the NRC's nuclear export licensing decisions.

Briefly summarized, the Atomic Energy Act established two preconditions for the commercial export of nuclear reactors and fuel from the United States. See 42 U.S.C. §§ 2074, 2077, 2133, 2153, 2094 (1976). First, the Act required that all exports be pursuant to an agreement for cooperation between the U.S. and the export-recipient country setting forth the overall framework for such exports and specifically precluding recipients from using any export for atomic weapons or any other military purpose. (Although these agreements contain numerous restrictions in addition to those expressly required by the Atomic Energy Act, none of these address the disposal of post-fission waste produced from U.S. exports. *But see* text accompanying notes 264-65 *infra*.) See generally CONGRESSIONAL RESEARCH SERVICE, LIBRARY OF CONGRESS, 96TH CONG., 2D SESS., UNITED STATES AGREEMENTS FOR COOPERATION IN ATOMIC ENERGY: AN ANALYSIS (Comm. Print 1976); ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION, FINAL ENVIRONMENTAL IMPACT STATEMENT, U.S. NUCLEAR POWER EXPORT ACTIVITIES ch. 3 (ERDA-1542) (1976); Brush, *The Current and Future Role of Agreements for Cooperation as the Framework for International Nuclear Commerce*, 18 ATOM. ENERGY L.J. 103 (1976).

Second, the Act required that commercial exports of nuclear equipment and material be licensed, with approval to be granted only if issuance of the license would not be inimical to the common defense and security or to the health and safety of the United States' public. See generally Transnuclear, Inc., 6 Dec. Nuc. Reg. Comm'n 719, [1975-1978 Transfer Binder] NUC. REG. REP. (CCH) ¶ 30,247 (Nov. 10, 1977); Edlow Int'l Co., 5 Dec. Nuc. Reg. Comm'n 1358, [1975-1978 Transfer Binder] NUC. REG. REP. (CCH) ¶ 30,206 (June 28, 1977); Babcock & Wilcox, 5 Dec. Nuc. Reg. Comm'n 1332, [1975-1978 Transfer Binder] NUC. REG. REP. (CCH) ¶ 30,205 (June 27, 1977). These standards conferred considerable discretion on export licensing authorities; as noted above, however, in ruling on export licenses neither the AEC nor the NRC examined health and safety impacts of proposed exports abroad. The NRC has recently taken the position in litigation that in some circumstances the common defense and security standard (which has remained in force even after the changes in U.S. nuclear export licensing standards wrought by the 1978 Non-Proliferation Act) may necessitate scrutiny of such foreign health and safety considerations. See Defendants' Points and Authorities in Support of Their Motion to Dismiss, at 26-29, Westinghouse Elec. Corp. v. Hendrie, 2 Nuc. Reg. REP. (CCH) ¶ 20,125 (No. 79-2060, D.D.C. 1979). (All U.S. power reactor exports and all but a small fraction of U.S. nuclear equipment and material exports have been made on a private commercial basis. The remainder have been transferred directly by the U.S. government, pursuant to similar export criteria. Telephone communication with the Office of International Programs, Nuclear Regulatory Commission (Dec. 21, 1979). See 42 U.S.C. §§ 2051, 2071, 2077, 2112 (1976). The authority to make such direct transfers was considerably restricted by the 1978 Nuclear Non-Proliferation Act. 42 U.S.C.A. § 2074d, 2094, 2111, 2141 (Supp. I 1978).)

Procedurally, during the period of the AEC's authority, that agency had responsibility not only for export licensing actions themselves, but also to a preponderant degree for the development of overall U.S. nuclear export policy. Inasmuch as only the former functions were expressly transferred to the NRC, that Commission soon after its inception developed formal arrangements for consulting with concerned Executive Branch agencies, including the Department of State, the Arms Control and Disarmament Agency, and the Energy Research and Development Administration (which succeeded to the non-regulatory functions of the Atomic Energy Commission under the 1974 Energy Reorganization Act, 42 U.S.C. §§ 5801, 5814 (1976)). See, e.g., Babcock &

cipients virtually complete discretion in developing—or in deferring the development of—technologies, standards, and timetables for post-fission waste disposal programs. Indeed, the Energy Research & Development Administration's environmental impact statement on U.S. nuclear power export activities, prepared in 1976, expressly excludes consideration of the impacts of long-term disposal of the wastes produced from these exports in export-recipient nations, a clear reflection of the U.S. *laissez-faire* approach to the issue at the time.²⁶³

U.S. agreements for nuclear cooperation now in force (with two exceptions)—all of which were entered into prior to 1975—did, in fact, provide a mechanism for active U.S. involvement in one phase of the export recipients' nuclear waste management decision-making by granting the United States a right of prior approval over the reprocessing of U.S.-origin spent fuel.²⁶⁴ Prior to the emergence of the new

Wilcox, 5 Dec. Nuc. Reg. Comm'n 1332, [1975-1978 Transfer Binder] NUC. REG. REP. (CCH) ¶ 30,205 (June 27, 1977); Westinghouse Elec. Corp., 3 Dec. Nuc. Reg. Comm'n 739, [1975-1978 Transfer Binder] NUC. REG. REP. (CCH) ¶ 30,080 (June 21, 1976); Edlow Int'l Co., 3 Dec. Nuc. Reg. Comm'n 563, [1975-1978 Transfer Binder] NUC. REG. REP. (CCH) ¶ 30,069 (May 7, 1976), *aff'd on other grounds sub nom.* Natural Resources Defense Council v. NRC, 580 F.2d 698 (D.C. Cir. 1978) (per curiam). See generally Weiss, *The Role of the NRC in Export Licensing*, 18 ATOM. ENERGY L.J. 85 (1976). These consultative arrangements were codified with some modifications in the Nuclear Non-Proliferation Act of 1978, 42 U.S.C.A. § 2155 (Supp. I 1978).

²⁶³ ENERGY RESEARCH & DEVELOPMENT ADMINISTRATION, *supra* note 262, at ii-iii, 2-11, 14-11.

²⁶⁴ The U.S. has agreements for cooperation in the peaceful uses of nuclear energy currently in force with the following: Argentina, Australia, Austria, Brazil, Canada, Finland, India, Indonesia, Iran, Japan, South Korea, Norway, the Philippines, Portugal, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, Venezuela, EURATOM, and the IAEA. See 3 REPORT OF THE PRESIDENT, note 190 *supra* (compiling current texts of all agreements). See also CONGRESSIONAL RESEARCH SERVICE, note 262 *supra*; ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION, *supra* note 262, 3-91 to 3-124.

This approval right, though not mandated by the Atomic Energy Act, was included in all U.S. agreements for cooperation, except the U.S.-IAEA Agreement, note 192 *supra*, and that with EURATOM. Additional Agreement for Cooperation Concerning the Peaceful Uses of Atomic Energy, June 11, 1960, United States-European Atomic Energy Community, 11 U.S.T. 2589, T.I.A.S. No. 4650, *as amended* May 21 and 22, 1962, 13 U.S.T. 1439, T.I.A.S. No. 5104, Aug. 22 and 27, 1963, 14 U.S.T. 1459, T.I.A.S. No. 5444, Sept. 20, 1972, 24 U.S.T. 472, T.I.A.S. No. 7566. See also CONGRESSIONAL RESEARCH SERVICE, *supra* note 262, at 11, 61B (Comm. Print 1976); HOUSE COMM. ON INT'L RELATIONS, NUCLEAR ANTIPROLIFERATION ACT OF 1977, H.R. REP. NO. 95-587, 95th Cong., 1st Sess. 13-14 (1977), *reprinted in* SENATE COMM. ON GOVERNMENTAL AFFAIRS, 96TH CONG., 1ST SESS., LEGISLATIVE HISTORY OF THE NUCLEAR NONPROLIFERATION ACT OF 1978 426-27 (1979).

It may be noted that early U.S. agreements for cooperation signed between 1957 and 1970 (only a few of which are currently in force) provided for the reprocessing of U.S.-origin spent fuel in U.S. facilities, either mandatorially or at the option of the United States, and apparently contemplated that the United States would retain the resulting wastes. See, e.g., Agreement for Cooperation in the Peaceful Uses of Atomic Energy, *as amended* May 21 and 22, 1962, United States EURATOM 13 U.S.T. 2589, T.I.A.S. No. 4650, arts. III(E), III(G); ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION, *supra* note 262, at 14-5. To date, the United States has not

U.S. non-proliferation strategy, however, these approval rights were not exercised to encourage any particular approach to post-fission waste management. In practice, through mid-1976, individual export recipient nations initiated reprocessing approval requests as, in their view, the need arose. These requests, after review by low-level officials within the U.S. government, were routinely approved upon verification that the elementary non-proliferation controls specified in the relevant agreement for cooperation would apply to the transaction.²⁶⁵ If the reprocessing were being performed in a third country, the U.S. thereafter retained prior approval controls over the subsequent disposition of the resulting plutonium by virtue of its agreement for cooperation with that nation. However, regardless of where the reprocessing was to take place, disposal of the separated high-level wastes from the reprocessing was a matter left to the other nation or nations involved in the transaction.

Although the U.S. refrained in its bilateral nuclear trade relations from actively encouraging the development of particular waste disposal

reprocessed any foreign power reactor fuel, whether under the earlier agreements or otherwise, nor since 1970 has it been U.S. policy to offer reprocessing services for foreign power reactor fuel. Telephone conversation with DOE Office of Congressional Affairs (Sept. 1979); ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION, *supra* note 262, at 14-5. DOE and its predecessors have, however, reprocessed some 1.1 metric tons of spent United States-origin research reactor fuel and have retained the wastes produced from this activity. These wastes, commingled with liquid wastes from DOE's reprocessing activities for the U.S. nuclear weapons program, are now stored in liquid form at the DOE Savannah River facility. Telephone conversation with DOE Office of Congressional Affairs (Sept. 1979).

²⁶⁵ The rank of AEC officials scrutinizing these approvals was verified with officials of the Department of Energy (the successor to these AEC functions under the Energy Reorganization Act, 42 U.S.C. §§ 5801, 5814 (1976)) familiar with these AEC practices. These officials also verified that the non-proliferation controls imposed were typically that the safeguards of the International Atomic Energy Agency against diversion of nuclear materials to military purposes would be applied to the reprocessing activity and to any separated plutonium, as appropriate, and, if transfers of spent nuclear fuel to another nation for reprocessing were involved, that the transferred material and any resulting separated plutonium be subject to an agreement for cooperation between the receiving nation and the United States.

As a result of increased U.S. concerns over the connection between the availability of separated plutonium and the possible proliferation of nuclear weapons after mid-1976, see text accompanying notes 271-80 *infra*, U.S. controls over reprocessing by its export recipients were gradually tightened and reprocessing approval requests began to receive attention from more senior U.S. officials. During 1977, for example, the U.S. limited approvals to those cases where (1) reprocessing would take place in the U.K. or France (nations which already possessed nuclear weapons), (2) U.S. controls over the subsequent disposition of the spent fuel to be reprocessed and/or over any separated plutonium were clear, and (3) a near-term need for the requested reprocessing existed owing to limitations on spent fuel storage space. See Letter from Joseph S. Nye to Clement J. Zablocki (Jan. 25, 1978), reprinted in SENATE COMM. ON GOV'TAL AFFAIRS, 96TH CONG., 1ST SESS., LEGISLATIVE HISTORY OF THE NUCLEAR NONPROLIFERATION ACT OF 1978, at 894 (1979). Subsequent U.S. law and policy governing U.S. reprocessing approvals are discussed in the text accompanying notes 275, 288-89 and 291-302 *infra*.

programs, the U.S. during the pre-1976 period did engage in a number of research and development projects with other nations in the field of radioactive waste disposal and lent its support to the activities of the International Atomic Energy Agency in this and other nuclear safety and environmental protection areas.²⁶⁶ During this period, too, the U.S. ratified the London Convention²⁶⁷ and the Antarctic Treaty,²⁶⁸ both of which contain prohibitions on certain nuclear waste disposal practices.²⁶⁹ Through these cooperative and multilateral efforts, the U.S. was broadly encouraging responsible disposal of post-fission nuclear wastes, notwithstanding its hands-off policy with respect to the nuclear waste disposal programs of its individual nuclear export recipients.

Beginning in mid-1976, however, U.S. policy makers became increasingly concerned over the risk that nations might acquire nuclear weapons by appropriating stocks of separated plutonium accumulated for ostensibly peaceful uses.²⁷⁰ As discussed below, this has led to a

²⁶⁶ U.S. agreements providing for cooperation in the area of post-fission waste management signed prior to 1975 include: Technical Exchange Arrangement on Radioactive Waste Management between the United States Atomic Energy Commission and the European Company for the Chemical Processing of Irradiated Fuels [Eurochemic], (Jan. 31, 1973) (provides for cooperation in the "field of radioactive waste management" but appears to be focused exclusively on the provision of U.S. assistance in the area of high-level waste solidification); Technical Exchange and Cooperative Agreement between the United States Atomic Energy Commission and the Federal Ministry for Research and Technology of the Federal Republic of Germany in the Field of Management of Radioactive Wastes (Dec. 20, 1974) (provides *inter alia* for cooperation regarding the disposal of radioactive wastes in salt deposits; retrievable surface storage facilities; waste solidification). K. HARMON, note 1 *supra*.

The United States has entered into a number of additional agreements for cooperation in this sphere since 1975: Agreement between the United States Energy Research and Development Administration and the United Kingdom Atomic Energy Authority for Cooperation Concerning Liquid-Metal-Cooled Fast Breeder Reactors, September 20, 1976, as amended October 6, 1977 (amendment extends coverage of agreement to include cooperation in the areas of solidification of high-level liquid wastes, interim storage of such materials in liquid form, and retrievable and permanent radioactive waste disposal); Memorandum of Understanding—Arrangement Between the United States Energy Research and Development Administration and Atomic Energy of Canada, Ltd., Relating to Information in the Nuclear Field, Annex 1 (Sept. 8, 1976) (provides for exchange of information in the areas, *inter alia*, of terminal storage in geologic formations (including characterization of geologic formations and development and testing of facilities); technology of retrievable storage; waste processing technology (including high-level waste solidification); and environmental effects); Agreement between the United States Energy Research and Development Administration and the Swedish Nuclear Fuel Supply Company Concerning a Cooperative Program on Radioactive Waste Storage in Deep Geologic Formations, June 17, 1977 (provides principally for jointly conducted experiments on the behavior of granite under heat stress). *Id.*

²⁶⁷ See note 24 *supra* and note 350 *infra*.

²⁶⁸ Antarctic Treaty, Dec. 1, 1959, 12 U.S.T. 794, T.I.A.S. No. 4780.

²⁶⁹ See, e.g., London Convention, *supra* note 24, at art. XII(d); Antarctic Treaty, art. V. See also notes 349-56 *infra*.

²⁷⁰ See, e.g., *Export Reorganization Act of 1976: Hearings on S. 1439 Before the Senate Comm.*

series of U.S. initiatives, as well as changes in U.S. law, aimed at discouraging the reprocessing of spent fuel around the world except under the most stringent controls. An important element of U.S. efforts in this regard has been to promote the concept of direct, permanent disposal of spent fuel, without the intermediate step of reprocessing, as a means for effectively addressing the long-term radiation hazard posed by this material. Thus, as discussed more fully below, although the impetus for the new U.S. initiatives has been the desire to control the spread of nuclear weapons, the intimate link between reprocessing, plutonium, and permanent waste disposal has caused the U.S. to involve itself far more deeply than in the past in the waste management aspects of its export recipients' respective nuclear programs.

Increased U.S. government interest in the disposition of U.S.-origin spent fuel first became manifest in 1976.²⁷¹ In the summer of that year, the Nuclear Regulatory Commission, in consultation with the Department of State and the Arms Control and Disarmament Agency, deferred issuance of a nuclear fuel export license to India pending further negotiations with that country over its future use of accumulated U.S.-origin spent fuel.²⁷² The underlying cause for concern was that in May, 1974, India had detonated a nuclear explosive device using plutonium derived from supposedly peaceful nuclear activities, relying in part on U.S.-supplied material.²⁷³ The 1976 negotiations were aimed at developing arrangements for the U.S. to take back spent fuel irradiated in the U.S.-supplied Tarapur reactors near Bombay, so as to eliminate the possibility of this material's being subsequently reprocessed in India and its plutonium content thereby being made available for possible illicit military use at a later time.²⁷⁴ Although U.S. take-back of this material, has, to date, proven infeasible, the United States has in the interim exercised its right under the U.S.-India agreement for coop-

on *Gov't Operations*, 94th Cong., 2d Sess. 397 (testimony of Commissioner Victor Gilinsky), 565, 568 (testimony of Dr. Fred C. Ikle), 765, 768, 770 (testimony of Henry A. Kissinger).

²⁷¹ See *Edlow Int'l Co.*, 5 Dec. Nuc. Reg. Comm'n 1358, [1975-1978 Transfer Binder] Nuc. REG. REP. (CCH) ¶ 30,206 (June 28, 1977) (especially concurring opinion of Commissioner Gilinsky).

²⁷² *Id.*

²⁷³ *Id.*

²⁷⁴ The United States concern was that if at some time in the future the U.S. should decide to terminate nuclear cooperation with India (in response, for example, to an acceleration of India's nuclear explosives program), India might declare that it was released from the non-proliferation controls contained in the 1963 U.S.-India agreement for cooperation (Agreement for Cooperation Concerning Civil Uses of Atomic Energy, Aug. 8, 1963, United States-India, 14 U.S.T. 1484, T.I.A.S. No. 5446) covering previously exported U.S. nuclear fuel and might thereafter reprocess this material and use any plutonium separated in nuclear explosives. *Id.* (especially concurring opinion of Commissioner Gilinsky).

eration to hold up the reprocessing of U.S.-origin spent fuel.²⁷⁵ Thus, while the United States' negotiations in 1976 were not aimed at the radiological hazard posed by the Tarapur spent fuel, the U.S. initiatives to limit reprocessing have substantially affected India's post-fission waste disposal program, at least insofar as U.S.-origin spent fuel is concerned.

Of more far-reaching significance in 1976 was President Ford's October 28 statement on U.S. nuclear policy.²⁷⁶ That statement officially expressed the United States strong concerns over the spread of plutonium and technologies for its extraction and announced a number of new policy decisions, in essence stating that:

- (1) the U.S. would "no longer regard reprocessing of used nuclear fuel to produce plutonium as a necessary and inevitable step in the nuclear fuel cycle;"
- (2) the U.S. would defer domestic plans for the commercialization of reprocessing;
- (3) the U.S. would encourage other nuclear suppliers to exercise "maximum restraint" in the transfer of reprocessing technology, and
- (4) U.S. nuclear waste management activities would include development of the capability for permanent disposal of spent fuel itself.²⁷⁷

The policy statement also proposed discussions aimed at the establishment of an international regime for the storage of civilian plutonium and spent reactor fuel and indicated that the U.S. was "prepared to consider" providing a site for such activities under the supervision of the International Atomic Energy Agency.²⁷⁸

Although the Ford policy statement signaled what has, in fact, become an enduring shift in U.S. policy on these matters, the impact of this change of course on the reprocessing and associated waste management activities of U.S. nuclear trading partners was not fully achieved until after the Ford statement was ratified and extended by President Carter. On April 7, 1977, President Carter's first major statement on nuclear weapons proliferation made the Ford deferral of U.S. commercial reprocessing "indefinite" and proposed redirecting the U.S. nuclear reactor research and development program away from plutonium-using designs.²⁷⁹ The President also:

- (1) pledged continuing discussions with nuclear supplier and recipient

²⁷⁵ *Id.*

²⁷⁶ Statement by President Gerald Ford on Nuclear Policy, 12 WEEKLY COMP. OF PRES. DOC. 1624 (Oct. 28, 1976).

²⁷⁷ *Id.* at 1626.

²⁷⁸ *Id.* at 1628.

²⁷⁹ Statement by President Jimmy Carter on Nuclear Power Policy, 1 PUB. PAPERS 587 (Apr. 7, 1977).

- countries aimed at reducing the spread of reprocessing capabilities to additional countries beyond those already possessing such facilities;
- (2) proposed an international evaluation of the nuclear fuel cycle to seek, on a cooperative basis with other nations, methods of reducing proliferation risks posed by existing nuclear technologies; and
 - (3) reiterated the need for the U.S. to aid in developing alternatives to reprocessing for eliminating the hazard posed by spent fuel.²⁸⁰

During the ensuing months, various elements of the Carter policy announcement gradually took more concrete form. On October 18, 1977, the Department of Energy announced the new U.S. spent nuclear fuel policy, proposing to accept and take title to used nuclear fuel both from domestic utilities and from foreign users, the latter on a limited basis in support of U.S. non-proliferation goals.²⁸¹ At the same time, the DOE announcement stated that the U.S. would encourage other nations to expand their own storage capacity for spent fuel and would support the study of regional or international storage sites.²⁸² The overall objective of the U.S. offer to accept foreign spent fuel, the DOE announcement explained, was to enhance the United States "ability to negotiate more effective non-proliferation measures with foreign countries and to prevent premature entry into the plutonium economy."²⁸³ DOE indicated that it expected that foreign spent fuel would be but a small part of the total spent fuel stored in the United States.²⁸⁴ To date, this initiative has not reached fruition. No foreign spent fuel has been accepted by the United States.²⁸⁵

Also during October of 1977, the organizing conference for the International Nuclear Fuel Cycle Evaluation proposed by President Carter was held, launching a two-year study on methods for increasing the proliferation resistance of civilian nuclear technology.²⁸⁶

In the fall of 1977, the U.S. efforts to curtail the availability of separated plutonium also had a significant impact on reprocessing activities in one foreign nation, Japan. Japan had anticipated start-up of

²⁸⁰ *Id.*

²⁸¹ U.S. Dep't of Energy, *DOE Announces New Spent Nuclear Fuel Policy*, News Release R-77-017 (Oct. 18, 1977). For a detailed analysis of this policy and its alternatives, see U.S. DEP'T OF ENERGY, DRAFT ENVIRONMENTAL IMPACT STATEMENT, STORAGE OF FOREIGN SPENT POWER REACTOR FUEL (DOE/EIS-0040-D) (1978).

²⁸² *Id.*

²⁸³ *Id.*

²⁸⁴ *Id.*

²⁸⁵ No funds have yet been authorized for the construction or acquisition of facilities for storing foreign spent fuel in the United States. Nor have the preliminary studies which are the legal prerequisite to U.S. acceptance of foreign spent fuel been completed. See 42 U.S.C.A. §§ 2160(f), 2074a (Supp. I 1978).

²⁸⁶ See text accompanying notes 228-40 *infra*.

its Tokai-Mura reprocessing plant at approximately that time.²⁸⁷ Inasmuch as the plant had planned to reprocess U.S.-origin spent fuel and inasmuch as the reprocessing of this material was subject to prior U.S. approval under the terms of the U.S.-Japan agreement for cooperation,²⁸⁸ the United States had considerable leverage in establishing the terms for the operation of the plant. After extended negotiations, it was decided that the plant would be permitted to start up and reprocess a limited quantity of U.S.-origin spent fuel (ninety-nine metric tons) and that experiments in a facility adjacent to the reprocessing plant would be carried out on technologies aimed at increasing the proliferation resistance of this activity. The results of these experiments would then be incorporated into the International Nuclear Fuel Cycle Evaluation, which by this time was under way. The agreement between the United States and Japan on this matter, known as the Tokai Communique, was to have a two-year term and will shortly be the subject of renegotiation.²⁸⁹

Also during the latter part of 1977, the Carter Administration negotiated with the Congress key provisions of pending nuclear non-proliferation legislation concerning the exercise of U.S. reprocessing control rights found in then-existing U.S. agreements for cooperation. This legislation was enacted the following March as the Nuclear Non-Proliferation Act of 1978.²⁹⁰

Prior to the enactment of the Non-Proliferation Act, no statutory standard existed governing the exercise of this reprocessing approval right. In practice, as noted above, reprocessing requests involving U.S.-origin spent fuel were generally approved with little senior-level attention to the impact of such approvals on overall U.S. non-proliferation goals.²⁹¹ Under the new legislation, section 303 provides that the Sec-

²⁸⁷ NUCLEAR PROLIFERATION FACTBOOK, *supra* note 184, at 201.

²⁸⁸ Agreement Concerning Civil Uses of Atomic Energy, July 10, 1968, United States-Japan, 19 U.S.T. 5371, T.I.A.S. No. 6520, *as amended* Feb. 24, 1972, 23 U.S.T. 275, T.I.A.S. No. 7306, Mar. 28, 1973, 24 U.S.T. 2323, T.I.A.S. No. 7758, art. VIII(C)..

²⁸⁹ Joint Communique Concerning the Operation of the Tokai Reprocessing Facility, Sept. 12, 1977, United States-Japan, 28 U.S.T. 8008, T.I.A.S. 8734 (expiration date extended from Sept. 12, 1979, to Apr. 30, 1980. 44 Fed. Reg. 52741 (1979)).

²⁹⁰ For final text of this section of the Nuclear Nonproliferation Act, as enacted, see 42 U.S.C.A. § 2160 (1978).

²⁹¹ See text accompanying notes 261-65 *supra*. In addition to its actions relating to reprocessing activities in India and Japan, *see* text accompanying notes 271-75 and 287-89 *supra*, the United States in the spring of 1977 began to exercise more restrictively its right to approve the transfer of U.S.-origin spent fuel from its export recipients to third nations for reprocessing. Under the new U.S. policy, requests for such approvals were to be reviewed on a case-by-case basis, with approval contingent upon a clear showing of need, such as limited spent fuel storage capacity in the nation requesting approval. *U.S. Keys Okay of Foreign Reprocessing to Continued*

retary of Energy in consultation with the Secretary of State and other federal agencies may approve reprocessing requests, which are defined to include requests to retransfer material to third countries for reprocessing, only if he determines that such activity will not significantly increase the risk of proliferation.²⁹² This section also specifies that in making this determination, the Secretary shall give "foremost consideration" to whether the conditions under which the reprocessing or retransfer will take place will permit timely warning to the United States of any diversion of the material for nuclear weapons purposes.²⁹³

As the legislative history of the Act makes clear, the concern of the drafters was to limit national stockpiles of separated plutonium in countries not possessing nuclear weapons.²⁹⁴ In such circumstances, timely warning of diversion would be lacking, inasmuch as stores of separated plutonium can be transformed into weapons in a matter of days. Any warning of diversion would thus come too late to permit diplomatic or other reaction to the diversion before the diversion had achieved its objective—nuclear weapons. Timely warning, however, may well be provided if certain institutional or technological approaches to reprocessing and plutonium use are implemented, such as the storage of plutonium under international auspices, or its physical commingling with other materials which reduce its weapons-usability. The Non-Proliferation Act also provides opportunity for congressional involvement in any decisions to approve reprocessing of U.S.-origin spent fuel thereby emphasizing the degree of importance which the United States now attaches to this matter.²⁹⁵

Reactor Usability, NUCLEONICS WK. 1 (May 9, 1977); letter from Louis V. Nosenzo, Deputy Ass't Sec'y, Bureau of Oceans and International Environmental and Scientific Affairs, Dep't of State, to Jacob Scherr, Natural Resources Defense Council (July 1, 1977). As this policy evolved, the U.S. added restrictions requiring that reprocessing be performed in France or Great Britain (nations already possessing nuclear weapons) and that the U.S. be granted the right to approve any subsequent re-export or use of the plutonium separated by such reprocessing. Letter from Joseph Nye to Congressman Clement Zablocki (Jan. 25, 1978), note 264 *supra*. This policy principally affected transfers of U.S.-origin spent fuel from Japan, Sweden, Switzerland, and Spain to Great Britain and France. *Id.*

²⁹² 42 U.S.C.A. § 2160 (Supp. I 1978).

²⁹³ *Id.*

²⁹⁴ See H.R. REP. NO. 587, 95th Cong., 1st Sess. 1820 (1977); S. REP. NO. 467, 95th Cong., 1st Sess. 467-68 (1977); 95 CONG. REC. H10280, 10282 (daily ed. Sept. 28, 1977); 95 CONG. REC. S1065, 1066 (daily ed. Feb. 2, 1978).

²⁹⁵ 42 U.S.C.A. § 2160(b) (Supp. I 1978). See generally *Nuclear Fuel Transfer Hearings*, note 17 *supra*.

The Non-Proliferation Act also amends the Atomic Energy Act by adding a number of new nuclear export licensing criteria. 42 U.S.C.A. §§ 2156, 2157 (Supp. I 1978); Edlow Int'l Co., 7 Dec. Nuc. Reg. Comm'n 436, [1975-1978 Transfer Binder] NUC. REG. REP. (CCH) ¶ 30288 (Apr. 24, 1978). With one exception, the Non-Proliferation Act made no changes in existing law with re-

As rigorous as the statutory standard is, in practice the Carter Administration has superimposed still more stringent standards in approving reprocessing requests involving U.S.-origin material. At present, the United States will approve such requests on a case-by-case basis only where a physical need for the requested reprocessing is manifest, (as, for example, where spent fuel storage space is running out in the requesting nation), or if the contract for the reprocessing for which approval is sought was entered into prior to the announcement of the new U.S. non-proliferation policy in April 1977, and then only if granting the request will directly assist U.S. non-proliferation efforts.²⁹⁶

Under these combined requirements, the United States has thus far approved reprocessing of material in the U.K. and France from Japan, Sweden, Switzerland, and Spain.²⁹⁷ In approving these transactions, the United States has specified that the subsequent disposition of the plutonium derived from such reprocessing is also subject to U.S. approval.²⁹⁸ Complementing its tough position on reprocessing approvals, the U.S. government has taken strong initiatives to encourage nations to expand spent fuel storage capacity at existing reactors.²⁹⁹ Under these initiatives Japan, for one, is providing storage capacity expansion at a number of facilities.³⁰⁰

U.S. restrictions on reprocessing approvals are also said to have

spect to the consideration of the health, safety, or environmental impacts of U.S. nuclear exports including post-fission waste disposal. The sole exception is found in section 407 of the Non-Proliferation Act which specifies that in any new agreement for cooperation in the field of civilian nuclear power the President shall endeavor to provide for cooperation between the parties in protecting the international environment from radioactive, chemical or thermal contamination arising from peaceful nuclear activities. 42 U.S.C.A. § 2153(e) (Supp. I 1978).

While not an export licensing criterion, this provision, which would extend to contamination from post-fission wastes, indicates congressional recognition of the potentially adverse environmental impacts arising from U.S. nuclear exports and the desirability of working with export recipients to avert them.

The first U.S. agreement for cooperation to be negotiated pursuant to the terms of the Non-Proliferation Act (Agreement Concerning the Peaceful Uses of Nuclear Energy, July 5, 1979, United States-Australia), however, does not address this subject specifically but states more generally in the Minute accompanying the agreement that "the parties have been engaging and will continue to engage actively in international cooperation on international environmental considerations relevant to peaceful nuclear activities." Message of the President of the United States Transmitting the Text of the Proposed Agreement between the United States and Australia Concerning the Peaceful Uses of Nuclear Energy Pursuant to Section 123d. of the Atomic Energy Act of 1954, as amended (92 Stat. 144) (July 27, 1979).

²⁹⁶ *Nuclear Fuel Transfer Hearings*, *supra* note 17, at 48 (statement of Joseph S. Nye).

²⁹⁷ *Id.* at 49-51. *See, e.g.*, 44 Fed. Reg. 25,347 (Apr. 30, 1979); 44 Fed. Reg. 30,167 (May 24, 1979).

²⁹⁸ *Id.* at 51 (statement of Joseph S. Nye) and app. 3.

²⁹⁹ *Id.* at 51 (statement of Joseph S. Nye) and app. 3, at 145-46.

³⁰⁰ *Id.*

affected the Austrian referendum on start-up of the Zwetendorf nuclear plant. Under Austrian law, arrangements must be made for ensuring adequate post-fission nuclear waste disposal prior to the time of reactor start-up. As this reactor was to be fueled with enriched uranium exported from the United States, concerns were raised during the public debate on the referendum as to how the U.S. might exercise its controls over reprocessing as this material began to accumulate in an irradiated form at the Zwetendorf facility.³⁰¹ It has been suggested that the difficulties experienced in establishing a workable arrangement with the United States on this matter contributed significantly to uncertainties as to Austria's plans for managing the post-fission wastes from this facility and that this, in turn, was a negative factor taken into account by the Austrian public which narrowly disapproved the facility in the November 1978 referendum.³⁰²

In addition to the foregoing, another initiative which has been announced by the United States in conjunction with its spent fuel offer has been the investigation of isolated Pacific islands as possible storage sites for spent fuel from Pacific Basin nations such as Japan, Korea, Taiwan and the Philippines.³⁰³ Preliminary site studies of one island, Palmyra, have been undertaken, and negotiations have been conducted with the Japanese to determine the possible acceptability of the Pacific island approach as a storage alternative for significant quantities of Japanese spent fuel.³⁰⁴ Although these investigations are in their preliminary stages, the island storage concept contemplates retention of spent fuel for a number of decades rather than permanent disposal of this material.³⁰⁵

In essence, therefore, U.S. initiatives potentially affecting the post-fission nuclear waste management strategy of U.S.-export recipients fall into three categories: (1) international discussions and cooperative efforts aimed at establishing a consensus on the desirability of alternatives to national reprocessing programs; (2) restrictions on U.S. approvals of reprocessing within individual export-recipient nations and of transfers for reprocessing to third nations, such as England and

³⁰¹ *Id.* at 32-47 (statement of Janet E. Hieber), 83 (statement of Joseph S. Nye).

³⁰² Conversation with Fritz Schmidt, Counselor of the Austrian Federal Chancellery (June 30, 1979).

³⁰³ See Dep't of State, Preliminary Studies of Possible Island Sites for Temporary Storage of Spent Nuclear Fuel (June 14, 1979) (press background paper); S. REP. NO. 205, 96th Cong., 1st Sess. 1 (1979) (directing the Secretary of the Interior to report to Congress on plans or projects affecting the territories and possessions of the United States).

³⁰⁴ *Id.*

³⁰⁵ Dep't of State, note 303 *supra*.

France; and (3) proposals for the storage of foreign spent fuel in the United States, including its possessions and territories in the Pacific. While the motivation behind all of these initiatives, as noted above, has been to curtail the risks of nuclear proliferation associated with the accumulation of separated plutonium under national control rather than to address the radiation hazard posed by spent fuel, the *impact* of U.S. policy has been to redirect at least the intermediate phase of a number of national post-fission nuclear waste management programs.

While efforts to curb the separation and the recycling of plutonium have been the most important U.S. initiatives affecting the nuclear waste management activities of its export recipients, another development of particular interest has been the outcome of the long-standing debate over whether an environmental impact statement must be prepared when the U.S. sells nuclear fuel, power plant equipment, or technology abroad.³⁰⁶ If the environmental impact statement requirements of NEPA were found to apply to these U.S. exports, then the adequacy of waste disposal, which could have a significant effect on the environment, undoubtedly would have to be considered on a case-by-case basis in determining whether such exports should be authorized.³⁰⁷

President Carter, under pressure to clarify the scope of environmental reviews which would be required for exports of environmentally hazardous materials and technology, on January 4, 1979, issued Executive Order 12114, which established U.S. policy on the international reach of NEPA.³⁰⁸ Under the terms of that order, export of nu-

³⁰⁶ See National Environmental Policy Act of 1969, § 102(2)(c), 42 U.S.C. § 4332(2)(c) (1976) (NEPA). See also Robinson, *Extraterritorial Environmental Protection Obligations of Foreign Affairs Agencies: The Unfulfilled Mandate of NEPA*, 7 N.Y.U. J. INT'L L. 257 (1974) (although dated, this article discusses the seminal State Department memorandum against the extraterritorial reach of NEPA); Comment, *Forthcoming CEQ Regulations to Determine Whether NEPA Applies to Environmental Impacts Limited to Foreign Countries*, 8 ENV'T L. REP. 10, III (1978) (review of case law, statutory interpretation and presumption against extraterritoriality); Comment, *Reinvigorating the NEPA Process: CEQ's Draft Compliance Regulations Stir Controversy*, 8 ENV'T L. REP. 1045 (1978); Note, *The Extraterritorial Scope of NEPA's Environmental Impact Statement Requirement*, 74 MICH. L. REV. 349 (1975) (examines limits on Congressional power, manifestations of Congressional intent, and policy considerations in reaching conclusion that NEPA has international scope).

³⁰⁷ In the context of domestic reactor licensing, at least, such issues are considered as part of environmental reviews. See, e.g., *Vermont Yankee Nuclear Power Corp. v. Natural Resources Defense Council, Inc.*, 435 U.S. 519 (1977) (Supreme Court upheld NRC procedures in enacting rules providing for consideration of waste disposal and reprocessing in individual domestic licensing proceedings).

³⁰⁸ Exec. Order No. 12114, 44 Fed. Reg. 1957 (1979). See also Concise Environmental Review, Philippines Nuclear Power Plant Unit 1, *supra* note 181, at I(B)(3) and Addendum 2. The first Concise Environmental Review pursuant to Executive Order 12114 was released in September 1979 and considered the export of a power reactor to the Philippines. The review says nothing of

clear reactors and radioactive waste management facilities will require a full-scale environmental impact statement only when the export affects "the environment of the global commons outside the jurisdiction of any nation" (e.g., the oceans or Antarctica). If the export may "significantly affect" only a foreign purchasing country or a third party country, then one of two types of environmental reviews is required: (1) bilateral or multilateral environmental studies of a general, rather than case-by-case, nature, or (2) concise reviews of the environmental issues involved in a short form, i.e., a summary environmental impact statement or analysis. Apparently, the Department of State will be required to determine which of these two procedures will govern nuclear exports in particular cases. Nuclear fuel exports are exempted from these requirements.

It is yet unclear how detailed the environmental reviews will be, but first indications are that they will be only cursory. Litigation will probably be used to test the adequacy of the procedures adopted to implement Executive Order 12114, though the Executive Order attempts to limit the scope of litigation on this question. The Executive Order may ultimately be interpreted to require a more detailed analysis of the environmental dangers resulting from use of United States-origin reactors and waste management facilities including the adequacy of disposal and storage techniques used by purchasing countries. The Philippines Nuclear Power Plant Concise Environmental Review, the first issued since the Executive Order, however, indicates that absent judicial intervention or a major shift in current policy little attention is likely to be paid to nuclear waste disposal questions.

Practices of Other Free World Suppliers

Judging from the available evidence, the principal free world nuclear exporters other than the U.S. (France, West Germany, and Canada) have left the matter of safely disposing of the radioactive wastes produced by their nuclear power related exports entirely to the nations receiving these commodities, to be addressed according to the latter's respective domestic health and safety policies and technological capa-

plans for disposal of post-fission wastes from the reactor, except to note that "Design specifications for spent fuel storage facilities . . . are not available," and that, "Common to many countries, especially those at the early stages of nuclear development, the Philippines has not yet developed any plans for the longer-term handling of spent fuel beyond ten to thirteen years storage capacity in the reactor spent fuel storage pool." This export license has been forwarded to the Nuclear Regulatory Commission for further consideration.

Procedures for implementing Exec. Order No. 12114 were issued on Nov. 13, 1979. 44 Fed. Reg. 65560 (1979).

bilities.³⁰⁹ None of these suppliers, for example, has required in those

³⁰⁹ This section is based principally on an extensive review of Canadian, West German, and French agreements for cooperation in the civil uses of nuclear energy which provide for the export of nuclear power reactors and associated fuel or of reprocessing equipment to particular nations or groups of nations. A number of such agreements, however, have not been made public by their parties, making a comprehensive review of such instruments for the purpose of determining their treatment of nuclear waste disposal issues impossible. See, e.g., Agreement for Cooperation on the Koeberg Nuclear Power Station, Stages I and II, Oct. 15, 1975, France-South Africa. This agreement is listed in Table 2.2, Bilateral Agreements for Peaceful Utilization of Nuclear Energy, by Main Supplier Country (governmental agreements in force by mid-1976), *World Armaments and Disarmament*, in STOCKHOLM INTERNATIONAL PEACE RESEARCH INSTITUTE, SIPRI YEARBOOK 40-41 (1977) [hereinafter cited as SIPRI YEARBOOK 1977], reprinted in NUCLEAR PROLIFERATION FACTBOOK, *supra* note 184, at 275-76.

In West Germany, a governmental agreement for cooperation is not a necessary prerequisite for commercial transactions in nuclear technology with a given country. *Id.*, note *a*. West German power reactor exports to the Netherlands, Spain, Austria, and Switzerland appear to have been made in the absence of such agreements. See SIPRI YEARBOOK, *supra* at 43 (Table 2.4), reprinted in NUCLEAR PROLIFERATION FACTBOOK, *supra* note 184, at 279. Any arrangements for the disposal of nuclear waste in the case of such exports would, thus, not be revealed by a review of West Germany agreements for cooperation. These knowledge gaps necessitate the qualifications to the conclusions in the text.

Six French power reactor or reprocessing plant export agreements have been examined: those with Belgium, Indonesia, Iraq, Switzerland, Pakistan, and Korea, as well as a draft accord with South Africa. Only Belgium and South Africa among these nations have, to date, actually imported French nuclear power reactor technology. See *World List of Nuclear Power Plants*, note 40 *supra*. Agreement for the Construction of an Irradiated Fuel Reprocessing Plant, Mar. 17, 1976, France-Pakistan (unpublished authors' copy); Agreement for Cooperation in the Peaceful Uses of Nuclear Energy, Nov. 18, 1975, France-Iraq, [1976] J.O. 3654; Agreement on Cooperation on the Koeberg Nuclear Power Station, Stages I and II, France-South Africa, *supra* (authors' copy of unpublished draft believed to reflect final text); Agreement for Cooperation Between the Ministry of Science and Technology and the Commission on Atomic Energy, Oct. 19, 1974, Korea-France (unpublished copy provided by Korean Embassy); Agreement for Cooperation in the Peaceful Uses of Atomic Energy, May, 14, 1970, France-Switzerland, 811 U.N.T.S. 301; [1969] Agreement for Cooperation in the Peaceful Uses of Nuclear Energy, Apr. 3, 1969, France-Indonesia, 748 U.N.T.S. 87; [1966] Convention on Radiological Protection with Regard to the Installations of the Ardennes Nuclear Power Station, Sept. 23, 1966, Belgium-France, 588 U.N.T.S. 227. In addition, France has entered into apparently unpublished agreements with Spain (which has also imported French nuclear power technology), Japan, and Iran.

All West German power reactor agreements have been reviewed except the agreement with the USSR which is apparently unavailable. The reviewed agreements include those with three nations that have either imported or ordered West German power reactors (Argentina, Iran, and Brazil), and two with nations which have not yet done so (Indonesia and Romania). Agreement on Cooperation in the Fields of Peaceful Uses of Nuclear Energy, Dec. 5, 1978, West Germany-Spain, Bundesgesetzblatt [BGBl] II 133; Agreement on Cooperation in the Fields of Peaceful Uses of Nuclear Energy, July 3, 1976, West Germany-Iran, reprinted in INTERNATIONAL INSTRUMENTS FOR NUCLEAR TECHNOLOGY TRANSFER 431 (M. Muntzing ed. 1978); Agreement on Cooperation Regarding the Peaceful Uses of Atomic Energy, June 14, 1976, West Germany-Indonesia, Bundesgesetzblatt [BGBl] II 361; Agreement Concerning Cooperation in the Field of Peaceful Uses of Nuclear Energy, June 27, 1975, West Germany-Brazil, reprinted in INTERNATIONAL INSTRUMENTS FOR NUCLEAR TECHNOLOGY TRANSFER, *supra*, at 411; Agreement on Cooperation Regarding the Peaceful Uses of Atomic Energy, July 31, 1973, West Germany-Romania, Bundesgesetzblatt [BGBl] II 1484; [1969] Basic Agreement Concerning Cooperation in Scientific

of its bilateral nuclear cooperation agreements examined by the au-

Research and Technical Development, March 31, 1969, Argentina-West Germany, 709 U.N.T.S. 197.

The author's review of available Canadian agreements for nuclear cooperation providing for nuclear power reactor exports included all agreements with nations which have actually imported or ordered Canadian-origin power reactors (India, Pakistan, Argentina and South Korea) as well as other such agreements which have been published (Finland, Japan, Spain, Switzerland, Iran, Sweden, Australia, EURATOM, and the United States). Agreement Concerning the Uses of Nuclear Material, Equipment, Facilities and Information Transferred between Canada and Sweden, Sept. 27, 1977, Canada-Sweden [1978] Can. T.S. No. 13; Agreement Concerning the Uses of Nuclear Material, Equipment Facilities and Information Transferred Between Canada and Finland, July 16, 1976, Canada-Finland, [1976] Can. T.S. No. 27; Agreement for Cooperation in the Development and Application of Atomic Energy for Peaceful Purposes, Jan. 30, 1976, Canada-Argentina, [1976] Can. T.S. No. 12; Agreement for Cooperation in the Development and Application of Atomic Energy for Peaceful Purposes, Jan. 26, 1976, Canada-Korea, [1976] Can. T.S. No. 11; Agreement for Cooperation in the Development and Application of Atomic Energy for Peaceful Purposes, July 7, 1975, Canada-Spain, [1976] Can. T.S. No. 19; Agreement for Cooperation in the Peaceful Uses of Atomic Energy, Jan. 7, 1973, Canada-Iran, [1973] Can. T.S. No. 2; Agreement Relating to the Rajasthan Atomic Power Station and the Douglas Point Nuclear Generating Station, Dec. 16, 1963, Canada-India, 528 U.N.T.S. 45, *as amended* Dec. 16, 1966, [1966] Can. T.S. No. 27; Agreement for Cooperation Concerning the Civil Uses of Atomic Energy June 15, 1955, United States-Canada, 235 U.N.T.S. 176, *as amended* June 26, 1956, 279 U.N.T.S. 318, *as modified* May 22, 1959, 354 U.N.T.S. 63, *as amended* May 25, 1962, 453 U.N.T.S. 362; Agreement for Cooperation in the Peaceful Uses of Atomic Energy, Oct. 6, 1959, Canada-European Atomic Energy Community, 485 U.N.T.S. 187; Agreement for Cooperation in the Peaceful Uses of Atomic Energy, Aug. 4, 1959, Canada-Australia, 391 U.N.T.S. 191; Agreement (July 2, 1959) and Exchange of Notes (July 27, 1960) for Cooperation in the Peaceful Uses of Atomic Energy, Canada-Japan, [1960] Can. T.S. No. 15; Agreement on the Peaceful Uses of Atomic Energy, May 14, 1959, Pakistan-Canada, 426 U.N.T.S. 129; Agreement to Provide for Cooperation in the Peaceful Uses of Atomic Energy, Mar. 6, 1958, Canada-Switzerland, [1958] Can. T.S. No. 8. Hereinafter, all bilateral agreements for nuclear cooperation will be denoted by reference to their parties, *e.g.* "Canada-Sweden agreement".

In the available nuclear power reactor agreements reviewed by the authors, there was a total absence of discussion of rights or duties with respect to permanent disposal of the post-fission wastes produced from transferred material and equipment. Despite the omission of some agreements from analysis, the existing documents support the view that such matters are similarly beyond the ambit of those unpublished agreements and quite possibly, of private reactor sales arrangements as well. *See also* INTERNATIONAL INSTRUMENTS FOR NUCLEAR TECHNOLOGY TRANSFER, *supra*, at 344, 346-47 (only one French agreement is identified as addressing the issue of "nuclear wastes," the Convention on Radiological Protection with Regard to the Installations of the Ardennes Nuclear Power Station, Sept. 23, 1966, Belgium-France, 588 U.N.T.S. 227. In actuality, even this agreement does not address post-fission wastes, as the term "nuclear wastes" in the agreement refers to the radioactive effluents discharged by the Ardennes plants in normal operation, not the post-fission wastes produced in the reactors' fuel.)

Many of the published West German and French agreements date from the mid-1970's—the period when nuclear waste disposal was beginning to emerge as an important public issue in these nations. The fact that this subject is not covered in any of these more recent agreements, allows the tentative inference that it was similarly beyond the scope of earlier, unpublished accords entered into when neither public, nor governmental, attention had yet focused on the nuclear waste issue.

In sum, the agreements reviewed reveal the practices of Canada, France, and West Germany with respect to the post-fission wastes produced from their exports in many, though not all, instances. For reasons noted above, however, it is not unreasonable to suggest that the picture

thors that, as a condition for receiving nuclear exports, recipient countries pledge to provide for the subsequent long-term isolation of the resulting wastes or take other measures to protect their own populations, that of the supplier state, or global common areas from the harmful effects of these materials. Indeed, although many agreements clearly recognize that nuclear power reactor fuels are subject to handling after irradiation and may be reprocessed,³¹⁰ none of the agreements reviewed ever specifically mentions the subject of post-fission radiological wastes or the permanent disposal of such materials or of spent fuel.³¹¹ Similarly, there is little evidence to suggest that technology exports or other assistance specifically relevant to the management or disposal of such materials is intended to be within the scope of the bilateral nuclear cooperation offered by these suppliers.³¹²

Nor has any of the above-noted suppliers undertaken through its agreements to accept responsibility for disposing of the radioactive wastes generated by its exports at an appropriate future time.³¹³ Al-

provided by these agreements is, in fact, fairly representative of these suppliers' practices in other cases, as well. See also note 311 *infra*.

³¹⁰ See, e.g., Canada-Iran agreement, *supra* note 309, art. IV(2)(b), requiring Canadian approval prior to the reprocessing of spent fuel produced through the use of exports transferred under the agreement; Canada-Argentina agreement, *supra* note 309, art. III(3), to similar effect; West Germany-Brazil agreement, *supra* note 309, art. 1.

³¹¹ The evidence that post-fission nuclear waste management is beyond the scope of cooperation contemplated by Canada in her agreements with Argentina (1976), Korea (1976), Finland (1976), and Spain (1976) is particularly strong, note 309 *supra*. In each, Appendix A defines with great specificity what comprises "equipment" transferrable under the agreement, listing in considerable detail types of matériel designed to aid in nuclear fuel preparation and reprocessing; the definition nowhere mentions, however, equipment useful for the solidification, storage, or permanent disposal of post-reprocessing high-level waste or for the permanent disposal of spent fuel. Earlier agreements with Switzerland (1958), Pakistan (1959), Japan (1960), and Iran (1972), include in the definition of "equipment" items "of particular utility in research, development, use processing or storage relating to atomic energy. . . ." (Canada-Switzerland agreement, art. VI; Canada-Pakistan agreement, art. VI; Canada-Japan agreement, art. VII; and Canada-Iran agreement, art. VI) (emphasis added) but no connection is made between spent fuel or post-reprocessing wastes and such "storage" nor is permanent disposal of such materials implied.

Similar evidence is provided in the West Germany-Brazil agreement, note 309 *supra*, that cooperation on post-fission waste management matters was outside the intent of the parties. That agreement provides for an unusually broad spectrum of cooperation, covering fields ranging from prospecting for uranium, to fuel manufacture and reactor construction, to reprocessing of irradiated fuels. No reference of any kind is made, however, to post-reprocessing wastes, waste solidification technology, or to the permanent disposal of this material or of spent fuel.

³¹² See note 311 *supra*.

³¹³ It is worth noting that the U.S.S.R. is said to require its Communist trading partners to return Russian-origin nuclear fuels to Russia after irradiation. The underlying motive is said to be to rule out the possibility of nuclear weapons development in those satellite nations. *U.S.S.R. Looks to Reactor Sales to Boost Prestige and Pocketbook*, *Energy Daily*, Nov. 7, 1978, at 2.

The U.K., which in the 1960's exported two small power reactors, one to Japan and one to Italy, may be another exception to the general proposition stated in the text. Its agreements for

though France and the U.K. have offered to reprocess foreign spent fuel on commercial terms, as noted above,³¹⁴ neither this, nor any other program for treating post-fission wastes, is a mandatory condition for receipt of exports from the principal suppliers mentioned earlier.³¹⁵ Moreover, current reprocessing contracts with France and the U.K. apparently call for the return of separated waste products to the country of origin, leaving the question of permanently disposing of such materials entirely to that nation.³¹⁶ Finally, like their export agreements, the nuclear export laws and licensing practices of these suppliers appear not to address the issue of post-export nuclear waste disposal.³¹⁷

One important exception to this pattern are those nuclear technol-

cooperation of the period (Agreement for Cooperation in the Peaceful Uses of Atomic Energy, May 24, 1968, United Kingdom-Finland, [1968] U.K.T.S. No. 43; Agreement for Cooperation in the Peaceful Uses of Atomic Energy, March, 6, 1968, United Kingdom-Japan, 667 U.N.T.S. 229; Agreement for Cooperation in the Peaceful Uses of Atomic Energy, Jan. 19, 1960, United Kingdom-Spain, 404 U.N.T.S. 41; Agreement for Cooperation in the Peaceful Uses of Atomic Energy, Dec. 28, 1957, United Kingdom-Italy, 305 U.N.T.S. 357) specify that the United Kingdom Atomic Energy Authority (U.K.A.E.A.) will provide reprocessing services for U.K.-origin fuel irradiated in the cooperating country to the extent and on such terms as might be subsequently agreed upon by the parties. The agreements do not indicate, however, how or where the high-level wastes resulting from this reprocessing were to be disposed of. To the extent that the signing parties to the U.K.'s agreements understood that the U.K.A.E.A. was offering not only reprocessing services, but also the permanent disposal of the resulting wastes in Great Britain, it may be said that the U.K. offered to take responsibility for the unwanted by-products of its export activities.

Britain has made no other exports of power reactors apart from those noted above and it appears that, today, its reprocessing contracts call for the return of the resulting high-level wastes to the nation contracting for such services. See *Nuclear Fuel Transfer Hearings*, *supra* note 17, at 87; *Windscale Inquiry*, *supra* note 124, at 17. Thus the British agreements of the 60's are something of an historic anomaly, with little current impact.

³¹⁴ See notes 132 and 139 *supra*.

³¹⁵ See text accompanying note 309 *supra*.

³¹⁶ See, e.g., *Nuclear Fuel Transfer Hearings*, *supra* note 17, at 87, 89 (colloquies between Joseph S. Nye and Congressmen Findlay and Bingham on French and British reprocessing contract with Austria); Agreement Concerning the GKT [Austria] COGEMA [France] Reprocessing Contract, *reprinted in* 22 NUCLEAR L. BULL. 36 (French specify that reprocessing will not commence unless agreement is reached on waste form suitable for transport of material from France); *Windscale Inquiry*, note 124 *supra* (BNFL under contract with Japanese customer has option to return waste which is in form suitable for safe transportation and to defer reprocessing until such form is developed).

³¹⁷ Letters to Sen. John Glenn from Carleton Kenyon, Law Librarian of Congress (May 24, 1979 and July 31, 1979).

In the case of France, there appears to be no statutory law governing nuclear exports. *Id.* Since 1976, nuclear export decisions have been made by a senior Foreign Nuclear Policy Council according to certain general principles which state, in essence, that (1) France is prepared to assist other nations in the peaceful use of nuclear energy; (2) that its nuclear export policy will seek to reduce the risk of nuclear weapons proliferation and that France will cooperate with other nuclear supplier nations in this regard; and (3) that France will provide assured fuel supplies for its exported power reactors and, as requested, will also provide reprocessing and related services. *Sénat Rapport No. 357 sur le contrôle et la protection des matières nucléaires* (May 30, 1979). The provi-

ogy exports for which the IAEA serves as intermediary.³¹⁸ Under the terms of the IAEA Statute, the Agency, at the request of the appropriate parties, may assist any member nation toward the peaceful uses of atomic energy³¹⁹ and “may arrange for the supplying of any materials, services, equipment, and facilities necessary for the project by one or more members or may itself undertake to provide any or all of these directly. . . .”³²⁰ For all such agency projects, Article XII of the Statute goes on to mandate that the agency’s health and safety standards³²¹ shall be applied,³²² a requirement expressly included in the Agency’s agreements for specific projects with project recipients.³²³ General procedures for applying these standards to agency projects are today embodied in the Agency’s Information Circular 18, revision 1 (1976) (the Circular), with the standards themselves contained in detailed IAEA

sion of reprocessing services does not, as noted above, encompass permanent disposal of the resulting high-level waste.

West German nuclear exports, in contrast, are subject to statutory controls. These controls, however, provide that only the “reliability” of the export recipient country and the impacts of a proposed export on West German security and on that nation’s international obligations in the field of nuclear energy need be considered in authorizing exports. Atomic Energy Statute of 1959, *reprinted in* 18 NUCLEAR L. BULL., Supp.

Similarly, Canada does not take into account in approving nuclear exports how post-fission wastes from those exports will be handled by the recipient nation, according to Canadian officials. Telephone communication with R.W. Blackburn, Secretary, (Canadian) Atomic Energy Control Board (April 27, 1979).

³¹⁸ Statute of the International Atomic Energy Agency, art. III (A)(1), Oct. 26, 1956, 8 U.S.T. 1093, T.I.A.S. No. 3873.

³¹⁹ *Id.* at art. XI(A).

³²⁰ *Id.* at art. XI(C).

³²¹ *Id.* at art. III(A)(6).

³²² *Id.* at art. XII(2). *See also id.*, art. XI (E)(3), providing that before approving any Agency project the IAEA Board of Governors shall give due consideration to, *inter alia*, “the adequacy of proposed health and safety standards for handling and storing materials and for operating facilities.”

³²³ Specific projects are the subject of individual “project agreements” with recipient nations IAEA Statute, *supra* note 193, at art. XI(F). *See, e.g.*, Yugoslavia-IAEA project agreement, Agreement for Assistance by the Agency in Establishing a Nuclear Power Facility, June 14, 1974, IAEA-Yugoslavia, IAEA INFCIRC/213 Part II (Nov. 8, 1974). Where a supplier other than the Agency itself is involved, the supplier’s participation may be set forth in a separate agreement between the supplier and the Agency. *See, e.g.*, US-IAEA Supply Agreement Regarding Yugoslavia Project, Agreement for the Supply of Uranium Enrichment Services for a Nuclear Power Facility in the Socialist Federative Republic of Yugoslavia, June 14, 1974, IAEA INFCIRC/213 Part I. Or, the supplier’s role may be reflected in a trilateral accord including the participation of the recipient, as well. *See, e.g.*, Agreement for the Transfer of a Training Reactor and Enriched Uranium Therefor, Feb. 24, 1970, Mar. 12-13, 1970, IAEA-Argentina-West Germany, IAEA INFCIRC/143.

In accordance with the provisions of article XII of the Agency statute, these agreements expressly provide that the provisions of the IAEA’s Safety Standards and Measures, IAEA INFCIRC/18 (May 31, 1960), shall apply to the respective projects they cover. IAEA-Yugoslavia agreement, art. V and Annex; IAEA-Argentina-West Germany agreement, art. VI.

safety issuances.³²⁴

In essence, this Circular specifies that the agency is to assess the measures and procedures which the project recipient intends to implement to determine whether they will be adequate to "ensure the observance of the safety standards specified in the agreement between the Agency and the recipient states"³²⁵ which in practice are the Agency's own standards.³²⁶ If the Agency determines the proposed measures and procedures are adequate for this purpose, "the Agency shall agree to the starting of the assisted project."³²⁷ Where the project is a "nuclear facility," such as a nuclear power reactor,³²⁸ and in certain other cases, the Circular provides that information on "the quantities of radioactive waste which are likely to be produced and the methods of waste management to be employed" shall be considered in determining whether to permit the sale.³²⁹ In other words, nuclear waste management is an issue which the Agency is to take into account in determining whether its safety standards can be effectively applied to a proposed Agency project and, hence, whether the project should be approved.³³⁰

The Circular does not, however, state how much weight is to be given to the waste management aspects of a proposed project in comparison to the other subjects it specifies as also "necessary to" the Agency's safety decision. Thus, in theory, the Agency could overlook deficiencies on the former subject, if it were satisfied other aspects of the project were acceptable. Moreover, as of this writing, the Agency's safety standards relating to the permanent disposal of post-fission wastes are in only the preliminary stages of preparation. Hence, it would be impossible for any candidate for an Agency project to demonstrate that its safety measures would result in the effective implementation of these, yet unwritten, standards. In practice, therefore, the Agency has not required recipients to possess a future permanent waste disposal capability as a condition for Agency approval of a proposed

³²⁴ IAEA INFCIRC/18/Rev. 1, § I(2) (Apr. 1976).

³²⁵ *Id.* at § 4.8.

³²⁶ IAEA-Argentina-West Germany agreement, *supra* note 323, at art. VI; Yugoslavia-IAEA Project Agreement, *supra* note 323, at Annex; Agreements for the Supply of Uranium Enrichment Services for a Nuclear Power Facility in Mexico and Agreement for Assistance by the Agency in Establishing a Nuclear Power Facility, IAEA-Mexico, INFCIRC/203, Annex (Apr. 5, 1974) (agreement for the U.S. to supply through the Agency uranium enrichment services and a nuclear power reactor to Mexico).

³²⁷ IAEA INFCIRC/18/Rev. 1, *supra* note 324, at § I(2).

³²⁸ *Id.* at § 1.5.

³²⁹ *Id.* at § 4.8. In INFCIRC/18, as originally adopted in 1960, the Agency was similarly authorized to require from project applicants information on "the methods of waste disposal." INFCIRC/18, art. V(29)(b).

³³⁰ IAEA INFCIRC/18/Rev. 1, *supra* note 324, at § 1.5.

project. Nevertheless, post-fission nuclear waste management on an *interim* basis has been a factor in the Agency's approval of its first two power reactor projects, the Laguna Verde Nuclear Power Plant, Unit 1, in Mexico and the Krsko Nuclear Power Plant in Yugoslavia.³³¹ The project agreements for these facilities specify that the Agency shall consider the acceptability of the measures for the "handling and storage of spent fuel after unloading from the reactor," the first phase of a waste disposal program.³³²

The day may still be distant when the Agency would reject a proposed project for want of an adequate permanent disposal program for the project's undesired post-fission byproducts. It is, however, significant that the Agency has, in its principal safety document, already chosen to identify nuclear waste disposal as a subject relevant to project approvals and has in practice scrutinized at least the first phase of waste disposal in its two nuclear power reactor project approvals to date.³³³ If nothing else, the Agency's policies lend legitimacy to the view that nuclear supplier and recipient, alike, have an interest in considering the waste disposal aspects of major exports at the time the arrangements for the export are being concluded. As the introductory portion of the Circular states with respect to this and other safety issues:

The safe operation of nuclear facilities and the safe use of radiation sources are of great importance to all persons connected with such facilities and sources, to the State authorizing their operation or use, and to other persons and States that might be adversely affected by their unsafe operation or use.³³⁴

In light of this statement, the failure of the principal free-world nuclear suppliers (and the United States may be included in this group) to examine the nuclear waste issue as part of their respective bilateral nuclear cooperation programs is noteworthy since, as important members of the IAEA Board of Governors,³³⁵ they have acquiesced in the safety review requirements set forth in the Agency's Statute and the

³³¹ See agreements discussed in notes 323 and 326 *supra* (the U.S. supplied the reactors for these Agency projects).

³³² See IAEA-Mexico agreement, *supra* note 326, at Annex; IAEA-Yugoslavia agreement, *supra* note 326, at Annex.

³³³ See the agreements listed in note 332 *supra*.

³³⁴ See IAEA INFCIRC/18/Rev. 1, *supra* note 324, at § 2.2.

³³⁵ Canada, France, the Federal Republic of Germany, and the U.S. were members of the IAEA Board of Governors in 1976, when INFCIRC/18/Rev. 1 was adopted, and they concurred in this action. IAEA GOV/OR. 486 (June 1, 1976). All of these nations, except for West Germany, also served on the Board when INFCIRC/18 was adopted. IAEA GOV/DEC/17(III) (June 10, 1960).

Circular, and presumably support their substance.³³⁶ Moreover, at least two of these suppliers, West Germany and the United States, have acquiesced in IAEA safety reviews of specific exports made through the Agency,³³⁷ indicating their willingness to have the nuclear waste issue, among others, examined with respect to at least some of their exports, though they have declined to undertake such examination in other cases.³³⁸

A number of reasons may explain why nuclear supplier countries have been reluctant in their respective bilateral nuclear trade relations to take up the waste disposal issue with their export recipients. None of these reasons, however, fully explains why these suppliers have taken such a decidedly different position with respect to exports made through the IAEA.

Perhaps the prime explanation for the suppliers' avoidance of the waste issue in dealing with their direct trading partners is that supplier country governments have only begun to acknowledge the seriousness of the nuclear waste disposal issue insofar as their own domestic nuclear programs are concerned within the past several years. This acknowledgment has resulted largely because of extra-governmental political pressure, and only in this recent period have supplier nations begun to accelerate domestic efforts to address the problem.³³⁹ Most agreements for cooperation pre-date this change in the pace of suppliers' domestic waste disposal programs.³⁴⁰ It is reasonable to assume that when these agreements were drafted, supplier governments held the same view toward wastes generated from exports as they held for wastes generated at home, namely, that the technology for safe and permanent disposal of these wastes would be developed in the future to be available as the need for it arose. Accordingly, since wastes were not a problem requiring immediate attention, there was no need to address their disposition in export arrangements.

Moreover, with permanent waste disposal technologies as yet un-

³³⁶ INFCIRC/18 was approved by the Board of Governors on March 31, 1960. INFCIRC/18/Rev. 1 was approved by the Board of Governors on February 25, 1976.

³³⁷ IAEA-Argentina-West German agreement, *supra* note 323, at art. VI; US-IAEA supply agreement/IAEA-Mexico project agreement, *supra* note 326, at Annex (containing safety review requirements); US-IAEA supply agreement/IAEA-Yugoslavia project agreement, *supra* note 323, at Annex (containing safety review requirements).

³³⁸ See text accompanying notes 259-63 and 309-11 *supra*.

³³⁹ See text accompanying notes 74-192 *supra*.

³⁴⁰ In the United States, for example, the major expansion of governmental programs for disposing of post-fission wastes dates from FY 1975, see notes 76-114 *supra*, while virtually all U.S. agreements for cooperation with its current nuclear trading partners were signed prior to that date. NUCLEAR PROLIFERATION FACTBOOK, *supra* note 184, at 274.

demonstrated in supplier states, suppliers, had they sought a commitment from recipients to the safe disposal of export-produced wastes, would have been seeking a pledge whose terms they themselves had neither fulfilled nor even shown to be technologically feasible. In these circumstances, recipient nations could fairly have questioned why their right to go forward with nuclear power programs should be in any way conditioned on the future disposal of produced wastes, while suppliers, in view of their continued failure to implement comprehensive waste disposal programs domestically, had obviously proceeded on a different basis. In addition, it has been suggested that recipient states perceive nuclear waste disposal and other hazards of nuclear power generation as internal matters going to the exercise of their domestic authority for the protection of their citizens and would view foreign insistence on the implementation of specific health and safety measures as an infringement of recipient state sovereignty.³⁴¹ Thus, even had supplier nations come to the view that the future disposal of export produced nuclear wastes was a topic worthy of discussion with recipients, fear of recipient resistance to such an initiative on the grounds just noted could well have led suppliers to avoid pressing the waste disposal issue during negotiations on nuclear trade relations.

Indeed, emphasizing the problems of the future management of nuclear wastes during the course of negotiations with potential export recipients would hardly have served the immediate interests of the supplier nation. Whatever the supplier's reasons for entering into nuclear commerce—extension of nonproliferation controls, maintaining stature as a leader in the nuclear field, improving payment balances, cementing relations with an ally, or wooing a new client state—to have stressed an inevitable, increasingly politicized, and as yet unsolved drawback to nuclear power would surely not have helped achieve this objective. Within a given negotiation, moreover, supplier states may well have had higher priority commitments (concerning, e.g., non-proliferation restraints) to obtain and may have been reluctant to burden the negotiating process with additional demands regarding what they perceived as secondary issues.

Also militating against the implementation of conditions establishing recipients' responsibility for the safe disposal of nuclear wastes through nuclear trade agreements or export controls has been the competition among suppliers to develop nuclear trade with particular recip-

³⁴¹ See, e.g., *Hearings on Export-Import Bank Act Amendments for 1978 Before the Subcomm. on Resource Protection, Comm. on Environment and Public Works, 95th Cong., 2d Sess. 14-16 (June 20, 1978) (testimony of Marcus Rowden).*

ients. In such a setting, a supplier can "price himself out of the market" by imposing conditions on such trade which go beyond those of his competitors. Indeed, it was this perception which led a group of nuclear supplier nations, the so-called London Suppliers Group, to establish uniform minimum non-proliferation controls over their exports as a mechanism for averting a bargaining process in which such controls might be traded away by one or another supplier for commercial advantage.³⁴² These guidelines, however, do not establish a uniform position with respect to recipients' responsibility for nuclear waste disposal. Thus, any supplier state seeking to include such terms in a nuclear trade agreement could well be placing itself at a competitive disadvantage.

Assuming that some or all of the foregoing factors have influenced these suppliers' thinking, there remains the question of why they have nevertheless endorsed the IAEA's mandatory safety reviews, including consideration of waste disposal issues. At a minimum, support for Article XII of the IAEA Statute and for the Circular would seem to imply that these suppliers consider reviews of the nuclear waste aspect of exports to be desirable. This being the case, perhaps the most likely explanation as to why suppliers have provided such reviews solely in the case of IAEA projects is that only in this setting did these suppliers believe such reviews could be implemented at an acceptable cost politically and commercially. Recipient nations, as well as suppliers, it may be noted, have ratified Article XII of the IAEA Statute and, by virtue of their representation on the Agency's Board of Governors, the Circular.³⁴³ Recipients have thus, in effect, agreed in principle to prior-to-transfer review by the Agency of the waste management aspects of exports made under its auspices. From the supplier point of view, this means that many of the political strains alluded to earlier, which might be triggered by supplier insistence on such reviews in the context of direct, bilateral exports, would not be likely to arise when the Agency serves as intermediary. Similarly, since all suppliers desiring to use the Agency in this capacity for particular exports would be equally subject to the Circular, Agency review of the waste management aspects of such exports would not commercially disadvantage one supplier vis-à-vis another.

Although the history of nuclear cooperation over the past two decades makes it most unlikely that IAEA intermediation will displace bilateral cooperation as the basis for trade in the great majority of

³⁴² See the Guidelines for Nuclear Transfer, note 190 *supra*.

³⁴³ See, e.g., note 335 *supra*.

nuclear power reactor and associated fuel exports, the acceptance by suppliers and recipients of the principle of the Agency's examining waste disposal issues before Agency-sponsored exports are approved may provide a basis for introducing consideration of these issues in the context of bilateral trade. Where, for example, both a supplier and a recipient engaged in bilateral nuclear cooperation have, through their participation in Agency activities, indicated their support for the Circular and its subsidiary nuclear safety guides, it does not appear unreasonable or necessarily controversial for the supplier to propose that the recipient agree to follow such internationally developed guidelines with respect to the wastes produced by the supplier's direct exports. If such recipients were to adhere to these guidelines, they could develop a strongly rooted international consensus on the issue. Suppliers, it may be noted, have obtained recipient adherence to another set of erstwhile voluntary Agency standards, those concerning physical security measures for protecting nuclear materials against theft and sabotage,³⁴⁴ with considerable success.³⁴⁵

TREATIES AND MULTILATERAL AGREEMENTS

A number of widely ratified treaties and multilateral agreements include provisions which restrict nuclear waste disposal activities or otherwise seek to lessen nuclear waste pollution. While none of these deals primarily with nuclear waste disposal, each demonstrates the willingness of certain countries to be restricted in their freedom to pollute the global commons or frontier areas by multilateral agreement.

For example, the Antarctic Treaty signed at Washington, D.C., on December 1, 1959, and ratified by a total of twenty-two countries through June of 1979,³⁴⁶ is a broad document, limiting the exploitation and use of the entire continent from a broad number of perspectives, one of which deals explicitly with nuclear waste disposal.³⁴⁷ Article V, section 1, of the Antarctic Treaty prohibits nuclear explosions in Ant-

³⁴⁴ IAEA INFCIRC/225 (Sept. 1975).

³⁴⁵ The major nuclear supplier countries in their Guidelines for Nuclear Transfer have adopted the categorization of nuclear materials contained in the IAEA's voluntary guidelines on physical protection of nuclear materials, IAEA INFCIRC/225, as the "agreed basis" for physical security covering future exports. INFCIRC/254, Annex B. *See* note 190 *supra*.

³⁴⁶ 12 U.S.T. 794, T.I.A.S. 4780. States which are parties: Argentina, Australia, Belgium, Brazil, Bulgaria, Chile, Czechoslovakia, Denmark, the Federal Republic of Germany, France, the German Democratic Republic (with declaration), Japan, the Netherlands (including the Netherlands Antilles), New Zealand, Norway, Poland, Romania (with a statement), Spain, South Africa, the U.S.S.R., the United Kingdom, and the United States.

³⁴⁷ *Id.* at art. V, § 1.

arctica and the disposal there of "radioactive waste material."³⁴⁸

Similarly, the London Convention is the leading international agreement on pollution of the oceans and covers a broad range of issues on this subject.³⁴⁹ In its annexes, it deals specifically with the dumping of nuclear waste in the world's oceans.³⁵⁰ Annex I, relating back to Article Four's prohibition of certain types of dumping in the oceans, states: "High-level radioactive wastes or other high-level radioactive matter, defined on public health, biological or other grounds, by the competent international body in this field, at present the International Atomic Energy Agency, [are] unsuitable for dumping at sea."³⁵¹

The Convention allows for dumping of non-high-level wastes only under special permits, with the added understanding that the Contracting Parties should take full account of the recommendations of the IAEA in seeking such permits.³⁵² There has been some concern expressed that the Article 4/Annex I ban on dumping of high-level radioactive waste is itself weak since it relies on the IAEA's recently recommended revision to its definition of high-level radioactive waste.³⁵³ This definition of "high-level" radioactive waste is based on immediate release and dispersion rates of the radioactive material, but

³⁴⁸ *Id.*

³⁴⁹ Convention on the Prevention of Marine Pollution by Dumping of Wastes, 26 U.S.T. 2403, T.I.A.S. No. 8165, entered into force August 30, 1975. See D. DEESE, *supra* note 1, at 68, 91.

³⁵⁰ The London Convention was developed in a series of four intergovernmental meetings in 1971 and 1972 and a Conference in October and November 1972. With fifteen ratifications or accessions, it entered into force on August 30, 1975. See 26 U.S.T. 2403, T.I.A.S. No. 8165, at Annex I.

States which are parties include Afghanistan, the Byelorussian Soviet Socialist Rep., Canada, Cape Verde, Cuba, Denmark (extended to Faore Islands), the Dominican Rep., France (with reservation and statement), the German Democratic Rep., Guatemala, Haiti, Hungary, Iceland, Jordan, Kenya, Libya, Mexico, Monaco, Morocco, New Zealand (not applicable to Cook Islands, Niue, and Tokelau Islands), Nigeria, Norway, Panama, the Philippines, Spain, Sweden, Tunisia, the Ukrainian Soviet Socialist Rep., the Union of Soviet Socialist Reps., the United Arab Emirates, the United Kingdom (extended to Bailiwick of Guernsey, Belize, Bermuda, British Indian Ocean Territory, British Virgin Islands, Cayman Islands, Ducie and Oneo Islands, Falkland Islands and dependencies, Gilbert Islands, Henderson, Hong Kong, Isle of Man, Bailiwick of Jersey, Montserrat, Pitcairn, St. Helena and dependencies, Solomon Islands, Turks and Caicos Islands, Tnvalu, and United Kingdom Sovereign Base Areas of Akotiri and Dhekelai on the Island of Cyprus), the United States, Yugoslavia, and Zaire.

Implementing legislation: Marine Protection Research and Sanctuaries Act of 1972, Pub. L. No. 92-532, 86 Stat. 1052 (1972), as amended Pub. L. No. 93-254, 88 Stat. 50 (1974). For a comprehensive discussion on sea dumping and seabed disposal of nuclear wastes, see D. DEESE, note 1 *supra*.

³⁵¹ See 26 U.S.T. 2403, T.I.A.S. No. 8165, at Annex I.

³⁵² *Id.* at Annex I and art. IV.

³⁵³ See Statement of Clifton E. Curtis on behalf of the Environmental Defense Fund et al., Before the Subcomm. on Oceanography of the House Comm. on Merchant Marine and Fisheries (July 11, 1978) (concerning nuclear waste disposal in the oceans).

it does not include criteria concerning the isolation and containment of wastes or minimizing the number of dumping sites, criteria espoused by some critics, including the U.S. Environmental Protection Agency.³⁵⁴ However, EPA prodding has led to IAEA Advisory Group recommendations which, if adopted, would amend the definition of "high-level" wastes to incorporate these broader principles, thereby tightening still further the restrictions on the ocean dumping of these radioactive waste materials.³⁵⁵

An analysis of the signatories to the London Convention and to the Antarctic Treaty demonstrates that, while all the major supplier countries are signatories to these agreements, with the sole exception that Canada and Sweden have not yet signed the Antarctic Treaty, many of the purchaser countries have not signed one or both agreements.³⁵⁶ In other words, the supplier countries are more likely to

³⁵⁴ *Id.* (statement of Dr. William D. Rowe, Deputy Ass't Administrator, Environmental Protection Agency).

³⁵⁵ See, Statement of Clifton E. Curtis, note 353 *supra*. Statement of Dr. William D. Rowe, note 354 *supra*.

³⁵⁶

	<u>London Convention</u>	<u>Antarctica Treaty</u>
CANADA ^a	x ^b	—
India	—	—
Pakistan	—	—
Argentina	NR	x
South Korea	—	—
FRANCE	x	x
Belgium	NR	x
Spain	x	—
Iran	—	—
South Africa	—	x
FR GERMANY	x	x
Argentina	NR	x
Netherlands	x	x
Austria	—	—
Brazil	—	x
Iran	—	—
Spain	x	—
Switzerland	NR	—
SWEDEN	x	—
Finland	x	—
UK	x	x
Italy	NR	—
Japan	NR	x

^a Country names in upper-case lettering are nuclear support nations; listed beneath each supplier nation are its principal nuclear export recipients.

^b x indicates that the country has ratified the treaty; NR indicates that the country has signed, but not yet ratified the agreement under consideration.

agree to restrictions on the use of the global commons than are purchaser countries, especially less developed purchaser countries. Presumably, supplier countries which have agreed to such restrictions on their own waste disposal activities to protect the global environment would wish to see their purchaser countries abide by comparably rigorous standards. Otherwise wastes from a supplier's nuclear exports could cause the very harm the supplier had wished to avoid in ratifying the anti-pollution accords. Supplier countries, however, have not sought to influence purchaser countries to abide by restrictions on their disposal of nuclear wastes by seeking assurances on this issue in nuclear fuel and equipment supply agreements.

A third agreement of note is the Convention on Third Party Liability in the Field of Nuclear Energy (the Paris Convention) ratified by most of the OECD nations.³⁵⁷ This Convention binds the signatories to share in a portion of the financial liability for injuries arising from civil nuclear accidents, including those arising from nuclear waste.³⁵⁸ It also sets an upper limit of liability on the operators of nuclear installations

USA	x	x
Belgium	NR	x
Germany FR	x	x
India	—	—
Italy	NR	—
Japan	NR	x
Netherlands	x	x
Spain	x	—
Sweden	x	—
Switzerland	NR	—
UK	x	x
Brazil	—	x
South Korea	—	—
Mexico	x	—
Taiwan	—	—
Yugoslavia	x	—
Philippines	x	—
USSR	x	x
Bulgaria	—	x
German DR	x	x
Hungary	x	—
Czechoslovakia	—	x
Poland	—	x
Romania	—	x

Source: *World List of Nuclear Power Plants*, note 40 *supra*.

³⁵⁷ Doc. C (60) 93 (Final Text). Published at Paris, July 29, 1960, by the European Nuclear Energy Agency, Organization for European Economic Co-operation, and Convention of 31st January 1969 Supplementary to the Paris Convention of 29th July 1960 on Third Party Liability in the Field of Nuclear Energy.

³⁵⁸ See *id.* at arts. 1(a)(i), 1(a)(iv), and 7.

and waste disposal sites.³⁵⁹ The shared liability for nuclear accidents should give the signatories of the Paris Convention an incentive to co-operate toward assuring safe disposal of nuclear wastes.

The scope of the application of the Paris Convention to nuclear waste, however, is very limited. Under articles 3(a) and 4(a) of the Paris Convention, the operator of a nuclear installation is liable for damage caused by a nuclear incident involving radioactive waste in, or coming from, his installation until the operator of another nuclear installation has taken charge of such wastes. Facilities for storage of radioactive waste are among the installations to which the Paris Convention applies, but disposal repositories are not referred to in the Convention. It seems impracticable to consider that all operators in whose installations the waste was last held before disposal into a repository would forever remain liable and would forever have the obligation to maintain insurance coverage under article 10 of the Convention. This problem is dealt with in part by article 8 which limits the period of liability of the operator to only ten years after abandonment of nuclear waste. Further elaboration and expansion through amendment is clearly desirable on the question of very long-term liability after a post-fission waste repository were sealed and on the need to provide reserves of money or substitute comfort to cover liability for centuries into the future.

The Vienna Convention is an attempt to apply more broadly the third party liability concept to any signatory nation, while the Paris Convention is limited to OECD members.³⁶⁰ Though its terms apply to nuclear waste,³⁶¹ the Vienna Convention suffers from the same lack of clarity as the Paris Convention with regard to long-term waste disposal. Article VI limits the liability of an "operator" of a nuclear waste disposal site to the first twenty years after the abandonment of the site, again raising questions as to the Convention's long-term applicability following the closing of a post-fission nuclear waste repository. Amendments to the Vienna Convention to clarify liability for damage stemming from waste disposal are clearly desirable.

Although it does not allude to nuclear waste disposal, the Nuclear

³⁵⁹ *Id.*

³⁶⁰ Vienna Convention on Civil Liability for Nuclear Damage, *opened for signature* May 21, 1963, IAEA Doc. LN-12/46.

³⁶¹ *Id.* at art. I(1)(h)(ii). See text accompanying note 359 *supra*; and see especially art. VI(1) of the Vienna Convention which limits liability to damage within ten years of a "nuclear incident" and art. XXV(2), which allows countries to terminate participation in the convention each five years.

Test Ban Treaty³⁶² is an example of a treaty limiting certain types of nuclear activity. This treaty bars any nuclear weapons tests in the atmosphere, in outer space, under water (including territorial waters or high seas), or in any other environment if such explosion causes radioactive debris to be present outside the territorial limits of the State under whose jurisdiction or control such explosion is conducted.³⁶³ Similarly, the currently pending Treaty between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Underground Nuclear Weapon Tests,³⁶⁴ the currently pending Treaty Between the United States of America and the Union of Soviet Socialist Republics on Underground Nuclear Explosions for Peaceful Purposes,³⁶⁵ and the ratified Treaty on the Non-Proliferation of Nuclear Weapons³⁶⁶ all place limits on the signatories' use of or experimentation with nuclear materials.

The "Recommendation of the Council" of the Organization for Economic Co-operation and Redevelopment "For Strengthening International Co-operation and Environmental Protection in Frontier Regions" was adopted on September 21, 1978.³⁶⁷ It sets forth non-binding guidelines for member countries to use when activities within their borders threaten to pollute the territory of a neighboring country. Among these guidelines are: sharing with the government and public of neighboring countries any environmental impact studies on the effects of border area pollution, the inclusion in environmental impact studies of the impact on neighboring countries of polluting activity, and cooperation with neighboring countries in developing and implementing environmental standards. However, it does nothing specific to adopt or advance standards for nuclear waste disposal.

These multilateral agreements show a willingness of nations to

³⁶² 14 U.S.T. 1313, T.I.A.S. No. 5433 (1963). The U.S.S.R., United Kingdom, and U.S. are signatories.

³⁶³ *Id.* at art. I (1)(a) and (b).

³⁶⁴ Signed on July 3, 1974, *reprinted in* DEP'T STATE BULL., July 29, 1974, at 216.

³⁶⁵ Signed on May 28, 1976, *reprinted in* DEP'T STATE BULL., June 28, 1976, at 802.

³⁶⁶ 21 U.S.T. 438, T.I.A.S. No. 6839 (1970). *See also* Treaty for the Prohibition of Nuclear Weapons in Latin America, Feb. 14, 1967, 22 U.S.T. 754, T.I.A.S. No. 7137; Seabed Arms Control Treaty, Feb. 11, 1971, 23 U.S.T. 701, T.I.A.S. No. 7337 (prohibits emplacement, storing, and testing of nuclear weapons on the ocean floor outside territorial waters).

³⁶⁷ O.E.C.D. Doc. C (78) 77 (Final) of September 27, 1978. This Recommendation was based upon earlier Council Recommendations; specifically, the Council Recommendations or Principles concerning Transfrontier Pollution (November 14, 1974), on Equal Right of Access in relation to Transfrontier Pollution (May 11, 1976), and on Implementation of a Requirement of Equal Right of Access and non-Discrimination in relation to Transfrontier Pollution (May 17, 1977) appear respectively at 14 INT'L LEGAL MATERIALS 242 (1975), 15 INT'L LEGAL MATERIALS 1218 (1976), and 16 INT'L LEGAL MATERIALS 977 (1977).

deal with pollution and nuclear matters by treaty and convention. While the developed countries generally have been more willing to agree to the requirements of these agreements than have less developed countries, participation has been broad enough to suggest that an accord on nuclear waste disposal might be feasible and worth pursuing.

CONCLUSION

A number of points have emerged from the preceding discussion. First, the accumulation of post-fission nuclear wastes has become a subject of public concern and political controversy in the great majority of nations where nuclear power has begun to play an important role in electric power generation. Such concern and controversy in many of these cases threatens the continued use of nuclear power or its expansion, outcomes which could undermine efforts of these nations to decrease their dependence on imported oil as an energy source.³⁶⁸ In addition, improper disposal of post-fission wastes can lead to serious transboundary pollution and environmental degradation of global common areas.³⁶⁹

These risks notwithstanding, no nation anywhere in the world has successfully implemented a complete program for the disposal of post-fission wastes.³⁷⁰ To date, not one facility for the permanent disposal of high-level wastes or spent fuel has been placed in operation, and in many nations, including the United States, other major facets of nuclear waste disposal programs have yet to be decided upon or implemented.³⁷¹ In less developed countries with nuclear power programs, moreover, planning for post-fission waste disposal often appears to be rudimentary at best.³⁷²

Furthermore, despite the fact that all nations relying on nuclear power confront a common problem in disposing of their post-fission by-products and despite the fact that actions taken by any one of them to deal with the matter may affect the safety and environmental interests of other nations, either directly or by contaminating areas shared by all nations, international efforts to address the nuclear waste hazard have been limited, both in terms of developing common technical solutions to the problem and in terms of establishing norms for the avoidance of international injury from the conduct of disposal activities.

³⁶⁸ See text accompanying notes 2-18 *supra*.

³⁶⁹ See text accompanying notes 22-26 and 69-70 *supra*.

³⁷⁰ See text accompanying notes 74-192 *supra*.

³⁷¹ *Id.*

³⁷² See text accompanying notes 179-92 *supra*.

While, for example, the Euratom nations have agreed to the pooling of information from national waste disposal research and development activities and to the coordination of efforts so as to avoid duplication, other nations with active R & D programs, including the U.S. and Sweden, are proceeding largely on their own, sometimes covering the same ground. Similarly, although international organizations have developed widely accepted guidelines addressing a number of potentially hazardous aspects of nuclear commerce, they are only at the preliminary stages of developing comparable guides for post-fission waste disposal. International agreements rule out disposal of post-fission wastes in the global common areas of the high seas and Antarctica, but do not appear to have addressed definitively the issue of transborder pollution nor to have established affirmatively acceptable standards of conduct for post-fission waste disposers.³⁷³

Nuclear export activities on the part of the United States, France, West Germany, and Canada have, in a sense, contributed to the worldwide burden posed by nuclear wastes through the dissemination of nuclear technology.³⁷⁴ Yet these nuclear suppliers appear to have provided recipient nations with little in the way of technical assistance to address this inevitable problem. Nor have suppliers sought pledges from recipients that such wastes will be disposed of in an internationally responsible manner, even though (1) concerns have been raised as to the adequacy of less developed recipient country disposal programs,³⁷⁵ (2) exporters have demanded and obtained numerous other guarantees concerning the use of exported nuclear technology,³⁷⁶ and (3) suppliers and recipients alike have endorsed IAEA documents which, in general terms, recognize the hazardous nature of nuclear wastes and the overall need for their safe disposal.³⁷⁷ Indeed, suppliers have continued exports to nations which have so far refused to ratify international agreements prohibiting disposal of post-fission wastes in the high seas and on Antarctica—pacts to which the suppliers themselves have adhered—leaving open the possibility that wastes from nuclear exports will be disposed of in a manner directly at odds with the policies of the exporting nation.³⁷⁸

³⁷³ See text accompanying notes 345-67 *supra*.

³⁷⁴ See text accompanying notes 259-345 *supra*.

³⁷⁵ See notes 28 and 181 *supra*.

³⁷⁶ Under all the agreements cited in note 309, *supra*, for example, recipients pledge not to use imported nuclear technology for nuclear weapons. See also Guidelines for Nuclear Transfer, note 190 *supra*, under which exporter nations will require numerous guarantees from their export recipients.

³⁷⁷ See text accompanying notes 318-32 *supra*.

³⁷⁸ See text accompanying notes 346-56 *supra*.

Finally, concerns that the proliferation of nuclear weapons would be spurred by the spread of reprocessing capabilities and the accumulations of plutonium under national control have introduced major uncertainties into the post-fission waste disposal programs of many nations regarding whether spent fuel will be disposed of directly or reprocessed.³⁷⁹ These uncertainties are particularly acute in countries for which the United States has been the principal supplier of nuclear fuel inasmuch as reprocessing decisions concerning this material are subject to U.S. approval. As long as the issue remains unresolved, increased reliance on interim spent fuel storage appears inevitable and it is quite possible that ultimate decisions on reprocessing and, thus on the direction of waste disposal programs, may be deferred until further information on the need to recover the uranium and plutonium in spent fuel is available.

This analysis suggests a number of areas where increased international cooperation may be fruitful in alleviating the adverse environmental—and political—impacts of post-fission wastes within individual nations, between neighboring nations, and on commonly shared portions of the globe.

International Technical Cooperation

National efforts to address the problems posed by post-fission wastes are likely to be aided by expanded cooperation among nations on the technical aspects of this issue. Such cooperation would appear to be a valuable, uncontroversial, and easily accomplished means for achieving more efficient deployment of worldwide scientific and financial resources devoted to this subject and, by fostering the exchange of information, could well reduce the time needed to develop effective waste disposal mechanisms. This would yield obvious benefits to all cooperating nations. Cooperative efforts could also prove beneficial because any proposed post-fission waste disposal plan supported by the technical communities and governments of several nations might enjoy greater credibility in the eyes of their respective publics than proposals advanced by a single government. Improved national programs for post-fission waste disposal would, in turn, lessen the risk of radiological pollution beyond national borders.

A variety of mechanisms may be conceived for expanded international cooperation on the technical aspects of nuclear waste disposal, many of them already tested in practice. These include general agree-

³⁷⁹ See text accompanying notes 91-97, 191, 276-89, and 293-305 *supra*.

ments for the exchange of technical information,³⁸⁰ jointly funded and executed research and development projects,³⁸¹ coordinated independent research and development efforts, and the funding of R & D activities to be performed under the supervision of international organizations such as the IAEA or the CEC.³⁸² As national programs progress, one option which may merit further study would be joint technical involvement in the first national repository to be built—be it a “pilot scale” or full-size facility—where all cooperating nations would share in the scientific data generated. Not only would cooperating nations receive invaluable technical knowledge, but their first hand involvement in the project itself could enhance their credibility in addressing public concerns over post-fission waste disposal at home.

Another alternative worthy of consideration would be the initiation of a major international “study”, modeled after the on-going International Nuclear Fuel Cycle Evaluation³⁸³ which could attempt to pool existing knowledge from various national sources, delineate current research needs, and recommend a coordinated attack on major knowledge gaps by the national research and development programs of participating governments. The study could be reconvened periodically to incorporate new developments, gradually progressing toward a definitive international consensus on acceptable waste disposal practices.

As noted, many of these cooperative mechanisms have been employed previously, usually on an occasional and ad hoc basis. A concerted effort to maximize international cooperation on nuclear waste management issues, however, has never been mounted. In view of the considerable importance of these issues to all nations seeking to rely on nuclear power as a means for reducing dependence on foreign energy sources, such a concerted effort may now be timely. Progress can be made, notwithstanding uncertainties regarding reprocessing, by focusing on post-fission waste disposal mechanisms which could be used both for post-reprocessing high-level wastes and spent fuel. Both the U.S. and Sweden are already following this approach.³⁸⁴

³⁸⁰ See, e.g., AEC-Eurochemic agreement, note 266 *supra*; ERDA-U.K.A.E.A. agreement, note 266 *supra*.

³⁸¹ See, e.g., ERDA-Swedish Nuclear Fuel Supply Company agreement, note 266 *supra*.

³⁸² See text accompanying notes 193-223. See also NEA GROUP REPORT, *supra* note 58, at 68 (“Geologic disposal is a primary candidate for [research, development, and demonstration] work both at national and international levels.”).

³⁸³ See text accompanying notes 228-40 *supra*.

³⁸⁴ See text accompanying notes 90-97 and 151-57 *supra*.

Actions by Nuclear Supplier Nations

Nuclear supplier states may take a number of steps to reduce the risk of transborder pollution and contamination of global common areas arising from the disposal of post-fission waste produced by their exports. Most readily implemented would be an affirmative offer of technical assistance by suppliers in all facets of post-fission waste management. This would provide the basis for recipients to implement disposal practices akin to those of suppliers and would offer the occasion for suppliers, as they tendered such assistance, to encourage this outcome. Waste disposal assistance could be offered at normal market prices, much as other nuclear technology is sold to recipients, avoiding the need for significant financial commitments by suppliers. Unlike the apparent situation today, however, suppliers would be acting affirmatively to address the international hazard (as well as the hazard to recipient nations themselves) arising from the unwanted byproducts of suppliers' nuclear commercial activities.

A second approach would be for suppliers to seek assurances from recipients that nuclear wastes from supplied technology will be disposed of responsibly. Such assurances could be sought informally through consultations and other diplomatic exchanges, or could be made a condition for further nuclear technology exports, although the latter approach may be undesirable for a number of reasons discussed earlier.³⁸⁵ Suppliers who are parties to the 1972 London Ocean Dumping Convention and the 1957 Treaty on Antarctica would appear to have a strong interest in obtaining assurances from recipients which have not adhered to either or both of these accords that they will abide by the strictures of these instruments concerning the disposal of post-fission nuclear wastes so as to avoid undermining the effect of the suppliers' own ratification of these agreements.³⁸⁶

Apart from suppliers' presumed interest in effectuating the purposes of these two accords, however, supplier nations, as world leaders in the field of nuclear power and as the parties which have reaped the profit from world nuclear trade, may be charged with at least a modicum of responsibility for the hazards which inevitably arise from their exports. Where, for example, post-fission waste management practices of a recipient nation were despoiling global common areas, the world community could well hold a supplier country making nuclear technology transfers to such a recipient without regard to its waste disposal

³⁸⁵ See text accompanying notes 339-42 *supra*.

³⁸⁶ See text accompanying notes 346-56 *supra*.

program at least partly to blame for the resulting harm. These considerations suggest that suppliers may have a legitimate interest in encouraging safe nuclear waste management practices on the part of their customers and, accordingly, in seeking assurances that such practices will be implemented.

It may also be recalled that suppliers and recipients through their participation in the IAEA may be said to have broadly endorsed the notion that recipient waste disposal practices may be considered in the course of deciding whether particular nuclear technology transfers should be authorized.³⁸⁷ This fact would add legitimacy to supplier requests for assurances on this subject and correspondingly weaken the basis for recipient country objections thereto. For a variety of reasons noted earlier, unilateral action by individual suppliers may be an unattractive approach to guaranteeing nuclear waste disposal safety on the part of recipients.³⁸⁸ Most salient, perhaps, is that such actions may prove ineffectual if recipients are free to turn to alternate suppliers not seeking this additional constraint on their conduct. This suggests that multilateral efforts, either on the part of suppliers as a group, following the approach of the London Suppliers Group nonproliferation guidelines,³⁸⁹ or in a wider context, such as through an international accord, may be a more fruitful alternative for implementing norms concerning acceptable post-fission waste disposal methods.

A final option for supplier action to alleviate the risks of international pollution from the post-fission wastes produced by exported nuclear technology would be for suppliers to assume responsibility for disposing of such materials by taking them back, much as the United States has offered to do on a limited basis. Such proposals, however, are likely to encounter considerable domestic opposition within supplier nations and, accordingly, to be difficult to implement. They may, however, stand a greater chance of gaining public acceptance if they are perceived as conferring a benefit, in addition to a reduction of world-wide post-fission waste pollution risks, on the supplier state, for example, by diminishing the danger of nuclear weapons proliferation. In this context, supplier take-back of spent fuel would appear more likely to achieve public acceptance than retention in supplier countries of post-reprocessing high-level waste.³⁹⁰

³⁸⁷ See text accompanying notes 318-34 *supra*.

³⁸⁸ See text accompanying notes 339-42 *supra*.

³⁸⁹ See note 190 *supra*.

³⁹⁰ See text accompanying notes 281-85 *supra*.

International Agreements, Guidelines, and Storage Arrangements

Although the discussion immediately preceding has focused on possible future transboundary and global common area pollution by nuclear recipient nations, such harms can arise from the conduct of *any* nation using nuclear power, including the principal nuclear suppliers themselves and other states with indigenous nuclear programs. For this reason, efforts to lessen the risks of such pollution which focus exclusively on nuclear importer nations will, at best, be only partially effective in addressing this issue. Accordingly, while concerted supplier action to seek recipient assurances regarding future waste disposal practices could well prove beneficial, if only in a limited sphere, the remainder of this article will focus on more comprehensive international approaches to this subject.

Undoubtedly the most effective means for minimizing cross-border global common area pollution from post-fission wastes would be wide-scale adherence to a treaty or international convention on this subject which set forth the duty of adherents to avoid nuclear waste pollution beyond their borders. As noted above, such accords for protecting global common areas have for a number of years been open for ratification. Unfortunately, a large number of nuclear power user states have not yet ratified these instruments. Encouraging adherence by these nations is obviously desirable.

It may also be noted, however, that since these accords involve many issues apart from nuclear waste disposal, nonadherence in these cases may not necessarily signify opposition to the conventions' restrictions on this activity. This fact suggests an additional approach which might be fruitful, namely, an initiative, perhaps under the auspices of the IAEA, to obtain less formal undertakings from nonadherents to the London Convention and the Antarctic Treaty to the effect that they intend to act in consonance with the prohibitions in these accords regarding post-fission waste disposal. This could reduce risks of global common area pollution from these materials while not affecting other objections which nonadherents may have to these accords. A precedent for such *de facto* adherence to international agreements concerning nuclear technology, it may be noted, is France's undertaking to behave as though it had ratified the Treaty on the Non-Proliferation of Nuclear Weapons, even though it has not, in fact, formally adhered to that instrument.³⁹¹

³⁹¹ Treaty on the Non-Proliferation of Nuclear Weapons, note 366 *supra*; *Hearings on the Second Nuclear Non-Proliferation Treaty Review Conference before the Subcomms. on Int'l Security*

Accords also exist concerning third party liability for nuclear accidents with impacts in foreign nations.³⁹² The Paris and Vienna Conventions specifically address third-party liability for injuries resulting from nuclear waste and cover injuries from interim waste storage and the first years of long-term disposal. This is an excellent beginning and could be followed up with amendments to the Paris and Vienna Conventions clarifying long-term coverage of injury resulting from permanent post-fission waste disposal. Neither convention, however, specifically addresses the development of strict nuclear waste disposal standards.³⁹³ More broadly, accords concerning transboundary pollution, generally, do not address the specific issue of pollution from post-fission radioactive wastes.³⁹⁴ Extending the coverage of both types of accords to include long-term post-fission waste contamination may well be a practical approach to reducing the risk of cross-border pollution from these materials inasmuch as these agreements already embody a recognition of the general class of hazard posed by such radioactive wastes and set forth rights and duties for alleviating such hazards, either through compensation of resulting injuries or by direct reduction of the hazard itself.

Development of an entirely new international accord to cover transborder and global common area pollution from post-fission wastes may thus be unnecessary. In addition, development of such a new accord would likely be considerably more protracted both for the time needed to negotiate its text and for obtaining formal ratifications, than would be the case if the initiatives suggested above, based on the framework of existing accords, were pursued.

An additional approach for achieving international agreement on basic standards for disposing of post-fission waste so as to reduce the dangers of international pollution would be the promulgation by the International Atomic Energy Agency of guidelines covering this field to which IAEA member states could adhere on a voluntary basis. This approach has proven successful in the areas of international transportation of radioactive materials and in the implementation of physical security standards against illicit seizure of nuclear materials by terrorists or other subnational groups.³⁹⁵ In both instances the Agency's guidelines have gained virtually universal acceptance by nations with nu-

and Scientific Affairs and on Int'l Economic Policy and Trade of the House Foreign Affairs Comm., 96th Cong., 1st Sess. 44 (July 16, 1979) (testimony of Charles Van Doren).

³⁹² See text accompanying notes 357-61 *supra*.

³⁹³ *Id.*

³⁹⁴ See text accompanying note 367 *supra*.

³⁹⁵ See note 204 *supra*.

clear programs. Significantly, because the development of such guides takes place as part of the on-going business of the Agency, avoiding the need for formal treaty negotiations; and because adherence to such guides does not entail the formal processes mandated for treaty ratification, this approach could prove more efficient in establishing an international consensus on post-fission waste disposal than the development of a new convention on the subject or even the extension of existing conventions to encompass this area.

While the Agency, as noted earlier, is still in the early stages of developing its technical safety standards for post-fission waste disposal,³⁹⁶ the voluntary guidelines, if worded broadly in terms of basic principles and performance standards, could be promulgated in advance of the completion of these detailed safety standards and revised in the future to incorporate the standards, as needed. To provide an example, the guidelines when first issued might include a statement that post-fission wastes are to be disposed of in a manner which will not cause injury beyond the border of the disposing nation and that use of geologic repositories for disposal under conditions which ensure repository integrity for a minimum period of time—perhaps 10,000 years—is an acceptable disposal mechanism.

As noted above, Working Group 7 of the International Nuclear Fuel Cycle Evaluation will apparently endorse accelerated development of internationally agreed upon codes and standards for post-fission waste disposal.³⁹⁷ This broad support should give added impetus to the IAEA's work on this promising approach for lessening the risk of international contamination from these materials. It is worth noting in this regard that as international standards are developed they could prove most valuable in aiding individual nations in the development of their domestic nuclear waste disposal programs, on the one hand providing guidance to those nations with programs and standards in the early stages of evolution, and on the other, enhancing the credibility before domestic publics of more developed programs which conform to such standards.

Finally, on-going international efforts to develop joint spent fuel storage facilities may also play an important role in curtailing the risks of transboundary and global commons pollution. Since, for example, the concept of such facilities will inevitably entail one nation's playing host to the facility—and thus to the wastes of other nations—safety conditions are likely to be especially rigorous; absent such conditions, it

³⁹⁶ See text accompanying notes 199-202 *supra*.

³⁹⁷ See text accompanying notes 228-40 *supra*.

is hard to imagine the public in a potential host country, already concerned over the management of domestically produced wastes, accepting additional radioactive materials from abroad. The stringency of waste management safety standards in other nations participating in such a joint storage facility, conversely, might vary across a wide range. On balance, therefore, placement of post-fission wastes in multilateral facilities is likely to provide a high degree of protection against pollution for all stored materials, whereas retaining the materials under the national programs of the respective participating nations might not provide comparable protection in all cases. Even assuming that the multilateral facility provided only interim storage, rather than a permanent disposal capability, a net benefit in terms of reducing the risk of radioactive pollution over the short run could still be achieved.

As noted above, moreover, cooperation in the development of international post-fission wastes storage facilities is likely to aid in the development of an international consensus on acceptable longer term disposal mechanisms.³⁹⁸ Thus in addition to their contribution to non-proliferation objectives, multinational spent fuel storage facilities could aid in a number of respects in reducing the risk of international radioactive pollution from post-fission wastes, assuming political and other obstacles can be overcome.

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The foregoing analysis indicates that while national and international activities for disposing of post-fission wastes today remain unfinished, and in some cases rudimentary, a wide range of international cooperative initiatives would appear to be available for helping to address the political, health, safety, and environmental risks posed by these materials. Some of these initiatives, at least, would seem relatively uncontroversial and fairly easy to implement; and, in some instances, work is already underway to bring them to fruition.

³⁹⁸ See text accompanying notes 257-58 *supra*.